EURANDOM

Annual Report 2004

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

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1. PREFACE

For EURANDOM the year 2004 has brought many changes. Research was re-aligned into three parallel programmes, each with three themes:

Queueing and Performance Analysis (QPA)
- Queueing Theory
- Performance Analysis of Production Systems
- Performance Analysis of Communication Systems

Random Spatial Structures (RSS)
- Critical Phenomena
- Disordered Media
- Combinatorial Probability

Statistical Information and Modelling (SIM)
- Statistical Learning
- Statistics in Biology
- Industrial Statistics

Alongside these programmes, two projects are running:

- Battery Modelling and Management (BMM)
- Reinsurance (RI)

(See www.eurandom.tue.nl for more information.) As part of this re-alignment, EURANDOM welcomes five new scientific advisors:

QPA:
- Dr. I. Adan (Technische Universiteit Eindhoven)
- Prof.dr. R. Boucherie (Universiteit Twente)
- Prof.dr. M. Mandjes (Centrum voor Wiskunde en Informatica & Universiteit van Amsterdam)

RSS:
- Prof.dr. R. van der Hofstad (Technische Universiteit Eindhoven)

SIM:
- Prof.dr. S. van de Geer (Universiteit Leiden)

QPA developed out of the former programme Stochastic Networks (SN), RSS developed out of the former programme Interacting Stochastic Systems (ISS), while SIM is a joining of three former programmes in statistics: Applications of Statistics (AS), Statistical Inference in Complex Statistical Models (CSM) and Computational Molecular Biology (CMB).

The former programme Stochastics of Extremes and Risk Analysis (SERA) - called Financial Stochastics (FS) in previous years- was ended (part of it continues as the project RI). We are grateful to professors J.H.J. Einmahl (Universiteit van Tilburg) and C.G. de Vries (Erasmus Universiteit Rotterdam) for having supervised FS and SERA successfully for many years and for having given it their best energy and creativity.

In July 2004, six members left the Scientific Council: O. Barndorff-Nielsen, P. Bickel (chair), R. Gill, F. Goetze, M. Keane and F. Kelly. They had served on the Scientific Council since the start of EURANDOM in 1998. The management of EURANDOM is grateful for their valuable input in shaping the institute. Five new members were appointed: S. Borst, D. Dawson (chair), A. Frigessi, P. Green and N. Veraverbeke. The Scientific Council met on July 29, 2004 during the 4th World Congress of the Bernoulli Society in Barcelona. The re-alignment and future development of EURANDOM were on the agenda.

In its meeting of November 22, 2004 the Board decided to appoint Prof.dr.ir. O.J. Boxma as next scientific director, for the period October 1, 2005 to September 30, 2010. The management of EURANDOM is very happy with this choice. Professor Boxma will bring considerable expertise, experience and energy to

EURANDOM. He is well at home at EURANDOM, being on the team of scientific advisors since the start of EURANDOM in 1998. Professor Boxma holds the chair of stochastic operations research at the Department of Mathematics and Computer Science at TU/e.

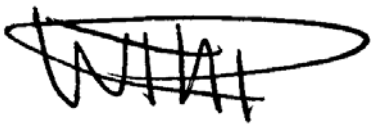
On January 1, 2005, Dr.ir. J.M.M. Ritzen (President of the University of Maastricht) took over as chair of the Board from Prof.dr.ir. P.J. Zandbergen. On December 31, 2004 Prof.dr. P.C. Baayen stepped down as secretary and treasurer of the Board. The institute is grateful for his creative guidance and for his steady support during the six years that he served on the Board, in the course of which EURANDOM faced a number of difficult challenges. I am pleased that Prof.dr. J.-K. Lenstra (director of CWI, Amsterdam) has agreed to succeed him.

The EURANDOM Chair is a joint initiative with the Department of Mathematics and Computer Science at TU/e. For the academic year 2004/2005, the EURANDOM Chair is occupied by Prof.dr. F. Baccelli. He is working at INRIA (Rocquencourt) and ENS (Paris), France, and is a member of the steering committee of QPA. He visits EURANDOM one week per month during the period October 2004 - May 2005, gave a public lecture on November 23, 2004 and is offering a mini-course: "Stochastic Geometry and Wireless Network Modelling".

Core funding for EURANDOM comes from NWO (Netherlands Organisation for Scientific Research) and Technische Universiteit Eindhoven (TU/e) and is based on the EURANDOM Business Plan 2003-2007. Together they provide 57% of the total cost. We are grateful to both institutions for their continued support. Additional funding comes from industry (5 researchers), European Union (1 researcher), NWO (3 researchers), and various other sources.

Like previous years, 2004 has been very busy for EURANDOM. We said goodbye to 9 PDs, welcomed 10 new PDs and 1 PhD, organised 7 workshops with 330 participants; and participated in 3 other meetings, hosted 52 visitors for periods of 1 week up to 6 months, ran 106 seminars, and produced 49 scientific reports. These figures show that EURANDOM continues to be a place of intense scientific activity. The support staff works around the clock to make this possible.

In the course of 2004, the Board, the Scientific Council and the directors agreed that it is time for EURANDOM to undergo an international scientific evaluation. NWO and TU/e were approached to organise this evaluation in 2005. I am looking forward to it eagerly.



Frank den Hollander
scientific director
May 2005

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 P.C. Baayen (secretary / treasurer);
Professor R.A. van Santen (member).

Directors:

Professor W.Th.F. den Hollander, scientific director (TU/e, Universiteit Leiden & EURANDOM);
Professor H.P. Wynn, scientific co-director (London School of Economics, UK & EURANDOM);
Ir. W.J.M. Senden, managing director.

2.2. Scientific Council

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

- Professor S. Asmussen, Department of Mathematical Statistics, Lunds Universitet, Sweden
- Professor F. Baccelli, École Normale Supérieure, Paris, France
- Professor E. Bolthausen, Universität Zürich, Switzerland
- Professor F. Delbaen, Eidgenössische Technische Hochschule Zürich, Department of Mathematics, Zürich, Switzerland
- Professor A. Greven, Mathematisches Institut, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
- Professor P. Hall, Centre for Mathematics and its Applications, Australian National University, Canberra, Australia
- Professor C. Klüppelberg, Technische Universität München, Germany
- Professor P. Massart, Université Paris Sud XI, Orsay, France.

New members as of July 1, 2004:
- Professor S. Borst, Centrum voor Wiskunde en Informatica, Amsterdam, The Netherlands
- Professor D. Dawson (chair), Carlson University, Ottawa & McGill University, Montreal, Canada
- Professor A. Frigessi, Universitetet i Oslo, Norway
- Professor P. Green, University of Bristol, U.K.
- Professor N. Veraverbeeke, Limburgs Universitair Centrum, Diepenbeek, Belgium.

Members who stepped down on June 30, 2004:
- Professor P.J. Bickel (chair), University of California, Berkeley, USA
- Professor O.E. Barndorff-Nielsen, Aarhus Universitet, Denmark
- Professor R.D. Gill, Universiteit Utrecht, The Netherlands
- Professor F. Götze, Universität Bielefeld, Germany
- Professor M.S. Keane, Wesleyan University, Middletown, Connecticut, USA, Korteweg de Vries Instituut, Universiteit van Amsterdam & EURANDOM, The Netherlands
- Professor F.P. Kelly, University of Cambridge, UK.

The Scientific Council of EURANDOM met on July 29, 2004 during the 4th World Congress of the Bernoulli Society in Barcelona, Spain. Main items on the agenda were the rounding off of the research re-alignment, the upcoming peer review as well as a discussion on the profile and how to find the best candidates for the scientific directorship of EURANDOM after October 1, 2005. Before and after the meeting there was

intensive e-mail contact with the chair, professor Don Dawson.

2.3. Programme co-ordinators and steering committees

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

Queueing and Performance Analysis (QPA)

- Scientific advisors:

Dr. I. Adan (TU/e & EURANDOM), *since 01-01-2004*
Professor R. Boucherie (Universiteit Twente & EURANDOM), *since 01-09-2004*
Professor O.J. Boxma (TU/e & EURANDOM)
Professor M. Mandjes (CWI, Universiteit van Amsterdam & EURANDOM), *since 01-09-2004*

- Steering committee:

Professor F. Baccelli (École Normale Supérieure, Paris, France)
Professor S.G. Foss (Heriot Watt University, Edinburgh, UK)
Professor A. Hordijk (Universiteit Leiden, The Netherlands)
Professor F.P. Kelly (Cambridge University, UK)
Professor V. Schmidt (Universität Ulm, Germany)
Professor J. Wessels (TU/e & EURANDOM)

Random Spatial Structures (RSS)

- Scientific advisors:

Professor R. van der Hofstad (TU/e & EURANDOM), *since 01-01-2004*
Professor W.Th.F. den Hollander (TU/e, Universiteit Leiden & EURANDOM)

- Steering committee:

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

Statistical Information and Modelling (SIM)

- Scientific advisors:

Dr. A. Di Bucchianico (TU/e & EURANDOM)
Professor S. van de Geer (Universiteit Leiden & EURANDOM*), since 01-12-2004*
Professor R. Gill (Universiteit Utrecht & EURANDOM)
Dr. M. de Gunst (Vrije Universiteit Amsterdam & EURANDOM)
Professor C. Klaassen (Universiteit van Amsterdam & EURANDOM)
Professor H. Wynn (London School of Economics, UK & EURANDOM)

- Steering committee:

Professor P. Donelly (University of Oxford, UK)
Professor U. Gather (Universität-Dortmund, Germany)
Professor P. Green (University of Bristol, UK)
Professor M. Newby (City University, London, UK)
Professor S. Tavaré (University of South Carolina, USA)

Professor A. Tsybakov (Université Paris VI, France)

In addition to these programmes, two projects are currently running:

Battery Modelling and Management (BMM)

- Scientific advisor:

Dr. W. Rey (Philips Research Laboratories, The Netherlands & EURANDOM)

Reinsurance (RI).

- Scientific advisor:

Professor J. Teugels (Katholieke Universiteit Leuven, Belgium & EURANDOM)

The following programme was ended as part of the research re-alignment:

Stochastics of Extremes and Risk Analysis (SERA) *–until July 2004*

- Scientific advisors:

Professor J.H.J. Einmahl (Universiteit van Tilburg, The Netherlands & EURANDOM)
Professor C.G. de Vries (Erasmus Universiteit Rotterdam, The Netherlands & EURANDOM)
Professor J.L. Teugels (Katholieke Universiteit Leuven, Belgium)

- Steering committee:

Professor O.E. Barndorff-Nielsen (Aarhus Universitet, Denmark)
Professor R. Davis (Colorado State University, Fort Collins, USA)
Professor F. Drost (Universiteit van Tilburg, The Netherlands)
Professor P.A.L. Embrechts (Eidgenössische Technische Hochschule Zürich, Switzerland)
Professor L.F.M. de Haan (Erasmus Universiteit Rotterdam, The Netherlands)
Professor J. Hüsler (Universität Bern, Switzerland)
Professor C. Klüppelberg (Technische Universität München, Germany)
Professor F. Longin (Le Campus de Cergy, ESSEC Business School, France).
Professor T. Mikosch (Københavns Universitet, Denmark)
Professor J.M. Schumacher (Universiteit van Tilburg, The Netherlands)
Dr. P.J.C. Spreij (Universiteit van Amsterdam, The Netherlands)

2.4. Scientific staff

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

14 PDs and 4 PhDs were financed by external funds:

In natura:

- 1 PD with an NSF grant (December 2003 – September 2004);
- 1 PD via an appointment at the Mathematics Department of the TU/e, NWO-VIDI grant (since April 2004);
- 1 PhD via an appointment at the Vrije Universiteit Amsterdam, NOW-VIDI grant (since March 2004);
- 1 PD via an appointment at the Universiteit Leiden, NWO Open Competition grant (since November 2004);
- 1 PD with a FOM grant (until December 2004);
- 1 PD via Deutsche Forschungs Gemeinschaft (DFG) (February – June 2004);
- 1 PD via TU/e, Department of Mathematics (until April 2004).

Additionally:

- 2 PDs with an NWO Open Competition grant;
- 1 PD with a Marie Curie Individual Fellowship (since February 2004);
- 1 PD with a part-time appointment at the TU/e Department of Technology Management (until December 2004);
- 1 PhD working on a contract with Philips;
- 1 PD and 1 PhD working on an EET contract with Philips and the TU/e Department of Chemical Engineering;
- 1 PD and 1 PhD working on an EET contract with Flextronics, the TU/e

Department of Technology Management, and EURANDOM;
- 1 PD with BRICKS funding via the TU/e Department of Mathematics and Computer Science (since October 2004);
- 1 PD position on a Vodafone contract (since April 2004).

On December 31, 2004, 26 researchers (research fellows, PDs and PhDs) were working at EURANDOM.

Queuing and Performance Analysis (previously Stochastic Networks)

PDs:

Dr. D. Denisov (October 2004), BRICKS funding
Dr. H.C. Gromoll (November 2001 - September 2004), EURANDOM November 2001 – September 2002, NSF grant September – December 2002 and December 2003 – September 2004, Marie Curie Fellowship December 2002 –December 2003
Dr. N. Hegde (January 2004 – August 2004), partly on industry contract
Dr. K. Maulik (September 2002 – December 2004), partly on industry contract
Dr. A. Sleptchenko (December 2002 – December 2004)
Dr. H.P. Tan (December 2004), Vodafone contract
Dr. E. Tzenova (September 2004)

PhDs:

J. van Leeuwaarden (September 2002), industry contract (Philips)
M. Vlasiou (September 2002)

Research Fellows:

Dr. A. Bumb (October 2004), Technische Universiteit Twente
Dr. N. Litvak (September 2002), Technische Universiteit Twente

Random Spatial Structures (previously Interacting Stochastic Systems)

PDs:

Dr. F. Camia (April 2003), Marie Curie Individual Fellowship since February 2004
Dr. G. Maillard (February 2004), NWO Open Competition, Den Hollander
Dr. R. –J. Messikh (October 2004)
Dr. K. Netočný (December 2003 – December 2004), FOM grant
Dr. A. Sakai (EURANDOM, January 2003 – 2004), NWO-VIDI grant van der Hofstad, since April 2004)
Dr. R. Sun (October 2004)
Dr. F. Toninelli (February 2003 – March 2004)
Dr. P. van der Wal (August 2002 – August 2004)
Dr. D. Znamenskiy (October 2003), NWO Open Competition van der Hofstad jointly with Hooghiemstra and van Mighem, Technische Universiteit Delft.

PhDs:
A. Fey–den Boer (March 2004), NWO-VICI grant Meester, Vrije Universiteit Amsterdam)

Research Fellow:

Dr. F. Redig (January 2001)

Statistical Information and Modelling (a combination of the former programmes Applications of Statistics, Computational Molecular Biology, Statistical Inference in Complex Statistical Models)

PDs:

Dr. N. Armstrong (February 2002 – April 2004)
Dr. L. Artiles Martinez (January 2002 – July 2002; May 2003 – December 2004)
Dr. W. Bergsma (September 2003), partly on industry contract
Dr. F. Enikeeva (May 2003)
Dr. A. Koloydenko (October 2002)
Dr. V. Kulikov (May 2003) partly on industry contract
Dr. N. Lalam (February 2004)
Dr. L. Mohammadi (November 2004) NWO Open Competiton Van de Geer, Universiteit Leiden)
Dr. F. Rigat (September 2004)

PhDs:

T. Figarella (June 2003), industry contract
P. van de Ven (February 2003)

Research Fellows:

Dr. P. Lindsey (September 2003), Universiteit Maastricht
Dr. P. Grünwald (January 2002), CWI Amsterdam
Dr. L. Artiles Martinez (December 2004)
Dr. M. Guta (January 2004), Universiteit Utrecht, currently working at Universiteit Nijmegen.

Stochastics of Extremes and Risk Analysis

PD:

Dr. M. Sarma (May 2003)

Reinsurance

PD:

Dr. S. Ladoucette (March 2003)

Battery Modelling and Management

PD:

Dr. D. Danilov (October 2002), industry contract

PhD:

I. Snihir (September 2003), industry contract

For details on their work, see section 3, and for their publications, see section 5.

2.5. Administrative support

Mrs. M.E.J.G.H. Brangers-Lempens - management assistant (April 2001) 0,9 fte
Drs. C.M.M. Cantrijn - policy officer (October 1997) 0,8 fte
Mrs. L. Coolen-van Will - workshop officer (June 1998) 0.7 fte
Drs. J.J. Kamperman - personnel officer (October 1998) 0,8 fte
Mrs. P.M. Koorn-van Hulten - administrative officer (January 2003) 0,4 fte

The scientific and administrative staff is appointed by TU/e and detached at EURANDOM.

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

- Organisation of workshops and conferences (Congress Office);
- 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 (ICT Services);
- Financial administration (Administrative Department).

A total of 29 persons were employed by EURANDOM on December 31, 2004, including the scientific and managing director. In addition, 13 senior scientists were associated with EURANDOM as co-director (1) or scientific advisor (12), 7 scientists were associated as research fellow. The support staff consisted of 5 persons.

3. RESEARCH PROGRAMMES

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

For details concerning the scientific results obtained, we refer to the EURANDOM Report series and to the published reports (see section 5).

3.1. Queueing and Performance Analysis (QPA)

Scientific advisors for this programme are Ivo Adan – since January 1, 2004 (TU/e & EURANDOM), Richard Boucherie – since September 1, 2004 (Universiteit Twente & EURANDOM), Onno Boxma (TU/e, CWI & EURANDOM) and Michel Mandjes – since September 1, 2004 (CWI, Universiteit van Amsterdam & EURANDOM).

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

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

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

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

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

The programme keeps close ties with the Stochastic Operations Research group (SOR) at the TU/e Department of Mathematics and Computer Science. Several members of the latter group are involved in the activities of the project,

including Dr. I. Adan, Professor S. Borst, Professor O. Boxma, Dr. S. Núñez-Queija, Dr. J. Resing, Professor J. van der Wal and Dr. B. Zwart, as well as a number of PhDs. There are also several interactions with researchers from the group of Professor M. Mandjes at CWI, Professor R. Boucherie's group at the Universiteit Twente, and other institutes.

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

Dr. Ivo Adan worked on various stochastic models. Together with Andrei Sleptchenko (EURANDOM) and Geert-Jan van Houtum (TU/e) he worked on multi-class single-server queues with preemptive priorities. With Elena Tzenova (EURANDOM) he studied a multi-class fluid flow model with a static priority discipline. He also worked with Maria Vlasiou (EURANDOM) on a Lindley-type equation arising from a carousel application. Together with Gideon Weiss (University of Haifa, Israel) he worked on queueing networks with infinite supply of work.

Professor Onno Boxma's main research activities in the framework of EURANDOM were:
(1) Joint research with Sem Borst (CWI, TU/e and Bell Laboratories, Murray Hill), Sindo Nuñez-Queija (TU/e) and EURANDOM PD Nidhi Hegde on queues with some processor sharing service mechanism. Exact sojourn time transforms have been obtained for the case of exponential service time requirements and a finite capacity for the number of customers that is admitted to the system. Several variants and extensions are also being considered. The research is motivated by performance issues in UMTS mobile communications, and fits in the framework of a project with Vodafone on UMTS.
(2) Joint research with Bert Zwart (TU/e) and EURANDOM visitor Offer Kella (Hebrew University of Jerusalem, Jerusalem) on time-dependent properties of symmetric queues (like the M/G/1 queue with processor sharing or with preemptive LIFO).
(3) Work with EURANDOM visitor Hans-Jörg Albrecher (Graz University, Graz) on relations between queueing and risk models.
(4) With Jacques Resing (TU/e) and EURANDOM PD Krishanu Maulik, a methodology has been developed for accurately approximating sojourn time distributions in open queueing networks. It has been applied, a.o., to a queueing model with feedback that represents the operation of a patent office.
(5) With Ivo Adan (EURANDOM & TU/e) and EURANDOM visitor David Perry (University of Haifa, Haifa), variants and generalizations of the classical G/M/1 queue were studied.

Professor Richard Boucherie worked on performance evaluation of Wireless LANs and UMTS (CDMA) systems. In particular, with Andrea Bumb (Universiteit Twente, Enschede) he worked on capacity and rate allocation in CDMA systems, where he studied rate allocation to calls in relation to the location of the calls, so as to optimize performance measures such as the total throughput or the number of carried calls. He also worked on modelling and analysis of (discriminatory) processor systems with emphasis on applications to Wireless LANs.

Dr. Denis Denisov's reseach is mainly concerned with random walks with heavy-tailed increments. In particular, he was collaborating with Seva Shneer (Heriot-Watt University, Edinburgh) on studying the local asymptotics for the maximum workload on a busy cycle of the single-server queue. In solving this problem they rely on a recent work of Denisov, where he gives a simple derivation of the global asymptotics for the cycle maximum. He and Seva Shneer have also been considering asymptotics for the length of the busy period of the single-server queue. The main tool for solving the latter problem is the theory of large deviations for heavy-tailed ran-

dom walks. He studied several other queueing problems as well.

Dr. Nidhi Hegde has been studying the distribution of sojourn time in finite processor sharing queues, in collaboration with Onno Boxma (TU/e & EURANDOM). The technique of deriving the distribution of sojourn time has been applied to a finite processor sharing with processor speed dependent on the number of customers in the system, and to a multi-class finite discriminatory processor sharing queue, with application wireless networks. This latter work has been conducted as part of the EURANDOM-Vodafone project.

Johan van Leeuwaarden has been further developing queueing models for cable access networks, which is the main subject of his PhD work (funded by Philips research). He works on this subject mainly with Dee Denteneer (Philips Research Laboratories, Eindhoven), Guido Janssen (Philips Research Laboratories, Eindhoven) and Jaques Resing (TU/e). Next to this work, he did some work on traffic models (jointly with Monique van den Broek (TU/e), Ivo Adan (EURANDOM & TU/e) and Onno Boxma (EURANDOM & TU/e)), and he worked on several other projects with Erik Winands (TU/e). Johan van Leeuwaarden will defend his PhD thesis in June 2005.

Professor Michel Mandjes worked on several problems in queueing theory and performance evaluation of wireline and wireless networks. With EURANDOM PD Elena Tzenova and Ivo Adan (TU/e & EURANDOM) he considered workload asymptotics in fluid priority queues. They have compared expressions derived by applying large-deviations methods, with results stemming from the Laplace transforms derived earlier by Adan, Kulkarni, and Tzenova. Research on convergence of the transient supremum to the stationary workload has been initiated, and will be continued together with EURANDOM PD B. D'Auria. The leading example in this study is the queue fed by fractional Brownian motion.

Dr. Krishanu Maulik. During his stay at EURANDOM, he worked on four different but related topics. First, he continued to work on modelling internet traffic, which is a problem from his PhD research, partly during his visit to the Mittag-Leffler Institute in Stockholm, September – October 2004. Second, he worked on hidden regular variation with Sid Resnick (Cornell University, Ithaca) during his visit to EURANDOM in January 2003. Third, he worked on a feedback queue model, inspired by a problem from the European Patent Office, with Onno Boxma (TU/e & EURANDOM). Fourth, he worked on exponential functionals of Levy processes with Bert Zwart (TU/e).

Dr. Andrei Sleptchenko studied:
1) Mathematical models for systems of maintenance logistics that are responsible for keeping equipment up and running, i.e., for systems controlling stocks, delivery and repair processes of spare parts.
2) Mathematical models for priority queing systems, which can be used in the systems of maintenance logistics mentioned above.
3) Cost/performance optimization of the systems of maintenance logistics.

Dr. Hwee Pink Tan. The importance of mobile connectivity along with the popularity of the Internet is fueling the development and roll-out of Third Generation (3G) wireless systems and Wireless local area networks (WLAN). A demand for such a network to deliver wireless services from the wired network to the wireless users (downlink) is envisaged. Examples of such services include multimedia messaging, voice over WLAN and localized content distribution. In order to be meaningful, the data traffic associated with these services must be delivered at specific data rates and/or within specific delay, packet loss and jitter bounds. These requirements can be collectively termed Quality of Service (QoS). While the capacity of a wired link is usually assumed to be constant, the wireless link is characterized by high channel error rate, bursty and time-

varying channel capacity and location dependent channel capacity. These characteristics make the provisioning of QoS in wireless networks a hard and challenging problem. Together with his advisors Raphael Rom (Technion, Israel Institute of Technology, Haifa) and Moshe Sidi (Technion, Computer Networks Laboratory, Haifa), Hwee-Pink Tan developed a performance modeling and analysis framework that generates QoS metrics for a given wireless scheduler design, input flow and wireless channel specification. As such, the framework can be used to determine:
(a) the trade-offs amongst various QoS metrics for a particular scheduler design under a homogeneous scheduling scenario;
(b) the contribution of each component of the wireless scheduler to a particular QoS metric under a homogeneous scheduling scenario;
(c) the effects of channel heterogeneity on the wireless scheduler's performance;
(d) the effects of input heterogeneity on the wireless scheduler's performance.

Dr. Elena Tzenova worked on finalizing her previous research (joint work with Ivo Adan and her former PhD advisor, Vidyadhar Kulkarni (University of North Carolina, Chapel Hill)) on a two-priority fluid model where an analytic method is presented for exact computation of the Laplace-Stieltjes transform of the joint steady-state distribution of the two buffer content process. This includes an additional paper containing important results on the performance output analysis of the system, which will be submitted soon. Moreover, she started working on two new projects. One of them is together with José Niño Mora (Universidad Carlos III, Madrid), who visited EURANDOM for a month in November, and considers the study of dynamic resource allocation in the case of Markov modulated fluid systems through marginal productivity index policies. The other one is concerned with the asymptotic analysis of multiclass priority fluid systems and involves a comparison with heuristic large deviations results of Michel Mandjes (EURANDOM & CWI).

Together with Ivo Adan (EURANDOM & TU/e), **Maria Vlasiou** has been studying a Lindley-type recursion that describes an alternating service system which is analogous to the single server queue. The system consists of a server alternating between two service points. At both service points there is an infinite queue of customers that have to undergo a preparation phase before being served. The main question is to define the distribution of the waiting time of the server. Together with Ivo Adan (EURANDOM & TU/e) she has obtained some results for this problem and studied various performance characteristics. Furthermore, she has been working with Nelly Litvak (Universiteit Twente, Enschede) on various aspects of this problem that apply to carousel systems. The main characteristic of this work in progress is that it allows for certain types of dependency between the interarrival and the service time of the customers.

3.1.2. Activities, collaboration and contacts

Workshops:
July 5 and 6, 2004
Quantitative Models for Production and Communication Networks
Participants: 45
Sponsored by EURANDOM, BETA Research School and NWO.

Visitors:
14 researchers visited the QPA-group for a total of 62 weeks.

Seminars:
23 (including the lecture series of the EURANDOM Chair, F. Baccelli); see 6.2.

General remarks:
In 2004 Nidhi Hegde arrived and started working on the Vodafone contract. She left in August for a permanent position at France Telecom. Denis Denisov arrived in October, after finishing his PhD research at Heriot Watt University, UK, for which he was awarded one of the

MacFarlane Prizes for an outstanding PhD thesis. Elena Tzenova arrived in September 2004 and Hwee Pink Tan in December 2004. Adriana Bumb (Universiteit Twente) started in October 2004 as research fellow. She participates in the Vodafone research.

Christian Gromoll left EURANDOM in September 2004, after a period with different types of contracts: he started with a EURANDOM appointment, went on with a Marie Curie Fellowship under FP5, and finally left EURANDOM during his NSF granted period, which he partly capitalized during his stay at EURANDOM. He is now at Stanford University, USA. Krishanu Maulik left EURANDOM in December for a permanent position at the Indian Statistical Institute in Kolkatta. Andrei Sleptchenko left in December for a postdoctoral contract at Tuck School of Business, Dartmouth College, USA. He received the first BETA prize for a best PhD thesis.

3.1.3. External contacts / cooperation

There are close ties with the TU/e Department of Mathematics and Computer Science, as well as with CWI. Onno Boxma and Michel Mandjes are part of a EU Network of Excellence (EURO-NGI), which will bring activities to EURANDOM in 2005. One PhD of the group is working on a contract with Philips on cable access networks; one PD participated in a joint contract with industry through the TU/e Department of Technology Management. One of the PDs was working on a Marie Curie Individual Fellowship, which was followed by an NSF grant.

Participation in BRICKS brought closer cooperation with CWI, Technische Universiteit Delft, Universiteit Twente and Universiteit Utrecht. Moreover, one PD position was (partly) financed by this programme.

See section 6 for more details on publications, authors, workshops and visitors Mentioned in section 3.

3.2. Random Spatial Structures (RSS)

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

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

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

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

The RSS-programme focusses 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

Together with Chuck Newman (Courant Institute, New York), **dr. Federico Camia** has applied the Stochastic Loewner Evolution to the study of the scaling limit of 2D critical percolation. He has also worked on the problem of universality of critical exponents and crossing probabilities in percolation, studying various dependent percolation models.

Together with Frank Redig (TU/e) and under supervision of Ronald Meester

(Vrije Universiteit Amsterdam), **Anne Fey-den Boer** has been studying various aspects of the abelian 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. They have obtained interesting results, but a lot of open questions still remain. Furthermore, together with Corrie Quant (Vrije Universiteit Amsterdam) she is studying Zhang's sandpile model, a non-abelian variant that has hardly been studied analytically before. The stationary behaviour differs considerably from the abelian model. They have results for the model on one or two sites, and are working on many sites in one dimension.

Professor Remco van der Hofstad has worked along three major lines of research. The first topic is to study high-dimensional interacting systems at criticality, such as (oriented) percolation and the contact process above the upper critical dimension, and to identify properties of its scaling limit. This is joint work with Markus Heydenreich (TU/e), Frank den Hollander (TU/e, Universiteit Leiden & EURANDOM), Akira Sakai (TU/e) and Gordon Slade (University of British Columbia, Vancouver). The second topic is the study of random graphs as models for real networks, such as the Internet, and to study the distances in such graphs. This is joint work with Henri van den Esker (Technische Universiteit Delft, The Netherlands), Gerard Hooghiemstra (Technische Universiteit Delft, The Netherlands), Piet van Mieghem (Technische Universiteit Delft, The Netherlands) and Dmitri Znamenskiy (EURANDOM). The third topic is the study of the properties of random walk local times, which describe the amounts of time a random walker spends at the various locations of the state space, and which are essential in studying various models of random walks with interactions. This is joint work with Nina Gantert (Universität Karlsruhe, Germany), Wolfgang König (Universität Leipzig, Germany), Peter Mörters (University of Bath, UK), and David Brydges (University of British Columbia, Vancouver, Canada).

Professor Frank den Hollander has worked on intermittency in catalytic random media with Jürgen Gärtner (Technische Universität Berlin, Germany) and Grégory Maillard (EURANDOM), on Wulff shapes of large critical droplets for the metastable lattice gas with Anton Bovier (Technische Universität Berlin, Germany) and Reda-Jürg Messikh (EURANDOM), on renormalization of interacting diffusions subject to non-linear selection with Rongfeng Sun (EURANDOM), on bad configurations for random walk in random scenery with Jeffrey Steif (Chalmers University of Technology, Gothenburg, Sweden) and Peter van der Wal (EURANDOM), on critical oriented percolation with Remco van der Hofstad (TU/e & EURANDOM) and Gordon Slade (University of British Columbia, Vancouver, Canada), on critical large deviations for Brownian motion among Poissonian traps with Michiel van den Berg (University of Bristol, UK) and Erwin Bolthausen (University of Zürich, Switzerland), and on copolymers in emulsions with Stu Whittington (University of Toronto, Canada).

Together with Jürgen Gärtner (Technische Universität Berlin, Germany) and Frank den Hollander (TU/e, Universiteit Leiden & EURANDOM), **dr. Grégory Maillard** has worked on intermittency in a catalytic random medium. In particular, they have focussed on the case where the catalyst is simple exclusion with a symmetric random walk transition kernel, starting from equilibrium. They have shown that Lyapunov exponents display an interesting dependence on dimension. Furthermore, in collaboration with Roberto Fernández (Université de Rouen, France), he has obtained some result concerning the construction of a specification from its singleton part for one-dimensional random processes.

Together with Anton Bovier (WIAS-Berlin, Germany) and Frank den Hollander (TU/e, Universiteit Leiden &

EURANDOM), **dr. Reda-Jürg Messikh** started to investigate metastability in the context of the lattice gas at finite temperature under Kawasaki dynamics. Furthermore, he is working on the isotropy of the Wulff shape near the critical point with Rafael Cerf (Université of Paris, France)

Dr. Karel Netočný has been working on various aspects of the statistical mechanics of interacting spin systems, mainly within a perturbative framework. Together with Frank Redig (TU/e & EURANDOM), he has started a project aiming to formulate a large deviation theory for states on non-commutative algebras. In a pilot work he has obtained a result on the large deviation property of empirical averages under high-temperature KMS states. Within another project, started in 2003, together with Aernout van Enter (Rijksuniversiteit Groningen) and Hendrikjan Schaap (Rijksuniversiteit Groningen) he has finished a paper concerning chaotic size-dependence behavior of the Ising model with a random boundary condition. During his visit to Christian Maes at the Instituut voor Theoretische Fysica, Katholieke Universiteit Leuven, Belgium, he has been working on the Gibbs structure of classical projections in quantum spin models.

Dr. Frank Redig's subjects of research were:
-Abelian sandpile model: infinite volume limits on transient graphs (with Antal Jarai, Carleton University, Canada)
-Several other subjects related to self-organized criticality:
1) Organized versus self-organized criticality, with Anne Fey and Ronald Meester (Vrije Universiteit Amsterdam, The Netherlands).
2) Zhang's model (with Anne Fey and Corrie Quant (Vrije Universiteit Amsterdam, The Netherlands)).
3) Dissipative and sticky abelian sandpiles, with Ellen Saada (Université de Rouen, France and Christian Maes (Katholieke Universiteit Leuven, Belgium).
- Time evolution of continuous spin systems under independent diffusions, with Christoph Külske (Rijksuniversiteit Groningen, The Netherlands).
- Quantum large deviations (with Karel Netočny, EURANDOM).
- Approximate matching and matching with scores for Gibbsian random fields (with Evgeny Verbitskiy (Philips Research Laboratories, Eindhoven, The Netherlands, Jean-René Chazottes (CNRS Paris, France) and Cristian Giardina (EURANDOM)).
- Deviation inequalities for dependent random variables and random fields (with Jean-René Chazottes (CNRS Paris, France), Christoph Külske (Rijksuniversiteit Groningen, The Netherlands) and Pierre Collet (Ecole Polytechnique, Paris, France)).

Dr. Akira Sakai's most active work in progress is:
(1) Convergence of the critical finite-range contact process to super-Brownian motion above the upper critical dimension (with Remco van der Hofstad).
(2) Asymptotic behavior for the critical two-point function for spread-out Ising ferromagnets above four dimensions.
(3) Bounds on the lace-expansion coefficients for spread-out Ising ferromagnets above four dimensions.
(4) Limit distribution and critical behavior for long-range oriented percolation (with Lung-Chi Chen (Institute of Mathematics, Academia Sinica, Taipei, Taiwan).
Akira Sakai gave public speeches at the YEP Workshop (EURANDOM), at the Courant Probability and Mathematical Physics Seminar (New York University) and in Nagoya, Japan.

After coming to EURANDOM, **Dr. Rongfeng Sun** has been working with Frank den Hollander (TU/e, Universiteit Leiden & EURANDOM) on the analysis of a nonlinear integral transform arising from renormalization of interacting diffusions. He has also been working with Chuck Newman at Courant Institute, New York, in completing a work on the

convergence of coalescing nonsimple random walks to the Brownian web. He has further been working with Samir Belhaouari, Thomas Mountford and Glauco Valle (Ecole Polytechnique Fédérale de Lausanne, Switzerland) on a study of one-dimensional voter model interfaces. Glauco Valle visited EURANDOM and gave a talk in December.

Dr. Fabio Toninelli wrote with Frank den Hollander a non-technical paper about the history of the mathematical theory of spin glasses, with particular attention to the most recent developments: infinite volume limit and computation of the free energy. Furthermore, he worked with Silvio Franz (ICTP Trieste Italy). The collaboration mainly concerned the study of the thermodynamic properties of spin glasses in finite dimension, when the interaction range is very large but finite. The main result is the proof that, in this limit, the behavior of the system is essentially mean-field like, as far as only the free energy and a suitably defined local order parameter are considered. This is intended to be a first step towards a better understanding of realistic spin glass systems. He gave lectures at the Université de Paris Sud, Orsay, at the WIAS, Berlin and at CPT, Luminy. Furthermore, he visited CPT, Marseille and the WIAS, Berlin.

Dr. Peter van der Wal collaborated with Frank den Hollander (TU/e, Universiteit Leiden & EURANDOM) and Jeff Steif (Chalmers University of Technology, Gothenborg, Sweden) on random walk in random scenery (RWRS). In particular, they managed to characterize the bad configurations for RWRS, i.e., the discontinuity points of the conditional probability distribution for the configuration inside a finite time interval given the configuration outside. A paper on this subject was finished. Furthermore, he worked with Alexis Gillett and Ronald Meester (Vrije Universiteit Amsterdam, The Netherlands) on the average duration of avalanches in the Bak-Sneppen evolution model. This resulted in a paper that has been submitted.

Together with Gerard Hooghiemstra (Technische Universiteit Delft, The Netherlands) and Remco van der Hofstad (TU/e & EURANDOM), **Dr. Dmitri Znamenskiy** worked on connectivity properties of random graphs describing Internet and the World Wide Web. Three articles have been written, one has been submitted (EURANDOM Report 2004-38), the second and third are to be submitted in 2005 (EURANDOM Report 2005-10 and 2005-11). The articles describe the hopcount distribution and the connected component sizes in power law random graphs.

3.2.2. Activities, collaboration and contacts

Workshops:
February 23 – 24, 2004
Meeting of the Dutch-German Bilateral Research Group on "Mathematics of Random Spatial Models from Physics and Biology"
Participants: 20.
The BRG programme is sponsored by DFG and NOW.

March 29 to April 2, 2004
Workshop on "Conformal invariance, Scaling Limits and Percolation", which is part of a series of workshops entitled **"Young European Probabilists" (YEP)**, hosted at EURANDOM 2004-2006.
Participants: 35.
The workshop was sponsored by EURANDOM, the ESF Scientific Programme RDSES, the Thomas Stieltjes Institute for Mathematics, and the DFG-Schwerkpunkt SPP 1033.

Visitors:
20 researchers visited the RSS-group for a total of 33 weeks.

Seminars:
28 seminars were organised (including the Mark Kac seminar at EURANDOM); see 6.2.

General remarks:
Federico Camia has been working at EURANDOM since April 2003, but changed his EURANDOM appointment into a Marie Curie Individual Fellowship as from February 2004. In the same month Grégory Maillard started working at the institute, while in March 2004 Fabio Toninelli left for a PD position at the University of Zürich; he is now working at the Laboratoire de Physique, ENS Lyon, France. In April 2004, Akira Sakai moved from a regular EURANDOM appointment to an appointment as part of the VIDI grant of Remco van der Hofstad, at the TU/e Department of Mathematics and Computer Science (although still doing his research at EURANDOM). In October 2004, Rongfeng Sun and Reda-Jürg Messikh arrived, while Peter van der Wal left EURANDOM for a position at the ABN-AMRO Bank in Amsterdam. Karel Netočny left EURANDOM for a permanent position "back home", at the Institute of Plasma Physics, Academy of Sciences Prague, Czech Republic.

3.2.3. External contacts / cooperation

The RSS-group continued to have intensive contacts with scientists of the former German Schwerpunkt "Interacting Stochastic Systems of High Complexity", through a visitor programme on a more modest scale than the years before, and by jointly organising the YEP 2004 workshop. Exchange also took place with Hungarian researchers through an NWO/OTKA grant.

The RSS-group participates in the Dutch-German Bilateral Research Group on "Mathematics of Random Spatial Models from Physics and Biology" (2002-2008), which is funded by DFG and NWO.

Frank den Hollander chairs the ESF Scientific Programme "Random Dynamic Systems in Spatially Extended Systems" (2002-2006), which involves 13 European countries.

See section 6 for more details on publications, authors, workshops and visitors mentioned in section 3.

3.3. Statistical Information and Modelling (SIM)

Scientific advisors for this programme are Alessandro Di Bucchianico (EURANDOM & TU/e), Sara van de Geer (Universiteit Leiden & EURANDOM) since December 1, 2004, Richard Gill (Universiteit Utrecht & EURANDOM), Mathisca de Gunst (Vrije Universiteit, Amsterdam & EURANDOM), Chris Klaassen (Universiteit van Amsterdam & EURANDOM), Henry Wynn (London School of Economics, UK & EURANDOM).

Statistical Information and Modelling evolved from the following three former EURANDOM research programmes: Applications of Statistics (AS), Computational Molecular Biology (CMB), Statistical Inference in Complex Statistical Models (CSM).

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

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

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

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

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

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

Together with Madalin Guta (EURANDOM), **Dr. Luis Artiles Martinez** has studied the problem of efficient statistical estimation of the quantum state throughout Quantum Tomography technique. Concretely, they have considered the homodyne detection of scheme and

looked for estimators for the Wigner function of the light, given the data obtained for the measurements of the quadratures X_θ at uniform random angles θ. They have been studying the problem of showing minimax rates of convergence of kernel estimators of the Wigner function of the quantum state, under a pointwise norm. During a visit of Cristina Butucea (Universités de Paris VI et VII CNRS, Jussieu, France) to EURANDOM, they started to study the problem in a more general setup. They considered noisy tomography data, then introduced an appropriate estimator and studied its behavior under different types of norms, namely pointwise and L2 norms.

Dr. Alessandro Di Bucchianico is working on statistical process control, design of experiments and reliability. With Marie Hušková (Charles University, Prague, Czech Republic) and Willem van Zwet (Universiteit Leiden, The Netherlands) he continued his investigations of developing control charts for specific alternative hypotheses. The idea is to incorporate the Neyman-Pearson paradigm of hypothesis testing into a sequential framework. Various specific alternative hypotheses have been investigated. The corresponding new control charts turn out to perform quite well. On design of experiments he has been working with Peter van de Ven (EURANDOM) and Henry Wynn (London School of Economics, London, UK & EURANDOM) on finding necessary and sufficient estimability conditions in mixed linear models as an attempt to obtain a good understanding of confounding in the case of location-dispersion models. Activities in reliability theory encompass both hardware reliability and software reliability. The Signature Analysis project funded by the Dutch government mainly deals with hardware reliability. Together with the EURANDOM collaborators Wicher Bergsma, Talía Figarella, Vladimir Kulikov and Henry Wynn and TU/e colleague Maarten Jansen, he is working on setting up experiments and analyzing data performed by Flextronics. The analyses involve combining multivariate statistics with wavelets. A next phase in this project is to develop monitoring schemes by developing appropriate control charts. Research on software reliability was performed jointly with Kees Van Hee and Jan-Friso Groote from LaQuSo (Laboratory of Quality Software, TU/e). A new software reliability model has been developed with no assumption on the initial number of errors. For this model, they developed a release procedure that guarantees error-freeness of software for a given confidence level. This project will be further expanded using the successful application for a NWO grant for 2 PhD students.

Dr. Wicher Bergsma and Vladimir Kulikov (EURANDOM) have worked jointly on the Signature Analysis project, investigating the feasibility of using vibration measurements for the ultimate goals of online monitoring of machine performance (rather than failure) and the assessment of the remaining life-time of components. Using data from an experiment performed by Flextronics and Product Design and Engineering (PD&E), they obtained several new results, which open up the possibility for online monitoring of machine performance by dynamic calibration of the aggregated profile of the machine's vibrations. The results have been written up in detail in a paper that has been submitted to Quality and Reliability Engineering International. Additionally, Wicher Bergsma has done research in nonparametric statistics and optimization theory. He has obtained a general solution to the problem of testing conditional independence for continuous random variables. Together with Tamas Rapcsak, whom he visited in Budapest, Hungary, a new approach has been developed to solve smooth constrained optimization problems. This approach has been succesfully applied to the problem of maximum likelihood estimation for complex models for large contingency tables.

Together with Eduard Belitser (Universiteit Utrecht, The Netherlands) **Dr. Farida Enikeeva** has been studying the empirical Bayes approach to problems of testing and adaptive estimation in a Gaussian white noise model. In this work it is assumed that the unknown parameter belongs to a Sobolev subspace with unknown smoothness. Together with Eduard Belitser she proposed a method of estimating the smoothness of a signal, which is based on a combination of frequentist and Bayesian approaches and leads to adaption procedures. The statistic is based on a marginal maximal likelihood estimator of the smoothness for an appropriate prior distribution on the unknown signal and is easily computable. Under the Sobolev class assumption she obtained a test statistic for the corresponding goodness-of-fit problem. Under certain assumptions this test is consistent and asymptotically unbiased. She also studied the problem of adaptive by estimating a fractional derivative of order 1/2 of the signal in the white noise model. This problem is similar to the famous Wicksell problem and consists of two parts: estimating an infinite-dimensional vector and estimating a linear functional of observations. An adaptive estimator based on the technique of unbiased risk estimation is obtained for the problem of estimating the vector. The problem of adaptive by estimating the linear functional is being considered by applying the method of risk envelope proposed by Youri Golubev.

The research of **Mrs. Talía Figarella** in this period was concentrated on analyzing two experiments performed in the BDT module of the copier machine. The BDT module stores and supplies paper for the copy process. The first experiment consisted of a factorial design with two factors, load and voltage, each at three levels, and the motor current was measured as response. The goal of this experiment is to check whether it is possible to monitor some parts of the motor system using current. From the analysis she concluded that the effect of the load and voltage can be identified in both frequency and wavelet domains. Specifically, the (low) frequencies that correspond to the gearbox were sensitive to changes of the load. The results of these analyses can be used to define the indicators for monitoring the condition of the machine in future research. The second experiment was a life test and was stopped after 202 hours because of wear of two gears connected to the mechanical load. During the test only new motors were used and the voltage and load were constant. The goal of this experiment was to obtain degradation indicators for the gearbox and brushes, since they are the most sensible parts of the motor system to wear out. During the test, major changes were observed in the low frequency region of the spectrum, specifically the meshing frequencies corresponding to the gears that wore out. For the brushes she extracts the length of the rising curve of the commutation wave as indicator of wear using a wavelet-based approach. She observed that there is a linear relationship between the mean rising length and the time measurements. Furthermore, she is designing the control charts for this wear indicator.

Professor Richard Gill is working on probability and statistics in quantum information and quantum measurement. With Luis Artiles Martinez and Madalin Guta (EURANDOM), he studied a celebrated problem in quantum optics called "quantum tomography": how to reconstruct the quantum state of light. This can be thought of as a nonparametric statistical inverse problem, and it is actually quite closely related to statistical problems in medical tomography. But there are also some fundamental differences. This work led to the paper by Luis Artiles Martinez, Richard Gill and Madalin Guta (2005) in the Journal of the Royal Statistical Society, which seems to be the first time quantum tomography is properly studied from a mathematical statistical perspective. There is much interest in the quantum information community at present in experimental proof of "quantum nonlo-

cality", so-called Bell experiments. With EURANDOM research fellow Peter Grünwald and with physicist Wim van Dam (University of California, Santa Barbara, USA) he worked on quantifying the strength of such experiments in statistical terms, leading to an objective way of comparing different experiments. A counter-intuitive finding was that more entanglement does not necessarily mean more quantum non-locality. A joint paper is expected to appear in IEEE-TIT in 2005. With Jan-Åke Larsson, a physicist from Linkjoping University, Sweden, he worked on loopholes to Bell experiments, discovering a previously unknown major defect to one of the best recent experiments.

Dr. Mathisca de Gunst continued her research on modelling and analysis of ion channel kinetics with Bert van Duijn (TNO-voeding, Leiden, The Netherlands), Barry Schouten (CBS, Voorburg, The Netherlands) and Olga Shcherbakova (Department of Mathematics, Vrije Universiteit Amsterdam, The Netherlands). She also worked on a project on modelling the gene network underlying neuronal outgrowth with Nicola Armstrong (EURANDOM & Department of Mathematics, Vrije Universiteit Amsterdam, The Netherlands), Guus Smit (Molecular and Cellular Neurobiology, Vrije Universiteit Amsterdam) and Joost Verhaagen (Netherlands Institute for Brain Research, Amsterdam). She started a new project on the analysis of spatio-temporal patterns in neuronal networks with Fabio Rigat (EURANDOM), Jaap van Pelt (Netherlands Institute for Brain Research, Amsterdam), Arjen Brussaard and Arjen van Ooyen (Department of Experimental Neurophysiology, Vrije Universiteit Amsterdam).

The research in Statistics in Biology of **Professor Chris Klaassen** has been focussed on genetic regulatory networks in collaboration with Dr. Nadia Lalam (EURANDOM) and Dr. J. Kaandorp (UvA). A description of this research may be found in Section 4 of this annual report. Furthermore, cooperation has continued with Dr. Bojan Basrak (University of Zagreb, formerly EURANDOM) on a normal copula model for the linkage analysis of quantitative trait loci in human genetics.

In collaboration with Donald Geman (JHU, USA and ENS de Cachan, France), **Dr. Alexey Koloydenko** has been searching for efficient coding of microstructure in digital images of natural scenes. Motivated by studies of similar processings in the neuronal systems, he has empirically investigated the problem of adapting the coding mechanism to a micro-image context. His results include measurements of coded information as function of the coding context and are based on a large popular database of natural images. Furthermore, his contacts with Philips Medical Systems (PMS) have resulted in a joint project of EURANDOM and PMS to develop advanced algorithms for computer-aided diagnostics of cancer via 3-dimensional computed tomography. His contribution to this project includes the development of statistical models for robust discrimination between detections of actual cancerous formations and false alarms.

Together with Hendrik Lopuhaa (Technische Universiteit Delft, The Netherlands), **Dr. Vladimir Kulikov** has worked on different aspects of monotone density estimation. Uniformly consistent modifications of the NPMLE were developed and compared. Moreover, the limiting distribution of the error of the Grenander estimator in the supremum distance was obtained. Together with Wicher Bergsma (EURANDOM), he also worked on dynamic calibration applied to online monitoring of photocopying machines using vibration data.

Dr. Nadia Lalam has been investigating the problem of efficient estimation of parameters arising in a model of genetic regulatory networks these play a fundamental role in many biological processes. This research is part of the project "Simulation of developmental regulatory networks" of Universiteit van Amsterdam. The aim is to quantify the in-

teractions between genes occurring in a regulatory network when considering gene expression data obtained by confocal laser scanning microscopy. As a case study, the segmentation of the Drosophila embryo is investigated. A new method for constructing efficient estimators relying on the one-step Newton-Raphson procedure has been elaborated. These estimators should entail a better summary of the information contained in the gene expression data than the currently used least squares estimators. Moreover, she has been studying the Polymerase Chain Reaction for which an unknown quantity of DNA molecules is amplified through the succession of PCR cycles. Earlier results have been obtained concerning the inference of the probability of replication of a molecule when modelling PCR with branching processes. Based on these results, the goal of the study is to propose estimators of the initial quantity of molecules.

The research of **Dr. Leila Mohammadi** was done as joint work with Gabor Lugosi (Pompeu Fabra University Barcelona, Spain). She investigated the methodology introduced by Boucheron et. al. (2003) for a more general class of functions. The method is based on certain modified logarithmic Sobolev inequalities. Boucheron et. al. (2003) proved a concentration inequality for the infimum of the empirical 0/1 loss function. Her main theorem can be easily generalized to the case where the loss function is bounded. To use the theorem for a star shaped class of functions, it is necessary to apply some new techniques. The hope is that the new exponential inequality can be used to obtain both distribution dependent and data dependent upper bounds on the excess risk in model selection.

Dr. Fabio Rigat spent the majority of his time working on statistical modelling of neuronal networks with Mathisca De Gunst and Jaap van Pelt (Vrije Universiteit Amsterdam, The Netherlands). He elaborated a Bayesian model that considers digital recordings of the network's activity. From such data the model produces inferences on the network's functional connectivity. He investigated simulation based methods to fit the model parameters, and evaluated the goodness of fit and of the predictions obtained from the model. Furthermore, he studied the applicability of Swartz' approximation for the computation of the marginal posterior density in the context of Weibull survival tree models.

The research of **Peter van de Ven** concerns the application of Gröbner bases to a joint modelling of mean and variance in design of experiments. The project aims at extending the Pistone-Wynn algebraic geometric framework for designs aimed at describing confounding relations arising when designs are used to model mean and variance simultaneously. These confounding relations require abstract definitions in the spirit of work by Pistone and Rogantin. This can be used to improve upon existing inference procedures for analysing location-dispersion models, which are known to possess inherent disadvantages. The second goal is to use the algebraic machinery to find minimal designs that identify given location-dispersion models and initiate theory of optimal designs for such models. The aim is to derive a special quadratic form theory attached to the underlying Gröbner basis theory. This may lead to designs that may be more efficient than the compound arrays proposed in papers of Hedayat, Stufken and Rosenbaum. Together with Henry Wynn (London School of Economics, UK & EURANDOM) and Alessandro Di Bucchianico (TU/e & EURANDOM), he formulated necessary and sufficient conditions for all parameters in a mixed linear model to be estimable. Furthermore, he has been investigating the different estimation methods for dispersion effects already proposed in the literature and showed the equivalence of some of them. Also, he made a first start with investigating the question how to define confounding when mean and variance are modelled simultaneously.

Professor Henry Wynn was active in various parts of the EURANDOM programme and beyond. He was chair of the MODA 7 conference which was supported on an EU conference grant and held in Heeze in June 2004 just outside Eindhoven with the organisation carried out by EURANDOM. This is the lead workshop/conference on optimal experimental design in Europe. Henry Wynn was also co-editor with Sandro Di. Bucchianico of the conference volume. He gave the the opening plenary talk at the MMR2000 (Mathematical Methods in Reliability) in Sante Fe in June 2004. He co-organised and spoke at a workshop under the pro-ENBIS EU Thematic Network (EURANDOM is partner) at the Norwegian Food reserach Centre, Matforsk in May 2004 and was a member of the Committee and participant in the ENBIS annual conference in Copenhagen in August 2004. He is on the Steering Committee of the Network of Excellence PASCAL and has been active in promoting PASCAL activity at EURANDOM. Henry is active over a wide area of research but notably algebraic statistics and industrial/engineering statistics, which form the backbone of the IS subprogramme at EURANDOM, and optimisation. He spent April 2004 at the CNRS I3S laboratory doing joint work on the application of dynamical systems to optimisation.

3.3.2. Activities, collaboration and contacts

Workshops:
June 14 – 18, 2004
"mODa (Model Oriented Design and Analysis) 7"
Participants: 60
Sponsored by EURANDOM, the European Commission, GlaxoSmithKline, London School of Economics, and NWO.

October 7 – 9, 2004
PASCAL workshop on "Notions of Complexity: information-theoretic, computational and statistical approaches"
Participants: 27
The workshop was sponsored by EURANDOM and the EC Network of Excellence PASCAL.

Visitors:
12 researchers visited the SIM-group for a total of 13 weeks.

Seminars:
24 seminars were organised, including the Qrandom seminars; see 6.2.

General Remarks:
In February, September and November of 2004, three new researchers arrived: Nadia Lalam, Fabio Rigat and Leila Mohammadi. Nicola Armstrong left in February 2004 for a postdoc position at the Vrije Universiteit (Amsterdam) and Luis Artiles Martinez left EURANDOM in December 2004; he went back to Cuba and is working as a free lance consultant; he is still involved with EURANDOM via a research fellowship, like Madalin Guta, since his appointment January 2004 at Utrecht University (from April 2005 Universiteit Nijmegen), Peter Grünwald (CWI) and Patrick Lindsey (Universiteit Maastricht).

3.3.3. External contacts / cooperation

Via the Qrandom seminars, contacts with the universities of Nijmegen and Utrecht were continued.

EURANDOM did put a lot of effort in the EU FP6. Besides the Thematic Network (Pro-ENBIS), which was already running under FP5, EURANDOM participates since December 1, 2003 in the Network of Excellence PASCAL. Apart from these two EU Networks and the Dutch research groups with an interest in quantum information, the group has contacts with industrial partners, a.o. via the Flextronics project (with Flextronics and TU/e). We also have several contacts with groups in life science in The Netherlands

See section 6 for more details on publications, authors, workshops and visitors mentioned in section 3.

3.4. Battery Modelling and Management (BMM)

Scientific advisor for this programme is dr. William Rey (Philips Research Laboratory & EURANDOM)

The project Battery Modelling and Management aims at a better understanding of the battery processes (modelling) with the goal of improving the way batteries are being used (management). EURANDOM places emphasis on the mathematical modelling which, clearly, has to be done in close collaboration with other specialists. This multidisciplinary project involves three main partners: the electrochemical expertise is brought in by the TU/e Department of Chemistry, the industrial know-how is provided by Philips Research Laboratories (Physics Laboratory), while EURANDOM investigates the mathematical facets. All three partners are located in Eindhoven and this allows for constant communication between the team members. Contacts are developed and maintained with the scientific community in Europe and worldwide. The project leader is Professor Peter Notten (TU/e & Philips), who is known for his fundamental and experimental work on Electrochemical Energy Storage.

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

Jointly with Peter Notten (TU/e & Philips), **Dmitry Danilov** investigates ageing of Li-ion batteries, which involves finding the electrochemical description of the discharge-recharge process and creating a mathematical model that describes this process. Jointly with Peter Notten (TU/e & Philips) and Alexander Ledovskikh (TU/e), he takes part in an investigation of electrochemical properties of hydrid forming materials, in particular, creating the mathematical description of equilibrium voltage dependencies.

Iryna Snihir Analysis of life-test experiments and modelling of battery behaviour are aimed at developing the Battery Management System (BMS). The goals of BMS are: optimal energy utilization and minimal degradation of the battery. It has also been found that for BMS it is critical that the State-of-Charge (SoC) is accurately determined. Therefore, activities were focused around the indication of SoC. Seeing that an open-circuit voltage (OCV) is found to be an effective indicator of the State-of-Charge, several methods for OCV-estimation (a method of statistical prediction of the zero-current potential based on Karhunen-Loeve expansion; a method based on relaxation of the battery voltage to the OCV after current interruption) were under consideration, as well as their mutual comparison and a fundamental understanding of electrochemical mechanisms. One of the main objectives of the work is to analyse the data obtained from experiments with varying currents, which allows for learning about the battery response to currents that vary in time, gaining information on the adaptation of voltage curves to different current regimes and extracting the State-of-Charge.

Dr. William Rey The modelling activity has two facets that are simultaneously developed. He contributes to both. You need to observe how a battery behaves in order to be able to build up appropriate model. One facet is the experimental observation of the battery, which must yield the proper information to be used in model construction. On the other hand, the model understanding drives the design of the laboratory experiments. Within the battery team, he specifies the experiments according to the followed objectives. However, running experiments is a life full of hazards, and a thorough monitoring of the data flow is peremptory. He runs the data debugging and data screening in collaboration with Martin Otten (TU/e Department of Chemical Engineering). The subsequent data analysis is driven (and/or executed) by him, partly by coaching Iryna Snihir. He also actively participates in the modelling discussions and into developing battery managing strategies.

See section 6 for more details on publications, authors, workshops and visitors mentioned in section 3.

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

This programme ended in the summer of 2004 as part of the research realignment

Scientific advisors for this programme were professor John Einmahl (Universiteit van Tilburg & EURANDOM) - until July 2004, professor Jef Teugels (Katholieke Universiteit Leuven, Belgium & EURANDOM) and professor Casper de Vries (Erasmus Universiteit Rotterdam & EURANDOM) - until July 2004.

The SERA programme focused on theoretical and applied issues in probability and statistics related to finance, insurance and economics. It built up particular expertise in the area of extreme value theory and its application to risk management procedures. The SERA group was leading in the analysis of financial market risks that occur relatively infrequently but have a dramatic impact on the economy, such as the 1987 minicrash and the recent financial meltdown. The group specialised in developing estimation techniques suited for fat-tail natured financial data. The scientific projects of the SERA group focused on where the tail risk kicks in, on the optimal rate for the estimators, on multivariate risk analysis, and on statistics of extremes for function-valued data relevant for portfolio decisions. Special attention was given to the fact that the typical financial data exhibit volability dependence, which influences the quality of the estimators. Other potential application of extreme value theory are in auction theory, in case the numbers of bidders is large, like internet auctions.

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

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

Together with Professor Jef Teugels (Katholieke Universiteit Leuven, Belgium & EURANDOM), **Dr. Sophie Ladoucette** has studied distributional questions connected to large claims reinsurance treaties, along with some asymptotic properties and applications to risk measures. Furthermore, she has been working on asymptotic problems (weak laws, arbitrary moments) of a statistic that permits, in particular, to analyse asymptotic properties of some risk measures. Together with Jef Teugels (Katholieke Universiteit Leuven, Belgium & EURANDOM), she has obtained accurate results. She has also worked with Dominique Guégan (ENS Cachan, France) on a practical aspect of the characterization of the joint extremes using specific copulas. Furthermore, she has worked with Jérôme Collet (Queensland University of Technology, Brisbane, Australia) on a new kind of switching process.

Dr. Mandira Sarma has worked on characterising empirical behaviour of the tail region of financial series. Using extreme value theory, she has estimated the tails of two prominant financial series, viz., the Nifty index and the 1-month interbank interest rates from the emerging markets of India. She has found heavy and asymmetric behaviour in both series, as shown by the positive value of the estimated tail indexes. These findings conform to the stylised

features of financial data, as discussed in the literature. Together with Casper de Vries (Erasmus Universiteit Rotterdam, The Netherlands & EURANDOM), she has studied the issue of sub-additivity of the risk measure Value-at-Risk (VaR). Although VaR is not sub-additive for a generic distribution, it is found to be sub-additive in the tail regions of heavy-tailed distributions. This throws interesting light on the recent debate on sub-additivity of VaR, since financial series are mostly heavy tailed, and since only the tail region (and not the entire distribution) is most relevant for a risk manager. Together with Professor Dominique Guégan (ENS-Cachan, France), she is working on empirical estimation of the dependence structure of interest rates of four different types of maturity, using data from the interbank currency market of India. During her visit to ENS Cachan in November 2004, they have obtained an empirical description of the four datasets, including descriptive statistics and preliminary statistical tests. The aim of this work is to use copulas to study the dependence structure between the four interest rates of varying maturity and to link the empirical findings to the theoretical framework of interest rate determination.

Professor Jef Teugels has constructed a random walk model employing copulas to deal with dependence between claim times and claim amounts. Under the assumption of small claims, he has proved exponential behavior of total claim amount and ruin probabilities. In connection with reinsurance, he was able to make a thorough study of the ECOMOR-reinsurance and the drop-down-excess of loss contracts. This work led to a structured investigation of the quality and asymptotic analysis of measures of variation.

3.5.2. Activities, collaboration and contacts

Workshops:
May 3 and 4, 2004

Workshop on "Exotic Option Pricing under Advanced Lévy Models"
Participants: 116 (from academia and financial industry)
The workshop was sponsored by EURANDOM, NWO, KNAW and Journal of Applied Econometrics.

Visitors:
8 researchers visited EURANDOM for 8,5 weeks

Seminars:
9 seminars took place; see 6.2.

A NEST application, together with three other ERCOM members (from France, Israel and Spain), is in the negotiation phase.

4. EXAMPLE OF RESEARCH: Statistical analysis of developmental genetic regulatory networks
Dr. Nadia Lalam

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

4.1. What is a genetic regulatory network?

Gene regulation presents a fundamental interest in modern genomics, since it controls many biological processes. A genetic regulatory network is constituted by the interaction of several genes. Expression of genes is turned on (activation) and off (repression) in specific cells at particular times: activators and repressors bind to other DNA sequences to affect the transcriptional activity of the gene. We consider more specifically developmental genetic regulatory networks, since it is well known that development is a process orchestrated by the products of genes (Carroll *et al.* (2001)).

4.2. The problem

The general aim of the study is to quantify the genetic mechanisms underlying animal design. This is of main importance in developmental biology, which studies the sequential activation and interaction of genes, in relation to developing morphology. The challenge consists in understanding how the genes interact together over space and time to control the formation and patterning of the animal body. Our goal is to evaluate the hierarchical relationships between genes arising in a regulatory network assumedknown from a qualitative point of view.

As a case study, we are interested in the developmental genetic regulatory network of the fruit fly model organism *Drosophila melanogaster*. More precisely, we study the early development of the Drosophila embryo, called segmentation. The Drosophila body is made of repeated units, called segments, the formation of which is named segmentation. We want to elucidate the network of interactions involved in gene regulation, in order to fully understand how the process of Drosophila segmentation is programmed. The knowledge of the Drosophila case may reveal some general commonalities of genetic regulatory networks underlying developmental programs of more complex animals. One needs to perform a spatial and temporal study *in situ* in order to understand the link between the developmental genes and patterning. Methods needing the preparation of homogenates of cells as an initial step prior to measurement, such as microarrays, are unable to capture spatial information about gene expression. Confocal laser scanning microscopy is a powerful tool for the imaging of gene expression in a de-

veloping embryo, and the experimental gene expression data that we consider are obtained with this methodology by Reinitz's team (Stony Brook University, New York). Its advantage over DNA microarrays is its ability to measure expression level over space at cellular resolution, but a concomitant disadvantage is its inability to measure at the same time more than a relatively small number of gene products. The gene expression data set consists of microphotographs at the resolution of a cell nucleus, of embryos stained at different developmental times. With the current measuring device, 3 gene products at most may be stained at a time on a fixed tissue, whereas the developmental regulatory network related to the segmentation of the Drosophila is formed by 16 interacting genes (Kozlov *et al.* (2000)). The microphotograph is an image of the concentrations of 3 gene products in each nucleus of the embryo (see figure 1): the observed staining intensity is converted into numerical data indicating the concentrations of the stained gene products within each nucleus.

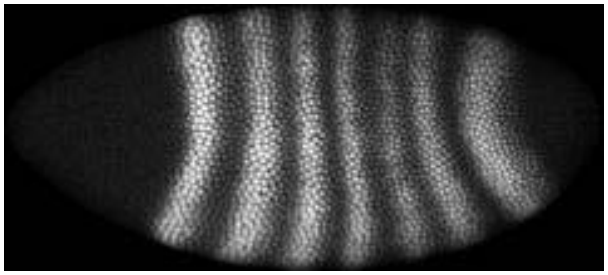


Figure 1. Microphotograph of a stained embryo

4.3. Regulatory network model

We employ quantitative modelling as a means for a deeper understanding of the mechanisms that control and operate the program for the developmental process. The formalism that we use to analyze the genetic regulatory system consists in nonlinear ordinary differential equations satisfied by the gene product concentrations that are the state variables describing each nucleus: gene regulation is mathematically modelled by rate equations expressing the rate of production of a component of the system as a function of the concentrations of other components. The model that we consider, and that is proposed by Reinitz and Sharp (1995) for the genetic regulatory network controlling the segmentation mechanism of the Drosophila embryo, is based on the assumption that concentrations of regulatory molecules change in response to existing concentrations of regulators, exchange of regulatory molecules between nuclei by diffusion, and decay. Mjolsness *et al.* (1991) noted that the level of expression of segmentation genes is approximately a function of only the position along the antero-posterior axis of the trunk region of the embryo, and that antero-posterior and dorso-ventral patterning systems are largely independent of each other in this region, so that one can

approximate the region of interest for the emergence of Drosophila segmentation patterns by a line of K equally spaced nuclei being indexed by k, such that nucleus $k-1$ and nucleus $k+1$ are the neighbors of k. The gene product concentrations $\{g_{k\ell}(t)\}_{1\le k\le K, 1\le \ell\le N_g}$, with N_g the number of interacting gene products, are assumed to satisfy the following set of differential equations:

$$\frac{dg_{k\ell}(t)}{dt} = R_\ell \Phi\Big(\sum_{\ell'=1}^{N_g} W_{\ell\ell'} g_{k\ell'}(t) + m_\ell g_{kbcd}(t) + h_\ell\Big) \qquad (1)$$
$$+D_\ell(n)[g_{k-1\ell}(t) - 2g_{k\ell}(t) + g_{k+1\ell}(t)] \; -\lambda_\ell g_{k\ell}(t).$$

The first term on the right-hand side models the gene regulation and protein synthesis, the second term models the exchange by diffusion of gene products between neighboring cell nuclei, while the third term takes into account the decay of the gene product. The interaction between genes ℓ and ℓ' is represented by a single real number $W_{\ell\ell'}$, corresponding to a connection strength. The matrix $(W_{\ell\ell'})_{1\le \ell,\ell'\le N_g}$ contains the genetic regulatory coefficients (the connectionist matrix): if the product of gene ℓ' activates gene ℓ, then $W_{\ell\ell'}$ is positive; if the product of gene ℓ' represses gene ℓ, then $W_{\ell ell'}$ is negative; if genes ℓ and ℓ' do not interact, then $W_{\ell\ell'}=0$. The connectionist matrix does not depend on the considered nucleus in order to take into account the fact that the same DNA material is contained in each nucleus. The bias term $m_\ell g_{kbcd}(t)$ arises from the *bicoid* protein (*bcd*); m_ℓ is the regulatory coefficient of *bcd* acting on gene ℓ, i.e. $m_\ell = W_{\ell bcd}$, and $g_{kbcd}(t)$ is the concentration of bcd protein in nucleus k. $\Phi(\cdot)$ is a one-to-one sigmoidal function, tending to 0 (respectively 1) at low (respectively high) values, and accounts for the non-linearity of the model. The constant R_ℓ is the maximum rate of synthesis from gene l. The constant h_ℓ is the activation threshold summarizing the effect of general transcription factors on the product of gene ℓ. The diffusion parameter $D_\ell(n)$ depends on the number n of cell divisions that have occurred. Equations for a given number of nuclei are valid during the interphase arising between two consecutive mitoses; nuclear divisions are incorporated by shutting down synthesis during each mitosis, and by doubling the number of nuclei; all nuclei divide equally and simultaneously. λ_ℓ is the decay rate of the product of gene ℓ.

Under this modelling (Jaegers *et al.* (2004)), cleavage cycle 13 being taken as the initial time point $t=0$, a regulatory network of $N_g=6$ genes observed in $K=58$ nuclei at

cleavage cycle $n = 14A$ is considered, leading to a set of 6x58=348 differential equations for one embryo. We aim at inference for the parameters of the model, i.e., the regulation matrix W, the maximum rates of synthesis (written as a column vector R of dimension N_g), the bias terms (m), the activation thresholds (h), the diffusion constants at cleavage cycle 14A ($D(14A)$), and the decay rates (λ).

4.4. Statistical modelling

In order to develop an adequate inference methodology, we elaborate a stochastic modelling corresponding to the available gene expression data, which takes into account the structure of the observations and the measurement errors. This new approach enables us to perform a statistical analysis that should lead to an improvement of the current least squares estimation procedure.

Let a subgroup i of individuals be formed by embryos belonging to the same temporal class and stained for the same 3 gene products. For each embryo j of the subgroup i, the set of gene product concentrations $\{g_{k\ell}(t)\}_{k,\ell}$ will be denoted by $\{g_{ijk\ell}(t)\}_{k,\ell}$. Let us denote by $\theta = (W, R, m, h, D(14A), \lambda)$ the parameter of interest and write $V(k) = \{k-1, k, k+1\}$. The previous system of differential equations may be rewritten

$$\frac{dg_{ijk\ell}(t)}{dt} = f_\theta(\{g_{ijk'\ell'}(t)\}_{k' \in V(k), \ell' \in \{1,\ldots,N_g\}})$$

with $f_\theta(\cdot)$ a nonlinear function. For such systems, one cannot derive an explicit solution. Therefore the system is solved numerically. Let us denote by $g^{model}_{ijk\ell}(t;\theta)$ such a solution. For each embryo j of subgroup i, the measurement is the table $x_{ij} = \{\text{position of nucleus } k, g^{data}_{ijk\ell}(t_i)\}_{1 \le k \le K, \ell \in L_i}$, with L_i the subset of 3 stained gene products among the N_g considered gene products and t_i the developmental stage of the embryo. The quantities L_i and t_i characterize the subgroup i. Note that the positions of the nuclei are deterministic and common for all embryos (Jaegers *et al.* (2004)).

Let n_i be the number of embryos belonging to subgroup i, let the total number of subgroups be a fixed constant d and let $N = \sum_{i=1}^{d} n_i$ be the total number of observations. The cost function currently used (Reinitz and Sharp (1995)) to derive an estimator of the true parameter value is the sum of squares, resulting in a least squares estimate (LSE):

$$\hat{\theta}_N^{LSE} = \operatorname{argmin}_\theta \sum_{j=1,..,n_i,i=1,..d} \sum_{k,\ell} (g_{ijk\ell}^{data}(t_i) - g_{ijk\ell}^{model}(t_i;\theta))^2.$$

Performing the least-squares method may be a suboptimal estimation procedure if the noise related to the measurement of the gene product concentrations is not Gaussian. However, no noise study has been carried out so far. As a first approach, one can suggest to deal with the Minimum Absolute Deviations Estimator (MADE) requiring milder assumptions than LS to get consistent and robust estimators:

$$\hat{\theta}_N^{MADE} = \operatorname{argmin}_\theta \sum_{j=1,..,n_i,i=1,..d} \sum_{k,\ell} | g_{ijk\ell}^{data}(t_i) - g_{ijk\ell}^{model}(t_i;\theta) | .$$

Preliminary estimators of the parameters would be obtained by minimizing the MAD cost function. Because of the system in (1), this is a highly complex function. Therefore, it is minimized via Simulated Annealing (Kirkpatrick *et al.* (1983)), a stochastic optimization algorithm introduced in this framework by Reinitz and Sharp (1995): an initial approximate solution is repeatedly improved by making small local alterations, until no such alteration yields a better approximate solution. (The alterations being stochastically driven). Using this MADE, we apply the theory of asymptotically efficient estimation together with an adequate modelling of the measurement errors in order to improve the current estimators. The framework we consider in order to model the available gene expression data from Drosophila embryos consists in independent random variables $\{X_{ij}\}_{1\le j\le n_i}$, $1 \le i \le d$, each subgroup i being formed by n_i random variables identically distributed with common log-density $l_i(X_{i1};\theta)$. The asymptotics consists in letting $\lim_{N\to\infty} n_i/N = p_i > 0$. Consider the score function

$$S_N(\theta) = \frac{1}{\sqrt{N}} \sum_{i=1}^{d} \sum_{j=1}^{n_i} \dot{l}_i(X_{ij};\theta)$$

and define the Fisher information matrix about θ by $I(\theta) = \sum_{i=1}^{d} p_i \tilde{I}_i(\theta)$ with $\tilde{I}_i(\theta) = E_\theta(\dot{l}_i(X_{i1};\theta)\dot{l}_i^T(X_{i1};\theta))$. Under some regularity assumptions, *e.g.* nonsingularity of $I(\theta)$, Local Asymptotic Normality holds. One can then characterize asymptotically efficient estimators attaining a performance bound through the Convolution Theorem. Starting from preliminary $\sqrt{N}$-consistent estimators, one can construct asymptotically efficient estimators by using a modified one-step Newton-Raphson procedure. These estimators are approximate solutions of the maximum likelihood equation $S_N(\theta) = 0$, which explains the name one-step Newton-Raphson procedure related to the search of roots of an equation. Let θ_N^* be a preliminary $\sqrt{N}$-consistent estimator of θ. We will

take $\theta_N^* = \hat{\theta}_N^{MADE}$. One defines $\hat{\theta}_N = \theta_N^* - [\dot{S}_N(\theta_N^*)]^{-1} S_N(\theta_N^*)$ and approximates $\dot{S}_N(\theta_N^*)/\sqrt{N}$ by $-I(\theta_N^*)$ thanks to the law of large numbers and the continuity of the Fisher information matrix. This leads to the approximation

$$\hat{\theta}_N \approx \theta_N^* + \frac{1}{\sqrt{N}} I(\theta_N^*)^{-1} S_N(\theta_N^*). \tag{2}$$

We have then to propose a specific choice for the score function, which amounts to appropriately model the noise inherent to the observations.

We assume that the gene product concentrations in each nucleus satisfy

$$X_{ijk\ell} = g_{ijk\ell}^{model}(t_i;\theta) + \varepsilon_{ijk\ell}(t_i)$$

with $\{X_{ijk\ell}\}_{k,\ell}$ independent. In a first simplifying approach, we assume that $\varepsilon_{ijk\ell}(t_i)$ does not depend on the embryo j, the nucleus k and the stained gene product ℓ, nor on the developmental stage t_i, and that $\varepsilon_{ijk\ell}(t_i)$ is centered and has a known density $f(\cdot)$ on the real line. Then

$$l_i(X_{ij};\theta) = \sum_{k=1}^{K} \sum_{\ell \in L_i} \log f(X_{ijk\ell} - g_{ijk\ell}^{model}(t_i;\theta)),$$

whose derivative with respect to θ has to be substituted into (2). This modified one-step Newton-Raphson procedure enables us to construct asymptotically efficient estimators.

Future work consists in relaxing the simplifying assumptions on the measurement error and estimating the score function from the data, more precisely, from the residuals $g_{ijk\ell}^{data}(t_i) - g_{ijk\ell}^{model}(t_i;\theta_N^*)$. It may also be of interest to perform the analysis starting from a different model than (1). This alternative model should involve stochastic components, which seems more realistic since gene regulation is intrinsically noisy. This might facilitate the estimator computations since solving (1) numerically, which is necessary to get the estimator, is computationally rather costly.

Acknowledgment We are thankful to Jaap Kaandorp, University of Amsterdam, for having introduced us to the topic and for his guidance about the biological issues treated in this work.

5. PUBLICATIONS

5.1. Papers in journals and proceedings

(For the EURANDOM Report series, see 5.2)

Queueing and Performance Analysis (QPA)

*** Ivo Adan**

Vlasiou, M.; **Adan, I.J.B.F.** and Wessels, J.: A Lindley-type equation arising from a carousel problem. *Applied Probability*, **41** (2004), 1171-1181.

Tzenova, E.; **Adan, I.J.B.F** and Kulkarni, V.G.: Fluid models with jumps. *Stochastic Models* **21** (2005) 37-55 (accepted for publication in 2004).

Adan, I.J.B.F. and Weiss, G.: A two node Jackson network with infinite supply of work. To appear in *Probability in the Engineering and Informational Sciences*, 2005.

Vlasiou, M. and **Adan, I.J.B.F.:** An alternating service problem. To appear in *Probability in the Engineering and Informational Sciences.*

Adan, I.J.B.F.; Boxma, O.J.; van den Broek, M. and van Leeuwaarden, J.S.H.: Bounds and approximations for the fixed-cycle traffic-light queue. *SPOR report 2004-18.*

Adan, J.B.F.; Boxma, O.J. and Perry, D.: The G/M/1 queue revisited. To appear in *Mathematical Methods of Operations Research,* 2005.

***Richard Boucherie**

Van den Berg, J.L.; **Boucherie, R.J**.; Fleuren, M.; Foijers, F. and Litjens, R.: Analysis of flow transfer times in IEEE 802.11 WLANs. *Annales des télécommunications* **59** (2004), no.11-12, 1389-1414.

Boucherie, R.J. ; Bumb, A.F. and Endrayanto, A.I.**:** A multiple-choice knapsack based algorithm for CDMA downlink rate differentiation under uplink coverage restrictions. *Proceedings 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems*, August 31– September 02, 2004, University of Antwerp, Antwerp, Belgium, C. Blondia (editor), 201-210.

*** Onno Boxma**

Albrecher, H. and **Boxma, O.J.:** A ruin model with dependence between claim sizes and claim intervals. *Insurance: Mathematics & Economics* **35** (2004), 245-254.

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Teugels, J.: Extreme value distributions in geology Invited discussion, Seoul ISI-session *Bull. Intern. Statist. Inst.* **59** (2004), III, 194-196.

Ladoucette, S. and **Teugels, J.**: The largest claims treaty ECOMOR. *Proc. European Conference on Mathematics for Industry*, Eindhoven, The Netherlands, 2004.

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El-Shaarawi, A.H. and **Teugels, J.**: Environmental statistics: current and future. *The 2004 ISI Special Conference*, Daejon, Korea, 2004.

Teugels, J.: Internal cohesion within ISI. *The 2004 ISI Special Conference*, Daejon, Korea, 2004.

5.2. EURANDOM Report series

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

No.	Titel	Author(s)
2004-001	Critical points for spread-out self-avoiding walk, percolation and the contact process above the upper critical dimensions	R. van der Hofstad, A. Sakai
2004-002	Gibbs under stochastic dynamics?	F. den Hollander
2004-003	Replica bounds for diluted non-Poissonian spin systems	S. Franz, F. Toninelli, M. Leone
2004-004	Fractal Percolation and Set-valued Substitutions	P. van der Wal
2004-005	Analytic computation schemes for the discrete-time bulk service queue	A. Janssen, J. van Leeuwaarden,
2004-006	A tandem queue with coupled processors: computational issues	J. van Leeuwaarden, J. Resing
2004-007	Metastability under stochastic dynamics	F. den Hollander
2004-008	Spin glasses: a mystery about to be solved	F. den Hollander, F. Toninelli
2004-009	A Particular Bit of Universality: Scaling Limits of Some Dependent Percolation Models	F. Camia, Ch. Newman, V. Sidoravicius
2004-010	Scaling Limit and Critical Exponents for Two-Dimensional Bootstrap Percolation	F. Camia
2004-011	Exponential Behavior in the Presence of Dependence in Risk Theory	H.-J. Albrecher, J. Teugels
2004-012	Symmetric Measures via Moments	A. Koloydenko
2004-013	Portfolio Selection with Heavy Tails	N. Hyung, C. de Vries
2004-014	Downside Risk Portfolio Diversification Effects	N. Hyung, C. de Vries
2004-015	The Simple Economics of Bank Fragility	C. de Vries
2004-016	Fundamentals and Joint Currency Crises	P. Hartmann, S. Straetmans, C. de Vries
2004-017	Adaptive minimax estimation of a fractional derivative	F. Enikeeva
2004-018	Measuring Financial Contagion: A Copula Approach	J.-C. Rodriguez
2004-019	Intermittency in a catalytic random medium	J. Gärtner, F. den Hollander
2004-020	Large deviations for quantum spin systems	K. Netočný, F. Redig
2004-021	Sharp asymptotics for Kawasaki dynamics on a finite box with open boundary	A. Bovier, F. den Hollander, F. Nardi
2004-022	How non-Gibbsianness helps a metastable Morita minimizer to provide a stable free energy	Ch. Külske

2004-023	Multi-layered Round Robin Routing for Parallel Servers	D. Down, R.Wu
2004-024	An invitation to quantum tomography II	L.M. Artiles Martinez, R. Gill, M. Guta
2004-025	Reinsurance of large claims	S. Ladoucette, J. Teugels
2004-026	A Lindley-type equation arising from a carousel problem	M. Vlasiou, I. Adan, J. Wessels
2004-027	The limit process of the difference between the empirical distribution function and its concave majorant	V. Kulikov, H. Lopuhaä
2004-028	Testing for a monotone density using Lk-distances between the empirical distribution function and its concave majorant	V. Kulikov, H. Lopuhaä
2004-029	Asymptotic normality of the Lk-error of the Grenander estimator	V. Kulikov, H. Lopuhaä
2004-030	A new kind of switching process: the periodic switching process	J. Collet, S. Ladoucette
2004-031	Chains and specifications	R. Fernandez, G. Maillard
2004-032	Some Time-Dependent Properties of Symmetric M/G/1 Queues	O. Kella, B. Zwart O, Boxma
2004-033	An alternating service problem	I. Adan, M. Vlasiou
2004-034	Weighted Approximations of Tail Copula Processes with Applications to Testing the Multivariate Extreme Value Condition	J. Einmahl, L. de Haan, D. Li
2004-035	The behavior of the NPMLE of a decreasing density near the boundaries of the support	V. Kulikov, H. Lopuhaä
2004-036	Tail asymptotics for exponential functionals of Levy processes	K. Maulik, B. Zwart
2004-037	Bad Configurations for Random Walk in Random Scenery and Related Subshifts	F. den Hollander, J.E. Steif, P. van der Wal
2004-038	Distances in random graphs with infinite mean degrees	R. van der Hofstad, G. Hooghiemstra, D. Znamenskiy
2004-039	Relaxation Time for the Discrete D/G/1 Queue	A. Janssen, J. van Leeuwaarden,
2004-040	On the Ising model with random boundary condition	A. van Enter, K. Netočný, H. Schaap
2004-041	Loss without recovery of Gibbsianness during diffusion of continuous spins	Ch. Külske, F. Redig
2004-042	Asymptotic Analysis of Measures of Variation	H.J. Albrecher, J. Teugels
2004-043	A Note on Edwards' Hypothesis for Zero-Temperature Ising Dynamics	F. Camia

2004-044	Construction of a specification from its singleton part	G. Maillard, R. Fernandez
2004-045	Joint queue length distribution of multi-class, single-server queues with preemptive priorities	A. Sleptchenko, I. Adan, G. van Houtum
2004-046	Random Dynamics in Spatially Extended Systems	F. den Hollander
2004-047	Risk measures for a combination of quota-share and drop down excess-of-loss reinsurance treaties	S. Ladoucette, J. Teugels
2004-048	Testing Conditional Independence for Continuous Random Variables	W. Bergsma
2004-049	Decoding aggregated profiles using dynamic calibration of machine vibration data	V. Kulikov, W. Bergsma

In total 49 EURANDOM Reports

RSS:	20
QPA:	9
SIM:	9
SERA & RI:	11

6. ACTIVITIES

6.1. Workshops and Conferences

January 9 and 10, 2004 General
EURANDOM Alumni Day

Organisers: B. Lemmens (University of Warwick), N. Litvak (Universiteit Twente), P. Mandal (Universiteit Twente) and J. Kamperman (EURANDOM)
Participants: 20

Lectures were given by M. Keane (former EURANDOM scientific advisor and Professor of Mathematics at Wesleyan University, Connecticut, USA) on "Binominal Tranformation", C. Gromoll (PD QPA and Marie Curie Fellow) on "Measure valued processes and queues", B. Witcher (former PD SIM and senior researcher in Imaging at Glaxo Smith Kline, Harlow, UK) on "Magnetic Resonance Imaging Data and a Spatial Bootstrap", W. van Zwet (former scientific director EURANDOM and scientific advisor) on "Kakutani's interval splitting scheme", N. Armstrong (PD SIM) on "Identifying transcription factor binding sites" and M. Löwe (former PD RSS and Professor at the Westfälische Wilhelms Universität Münster, Germany) on "The Voter Model with Antivoter Bonds".

Follow up of the meeting was discussed.

February 23 and 24, 2004 RSS
Meeting of the Dutch-German Bilateral Research Group on "Mathematics of Random Spatial Models from Physics and Biology"

Organiser: F. den Hollander (EURANDOM)
Participants: 20

BRG is a collaboration between EURANDOM (RSS) and four probability groups in Germany: A. Bovier (Berlin), F. Götze (Bielefeld), A. Greven (Erlangen), A. Wakolbinger (Frankfurt).

A total of 7 PD positions are jointly funded by DFG and NWO. BRG meets twice a year for a 2-day meeting, with presentations by the PDs, the supervisors and a number of invited guests. In addition, exchange visits take place during the year to work on joint projects. The meeting at EURANDOM focussed on three topics:

- branching processes with applications in biology
- random walk in random scenery/environment
- spectral theory for random matrices.

March 28 – April 2, 2004 RSS
Conformal Invariance, Scaling Limits and Percolation

Organisers: N. Gantert (Universität Karlsruhe, Germany) and R. van der Hofstad (EURANDOM & Technische Universiteit Eindhoven)
Participants: 35

In this workshop, young probabilists from various European countries exchanged research experience in the area of scaling limits in percolation. Two mini-courses gave a more substantial introduction to two particular aspects of percolation and scaling limits. The first mini-course was given by V. Beffara, and was an introduction to two-dimensional results and conjectures using "Stochastic Loewner Evolution". The second mini-course was given by A. Járai on the "incipient infinite cluster" (iic), which describes the structure of large critical percolation clusters. Both lectures were excellent and well received, and were interesting for researchers not acquainted with the topics as well as for specialists.

Apart from the two mini-courses, there were 5 lectures of 60 minutes by more senior researchers working in The Netherlands, on percolation and related topics. R. Meester gave an introduction to fractal percolation, R. van den Berg to correlation inequalities, B. Nienhuis explained recent results on exact formulas arising in $2d$-percolation, F. den Hollander described recent progress on the incipient infinite cluster for critical oriented perco-

lation, while F. Redig gave an introduction to the use of exponential laws in percolation and related Ising models.

Moreover, there were 10 lectures of 45 minutes by the participants, where they presented various results and open problems. The participants made use of the possibility to discuss problems among themselves.

The workshop received support from ESF / RDSES, the Thomas Stieltjes Institute for Mathematics, as well as from the German Schwerpunkt programme ("Interagierende stochastische Systeme hoher Komplexität").

May 3 and 4, 2004 RI
Exotic Option Pricing under Advanced Levy Models

Organisers: A. Kyprianou (Universiteit Utrecht) and W. Schoutens (Katholieke Universiteit Leuven)
Participants: 120

This workshop was a follow-up event to the workshop entitled "Applications of Levy Processes in Financial Mathematics", held at EURANDOM in 2001. As was the case in 2001, the workshop of 2004 attracted top scientists working in this field. This time the participation was almost double, coming to around 120 in total. Approximately 25% of the participants was from Dutch or Belgian universities or research institutes, while the remaining 75% came mostly from Germany, France, Sweden, Spain, UK and the USA. There were some participants who had travelled from as far as Korea. As expected, there was a healthy industrial participation, with approximately 13 people from banks or other financial organisations.

As a spin-off project from the workshop, a book has been initiated in collaboration with Wiley publisher and Wilmott Associates (financial consultancy/publisher). This book will contain a number of invited review-type articles written by the main speakers of the workshop and will hopefully be published by the beginning of 2005.

The workshop was funded by three main sources. Two grants came from Dutch sources, NWO and KNAW, while a third grant was awarded by an international source, The Journal of Applied Econometrics. Industrial participants were required to pay a registration fee, while academic participants had no fee.

June 14 – 18, 2004 SIM
mODa7 (Model Oriented Design and Analysis)

Organisers: H.P. Wynn (London School of Economics, UK & EURANDOM), A. Di Bucchianico, (Technische Universiteit Eindhoven & EURANDOM), P. van de Ven (EURANDOM)
Participants: 60

The majority of the participants were young scientists. In order to achieve maximal interaction among the participants, there were no parallel sessions. This worked well, with several illuminating discussions after talks.

On Monday there were sessions on compartmental models with applications to biokinetics, designs for nonlinear models and screening designs. The talks by Biedermann et al., López-Fidalgo and Trandafir showed progress in obtaining locally optimal designs for compartmental models. The talks by Gauchi et al. and Pázman et al. contained new ideas for algorithms to obtain nonlinear optimal designs. Powerful techniques from stochastic programming seem to be very promising. From the remaining talks on Monday we mention the talk by Dean, showing an integrated system for improving engines at Rolls-Royce factories.

On Tuesday there were sessions on designs for responses with non-constant variance, multi-factor models and two general sessions. Fedorov et al. used deep results from random field theory to obtain unexpected optimality results. Atkinson and Rodrigues Pinto et al. showed how to use Bayesian techniques for responses with non-constant variance. For multi-factor models, Martinez et al. gave

nice algebraic characterizations of L-optimum designs, while Bogacka obtained several interesting T-optimum designs using dynamic programming techniques. From the remaining talks we mention the talk by Harman, who gave very general lower bounds for efficiency ratios for several classes of optimum designs and the talk by TorQPAey et al., where impressive progress was shown on determining properties of multiplicative algorithms for constructing optimum designs.

On Wednesday there were few talks, since an excursion was scheduled for the afternoon. From the talks on Wednesday morning we mention the talk by Maruri-Aguilar, who showed interesting results on extending the computational algebra approach of Pistone and Wynn to the case of fractional polynomial models, and the talk by Ye, who lucidly explained many issues in model discrimination and optimum designs.

Thursday morning was devoted to sequential designs for medical applications. The field of urn designs turned out to develop quite well. There are now several well-developed classes, like biased coin designs and Ehrenfest urn designs. As could be inferred by talks from Rosenberger et al., Giovagnoli et al. and Rabie et al., the asymptotical properties of these designs are now being well understood. Stufken and Nguyen et al. showed applications of combinatorial and algebraic methods to factorial designs. Leonov et al. solved a hard design problem involving regression models with forced base-line. Such models are frequently used in drug testing studies. Malyutov showed very delicate asymptotic properties of sequential discrimination procedures for Markov processes. The programme of Thursday ended with a lively poster session, where PhDs showed their results. The session was well attended, with stimulating interaction between senior researchers and PhDs.

The conference ended on Friday morning with four talks. Stehlík et al. talked on spatial design problems. Müller et al. showed several results for extending the optimal design framework to tolerance regions, a topic of great practical interest, but often neglected in mathematical statistics. The two remaining talks were devoted to the use of entropy. Pronzato et al. showed how to perform adaptive minimum entropy estimation for semi-parametric models. Wynn concluded the conference with a talk showing the intimate relations between Shannon entropy and the Kiefer General Equivalence Theorem, which lies at the very heart of optimal design.

In line with the tradition of the mODa conferences, proceedings were published before the conference. The proceedings were published by Physica Verlag (part of Springer) and contained around 20 papers.

July 5 and 6, 2004 QPA

Quantitative Models for Production and Communication Networks

Organisers: G.J. van Houtum (BETA Research School of Technische Universiteit Eindhoven), O. Boxma (Technische Universiteit Eindhoven & EURANDOM) and T. de Kok (BETA Research School of Technische Universiteit Eindhoven)
Participants: 45

To strengthen the research collaboration between researchers of Carnegie Mellon University and BETA researchers of the Technische Universiteit Eindhoven, on July, 5 and 6 the workshop "Quantitative Models for Production and Communication Networks" took place. The purpose of the workshop was to exchange knowledge on quantitative models, to strengthen the cooperation between CMU and BETA, and to explore mutual interests. During this workshop, which was sponsored by NWO and BETA, about 20 researchers presented their research.

Workshop results:

- Harchol-Balter (CMU) discussed possibilities with 'Philips Research Laboratories' to start a new joint project.

- Debo (CMU) discussed possibilities with Flapper (Technische Universiteit Eindhoven) to start a new joint project.
- In 2005, Kranenburg (Technische Universiteit Eindhoven) will visit CMU for a few months in the framework of the research for his thesis defense.
- A second workshop on the subject will be organised in the USA by CMU next year.

October 7 – 9, 2004 SIM

Notions of Complexity: Information-Theoretic, Computational and Statistical Approaches

Organisers: S. van de Geer (Universiteit Leiden & EURANDOM), R. Gill (Universiteit Utrecht & EURANDOM), P. Grünwald (CWI Amsterdam & EURANDOM) and A. Koloydenko (EURANDOM)
Participants: 30

Theoretical statisticians included researchers like A. Tsybakov, who gave a talk on recent results concerning comparison of classification by 'plug-in' vs. 'direct' methods. With plug-in methods, one tries to learn the underlying conditional probability mass function, and then classifies new examples using the Bayes classifier corresponding to the learned distribution. With direct methods (as mainly used in the machine learning and pattern recognition communities), one tries to directly find a classifier from some given set of 'candidate' classifiers. Tsybakov also referred to what has become known as the 'Tsybakov condition'. If the Bayes classifier satisfies a form of this condition, and the Bayes classifier is in the set of considered classifiers, then better rates of convergence can be obtained than the worst-case rates. New types of conditions with a similar intent were provided by I. Steinwart of Los Alamos National Laboratory in the USA, in the context of support vector machine classification.

A prime example of a machine learning researcher is J. Langford of the Toyota Technological Institute in Chicago, who gave a talk on generalization bounds and confidence intervals in classification, highlighting the use of Bayesian priors to avoid overfitting in a non-Bayesian context (the so-called 'PAC-Bayesian method').

A prime example of an information theory approach was provided by P. Grünwald of the CWI in Amsterdam (co-organizer of the workshop), who gave a talk on sequential prediction and how it relates to both consistency and inconsistency of Bayesian statistical procedures.

A totally different approach was advocated by Volodya Vovk, who showed that the recent Vovk-Shafer framework for game-theoretic (rather than measure-theoretic) probability can be used to derive feasible and very interesting prediction algorithms that are neither probabilistic nor of the 'prediction with expert advice' kind.

There were also researchers present whose research lies on the interface between all three of the paradigms considered: Gabor Lugosi, who spoke about regularization and boosting, and Tong Zhang, who gave a talk on his recent work, where he proves optimal convergence rates of the information-theoretic MDL method using ideas from the computational - PAC-Bayesian paradigm - statistical - empirical process techniques. It turns out that the convergence rates found are, in a sense, minimax optimal.

The workshop was part of the PASCAL thematic programme 'Interfacing Bayesian and Frequentist Approaches'. Another interesting workshop on this topic, called "PASCAL Learning Theoretic and Bayesian Inductive Principles Workshop" was held in July 2004 at the Gatsby Unit of University College London. Whereas that workshop emphasized the differences between Bayesian and frequentist (Vapnik-style) researchers within the machine learning community, the EURANDOM workshop brought together people whose research lies even further apart: (mostly non-Bayesian) theoretical statisticians, on the one hand, and people from the machine learning community, on the other hand.

The meeting was videotaped. Videos of the presentations will be made available on the PASCAL website.

Summary of the workshops

QPA:	1
RSS:	2
SIM:	2
RI:	1
General:	1

In total 7 workshops were (co)-organised. The public lecture of the EURANDOM chair was held on November 23, see 6.2.

Furthermore, EURANDOM co-sponsored:

- "Nederlands-Belgisch Mathematisch Congres 2004", April 16 and 17, 2004 at the Universiteit van Tilburg.
- "ECMI", 10th European Conference on Mathematics for Industry, 21 – 25 June, 2004 at the Technische Universiteit Eindhoven.
- Colloquium on "Risk Analysis: Statistical and Probabilistic Methods", May 27 and 28, 2004, which was organised on the occasion of the retirement of Professor J. Teugels from the Katholieke Universiteit Leuven.
- Workshop "Stochastic Processes from Physics and Biology", November 26 and 27, of the Dutch-German Bilateral Research Group "Mathematics of Random Spatial Models from Physics and Biology", Erwin Schrödinger Institute, Vienna.

6.2. Lectures and Seminars

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

- **QPA / Joint SOR-QPA Seminar**

Extremes of Gaussian processes with stationary increments
T. Dieker, CWI, The Netherlands
January 20

The discrete-time bulk service queue and Fourier sampling
J. van Leeuwaarden, EURANDOM, The Netherlands
February 3

Decentralized scheduling of parallel servers
D. Down, McMaster University, Canada
February 10

A two-station queueing network with coupled processors
J. Resing, Technische Universiteit Eindhoven, The Netherlands
February 17

Dynamic Server Assignment for Queueing Networks with Flexible Servers
D. Down, McMaster University, Canada
March 2

Wireless Data Performance in Multi-Cell Scenarios
N. Hegde, EURANDOM, The Netherlands
March 16

Fluid Limit Approach to Stability
D. Down, McMaster University, Canada
April 20

Urban Networks with Ring Roads: A Two-level, Three Player Game
H. Taale, Department of Public Works & Technische Universiteit Delft, The Netherlands
April 27

Delay Asymtotics in the GI/GI/1 PS Queue
B. Zwart, Technische Universiteit Eindhoven, The Netherlands
July 13

A Review of Perishable Inventory Systems with Random Input and Random Output
D. Perry, University of Haifa, Israel
July 13

Analysis of Performance Tradeoffs with Wireless Scheduling
H.P. Tan, Department of Electrical Engineering, Technion, Israel
July 15

On the busy period asymptotics of a GI|G|1 FCFS queue
Z. Palmowski, University of Wroclaw, Poland
September 14

A two-priority fluid model: joint steady state distribution of the buffer content
E. Tzenova, EURANDOM, The Netherlands
October 12

Random walks with heavy-tailed increments
D. Denisov, EURANDOM, The Netherlands
November 2

Marginal productivity index policies for scheduling a multiclass loss queue
J. Niño-Mora, Universidad Carlos III, Madrid, Spain
November 16

Mean-Field Interaction Models for Large TCP Networks
F. Baccelli, INRIA & ENS, France
November 23

Asymptotics for the tail distribution of the maximum of a Markov-modulated random walk with heavy-tailed increments
V. Shneer, Heriot-Watt University, Edinburgh, UK
November 30

Analysis and Fairness of Scalable TCP
B. Prabhu, Sophia Antipolis, INRIA, France
December 7

Stochastic Control of Transmissions over Multiaccess Fading Channels
M. Goyal, Indian Institute of Science, Bangalore, India
December 9

Wiener-Hopf factorizations
B. Zwart, Technische Universiteit Eindhoven, The Netherlands
December 14

Fluid limit of a network with fair bandwidth sharing and general document size distributions
C. Gromoll, Stanford University, USA
December 15

- **RSS**

Non-ergodicity in a 1-D particle process with variable length
A. Toom, Federal University of Pernambuco, Brasil
January 6

Stationarity of the Lagrangian velocity of a passive tracer in compressible environments; invariant measures and the Stokes drift
G. Krupa, Catholic University Lublin, Poland
January 30

Diffusion in random environment and the renewal theorem
D. Cheliotis, Stanford University, USA
February 5

Convergence of Coalescing Nonsimple Random Walks to the Brownian Web
R. Sun, Courant Institute of Mathematical Sciences, New York, USA
February 16

Limit theorems for a periodically or randomly driven semilinear equation
N. Zygouras, Courant Institute of Mathematical Sciences, New York, USA
February 16

Hitting Times and Loss Network for Independent Random Walks
A. Asselah, Centre de Mathématiques et Informatique, Université de Provence, France
March 2

Fluctuations of empirical entropies for Gibssian sources
J.-R. Chazottes, CPHT, CNRS-Ecole Polytechnique, Palaiseau, France
March 3

The Beurling estimate for a class of random walks
V. Limic, University of British Columbia, Vancouver, Canada
April 6

Adsorption and localization of polymers in the presence of an applied force
S. Whittington, University of Toronto, Canada
May 6

The dimension of graph directed attractors with overlaps on the line, with an application to a problem in fractal image recognition
K. Simon, Technical University of Budapest, Hungary
May 12

An introduction to perturbation techniques in statistical mechanics. Part I: Cluster expansions and Pirogov-Sinai theory
K. Netočný, EURANDOM, The Netherlands
May 18

An introduction to perturbation techniques in statistical mechanics. Part II: Cluster expansions and Pirogov-Sinai theory
K. Netočný, EURANDOM, The Netherlands
May 19

Renormalizing disordered contour models
Ch. Külske, WIAS Berlin, Germany & EURANDOM
May 25

The Problem of Coexistence in Two-Type Competition Models-I
G. Kordzakhia, University of Chicago, USA
June 8

Spectral characterization of aging: the REM-like trap model.
A. Faggionato, WIAS, Berlin, Germany

June 9

The Problem of Coexistence in Two-Type Competition Models-II
G. Kordzakhia, University of Chicago, USA
June 11

Euler hydrodynamics of one-dimensional attractive particle systems
E. Saada, Université de Rouen,France
September 8

The critical branching random walk is transient
N. Gantert, Universität Karlsruhe, Germany
September 21

Random walks in random environments on a strip: linear and sub-linear growth
I. Goldstein, University of London, UK
September 27

A Large Deviation Principle for Free Energy Densities - Capacity and Error Exponent in Shannon Random Codes
M. Fedrigo, Scuola Normale Superiore, Pisa, Italy
October 27

Thermodynamic limit and stochastic stability of spin glasses
C. Giardiná, Dipartimento di Matematica, Università di Bologna, Bologna, Italy
October 28

Endogeny for Recursive Tree Processes
A. Antar Bandyopadhyay, Chalmers University of Technology, Sweden
November 2

Connectivity, component sizes and distances in the power law random graphs
D. Znamenskiy, EURANDOM, The Netherlands
November 9

Phase separation phenomenon for polygonal Markov fields in the plane
T. Schreiber, Nicolaus Copernicus University, Torun, Poland
November 11

Stable, but critical; infinite sandpile diagnostics
A. Fey, EURANDOM, The Netherlands
November 23

Chains with complete connections and Gibbs measures
G. Maillard, EURANDOM, The Netherlands
November 30

The Wulff shape of the two dimensional Ising model in the vicinity of T_c
R.-J. Messikh, EURANDOM, The Netherlands
December 7

Hydrodynamics for Interacting Particle Systems with Moving Boundaries
G. Valle da Silva, Ecole Polytechnique Fédérale de Lausanne, Switzerland
December 13

Implications of the triangle condition for percolation on the infinite lattice above the critical dimension
M. Heydenreich, Technische Universiteit Eindhoven, The Netherlands
December 14

- **Marc Kac Seminar** (at EURANDOM)

Coarse graining techniques for random long-range lattice spin models
Ch. Külske, WIAS Berlin, Germany & EURANDOM
May 7

Randomly coloured self-avoiding walks: a model of random copolymers
S. Whittington, University of Toronto, Canada
May 7

- **SIM**

Empirical Measures in Adjusted Vitrebi Training
J. Lember, University of Tartu, Estonia
January 13

Towards A Unified Theory of First and Higher Order Statistics
J. Robins, Harvard School of Public Health, USA
January 28

Marginal models for categorical data
W. Bergsma, EURANDOM, The Netherlands
February 13

On the statistical theory of classification
L. Mohammadi, Universiteit Leiden, The Netherlands
February 13

Bayesian CART modelling
F. Rigat, Institute of Statistics and Decision Sciences, Duke University, USA
February 23

Quadratic functional estimation in the convolution model
C. Butucea, Université Paris X, Nanterre and Paris VI, France
February 24

Combining kernel estimators in the uniform deconvolution problem
B. van Es, Korteweg de Vries Instituut, Universiteit van Amsterdam, The Netherlands
March 19

Life testing: can we predict the battery life?
I. Snihir, EURANDOM, The Netherlands
April 16

Karhunen-LoXve, Principal components and SVD
W. Rey, Philips Research Laboratories, The Netherlands
May 26

Log-linear models for multidimensional contingency tables: interpretation and estimation
T. Rudas, Eötvös Loránd University, Hungary
May 28

Moment Analysis of Distributions
J. Stoyanov, University of Newcastle, UK
June 4

Bridges and Networks: Exact Asymptotics
D. R. McDonald, University of Ottawa, Canada
June 8

On a combination of convex risk minimization methods to analyze data from insurance companies
A. Christmann, Universität Dortmund, Germany
June 11

On fluctuation of the length of the longest common subsequence
J. Lember, Institute of Mathematical Statistics, Estonia
October 5

Empirical Bayesian Test of the Smoothness Parameter
F. Enikeeva, EURANDOM, The Netherlands
December 7

- **QRANDOM Seminars**

Dissipation, transport and coherence in quantum physics I
L. Accardi, University of Rome, Italy
January 22

Dissipation, transport and coherence in quantum physics II
L. Accardi, University of Rome, Italy
January 23

Quantum state estimation and large deviations
M. Keyl, Technische Universität, Braunschweig, Germany
February 25

Squeezing enhanced control
L. Bouten, Universiteit Nijmegen, The Netherlands
February 25

Steady state fluctuations of the dissipated heat in a quantum
W. de Rock, Katholieke Universiteit, Leuven, Belgium
March 31

Quantum Measurement

B. Janssens, Katholieke Universiteit Nijmegen, The Netherlands
March 31

- **SERA RI Seminars**

A continuous time GARCH (1,1) model
A. Lindner, Technische Universität München, Germany
February 19

Extremal behaviour of infinite moving average processes with light tailed innovations.
A. Lindner, Technische Universität München, Germany
February 19

Extreme US stock market fluctuations in the wake of 9/11
S. Straetmans, Universiteit Maastricht, The Netherlands
March 11

Large claims reinsurance
S. Ladoucette, EURANDOM, The Netherlands
March 18

Exponential behavior in the presence of dependence in risk theory
H. Albrecher, Katholieke Universiteit Leuven, Belgium
March 18

Pricing Credit Default Swaps under Lévy Models
W. Schoutens, Katholieke Universiteit Leuven, Belgium
March 18

Financial challenges in power markets
M. Verschuere, Luminus Corporation, Hasselt, Belgium
March 18

How Can We Define The Long Memory Concept? An Econometric Survey
D. Guégan, Ecole Normale Superieure de Cachan, France
June 17

Reinsurance Analyser
D. Silvetrov, Mälardalen University, Sweden
December 2

- **EPS-EPPS and Problem Sessions**

Statistical Analysis of Internet Data
D. Znamenskiy, EURANDOM, The Netherlands
January 8

Measurement of three variable interactions
W. Bergsma, EURANDOM, The Netherlands
January 22

Testing monotonicity of a density
V. Kulikov, EURANDOM, The Netherlands
February 5

On the problem of quantum state estimation
M. Guta, EURANDOM, The Netherlands
February 19

Chaotic size-dependence in the Ising model
K. Netočný, EURANDOM, The Netherlands
March 4

Gaussian bounds for moment generating functions of squares
R. van der Hofstad, EURANDOM, The Netherlands
March 4

Chains and Gibbs measures
G. Maillard, EURANDOM, The Netherlands
March 18

Performance bounds for monomial basis construction
A. Koloydenko, EURANDOM, The Netherlands
March 19

Modelling the Polymerase Chain Reaction amplification process by a size-dependent branching process. Estimation of the reaction efficiency
N. Lalam, EURANDOM, The Netherlands
April 15

Identifying transcription factor binding sites

N. Amstrong, EURANDOM, The Netherlands
April 29

Wireless Data Performance in Multi-Cell Scenarios
N. Hegde, EURANDOM, The Netherlands
May 13

Characterizations and Examples of Hidden Regular Variation
K. Maulik, EURANDOM, The Netherlands
May 27

Mixing properties of random walk in random scenery
P. van der Wal, EURANDOM, The Netherlands
June 10

Out- and In- of Gibbsianness
Ch. Külske, WIAS Berlin, Germany & EURANDOM, The Netherlands
September 2

An alternating service problem
M. Vlasiou, EURANDOM, The Netherlands
September 16

Joint Queue Length Distribution of Multi-Class, Single-server Queues with Preemptive Priorities
A. Sleptchenko, EURANDOM, The Netherlands
September 30

Survival CART: Bayesian Weibull survival trees
F. Rigat, EURANDOM, The Netherlands
October 14

A two-priority fluid model: joint steady state distribution of the buffer content processes
E. Tzenova, EURANDOM, The Netherlands
October 28

Some statistical problems of Quantum Homodyne Tomography
L. Artiles Martinez, EURANDOM, The Netherlands
November 11

Large Deviations: From Classical to Quantum
K. Netočný, EURANDOM, The Netherlands
November 25

Convergence of Coalescing Nonsimple Random Walks to the Brownian Web
R. Sun, EURANDOM, The Netherlands
December 8

- **EURANDOM Chair lectures**

Mini course I: Signal-to-Interference-Ratio Cells of a Spatial Point Process
F. Baccelli, EURANDOM and INRIA & ENS, France
October 26

Mini-course II: Percolation and Connectivity in Mobile Ad Hoc Networks
F. Baccelli, INRIA & ENS, France
December 14

Distribution over the programmes:

QPA:	21
RSS (incl. the Mark Kac seminars at EURANDOM:	31
SIM (incl. the Qrandom seminars at EURANDOM):	21
RI:	9
EPPS and Problem sessions:	21
EURANDOM Chair lectures	2
	106

November 23, 2004 **General Public Lecture Professor F. Baccelli**

Professor Baccelli (INRIA, Rocquencourt and ENS, Paris) has been appointed EURANDOM Chair for 6 months starting October 2004. His public lecture on November 23, 2004 was on "Mean-Field Interaction Models for Large TCP Networks".

In the lectures he gave a review on various dynamical interaction models allowing to analyze the throughputs obtained by a large collection of TCP-controlled flows, sharing many links and routers, from the sole knowledge of the network parameters (capacity, buffer sizes, topology) and of the characteristics of each flow (RTT, route, on-off structure, etc.). In

the tail-drop link persistent flow case, the mean-field limit can be described geometrically as billiards in Euclidean space. These billiards have as many dimensions as the number of flow classes and as many reflection facets as there are routers and links. For non-persistent flows with an on-off structure, TCP can induce a turbulence-like phenomena that translate into two possible stationary regimes for the mean-field limit. Also the AQM-RED link case can be investigated by such mean-field techniques and leads to transport-type PDEs. In the single link case, this allows to determine in closed form the stationary distribution of the stationary throughputs obtained by the flows, both in the persistent and the on-off cases. When aggregated, the traffic generated by these models exhibits TCP and network-induced fluctuations that might explain some of the statistical properties observed on real traces.

50 people attended.

6.3. EURANDOM visitors in 2004

	January	
H.-J. Albrecher (Graz University, Austria)	Jan.1 – Dec. 31 biweekly	SERA/RI
D. Down (McMaster University, Hamilton, Canada)	Jan. 8 – July 1	QPA
A. Toom (Federal University of Pernambuco, Brasil)	Jan. 4 – 7	RSS
J. Lember (University of Tartu, Estonia)	Jan. 9 – 16	SIM
P. Taylor (University of Melbourne, Australia)	Jan. 15	QPA
V. Kulkarni (University of North Carolina, USA)	Jan. 15 + 16	QPA
L. Accardi (University of Roma II, Italy)	Jan. 20 – 24	SIM
J. Robin (Harvard School of Public Health,Boston, USA)	Jan. 28	SIM
G. Krupa (Catholic University Lublin, Poland)	Jan 30	RSS
	February	
R. Wu (McMaster University, Ontario, Canada)	Febr. 4 – 27	QPA
E. Baake (Ernst-Moritz-Arndt-Universität Greifswald, Germany)	Febr. 17 – 21	RSS
A. Lindner (Technische Universität München, Germany)	Febr. 18 – 20	SERA/RI
C. Butucea (Université Pierre et Marie Curie, Jussieu, France)	Febr. 23 – 27	SIM
M. Keyl (Technische Universität Braunschweig, Germany)	Febr. 22 – 28	SIM
J. Gärtner (Technische Universität Berlin, Germany)	Febr. 29 – Mar.13	RSS
A. Assalah (Centre de Mathématiques et Informatique, Université de Provence, France)	Febr. 29 – Mar.6	RSS
	March	
R. Brummelhuis (Laboratoire de Mathématiques, Reims, France)	March 6 – 10	RSS
J.-R. Chazottes (CNRS, Ecole Polytechnique, Palaiseau, France)	March 1 – 7	RSS
V. Limic (University of British Columbia, Vancouver, Canada)	March 28 – April 8	RSS
	May	
S. Whittington (University of Toronto, Canada)	May 4 – 11	RSS
T. Rudas (TARKI, Budapest, Hungary)	May 24 – 29	SIM
K. Simon (Technical University of Budapest, Hungary)	May 12	RSS
G. Weiss (University of Haifa, Israel)	May 24 – 26	QPA

	June	
J. Stoyanov (Newcastle University, UK)	June 3 – 4	SIM
G. Kordzakhia (University of Chicago, USA)	June 7 – 16	RSS
A. Faggionato (WIAS Berlin, Germany)	June 7 – 16	RSS
D. McDonald (University of Ottawa, Canada)	June 7 – 10	QPA
D. Guégan (Ecole Normale Supérieure de Cachan, France)	June 16 – 17	SERA/RI
J. Kahn (Cornell University, Ithaca, USA)	June 11 – 17	SIM
A. Christman (Dortmund University, Germany)	June 11	SERA/RI
	July	
D. Perry (University of Haifa, Israel)	July 11 – 16	QPA
O. Kella (Hebrew University of Jerusalem, Israel)	July 1 – 31	QPA
	August	
E. Bagan (Universitat Autònoma de Barcelona, Spain)	Aug. 1 – 14	SIM
	September	
J. Gärtner (Technische Universität Berlin, Germany)	Sept. 4 – 18	RSS
E. Saada (Université de Rouen, France)	Sept. 6 – 9	RSS
N. Gantert (Universität Karlsruhe, Germany)	Sept. 19 – 25	RSS
A. Le Ny (Université de Paris-Sud, France)	Sept. 22 – 24	RSS
P. Mörters (University of Bath, UK)	Sept. 27 – Oct. 2	RSS
	October	
F. Baccelli (INRIA & ENS, Paris, France)	Oct. 23 – 27	EURANDOM Chair
J. Lember (University of Tartu, Estonia)	Oct. 4 – 8	SIM
G. Lugosi (Pompeu Fabra University, Spain)	Oct. 6 – 9	SIM
J. Niño-Mora (Universidad Carlos III, Madrid, Spain)	Oct. 31 – Nov. 28	QPA
	November	
A. Bandyopadhyay (Chalmers University of Technology, Gothenburg, Sweden)	Nov. 1 – 5	RSS
F. Baccelli (INRIA & ENS, Paris, France)	Nov. 21 – 24	EURANDOM Chair
V. Shneer (Heriot-Watt University,Edinburgh, UK)	Nov. 21 – Dec. 2	QPA
	December	
D. Silvestrov (Mälardalen University, Sweden)	Dec. 1 – 3	RI
E. Silvestrova (Mälardalen University, Sweden)	Dec. 1 – 3	RI

V. Masol (Mälardalen University, Sweden)	Dec. 1 – 3	RI
A. Malyarenko (Mälardalen University, Sweden)	Dec. 1 – 3	RI
F. Comets (Université Paris 7, France)	Dec. 2 – 7	RSS
U. Gather (Universität Dortmund, Germany)	Dec. 16	SIM
C. Gromoll (Stanford University, USA)	Dec. 9 – 17	QPA
F. Baccelli (INRIA & ENS, Paris, France)	Dec. 12 – 15	EURANDOM Chair
G. Valle da Silva (Ecole Polytechnique Fédérale de Lausanne, Switzerland)	Dec. 13 – 15	RSS

In total 52 researchers visited EURANDOM in 2004 (from several days up to 6 months). Total residence time: 89,5 weeks.

Distribution over the programmes:

QPA	11	researchers	45	weeks
RSS	20	researchers	20	weeks
SIM	12	researchers	13	weeks
SERA/RI	8	researchers	8,5	weeks
EURANDOM Chair	1	researcher	3	weeks over 6 months

The QPA programme had 1 long term visitor for 6 months; this visit is included in the above mentioned number.

7. INTERNATIONAL COOPERATION and FUNDING

7.1. International Cooperation

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

During 2004 EURANDOM continued to integrate workshops with visits of senior and junior scientists for a period before or after the workshop. Many researchers from EURANDOM went to work with colleagues abroad, e.g. Camía and Sun with Newman in New York, USA, Koloydenko with Lember in Tartu, Estonia, Ladoucette and Sarma with Guégan, Paris, Denisov with Foss in Edinburgh, UK and Lalam with C. Jacob, INRA, Jouy-en-Josas, France.

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

EURANDOM continued tightening the Alumni network. A second meeting is planned for 2005.

The scientific directors of EURANDOM chairs the ESF Scientific Programme on "Random Dynamics in Spatially Extended Systems" involving 13 European countries. EURANDOM is involved in a Thematic Network under the EC, Pro-ENBIS (European Network for Promoting Business and Industrial Statistics). This network will strengthen our contacts in this area. EURANDOM participates in a Network of Excellence, PASCAL, "to build a Europe-wide Distributed Institute that will pioneer principled methods of pattern analysis, statistical modelling and computational learning as core enabling technologies for multimodal interfaces that are capable of natural and seamless interaction with and among individual human users", and EURO-NGI "Design and Engineering of the Next Generation Internet", which main target is "to create and maintain the most prominent European centre of excellence in Next Generation Internet design and engineering, leading towards a leadership in this domain".

EURANDOM joined an application for a Network of Excellence, Bio-CONECT, as a follow up to the earlier application for an IP: Bitopia.

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

7.2. Cooperation in The Netherlands

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

There are intensive links with the Department of Mathematics in Eindhoven through joint seminars, visitors, researchers working together etc. and, on a less intensive level, with the De-

partments of Technology Management, Chemical Engineering and Chemistry and Biomedical Technology. Some PDs were involved in teaching activities at TU/e.

7.3. Funding

On the national level, 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 some additional funding from European research councils. However, these efforts so far are not successful. European science foundations declared their willingness to cooperate, but not to co-fund a European institute. Grants can only be obtained through national researchers. With DFG and FWO such cooperation is on going.

In 2004, 13 PDs and PhDs were paid via external funds, among which grants from NWO (4, directly and/or via appointments at other universities), NSF (1), EC/Marie Curie Fellowship (2) and TU/e (Department of Technology Management and Department of Mathematics and Computer Science) (2), FOM (1). Philips Electronics Nederland BV funded one PhD position for cooperation in the area of cable access networks. The project with Philips on "Modelling and Management of Batteries", which started in 2000, was extended in 2001 and continued to receive funding through the EET-programme of the Ministry of Economic Affairs (1 PD, 1 PhD and additional support for scientific guidance). The research project on "Signature Analysis" was continued with Flextronics (after the take over of the Dutch Xerox organisation by Flextronics) and was also EET-funded (1 PD, 1 PhD and additional support for scientific guidance).
Furthermore, KNAW and NWO co-financed workshops in 2004.

Several German scientists visited EURANDOM on DFG sponsoring; Christof Külske worked for 6 months at EURANDOM with a DFG-grant. Another long term visit, by Professor Doug Down, was funded by his own university (McMaster University, Hamilton, Ontario, Canada). PASCAL financed the SIM workshop in September.

On the European level (ESF and EU), EURANDOM continues investing in the concept of a "European Research Area".

8. FACILITIES

8.1. Computing and Communication

EURANDOM has ample computing facilities. Desktop equipment consists of personal computers that offer access to the Windows / NT and the Unix servers. The personal computers are connected through a high-speed network to these servers and to the Internet. EURANDOM has its own Unix computing server with 4 processors (SGI 200) and uses the NT servers of TU/e. If needed, computing time can be bought on the supercomputing facilities of NCF. The available mathematical software consisted 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 a.o. J-STOR.

8.3. Housing

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

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

9. EXPENDITURE

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

Expenditure (in K euro)	
Staff	1348
Advisors	124
Travel	53
Visitors	28
Housing	121
Workshops, Seminars	86
Books, Journals, Software	14
Depreciation costs	27
General costs	45
ICT Support	33
Software	4
TOTAL	1883