Annual Report 2009

EURANDOM

European Institute for Statistics, Probability,
Stochastic Operations Research
and their Applications

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Stochastic Operations Research
and their Applications**

The core business of EURANDOM is fundamental research in the stochastic sciences and their applications in an international environment

1. Introduction

EURANDOM was founded as an international institute on June 30, 1997 by the Netherlands Organization for Scientific Research (NWO) and Eindhoven University of Technology (TU/e), with a large grant from the Ministry of Education and Science, and has been operational since the summer of 1998. Basic funding came from NWO and TU/e, until January 1, 2008.
Since January 1, 2008 the institute is organizationally embedded in the Department of Mathematics & Computer Science. Our location (Laplace building) will not change until the Department of Mathematics & Computer Science will move into a new building.
Funding from the foundation EURANDOM is presently supplemented with money from grant applications. In addition, part of the costs are since 2008 covered by (in kind) contributions by the general board of TU/e and the Department of Mathematics & Computer Science, TU/e.

An important development in Dutch stochastics and in the evolution of EURANDOM, was the start of a fourth mathematics cluster, STAR: Stochastics – Theoretical and Applied Research. STAR was launched with a kick-off meeting in EURANDOM on May 15, 2009. The scientific committee of STAR, consisting of Frank den Hollander, Chris Klaassen, Rob van der Mei, Aad van der Vaart and Onno Boxma (chair), subsequently asked NWO for financial support. In December NWO decided to give STAR a 1,5 Meuro grant, covering a 2 year period.

2. Mission Statement

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

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

Excursion to Den Bosch, June 2009

3. The role of stochastics

Stochastics, consisting of statistics, probability theory and stochastic operations research, is a mathematical discipline that plays an important role in our technological society. We are more and more faced with organizations, systems and processes so complex that description and analysis in terms of random elements is more appropriate and effective than a fully deterministic approach. Accordingly, stochastics is becoming increasingly important in other disciplines, like physics, chemistry, biology, economics and telecommunication.
Stochastics is internationally flourishing. Consequently, there is a great need to train a new generation of mathematicians with a strong knowledge of the foundations of stochastics, a good insight into the applicability of stochastics in diverse areas, and an open attitude towards newly developing theories and applications.

4. Research at EURANDOM

Research at EURANDOM covers stochastics and its applications, as well as its interfaces with other disciplines. The core business of EURANDOM is fundamental research in an international environment, carried out by a select and non-tenured staff of senior and junior researchers, supplemented with an extensive program of seminars, workshops and visitors. In spite of its modest size, EURANDOM is engaged in many activities on a local, national and international scale, making it into an important research facility in Europe.

One of the key instruments of EURANDOM in realizing its mission is its workshop and visitor program. This program offers young scientists a well developed training opportunity. Workshops gather top researchers in the field to exchange the latest developments and ideas; sometimes concentrated minicourses are given, in some cases junior researchers play a special role in a workshop. Senior and junior researchers frequently develop a close cooperation with the visitors.

The scientific activities of EURANDOM are organized in four research programs, which are all central in the area of stochastics. Programs have two to four themes. In addition to the four programs, other projects may be running. In 2009 a project started as a follow-up of the Integrated Batteries (i-Bat) project: NiMH Battery Modelling for Automotive BMS. It is performed in collaboration with the TU/e Department of Chemical Engineering and sponsored by Senter Novem.

An Example of Research in Multivariate Risk Modelling (MRM)
Mitja Stadje

A New Theory for Decision under Risk and Ambiguity
We axiomatize a new theory for decision under risk and ambiguity. Consider a position yielding a payoff depending on some random scenario. This position could be a portfolio containing assets and liabilities, a derivative, or an insurance contract. The various probabilities of possible scenarios occurring might not be completely known. A classical question then is how to model preferences of some agents and further to find a reasonable way to quantify the value of these positions. Since the probabilities of the scenarios might be unknown, one has to distinguish risk (probabilities given) from ambiguity (probabilities unknown). Since Ellsberg, the importance of this distinction has been apparent: while in the classical subjective expected utility model of Savage, the distinction between risk and ambiguity is nullified through the assignment of subjective probabilities to the scenarios, the Ellsberg paradox shows experimentally that decisions under ambiguity cannot be reconciled with any such assignment of subjective probabilities. We model payoffs as random variables, each containing a source of ambiguity. By adding one additional axiom to some standard axioms, we obtain a proper disentanglement of risk and ambiguity. In addition, we discuss the possibility of resolving paradoxes which appear in other decision theories and characterize risk and ambiguity aversion within our new theory.

To Risk or Not to Risk

Source: http://www.fayerwayer.com/up/2007/05/stock-crash.jpg

Multivariate Risk Modelling (MRM)
This topic lies at the interface of economics, finance and insurance. The research of the **MRM** group focuses on subjects closely related to the credit crisis that developed during 2008. The research is directed towards both fundamental and applied research. The aim is to always relate new models, techniques and settings to real world data, cases and situations. To realize this we have a close cooperation with people active in the financial industry.

Currently there are three themes in the MRM Group:
- New Rating Models for Asset Backed Securities (ABSs)
- Alternative Volatility models
- Credit derivatives and their risk management

An Example of Research in QPA

Yoni Nazarathy

The single server queue has for long been a central object of study in queueing theory. This is a model of a service facility which sequentially renders service to customers that arrive according to a random process and require random service times. It is often used as a basic building block in modeling customer service centers, telephone exchanges, data transfer systems, manufacturing lines and road traffic. Performance measures such as waiting times, the server utilization and the number of customers present are typically of interest. It is beneficial to characterize these quantities in terms of the parameters of the arrival and service processes.

The departure process of customers from the queue is also of significant importance. Insight into the structure of this process allows analyzing more complex queueing networks by means of cascading queues: The output of one queue becomes the input of another. While a full characterization of the departure process is interesting, this is often an intractable problem and thus one often resorts to an approximate asymptotic analysis. In this respect, an interesting measure is the variability of the number of items produced as time goes to infinity.

For critically loaded single server queues, we have discovered the following:

$$\lim_{t\to\infty}\frac{\mathrm{Var}\,D(t)}{t}=\begin{cases}\left(1-\frac{2}{\pi}\right)\left(\sigma_a{}^2+\sigma_s{}^2\right) & \text{when capacity is infinite}\\ \frac{1}{3}\left(\sigma_a{}^2+\sigma_s{}^2\right)+o(1) & \text{when capacity is finite}\end{cases}.$$

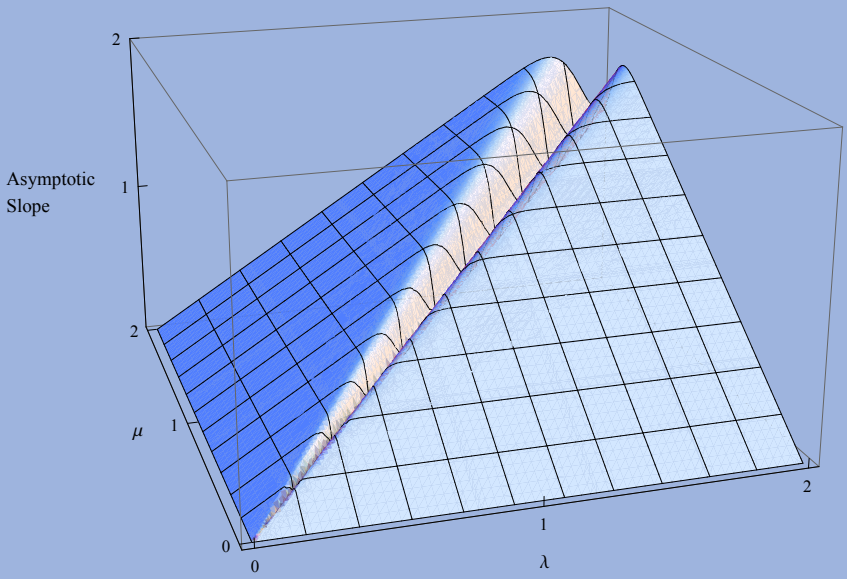
Here $D(t)$ is a count of the number of departures during the first t time units of operation of a critically loaded single server queue, either with an infinite capacity, or with a finite capacity (customers that arrive to a full queue are rejected). For simplicity the mean inter-arrival and service times are both equal to 1; the important thing is that they are identical. The variance of the inter-arrival and service times is given by $\sigma_a{}^2$ and $\sigma_s{}^2$ respectively.

Note that when the queue is underloaded, it is well known that the asymptotic slope of the variance curve is $\sigma_a{}^2$. Similarly, when the queue is overloaded, the asymptotic slope is $\sigma_s{}^2$. Our contribution is in finding the asymptotic slope in the balanced case which is determined by both the arrival and service processes. Surprisingly, the asymptotic slope of the variance curve is not the average of the two variances but is either approximately 72% of that quantity for the infinite capacity case or is 2/3 of that quantity for the finite capacity case, with the o(1) term vanishing as the capacity goes to infinity. See also the figure on the next page.

The infinite capacity result is proven true in collaboration with Ahmad Al Hanbali (EURANDOM post-doc), Michel Mandjes (EURANDOM senior researcher) and Ward Whitt (Columbia University). The finite capacity case has so far only been shown numerically. Both results are of significant impact to the management, operations and industry sectors since they highlight a newly discovered phenomenon that occurs in balanced systems.

Queueing and Performance Analysis (QPA)
The goal of **QPA** 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 program consists of three themes:

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



The asymptotic slope of a finite capacity system with 40 waiting rooms is plotted as a function of the arrival and service rates. The crevice in the center of the curve is on the line in which the system is balanced.

An Example of Research in Random Spatial Structures (RSS)
Artem Sapozhnikov

In the classical mathematical theory of percolation, the edges (or vertices) of an infinite lattice are deleted independently with probability 1-p, and the properties of the remaining components are studied.
There is a phase transition in the parameter: if p is bigger than some critical value, there is an infinite component with probability 1 (in this case, we say that percolation occurs), and if p is below that value, the probability of the existence of an infinite component is 0. If p equals the critical value, the geometric properties of connected components are highly non-trivial. It is expected (and has been proved for certain lattices) that simple characteristics of connected components (e.g., diameter, volume) obey power laws. In other words, at criticality, connected components are self-similar random objects.
Invasion percolation is a stochastic growth model that mirrors aspects of the critical percolation picture without tuning any parameter. To define the model, we attach uniformly distributed weights to edges of the lattice independently. We then grow an infinite cluster from a single vertex, the origin, by adding at each step the edge from the boundary of the current graph with the least weight.
In two joint papers (with M. Damron and B. Vágvölgyi and with M. Damron) and in an ongoing project with M. Damron we make a comprehensive study of invasion percolation on two-dimensional lattices. We compare connectivity properties of the origin's invaded region to those of (a) the critical percolation cluster of the origin and (b) the so-called incipient infinite cluster.
We also prove a central limit theorem and strong law of large numbers for certain characteristics of the invasion.

Giant's Causeway (County Antrim, Northern Ireland)

Random Spatial Structures (RSS)
The **RSS**-program 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.

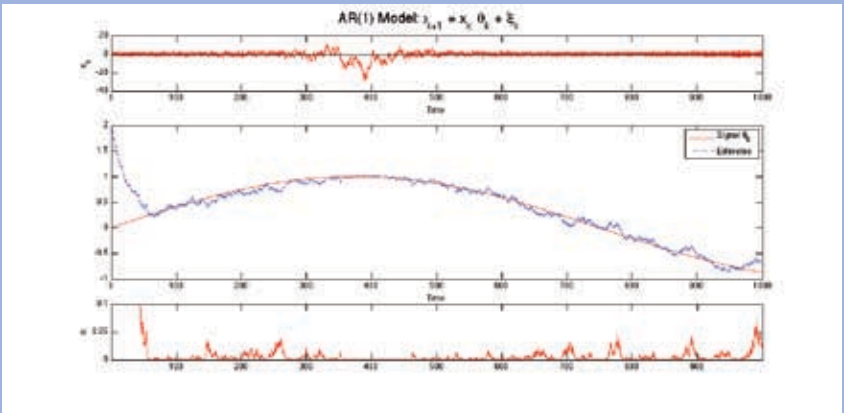
Themes:
- Critical phenomena
- Disordered media
- Combinatorial probability
- Applications in biology

Statistical Information and Modelling (SIM)
The **SIM**-program conducts research on a variety of topics in mathematical and applied statistics. The research currently focuses mainly on semi- or nonparametric problems. Such problems naturally arise in many different contexts, when complex statistical models are used that involve a very large number of unknown parameters, possibly infinitely many. These so-called high-dimensional statistical models are for instance often encountered in areas like image analysis, mathematical biology, finance or climate science. Particular fields of interest in mathematical statistics include inverse problems, nonparametric Bayesian inference and non- or semi parametric inference for stochastic processes. On the applied side the group is among others involved in projects in image analysis and climate predictions.

An Example of Research in Statistical Information and Modelling (SIM)

Paulo De Andrade Serra MSc

My current research as part of the SIM group includes several topics close to the border between Statistics and Stochastics.
I've been applying some entropy based methods to study an M-estimator for the period of a cyclical non-homogeneous Poisson process where the non identically distributed increments of the process pose some challenges in establishing results such as identifiability of the parameter in question and uniform convergence results.
Another topic I've been dedicating some attention to is the design of recursive estimators for models with drifting parameters. When observations are being drawn over time from a given model the assumption that the model's parameters are constant over time might not be reasonable; the algorithm updates the most recent estimate for the parameter based on recent observations and can be shown to be consistent under some conditions on the speed at which the parameter is changing -- most recently I've started looking into applying this algorithm to the quantile regression.



The figures show a trajectory of an AR(1) model where the value of the auto-regressive parameter is not fixed, the respective signal for the parameter and the produced estimates and the associated squared error.

Board, Scientific Council and Directors

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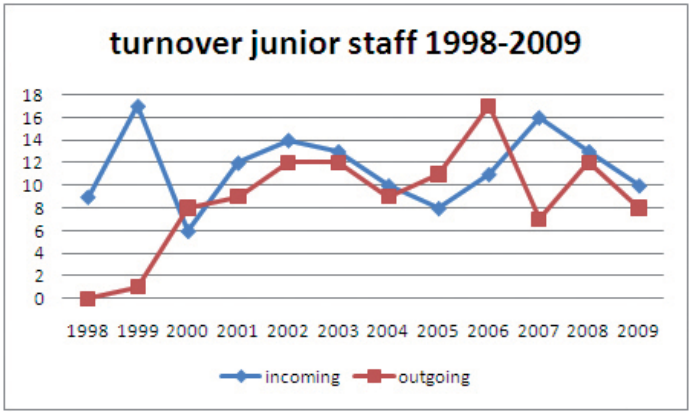
Drs. C.M.M. Cantrijn, managing director

5. Scientific staff

At any time about 25 junior researchers are working at EURANDOM, from which in 2009 about 14 were employed by the institute (through TU/e). Each program hosts postdocs and graduate students, supervised by senior fellows, and guided by an international steering committee. Since its start, over 100 PD's and PhD's have been working at the institute.
Most of the researchers (about two third) found tenured positions in academia or industry after leaving the institute; about 10 were appointed full professor at different universities. About one third of the former employees found a position at a Dutch university or in a research program of a Dutch company.



Senior fellows
January 1, 2009 two new senior fellows started. In the RSS program Vladas Sidoravicius from CWI and University of Leiden started and in the MRM program, Roger Laeven, University of Tilburg took over from Bas Werker (also UvT). In September 2009 two new SIM fellows started: Harry van Zanten, recently appointed at TU/e and Eduard Belitser from Utrecht University.

Their research interests are respectively: random spatial processes, in particular percolation, interacting particle systems and Gibbs measures (Sidoravicius); probability and mathematical statistics, (micro) economic theory, actuarial science and quantitative finance (Laeven); the analysis of statistical procedures for high-dimensional or nonparametric statistical problems; special focus on the study of nonparametric Bayes procedures for such problems (Van Zanten); mathematical statistics, primarily in the general area of nonparametric estimation (Belitser).
April 2009 we said goodbye to Laurie Davis. At the end of 2009 we said goodbye to Richard Boucherie (Twente University) and Nico Dellaert (Department of Industrial Engineering and Innovation Sciences at TU/e). We thank them for their valuable contributions as senior fellows.

Awards & Grants

Roger Laeven, senior fellow of the MRM program, received a grant in the "Innovative Research VIDI Scheme".

The University of Haifa conferred **Onno Boxma** in June 2009 an honorary doctorate.

Jef Teugels became president of ISI

Johan van Leeuwaarden obtained a Grant in the Open Competition at NWO for his project: queues and random walks in the quarter plane. He and Sem Borst received a Microsoft grant for a PhD project on wireless communications.

Bernd Heidergott (former postdoc) received the Best Lecturer Award of the faculty of Economics and Business Administration of the VU for the academic year 2008/2009.

Bernardo D'Auria (former postdoc) received the Ramon y Cajal grant (Spanish equivalent of the Dutch VIDI-grant of NWO).

Out of 9 postdocs and PhD students who left EURANDOM, 5 got a position as assistant professor or lecturer at a university in The Netherlands (2) or abroad (3), one got a position in the financial industry in The Netherlands and 3 started another postdoc position in The Netherlands (2) or abroad (1).

6. Facts and Figures

Workshops and Conferences
Workshop topics are chosen by the senior fellows and other people linked to the research programs. Ideas for topics also come from postdocs and visitors, and through the various European networks and programs in which EURANDOM participates. An overview of all workshops is available on: http://www.eurandom.tue.nl/events/workshops/all_workshops.htm

On December 14-18, 2009 we organized the 100th workshop at the institute, reason for a small party.

January 5-7, 2009 (QPA)	Quantitative Models for Production and Communication Networks
March 23-27, 2009 (RSS)	YEP VI - Fragmentation, Coalescence and Probabilistic Genetics
May 11-13, 2009 (SIM)	Climate Change and Extreme Value Theory
June 8-10, 2009 (SIM)	Parameter Estimation for Dynamical Systems
June 25-26, 2009 (QPA)	SPOTNET meeting
July 15-17, 2009 (SIM)	Statistical Inference for Lévy Processes with Applications to Finance
August 24-28, 2009 (RSS)	Order, Disorder and Double Disorder
October 5-7, 2009 (SIM)	YES-III - Paradigms of Model Choice
October 29-30, 2009 (QPA)	Stochastic Models for Warehousing Systems
October 29-30, 2009 (MRM)	Asset Backed Securities (venue EIB, Luxemburg)
November 19-21, 2009 (QPA)	YEQT III - Scheduling and Resource Sharing in Queueing Networks
November 23-25, 2009 (QPA)	NET-COOP
December 14-18, 2009 (RSS)	Dynamic Random Environments

Number of workshops in 2009: **13 from which 12 at EURANDOM**
Total number of participants in 2009: **620**

Furthermore:

- we organized a festive gathering on the occasion of the 100th workshop in December 2009;
- we sponsored the Nederlands Mathematisch Congres 2009, which took place on April 14 and 15, 2009 in Groningen;
- on March 3, 2009 the EURANDOM Chair 2008-2009, professor Anton Bovier, gave a Public Lecture as well as a lecture series during the following months;
- on December 7, 2009 the EURANDOM Chair 2009-2010, professor Dilip Madan, gave a Public Lecture.

Professor Anton Bovier,
Bonn, Germany

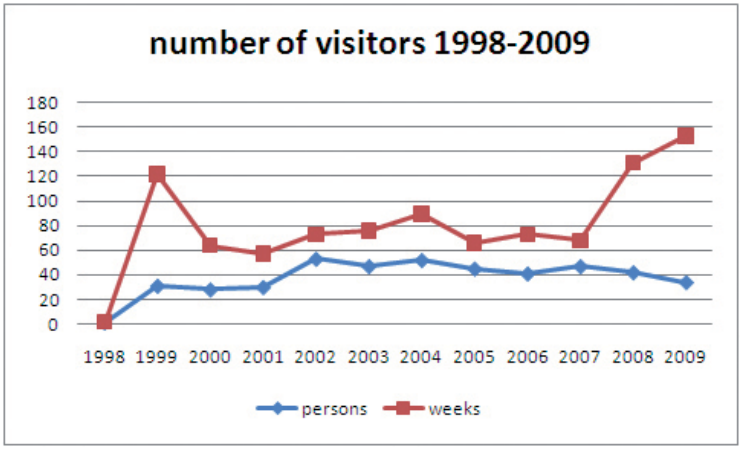
Professor Dilip Madan,
University of Maryland, USA

Lectures and seminars
Number of seminars in 2009: **78**

Lectures and seminars are organized on a regular basis within the framework of each of the four research programs. Sometimes seminars are joint events, e.g. the Informal Meetings of Eindhoven Statisticians with TU/e.
An overview of all seminars is available on:
http://www.eurandom.tue.nl/events/seminars/2009tot.htm

Visitors
Number of visitors (and visits) in 2009: **34**
Total duration of stay in weeks: **153**

One long term visitor stayed for almost 7 months, two others 4 and 3 months. However, most visitors come for a period from a few days up to one month.

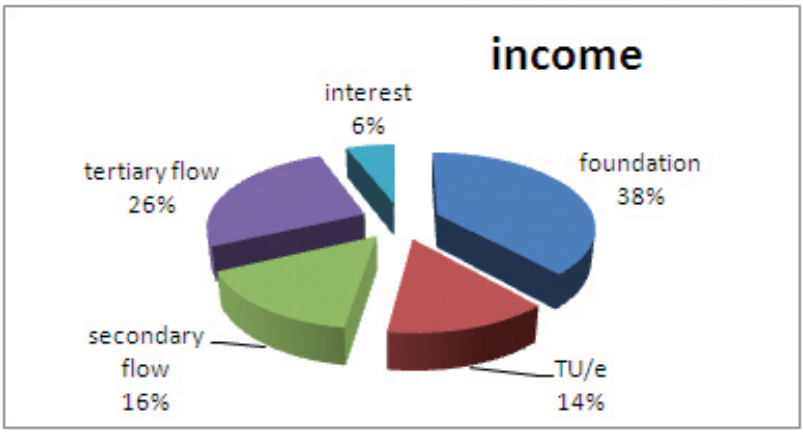


An overview of visitors is available on:
http://www.eurandom.tue.nl/Past%20years/visitors2009.htm

Publications
In 2009, **65 EURANDOM reports** were written, while the website of the Department of Mathematics and Computer Science mentions **67 external EURANDOM (-linked) publications** (articles in refereed journals, external reports, conference proceedings and book(chapter)s).

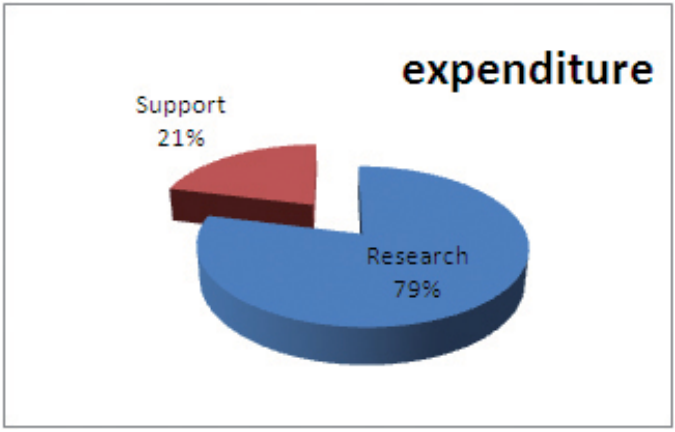
An overview is available on:
http://oametuep.uci.ru.nl/metue/pk_apa_n.onderzoek?p_url_id=5205

Finance
The following figures report on income and expenditure:



Research includes costs of salary of postdocs and graduate students, scientific director, senior fellows, EURANDOM chair, computing, library, workshops & visitors and travel costs.

Support includes salary of the administrative staff and managing director, depreciation and general costs.



Location
EURANDOM is located on the campus of Eindhoven University of Technology, The Netherlands, Laplace building. The TU/e campus is situated close to the centre and the railway station of Eindhoven.

Facilities
EURANDOM provides office space and computing facilities. Lecture rooms and a modest library annex common room are also available. Full scale libraries may be found on the campus of the TU/e.
The TU/e campus offers facilities such as a sports centre, a language lab and restaurants, also available for EURANDOM staff.

Postdocs and long-term guests can be accommodated in one of the University guest houses. All employees are allowed to join the TU/e collective health insurance and can get help with procedures concerning visa, work permit etc.

Eindhoven, May 2010
Prof.dr.ir. Onno Boxma,
scientific director

Colofon

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More information at: www.eurandom.tue.nl
and for the annual report on:
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