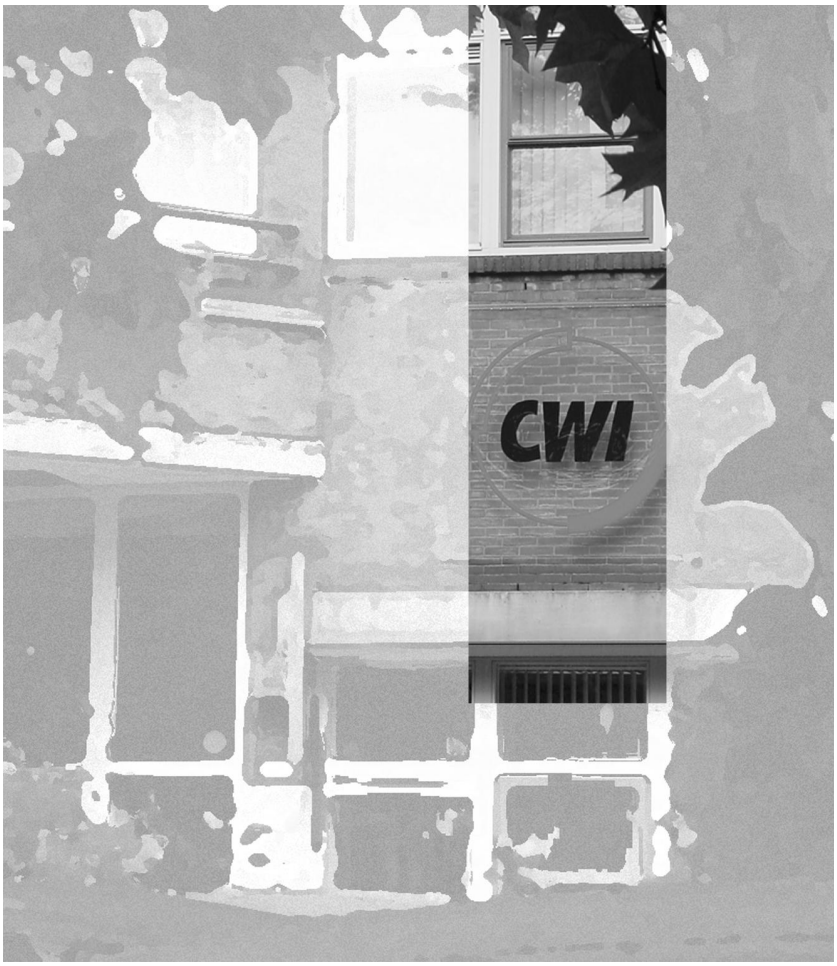
Overview Research Activities 2005

15th June 2006



Centrum voor Wiskunde en Informatica (CWI) is the national research institute for mathematics and computer science. It is sponsored by the Netherlands Organisation for Scientific Research (NWO). CWI is a founding member of ERCIM, the European Research Consortium for Informatics and Mathematics. It participates in the Telematica Instituut and the Amsterdam Science Park. CWI is a Member of the World Wide Web Consortium (W3C) and it runs the W3C Office in the Benelux.

General Director

Jan Karel Lenstra

Colophon

Issued by	Stichting Centrum voor Wiskunde en Informatica, June 2006 ©
Production	Communications, Library and Information services CWI
Printing	Grafisch bedrijf Ponsen & Looijen bv, Wageningen

Centrum voor Wiskunde en Informatica

Visiting address	Kruislaan 413, 1098 SJ Amsterdam, The Netherlands
Postal address	P.O. Box 94079, 1090 GB Amsterdam, The Netherlands
Telephone	+31 20 592 9333
Telefax	+31 20 592 4199
Website	www.cwi.nl

ISSN 1380-7846

CONTENTS

The CWI annual report series consists of:

- Annual Report (English), a full colour document giving a general overview of CWI's scientific activities and some research highlights
- Overview Research Activities (English), a comprehensive enumeration of CWI's scientific activities
- Sociaal-Financieel Jaarverslag (Dutch), a supplement containing the social and financial report and the works council report

They can be ordered at the department of Communications, Library and Information Services (cbi@cwi.nl)

PREFACE

This overview

This overview is a comprehensive report of the CWI research activities in 2005 and is a supplement to CWI Annual Report 2005, which highlights CWI's scientific research.

Mission of CWI

CWI is the national research institute for mathematics and computer science. It is a private, non-profit organization. Founded in 1946 (as Mathematisch Centrum), it aims at fostering mathematics and computer science research in the Netherlands. CWI receives a basic funding from the Netherlands Organization for Scientific Research (NWO), amounting to about 70% of the institute's total income. The remaining 30% is obtained through national research programmes, international programmes, and contract research commissioned by industry.

CWI's mission is twofold: To perform frontier research in mathematics and computer science, and to transfer new knowledge in these fields to society in general and trade and industry in particular.

This mission is realized by several means. In addition to the standard ways of disseminating scientific knowledge, for example through publications, presentations at conferences, organization of workshops and exchange of researchers, CWI actively pursues joint projects with external partners, provides consulting services, and actively stimulates the creation of spin-off companies. A technology transfer event is organized annually to promote these activities. Also special efforts are made to make research results known to non-specialist circles, ranging from researchers in other disciplines to the public at large. CWI has many contacts with national organizations for applied research with wide experience in turning research results directly into practical applications. Its researchers are supported by state-of-the-art computing facilities and a library of national importance.

CWI has always been very successful in securing considerable participation in European research programmes (e.g., ESPRIT, ACTS, TELEMATICS, BRITE, TMR, IST, and others) and national research programmes (ICES/KIS programmes; NWO Veni, Vidi, Vici grants; TI projects and, more recently, Bsik programmes BRICKS, MultimediaN, and Vl/e) and has extensive experience in managing these collaborative research efforts. CWI is also strongly embedded in Dutch university research: about twenty-five of its senior researchers hold part-time positions as professors at universities and several projects are carried out in cooperation with university research groups. Annually CWI hosts some 200 visiting scientists from abroad.

CWI hosts a staff of 235 fte (full time equivalent), 185 of whom are scientific staff. It operates on an annual budget of M€ 16.3 (2005).

CWI's research entities

CWI's scientific research is organized in four scientific clusters, each consisting of 3 to 6 scientific research themes.

PNA – Probability, Networks and Algorithms

Research themes:

- PNA0 – Algebra and Statistics
- PNA1 – Algorithms, Combinatorics and Optimization (until July 2005 Networks and Logic – Optimization and Programming)
- PNA2 – Advanced Communication Networks(as of January 2006 Performance Analysis of Communication Networks)
- PNA3 – Stochastics (as of January 2006 Stochastic Dynamics and Discrete Probability)
- PNA4 – Signals and Images
- PNA5 – Cryptology and Information Security (pilot)

SEN – Software Engineering

Research themes:

- SEN1 – Interactive Software Development and Renovation
- SEN2 – Specification and Analysis of Embedded Systems
- SEN3 – Coordination Languages

- SEN4 – Computational Intelligence and Multi-agent Games (until July 2005 Evolutionary Systems and Applied Algorithmics)
- SEN5 – Convergent Media Infrastructures (as of January 2006 Distributed Multimedia Languages and Infrastructures)

MAS – Modelling, Analysis and Simulation

Research themes:

- MAS1 – Nonlinear PDEs: Analysis and Scientific Computing
- MAS2 – Computing and Control
- MAS3 – Nonlinear Dynamics and Complex Systems

INS – Information Systems

Research themes:

- INS0 – Standardization and Knowledge Transfer
- INS1 – Database Architectures and Information Access
- INS2 – Multimedia and Human-Computer Interaction (as of January 2006 Semantic Media Interfaces)
- INS3 – Visualization and 3D Interfaces
- INS4 – Quantum Computing and Advanced Systems Research

Summary of contents

This overview contains:

- Reports of the four clusters and their themes
- Appendices:

  A Statistics of CWI publications
  B CWI reports
  C Publications outside the research clusters
  D ERCIM Fellows
  E Acronyms of universities in the Netherlands
  F PhD theses

Items per cluster

- Principal research area + mission
- Cluster staff
- Research themes and their leaders

Items per theme

- Name + acronym
- Mission
- Theme leader
- MSC or CR classification
- Subthemes and their leaders
- Staff (+ affiliation of seconded staff)
- Scientific report: highlights, PhD students, and report per subtheme/project
- Societal aspects and knowledge transfer: external contacts, projects with partners in public and private sector, contract research, teaching.
- Organization of conferences, workshops, courses
- Lectures, conferences, courses, project meetings, working visits
- Visitors
- Memberships of committees and other professional activities
- Academic publications (papers in journals or proceedings, monographs, book chapters, CWI reports, other publications)
- Professional products (patents, contracts, publications for a broad audience, contributions to documentaries or radio or TV broadcastings)
- Other output (awards, grants)

PROBABILITY, NETWORKS AND ALGORITHMS

Principal research area and mission

PNA focuses on discrete and probabilistic analysis, modelling, algorithms, and optimization; and on their applications in technology, management, trade, and biology. PNA's research lies in the interface between mathematics and computer science.

PNA's first and foremost research objective is to make fundamental and applied contributions to problems and techniques in these areas. Developing, implementing and testing new techniques and algorithms for practical use also belong to the objectives.

Tools are found in a wide range of pure and applied mathematics and computer science: algebra, analysis, discrete mathematics, complexity theory, game theory, geometry, (computational) logic, number theory, operations research, and stochastics. Particular application areas are: information and communication technology, in particular performance of communication networks, cryptology and information security; operations management, traffic and transport, image and signal analysis, combinatorial and computational biology and the environment.

Algorithms, networks, operations research, stochastics, and security are central to PNA and connect its themes.

Cluster staff

Name	Fte	Function
Prof.dr. A. Schrijver	0.2	Cluster leader, till 30-06
Prof.dr.ir. A.M.H. Gerards	0.2	Cluster leader, as of 01-07
S.J. van Dam	0.4	Secretary

Research themes

Name		Leader
PNA0	Algebra and Statistics	A. Schrijver (till 30-06), A.M.H. Gerards (as of 01-07)
PNA1	Networks and Logic - Optimization and Programming (since October 2005: Algorithms, Combinatorics and Optimization)	A.M.H. Gerards (till 30-06), M. Laurent (as of 01-07)
PNA2	Advanced Communication Networks	M.R.H. Mandjes
PNA3	Stochastics	J. van den Berg
PNA4	Signals and Images	H.J.A.M. Heijmans (till 01-09) E.J.E.M. Pauwels (as of 01-09, deputy till 31-08)
PNA5	Cryptology and Information Security (pilot)	R.J.F. Cramer

Developments

In 2005, A. Schrijver received the Spinoza Prize. On July 1, he stepped down as cluster leader PNA and became CWI-fellow. The management of PNA was taken over by A.M.H. Gerards. Also at July 1, the management of PNA1 was taken over by Ms. M. Laurent.

Algebra and Statistics – PNA0

Mission

Algebra

The research in algebra concentrates on Hopf algebra and thesauri. The Hopf algebra, NSymm, of noncommutative symmetric functions and the Hopf algebra, QSymm, of quasisymmetric functions are two important generalizations of the very rich (in theory as well as applications) and important Hopf algebra of symmetric functions.

Statistics

The research in mathematical statistics focuses on saddlepoint approximations, Poisson intensity functions, Edgeworth expansions and bootstrap resampling.

Theme leader

Prof.dr. A. Schrijver, till 30-06, Prof.dr.ir. A.M.H. Gerards, as of 01-07

MSC or CR classification

05E, 16W30, 60F15, 62G20, 62G30, 68P20

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. M. Hazewinkel	1.0	researcher	till 30-11	PNA0
Dr. R. Helmers	0.1	researcher	till 2006-04-30	PNA0
Prof.dr. A. Schrijver	p.m.	theme leader	till 30-06	PNA0
Prof.dr.ir. A.M.H. Gerards	p.m.	theme leader	as of 01-07	PNA0

Scientific report

Activities by M. Hazewinkel

Title	Hopf algebras
Period	indefinite
Leader	M. Hazewinkel
Funding	CWI

Progress report. There is a most important and beautiful Hopf algebra called MPR, the Malvenuto-Poirier-Reutenauer Hopf algebra of permutations. It generalizes both QSymm, the Hopf algebra of quasisymmetric functions and NSymm, the Hopf algebra of noncommutative symmetric functions. These two, in turn, are dual (important) generalizations of Symm, the Hopf algebra of symmetric functions. Everything is over the integers. Now for Symm there is the Zelevinsky uniqueness theorem which says that a PSH (positive self-adjoint Hopf) algebra with precisely one primitive distinguished basis element is neccessarily isomorphic to Symm. There is also an almost rigidity theorem due to Liulevicius which says that over the integers there are precisely four automorphisms. At a meeting in August 2004 at Jeonju Univ. the question was raised whether there might be similar theorems for MPR. This is the matter investigated by Hazewinkel in 2005. The current situation is that there is a strict rigidity theorem: the only Hopf algebra automorphisms of MPR is the identity and that as a PtwsH (positive twisted selfadjoint Hopf) algebra is unique up to and including level 5. These results are recorded in two preprints, see below, meanwhile submitted (by request) to the *Honam Math. J.*

Hazewinkel also obtained the precise recipe in general for the necessarily unique isomorphism of an abstract PtwSH algebra with MPR. (Not yet written down, even in preprint form). It remains to verify that this recipe does indeed do the job.

Activities by R. Helmers

Title	Research in statistics
Period	August 2003–April 2006
Leader	R. Helmers
Funding	p.m.
Partners	M. Hušková (Prague), B-Y Jing (Hong Kong), R. Zikitis (London, Ontario), N. Gribkova (St Petersburg), I W. Mangku (Bogor) Q. Wang (Sydney), Wang Zhon (Singapore)

Progress report. With N. Gribkova (St Petersburg) the second order correctness of the bootstrap approximation for a studentized trimmed mean was established, using Edgeworth expansions obtained in a previous paper. With Q. Wang (Sydney) we are in the process of deriving confidence regions for the intensity function of a cyclic Poisson process. A paper 'Saddlepoint approximations for a studentized compound sum with no moment conditions', joint with Bingyi Jing (Hong Kong) and Wang Zhou(Singapore), was almost completed. We derive a saddlepoint approximation of the classical Lugannani - Rice form for studentized compound sums under minimal conditions. With I W. Mangku (Bogor) a revision of a paper 'Estimating the intensity of a cyclic Poisson process in the presence of linear trend' for The Annals of the Institute of Statistical Mathematics is in progress.

Societal aspects and knowledge transfer

External contacts

M. Hušková (Prague), R. Zitikis (London Ont. Canada), Bingyi Jing (Hong Kong), Q. Wang (Sydney), N. Gribkova (St Petersburg), W. Zhou (Singapore), I W. Mangku (Bogor).

Projects with partners in public and private sector

- IMI, Lithuanian Acad. Sci. (Probabilistic models for identification clouds).
- Index for probability and statistics (with Inst. Math. Stat., USA; Bernouilli Soc.; Zentralblatt fuer Mathematik).

Teaching at university

- Special course on Hopf algebras, Taras Shevchenko Univ., Kiev, Ukraine, six lectures, May 2005: M. Hazewinkel.
- Special course on combinatorial Hopf algebras (especially word Hopf algebras), Vilnius Univ. and Vilnius Technical Univ., six 2-hour lectures, August 22–September 2: M. Hazewinkel.

Organization of conferences, workshops, courses, meetings

- Minisymposium 'Mathematical Statistics', Friday August 26, part of the International Conference on Applied Mathematics (ICAM05), Bandung, Indonesia, August 22–26 (sponsered by the Royal Netherlands Academy of Arts and Sciences (KNAW)): R. Helmers.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- International Symposium on Stochastic Models in Reliability, Safety, Security and Logistics, Beersheva, Israel, February 14–17: R. Helmers (Contributed paper, February 16: Inference on rare errors using saddlepoint approximations).
- Special meeting in honour of Yuri Manin, Max Planck Inst. for Math., Bonn, Februari 25: M. Hazewinkel.
- 55th Session of the International Statistical Institute (ISI 2005), Sydney , Australia, April 5–12: R. Helmers (Contributed paper, April 7: Strong Laws for generalized absolute Lorenz curves when data are ergodic and stationary sequences).
- 2nd joint meeting of the AMS, DMV, OMG, Mainz, June 16–19: M. Hazewinkel (Invited lecture in the special session on Hopf algebras: LSD permutations).
- Fifth Int. Algebraic Conf. In the Ukraine, Odessa, July 20–27: M. Hazewinkel (Plenary lecture, July 25: Hopf algebras of endomorphisms of Hopf algebras).
- International conference on Applied Mathematics (ICAM05), Bandung, Indonesia, Au-

gust 22–26: R. Helmers (Invited lecture, August 26: Compound sums: a survey of some recent developments).

Working visits

- Prof. D. Gilat, Department of Statistics, Univ., Israel, Tel Aviv, February 22: R. Helmers (Lecture: The empirical Edgeworth expansion for a studentized trimmed mean).
- Dr. Q. Wang, Department of Applied Probability and Statistics Univ. of Sydney, Sydney, Australia, April 13–20: R. Helmers.
- Prof. A. Lo, ISMT Department Hong Kong Univ. of Science and Technology, Hong Kong, China, April 20–24: R. Helmers (Lecture, April 22: Strong laws for generalized absolute Lorenz curves when data are stationary and ergodic sequences).
- Taras Shevchenko, Univ. and Inst. of Math. Ukrainian Acad. Sci., Kiev, May 21–28: M. Hazewinkel.
- Department of Mathematics, Institute of Technology, Bandung, Indonesia, August 29–September 2: R. Helmers.
- Dr. W. Zhou, Department of Applied Probability and Statistics National Univ. of Singapore, Singapore, September 5–9: R. Helmers (Lecture, September 7: Strong laws for generalized absolute Lorenz curves when data are stationary and ergodic sequences).
- Prof. M. Hušková, Department of Probability and Statistics Charles Univ., Prague, December 5–10: R. Helmers (Lecture, December 7: Strong laws for generalized absolute Lorenz curves when data are stationary and ergodic sequences).

Project meetings

- Project meeting 'Extended Programme Applied Mathematics' (EPAM), of the KNAW, Bandung, Indonesia, August 25: R. Helmers.

Other lectures

- Steering committee statistical auditing NIVRA/-Nijenrode, Nijenrode Univ., Breukelen: R. Helmers. (Invited lecture: Calibrated Stringer bounds).

Visitors

- P. Malyshev, Kiev, January 31–February 5; June 20–26; October 2–12. Host: M. Hazewinkel.
- D. Malyshev, Kiev, October 2–12. Host: M. Hazewinkel.
- I W. Mangku, Bogor, Indonesia, October 20–December 15. Postdoc in 'Extended Programme on Applied Mathematics' (EPAM), part of SPIN (Scientific cooperation Indonesia/Netherlands), a programme of the KNAW. Host: R. Helmers.
- Prof. D. Gilat, Tel Aviv, Israel, November 17. Host: R. Helmers.

Memberships of committees and other professional activities

M. Hazewinkel

- Member programme committee, International workshop on computer algebra and informatics, MSU, Moscow, November 9–11.
- Managing editor Acta Applicandae Mathematicae.
- Managing editor Mathematics and its Applications.
- Editor in chief Encyclopaedia of Mathematics.
- Managing editor Handbook of Algebra.

R. Helmers

- Co-organizer International Conference on Applied Mathematics, Bandung, Indonesia, August 22–26.
- Steering committee Statistical Auditing NIVRA/Nijenrode.

Academic publications

Publications in refereed journals or proceedings

1 M. Hazewinkel (2005). Symmetric functions, noncommutative symmetric functions and quasisymmetric functions II. Acta Appl. Math. 85, 319–340.

2 M. Hazewinkel (2005). Endomorphisms of Hopf algebras and a little bit of control, W.P. Dayawansa a.o. (eds). New directions and applications in control, LNCIS 321, Springer, 107–122.

3 R. Helmers, I W. Mangku, R. Zitikis (2005). Statistical properties of a kernel-type estimator of the intensity function of a cyclic Poisson process. Journal of Multivariate Analysis 92, 1–23.

4 R. Helmers, R. Zitikis (2005). Strong laws for generalized absolute Lorenz curves when data are stationary and ergodic sequences. Proceedings of the American Mathematical Society 133(12), 3703–3712.

Publications in other journals or proceedings and other scientific output

CWI reports

PNA-R0407, SEN-E0508.
See B.2 on page 201 and B.3 on page 202 for complete titles.

Preprints

1 M. Hazewinkel (2005). A lemma on symplectic matrices.
2 M. Hazewinkel (2005). Rigidity for MPR, the Malvenuto-Poirier-Reutenauer Hopf algebra of permutations.
3 M. Hazewinkel (2005). Towards uniqueness of the Malvenuto-Poirier-Reutenauer Hopf algebra of permutations.
4 V. Balys, R. Rudzkis, M. Hazewinkel (2005). Stochastic modeling of of scientific terms in publications.

Book chapters

1 M. Hazewinkel (2005). Hilbert's 1990 ICM lecture. The 23 problems. I. Grattan-Guinness (ed). Landmark writings in Western mathematics 1640-1940, Elsevier, 732–747.

Algorithms, Combinatorics and Optimization – PNA1

This theme was called 'Networks and Logic - Optimization and Programming' until October 2005.

Mission

This theme focuses on fundamental and applied research in the areas of combinatorics, optimization, algorithmics, complexity, and transportation. The problems studied originate from fields like networks, combinatorial optimization, coding theory, game theory, computational complexity, and from practice, in particular from production and transportation planning, routing, scheduling, time-tabling, computational biology. The techniques developed make use of models and methods from mathematics (algebra, geometry, topology, graph theory, discrete mathematics), operations research (linear, integer, and semidefinite programming), and computer science (constraint programming and complexity theory).

Theme leader

Prof.dr.ir. A.M.H. Gerards (until July 2005), Dr. M. Laurent (from July 2005).

MSC or CR classification

05-xx, 90-xx, D.3.2, D.3.3

Subthemes

Name	Leader
PNA1.1 – Combinatorics and Optimization	A.M.H. Gerards, M. Laurent, A. Schrijver
PNA1.2 – Constraint and Integer Programming	K.I. Aardal, K.R. Apt
PNA1.3 – Algorithmic and Combinatorial Methods for Molecular Biology	L. Stougie

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr.ir. K.I. Aardal (0.2 TUE)	0.6	leader PNA1.2	indefinite	PNA1.2: IP, BRICKS-is3
Prof.dr. K.R. Apt (0.2 UvA)	0.8	leader PNA1.2	indefinite	PNA1.2: CPG
Dr. H. Bosse	1.0	postdoc	2005-05-01 till 2007-02-01	PNA1.1: C&O, ADONET
J. Byrka	1.0	PhD student	2004-10-01 till 2008-10-01	PNA1.2: IP, ADONET
Prof.dr.ir. A.M.H. Gerards (0.2 TUE and		leader PNA1.1	indefinite	PNA1.1: Matroids, BRICKS - is3
0.4 cluster management	0.8		till 2005-06-30	
from 2005-07-01)	0.4		from 2005-07-01	
N. Gvozdenović	1.0	PhD student	2004-03-01 till 2008-03-01	PNA1.1: SPCO
Ir. W.J. van Hoeve	1.0	PhD student	2000-10-01 till 2005-05-01	PNA1.2: CPG, BRICKS-is3
Dr. S. Kelk	1.0	postdoc	2004-11-01 till 2006-11-01	PNA1.3: ACMB
Dr. M. Laurent	0.8	leader PNA1.1	indefinite	PNA1.1: SPCO
E.J. van Leeuwen	1.0	PhD student	2005-02-15 till 2009-02-14	PNA1.1: BRICKS-is3
Prof.dr. J.K. Lenstra	p.m.		indefinite	PNA1.1: C&O
G. Maróti, MSc	1.0	PhD student	2001-02-01 till 2005-10-01	PNA1.1: BRICKS-is3
Prof.dr. A. Schrijver (0.2 UvA and		leader PNA1.1	indefinite	PNA1.1: C&O, BRICKS-is3
0.4 cluster management	0.4		till 2005-06-30	
till 2005-06-30)	0.8		from 2005-07-01	
A.G. Steenbeek (0.4 PNA4)	0.6	programmer	indefinite	PNA1.1: STAGESPOREN
F. Vallentin	1.0	postdoc	2005-10-01 till 2006-11-30	PNA1.1: SPCO

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. D.C. Gijswijt (UvA)	0.4	PhD student	2002-01-01 till 2005-10-01	PNA1.1: C&O
J. van Kempen (UU)	1.0	Trainee	2005-05-01 till 2006-04-31	PNA1.2: IP
F.M. de Oliveira Filho (Capes, Brasil)	1.0	PhD student	2005-11-15 till 2009-11-14	PNA1.1: C&O
Dr. L. Stougie (TUE)	0.2	leader PNA1.3	2000-01-01 till 2005-03-01	PNA1.1: C&O; PNA1.3: ACMB

Scientific report

Highlights

- K.I. Aardal has been appointed full professor at TUE where she holds the chair of Combinatorial Algorithmics at the department of Mathematics and Computer Science since April 1, 2005.
- A. Schrijver has been awarded the Spinoza prize 2005, 'for his outstanding, pioneering and inspiring research in the field of combinatorics and algorithms' (quoting from the jury report).
- A. Schrijver has been appointed 'Ridder in de Orde van de Nederlandse Leeuw'.
- The doctoral school on Optimization of Polynomials and Semidefinite Programming took place at the Univ. of Klagenfurt on September 12–16. It was co-organized by M. Laurent as part of the Marie Curie RTN Algorithmic Discrete Optimization Network.
- The *Handbook on Discrete Optimization* co-edited by K.I. Aardal was published by Elsevier in December 2005 as volume 12 in the series of handbooks in Operations Research and Management science. This volume of more than 600 pages offers a comprehensive state of the art of Discrete Optimization.

PhD students

J. Byrka
D.C. Gijswijt
N. Gvozdenović
W.J. van Hoeve
E.J. van Leeuwen
G. Maróti
F.M. de Oliveira Filho

PNA1.1 – Combinatorics and Optimization

Title	C&O – Combinatorics and Optimization techniques
Period	January 2002–December 2010
Leader	A. Schrijver
Staff	H. Bosse, D.C. Gijswijt, J.K. Lenstra, F.M. de Oliveira Filho, A. Schrijver, L. Stougie
Funding	CWI, Bsik, NWO-GBE, CAPES, NWO-Diamant
Partners	INS4, TUE, UvA, UU, Ecole Normale Supérieure Paris, MIT (Cambridge, MA), Microsoft Research (Redmond, WA), Princeton Univ. (Princeton, NJ), Tohoku Univ. (Japan), TU Berlin, ZIB (Berlin), Univ. Dortmund, La Sapienza (Rome), Instituto Politecnico de Setubal (Portugal), NTNU Trondheim

Progress report. Algebraic and geometric techniques and semidefinite programming in combinatorics: At the beginning of his stay in PNA1, Bosse successfully defended his PhD thesis at the Technical Univ. in Berlin, whose main result is that every n-dimensional polyhedron can be described using at most $2n$ polynomial inequalities. Then Bosse worked on geometric properties of the cone of sums of squares of polynomials. He proved that when fixing the degrees of all polynomials to 2 or 4, the resulting cone contains its own dual; the same holds for polynomials of degree at most 12 with at most 10 variables. Moreover Bosse investigated semidefinite programming (SDP) approaches to the maximum likelihood mobility location problem; he bounded the integrality gap of the natural SDP relaxation and characterized the instances for which this SDP relaxation is exact.

Gijswijt (thesis supervisor: Schrijver) gave new lower bounds on the size of covering codes. The method relies on a block diagonalization of the Terwilliger algebra of the binary and nonbinary Hamming scheme given by Schrijver, resp., Gijswijt, Schrijver and Tanaka. The work is included in his PhD thesis 'Matrix algebras and semidefinite programming bounds for codes' successfully defended at the UvA in September 2005.

De Oliveira Filho completed his master thesis on the group Steiner tree problem at the Univ. of São Paulo in Brazil before joining PNA1. He started investigating faster algorithms for matrix multiplication using group representations and combinatorial 'uniquely solvable puzzles'.

With L. Lovász (Microsoft Research, Redmond), Schrijver proved a general theorem on semigroup functions that implies characterizations of graph partition functions in terms of the positive semidefiniteness ('reflection positivity') and the rank of certain associated matrices. Schrijver found a theorem on extending algebra homomorphisms from subalgebras to the full tensor algebra that extends earlier results of B. Szegedy on combinatorial parameters and im-

plies new characterizations of hypergraph and directed graph parameters.

In collaboration with H. Buhrman, F. Unger (both from INS4), R. Cleve (Univ. Waterloo), N. Linden (Univ. Bristol), and Laurent, Schrijver gave a new bound on the noise threshold for fault-tolerant quantum computation; the computation of the bound involves an optimization problem which could be solved using polyhedral techniques.

Routing, scheduling and facility location problems: Together with V. Bonifaci (La Sapienza, Rome and TUE), Stougie worked on multi-server on-line vehicle routing and dial-a-ride problems. They gave one of the first results in on-line routing and scheduling in which more servers lead to provably lower competitive ratios. Together with A. Tomasgard (NTNU, Trondheim) and P. Schülz (NTNU, Trondheim), Stougie completed the study of a stochastic facility location problem under a non-linear non-convex objective function, with an application to the Norwegian Meat Cooperation.

Stochastic programming: Together with S. Leonardi (La Sapienza, Rome) and C. Swami (Caltech, Los Angeles), Stougie continued work on stochastic scheduling problems. For first results they concentrated on the second stage problem in which jobs are to be scheduled over cheap and expensive time intervals.

Network optimization problems: Together with L. Becchetti, A. Marchetti Spaccamela, and A. Vitaletti (La Sapienza, Rome), M. Skutella (Univ. Dortmund), and P. Korteweg (TUE), Stougie continued research on sensor networks. Results on natural on-line versions of the problems have been obtained. A first paper on this project is in preparation. Together with A. Marchetti Spaccamela (La Sapienza, Rome), V. Bonifaci (La Sapienza, and TUE), and P. Korteweg (TUE), Stougie started working on the problem of gathering data through a wireless network, in which transmission power and interference restrict the transmission process. A first paper on off-line computational aspects of the problem is in preparation.

Other work on wireless networks is described under the Bsik project 'Decision-support systems for logistic networks and supply chain optimization' (BRICKS-is3) on page 15.

Title	SPCO – Semidefinite Programming and Combinatorial Optimization
Period	January 2003–December 2007
Leader	M. Laurent
Staff	N. Gvozdenović, M. Laurent, F. Vallentin
Funding	CWI, NWO-Vidi project
Partners	TUE, UvT, UU, LAAS-CNRS (Toulouse), Univ. Klagenfurt (Austria), Univ. Magdeburg, Univ. of Cantabria (Santander), Rudjer Boskovic Inst. (Zagreb)

Progress report. Laurent gave a hierarchy of upper bounds for the coding problem, which strengthens the bounds of Delsarte and Schrijver. The bound at any fixed order can be computed in polynomial time in terms of the length of the code. This is based on casting the coding problem as an instance of the stable set problem in Hamming graphs and exploiting symmetry via the regular $*$-representation for matrix algebras and the block-diagonalization of the Terwilliger algebra.

Gvozdenović and Laurent investigated new methods for constructing sharper SDP bounds for the chromatic number of a graph; in particular, a technique mapping any upper bound on the stability number to a lower bound on the chromatic number. The computation involves exploiting symmetry; stronger bounds are obtained, e.g., for Hamming graphs. A somewhat surprising application is that there is no polynomial time computable graph parameter nested between the fractional chromatic number and the chromatic number unless P=NP.

Gvozdenović and Laurent finalized their work giving a partial solution to a conjecture of De Klerk and Pasechnik about SDP bounds for the stability number of a graph via sums of squares of polynomials.

More work of Gvozdenović (thesis supervisor: Laurent) is described under project 'Integer Programming Techniques' (IP).

Laurent wrote a survey paper on SDP approximations for polynomial optimization problems via moment matrices that served as course material for the ADONET doctoral school on semidefinite programming and polynomial optimization organized in Klagenfurt in September 2005.

Vallentin provided a general group theoretic framework for exploiting symmetry in large SDP problems and giving more compact SDP formulations. This applies in particular to the

semidefinite programming bounds for codes of Schrijver. Vallentin applied this method for finding optimal distortion embeddings of distance transitive graphs.

With M. Dutour Sikiric, F. Santos and A. Schuermann, Vallentin studied aspects of polyhedral combinatorics in lattice theory where highly symmetric polyhedra are omnipresent. They classified the 8-dimensional perfect lattices. They classified the thin totally real number fields, they found new best-known sphere coverings in dimension 9–15, 17, 19–21. They found Delone polytopes with super-exponential volume. They showed that counting the vertices of a Voronoi cell of a lattice is #P-hard.

Other work on semidefinite programming in PNA1 is described under project C&O.

Title	Matroids – Structure and representability of graphs, matrices and matroids
Period	January 2004–December 2007
Leaders	A.M.H. Gerards
Funding	CWI
Partners	TUE, McGill Univ. (Montréal, Quebec), Ohio State Univ. (Columbus, Ohio), Princeton Univ. (NJ), Simon Fraser Univ. (Vancouver, BC), Univ. of Padova, Univ. Waterloo (Ontario), Victoria Univ. (Wellington, New Zealand)

Progress report. In their long-term project on matroid structure and matroid representability, Gerards, J. Geelen (Univ. Waterloo, Ont.) and G. Whittle (Victoria Univ., Wellington, New Zealand) proved that the matroids that are represented over a finite field and do not have the cycle matroid nor the cocycle matroid of a big complete graph as a minor are 'a tree-structure of low rank perturbations of Dowling geometries on a fixed surface with vortices and their duals'. Next they investigated the structure of matroids over a finite field that do have the cycle matroid of a large complete graph as a minor but do not have a big projective geometry over the corresponding prime field as a minor. The conjecture is that these are a tree-structure of low-rank perturbations of Dowling geometries. The proof of that conjecture is not complete yet, but much progress has been made.

PNA1.2 – Constraint and Integer Programming

Title	CPG – Constraint Programming and Game Theory
Period	January 2002–December 2007
Leader	K.R. Apt
Staff	K.R. Apt, W.J. van Hoeve
Funding	CWI, Bsik, NWO-GBE
Partners	SEN3, Univ. of Melbourne, Monash Univ. (Australia), Univ. of Padova, National Univ. of Singapore, The Chinese Univ. of Hong Kong, Univ. Montréal (Quebec)

Progress report. Constraint programming: Apt proposed with S. Brand (Univ. Melbourne) a new constraint-based framework for reasoning about qualitative reasoning. It is supported by an implementation in the Eclipse system. He also wrote an article in which constraint programming is explained using a proof-theoretic perspective. Finally, he worked on a joint book with M. Wallace (Monash Univ.) titled 'Constraint Logic Programming using Eclipsesi'. For the work of Van Hoeve see the Bsik project 'Decision-support systems for logistic networks and supply chain optimization' (BRICKS-is3) on page 15.

Game theory: Apt worked on various issues concerned with rationalizability and iterated elimination of dominated strategies for infinite strategic games. Also, in a joint paper with F. Rossi and K.B. Venable (both Univ. Padova), he related two formalisms that are used for different purposes in reasoning about multi-agent systems: strategic games and CP-nets.

Title	IP – Integer Programming techniques
Period	January 2004–December 2008
Leader	K.I. Aardal
Staff	K.I. Aardal, J. Byrka, J. van Kempen
Funding	CWI, Bsik, ADONET
Partners	TUE, Univ. Leiden, TNO-ICT (Delft), CORE (Louvain-la-Neuve), EPFL (Lausanne), Univ. Magdeburg, TU Darmstadt, Univ. Paderborn, Lucent Technologies (NJ), Georgia Tech. (Atlanta), Univ. Washington (Seattle), UC Davis (Ca)

Progress report. Together with A.K. Lenstra (EPFL, Lausanne) and C.A.J. Hurkens (TUE), Aardal and Byrka are working on improved algorithms for solving the Cornuéjols-Dawande market share instances. The algorithms are based on lattice reformulation.

Aardal and Byrka are also working on getting a better understanding of the strength of the linear relaxation of certain facility location problems.

Byrka (thesis supervisor: Aardal) studies the facility location problem and its connection with the set covering problem. Together with M. Bienkowski (Paderborn Univ.) he developed an 'exponential balancing strategy' that was used to construct an approximation algorithm for the set multicover problem and a randomized online algorithm for the dynamic page migration problem.

Byrka, together with Gvozdenović, S. Ceav-Erbas (Univ. Catholique de Louvain), and R. Pendavingh (TUE) worked on integer programming formulation for hypergraph partitioning problems. Using some symmetry reduction techniques and branching rules obtained by exploring a hypergraph structure, they solved to optimality sparse hypergraph instances with up to 1200 vertices. Gvozdenović created a new combinatorial algorithm which is in implementation phase.

Van Kempen is working on his master thesis under supervision of Aardal. He worked on determining, solving and implementing a planning problem posed by Rüttchen Holding (Breda) which comprises a large group (more than 30 franchises) of Mercedes car dealers. The goal of the planning is to automatically compute whether there is enough capacity left on the workfloor to do a certain repair on a car in a certain time interval.

PNA1.3 – Algorithmic and Combinatorial Methods for Molecular Biology

Title	ACMB – Algorithmic and Combinatorial techniques in Molecular Biology
Period	January 2001–December 2009
Leader	L. Stougie
Staff	S. Kelk, L. Stougie
Funding	CWI, Bsik (BRICKS-afm2.1)
Partners	INS4, TUE, UU, VU, KNAW-CBS (Utrecht), Univ. Bielefeld, INRIA Rhône-Alpes, Univ. Lyon

Progress report. This project investigates the application of algorithmic and combinatorial methods to biology. The work is carried out in close collaboration with R. Cilibrasi and J. Tromp, both members of INS4, and the team at TUE consisting of C.A.J. Hurkens, J. Keijsper, L. van Iersel (doing his PhD research under the supervision of Stougie en Keijsper).

With Cilibrasi, Van Iersel, and Tromp, Kelk proved tractability and inapproximability results for the reconstruction of haplotypes from short, overlapping, error-prone fragments of haplotype sequencing data. Positive results were also obtained for the computation of the smallest possible number of haplotypes needed to explain the distribution of genotypes in a population.

Together with Hurkens, van Iersel, Keijsper and Tromp, Kelk and Stougie proved results concerning the minimum number of 'prefix reversals' required to transform strings into one another. A 'prefix reversal' is a string rearrangment operation inspired by the biological phenomenon of 'genomic rearrangment events' in which entire regions of DNA are reversed, transposed, duplicated, and so on.

This project has initiated the investigation of problems related to phylogenetic trees.

General PNA1 projects

The two projects below support activities all over PNA1.

Title	Decision-support systems for logistic networks and supply chain optimization (BRICKS-is3)
Period	January 2004–December 2009
Leader	K. Aardal
Staff	K. Aardal, A.M.H. Gerards, W.J. van Hoeve, E.J. van Leeuwen, G. Maróti, A. Schrijver
Funding	Bsik, NS-reizigers
Partners	TUE, UT, UU, EUR

Progress report. Design and analysis of algorithms for railway network optimization: Maróti worked with L.G. Kroon (NS reizigers and EUR) on operations research models for operational planning of railway rolling stock, this concerns planning tasks with horizons of 3 days up to 2 months in which existing plans have to be adjusted to the specific demands of a particular week, for instance when railway tracks are unavailable because of maintenance. Maróti (thesis supervisor: Gerards) also compiled his work over the last years in the PhD thesis: 'Operations Research Models for Railway Rolling Stock Planning' to be defended at TUE in April 2006.

With L. Kroon, R. Lentink, Maróti, Schrijver

finished composing manuscripts on their results on optimal stock circulation and on planning and optimizing the shunting and maintenance of trains at railway yards. A. Hartog is working on her master thesis under the supervision of Schrijver; they investigated new methods for planning of drivers and conductors at NS Reizigers.

Wireless communication networks: Van Leeuwen (thesis supervisor: Schrijver) studied the unit disk graph model for wireless communication networks. He gave new asymptotic fully polynomial time approximation schemes for the maximum independent set and the minimum (connected) dominating set problem under the assumption that the density of the communication devices in the network is bounded. The techniques applied for the minimum connected dominating set problem can also be used to improve approximation schemes for this problem on other graphs, such as planar graphs.

Methods for integer and constraint programming: Van Hoeve (thesis supervisor: Apt) applied techniques from flow theory to efficiently handle 'soft constraints' in over-constrained and preference-based constraint satisfaction problems. He successfully defended his PhD thesis on 'Operations Research Techniques in Constraint Programming' at UvA in April 2005.

Together with L.A. Wolsey, Aardal is working on gaining insights in how certain structure that is detected by using lattice reformulations on integer programming problems can help in improving the performance of standard algorithms for these problems, such as branch-and-bound.

Title	ADONET – Algorithmic Discrete Optimization Network
Period	January 2004–December 2007
Leader	M. Laurent
Staff	H. Bosse, J. Byrka
Funding	EU (Marie Curie research training network)
Partners	Otto-von-Guericke-Univ. (Magdeburg, Germany), Univ. Catholique de Louvain (Belgium), IASI (Rome, Italy), Univ. of Lisbon, CNRS (France), Ecole Polytechnique Fédérale de Lausanne (Switzerland), Faculdade de Ciencias da Univ. de Lisboa, Dash Optimization Ltd. (UK), TU Wien, Inst. Computergraphik und Algorithmen (Austria), Univ. of Klagenfurt (Austria), Egerváry Research Group, Eőtvős Univ. Budapest (Hungary), Univ. zu Köln (Germany)

Progress report. This Marie Curie research training network funds the full training of Byrka (thesis supervisor: Aardal), one-year postdoc for Bosse, as well as networking costs for all other young PNA1 researchers.

Societal aspects and knowledge transfer

External contacts

M. Bienkowski (Univ. Paderborn, Germany), R. Bisseling (Univ. Utrecht), V. Bonifaci (La Sapienza, Rome), S. Brand (Univ. Melbourne, Australia), R. Cleve (Univ. Waterloo, Canada), E. Colin de Verdière (ENS Paris, France), M. Conforti (Univ. Padova, Italy), M.F. Constantino (Univ. de Lisboa, Portugal), D. Cornaz (France Télécom, Paris, France), B. Daniel (Dash, UK), R. Diestel (Hamburg Univ., Germany), I. Dukanovic (Univ. Maribor, Slovenia), M. Dutour Sikirc (Rudjer Boskovic Institute, Zagreb, Croatia), M. Dyer (Leeds Univ., UK), P.J. Fioole (NS Reizigers), E. Fledderus (TNO and TUE), A. Frank (Eőtvős Univ. Budapest, Hungary), J.F. Geelen (Univ. Waterloo, Ont., Canada), L. Goddyn (Simon Fraser Univ., Vancoucer, BC, Canada), M. Henz (National Univ. Singapore), J. Heringa (VU), C.A.J. Hurkens (TUE), L. van Iersel (TUE), J. Jaffar (National Univ. Singapore), M. Jünger (Univ. Köln, Germany), V. Kaibel (Matheon, TU Berlin, Germany), J. Keijsper (TUE), E. de Klerk (UvT), A. Kröller (TU Braunschweig, Germany), L.G. Kroon (Erasmus Univ., Rotterdam and NS Reizigers), J.B. Lasserre (LAAS, Toulouse, France), Jimmy Lee (The Chinese Univ. of Hong-Kong), A.K. Lenstra (EPFL, Lausanne, Switzerland and Lucent Technologies, USA), H.W. Lenstra, Jr. (Univ. Leiden), S. Leonardi (La Sapienza, Rome), Ho-fung Leung (The Chinese Univ. of Hong-Kong), T. Liebling (EPFL, Lausanne, Switzerland), N. Linden (Univ. Bristol, UK), L. Lovász (Microsoft Research, Redmond, USA), C. Luz (Instituto Politecnico de Setubal, Portugal), A. Marchetti Spaccamela (La Sapienza, Rome), A. Martin (TU Darmstadt, Germany), J. Mixtacki (Univ.

Bielefeld, Germany), B. Mounits (Technion, Haifa, Israel), G.L. Nemhauser (GaTech, Atlanta, USA), S. Orlowski (ZIB, Berlin, Germany), P. Parrilo (MIT, Cambridge, USA), D.V. Pasechnik (UvT/Singapore), R. Pendavingh (TUE), B.A. Reed (McGill Univ., Montréal, Canada), F. Rendl (Univ. Klagenfurt, Austria), G. Rinaldi (CNR/IASI, Rome), F. Rossi (Univ. Padova, Italy), F. Santos (Univ. Cantabria, Santander, Spain), A. Schuermann (Univ. of Magdeburg, Germany), A. Sebő (IMAG, Grenoble, France), P.D. Seymour (Princeton Univ., NJ, USA), R. Sitters (Max-Planck-Inst., Saarbrücken, Germany), M. Skutella (Univ. Dortmund, Germany), N. Stier Moses (Columbia Business School, New York, USA), J. Stoye (Univ. Bielefeld, Germany), H. Tanaka (Tohoku Univ., Sendai, Japan), R. Thomas (Georgia Tech., Atlanta), A. Tomasgard (NTNU, Trondheim, Norway), M. Wallace (Monash Univ., Australia), R. Weismantel (Univ. Magdeburg, Germany), G. Whittle (Victoria Univ., Wellington, New Zealand), A. Wiegele (Univ. Klagenfurt, Austria), G.J. Woeginger (TUE), L.A. Wolsey (CORE, Louvain-la-Neuve, Belgium), R. Yap (National Univ. Singapore).

Projects with partners in public and private sector

- C&O (page 12).
- ACMB (page 15).
- ADONET (page 16).
- Eigenvalue methods for graphs (Microsoft Research).
- Optimum stock circulation (NS Reizigers).
- Planning of railway yards (NS Reizigers).
- Crew planning (NS Reizigers).
- Planning job assignments (Rüttchen Holding, Breda).

Contract research

- A.G. Steenbeek develops and maintains software for VU, for UL, and for UM to route medical students along trainee posts in hospitals.

Teaching at university

- Linear and integer programming, Bachelors programme, TUE: K.I. Aardal.
- Logic Programming and Constraints, National Univ. of Singapore: K.R. Apt.
- Combinatorial optimization, UvA: A. Schrijver.

Courses, tutorials

- Game-theoretic approach to multi-agent systems, Univ. Padova, Italy, April 20-27: K.R. Apt.
- LNMB graduate-course Randomized Algorithms: L. Stougie.
- Tutorial lectures on Moment Matrices and Optimization over Polynomials at the ADONET Doctoral school on Optimization over Polynomials and Semidefinite Programming, Univ. Klagenfurt, Austria, September 12–16: M. Laurent.
- Tutorial lectures on Exploiting Symmetry in Semidefinite Programs at the ADONET Doctoral school on Optimization over Polynomials and Semidefinite Programming, Univ. Klagenfurt, Austria, September 12–16: A. Schrijver.

Organization of conferences, workshops, courses, meetings

- Tagung Graphentheorie, Mathematisches Forschungsinstitut, January 16–22: A. Schrijver (organizer).
- 10th Conference on Theoretical Aspects of Rationality and Knowledge, Singapore, June 10–12: K.R. Apt (organizer).
- Programme 'Uncertainty and Information in Economics', organized at the Institute for Mathematical Sciences, National Univ. of Singapore, May 9–July 3: K.R. Apt (member organizing committee).
- First International Summer School on Constraint Programming, Acquafredda di Maratea, Italy, September 11–15: K.R. Apt.
- ADONET Doctoral school on Optimization over Polynomials and Semidefinite Programming, Univ. Klagenfurt, Austria, September 12–16: M. Laurent (organizer).
- CWI Lectures in Mathematics and Computer Science, for Alexander Schrijver, September 19: A.M.H. Gerards (member organizing committee).
- CWI/BRICKS Seminar day on Algorithms and Processes in Life Sciences, November 29: S. Kelk (co-organizer), L. Stougie (organizer).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Tagung Graphentheory, Oberwolfach, Germany, January 16–22: A.M.H. Gerards, D. Gijswijt, A. Schrijver.
- Workshop on Algorithms for Optimization under Uncertainty, Dagstuhl, Germany, January 16–21: L. Stougie (Lecture: Complexity and approximation in stochastic programming problems).
- One-Day Combinatorics Meeting, Univ. College, London, February 2: A. Schrijver (Invited lecture: New bounds on codes with noncommutative algebra).
- COST-meeting, Milan, Italy, February 8–11: L. Stougie.
- 9th Combinatorial Optimization workshop, Aussois, France, March 14–18: K.I. Aardal, J. Byrka.
- Conference on Positive Polynomials, Luminy, France, March 14–18: H. Bosse, M. Laurent (Invited lecture: Approximating polynomials on the simplex and Approximating the stability number of a graph via sums of squares).
- The Eighth SIAM Conference on Optimization, Stockholm, Sweden, May 15–19: M. Laurent (Plenary lecture: Semidefinite Programming in Polynomial Optimization).
- Workshop on Design and Analysis of Randomized and Approximation Algorithms, Dagstuhl, Germany, May 15–20: L. Stougie.
- FIM Workshop on Geometric Combinatorics and Optimization, ETH Zurich, Switzerland, May 23–25: H. Bosse, J. Byrka, N. Gvozdenović, A. Schrijver (Invited lecture: New code bounds with algebra and semidefinite programming).
- COST-meeting, Paris, France, May 26–28: L. Stougie.
- 11th Conference on Integer Programming and Combinatorial Optimization (IPCO 2005), Berlin, Germany, June 8–10: K.I. Aardal, H. Bosse, N. Gvozdenović (Accepted lecture (after selection committee): Semidefinite Bounds for the Stability Number of a Graph via Sums of Squares of Polynomials).
- 10th Conference on Theoretical Aspects of Rationality and Knowledge Conference (TARK '05), Singapore, June 10–12: K.R. Apt (Lecture: Order Independence and Rationalizability).
- 31st Workshop on Graph Theoretic Concepts in Computer Science, Metz, France, June 23–25: E.J. van Leeuwen (Accepted lecture (after selection committee): Approximation Algorithms for Unit Disk Graphs).
- Oxford-Princeton Workshop on Discrete Mathematics, Oxford Univ., Oxford, UK, June 30–July 4: A.M.H. Gerards (Lecture: Triples not on matroid circuits).
- Foundations of Computational Mathematics, Univ. de Cantabria, Santander, Spain, June 30–July 9: N. Gvozdenović.
- Second MISTA Conference, New York, U.S.A., July 20: J.K. Lenstra (Plenary lecture: Scheduling in perspective).
- 5th Panhellenic Logic Symposium, Athens, Greece, July 25–28: K.R. Apt (Invited lecture: On the order of strategy elimination procedures in strategic games).
- European Conference on Combinatorics, Graph Theory and Applications (EUROCOMB 2005), Technische Univ. Berlin, September 4–9: A. Schrijver (Invited lecture: New Code Bounds With Noncommutative Algebra and Semidefinite Programming).
- Operations Research 2005, Bremen, Germany, September 9: J.K. Lenstra (Semi-plenary lecture: Scheduling in perspective).
- Mathematics for Efficiency - CWI Lectures in Mathematics and Computer Science, for Alexander Schrijver. September 19: whole group PNA1.
- Trends in Logic III, (International Conference in memoriam A. Mostowski, H. Rasiowa and C. Rauszer), Warsaw and Ruciane-Nida, Poland, September 23–25: K.R. Apt (Invited Lecture: Rule-based Programming and Constraints).
- Symposium in honour of J.H. van Lint, Veldhoven, October 2–5: A. Schrijver (Invited talk: New code bounds from the Terwilliger algebra).
- 5th Workshop on Algorithms in Bioinformatics (WABI 2005), Mallorca, Spain, October 3-6: S. Kelk, L. Stougie.
- 13th Annual European Symposium on Algorithms (ESA 2005), Mallorca, Spain, October 3–6: J. Byrka (Accepted lecture (after selection committee): Bucket Game with Applications

to Set Multicover and Dynamic Page Migration), L. Stougie.
- The Hungarian Method is 50, Hungarian Academy of Sciences, Budapest, Hungary, October 31: N. Gvozdenović, A. Schrijver (Invited lecture: Open problems in polyhedral combinatorics).
- Games and Social Software, 7th Augustus de Morgan Workshop, London, UK, November 4–7: K.R. Apt (Invited lecture: The Many Faces of Rationalizability).
- Tagung Combinatorial Optimization, Oberwolfach, Germany, November 7–11: K.I. Aardal, A. Schrijver (Invited lecture: Exploiting symmetry in optimization).
- DIAMANT/EIDMA Symposium 2005, Mierlo, November 16–18: A.M.H. Gerards, N. Gvozdenović, E.J. van Leeuwen, A. Schrijver (Invited lecture: Exploiting symmetry in optimization), F. Vallentin.
- Oberwolfach Seminar: Sphere Packings: Exceptional Geometric Structures and Connections to other Fields, Oberwolfach, Germany, November 20–26: F. Vallentin (Invited lecture: A (short) introduction to strongly perfect lattices).
- A Saturday on Discrete Mathematics in Darmstadt, Darmstadt, Germany, November 26: F. Vallentin (Invited lecture: Delone subdivisions with symmetries).
- CWI/BRICKS Seminar day on Algorithms and Processes in Life Sciences, CWI, Amsterdam, November 29: S. Kelk (Lecture: Combinatorics in computational biology: strings and permutations), L. Stougie (Lecture: The minimum test set problem).
- Workshop on Algebraic Coding Theory, Dortmund, Germany, December 1–2: F. Vallentin (Invited lecture: Semidefinite programming bounds for binary codes).
- Informatics in Neuroscience, Den Haag, December 9: S. Kelk.
- Third International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS 2005), Singapore, December 13–16: K.R. Apt (Lecture: CP-nets and Nash equilibria).

Working visits

- Waterloo Univ., Waterloo (Ont.), Canada, February 9–26: A.M.H. Gerards.
- UNU-IIST, Macao February 17–18: K.R. Apt (Lecture: Rule-based Approach to Constraint Programming).
- The Chinese Univ. of Hong-Kong, February 19–22: K.R. Apt (Lecture: Rule-based Approach to Constraint Programming).
- Leeds Univ., Leeds, England, February 12–26: L. Stougie.
- Univ. Dortmund, Dortmund, Germany, February 27–March 2: L. Stougie.
- Univ. La Sapienza, Rome, Italy, June 15–19: L. Stougie.
- Univ. of Lecce, Lecce, Italy, June 19–23: L. Stougie (Lectures: The on-line travelling salesman problem; Robust optimization problems in telecommunication).
- Univ. La Sapienza, Rome, Italy, July 14–20: L. Stougie.
- Univ. Dortmund, Dortmund, Germany, July 28–30: L. Stougie.
- Univ. of Kaiserslautern, Germany, September 14–15: L. Stougie (Lecture: Virtual private network design: a proof of the tree routing conjecture on ring networks).
- Univ. of Warsaw September 26–28: K.R. Apt.
- COST-meeting, Barcelona, Spain, September 29–October 1: L. Stougie.
- Eötvös Lorand Univ., Budapest, November 1–2: A. Schrijver.
- Victoria Univ., Wellington, New Zealand, November 29–December 23: A.M.H. Gerards.

Project meetings

- Regular meetings between the research groups at CWI and TUE on Algorithmic and Combinatorial Techniques in Molecular Biology, held alternatively at CWI and TUE.
- ADONET meeting, CORE, Louvain-la-Neuve, Belgium, October 10: M. Laurent.

Other lectures

- UM, June 2: A.M.H. Gerards (Lecture: Structure of Graphs and Matrices).
- General Mathematics Colloquium, UvA, September 7: D. Gijswijt (Lecture: Semidefinite programming and coding bounds).
- NWO-Spinoza Uitreiking 2005, Den Haag, November 23: A. Schrijver (Lecture: Optimaal combineren).
- TUE, December 9: K.I. Aardal (Inaugural lecture: Een, twee, ..., ontelbaar).

Courses

- LNMB PhD course Combinatorial Optimization 1a and 1b, Utrecht, February 28–May 2 and September 12–November 17: J. Byrka, E.J. van Leeuwen.
- LNMB PhD course Randomized Algorithms, Utrecht, September 12–November 7: J. Byrka, E.J. van Leeuwen.
- LNMB PhD course Combinatorial Optimization 2a, Utrecht, November 14–February 20 (2006): F.M. de Oliveira Filho.
- IPCO 2005 - Summerschool, Berlin, Germany, June 6–7: K.I. Aardal, H. Bosse, N. Gvozdenović.
- EIDMA Minicourse on Structural Graph Theory, TUE, June 6–10: J. Byrka, E.J. van Leeuwen.
- ADONET/CIM Summer School on Geometric and Algebraic Approaches to Integer Programming, Lisbon, Portugal, July 11–15: J. Byrka.
- First International Summer School on Constraint Programming, Acquafredda di Maratea, Italy, September 11–15: K.R. Apt.
- ADONET Doctoral School on Optimization over Polynomials and Semidefinite Programming, Univ. of Klagenfurt, Klagenfurt, Austria, September 12–16: H. Bosse, J. Byrka, N. Gvozdenović, M. Laurent, A. Schrijver, F. Vallentin.

Visitors

- L. Lovász (Microsoft Research, Redmond, USA), February 13–16. Host: A. Schrijver.
- Julia Mixtacki (Univ. Bielefeld, Bielefeld, Germany), June 27–29. (Lecture: On Sorting By Translocations.) Hosts: S. Kelk, L. Stougie.
- Jens Stoye (Univ. Bielefeld, Bielefeld, Germany), June 27–29. Algorithms for Finding Gene Clusters. Hosts: S. Kelk, L. Stougie.
- Jim Orlin (MIT, Cambridge, Massachussetts, USA), June 30–July 1. (Lecture: Sequence grammars for very large scale neighborhood search.) Host: L. Stougie.
- L. Lovász (Microsoft Research, Redmond, USA), September 18–21. Hosts: A.M.H. Gerards, A. Schrijver.
- P. Seymour (Univ. Priceton, USA), September 18–20. Host: A.M.H. Gerards.
- K. Vesztergombi (Eötvös Lorand Univ., Budapest, Hungary), September 18–20. Hosts: A.M.H. Gerards, M. Laurent, A. Schrijver.
- J.F. Geelen (Univ. Waterloo, Waterloo, Ont., Canada), September 22–October 12. Host: A.M.H. Gerards.
- G. Whittle (Victoria Univ., Wellington, New Zealand), September 22–October 12. Host: A.M.H. Gerards.
- B. Mounits (Technion, Haifa, Israel), November 29–December 4. (Lecture: Upper bounds on sizes of codes via association schemes and linear programming). Host: A. Schrijver.

Memberships of committees and other professional activities

K.I. Aardal

- Full professor TUE.
- Member of the Board of Directors INFORMS Computing Society, 2003–2005.
- Chairman of the executive committee of the Mathematical Programming Society, since 2004.
- Operations Research Letters, associate editor, since 1998.
- INFORMS Journal on Computing, associate editor, since 1999.
- Mathematical Programming B, associate editor, since 2000.
- Networks, associate editor, since 2003.
- One of three central moderators for Optimization Online, www.optimization-online.org, since 2000.
- Guest editor of the SIAGOPT Newsletter: Algebraic Methods for Integer Programming, Vol 16, No 1–2, 2005.
- Member of the jury of the 2005 INFORMS JFIG paper competition.

K.R. Apt

- Full professor at UvA.
- Editor Journal of Logic and Computation, since 1989.
- Editor Theory and Practice of Logic Programming (TPLP), since 2001.
- Founder and editor-in-chief ACM Transactions on Computational Logic (TOCL), since 1999 till July 2005. Since July 2005 area editor.
- Member of the advisory board of Logical Methods in Computer Science (LMCS), since 2004.

- Member of the Board of the International Federation for Computational Logic (IFCoLoG), since 1999.
- Member of the executive committee of the Association for Constraint Programming, since 2003.
- Member of the advisory board of the Computing Research Repository (CoRR), since 2004.
- Member of the Witold Lipski Prize Board, Poland, 2005.

A.M.H Gerards

- Full professor at TUE.
- Board member Landelijk Netwerk Mathematische Besliskunde, since 2001.
- Chair IPCO steering committee, Mathematical Programming Society, since 2005.
- Co-editor Mathematical Programming, Series A, since 2003.
- Editor SIAM Journal on Discrete Mathematics, since 1999.
- Member science committee Thomas Stieltjes Institute for Mathematics, since 2004.
- Member-at-large of the Council of the Mathematical Programming Society, since 2003.
- Member of the PhD committee of W.J. van Hoeve, defence at UvA, April 19.
- Member of the PhD committee of D. Gijswijt, defence at UvA, September 22.

W.J. van Hoeve

- Member of the programme committee of the Second International Workshop on Constraint Propagation and Implementation, Sitges, Spain, October 1, 2005.

M. Laurent

- Editor of the SIAM Journal on Optimization, since January 2001.
- Associate editor of Mathematics of Operations Research, since August 2001.
- Member of the editorial board of the MPS-SIAM book series on Optimization, since September 2003.
- Member of the programme committee of the third EuroComb conference, Berlin, September 5–9, 2005.
- Member of the programme committee of the Franco-Canadian Workshop on Combinatorial Algorithms, Hamilton, Canada, August 18–20, 2005.
- Member of the Tucker Prize committee, to be awarded at the International Symposium on Mathematical Programming, Rio de Janeiro, 2006.
- Member of the PhD committee of W.J. van Hoeve, defence at UvA, April 19.

J.K. Lenstra

- Full professor at TUE.
- Member editorial board CWI Tracts, CWI Syllabi, since 1984.
- Editor Handbooks in Operations Research and Management Science, North-Holland, since 1998.
- Member editorial advisory board Kluwer Series in Operations Research/Computer Science Interface, since 1991.
- Member editorial board Princeton Applied Mathematics Series, Princeton University Press, since 2000.
- Member advisory board SCIMA Special Series, since 1979.
- Member advisory board ACM Journal of Experimental Algorithmics, since 1995.
- Member editorial board Chinese OR Transactions, since 2001.
- Member advisory board Excerpta Informatica, since 1985.
- Member advisory board INFORMS Journal on Computing, since 2003.
- Advisory editor Mathematics of Operations Research, since 1999.
- Editor-in-chief, Operations Research Letters, since 2002.
- Member Akademie Raad voor de Wiskunde, since 1994.
- Member advisory board Baruch Prize, since 2004.
- Member scientific advisory board Schloss Dagstuhl, since 2004.
- Member program committee ESA '06, 14th Annual European Symposium on Algorithms, Zurich, Switzerland, September 2006.
- Vice-president ERCIM, European Research Consortium for Informatics and Mathematics, since 2005.
- Member board EURANDOM, European Institute for Statistics, Probability, Stochastic Operations Research and their Applications, since 2005.

A. Schrijver

- Full professor at UvA.
- Advisory editor Journal of Combinatorial Optimization, since 1996.
- Advisory editor North-Holland Mathematical Library, since 1995.
- Editor Discrete Applied Mathematics, since 1988.
- Editor Journal of Combinatorial Theory, Series B, since 1993.
- Editor Journal of Combinatorics, Information and System Sciences, since 1992.
- Editor SIAM Journal on Discrete Mathematics, since 1988.
- Editor-in-chief Combinatorica, since 1993.
- Member Algemeen Bestuur Landelijk Netwerk Mathematische Besliskunde, since 1989.
- Member Advies-Commissie Wiskunde (ACW), Nederlandse organisatie voor Wetenschappelijk Onderzoek, since 2002.
- Member board EIDMA—Euler Institute for Discrete Mathematics and Its Applications, since 1993.
- Member editorial board SIAM Monographs on Discrete Mathematics and Applications, since 2000.
- Member Akademie Raad voor de Wiskunde, since 1995.
- Member Koninklijke Nederlandse Akademie van Wetenschappen, since 1995.
- Member programme board for Mathematics, Lorentz Center Leiden, since 2003.
- Member Programma Commissie Netwerken, Nederlandse organisatie voor Wetenschappelijk Onderzoek, since 2000.
- Member science council Stieltjes Instituut voor Wiskunde, since 1992.
- Member of the evaluation committee Austrian Mathematics 2005.
- Member of the PhD committee of W.J. van Hoeve, defence at UvA, April 19.
- Member of the PhD committee of D. Gijswijt, defence at UvA, September 22.

L. Stougie

- Project leader of BRICKS-project AFM2, since 2005.
- National representative and member of the Management Committee of European COST-Action 293 GRAAL.
- Member of the steering committee of the Stieltjes research theme Mathematics and Biology.

Academic publications

Publications in refereed journals or proceedings

1 K.R. Apt (2005). Explaining Constraint Programming. A. Middeldorp, V. van Oostrom, F. van Raamsdonk, R. de Vrijer (eds). Processes, Terms and Cycles: Steps on the Road to Infinity. LNCS 3838, Springer Verlag, Berlin, 55–69.

2 K.R. Apt (2005). Order Independence and Rationalizability. Proceedings of the 10th conference on Theoretical Aspects of Rationality and Knowledge (TARK X), 22–38.

3 K.R. Apt, S. Brand (2005). Schedulers and Redundancy for a Class of Constraint Propagation Rules. Theory and Practice of Logic Programming 5(4&5), 441–465.

4 K.R. Apt, S. Brand (2005). Constraint-Based Qualitative Simulation. Proceedings of the 12th International Symposium on Temporal Representation and Reasoning (TIME '05), 26–34.

5 K.R. Apt, F. Rossi, K.B. Venable (2005). CP-nets and Nash equilibria. Proceedings of the Third International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS '05), Elsevier, 1–6.

6 M. Bienkowski, J. Byrka (2005). Bucket Game with Applications to Set Multicover and Dynamic Page Migration. Proceedings of the 13th Annual European Symposium on Algorithms (ESA 2005), 815–826.

7 H. Bosse, M. Grötschel, M. Henk (2005). Polynomial Inequalities Representing Polyhedra, Mathematical Programming 103(1), 35–44.

8 R. Cilibrasi, L. van Iersel, S. Kelk, J. Tromp (2005). On the complexity of several haplotyping problems. Proceedings 5th Workshop on Algorithms in Bioinformatics (WABI 2005), 128–139.

9 J. Geelen, B. Gerards (2005). Regular matroid decomposition via signed graphs. Journal of Graph Theory 48, 74–84.

10 D. Gijswijt (2005). Integer decomposition for polyhedra defined by nearly totally unimodular matrices. SIAM Journal on Discrete Mathematics 19 (3), 798–806.

11 N. Gvozdenović, M. Laurent (2005). Semidefinite bounds for the stability number of a graph via sums of squares of polynomials. Proceedings of the 11th International IPCO Conference, Berlin, LNCS 3509, Springer Verlag, Berlin, 136–151.
12 C.J.H. Hurkens, J.C.M. Keijsper, L. Stougie (2005). Virtual private network design: a proof of the tree routing conjecture on ring networks. Proceedings of the 11th International IPCO Conference, Berlin, LNCS 3509, Springer Verlag, Berlin, 407–421.
13 D. Jibetean, M. Laurent (2005). Semidefinite approximations for global unconstrained polynomial optimization. SIAM Journal on Optimization 16(2), 490–1514.
14 E. de Klerk, M. Laurent, P. Parrilo (2005). On the equivalence of algebraic approaches to the minimization of forms on the simplex. D. Henrion and A. Garulli (eds). Positive Polynomials in Control, LNCIS 312, Springer Verlag, Berlin, 121–133.
15 M. Laurent (2005). Revisiting two theorems of Curto and Fialkow on moment matrices. Proceedings of the American Mathematical Society 133(10), 2965–2976.
16 E.J. van Leeuwen (2005). Approximation Algorithms for Unit Disk Graphs. D. Kratsch (ed). Proceedings of the 31st International Workshop on Graph-Theoretic Concepts in Computer Science (WG 2005), LNCS 3787, Springer, 351–361.
17 C.J. Luz, A. Schrijver (2005). A convex quadratic characterization of the Lovász theta number, SIAM Journal on Discrete Mathematics 19, 382–387.
18 G. Maróti, L.G. Kroon (2005). Maintenance Routing for Train Units: The Transition Model. Transportation Science 39(4), 518–525.
19 A. Schrijver (2005). New code upper bounds from the Terwilliger algebra and semidefinite programming, IEEE Transactions on Information Theory 51, 2859–2866.
20 A. Schürmann, F. Vallentin (2005). Local covering optimality of lattices: Leech lattice versus root lattice E_8. International Mathematics Research Notices 32, 1937–1955.
21 A. Vandevelde, J.A. Hoogeveen, C.A.J. Hurkens, J.K. Lenstra (2005). Lower bounds for the head-body-tail problem on parallel machines: a computational study for the multiprocessor flow shop. INFORMS Journal on Computing 16, 305–320.

Publications in other journals or proceedings and other scientific output

Publications in other journals

1 K. Aardal (2005). Lattice basis reduction in integer linear optimization: Some basic topics. SIAM Activity Group on Optimization Newsletter 16, 20–27.
2 D. Gijswijt, P. Moree (2005). A combinatorial identity arising from cobordism theory. Acta Mathematica Universitatis Comenianae 74(2), 199–203.

Technical reports published elsewhere

1 J.J.J. van den Broek, P. Schűtz, L. Stougie, A. Tomasgard (2005). Location of slaughterhouses under economies of scale. SPOR-Report 2005-12, TUE.
2 M.E. Dyer, L. Stougie (2005). Computational complexity of stochastic programming Problems. SPOR-Report 2005-11, TUE.
3 W.K. Klein Haneveld, L. Stougie, M.H. van der Vlerk (2005). Simple Integer Recourse Models: Convexity and Convex Approximations. SPOR-Report 2005-16, TUE.
4 S.O. Krumke, M. Lipmann, A. Marchetti-Spaccamela, W.E. de Paepe, D. Poensgen, L. Stougie (2005). On minimizing the Maximum Flow Time in the Online Dial-a-Ride Problem. SPOR-Report 2005-17, TUE.
5 R. Sitters, L. Stougie (2005). The generalized two-server problem. SPOR-Report 2005-15, TUE.
6 L. Stougie, M.H. van der Vlerk (2005). Approximation in Stochastic Integer Programming. SPOR-Report 2005-10, TUE.

Preprints

1 K. Aardal, J. de Loera, S. Onn, R. Weismantel, L.A. Wolsey (2005). Generating functions in discrete optimization.
2 R.H. Bisseling, J. Byrka, S. Cerav-Erbas, N. Gvozdenovic, M. Lorenz, R. Pendavingh, C. Reeves, M. Roeger, A. Verhoeven (2005). Partitioning a Call Graph.
3 H. Buhrman, R. Cleve, N. Linden, M. Laurent, A. Schrijver, F. Unger (2005). New Limits on Fault-Tolerant Quantum Computation.

4 R. Cilibrasi, L. van Iersel, S. Kelk, J. Tromp (2005). On the complexity of the Single Individual SNP Haplotyping Problem.
5 M. Dutour Sikiric, A. Schuermann, F. Vallentin (2005). A Generalization of Voronoi's Reduction Theory and its Applications.
6 J. Geelen, B. Gerards, G. Whittle (2005). Matroid T-connectivity.
7 J. Geelen, B. Gerards, G. Whittle (2005). Towards a matroid-minor structure theory.
8 D. Gijswijt, A. Schrijver, H. Tanaka (2005). New upper bounds for nonbinary codes.
9 N. Gvozdenović and M. Laurent (2005). Approximating the chromatic number of a graph by semidefinite programming.
10 W.J. van Hoeve, G. Pesant, L.-M. Rousseau (2005). On Global Warming: Flow-Based Soft Global Constraints.
11 C. Hurkens, L. van Iersel, J. Keijsper, S. Kelk, L. Stougie, J. Tromp (2005). Prefix reversals on binary and ternary alphabets.
12 E. de Klerk, D. Pasechnik, A. Schrijver (2005). Reduction of symmetric semidefinite programs using the regular $*$-representation.
13 M. Laurent (2005). Moment matrices and optimization over polynomials - A survey on selected topics.
14 M. Laurent (2005). Strengthened semidefinite programming bounds for codes.
15 L. Lovász, A. Schrijver (2005). Graph parameters and semigroup functions.
16 F. Santos, A. Schuermann, F. Vallentin (2005). Lattice Delone simplices with superexponential volume.
17 A. Schrijver (2005). Tensor algebras and combinatorial parameters.
18 A. Schrijver, R.M. Lentink, L.G. Kroon (2005). Shunting of passenger train units: an integrated approach.
19 F. Vallentin (2005). Optimal Embeddings of Distance Transitive Graphs into Euclidean Spaces.

Book chapters

1 K. Aardal, F. Eisenbrand (2005). Integer Programming, Lattices and Results in Fixed Dimension. Chapter 4 in Handbook on Discrete Optimization, K. Aardal, G. Nemhauser, R. Weismantel (eds), 171–243, Elsevier, Amsterdam.
2 M. Laurent, F. Rendl (2005). Semidefinite Programming and Integer Programming. Chapter 8 in Handbook on Discrete Optimization, K. Aardal, G. Nemhauser, R. Weismantel (eds), 393–514, Elsevier, Amsterdam.
3 A. Schrijver (2005). On the history of combinatorial optimization (till 1960). Chapter 1 in Handbook on Discrete Optimization, K. Aardal, G. Nemhauser, R. Weismantel (eds), 1–68, Elsevier, Amsterdam.

Monographs

1 K. Aardal, G. Nemhauser, R. Weismantel (eds) (2005). Handbook of Discrete Optimization. Vol. 12 in Handbooks in Operations Research and Management Science, Elsevier, Amsterdam.

PhD theses

1 H. Bosse (2005). Describing polyhedra by few polynomial inequalities. TU Berlin, May 1. Thesis advisor: M. Grötschel, thesis co-advisor: M. Henk.
2 D.C. Gijswijt (2005). Matrix Algebras and Semidefinite Programming Techniques for Codes. UvA, September 22. Thesis advisor: A. Schrijver.
3 W.J. van Hoeve (2005). Operations Research Techniques in Constraint Programming. UvA, April 19, 2005. Thesis advisor: K.R. Apt.
4 P. Zoeteweij (2005). Composing Constraint Solvers. UvA, November 29. (Jointly with SEN3). Thesis advisors: K.R. Apt and F. Arbab (SEN3).

Professional products

Contracts

- ADONET (MRTN-CT-2003-R504438): EU-Marie Curie research training network, till 2008. Contractors: CWI, European Union, Otto-von-Guericke-Univ. (Magdeburg, Germany), Univ. Catholique de Louvain (Belgium), IASI (Rome, Italy), Univ. Lisbon, CNRS (France), Ecole Polytechnique Fédérale de Lausanne (Switzerland), Faculdade de Ciencias da Univ. de Lisboa (Portugal), Dash Optimization Ltd. (UK), TU Wien, Inst. Computergraphik und Algorithmen (Austria), Univ. Klagenfurt (Austria), Egerváry Research Group, Előtvős Univ. Budapest (Hungary), Univ. Köln (Germany).

- Long-term contract research for software development for scheduling internships for medical students. Contractors: CWI and Faculteit Geneeskunde, UM.
- Maintenance contract software 'automatisch verwerking co-schappen'. Analyses for making a long-term prediction on the demand for internships for medical students. Contractors: CWI and VUmc.
- Scheduling of internships for medical students, and advise on organizing internship assignment. Contractors: CWI and LUMC.
- Research contract for development of railway optimization software. Contractors: CWI and NS Reizigers.

Publications for a broad audience

- K. Aardal (2005). Een, twee, ..., ontelbaar. Intrerede, TUE, Faculteit Wiskunde & Informatica, December 9. Communicatie Service Centrum TUE.
- D. Gijswijt (2005). Moderne wiskunde bouwsteen voor IT. In Computable 41, October 14, interview of Gert Brouwer with D. Gijswijt.
- A. Schrijver (2005). Optimaal combineren, in NWO-Spinozapremies 2005, Nederlandse Organisatie voor Wetenschappelijk Onderzoek, Den Haag, 52–64.
- A. Schrijver (2005). Wat leuk, wiskunde!, in Folia, September 9, interview of B. Rouwe with A. Schrijver.
- A. Schrijver (2005). Wiskundige Lex Schrijver ontvangt Spinozapremie en lintje, in Beta Bulletin, November, interview of F. van Mil with A. Schrijver.
- A. Schrijver (2005). Wiskunde als uitdaging, in: NWO Eminent Talent, NWO, Den Haag, November 23, interview of M. Evenblij with A. Schrijver.
- A. Schrijver (2005). Dwaalgast, VARA TV Magazine, Augustus 6.

Contributions to documentaries or radio or TV broadcastings

- A. Schrijver, radio interview, Hoe?Zo! Radio, Radio 5, June 6.
- A. Schrijver, radio interview, Radio PingPong, Salto Radio, June 9. Interview of C. van Impelen with A. Schrijver.
- A. Schrijver, radio interview, BNR Nieuws Radio, June 11. Interview of Y. Albrecht with A. Schrijver.
- A. Schrijver, radio interview, Radio 1 Journaal, Radio 1, June 11. Interview of H. Pijpers with A. Schrijver.
- 'Een zoektocht naar de wondere wereld van genen en eiwitten, nano's en neutrino's, bits & bytes, ceta's en teras.', theatervoorstelling Theatergroep Adhoc, Science Park Amsterdam, A. Schrijver, October 7.

Other output

Awards

- A. Schrijver received the Spinoza prize 2005, *for his outstanding, pioneering and inspiring research in the field of combinatorics and algorithms* (quoting from the jury report). The prize was announced on June 6 and presented in The Hague on November 23.
- A. Schrijver has been appointed 'Ridder in de Orde van de Nederlandse Leeuw'. He received this 'royal decoration' at the occasion of the CWI Lectures in Mathematics and Computer Science - Mathematics for Efficiency, on September 19.

Grants

- M. Laurent, 'Semidefinite programming and combinatorial optimization' (Vidi grant, NWO-vernieuwingsimpuls: NWO-639-032-203, 2003-2007).

Advanced Communication Networks – PNA2

As of January 1, 2006: Performance Analysis of Communication Networks

Mission

Communication networks are expanding at an unprecedented rate, in terms of traffic volume, the number of users, as well as the range of applications. The use of both the Internet and wireless services has experienced an explosive growth. Network operators anticipate further expansion, fueled by the emer-

gence of all-optical networking as well as the convergence of wireless and Internet access, along with a fundamental trend towards service integration. Future communication networks are expected to accommodate a variety of new applications with a diverse range of Quality-of-Service (QoS) requirements. This motivates the research effort in QoS-enabling mechanisms, and, more specifically, QoS differentiation mechanisms. Some important subproblems are:

- Performance analysis of communication and computer networks, with emphasis on the integration of services in a single network, where differentiated QoS is offered. Analysis is mainly done by using methods from stochastics, in particular queueing theory. There is a focus on applications in both wireline and wireless systems;
- Network traffic analysis (heavy tails, long-range dependence, and their impact on system performance), and applications in measurements and network provisioning;
- Network economics (pricing and cost allocation issues in communication networks), and their use in achieving QoS differentiation;
- End-to-end QoS, including ICT performance analysis.

Theme leader

Prof.dr. M.R.H. Mandjes

MSC or CR classification

60K25, 68M20, 90B18, 90B22

Subthemes

Name	Leader
PNA2.1 – Traffic Modelling, Analysis & Performance	M.R.H. Mandjes
PNA2.2 – Wireless Networks	S.C. Borst
PNA2.3 – Service Differentiation	R. Núñez Queija
PNA2.4 – Performance of Distributed ICT Systems	R.D. van der Mei

PNA2.1: In various types of communication networks – in particular TCP/IP-based networks – the performance offered critically relies on the (stochastic) traffic characteristics of the input traffic. This motivates the study of traffic traces, and the identification of user traffic models. In this respect an important role is played by long-range dependent, heavy-tailed, and/or self-similar input traffic.

PNA2.2: The use of wireless communications continues to experience dramatic growth. While the proliferation of voice services has nearly reached ubiquity, the evolution of wireless data applications has only recently started to gain momentum. To accommodate future expansion, third-generation wireless communication systems such as UMTS and cdma2000 have been designed to provide Internet access and support high-speed wireless data applications, in addition to voice calls and short-messaging services. The research objective is to develop queueing-theoretic models and algorithms for dimensioning, engineering, and operating integrated-services wireless networks.

PNA2.3: With the integration of different services in a common network, operators aim at responding to the strong demand for new telecommunication services, and achieving a high utilization of network resources. The interaction between different service classes within a network has a significant impact on their performance. We develop queueing-theoretic models and techniques to study performance issues in networks with heterogeneous services that facilitate the design and control of future communication networks.

PNA2.4: The dramatic growth of the Internet, the developments in the hardware and software industry, and the recent advances in networking technology have boosted the emergence of distributed applications, divided in components that can be executed on geographically distributed IT systems, interconnected by a heterogeneity of networks, and owned by different parties. In the competitive market of telecommunications industry, a critical success factor for ICT services is the ability to deliver

high-quality, predictable end-to-end performance as perceived by the end user. This leads to a wide variety of research challenges, both from a fundamental and from a practical perspective.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. U. Ayesta (ERCIM)	1.0	postdoc	2005-01-18 till 2005-09-18	PNA2.1: FLOW; PNA2.3: QFN-IS
Drs. R. Bekker (TUE)	0.4	PhD student	2001-10-01 till 2005-12-31	PNA2.1: FLOW; PNA2.3: QFN-IS
Prof.dr.ir. S.C. Borst (0.1 fte at TUE, 0.5 fte at Bell Labs)	0.4	subtheme leader PNA2.2	indefinite	PNA2.1: FLOW, LT, RAPS; PNA2.2: BANCA, FLORIN, PROMO; PNA2.3: BRICKS, EFS, QFN-IS/PS
Drs. A.B. Dieker	1.0	PhD student	2002-04-01 till 2006-03-31	PNA2.1: FAST, LT
R. Egorova, MSc (0.4 fte at TUE)	0.6	PhD student	2004-09-01 till 2008-08-31	PNA2.1: RAPS
Dr. M. Jonckheere	1.0	postdoc	2005-11-15 till 2006-11-14	PNA2.1; PNA2.2
Drs. P.M.D. Lieshout	1.0	PhD student	2004-11-01 till 2008-10-31	PNA2.3: BRICKS
Prof.dr. M.R.H. Mandjes (0.2 fte at UvA, 0.1 fte at EURANDOM)	0.7	theme leader, subtheme leader PNA2.1	indefinite	PNA2.1: FAST, FLOW, LT, RAPS; PNA2.3: BRICKS, COST, PRICE, QFN-PS; PNA2.4: SLIS
Prof.dr. R.D. van der Mei (0.2 fte at VU)	0.8	subtheme leader PNA2.4	indefinite	PNA2.1: FAST; PNA2.2: BANCA, RAPS; PNA2.4: PCDP, PADAM, SLIS
Dr. R. Núñez Queija (0.5 fte at TUE)	0.5	subtheme leader PNA2.3	indefinite	PNA2.1: FLOW, RAPS; PNA2.2: BANCA, FLORIN; PNA2.3: BRICKS; EFS, PRICE, QFN-IS/PS
Drs. I.M. Verloop	1.0	PhD student	2005-08-01 till 2009-07-31	PNA2.3: EFS
Drs. W. van der Weij	1.0	PhD student	2005-02-01 till 2009-01-31	PNA2.4: SLIS

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. U. Ayesta (INRIA)	1.0	postdoc	2005-09-19 till 2006-02-28	PNA2.2: FLORIN; PNA2.3: QFN-IS
Prof.dr. R.J. Boucherie (UT)	p.m.	researcher	1994-09-01 till 2004-08-31	PNA2.2: BANCA, PROMO
Prof.dr.ir. O.J. Boxma (TUE, exchange with S.C. Borst)	0.1	researcher	1998-10-01 till 2005-09-30	PNA2.1: FLOW, LT, RAPS; PNA2.3: QFN-PS
Drs. S.K. Cheung (UT)	0.2	PhD student	2002-12-01 till 2006-11-30	PNA2.2: BANCA, PROMO
Drs. M. Harkema (UT)	1.0	PhD student	2004-05-01 till 2005-04-30	PNA2.4: PADAM
Drs. F. Roijers (TNO ICT)	0.4	PhD student	2004-02-01 till 2008-01-31	PNA2.3: COST

continued on next page

continuation from previous page

Dr.ir. W.R.W. Scheinhardt (UT)	0.2	researcher	2000-09-01 till 2005-09-30	PNA2.1: FAST, FLOW, LT
Drs. I.M. Verloop	1.0	trainee	2004-12-06 till 2005-07-29	PNA2.3: BRICKS
K. van Wingerden	1.0	trainee	2004-09-01 till 2005-01-31	PNA2.4: SLIS
Dr. A.P. Zwart (TUE)	0.2	researcher	2002-08-01 till 2008-09-30	PNA2.1: FLOW, LT, RAPS; PNA2.3: QFN-IS/PS

Scientific report

Highlights

- PNA2 has co-founded the expertise centre E-Quality, a joint initiative of CWI, UT and TNO, aimed at strengthening the research in the field of Quality of Service.
- S.C. Borst was co-recipient of the 2005 Van Dantzig prize.
- R. Bekker (TUE) defended his PhD thesis 'Queues with state-dependent rates' on December 12, 2005, supervised by O.J. Boxma and S.C. Borst.
- FLORIN-II was granted (research contract, funded by France Télécom).
- EQUANET (doorbraakproject, funded by SenterNovem) was extended until February 28, 2005.
- NWO Van Gogh project with INRIA Sophia Antipolis was extended for an additional year until December 31, 2005.

PhD students

R. Bekker
A.B. Dieker
R. Egorova
M. Harkema
P.M.D. Lieshout
F. Roijers
I.M. Verloop
W. van der Weij

PNA2.1 – Traffic modelling, analysis & performance

Title	FAST – Large-deviations asymptotics and fast simulation (embedded in this: the NWO-project EQUIP, funding A.B. Dieker)
Period	April 2002–April 2006
Leader	M.R.H. Mandjes
Staff	A.B. Dieker, M.R.H. Mandjes, R.D. van der Mei, W.R.W. Scheinhardt, A.P. Zwart
Funding	CWI, NWO
Partners	TUE, UT, Univ. Wrocław, Univ. of St. Louis, VTT

Progress report. Mandjes, P. Mannersalo (VTT), I. Norros (VTT) and M. van Uitert (VU, NKI) finished work on queues fed by a large number of fractional Brownian motion input processes. They have developed a general framework on events that are infinite intersections, and applied this to tandem and priority queues. Mandjes and P. Mannersalo have extended this analysis to the Markov-fluid framework.

Dieker and Mandjes completed work on the simulation of a queue fed by many Gaussian sources with stationary increments. The theoretical properties of four different simulation methods were investigated.

Dieker studied reduced-load equivalence for queues with multiple Gaussian inputs. The input with the highest Hurst-parameter is not always dominant (in which case we have a reduced-load equivalence). He provided a simple necessary and sufficient condition that characterizes this phenomenon.

Dieker and M. Lelarge (ENS Paris, IBM) finished work on large deviations of queueing networks under subexponentiality. Using max-plus algebra, they established the tail asymptotics of the sojourn time in a given group of queues in the network. Dieker also initiated work on extremes of heavy-tailed processes, with D. Denisov (EURANDOM) and V. Shneer (Heriot-Watt, Edinburgh).

Van der Mei and T.L. Olsen (Univ. of Washington, USA) have started to develop expressions for heavy-traffic limits for multi-server polling models, a class of models for which exact results are hardly available.

Van der Mei and J.A.C. Resing (TUE) have developed closed-form expressions for the heavy-traffic limits of the expected waiting

times in a so-called two-stage gated polling system.

Title	FLOW – End-to-end congestion-based flow control mechanisms
Period	2001–2005
Leader	S.C. Borst
Staff	U. Ayesta, R. Bekker, S.C. Borst, O.J. Boxma, M.R.H. Mandjes, R. Núñez Queija, W.R.W. Scheinhardt
Funding	CWI, Philips, SenterNovem (EQUANET), NWO (Van Gogh)
Partners	INRIA, Lucent, Philips, TNO ICT, TUE, UT

Progress report. K. Avrachenkov (INRIA), Ayesta and A.B. Piunovskiy (Univ. of Liverpool) have studied the optimal choice of the buffer size in the Internet routers. The objective was to determine the minimum value of the buffer size required in order to fully utilize the link capacity. The problem is formulated as a multi-criteria optimization problem, in which the Lagrange function corresponds to a linear combination of the average sending rate and average delay in the queue. The solution to this optimization problem provides evidence that the buffer size should be reduced in the presence of traffic aggregation. Furthermore, the result states that the minimum required buffer is smaller than what previous studies have suggested.

Ayesta and Mandjes have initiated work on networks with α-fair bandwidth sharing, where each flow has a class-specific peak rate. A fluid limit and diffusion scaling is considered. The single-node model was analyzed (which is closely related to DPS), which resulted in an easy criterion that determines which classes are peak-rate constrained in the fluid limit, and which are not. Correlations are evaluated between the number of flows of the various classes.

Bekker and Borst considered a queueing system with a workload-dependent service rate. They specifically assumed that the service rate is first increasing and then decreasing as a function of the amount of work. The latter qualitative behaviour is quite common in practical situations, such as production systems. The admission of work into the system is controlled by a policy for accepting or rejecting jobs, depending on the state of the system. The goal is to seek an admission control policy that maximizes the long-run throughput. They showed that a threshold policy is optimal, and derived a criterion for the optimal threshold value.

A.A. Kherani and Núñez Queija studied the fundamental relationship between variants of the predominant Transmission Control Protocol in the Internet (TCP) and scheduling disciplines. Each of the many variants of TCP have their own fairness and performance characteristics. Different flavours of TCP may be viewed as implementations of age-based scheduling disciplines. By parameterizing the scheduling disciplines of interest it was possible to position variants of TCP in a wide spectrum having FCFS (First-Come First-Served) and LAS (Least Attained Service First) as extremal policies, and including PS (Processor Sharing) as an intermediate case. Assuming infinite buffers, we showed that protocols that increase priority more than linearly with the age, ultimately tend to be similar to FCFS, whereas protocols with less than linear increase (or decrease) of the priority converges to PS scheduling.

N.D. van Foreest (UT), Mandjes, Scheinhardt, and J.C. van Ommeren (UT) also examined so-called back-pressure models, in which congestion in downstream queues determines the service rate of the upstream queues, relying on matrix-geometric techniques.

N.D. van Foreest, Mandjes and Scheinhardt have finished work on (Markov) fluid models with continuous feedback. The resulting models were applied for analyzing TCP, thus backing up earlier work on a Markov-chain modelling of TCP. The model was further enhanced by using a Petri-net representation – a collaboration with B. Haverkort (UT). Scheinhardt and L. Hoevenaars (UT) found explicit expressions for the system with continuous feedback in several special cases.

Title	LT – Performance analysis of communication networks; focus on long-tailed traffic characteristics and fluid queues
Period	1996–2007
Leader	M.R.H. Mandjes
Staff	S.C. Borst, O.J. Boxma, A.B. Dieker, P.M.D. Lieshout, M.R.H. Mandjes, W.R.W. Scheinhardt, A.P. Zwart
Funding	CWI, NWO
Partners	Columbia Univ., EURANDOM, Lucent, TUE, Univ. Wrocław, UT

Progress report. K. Dębicki (Univ. Wrocław),

Mandjes and M. van Uitert (VU, NKI) finished their study on the tandem queue with Lévy input. They derived a new representation for the probability distribution of the workload of the second queue in a two-node tandem network. For the case of Brownian input, exact expressions are derived for the probability of overflow in the second queue; Lieshout and Mandjes found the joint distribution of the first and second queue.

Dieker, K. Dębicki, and T. Rolski (both Univ. Wrocław) finished work on stochastic networks with Lévy input. They study both the (joint) distributions of the steady-state workload in each station and the (joint) distributions of the steady-state busy periods. Dieker and Mandjes extended this to a Markov-modulated framework.

Title	RAPS – Rare-event analysis of Processor-Sharing systems
Period	September 2004–August 2008
Leader	S.C. Borst
Staff	S.C. Borst, O.J. Boxma, R. Egorova, M.R.H. Mandjes, R. Núñez Queija, A.P. Zwart
Funding	CWI, NWO
Partner	TUE

Progress report. Borst, Núñez Queija and Zwart wrote a survey paper on the sojourn time asymptotics in the Processor Sharing queue. The focus in the survey was on heavy-tailed service requirements. The paper presents a unification of several methods that have been developed to obtain a so-called reduced service rate approximation. They further developed necessary and sufficient conditions for such an asymptotic equivalence to hold, and also considered the generalization to several extensions of the M/G/1 PS queue. Notably, a relationship was identified between the reduced service rate approximation and a queue length distribution with a geometrically decaying tail, and extended to so-called bandwidth-sharing networks.

Egorova, Zwart and Boxma investigated the sojourn time asymptotics in the M/D/1 Processor-Sharing queue. Using the additional structure in this special case, they managed to determine the exact tail asymptotics. The results reinforce the finding that service requirement distributions with bounded support give rise to a fundamentally different behaviour when it comes to sojourn time asymptotics. Numerical experiments demonstrate that the asymptotic estimate provides an excellent approximation.

Subsequently, Egorova and Zwart examined the asymptotic behaviour of the conditional sojourn time in the M/G/1 Processor-Sharing queue, and obtained a useful characterization of the decay rate. For the special case of exponential service requirements, they succeeded in finding the exact tail asymptotics.

Egorova, Mandjes, and Zwart initiated work on sojourn time in a PS queue with varying capacity, thus modelling resource sharing between streaming and elastic users.

PNA2.2 – Wireless Networks

Title	BANCA – Effective bandwidth calculations for integrated-services wireless networks
Period	2002–2007
Leader	S.C. Borst
Staff	S.C. Borst, R.J. Boucherie (UT), R.D. van der Mei, R. Núñez Queija
Funding	CWI, France Télécom (FLORIN)
Partners	EURANDOM, France Télécom, Lucent, TUE, UT, VU

Progress report. Borst and N. Hegde (France Télécom R&D) continued a study on the performance of an integrated wireless system, supporting a mixture of streaming and elastic traffic. They developed various models for evaluating the flow-level performance, capturing the detailed mechanics of the resource sharing between the streaming and the elastic traffic at the packet level.

Boxma, A. Gabor (EURANDOM & TUE), Núñez Queija and H.P. Tan (EURANDOM) studied an admission control strategy for integrated services in the context of a single UMTS radio cell with best-effort and streaming transfers. Various approximation approaches based on time-scale decomposition were developed and tested against simulation. Numerical results demontrate that the approximations are reasonably accurate in limiting regimes and almost insensitive to traffic parameter distributions.

A. Gabor (Eurandom & TUE), Núñez Queija and H.P. Tan (EURANDOM) continued to investigate extensions of this work by allowing different classes of data and streaming users so

as to incorporate the effects of signal attenuation within an radio cell.

Van der Mei, S. Bhulai and T. Yuan (both VU) have finalized their work on the development and validation of models for including user mobility in the throughput obtained in mobile cellular networks.

Van der Mei, C. Verhoef and E. Marchiori (both VU) have studied the usefulness of evolutionary algorithms in solving cell partitioning problems in cellular mobile networks, explicitly including the impact of mobility. The results show that evolutionary computing provides a viable means to tackle this type of complex problems.

Title	PROMO – Processor-sharing models for best-effort wireless services
Period	2002–2007
Leader	S.C. Borst
Staff	U. Ayesta, S.C. Borst, R.J. Boucherie (UT), M. Jonckheere, M.R.H. Mandjes, F. Roijers
Funding	CWI, France Télécom (FLORIN)
Partners	EURANDOM, France Télécom, Lucent, TUE, TNO ICT, UT

Progress report. The performance of wireless data systems has been thoroughly studied in the context of a single base station. Borst, N. Hegde (France Télécom R&D) and A. Proutière (France Télécom R&D) analyzed networks with several interacting base stations, and specifically examined the capacity impact of intra- and inter-cell mobility. They considered a dynamic setting where users come and go over time as governed by random finite-size data transfers, and explicitly allowed for users to roam around over the course of their service. It was shown that mobility tends to increase the capacity, not only in case of globally optimal scheduling, but also when each of the base stations operates according to a fair sharing policy. The latter approach offers the advantages that it avoids complex centralized control, and grants each user a fair share of the resources, preventing the potential starvation that may occur under a globally optimal strategy. An important implication is that a simple, conservative capacity estimate is obtained by 'ignoring' mobility, and assuming that users remain stationary for the duration of their service. They also demonstrated that the capacity region for globally optimal scheduling is in general strictly larger than the stability region for a fair sharing discipline. However, if the users distribute themselves so as to maximize their individual throughputs, thus enabling some implicit coordination, then a fair sharing policy is in fact guaranteed to achieve stability whenever a globally optimal strategy is able to do so.

In a further paper Borst, N. Hegde and A. Proutière examined the potential capacity gains in wireless data networks such as UMTS/HSDPA and CDMA 1xEV-DO from cell coordination which combines inter-cell scheduling and optimal cell selection. The inter-cell scheduling involves coordinating the activity phases of interfering base stations so as to avoid inter-cell interference and boost the transmission rates. The cell selection aims at improving the performance by assigning users to base stations based on load and other relevant considerations in addition to signal strength conditions. They considered a dynamic setting where users come and go over time as governed by the arrival and completion of random finite-size data transfers, and evaluate the capacity gains in terms of the maximum sustainable network throughput for a given spatial traffic pattern. They demonstrated that the relative merits of inter-cell scheduling and cell selection strongly depend on the network topology. In sparse (noise-limited) networks, optimal cell selection achieves substantial capacity gains and equalizes the loads across the various cells, while inter-cell scheduling yields no improvement. In contrast, in dense (interference-limited) networks, both inter-cell scheduling and optimal cell selection produce significant capacity gains, but due to interference, optimal cell selection no longer equalizes the loads and may even lead to strong load imbalances across cells.

Recently, some studies have explored the flow-level performance of channel-aware scheduling algorithms in a scenario with user dynamics governed by the arrival and completion of random service demands over time. Although in certain cases the performance may be evaluated by means of a Processor-Sharing model, in general the flow-level behaviour has remained largely intractable, even basic stability properties. Motivated by these observations, Borst and Jonckheere have examined the stability conditions, and proved that simple necessary conditions are in fact also sufficient for a

wide class of utility-based scheduling policies. This contrasts with the fact that the latter class of strategies generally fail to provide maximum-throughput guarantees at the packet level.

Ayesta and Borst have investigated the combination of size-based flow-level scheduling and opportunistic packet-level scheduling in wireless data networks. The throughput gains from channel-aware scheduling at the packet level cause the feasible rate region at the flow level to depend on the user population, and in particular to vary with the number of users of various classes. Preliminary results show that it is no longer optimal in those scenarios to give preferential treatment to users with smaller service requirements.

Mandjes, Roijers, and J.L. van den Berg developed a class of Markovian fluid models that enable the analysis of one cell in an ad hoc network; notably, when n users are transmitting, a fraction $1/(n+1)$ of the capacity is allocated to each of the users, and the remaining $1/(n+1)$ to the queue in the node. For this model the buffer content distribution has been determined, as well as characteristics of the sojourn time.

PNA2.3 – Service Differentiation

Title	COST – Cost allocation in communication networks; focus on statistical analysis of measurements
Period	2002–2006
Leader	M.R.H. Mandjes
Staff	M.R.H. Mandjes, R. Núñez Queija, F. Roijers
Funding	CWI, Telematica Instituut
Partners	Microsoft Research, Telematica Instituut, TNO ICT, UT

Progress report. Together with R. van de Meent, A. Pras (both UT), and J.L. van den Berg (TNO ICT and UT), Mandjes and Roijers have examined bandwidth provisioning procedures for supporting QoS in IP networks. The focus is on the minimal bandwidth provisioning required to ensure the QoS level agreed upon (for instance: the probability that the traffic supply exceeds the available bandwidth, over some predefined interval T, is below some small fixed number ε). It is shown that the required bandwidth has the form $\rho + \alpha\sqrt{\rho}$, where α depends on T and ε – this expression is derived under minimal model assumptions.

J.L. van den Berg, Mandjes, and Roijers also considered characteristics of the congestion period in the M/M/∞ queue, viz. the congestion duration, congestion area, and number of customers arriving in the congestion period. Explicit formula for their mean and variance, and all the mutual covariances, have been determined.

Mandjes studied the decay rate of overflow in a queue fed by many Gaussian sources, and in particular how this decay rate behaves as a function of the buffer size. Interestingly, it is possible to retrieve the variance function of the Gaussian sources by observing (i.e., measuring) the buffer content distribution. Work with R. van de Meent empirically shows the validity of this 'inversion' approach. R. van de Meent and Mandjes also performed detailed traffic analyses, thus verifying the claim that network traffic, after sufficient aggregation, can be accurately modelled as Gaussian.

Title	PRICE – Quality-of-service differentiation: microeconomic analysis
Period	2002–2006
Leader	M.R.H. Mandjes
Staff	M.R.H. Mandjes, R. Núñez Queija
Funding	CWI, Telematica Instituut
Partners	Microsoft Research, Telematica Instituut, TNO ICT, UT

Progress report. J.L. van den Berg (TNO), Mandjes and Núñez Queija continued their study of the interaction between different classes of document transfers in the Internet. If network resources are shared fairly, the performance of short TCP flows is seriously degraded by long flows. Web measurements have shown that TCP flow sizes vary over several orders of magnitude. This motivates prioritization of short over long flows, leading to significant performance improvement for short flows, without hardly any degradation for long ones. By imposing an appropriate pricing structure, users can be provided with incentives so as to enforce such a prioritization in a distributed manner. Using a two-level processor-sharing model the flow transmission times can be evaluated. Under mild modelling assumptions, the revenue maximizing Nash equilibrium is such that short flows opt for the premium service and long flows for the low-priority service. It is optimal for *medium-sized* flows to balk when the offered load is relatively high. Although this allocation is the result of distributed control, aside from

the flows that balk, it accomplishes precisely the prioritization of short flows which improves overall performance as mentioned above.

Mandjes and J. Timmer (UT) continued their work on a game-theoretic analysis of impatience and reattempts, for customers sharing a congested resource.

Title	EFS – Efficient scheduling in resource-sharing networks
Period	2005–2009
Leader	R. Núñez Queija
Staff	S.C. Borst, R. Núñez Queija, I.M. Verloop
Funding	CWI, NWO
Partner	TUE

Progress report. Borst, Núñez Queija and Verloop explored the design of efficient flow-level scheduling strategies in resource-sharing networks with simultaneous resource possession. They showed that traditional size-based scheduling strategies such as LAS, SRPT and SERPT fail to achieve optimality in these scenarios, and may even give rise to instability effects.

Subsequently, they set out to determine the scheduling policies that minimize the mean delay in some simple linear resource-sharing networks with exponential service requirements. They compared the performance of the optimal policies with that of so-called α-fair policies so as to assess the efficacy of the latter and gauge the potential room for improvement. The results indicate that the optimal policy achieves only modest improvements, even when the value of α is simply fixed, provided it is not too small. This suggests that (optimization within) the family of α-fair strategies is likely to be adequate for most practical purposes.

Title	QFN-IS – Quality-of-service in future networks; emphasis on integrated services
Period	2000–2005
Leader	S.C. Borst
Staff	U. Ayesta, R. Bekker, S.C. Borst, R. Núñez Queija, A.P. Zwart
Funding	CWI, NWO (Van Gogh), Philips
Partners	INRIA, Bell Labs, TUE

Progress report. S. Aalto (TKK) and Ayesta have studied the mean delay of Multilevel Processor-Sharing (MLPS) scheduling disciplines. Such disciplines have recently attracted attention in the context of the Internet as an appropriate flow-level model for the bandwidth sharing obtained when priority is given to short TCP connections. The authors prove that given an MLPS discipline, the mean delay is reduced whenever a level is added by splitting an existing one in several cases. The exceptions concern splitting the upper levels with PS internal discipline. The numerical examples, however, indicate that the level splitting be advantageous even in these cases. By numerical means we demonstrate that the mean delay of an MLPS discipline can get close to the minimum optimal delay with just a few levels.

E. Altman (INRIA), Ayesta and K. Avrachenkov (INRIA) have written a survey paper on the DPS (Discriminatory Processor Sharing) model summarizing the literature on the subject over the past three decades.

K. Avrachenkov, Ayesta and Núñez Queija continued their study of DPS initiated in their Infocom 2005 paper (with P. Brown). Using an earlier-developed conservation law, it can be shown that for a class with service requirements exhibiting an infinite variance, the asymptotic bias of the sojourn times conditional on the service requirements is finite, provided that the variances of the other classes' services are finite.

Title	QFN-PS – Quality-of-service in future networks; emphasis on packet scheduling algorithms
Period	1999–2004
Leader	S.C. Borst
Staff	U. Ayesta, S.C. Borst, O.J. Boxma, P.M.D. Lieshout, M.R.H. Mandjes, R. Núñez Queija, A.P. Zwart
Funding	CWI, SenterNovem (EQUANET)
Partners	Lucent, Philips, TNO ICT, TUE

Title	BRICKS-PDC2 – Quality-of-service differentiation mechanisms
Period	2004–2009
Leaders	S.C. Borst, M.R.H. Mandjes
Staff	S.C. Borst, M.R.H. Mandjes, P.M.D. Lieshout, R.D. van der Mei, R. Núñez Queija
Funding	Bsik
Partners	TUE, UT

The BRICKS-PDC2 project is a continuation of the QFN-PS project.

Progress report. Boxma, N. Hegde and Núñez Queija developed approximations based on time-scale decompositions of the queue length and sojourn time distributions for DPS systems.

Exact analysis of discriminatory processor sharing systems has proven to be extremely hard. The approximations were compared with existing approximations and numerical results were obtained for exponential service requirements. The results suggest that the new approximation is effective even when a time scale decomposition can not be justified by the dynamics of the various classes.

Lieshout, Mandjes, and Borst studied the weight setting problem in GPS. Using a Gaussian framework, they developed implicit expressions for the border of the admissible region (for given weights), as well as the border of the realizible region (union over all admissible regions). For the case of Brownian inputs, explicit expressions were derived. The numerical experiments indicate that the advantage (in terms of efficiency) of GPS over priority scheduling is often negligible.

PNA2.4 – Performance of distributed ICT systems

Title	PADAM – Performance Analysis of Distributed Applications and Middleware
Period	2004–2009
Leader	R.D. van der Mei
Staff	M. Harkema, R.D. van der Mei
Funding	CWI, SenterNovem (EQUANET), NWO, UT (cost of Harkema), VU
Partners	TNO ICT, UT, VU

Progress report. Harkema, B.M.M. Gijsen (TNO ICT) and Van der Mei have developed quantitative models for the performance of middleware-based distributed applications. The results demonstrate the usefulness of quantitative methods for modelling the performance of software systems.

M.A. Dobber, G.M. Koole (both VU) and Van der Mei have quantified the impact of implementing dynamic load balancing schemes in a world-wide Grid environment in an experimental setting. The results show that significant improvements can be made compared to static load balancing schemes.

Van der Mei, M.A. Dobber and G.M. Koole have performed extensive measurements to characterize the dynamic nature of the sources of running time of computationally intensive applications in large-scale Grid environments. The results provide new insights in the dynamics of large Grids, and are essential input for the development of effective predictors of running times, needed to enforce effective dynamic control actions.

Van der Mei, M.A. Dobber and G.M. Koole have developed a new class of predictors for the efficient prediction of job running times in large-scale grids environments. Statictical analysis shows that the new prediction method strongly outperforms the existing methods.

Van der Mei, M.A. Dobber, G.M. Koole and R. Righter (Univ. of Santa Barbara) have modelled and analyzed the performance improvements that can be obtained by effective duplicating jobs in a Grid environment. Both the theoretical and experimental results show that in this way dramatic improvements in the job-running can be achieved.

Van der Mei, P. Kampstra and A.E. Eiben (both VU) have finished a survey paper in the use of genetic algorithms for solving complex planning and design problems, listing over 350 references in the field.

Title	SLIS - Performance and scalability of large ICT infrastructures
Period	2004–2009
Leader	R.D. van der Mei
Staff	M.R.H. Mandjes, R.D. van der Mei, W. van der Weij, K. van Wingerden
Funding	CWI, SenterNovem (EQUANET)
Partners	Lucent Technologies, TNO ICT, UT, TUE, UvA, VU

Progress report. Van der Mei, H.B. Meeuwissen (Lucent Technologies) and F. Phillipson (TNO ICT) have finalized their work on the development of quantitative models for the end-to-end performance of voice-over-IP (VoIP) connections running over multiple domains.

Van der Mei and H.B. Meeuwissen have finalized their work on the development of a modelling framework for assessing the end-to-end performance of a class of web-based applications, including the impact of Service Level Agreements with third parties.

R. Kooij, R. Yang, J.L. van den Berg (all TNO ICT) and Van der Mei have developed a quantitative model for the end-to-end performance of TCP-based communication networks, where TCP connections cross multiple domains. The model-based performance predictions are shown to match very well with simulations.

R. Yang, R.E. Kooij (both TNO ICT) and Van der Mei have developed a performance model

for TCP on the case of bi-directional packet loss. This model deviates from the existing performance models that unanimously assume packet loss to occur in the downlink direction only. Simulation results show that the accuracy of the models outperforms the existing models.

Van der Mei and Van Wingerden have developed approximations for the variance of the sojourn times in a class of queueing networks with a single Processor-Sharing node and number of multi-server FIFO nodes with exponentialy distributed service times. Simulation results show that the approximations are highly accurate. Boxma, Van der Mei, J.A.C. Resing (TUE) and Van Wingerden have developed approximations r the mean sojourn times in a simple two-queue model with a PS node and a single-server FIFO node with general service times, perhaps the simplest non-trivial network for which no product-form solution exists. The results are shown to be highly accurate for a broad range of parameter settings.

Van der Weij and Van der Mei have studied throughput and stability in a two-layered two-node tandem of multiserver queues, where the active servers share an underlying resource in a PS fashion, and with multiple customer classes. For this model, they have derived a full and explicit characterization of the per-queue and per-class throughput and stability as a function of the arrival rate. This work constitutes a pioneering contribution in the analysis of hierarchical queueing networks.

Van der Weij, Van der Mei and S. Bhulai (VU) have extended the results for the two-node model (above) to a general two-layered network of multi-server queues, provide an explicit characterization of the per-class and per-queue stability and throughput figures in a general parameter setting.

Van der Weij, Van der Mei and G.J. Franx (VU) have started with the development of approximations for the sojourn-time distributions in a two-layered multi-server queue with deterministic service times, where the active servers share and underlying server in a PS fashion.

Van der Weij and Van der Mei have studied a two-node two-layered tandem of multiserver queues. For this model they have developed approximations and guidelines for the optimal choice of the numbers of servers at each of the queues, particularly depending on teh service-time distribution at both of the nodes.

Van der Weij, Van der Mei, N.M. van Dijk and J. van der Wal (both UvA) have studied a tandem of multiserver queues with threadpool sharing, providing initial insight in the impact of thread policies on the performance.

Van der Weij, Van der Mei and S. Bhulai have studied dynamic control schemes for the same model, and have derived explicit dynamic control policies that depend on the service-time distributions at the queues.

Title	PCDP – Performance analysis of Content-Delivery Platforms
Period	2004–2009
Leader	R.D. van der Mei
Funding	CWI, SenterNovem (EQUANET)
Partners	TNO ICT, Univ. of Geneva, Blekinge Institute of Technology, VU

Progress report. Van der Mei, M. Wu and S. Bhulai (both VU) have developed and analyzed quantitative models for bandwidth provisioning for access networks with video-on-demand (VoD) and near-VoD type of streaming video services.

Van der Mei and M. Taneja (VU) have started to develop models for the end-to-end response times for complex web-based systems in the presence of complex caching infrastructures.

Van der Mei, K. Wac (Univ. of Geneva), M. Fiedler (Blekinge Institute of Technology) and M. van Es (VU) have started with the modelling and analysis of end-to-end response-time performance measurements for electronic health applications via GPRS and UMTS networks.

S. Dijkstra, J.A. Jurriens (both VU Windesheim) and Van der Mei have started with the development of business and performance models in the homecare services domain.

Van der Mei, Van der Weij, S. Bhulai and D. Roubos (both VU) have started to work on the development of efficient load-balancing schemes for web-based service platforms. The results are currently validated in an experimental setting.

Societal aspects and knowledge transfer

External contacts

- AT&T Labs, Middletown, NJ, USA: G.L. Choudhury, W. Ehrlich, F. Huebner, J. Klincewicz, P.K. Reeser.

- Blekinge Institute of Technology, Sweden: M. Fiedler.
- Carnegie Mellon Univ., Pittsburgh, USA: M. Harchol-Balter.
- Columbia Univ., New York, USA: P.R. Jelenković.
- Computer Laboratory, Univ. Cambridge, UK: R.J. Gibbens, D.J. Wischik.
- École Normale Supérieure, Paris, France: F. Baccelli, M. Lelarge.
- France Télécom R&D, Paris, France: T. Bonald, N. Hegde, A. Proutière, J.W. Roberts.
- France Télécom R&D, Sophia Antipolis: P. Brown.
- Helsinki Univ. Technology, Finland: P. Lassila.
- IBM T.J. Watson Research Center, Yorktown Heights, USA: Z. Liu, M. Squillante.
- INRIA Rocquencourt, France: Ph. Robert.
- INRIA Sophia Antipolis, France: S. Alouf, E. Altman, K. Avrachenkov, C. Barakat, Ph. Nain.
- LogicaCMG: H. Kersten, W.P. Trienekens.
- Lucent Technologies, Bell Labs Innovations, Hilversum: E. Meeuwissen, F. Panken. Enschede: R. Malhotra, R. van Haalen.
- Lucent Technologies, Bell Labs Innovations, Murray Hill, USA: D.M. Andrews, D. Mitra, I. Saniee, A.L. Stolyar, P.A. Whiting.
- Microsoft Research, Cambridge, UK: A. Ganesh, P. Key, L. Massoulié.
- Philips Research, Eindhoven: J.P. Linnartz, D. Denteneer, R. Rietman.
- Statistical Laboratory, Univ. Cambridge, UK: F.P. Kelly.
- Tel Aviv Univ., Israel: H. Levy, U. Yechiali.
- TNO ICT: J.L. van den Berg, B.M.M. Gijsen, F. den Hartog, R.E. Kooij, R. Litjens, F. Roijers.
- Univ. of Geneva, Switserland: K. Wac, D. Konstantas.
- VTT, Helsinki, Finland: P. Mannersalo, I. Norros, B. Prabhu.
- Western Univ. of St. Louis, PA, USA: T.L. Olsen.
- Wrocław Univ., Poland: K. Dębicki, T. Rolski.

Projects with partners in public and private sector

- BRICKS page 33.
- EQUANET page 34.
- EURO-NGI.
- M2C-QoS.
- Van Gogh.

Contract research

- FLORIN page 27.

Teaching at university

- Exercises Calculus A voor ST, TUE: R. Bekker.
- Stochastic Performance Modelling, TUE: R. Bekker, O.J. Boxma, R. Núñez Queija.
- Queueing Networks, TUE: S.C. Borst, R. Núñez Queija.
- Bachelor case, Applied Mathematics, UT: M.R.H. Mandjes.
- Stochastic Processes for Telecommunications, LNMB: M.R.H. Mandjes, R.D. van der Mei.
- Kansrekening, UvA: M.R.H. Mandjes.
- Performance Analysis of Communication Networks, VU: R.D. van der Mei.
- Supervision BWI Bedrijfscase (consultancy by group of students for the Hoogheemraadschap van Delfland), VU: R.D. van der Mei.
- Supervision five BSc midterm theses, VU: R.D. van der Mei.
- Supervision four MSc student internships, VU: R.D. van der Mei.
- Stochastic Decision Theory, TUE: R. Núñez Queija.
- Mathematical Modelling (case studies), TUE: R. Núñez Queija.
- Exercises 'Wiskunde 3 voor Bouwkunde', TUE: R. Núñez Queija.

Courses, tutorials

- Lecturer of two-day course Performance Management and Design of ICT Systems, IT Architecten Leergang (ITAL), ING Nederland, December 16 and 19, Amsterdam: R.D. van der Mei.
- Lecturer of half-day tutorial on Large Deviations of Guassian Queues, Joint Korea-Netherlands seminar of Queueing Theory and Its Applications, June 22, Seoul, Korea: M.R.H. Mandjes.

Organization of conferences, workshops, courses, meetings

- Workshop on Resource Allocation in Wireless Networks (RAWNET 2005), Riva del Garda, Italy, April 3, 2005: S.C. Borst (jointly with A. Proutière).
- Reading Seminar, CWI, January 7, February 25, April 8, May 20, October 12, November 9: R. Bekker, A.B. Dieker.
- EURO-NGI workshop on Rare Events in Communication Networks, Eindhoven, February 2–5: M.R.H. Mandjes (jointly with O.J. Boxma).
- Queueing Colloquium, CWI, May 27 & November 23: R. Núñez Queija.
- IFIP WG7.3 Conference on Performance Evaluation (Performance 2005), Juan les Pins, France, October 3–7: R. Núñez Queija (Proceedings Chair).
- Workshop on Resource Allocation in Wireless Networks (RAWNET 2006), Boston MA, USA, April 3, 2006: S.C. Borst (jointly with A. Proutière).
- Stieltjes Afternoon, September 15: M.R.H. Mandjes.
- E-Quality symposium, UT, September 30: R.D. van der Mei.
- Workshop Wiskunde in de Bewegingswetenschappen, Amsterdam, November 4: R.D. van der Mei.
- Workshop on ICT Performance: where users, vendors and researchers meet, April 2006: R.D. van der Mei (jointly with B.M.M. Gijsen, TNO ICT).
- Workshops in conjunction with ValueTools 2006, Pisa, Italy, October 11–15, 2006: R. Núñez Queija (General Workshop Chair, jointly with G.M. Koole).
- EURO-NGI workshop on Performance Models for Efficient Resource Sharing, CWI, Amsterdam, November 8–10, 2006: M.R.H. Mandjes, R.D. van der Mei, R. Núñez Queija.
- 2nd Korean-Netherlands workshop on queueing, Tinbergen Institute, Amsterdam, October 24–28, 2006: M.R.H. Mandjes (jointly with H.C. Tijms).
- INFORMS Applied Probability, July 2007: M.R.H. Mandjes (jointly with O.J. Boxma).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- 30th Annual Mathematics of Operations Research Conference, Lunteren, January 18–20: R. Bekker, O.J. Boxma, A.B. Dieker, R. Egorova, P.M.D. Lieshout, M.R.H. Mandjes, R. Núñez Queija, A.P. Zwart.
- EURANDOM Workshop on Rare Events in Communication Networks, Eindhoven, February 2-5: R. Bekker (Talk: Performance of TCP-friendly streaming sessions in the presence of heavy-tailed elastic flows), S.C. Borst, O.J. Boxma, A.B. Dieker (Talk: On factorization identities and embeddings in Levy processes), M.R.H. Mandjes, R. Núñez Queija, A.P. Zwart (Talk: Fluid approximation of a processor sharing queue with impatient customers).
- Infocom 2005 Conference, Miami FL, USA, March 15–17: U. Ayesta (Talk: Discriminatory Processor Sharing revisited), R. Núñez Queija (Talk: Differentiated bandwidth sharing with disparate flow sizes).
- 1st Euro-NGI Conference, Rome, Italy, April 18-20: M.R.H. Mandjes.
- 7th Workshop on Mathematical Performance Modeling and Analysis (MAMA 2005), Banff, Canada, June 6: S.C. Borst.
- 2005 Sigmetrics Conference, Banff, Canada, June 8–10: S.C. Borst.
- Third international conference on Performance Evaluation of Heterogeneous Networks, Bradford, UK, July 18-20: W. van der Weij (Talks: Throughput and stability in a two-layered tandem of multiserver queues, and Threadpool optimization in a two-layered network of multiserver queues).
- Joint Korea - Netherlands Seminar on Queueing Theory and Its Application to Communication Systems, Seoul, South Korea, June 22-25: M.R.H. Mandjes (Tutorial: Large deviations of Gaussian queues; Invited talk: A versatile model for TCP bandwidth sharing in networks with user heterogeneity), R.D. van der Mei (Invited talk: Performance modelling and analysis of distributed ICT systems).
- IMA Workshop on Wireless Communications, Minneapolis MN, USA, June 27-30: S.C. Borst (Invited talk: Flow-level performance of

channel-aware scheduling algorithms in wireless data networks).

- Carnegie Mellon / Technische Universiteit Eindhoven Collaborative Workshop, Pittsburgh, July 2-3: U. Ayesta (Talk: Mean delay analysis of Multi-Level Processor Sharing).
- INFORMS Applied Probability Conference, Ottawa, Canada, July 5–7: U. Ayesta (Talk: Mean delay analysis of Multi-Level Processor Sharing), R. Bekker (Talk: Optimal Control of Queues with Workload-Dependent Service Rates), O.J. Boxma (Keynote talk: Processor Sharing), A.B. Dieker (Talk: Exact Large-buffer Asymptotics for Gaussian Queues), R. Egorova (Talk: Tail Behavior of the Sojourn Time in a Processor Sharing Queue with Deterministic Service Times), P.M.D. Lieshout, M.R.H. Mandjes (Talk: Asymptotics of Simple Gaussian Queues in the Many-sources Regime), A.P. Zwart (Talk: Fluid Approximation of a Processor Sharing Queue with Impatient Customers).
- European Meeting of Statisticians, Oslo, Norway, July 24–28: M.R.H. Mandjes (Invited talk: large deviations of infinite intersections).
- 19th International Teletraffic Congress, Beijing, China, August 29 - September 2: R.D. van der Mei (Talks: Sojourn time approximations in a two node queueing network, and End-to-end Quality of Service for Voice-over-IP in a multi-domain environment).
- Stochastics afternoon, EURANDOM, Eindhoven, September 23: O.J. Boxma, R. Núñez Queija, A.P. Zwart.
- E-Quality symposium, UT, September 30: O.J. Boxma, M.R.H. Mandjes, R.D. van der Mei, R. Núñez Queija, F. Roijers, W. van der Weij.
- Workshop Directoraal Generaal Telecommunicatie en Post, October 3, Den Haag: R.D. van der Mei (Invited talk: Research on Performance Modelling and Analysis: Research Challenges).
- Performance 2005 Conference, Juan-les-Pins, France, October 3–7: U. Ayesta, R. Núñez Queija (Talk: Stability of size-based scheduling disciplines in resource-sharing networks), I.M. Verloop.
- Minicourse 'Fundamentals of Wireless Communication' by D. Tse, EIDMA, Eindhoven, November 30–December 1: R. Núñez Queija.
- EURO-NGI Workshop on QoS and Traffic Control, Ecole Normale Supérieure, Paris, France, December 7–9: U. Ayesta (Talk: On the Non-Optimality of FB within the class IMRL), S.C. Borst, M. Jonckheere, R.D. van der Mei (Talks: Performance modeling of TCP in the presence of bidirectional packet loss, and Service level calculus for TCP-based services in a multi-domain environment), R. Núñez Queija, I.M. Verloop (Talk: Delay-optimal scheduling in bandwidth-sharing networks).

Working visits

- INRIA, Sophia Antipolis, France, April 7–8: M.R.H. Mandjes.
- INRIA, Sophia Antipolis, France, May 23–June 6: U. Ayesta.
- INRIA, Sophia Antipolis, France, June 20–23: R. Núñez Queija.
- Univ. of Geneva, Switzerland, September 19: R.D. van der Mei.
- INRIA, Sophia Antipolis, France, October 2–8: M. Verloop.
- INRIA, Sophia Antipolis, France, October 2–28: U. Ayesta.
- INRIA, Sophia Antipolis, France, October 4–10: R. Núñez Queija.
- INRIA, Sophia Antipolis, France, December 14–16: R. Núñez Queija.

Project meetings

- FLORIN project meeting, CWI, February 11: S.C. Borst, M.R.H. Mandjes, R. Núñez-Queija.
- FLORIN project meeting, France Télécom R&D, Paris, France, December 6: U. Ayesta, S.C. Borst.
- EURO-NGI Cellular project meeting, Paris, France, December 6: U. Ayesta (Talk: Combination of channel-aware and size-based scheduling in wireless data networks), S.C. Borst (Talk: Efficient scheduling in multi-user multi-antenna systems).
- BRICKS project meeting with Lucent Technologies, CWI, November 4: M.R.H. Mandjes, R.D. van der Mei (from Lucent: P. Reijnold, H.B. Meeuwissen).
- BRICKS project meeting with Lucent Technologies, Hilversum, November 21: M.R.H. Mandjes, R.D. van der Mei (from Lucent: G. Hoekstra, F. Panken).

Other lectures

- KdVI Wiskundig Colloquium, UvA, January 12: M.R.H. Mandjes (Talk: Large deviations for Gaussian queues).
- PNA Colloquium, CWI, February 24: A.B. Dieker.
- Leve de Wiskunde!, UvA, May 14: M.R.H. Mandjes (Talk: Over apen, typemachines en martingalen).
- Queueing Colloquium, CWI, May 27: R.D. van der Mei (Talk: Performance analysis of hierarchical queueing models).
- Alumnidag, VU, May 28: R.D. van der Mei (Talk: De ICT-wereld heft ICT-ers hard nodig!).
- BWI-middag, VU, October 7: R.D. van der Mei (Talk: Van Graham Bell tot John de Mol: Wiskunde is tijdloos!).
- Hogeschool Holland, Diemen, October 11: R.D. van der Mei (Talk: Wiskunde is gewoon hartstikke leuk!).
- Queueing Colloquium, CWI, November 23: R. Bekker (Talk: Queues with state-dependent rates).
- Queueing Colloquium, CWI, November 23: U. Ayesta (Talk: Delay analysis of discriminatory processor sharing).

Visitors

- M. Squillante, IBM T.J. Watson Research Center, Yorktown Heights, USA, January 24 – 25. Host: R.D. van der Mei.
- I. Norros, VTT, Finland, January 30 – February 8. Host: M.R.H. Mandjes.
- P. Mannersalo, VTT, Finland, January 30 – February 8. Host: M.R.H. Mandjes.
- M. Pagano, Pisa, Italy, January 30 – February 8. Host: M.R.H. Mandjes.
- P.A. Whiting, Bell Labs, Lucent Technologies, Murray Hill NJ, USA, January 31–February 4. Host: S.C. Borst.
- K. Wac, University of Geneva, April 1. Host: R.D. van der Mei.
- K. Avrachenkov, INRIA Sophia Antipolis, France, April 21–22. Host: R. Núñez Queija.
- K. Dębicki, Wrocław, Poland, April 23 – May 6. Host: M.R.H. Mandjes.
- A.A. Kherani, INRIA Sophia Antipolis, France, May 24–June 7. Host: R. Núñez Queija.
- K. Wac, University of Geneva, Switserland, December 9. Host: R.D. van der Mei.
- M. Fiedler, Blekinge Institute of Technology, Karlskrona, Sweden, December 9. Host: R.D. van der Mei.

Memberships of committees and other professional activities

U. Ayesta

- Referee for Operations Research Letters, Performance Evaluation, Stochastic Models, Queueing Systems.

R. Bekker

- Referee for Operations Research Letters.

S.C. Borst

- Professor of Stochastic Operations Research (part-time), TUE.
- Member scientific council EURANDOM.
- Member advisory board IFIP Working Group 7.3, IFIP Working Group 7.3.
- Member board of directors ACM Sigmetrics (till 30-06-2005).
- Member user committee STW project TWI.4412 (Stochastic network analysis for the design of self-optimizing cellular mobile communication systems; project leader: R.J. Boucherie), member user committee STW project EES.5202 (Modelling and performance analysis of telecommunication systems; project leader: J.P.M. Voeten).
- Area editor Operations Research Letters, associate editor IEEE/ACM Transactions on Networking, associate editor Operations Research, associate editor Performance Evaluation, associate editor Wireless Networks.
- Guest editor Queueing Systems, Special Issue on Queueing Models for Fair Resource Sharing (jointly with R. Núñez-Queija).
- Programme committee member HETNETs '05, Infocom 2005, Infocom 2006, MAMA 2005, Performance 2005, Sigmetrics / Performance 2006, WiOpt 2006.
- Programme committee co-chair Sigmetrics 2005 (jointly with J.C.S. Lui).
- PhD thesis advisor: T.J.J. Denteneer (TUE, March 7), J.S.H. van Leeuwaarden (TUE, June 13), R. Bekker (TUE, December 12).
- Master thesis advisor: I.M. Verloop (UU, August 23; jointly with R. Núñez Queija).

A.B. Dieker

- Referee for Stochastics and Stochastic Reports.

M.R.H. Mandjes

- Professor of Applied Probability and Queueing Theory (part-time, 0.2 fte), Korteweg-de Vries Institute, UvA.
- Advisor EURANDOM (0.1 fte), theme Queueing and Performance Evaluation.
- Member PhD committee D. Denteneer (TUE), R. Groenevelt (INRIA, Université de Nice) and R. Bekker (TUE).
- Member project steering committee EQUANET (funded by SenterNovem; partners: CWI, Lucent, TNO ICT, TUE, UT).
- Member Evaluation Committee Vidi, NWO.
- Leader WP 5.2 EU Network of Excellence EURO-NGI (Design and Engineering of the Next Generation Internet).
- Member programme committee International Teletraffic Congress (ITC-19), EMS 2005 (25rd European Meeting of Statisticians), EURO-NGI 2005 and 2006. Technical programme committee co-chair INFORMS Appl. Prob. 2007 (jointly with O.J. Boxma).
- Associate editor Stochastic Models.
- Member board Stieltjes Institute (representing CWI), project leader programme 4.2 Stochastic Operations Research (jointly with prof.dr. G.M. Koole).
- Member advisory group Voorverkenning ICT, KNAW.
- Referee for ACM Transactions on Modeling and Computer Simulation, Advances in Applied Probability, Annals of Operations Research, Computer Networks, IEEE Infocom 2005, IEEE/ACM Transactions on Networking, IEEE Communications Letters, ITC-19, Journal of Applied Probability, Mathematical Methods in Operations Research, Performance Evaluation, Probability in the Engineering and Informational Sciences, Queueing Systems, Stochastic Models, Telecommunication Systems.

R.D. van der Mei

- Professor of Performance Analysis of Communication Networks (part-time, 0.2 fte), VU.
- Associate editor Performance Evaluation and AEUE journal on Electronics and Communications.
- Co-founder and board member E-Quality, knowledge center in the field of Quality of Service of communication networks (participants CWI, TNO ICT and UT).
- Member management board sectie Industriële en Toegepaste Wiskunde (ITW) van het Koninklijk Wiskundig Genootschap.
- Member project management committee EQUANET (funded by SenterNovem; partners CWI, Lucent, TNO ICT, TUE, UT).
- Leader WP4 EQUANET (see above).
- Member advisory board for PhD project selection, IWT, Belgium.
- Member advisory board International Conference on Internet Surveillance and Protection (ICISP).
- Lecturer two-day course Performance Management and Design of ICT Systems, IT Architecten Leergang (ITAL), ING Nederland. Invited.
- External advisor for IT Architecten Leergang (ITAL), IBM Nederland.
- External reviewer for tenure track professorship C. Williamson, Univ. of Calgary, Canada.
- Member programme committee ACM Sigmetrics 2005, HETNETs 2005, ITCOM 2005.
- Referee for many leading journals in the field.
- Member of the Stieltjes Institute for Mathematics, Koninklijk Wiskundig Genootschap and LNMB (Dutch Network on the Mathematics of Operations Research).
- Master thesis advisor Karin van Wingerden (UvT), Ran Yang (VU), Mengxiao Wu (VU), Taoying Yuan (VU), Rogier Erdbrink (VU) and Wouter Radder (VU).

R. Núñez Queija

- Assistant professor of Stochastic Operations Research (part-time, 0.5 fte), TUE.
- Guest editor Queueing Systems, 'Special Issue on Queueing Models for Fair Resource Sharing' (jointly with S.C. Borst).
- Associate editor Operations Research Letters.
- Technical programme committee member for EURO-NGI 2005, RAWNET 2005, EURO-NGI 2006.
- Member of IFIP Working Group 7.3.
- Member of the research schools Beta, the Stieltjes Institute and LNMB (Dutch Network on the Mathematics of Operations Research).

- PhD thesis committee member: R. Bekker (TUE, December 12), P. Brown (INRIA Sophia Antipolis / Univ. of Nice, France, December 15).
- Master thesis advisor: I.M. Verloop (UU, August 23; jointly with S.C. Borst).
- Member project management committee EQUANET (funded by SenterNovem; partners: CWI, Lucent Technologies, TNO ICT, TUE, UT).
- Coordinator NWO Van Gogh project (partner: INRIA Sophia Antipolis, France).
- Referee for Appl. Prob. journals, Oper. Res., OR Let., Perf. Eval., Prob. Engrng. Inf. Sc., Stoch. Mod., IEEE Com. Let.

W. van der Weij

- Referee for IEEE Transactions of Automatic Control, and HETNETs 2005.

Academic publications

Publications in refereed journals or proceedings

1 S. Aalto, U. Ayesta (2005). On the non-optimality of the FB discipline within the service time distribution class IMRL, Euro-NGI Workshop on QoS and Traffic Control, 2005.

2 D. Abendroth, H. van den Berg, M. Mandjes (2005). A multiple time-scale model for TCP bandwidth sharing under user heterogeneity. R. Boutaba, K. Almeroth, R. Puigjaner, S. Shen, J. Black (eds). Networking Technologies, Services, and Protocols; Performance of Computer and Communication Networks; Mobile and Wireless Communication Systems. Fourth International IFIP-TC6 Networking Conference (Networking 2005), LNCS Series 3462, 561–573.

3 D. Abendroth, H. van den Berg, M. Mandjes (2005). A versatile model for TCP bandwidth sharing in networks with user heterogeneity. B.D. Choi (ed.). Proceedings Korea-Netherlands Joint Conference on Queueing Theory and its Applications to Telecommunication Systems, 173–188.

4 K. Avrachenkov, U. Ayesta, Patrick Brown, R. Núñez Queija. Discriminatory processor sharing revisited. Proceedings IEEE Infocom 2005. CD-rom.

5 K. Avrachenkov, U. Ayesta, A. Piunovskiy (2005). Optimal choice of the buffer size in the Internet routers, IEEE CDC.

6 R. Bekker, S.C. Borst, R. Núñez-Queija (2005). Performance of TCP-friendly streaming sessions in the presence of heavy-tailed elastic flows. Performance Evaluation 61, 143–162.

7 R. Bekker, A.P. Zwart (2005). On an equivalnce between loss rates and cycle maxima in queues and dams. Probability in the Engineering of Informational Sciences 19, 241–255.

8 T. Bonald, S.C. Borst, A. Proutière (2005). Inter-cell scheduling in wireless data networks. Proceedings 11th European Wireless Conference. CD-rom

9 S.C. Borst (2005). User-level performance of channel-aware scheduling algorithms in wireless data networks. IEEE/ACM Transactions on Networking 13, 636–647.

10 S.C. Borst, D.T.M.B. van Ooteghem, A.P. Zwart (2005). Tail asymptotics for Discriminatory Processor-Sharing queues with heavy-tailed service requirements. Performance Evaluation 61, 281–298.

11 S.C. Borst, A.P. Zwart (2005). Fluid queues with heavy-tailed $M/G/\infty$ input. Mathematics of Operations Research 30, 852–879.

12 O.J. Boxma, N. Hegde, S.C. Borst (2005). Sojourn times in finite-capacity Processor-Sharing queues. Proceedings NGI 2005 Conference. CD-rom.

13 O.J. Boxma, R.D. van der Mei, J.A.C. Resing, K.M.C. van Wingerden (2005). Sojourn-time approximations in a two-node queueing network. Proceedings 19th International Teletraffic Congress, ITC-19, 1121–1133.

14 N. van Foreest, J.C. van Ommeren, M. Mandjes, W. Scheinhardt (2005). A tandem network with server slow-down and blocking. Stochastic Models 21, 695–724.

15 T. Dieker (2005). Conditional limit theorems for queues with Gaussian input, a weak convergence approach. Stochastic Processes and their Applications 115, 849–873.

16 T. Dieker (2005). Extremes of Gaussian processes over an infinite horizon. Stochastic Processes and their Applications 115, 207–248.

17 T. Dieker (2005). Reduced-load equivalence for queues with Gaussian input. Queueing Systems 49, 405–414.

18 T. Dieker, M. Mandjes (2005). On asymptotically efficient simulation of large deviation probabilities. Advances in Applied Probability 37, 539–552.
19 M.A. Dobber, G.M. Koole, R.D. van der Mei (2005). Dynamic load balancing experiments for Grid applications. Proceedings IEEE/ACM International Symposium on Cluster Computing and the Grid, 1063–1070.
20 O. Kella, A.P. Zwart, O.J. Boxma (2005). Some time-dependent properties of symmetric $M/G/1$ queues. Journal of Applied Probability 42, 223–234.
21 G. van Kessel, R. Núñez-Queija, S.C. Borst (2005). Differentiated bandwidth sharing with disparate flow sizes. Proceedings Infocom 2005. Cd-rom.
22 R. Malhotra, R. van Haalen, M.R.H. Mandjes, R. Núñez Queija. Modeling the interaction of IEEE 802.3x hop-by-hop flow control and TCP end-to-end flow control. Proceedings 1st Euro NGI conference on Next Generation Internet Networks - Traffic Engineering. CD-rom.
23 M. Mandjes, M. Nuyens (2005). Sojourn times in the M/G/1 FB queue with light-tailed service times. Probability in the Engineering and Informational Sciences 19, 351–361.
24 M. Mandjes, M. van Uitert (2005). Sample-path large deviations for tandem and priority queues with Gaussian inputs. Annals of Applied Probability 15, 1193–1226.
25 M. Mandjes, M. van Uitert (2005). Sample-path large deviations for Generalized Processor Sharing queues with Gaussian inputs. Performance Evaluation 61, 225–256.
26 M. Mandjes, R. van de Meent (2005). Inferring traffic burstiness by sampling the buffer occupancy. R. Boutaba, K. Almeroth, R. Puigjaner, S. Shen, J. Black (eds). Networking Technologies, Services, and Protocols; Performance of Computer and Communication Networks; Mobile and Wireless Communication Systems. Fourth International IFIP-TC6 Networking Conference (Networking 2005), LNCS 3462, 303–315.
27 M. Mandjes, P. Mannersalo, I. Norros (2005). Priority queues with Gaussian input: a path-space approach to loss and delay asymptotics. Proceedings ITC 19, 1135–1144.
28 M. Mandjes, P. Mannersalo, I. Norros (2005). Gaussian tandem queues with an application to dimensioning of switch fabrics. Computer Networks. CD-rom.
29 M. Mandjes, I. Saniee, A. Stolyar (2005). Load characterization, overload prediction, and load anomaly detection for voice over IP traffic. IEEE Transactions on Neural Networks 16, 1019–1028.
30 R. van de Meent, M. Mandjes (2005). Evaluation of 'user-oriented' and 'black-box' traffic models for link provisioning. Proceedings 1st EuroNGI Conference on Next Generation Internet Networks - Traffic Engineering. CD-rom.
31 R.D. van der Mei, M. Harkema (2005). Modelling end-to-end performance for transaction-based services in a distributed computing environment. B.D. Choi (ed.). Proceedings Korea-Netherlands Joint Conference on Queueing Theory and its Applications to Telecommunication Systems, 1–8.
32 R.D. van der Mei, B.M.M. Gijsen, J.L. van den Berg (2005). End-to-end response time analysis for transaction-based services in a distributed computing environment. B.D. Choi (ed.). Proceedings Korea-Netherlands Joint Conference on Queueing Theory and its Applications to Telecommunication Systems, 9–16.
33 R.D. van der Mei, H.B. Meeuwissen, F. Phillipson (2005). Realizing end-to-end Quality of Service for voice-over-IP in a heterogeneous multidomain network environment. Proceedings 19th International Teletraffic Congress, ITC-19, 1109–1120.
34 T.L. Olsen, R.D. van der Mei (2005). Periodic polling systems in heavy-traffic: renewal arrivals. Operations Research Letters 33, 17–25.
35 A. Pras, R. van de Meent, M. Mandjes (2005). QoS in hybrid networks: an operator's perspective. H. de Meer, N. Bhatti (eds). Proceedings IW-QoS 2005, LNCS Series 3552, 388–391.
36 W. Scheinhardt, N. van Foreest, M. Mandjes (2005). Continuous feedback fluid queues. Operations Research Letters 33, 551–559.
37 I.M. Verloop, S.C. Borst, R. Núñez-Queija (2005). Stability of size-based scheduling disciplines in resource-sharing networks. Performance Evaluation 62 (Proceedings Performance 2005s), 247–262.

38 W. van der Weij, R.D. van der Mei (2005). Stability and throughput in a two-layered network of multi-server queues. Proceedings 3rd international working conference on Performance Modeling and Evaluation of Heterogeneous Networks, HETNETs, P02, 1–8.
39 W. van der Weij, B.M.M. Gijsen, R.D. van der Mei, F. Phillipson (2005). Threadpool dimensioning in a two-layered tandem of multiserver queues. Proceedings 3rd international working conference on Performance Modeling and Evaluation of Heterogeneous Networks, HETNETs, P51, 1–8.
40 R. Yang, R.E. Kooij, R.D. van der Mei (2005). TCP performance modeling in the case of bi-directional packet loss. Proceedings 3rd international working conference on Performance Modeling and Evaluation of Heterogeneous Networks, HETNETs, P29, 1–8.
41 A.P. Zwart (2005). Heavy-traffic asymptotics for the single-server queue with random order of service (2005). Operations Research Letters 33, 511–518.
42 A.P. Zwart, S.C. Borst, K. Dębicki (2005). Reduced-load equivalence for Gaussian processes. Operations Research Letters 33, 502–510.
43 A.P. Zwart, S.C. Borst, K. Dębicki (2005). Subexponential asymptotics of hybrid fluid and ruin problems. Annals of Applied Probability 15, 500–517.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 S.C. Borst, A. Buvaneswari, L.M. Drabeck, M.J. Flanagan, J.M. Graybeal, K.G. Hampel, M. Haner, W.M. MacDonald, P.A. Polakos, G. Rittenhouse, I. Saniee, A. Weiss, P.A. Whiting (2005). Dynamic optimization in future cellular networks. Bell Labs Technical Journal 10, Special Issue on Future Wireless Communications, 99–119.

MSc Theses

1 I.M. Verloop (2005). Efficient flow scheduling in resource-sharing networks. Master thesis, CWI & UU.
2 K.M.C. van Wingerden (2005). Sojourn time approximations in queueing networks. Master thesis, CWI & UvT.

CWI reports

PNA-E0501, PNA-E0502, PNA-E0503, PNA-R0504, PNA-E0505, PNA-E0507, PNA-E0508, PNA-E0509, PNA-E0511, PNA-E0512, PNA-E0513, PNA-E0514, PNA-E0516, PNA-E0517, PNA-E0518.
See B.2 on page 201 for complete titles.

Technical reports published elsewhere

1 S.C. Borst, M. Jonckheere (2005). Flow-level stability of channel-aware scheduling algorithms. Technical Memorandum, Bell Labs, Lucent Technologies.
2 S.C. Borst, A. Proutière (2005). Capacity of wireless networks with intra- and inter-cell mobility. Technical Memorandum, Bell Labs, Lucent Technologies.
3 R. Egorova, A.P. Zwart, O.J. Boxma (2005). Sojourn time tails in the M/D/1 processor-sharing queue. SPOR Report 2005-05, Department of Mathematics and Computer Science, TUE.
4 K.P. Jagannathan, S.C. Borst, P.A. Whiting, E. Modiano (2005). Efficient scheduling of multi-user multi-antenna systems. Technical Memorandum, Bell Labs, Lucent Technologies.

PhD theses

1 R. Bekker (2005). Queues with state-dependent rates. TUE, December 12. Thesis advisors: O.J. Boxma and S.C. Borst.

Professional products

Contracts

- End-to-end Quality of Service in Next-generation Networks (EQUANET), funded by SenterNovem (partners: CWI, Lucent Technologies, TNO ICT, TUE, UT).
- Impact of Resource Sharing on Capacity and Performance of Multi-Service Wireless Networks (FLORIN), funded by France Télécom R&D.
- External consultancy for IT Architecten Leergang (ITAL), funded by IBM Nederland.

Publications for a broad audience

1 W. van der Weij (2005). Nooit meer wachten op het Internet. AEnorm 47, 11–14.

2 R.D. van der Mei, R.E. Kooij (2005). Het berekenen van kwaliteit van Internet-telefonie met wiskundige modellen. AEnorm 48, 22–27.
3 R.D. van der Mei, R.E. Kooij (2005). Gaat Internet-telefonie de wereld veroveren? Alubull 19 (2005), 21–29.

Contributions to documentaries or radio or TV broadcasting

1 Live radio interview on queueing phenomena in highway traffic jams. Dolce Vita, July 1: R.D. van der Mei.

Other output

Awards

- R. Bekker received the 2005 Applied Probability Trust prize.
- S.C. Borst was co-recipient of the 2005 Van Dantzig prize.

Grants

- NWO Open Competitie proposal 'Efficient scheduling in resource-sharing networks' (S.C. Borst, R. Núñez-Queija).
- NWO Open Competitie proposal 'Logarithmic asymptotics for Gaussian queues: characterization and analysis' (M.R.H. Mandjes).
- NWO GLANCE proposal 'Coordination with performance guarantees' (R.D. van der Mei).
- EU Network of Excellence proposal EURO-NGI (S.C. Borst, O.J. Boxma, M.R.H. Mandjes, R.D. van der Mei).
- ICES-KIS proposal BRICKS (S.C. Borst, R.J. Boucherie, O.J. Boxma, M.R.H. Mandjes; partners TUE, UT).

Stochastics – PNA3

As of January 1, 2006: Stochastic Dynamics and Discrete Probability

Mission

Theoretical and applied research at the frontiers of modern probability, in particular on problems motivated by biology,(geo-)physics, finance and technology.
Moreover, we consider it as an important task to detect and study new challenging international developments and make these known to the Dutch community by means of lectures, informal discussions and working groups.

The following subjects have our particular attention:

- Percolation models and, more generally, stochastic systems with a large number of interacting components; these are motivated by a variety of biological and physical processes and by problems concerning wireless communication networks. The tools used are mainly probabilistic, combinatorial and analytic.
- Modelling and spectral analysis of stochastic processes driven by fractional Brownian motion; such processes play an important role in mathematical finance and in modern queueing theory. The tools used here are mainly a mixture of probability and analysis (stochastic analysis).

Theme leader

Prof.dr. J. van den Berg

MSC or CR classification

60GXX, 60HXX, 60K35, 60K37, 62E20, 62GXX, 62MXX, 62P05, 62F12, 82B43, 82C22, 82C43, 91B28, 91B84, 92D25

Subthemes

Name	Leader
PNA3.1 – Probability	J. van den Berg
PNA3.2 – Stochastic Analysis	K.O. Dzhaparidze

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. J. van den Berg	0.8	theme leader, leader PNA3.1	indefinite	PNA3.1
Dr. C. Boutillier	1.0	postdoc	2005-11-01 till 2007-11-01	PNA3.1: NWO-CPE
Drs. R.M. Brouwer	1.0	PhD student	2001-02-01 till 2005-05-01	PNA3.1: NWO-SOC
Dr. K.O. Dzhaparidze	1.0	leader PNA3.2	indefinite	PNA3.2

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. F. Redig (UL)	0.05	advisor	2005-10-01 till 2008-10-01	PNA3
B. Vágvölgyi (VU-NWO)	0.2	PhD student	2005-09-01 till 2009-09-01	PNA3.1: VU
J.H. van Zanten (VU)	0.05	senior researcher	2003-10-01 till 2007-10-01	PNA3.2: NWO-AGP
P. Zareba (VU-NWO)	0.8	PhD student	2003-10-01 till 2007-10-01	PNA3.2: NWO-AGP

Scientific report

Highlights

- In October R. Brouwer successfully defended her PhD thesis, which marked the end of the Open Competition project NWO-SOC.
- A new project, Critical Percolation and Excitable Media (NWO, open competition), started in November 2005 with the appointment of postdoc C. Boutillier.

PhD students

R.M. Brouwer
B. Vágvölgyi
P. Zareba

PNA3.1 – Probability

Title	NWO-SOC: Mathematical models of biological and physical processes with self-organized critical behaviour
Period	2001–2005
Leader	J. van den Berg
Staff	R.M. Brouwer
Funding	NWO: salary Brouwer
Partners	M.S. Keane (Wesleyan and UvA), A. Járai (Ottawa).

Progress report. The paper 'Self-Organized Forest-Fires near the Critical Time', which studies relations between 2-dimensional percolation and certain forest-fire models, has been accepted for publication in *Comm. Math. Phys.*

A joint paper with J. Pennanen (Finland), in which classical results by Drossel, Clar and Schwabl on 1D forest fires are considerably sharpened, has been submitted for publication.

Brouwer has also analyzed an interesting modification of Aldous's frozen percolation model.

The project was successfully completed in October, when Brouwer received her PhD degree at VU.

Title	NWO-CPE: Critical Percolation and Excitable Media
Period	2005–2007
Leader	J. van den Berg
Staff	C. Boutillier
Funding	NWO (open competition): salary C. Boutillier
Partners	R. Kenyon, W. Werner, V. Sidoravicius, A. Járai.

Progress report. This project started in November with the appointment of postdoc Boutillier. Boutillier has prepared publications of his earlier work, and has been introduced into the new problems of this project.

Title	VU
Period	2005–2007
Leader	J. van den Berg
Staff	B. Vágvölgyi
Funding	NWO (via VU): salary B. Vágvölgyi
Partners	R. van der Hofstad, A. Járai, R. Meester

Progress report. This project started in September with the appointment of PhD student B. Vágvölgyi. Vágvölgyi has studied a new and quite general Russo-Seymour-Welsh theorem of Bollobas and Riordan. We could slightly improve this theorem and modify it for use in the 2-dimensional self-destructive percolation model (sdp) introduced by Van den Berg and Brouwer. In this way we could finally prove continuity of the sdp model in an important region of the parameters. A paper with Brouwer is in preparation. The focus has now shifted to high dimensions. For that reason Vágvölgyi started to study Gordon Slade's St. Flour lecture notes on the lace expansion.

Title	General research in probability theory
Period	indefinite
Leader	J. van den Berg
Staff	R.M. Brouwer, F. Redig
Funding	CWI, BRICKS (part of salary Van den Berg)
Partners	Cornell Univ. (H. Kesten); Chalmers Univ. (J. Steif and O. Häggström); Univ. Florence, (A. Gandolfi); VU (R. Meester, F. Camia); IMPA, Rio de Janeiro (V. Sidoravicius and M.E. Vares); Rutgers Univ. (J. Kahn)

Progress report. With J. Kahn (Rutgers Univ.) and O. Häggström (Gothenburg), we have considerably refined and extended our results on correlation-like inequalities. One paper on this subject appears in *Random Structures and Algorithms*; another paper, where we use a suitable dual version of these results to prove a 10-year old conjecture of N. Konno for the 1D contact process, will appear in a volume of the IMS lecture note series in honour of Mike Keane.

Progress has also been made on a model of 'Random growth in dangerous environment' (with V. Sidoravicius, M.E. Vares and Y. Peres): in the special case when one of the parameters is small, suitable bounds on the components that grow in this model can be given. However, the general case appears to be extremely difficult.

PNA3.2 – Stochastic Analysis

Title	ESF-AMaMeF - Advanced Mathematical Methods for Finance
Period	2005–2009
Leader	K.O. Dzhaparidze
Funding	ESF
Partners	J.H. van Zanten, P. Spreij (UvA), E. Valkeila (Helsinki Univ. Technology)

Progress report. The collaboration with the Helsinki team on fractional Brownian motion was carried on during 2 visits to Helsinki by Dzhaparidze. The following meeting with D. Gasbarra and E. Valkeila will take place at CWI in January 2006.

Title	NWO-AGP - Spectral analysis of processes with stationary increments
Period	2003–2007
Leader	K.O. Dzhaparidze
Staff	P. Zareba, J.H. van Zanten
Funding	NWO (through VU): salary Zareba
Partners	See project 'General research in stochastic analysis'

Progress report. The study of Gaussian processes with stationary increments was extended to isotropic random fields with homogeneous increments. The series expansion and moving average representation has been reported (see CWI report PNA-EO519) and a paper entitled 'Representations of isotropic random fields with homogeneous increments' has been submitted to *Journal of Applied Mathematics and Stochastic Analysis*.

Title	General research in stochastic analysis
Period	indefinite
Leader	K.O. Dzhaparidze
Staff	P. Zareba
Partners	Several, including INRIA and Univ. Aarhus, Berlin, Freiburg, Helsinki, Padua and Paris, P.J.C. Spreij (UvA)

Progress report. Dzaparidze and Van Zanten continued their study of Gaussian processes and fields with the help of spectral methods for vibrating strings. Van Zanten submitted to the journal *Stochastic Processes and their Applications* a paper 'When is a linear combination of independent fBm's equivalent to a single fBm?'

Societal aspects and knowledge transfer

External contacts

H. Kesten (Cornell Univ.), V. Sidoravicius and M.E. Vares (IMPA, Rio de Janeiro), J. Kahn (Rutgers Univ.), M.S. Keane (Wesleyan and UvA), B. Nienhuis and W. Kager (Theoretical Physics, UvA), the probability groups at EURANDOM/TUE, Leiden and VU, A. van Enter (Groningen, Theoretical Physics), W. Werner (Orsay), S. Shlosman (Marseille), R. Kenyon (Vancouver), M.A. Lifshits and Y. Davidov (Lille), M. Mania and N. Lazrieva (Tbilisi), G. Grimmett (Cambridge), J. Steif, A. Bandyopadhyay and O. Häggström (Gothenburg), B. Tóth and D. Szász (TU Budapest), A. Gandolfi (Florence), M. Aizenman (Princeton), Y. Peres (Berkeley), C. Maes (Leuven, Theoretical Physics), E. Valkeila and D. Gasbarra (Helsinki), A. Malyarenko (Vasteras, Sweden), A.M. Yaglom and M. Taqqu (Boston).

Project with partners in public and private sector

- ESF-AMaMef

Teaching at university

- Probability course at VU: J. van den Berg.

Organization of conferences, workshops, courses, meetings

- Spatial Stochastic Seminars at CWI: J. van den Berg (with M.N.M. van Lieshout (PNA4).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Workshop 'Dynamical Systems, Probability Theory and Statistical Mechanics', EURANDOM and Philips Research, January 3–7: J. van den Berg (Invited short presentation in honour of M. Keane), R. Brouwer.
- Workshop Markov Chains in Algorithms and Statistical Physics, MSRI, Berkeley, January 31–February 4: J. van den Berg (Invited talk: Conditional correlation inequalities for percolation and contact processes).
- Fractional Brownian days, Helsinki Univ., May 23–28: K.O. Dzhaparidze (Invited talk: Series representation for the Levi's fractional Brownian motion).
- Workshop Large-scale Behaviour of Interacting Particle Systems: Fluctuations and Hydrodynamics, August 22–26: J. van den Berg (Invited talk: Conditional correlation inequalities in static and dynamic contexts).
- Probability meeting, Chateau du Magnet, Chateauroux, September 5–9: J. van den Berg (Talk on percolation and contact processes), B. Vágvölgyi.
- Small Deviations Probabilities and Related Topics II, Saint-Petersburg, September 12–19: K.O. Dzhaparidze (Contributed talk: Representations of isotropic random fields with homogeneous increments, with applications to spatial fractional Brownian motion).
- Workshop Interacting Stochastic Systems, EURANDOM, September 20–23: J. van den Berg, B. Vágvölgyi.
- NDNS+ Workshop, Groningen, October 10–13: J. van den Berg.
- Stochastics meeting, Lunteren, November 14–16: J. van den Berg, B. Vágvölgyi.
- IV Congress of Georgian Mathematical Society, November 14–16: K.O. Dzhaparidze (Invited talk: Series representation for isotropic random fields with homogeneous increments).
- BRICKS Seminar Day on Algorithms and Processes in Life Sciences, November 29: J. van den Berg (Talk: Models of forest-fires and other excitable media).

Working visits

- Helsinki Univ. of Technology, September 19–23: K.O. Dzhaparidze

Visitors

- C. Boutillier (Orsay), February 9–10. Host: J. van den Berg.
- A. Járai, Ottawa, May 9–14. Host: J. van den Berg.
- B. de Lima, Univ. Belo Horizonte (Brazil), June 25–July 4. Host: J. van den Berg.
- B. Tóth (Techn.Univ. Budapest), October 5–8. Host: J. van den Berg
- V. Sidoravicius, IMPA, Rio de Janeiro, November and December. Host: J. van den Berg.

Memberships of committees and other professional activities

J. van den Berg

- Full professor at VU (part-time).
- Member of the scientific committee of the workshop 'Dynamical Systems, Probability Theory and Statistical Mechanics', EURANDOM and Philips Research, January 3–7.
- Member of the committee BCW (NWO OC).

Academic publications

Publications in refereed journals or proceedings

1 J. van den Berg, A. Járai (2005). On the asymptotic density in a one-dimensional critical forest-fire model Comm. Math. Phys. 253, 633–644.

2 J. van den Berg, O. Häggström, J. Kahn (2005). Some conditional correlation inequalities for percolation and related processes Random Structures and Algorithms online publication December 12 on www.interscience.wiley.com (DOI: 10.1002/rsa.20102).

3 K. Dzhaparidze, H. van Zanten, P. Zareba (2005). Representations of fractional Brownian motion using vibrating strings. Stochastic Process. Appl. 115(12), 1928–1953.

4 K. Dzhaparidze, H. van Zanten (2005). Krein's spectral theory and the Paley-Wiener expansion for fractional Brownian motion. Annals of Probability 33(2), 620–644.

5 K. Dzhaparidze, H. van Zanten (2005). Optimality of an explicit series expansion of the fractional Brownian sheet. Statistics and Probability Letters 71(4), 295–301.

6 A. Járai, F. Redig (2005). Thermodynamic limits of high-dimensional sandpile models, Probability Theory and Related Fields.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 H. van Zanten, P. Zareba (2005). A note on wavelet density deconvolution for weakly dependent data. (Available from `http://www.math.vu.nl/~harry`)

CWI reports

PNA-E0510, PNA-E0515, PNA-E0519, PNA-E0520.

See B.2 on page 201 for complete titles.

PhD theses

1 R. Brouwer (2005). Percolation, forest-fires and monomer-dimers. VU, October 6. Thesis advisor: J. van den Berg.

Professional products

Publications for a broad audience

1 J. van den Berg (2005). Kans en Ruimte, Inaugural Lecture, Faculteit Exacte Wetenschappen, VU, June 15.

Signals and Images – PNA4

Mission

Due to rapid advances in computation-, communication- and sensor-technology, lay-people and professionals alike are amassing large collections of digital documents such as music, movies, photographs, webpages, etc. Although potentially very valuable, the usefulness of these resources is largely deter-

mined by their accessibility, and it is becoming abundantly clear that in order to be effective, access needs to be based on image content and semantics. However, the extraction, (self-)organization and interpretation of semantic meta-data in terms of computationally accessible 'low-level' features still poses tremendous scientific challenges.

The Signals and Images group therefore conducts research on the geometrical and statistical properties of image models that are directly tied to perceptually relevant content. This necessitates a multidisciplinary approach which draws on fields as diverse as PDEs, information theory, (spatial) stochastic processes, statistical modelling and estimation theory, information retrieval, cognition, data mining and machine learning. As for the latter, we are particularly interested in the application of statistical learning to data-driven or adaptive multimedia processing.

In addition, we are exploring the role of multimodal integration in SenseNets, i.e., sensor networks equipped with substantial computational resources. In such networks multimodal sensor data can be compared and fused at different levels to improve overall robustness and performance. Again, this gives rise to interesting statistical problems, particularly in Bayesian reasoning and classification.

The expertise developed in this group is being applied to vision problems in remote sensing and image mining (e.g., in astronomy or bio-diversity), surveillance through multimodal sensor networks, industrial inspection and machine vision.

Theme leader

Dr.ir. H.J.A.M. Heijmans (till September 30), Dr. E.J. Pauwels (as of October 1)

MSC or CR classification

42C40, 42A38, 60D05, 60G55, 62H11, 62H35, 62M30, 62M40, 62H30, 68T37, 68T45, 68U10, 94A08

Subthemes

Name	Leader
PNA4.1 – Image Understanding, Retrieval, and Indexing	E.J.E.M. Pauwels
PNA4.2 – Image Representation and Analysis	H.J.A.M. Heijmans
PNA4.3 – Stochastic Geometry	M.N.M. van Lieshout

PNA4.1 investigates mathematical methodologies to generate content-specific descriptions of images and video, for the purpose of robust indexing, understanding and retrieval from large databases.

PNA4.2 deals with multi-resolution signal and image representations in general, and methods in wavelet analysis and mathematical morphology in particular. Furthermore, it seeks to use such representations for problems in image analysis and coding. In addition, this group has recently branched out in biometrics.

PNA4.3 is concerned with the modelling and analysis of random geometric structures using techniques from spatial statistics and stochastic geometry.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
S. Bonchev	1.0	PhD Student	2004-06-01 till 2005-01-31	PNA4.2: BASIS
Dr.ir. H.J.A.M. Heijmans	1.0	theme leader (till 30-9), leader PNA4.2	indefinite	PNA4.2: BRICKS

continued on next page

continuation from previous page

Dr.ir. M.J. Huiskes	1.0	researcher	2001-08-01 till 2006-03-01	PNA4.1: MUSCLE, IU-CBIR
Dr. M.N.M. van Lieshout	0.8	researcher, leader PNA4.3	indefinite	PNA4.3: SEQ, MUSCLE
Dr. E.J.E.M. Pauwels	0.85	theme leader (as of 10-01), leader PNA4.1	indefinite	PNA4.1: IU-CBIR, PHOTO-ID, MUSCLE
Dr. R. Péteri	1.0	ERCIM Fellow	2004-10-11 till 2005-07-10	PNA4.1: MUSCLE
Dr. E.B. Ranguelova	1.0	researcher	2003-01-01 till 2007-08-31	PNA4.1: PHOTO-ID
Dr. B.A.M. Schouten	0.8	researcher	2004-05-01 till 2008-05-01	PNA4.2: BIOSECURE, BRICKS, BASIS
Dr. V.V. Shcherbakov	1.0	researcher	2004-03-01 till 2006-03-01	PNA4.3: SEQ, until mid November
A.G. Steenbeek	0.4	programmer	indefinite	PNA4.3: SEQ
Dr. J.W.H. Tangelder	1.0	researcher	2004-11-01 till 2006-10-31	BRICKS
Dr. P.M. de Zeeuw	0.90	programmer	indefinite	PNA4.1: MUSCLE; PNA4.2: NUMIP

Scientific Report

Highlights

- As WG-leader, E.J.E.M. Pauwels received the ERCIM's Best Working Group Award for the WG on Image and Video Understanding at the ERCIM meeting in Helsinki on May 29.
- E.J.E.M. Pauwels was supervisor and examiner of Greet Frederix's PhD thesis Beyond Gaussian Mixture Models: Unsupervised Learning with Applications to Image Analysis. (KU Leuven, Belgium, May 7)

PNA4.1 – Image Understanding, Retrieval, and Indexing

Title	MUSCLE – Multimedia Understanding through Semantics and Computation Learning
Period	March 2004–February 2007
Leader	E.J.E.M. Pauwels
Staff	M. Brouwer, M.J. Huiskes, P.M. de Zeeuw, M.N.M. van Lieshout
Funding	EU
Partner	42 European labs, see http://www.muscle-noe.org

Progress report. MUSCLE is a European Network of Excellence that aims at creating and supporting pan-European collaboration between research groups in multimedia data mining on the one hand, and machine learning on the other. In particular, MUSCLE teams intend to collaborate to harness the full potential of machine learning and cross-modal interaction for the (semi-)automatic generation of meta-data with high semantic content for multimedia documents.

Pauwels is in charge of the overall scientific coordination and organized a successful scientific meeting (April 27–29, Paris) which was attended by over 100 researchers. In addition, PNA4.1 was instrumental in setting up the scientific coordination and integration web-services that facilitates collaboration between the different network teams. In addition, PNA4.1 contributed to the network's scientific objectives through work on clustering, semi-supervised learning and the characterization of dynamic textures.

In collaboration with Peteri, Huiskes has set up the DynTex database of dynamic textures. Currently work is in progress to set up an international benchmark in the field of dynamic texture based on the texture sequences in the database.

Title	IU-CBIR – Visual saliency detection and image understanding
Period	indefinite
Leader	E.J.E.M. Pauwels
Staff	M.J. Huiskes
Funding	CWI
Partners	P. Pianezza (Pianezza, SRL, Italy), K. Noonan (ColourInterlink, Belgium)

Progress report. This project focuses on generic methodologies for content-based image re-

trieval (CBIR) and covers topics such as saliency detection, feature extraction and feature selection, relevance feedback and machine learning applied to image analysis.

Huiskes has extended his aspect-based relevance learning approach with various active learning and interaction strategies. This has led to the development of the Aspect Explorer system for content-based image retrieval. Additionally, work is in progress on machine learning methods for image classification based on segment properties and their relations by means of neuro-evolution of augmenting topologies.

Title	PHOTO-ID – Photo-ID for cetaceans using shape matching methods
Period	September 2004–Augustus 2007 (3 years)
Leader	E.J.E.M. Pauwels
Staff	E.B. Ranguelova
Funding	NWO (Wiskunde Toegepast)
Partners	CML (UL), Sea Watch Foundation (Oxford), The International Whaling Commission, St Andrews Univ. (UK), College of the Atlantic (Maine, USA)

Progress report. The work in the PHOTO-ID project involved further development of the semi-automatic system for humpback whale identification. In particular, a binary salient pattern detector has been proposed and implemented for the automatic detection of arbitrary form markings on the segmented flukes. A method for matching the extracted salient patterns in combination with grid region features has been developed. Thus a complete system involving fluke segmentation, feature extraction and matching of humpback whales has been created. The system has been tested on a database provided by an expert from the College of the Atlantic (Maine, USA) and had shown excellent result. The PNA 4.1 team also contributed to a number of public demonstrations and workshops to train the marine biologists to use the system.

Similar techniques have been employed for elephant identification in collaboration with students from UL. We have also used a global PDE-based shape descriptor in combination with salient pattern descriptor in the tree leaf classification application.

The current research involves robust colour segmentation and salient patterns detection and description for dolphins' dorsal fin extraction and matching. The tools investigated involve directional filters, multi resolution center-surround fields' etc.

Title	NUMIP - Numerical Methods for Image Processing
Period	indefinite
Staff	P.M. de Zeeuw
Funding	CWI (basic funding)
Partners	p.m.

Progress report. This research seeks to integrate multigrid methods for the numerical solution of PDEs with image processing. In 2005 the research focused on the application of an isotropic but inhomogeneous diffusion operator to an image function followed by a pyramidal decomposition using typical multigrid operators. It lead to a new nonlinear multiresolution scheme with little or no blurring of edges at approximations on coarser grids. The results have led to a publication in Springer's Lecture Notes in Computer Science and in CWI report PNA-E0506 (under review for publication).

PNA4.2 – Image Representation and Analysis

Title	BIOSECURE
Period	July 2004–July 2007
Leader	B.A.M. Schouten
Staff	J.W.H. Tangelder, S. Bonchev
Funding	EU (project funding)
Partners	30 Partners in Image Analysis, Biometrics and Vision throughout Europe, see http://www.biosecure.info

Progress report. The main objective of this network is to strengthen and integrate multidisciplinary research efforts in order to investigate biometrics-based identity authentication methods, for the purpose of meeting trust and security requirements in our progressively more pervasive digital information society. A large place will be given to dissemination through large scale events (i.e., conferences, common evaluation campaigns and advanced research institutes). These efforts will bring the community together and will facilitate the technology transfer to industry. PNA4.2. is in charge of the WP Biometrical Systems and Applications and is a member of the steering board. In June a masterclass was given at the 2nd Summer School for Advanced Studies on Biometrics for Secure Au-

thentication: Multimodality and System Integration, Alghero, Italy. CWI contributed to the research for face recognition and system design, through deliverables and scientific papers.

Title	BASIS
Period	July 2004–July 2008
Leader	B.A.M. Schouten, S. Bonchev
Funding	SenterNovem IOP GENCOM (project funding)
Partners	UT, TUE, Philips.

Progress report. The goal of this project is to investigate the possibilities of biometric authentication for securing the access to information and services in the personal environment, with a focus on user convenience and privacy protection. The project addresses (a) the problem of transparent biometric authentication as a means to enhance user convenience, (b) the problem of anonymous biometric authentication as a means to protect the user's privacy, and (c) the specific problems of the use of biometric authentication in the home environment. These three issues are addressed in three work packages: Transparent Biometrics, Template Protection and Home Biometrics. CWI is WP leader for Home Biometrics.

Title	Biometrics and Digital Watermarking
Period	May 2004–May 2011
Leader	B.A.M. Schouten
Staff	J.W.H. Tangelder
Funding	Dutch Bsik Theme ICT
Partners	UT, Associate Partners: Enschede/SDU, Nederlands Biometrie Forum (Knopjes), Ministry of Justice, TNO.

Progress report. One of the most crucial questions in any transaction is the identity of the entity (person) with whom the transaction is being conducted. Historically, personal relationships, face-to-face contract signings, notaries, and third party counsel are used to help establish trust in this most important aspect of conducting our business. As the reliance on paper shifts to electronic transactions and documents, so must the reliance on traditional trust factors shift to electronic security measures to authenticate before engaging in the exchange of information, goods, and services. The research project Biometrics and Digital Watermarking (PDC1.1.) as part of the BRICKS research programme aims at authentication protocols in networked and distributed systems and researches upon face recognition in particular. New research is targeted towards sensing and authentication in smart environments, using sensor networks.

PNA4.3 – Stochastic Geometry

Title	MUSCLE - Multimedia Understanding through Semantics, Computation and Learning
For further information see page 50	

Progress report. R. Kluszczyński (Torún), Van Lieshout, and Schreiber developed a novel algorithm for binary image segmentation based on polygonal Markov fields. The idea was to formulate image segmentation as a statistical estimation problem for a Gibbsian modification of an underlying polygonal Markov field, and to use Monte Carlo techniques, including novel Gibbs updates for the Arak model, to estimate the model parameters and to find an optimal partition of the image. The approach was applied to image data, the first published application of polygonal Markov fields to segmentation problems in the mathematical literature.

Title	SEQ - Sequential point processes
Period	March 2004–March 2006
Leader	M.N.M. van Lieshout
Staff	V.V. Shcherbakov
Funding	STW (Wiskunde Toegepast)
Partners	Centrum voor Milieukunde Leiden, FOM-AMOLF, ITC, Kapteyn Instituut, Philips Research

Progress report. A finite sequential spatial process is a vector of random length with components in some complete separable metric space. Examples include locally scaled point processes, random sequential adsorption, and occlusion models for object configurations in images. In contrast to classic point processes, the joint distribution of the components is not necessarily symmetric.

Van Lieshout laid the measure-theoretic foundations for finite sequential spatial processes. She showed how to carry out exterior conditioning by defining a suitable notion of conditional intensity which can be used to define Markovianity. She also proved a Hammersley–Clifford factorization.

With Steenbeek, a software library was developed to simulate a range of sequential spatial

processes by means of spatial birth-and-death processes and Metropolis-Hastings techniques. Convergence of these algorithms was formally proved.

From a statistical point of view, Van Lieshout proved existence and uniqueness of a maximum likelihood estimator for the time and range parameters in random sequential adsorption models, and estimated nuisance parameters of the reference distribution by means of profile likelihoods.

In collaboration with C. Varekamp (Philips Research), Van Lieshout is studying the use of Markov sequential object processes as priors in the high-level computer vision problem of tracking moving objects, that is the dual task of recognising the objects in an image sequence, and following their movements throughout the sequence. This work shall be continued in 2006.

Shcherbakov carried out a simulation study concerning the formation of clusters in cooperative sequential adsorption models, and fitted such a model to harbour porpoise data.

Societal aspects and knowledge transfer

External contacts

- Innovista (www.inovista.biz). SME Knowledge transfer for robust applications in intelligent video surveillance.

Projects with partners in public and private sector

- MUSCLE; see page 50.
- BRICKS; see page 52.
- SEQ; see page 52.
- BIOSECURE; see page 51.

Courses, Tutorials

- Biometrical Systems and Applications; 2nd Summer School for Advanced Studies on Biometrics for Secure Authentication: Multimodality and System Integration, Alghero, Italy, June 6–10: B.A.M. Schouten.

Organization of conferences, workshops, courses, meetings

- Signals and Images Seminar (bi-weekly): M.J. Huiskes.
- Spatial Stochastics Seminar (bi-weekly): M.N.M. van Lieshout in collaboration with J. van den Berg (PNA3).
- PNA Colloquium (bi-monthly until July 1): M.N.M. van Lieshout in collaboration with A. Schrijver (cluster leader).
- Organizer and chair 3rd MUSCLE Scientific Meeting, Paris, April 27–29: E.J.E.M. Pauwels.
- Bijeenkomst Stochastici, Lunteren, November 14–16: M.N.M. van Lieshout (assisted by CPD/CBI), in colloboration with R.D. Gill (UU) and M.S. Keane (Wesleyan).
- Organizer on behalf of the Bernoulli Society of session on 'Spatio-temporal models' at the 26th European Meeting of Statisticians to be held in Torún, Poland, July 2006: M.N.M. van Lieshout.
- EUROPHLUKES Photo-Identification Workshop,
  European Cetacean Society annual conference, La Rochelle, France, April 2:
  E.J.E.M. Pauwels, E.B. Ranguelova.
- 4th BioSecure Steering Board Meeting, CWI Amsterdam, April 12: B.A.M. Schouten.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Workshop 'Dynamical Systems, Probability Theory and Statistical Mechanics' Eurandom and Philips Research, Eindhoven, January 3–7: M.N.M. van Lieshout.
- Annual General Meeting Section Mathematical Statistics of the Netherlands Society for Statistics and Operational Research, UvA, January 27: M.N.M. van Lieshout.
- Meeting for PhD students under auspices of Section Mathematical Statistics of the Netherlands Society for Statistics and Operational Research, UvA, February 3: M.N.M. van Lieshout.
- Workshop Stochastic Geometry and Spatial Statistics, Freudenstadt, Germany, February 27–March 3: M.N.M. van Lieshout (Main speaker: Image segmentation by multi-coloured polygonal Markov fields).
- European Cetacean Society (ECS) conference, La Rochelle, France, April 2: E.B. Ranguelova, E.J.E.M. Pauwels.

- Scale Space 2005, Hofgeismar, Germany, April 7–9: P.M. de Zeeuw (Poster: A multigrid approach to image processing).
- Statistische Dag, VU, April 11: M.N.M. van Lieshout, B.A.M. Schouten, V.V. Shcherbakov.
- Joint BeNeLuxFra Conference in Mathematics, Ghent, Belgium, May 20–21: M.N.M. van Lieshout (Invited talk: Markov sequential spatial processes).
- CAID & CD 2005 Conference, Delft, the Netherlands, May 29–June 1: J.W.H. Tangelder (Talk: A multi-sensor architecture for human-centered smart environments).
- 2nd Summer School for Advanced Studies on Biometrics for Secure Authentication: Multimodality and System Integration, Alghero, Italy, June 6–10: J.W.H. Tangelder.
- 30th Conference on Stochastic Processes and their Applications, Santa Barbara, USA, June 26–July 1: V.V. Shcherbakov (Talk: Cooperative sequential adsorption and related sequential Markov point processes).
- Workshop 'Talking Heads', Nederlands Forensisch Instituut & PNA4, Ypenburg, the Netherlands, July 5: J.W.H. Tangelder, B.A.M. Schouten.
- Fourth International Conference on Image and Video Retrieval 2005, Singapore, July 20–22: M.J. Huiskes (Poster: Aspect-based Relevance Learning for Image Retrieval).
- 25th European Meeting of Statisticians, Oslo, Norway, July 23–29: M.N.M. van Lieshout (Talk: Markov sequential spatial processes), V.V. Shcherbakov (Talk: Cooperative sequential adsorption and related sequential Markov point processes).
- International Conference on Machine Learning (ICML'05), Workshop on Machine Learning Techniques for Processing Multimedia Content, Bonn, Germany, August 8–11: M.J. Huiskes (Talk: Addressing Partial Relevance in Image Retrieval through Aspect-based Relevance Learning).
- PDE-Based Image Processing and Related Inverse Problems, CMA, Oslo, Norway, August 8–12: P.M. de Zeeuw (Talk: The multigrid image transform).
- EBF Research Seminar, Brussels, Belgium, September 15: B.A.M. Schouten (Lecture: Biometrics & Vision of the Future).
- Presentation PDC1 on Sentinels Security Day, Amsterdam, the Netherlands, September 29: B.A.M. Schouten.
- Stochastic Geometry and its Applications, Bern, Switzerland, October 2–7: M.N.M. van Lieshout (Invited talk: J-functions for marked point patterns).
- Third Cost 275 Workshop: 'Biometrics on the Internet', Hertfordshire, UK, October 27–28: B.A.M. Schouten (Talk: Non-Intrusive Face Verification by a Virtual Mirror Interface using Fractal Codes), J.W.H. Tangelder.
- 9th SAFE-NL workshop, TNO Delft, the Netherlands, November 8: B.A.M. Schouten (Invited talk: Human Awareness in Intelligent System).
- Bijeenkomst Stochastici, Lunteren, November 14–16: M.N.M. van Lieshout, V.V. Shcherbakov.
- ICGST International Conference on Graphics, Vision and Image Processing (GVIP-05), Cairo, Egypt, December 19–21: E.B. Ranguelova (Talk: Saliency Detection and Matching Strategy for PHOTO-Identification of Humpback Whales).

Working visits

- Prof. Horvath, Faculty Industrial Design, TUD, March 1: J.W.H. Tangelder, B.A.M. Schouten, E.J.E.M. Pauwels.
- User Committee, STW project: 'Freeform shape techniques for improved product design', Faculty Industrial Design, TUD, March 10: J.W.H. Tangelder.
- Astron, Dwingelo, September 21: M.J. Huiskes, E.J.E.M. Pauwels, M.N.M. van Lieshout, E.B. Ranguelova, V.V. Shcherbakov.
- Participation and presentation Sentinels Security Day, Amsterdam, September 29: J.W.H. Tangelder, Ben Schouten,
- Dr. M. Månsson, Chalmers Univ. of Technology, Gothenburg, December 14–17: M.N.M. van Lieshout.
- Innovista, CWI, December 20: M.J. Huiskes, E.J.E.M. Pauwels, E.B. Ranguelova, B.A.M. Schouten, J.H.W. Tangelder.

Project meetings

- Second meeting users' committee STW project 'Markov sequential point processes for image analysis and statistical physics', CWI, Amsterdam, March 30: M.N.M. van Lieshout, V.V. Shcherbakov (with a presentation each).

- Third Scientific Meeting of EU FP6 Network of Excellence Multimedia Understanding through Semantics, Computation and Learning, ENST, Paris, April 27–29: M.J. Huiskes, M.N.M. van Lieshout (Lecture: Segmentation by means of Arak mosaics), E.J.E.M. Pauwels.
- Joint WP5 and WP7 First Focus Meeting, MUSCLE, Rocquencourt, France, December 1–2: M.J. Huiskes (Presentation: Visual Saliency at CWI), E.B. Ranguelova.
- 3rd BioSecure Steering Board Meeting, Univ. Surrey, Guildford, UK, January 10: B.A.M Schouten.
- 5th BioSecure Steering Board Meeting, Porto Conte Research Centre, Alghero, Italy, June 7: B.A.M Schouten.
- 6th BioSecure Steering Board Meeting, GET, Paris, France, August 26: B.A.M Schouten.
- Public Forum of the BioSecure Network, Paris, France, September 13: B.A.M Schouten.
- 1st Year Review of the BioSecure Network, Paris, France, September 13: B.A.M Schouten.
- General Assembly of the BioSecure Network, Paris, France, September 14: B.A.M Schouten.
- 7th BioSecure Steering Board Meeting, Otto-von-Guericke Univ. Magdeburg, Germany, November 14: B.A.M Schouten.

Other lectures

- Utrecht, March 2: V.V. Shcherbakov (Cooperative sequential adsorption and related sequential Markov point processes).
- TTT seminar INS1 (Database architectures and information access), CWI, September 22: M.J. Huiskes (Aspect-based relevance learning for image retrieval).

Visitors

- C. Varekamp, Philips Research, April 8. Host: M.N.M. van Lieshout.

External speakers for the Signals and Images seminar

- R. van Lier, Nijmegen Institute for Cognition and Information (NICI), RU, 'From images to interpretations', January 12.
- W. Kreiken and W. van Vliet, Institute of Environmental Sciences, UL, 'Elephind - Computer-aided Photo Identification on African Elephants', February 9.
- P. Min, Center for Geometry, Imaging, and Virtual Environments, Institute of Information and Computing Sciences, UU, 'Modeling by example', February 23.
- M. Pantic, Multimodal Man-Machine Interaction, Electrical Engineering / Computer Sciences, TUD, 'Learning spatiotemporal models of facial expressions', May 18.
- A. Jalba, Department of Mathematics and Computing Science, RUG, 'Efficient methods for semi-automatic image segmentation', June 1.
- E. Bovenkamp, Division of Image Processing, Department of Radiology, Univ. Medical Centre, Leiden, 'Collaborative multi-agent medical image segmentation', June 15.
- J. Bijhold, Netherlands Forensic Institute, 'Wanted: Dead or Alive – Investigation of Photo and Video Evidence at the Netherlands Forensic Institute (NFI)', June 29.
- M. Rouw, Hogeschool voor de Kunsten Utrecht, 'Meaningful Image Spaces', October 5.
- A. Coers Institute of Environmental Sciences, UL, 'Coral cover quantification through (semi)automated photo analysis', October 26.
- T. Moons, Economic and Applied Economic Sciences, Catholic Univ. Brussels, 'Reconstructing a 3-dimensional scene from digital images: A mathematician's point of view', November 16.
- P. Kemper, Kapteyn Institute, Department of Astronomy, RUG, ASTRON, Dwingelo, 'A multi-scale approach to automated feature extraction from HI data cubes', December 7.
- M. Tanase, Center for Geometry, Imaging, and Virtual Environments, Institute of Information and Computing Sciences, UU, 'Matching and Indexing through Shape Decomposition', December 14.

Memberships of committees and other professional activities

E.J.E.M. Pauwels

- External examiner of Beatrice Pesquet-Popescu's Habilitation à Diriger des Recherches de l'Université de Nice Sophia-Antipolis entitled Scalabilité et robustesse en codage vid'eo.
- Supervisor and examiner of Greet Frederix's PhD thesis Beyond Gaussian Mixture Models:

Unsupervised Learning with Applications to Image Analysis. KU Leuven, Belgium, May 7.
- Rapporteur Marin Ferecatu's PhD thesis Image retrieval with with active relevance feedback using both visual and keyword-based descriptors. Univ. Versailles and INRIA Rocquencourt, July 1.
- Invited EC-expert at FP7 Knowledge and Content Brainstorming Session at EWIMT 2005, London, November 30.
- Referee for various journals.

M.N.M. van Lieshout

- External examiner of PhD thesis 'Non-overlapping germ-grain models: Characteristics and material modelling' by J. Andersson, Chalmers Univ. of Technology, Gothenburg, Sweden, December.
- Referee for various journals.
- Member of RSS, Bernoulli Society, NVPHBV, Koninklijk Wiskundig Genootschap, VVS.

B.A.M. Schouten

- Evaluator FP6, Information Society Technologies, FET Open Program, European Committee , 2005
- Member of the Board, Head of R&D, European Biometrics Forum, Dublin (IRL) 2005
- Member of the Board, Head of R&D, Dutch Biometric Forum (NL) 2005

P.M. de Zeeuw

- Evaluation of a ZAP application for a chair at the KU Leuven, Belgium.
- Referee for various journals.

Academic publications

Publications in refereed journals or proceedings

1 P.M. de Zeeuw (2005). A multigrid approach to image processing. Proceedings of Scale Space 2005. R. Kimmel, N. Sochen, J. Weickert (eds). LNCS 3459, Springer-Verlag, 396–407.

2 E.B. Ranguelova, E.J.E.M. Pauwels (2005). 'Saliency Detection and Matching Strategy for PHOTO-Identification of Humpback Whales'. ICGST International Conference on Graphics, Vision and Image processing (GVIP05), 81–88 (Best paper award).

3 M.J. Huiskes (2005). 'Aspect-based Relevance Learning for Image Retrieval'. W.-K. Leow et at. (eds). International Conference on Video and Image Retrieval (CIVR'05), LNCS 3568, 639–649.

4 M.J. Huiskes (2005). 'Addressing Partial Relevance in Image Retrieval through Aspect-based Relevance Learning'. International Conference on Machine Learning (ICML'05), Workshop on Machine Learning Techniques for Processing Multimedia Content. CD-rom.

5 E.J. Pauwels (2005). 'FP6 Network of Excellence MUSCLE: Multimedia Understanding through Semantics, Computation and Learning'. Proceedings of EWIMT 2005, London, 385–390.

6 M.N.M. van Lieshout, R. Kluszczyński, T. Schreiber (2005). An algorithm for binary image segmentation using polygonal Markov fields. F. Roli and S. Vitulano (eds). Proceedings of the 13th International Conference on Image Analysis and Processing, LNCS 3617, 383–390.

7 B.A. Schouten, J.W. Tangelder (2005). Non-intrusive face verification by a virtual mirror interface using fractal codes. Proceedings Biometrics on the Internet - Third COST 275 Workshop 89–92.

8 J.W. Tangelder, B.A. Schouten, S. Bonchev (2005). A multi-sensor architecture for human-centered smart environments. Proceedings CAID&CD 2005 Conference.

Publications in other journals or proceedings and other scientific output

CWI reports

PNA-E0504, PNA-E0506, PNA-R0501, PNA-R0503, PNA-R0505, PNA-R0506.
See B.2 on page 201 for complete titles.

Software developed

- M.N.M. van Lieshout and A.G. Steenbeek. EQ-MPPLIB.
- P.M. de Zeeuw. NUMIP combined Fortran and Matlab software for the multigrid image transform.
- E.B. Ranguelova, E.J.E.M. Pauwels. PhlukePhinder and PhlukeMatcher: Matlab software for segmentation of flukes of humback whales, salient patches extraction and matching systems.

- M.J. Huiskes. Aspect Explorer retrieval system.
- M.J. Huiskes, E.J.E.M. Pauwels. Image understanding toolbox (in progress).
- R. Peteri, M.J. Huiskes. DynTex: Dynamic Texture Database.

Deliverables for projects

- Report on standardization activities Actual Date of Completion: February 28. Authors: Fi. Deravi, R. Ng, J.W.H. Tangelder, B.A.M. Schouten, B. Dorizzi.
- Specification of activities on future research activities. Actual Date of Completion: March 25. Authors: B.A.M. Schouten, J.W.H. Tangelder, and G. Parziale.
- Critical items and elements in biometrics systems Actual Date of Completion: March 29. Authors: G. Parziale, B.A.M. Schouten, and J.W.H. Tangelder.

Book chapters

1 M.J. Huiskes, E.J. Pauwels (2005). Indexing, Learning and Content-based Retrieval for Special Purpose Image Databases. M. Zelkovich (ed.). Advances in Computers. Elsevier, 204–259.

Professional products

Publications for a broad audience

1 M. van Lieshout (2005). Interview about work with R. Kluszczyński and T. Schreiber on image segmentation by polygonal markov fields (in Dutch), March. CWI Mededelingen.

2 B.A.M. Schouten (2005). Wie lacht wordt uit de rij gehaald. Natuur Wetenschap & Techniek. July/August 2005, interview, E. Verdult.

Other output

Grants

- M.N.M. van Lieshout. STW grant CWI.6156. Markov sequential point processes for image analysis and statistical physics.
- E.J.E.M. Pauwels is scientific coordinator of the FP6 Network of Excellence for Multimedia Understanding through Semantics, Computation and Learning (MUSCLE, FP6-507752, 2004-2007). Other CWI members are M.N.M. van Lieshout, M.J. Huiskes, P.M. de Zeeuw, T. Schreiber and M.W. Brouwer.

Cryptology and Information Security – PNA5

Mission

Cryptology deals with mathematical techniques for design and analysis of algorithms and protocols for digital security in the presence of malicious adversaries. For example, encryption and digital signatures are used to construct private and authentic communication channels, which are instrumental to secure internet transactions. Another example of increasing importance is secure computation, which in principle enables an arbitrary computation to be distributed among the processors in a network so that computations remain secret and are performed correctly, even if a certain quorum of the network is under full control by an adversary. Advancing our understanding of secure communications and secure computation are among the primary goals in cryptology. It is fascinating and promising that the connection between cryptology and fields such as algebra, number theory, geometry, complexity theory, quantum physics and information theory is in the process of becoming still deeper than ever before.

Focal points in the research of PNA5 are mathematics of cryptology, secure computation, formal security models (universal composability), public key cryptography (chosen ciphertext security for encryption, digital signatures), information theoretically secure cryptography (secret key establishment from correlated randomness by public discussion, privacy amplification, bounded storage model, secret sharing, algebraic and number theoretical aspects of secure multi-party computation), quantum cryptography (key exchange, protocols), the Number Field Sieve Project for factoring large integers, which is relevant to the security of the widely used RSA cryptosystem, as well as other issues in computational number theory with relevance for cryptology, and discrete tomography.

Theme leader

Prof.dr. R.J.F. Cramer

MSC or CR classification

94A60, 11Yxx, 11T71, 94A15, 81P68, E.3, E.4, F.2, G.2

Subthemes

Name	Leader
PNA5.1 – Mathematics of Cryptology	R.J.F. Cramer
PNA5.2 – Computational Number Theory and Discrete Tomography	H.J.J. te Riele

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. K.J. Batenburg (NWO)	1.0	PhD student	2002-09-01 till 2006-08-30	PNA5.2
Prof.dr. R.J.F. Cramer (0.2 Leiden)	0.8	leader PNA5.1	indefinite	PNA5.1
Drs. W.H. Ekkelkamp (NWO)	1.0	PhD student	2004-02-01 till 2004-01-31	PNA5.2
Dr. S. Fehr	1.0	postdoc	2004-08-01 till 2008-07-31	PNA5.1
Drs. R. de Haan	1.0	PhD student	2004-11-01 till 2008-10-31	PNA5.1
Dr. D. Hofheinz	1.0	postdoc	2004-10-01 till 2008-08-30	PNA5.1
Dr. E. Kiltz (STW Sentiels)	1.0	postdoc	2004-09-01 till 2007-09-31	PNA5.1
Prof.dr. A.K. Lenstra (EPF Lausanne)	0.1	advisor	2004-10-01 till 2008-09-31	PNA5.1
Dr.ir. H.J.J. te Riele	1.0	leader PNA5.2	indefinite	PNA5.2

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. P.L. Montgomery (Microsoft Research)	p.m.	advisor	indefinite	
Prof.dr. C. Padró (UPC Barcelona)	1.0	visiting professor PNA5.1	2005-09-012006-01-31	PNA5.1
Dr. L.A.M. Schoenmakers (TUE)	0.4	visiting scientist	2004-09-01 till 2005-08-30	PNA5.1

Scientific report

PhD students

K.J. Batenburg
W.H. Ekkelkamp
R. de Haan

PNA5.1 – Mathematics of Cryptology

Title	PASC – Practical Approaches to Secure Computation
Period	2004–2009
Leader	R.J.F. Cramer
Staff	E. Kiltz
Funding	STW
Partners	Philips Research, TUE (2 Phd students)

Progress report. Kiltz, together with I. Damgaard, M. Fitzi, J.B. Nielsen and T. Toft (Aarhus) finished his work on unconditionally secure constant-rounds multi-party computation for equality, comparison, bits and exponentiation.

Kiltz, together with J. Malone-Lee and N.G. Leander (Bochum) finished his work on secure cmputation of the mean.

Kiltz, together with Weinreb (Ben-Gurion), works on secure linear algebra.

Cramer and Kiltz, together with Padró, are working on application of the theory on Moore-Penrose pseudo-inverses to secure linear algebra.

Cramer and De Haan are working on low-communication secure multi-party multiplication.

Title	PDC 1-2 – Mathematical Cryptology
Period	2004–2009
Leader	R.J.F. Cramer
Staff	two Phd students, S. Fehr, R. de Haan
Funding	CWI, Bsik BRICKS
Partners	Aarhus Univ., UL, Bristol Univ., UPC Barcelona, EPFL

Progress report. Padró is working on matroidal aspects of secret sharing.

Cramer and De Haan, together with S. Agarwal (Aarhus) developed a new protocol for secure multi-party multiplication with significantly smaller communication complexity.

Cramer and Fehr, together with H.W. Lenstra (Leiden) and M. Stam (Bristol) finished their work on blackbox secret sharing and primitive sets in number fields.

Cramer, together with Padró et al., finished his work on the relationship between algebraic secure computation, matroids and linear error correcting codes.

Cramer is working on algebraic geometric aspects of secure computation (manuscript).

Cramer, Goldwasser and Vaikunathan are working on secure computation.

Cramer and Fehr, together with Padró, are working on algebraic manipulation detection codes (manuscript).

Title	Quantum Cryptology and Information Theory
Period	2005–indefinite
Leader	R.J.F. Cramer
Staff	D. Hofheinz
Funding	CWI
Partners	Aarhus Univ., ETH Zürich

Progress report. Fehr, together with I. Damgaard, L. Salvail and Ch. Schaffner (Aarhus), is working on information-theoretical reductions for oblivious transfer. Fehr, together with I. Damgaard and L. Salvail (Aarhus), completed his work on oblivious transfer in the bounded quantum storage model.

Title	Formal methods and simulatability
Period	2005–indefinite
Leader	R.J.F. Cramer
Staff	D. Hofheinz
Funding	CWI
Partners	IBM Zürich, IBM T.J. Watson, Univ. Saarbrücken, Univ. Karlsruhe

Progress report. Hofheinz has various ongoing projects with M. Backes (Saarland) on simulatability, and with J. Malone-Lee (Bristol) and M. Stam (EPFL) on obfuscation. Hofheinz, together with D. Unruh has finished his work on a comparison of two notions of simulatability.

Hofheinz, together with J. Müller-Quade and D. Unruh (Karlsruhe) as finished his work on polynomial runtime in simulatability definitions.

Hofheinz, together with J. Müller-Quade and D. Unruh, has finished his work on universally composable zero-knowledge arguments and commitments from signature cards.

Hofheinz, together with D. Unruh finshed his work on the notion of statistical security in simulatability definitions.

Hofheinz, together with Backes (Saarland), J. Müller-Quade and D. Unruh have finished his work on fairness in simulatability-based cryptographic systems.

Hofheinz, together with D. Unruh, has finished his work on simulatable security and polynomially bounded concurrent composition.

Title	General research in cryptology
Period	2004–indefinite
Leader	R.J.F. Cramer
Staff	D. Hofheinz
Funding	CWI
Partners	Aarhus Univ., ETH Zürich, UCSD, ENS, Technion Haifa

Progress report. Cramer, together with I. Damgaard (Aarhus) and Y. Ishai (Technion) finished their work on pseudo-random secret

sharing, share conversion and its applications to round reduction in secure computation. Its main application is a non-interactive threshold version of the Cramer and Shoup scheme.

Fehr, together with M. Abe (NTT Research Labs), is working on non-interactive zero-knowledge.

Kiltz has various research projects on identity-based encryption as well as chosen cipher-text security for encryption ongoing.

Kiltz, together with H.U. Simon (Bochum) finished their work on threshold circuit lower bounds on certain cryptographic functions

Kiltz, together with M. Abdalla (ENS), M. Bellare (UCSD), D. Catalano (ENS), T. Kohno, T. Lange (DTU), J. Malone-Lee (Bristol), G. Neven (ENS), P. Paillier (Gemplus) and H. Shi finished his work on searchable encryption.

Kiltz, together with A. Mityagin (UCSD), S. Panjwani and B. Raghavan, finished his work on append-only digital signatures.

Kiltz, together with Winterhof (Bristol) finished his work on polynomial interpolation of some cryptographic functions related to the Diffie-Hellman and Discrete Logarithm Problem.

Hofheinz, together with A. Groch (Karlsruhe) and R. Steinwandt (FAU) developed a practical attack on the root problem in braid groups.

Hofheinz, together with J. Müller-Quade and D. Unruh has finished his work on the (im-)possibility of extending coin toss.

PNA5.2 – Computational Number Theory and Discrete Tomography

Title	NWO3 –Algorithmic validation of RSA and other widely used cryptosystems
Period	January 1997–December 2008
Leader	H.J.J. te Riele
Staff	W.H. Ekkelkamp, A.K. Lenstra, P.L. Montgomery, H.J.J. te Riele
Funding	NWO (basic & project funding)
Partners	UL, Univ. Bonn, Microsoft Research, Lucent Technologies

Progress report. Te Riele, together with T. Kotnik (Ljubljana, Slovenia), started to extend his computations of 1984 concerning the Mertens conjecture (with Odlyzko).

Te Riele, together with J. van de Lune, T. Kotnik started to study the inequality $e^\gamma \log\log N_k < N_k/\phi(N_k)$, $k = 1, 2, \ldots$, where N_k is the product of the first k primes and ϕ is Euler's totient function, denoting the number of positive integers $\leq n$ that are relatively prime to n.

Te Riele, together with J. van de Lune, has studied inequalities involving the sums $\sigma_n(s) := 1^s + 2^s + \ldots + n^s$.

Te Riele, together with Ekkelkamp, and with Montgomery (Microsoft) factored various numbers from the Cunningham table.

Ekkelkamp has concentrated on the quadratic sieve factoring algorithm (QS) and the number field sieve (NFS) with Montgomery's NFS software for factoring very large numbers.

Title	NWO4 – Mathematical aspects of discrete tomography
Period	September 2002–August 2006
Leader	H.J.J. te Riele
Staff	K.J. Batenburg, H.J.J. te Riele
Funding	NWO (project funding)
Partners	UL, FEI Eindhoven, Lawrence Berkeley National Laboratory

Progress report. Batenburg developed an algorithm for reconstructing 3D images and extended it to several different projection geometries.

Batenburg applied the 3D reconstruction algorithm to the reconstruction of nanocrystals from projections obtained by electron microscopy.

Batenburg developed a different algorithm for the reconstruction of images that contain more than two gray levels. In collaboration with J. Sijbers (Antwerp), this algorithm was applied successfully to the reconstruction of the mouse trabecular bone structure from X-ray projections.

Batenburg, in collaboration with W.A. Kosters (Leiden), developed reconstruction methods based on neural networks.

Societal aspects and knowledge transfer

External contacts

- KU Leuven, Cosic, Belgium.
- Univ. Antwerp, Beligium.
- Aarhus Univ., Computer Science Department, Denmark.
- Technical Univ. Denmark, Mathematics Department, Copenhagen, Denmark.
- Ecole Normale Superieure, GRECC, Paris,

France.
- Univ. Bochum, Mathematics Department, Germany.
- NTT (Japanese PTT) Research, Yokosuka , Japan.
- Weizmann Institute of Science, Rehovot, Israel.
- Technion, Haifa, Israel.
- Ben-Gurion Univ., Beer-Sheba, Israel.
- HP Labs, Israel.
- UPC (Polytechnical Univ. Catalunya), Barcelona, Spain.
- CRM, Barcelona, Spain.
- Univ. Madrid (URJC), Mathematics Department, Madrid, Spain.
- Ecole federal polytechnique (EPF Lausanne), Computer Science Department, Lausanne, Switzerland.
- ETH Zürich, Computer Science Department, Switzerland.
- IBM Zürich Research Lab, Switzerland.
- Univ. Bristol, Computer Science Department, UK.
- Royal Holloway, Univ. London, Computer Science Department, UK.
- Univ. College London, UK.
- Courant Institute, New York Univ., USA.
- Univ. California at San Diego, Computer Science Department, USA, Univ. California at Berkeley, Lawrence Berkeley National Laboratory, USA.
- Univ. California at Los Angeles, Computer Science Department, USA.
- Univ. California at Davis, Computer Science Department, USA.
- Lucent Bell Labs, Murray Hil, Security Group, USA.
- IBM TJ Watson Research, Yorktown Heigths, USA.
- MIT, Computer Science Department, Cambridge, Massachusetts, USA.
- Florida Atlantic Univ., Boca Raton, USA.
- Microsoft Research, Seattle, USA.

Organization of conferences, workshops, courses, meetings

- 4th IACR Theory of Cryptography Conference (TCC), February 2007, KNAW (Trippenhuis), Amsterdam, the Netherlands: R.J.F. Cramer (General Chair), S. Fehr, D. Hofheinz, E. Kiltz.
- 3rd Mathematics of Cryptology Workshop, May 2007, Barcelona, Spain: R.J.F. Cramer.
- The Research in Information Security and Cryptology (RISC) Seminar, at CWI, regularly: R.J.F. Cramer, S. Fehr, E. Kiltz.
- 5ECM (the fifth European Congress of Mathematicians, Amsterdam, 2008: H.J.J. te Riele.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- TCC, MIT, Cambridge (Mass.), USA, February: R.J.F. Cramer (Talk: Share Conversion, Pseudorandom Secret-Sharing and Applications to Secure Computation).
- Annual NVTI (Dutch Theoretical Computer Science Association) Meeting, Utrecht, the Netherlands, March: R.J.F. Cramer (Talk: Share Conversion, Pseudorandom Secret-Sharing and Applications to Secure Computation).
- EIDMA Cryptography Working Group, Utrecht, the Netherlands, April 8: S. Fehr (Talk: Black-Box Secret Sharing from Primitive Sets in Number Fields); E. Kiltz (Talk: Public-key encryption with keyword search & anonymous IBE).
- Intercity Number Theory Seminar, Leiden, May: K.J. Batenburg (Talk: Small, smaller, smallest: steps toward the atomic resolution microscope).
- National RISC Seminar, CWI, May 5: R. de Haan (Talk: Hierarchical threshold secret sharing).
- Seminar Mathematics Applied to Cryptography, UPC, Barcelona, Spain, June: R. de Haan (Talk: More efficient secure multiplication of secrets).
- Discrete Tomography and its Applications, New York, USA, June: K.J. Batenburg (Talk: A new algorithm for 3D binary tomography).
- 2nd Joint Meeting of AMS, DMV, and ÖMV, Mainz, June: D. Hofheinz (Invited talk: An attack on a group-based cryptographic scheme).

- Seminar on Mathematics Applied to Cryptography, UPC, Barcelona, Spain, June 15: S. Fehr (Invited talk: Quantum Cryptography - Achieving Security by Restricting the Attacker's Memory).
- Workshop on the link between formal and computational models, Paris, June: D. Hofheinz (Talk: Simulatable security and concurrent composability).
- STAR seminar, UC, San Diego, CA, USA, June 2: E. Kiltz (Threshold Circuit Lower Bounds on Cryptographic Functions).
- ScyScan, Univ. Antwerp, July: K.J. Batenburg (Discrete Tomography).
- Microscopy and Microanalysis Meeting, Honolulu, July 31–August 4: K.J. Batenburg (Talk: Atomic resolution electron tomography on a discrete grid: atom count errors).
- National RISC Seminar, Lorentz Center, Leiden, September 9: R. de Haan (Talk: Applications of Shamir Multi-Secret Sharing).
- National RISC Seminar, CWI, October 6: S. Fehr (Invited talk: Cryptography in the Bounded Quantum-Storage Model).
- RISC/SEN2 seminar on Cryptography and Formal Methods, Amsterdam, October: D. Hofheinz (Talk: Protocol analysis using simulatable security).
- IEEE Information-Theory Workshop, Awaji Island, Japan, October 16–19: S. Fehr (Talk: Cryptography in the Bounded Quantum-Storage Model).
- 17th BNAIC (Belgium Dutch Artificial Intelligence Conference), Brussels, October 17–18: K.J. Batenburg (Talk: Neural networks for discrete tomography).
- Wetenschapsdag, UL, October 23: K.J. Batenburg (Talk: Onbegrensde rekenkracht van de computer: Realiteit of Science-Fiction?).
- EIDMA Cryptography Working Group, Utrecht, October 24: D. Hofheinz (Invited talk: Simulatable security and why subtleties make a difference).
- Univ. Bochum, graduate school seminar, Bochum, Germany, October 27: E. Kiltz (Talk: Chosen-Ciphertext Security from Tag-Based Encryption).
- Workshop 'Algebraic Methods in Cryptography', Ruhr-Univ. Bochum, November: D. Hofheinz (Invited talk: A practical attack on the root problem in braid groups).
- Intercity Number Theory Seminar, Leiden, December: W. Ekkelkamp (Talk: A variation of the MPQS factoring algorithm: analysis and experiments).

Working visits

- Philips Research, Eindhoven, the Netherlands, February: R.J.F. Cramer (Talk: Share Conversion, Pseudorandom Secret-Sharing and Applications to Secure Computation).
- Bellairs' Crypto-Workshop on Quantum and Classical Information Theory in Cryptography, Univ. Montréal, St. James, Barbados, March 6: S. Fehr.
- Bundesamt für Sicherheit in der Informationstechnik (BSI), Bonn, Germany, April: R.J.F. Cramer (Talk: Universal hash-proof systems and secure encryption).
- Univ. Dortmund, Comp. Sc. Dept., Dortmund, Germany, April: R.J.F. Cramer (Talk: Share Conversion, Pseudorandom Secret-Sharing and Applications to Secure Computation).
- CRM, Barcelona, Spain, May–July: R.J.F. Cramer.
- CRM, Barcelona, Spain, June: S. Fehr, R. de Haan.
- Computer Science Department, Bristol Univ., Information Security Seminar, November: D. Hofheinz (Invited talk: Simulatable security).

Other lectures

- Special session on Mathematics and Telecommunications, RSME (Royal Spanish Mathematical Society), Barcelona, June: R.J.F. Cramer (Invited talk: Chosen-ciphertext secure public key encryption).
- Mathematical Aspects of Cryptology, CRM (Catalan Research Centre for Mathematics), Barcelona, Spain, June 15: R.J.F. Cramer (Invited talk: Black-box secret sharing from primitive sets in algebraic number fields).
- Maths. Dept., UPC, Barcelona, Spain, July: R.J.F. Cramer (Invited tlak: Algebraic aspects of secret sharing).
- Algebraic Methods in Cryptography, Maths. Dept., Univ. Bochum, Germany, November: R.J.F. Cramer (Invited talk: Black-box secret sharing from primitive sets in algebraic number fields).
- Rijsenbrij Symposium, Eerste Christelijk Lyceum, Haarlem, The Netherlands, December: R.J.F. Cramer (Talk: De magie van

getallen en de wiskunde van de digitale veiligheid).
- Univ. Rennes, Maths. Dept., Rennes, France, December: R.J.F. Cramer (Talk: Black-box secret sharing from primitive sets in algebraic number fields).
- 'Wiskunde 1a', Mathematical Institute, UL: K.J. Batenburg.

Courses

- Number Theory / Cryptology course. National MSc programme in Mathematics, Mathematical Institute, UL, Fall 2005: R.J.F. Cramer, R. de Haan.
- National MSc programme in Mathematics, Eliptic Curves Cryptology, Mathematical Institute, UL (Prof. H.W. Lenstra), Spring 2005: W.H. Ekkelkamp.

Visitors

- S. Vadhan, Harvard Univ., January (Talk: Randomness extractors and their cryptographic applications). Host: R.J.F. Cramer.
- R. Ostrovsky, Univ. California at Los Angeles, January (Talk: Survey on Private Information Retrieval). Host: R.J.F. Cramer.
- Ph. Nguyen, Ecole normale superieure, Paris, January (Talk: From Euclid to Lenstra-Lenstra-Lovasz: Revisiting Lattice Basis Reduction). Host: R.J.F. Cramer.
- C. Padró, Polytechnical Univ. Catalunya, UPC Barcelona, January (Talk: Secret Sharing Schemes, Error Correcting Codes and Matroids). Host: R.J.F. Cramer.
- S. Galbraith, Royal Holloway, Univ. London, January (Talk: The Eta Pairing). Host: R.J.F. Cramer.
- G. Seroussi, Hewlett-Packard Labs, Palo Alto, May (Talk: Universal Types, Trees, and Simulation of Individual Sequences). Host: R.J.F. Cramer.
- P.L. Montgomery, Microsoft Research, Seattle), September (Talk: Polynomial Selection for General Number Field Sieve). Host: H.J.J. te Riele.
- A. Andics (ELTE, Budapest), November (Talk: Comparing Concepts of Complexity of Pseudorandom Binary Sequences). Host: R.J.F. Cramer.
- T. Pedersen, Technical Director, Cryptomathic, Denmark, November (Talk: Challenges when Applying Cryptography). Host: R.J.F. Cramer.
- C. Padró, UPC Barcelona, visiting Fall Semester 2005. Host: R.J.F. Cramer.
- G. Farkas, J. Kasza, and T. Csajbok, Faculty of Informatics, Eőtvős Lorand Univ., Budapest, Hungary, July 9–September 3. Host: H.J.J. te Riele.
- T. Kotnik, Faculty of Electrical Engineering, Univ. Ljubljana, Slovenia,, November 1 - December 31. Host: H.J.J. te Riele.

Membership of committees and other professional activities

R.J.F. Cramer

- Full Professor, Mathematical Institute, UL.
- National Course on Number Theory/Cryptology. Dutch National Master's Program in Mathematics, Fall Semester, 2005.
- Board of Directors, International Association for Cryptologic Research (IACR).
- Steering committee, Annual Public Key Cryptography Conference (PKC).
- Editorial board, Journal of Cryptology, Springer Verlag, 2000–present.
- Editorial board, Journal of Mathematical Cryptology, Walter de Gruyter Publ., 2006–.
- Editorial board, IEEE Proceedings Information Security, 2005–.
- Chair of the scientific programme committee, 24th Annual IACR EUROCRYPT Conference, May 22–26, Aarhus, Denmark.
- Co-chair of the scientific programme committee, Special Semester on Mathematical Cryptology, CRM (Catalan Research Center for Mathematics), Barcelona, Spain, Summer Semester.
- General Chair, 4th IACR Theory of Cryptography Conference, February 2007, KNAW (Trippenhuis), Amsterdam, The Netherlands.
- Member of scientific programme committee, Special Program on Cryptology, Univ. California at Los Angeles, Institute of Pure and Applied Mathematics (IPAM), Los Angeles, California, USA, Fall 2006.
- Member of scientific programme committee, Schloss Dagstuhl Meeting on Cryptology, Dagstuhl, Germany, Fall 2007.
- Member of scientific programme committee, 33rd Annual ICALP Conference, Venice, Italy, July 2006.

- Founder, and Co-organizer (with S. Fehr and E. Kiltz), RISC (Research in Information Security and Cryptology) Seminars, Lorentz Center, Leiden and CWI, Amsterdam.
- Wiskunde in Actie (WiA) committee, Akademie Raad voor de Wiskunde, KNAW.
- PhD committee S. Agarwal, Comp. Sc. Dept., Aarhus Univ.
- 2 PhD committees, Maths. Dept., TUE.

S. Fehr

- PhD committee, K. Dupont, Comp. Sc. Dept., Aarhus Univ., Kaspar Dupont.
- Member of scientific programme committee, Public Key Cryptography Conference (PKC 2006), Columbia Univ., New York, USA.
- Member of Scientific programme committee, WEWoRC 2005 (Western European Workshop on Research in Cryptology), Leuven, Belgium.
- Member of scientific programme committee, ICICS 2005, Korea.

H.J.J. te Riele

- Secretary, inspector of the Library, and Archivist of the Royal Dutch Mathematical Society.
- Secretary of the Beeger Committee (which biennially selects the Beeger Lecturer and organizes the Beeger Lecture during the Nederlands Mathematisch Congres).
- Member of the board of the Mathematisch Research Instituut onderzoekschool, on behalf of CWI.
- Editorial board, Contributions to Discrete Mathematics.
- Chairman of the CWI-Bibliotheekcommissie.
- Treasurer of the CWI Staff Club.
- Supervisor of several UvA MSc degree projects.

Academic publications

Publications in refereed journals or proceedings

1 R. Cramer, S. Fehr, M. Stam (2005). Primitive Sets over Number Fields and Absolutely Optimal Black-Box Secret Sharing. Proceedings of 25th Annual IACR CRYPTO '05 LNCS 3621, 344–360.

2 R. Cramer, V. Daza, I. Gracia, J. Jiménez Urroz, G. Leander, J. Martí-Farré, C. Padró (2005). On Codes, Matroids and Secure Multi-Party Computation from Linear Secret Sharing Schemes. Proceedings of 25th Annual IACR CRYPTO '05. LNCS 3621, 327–343.

3 R. Cramer, I. Damgaard, Y. Ishai (2005). Share Conversion, Pseudorandom Secret-Sharing and Applications to Secure Computation. Proceedings of Theory of Cryptography Conference (TCC '05). LNCS 3378, 342–362.

4 Ivan Damgaard, Serge Fehr, Louis Salvail, Christian Schaffner (2005). Cryptography in the Bounded Quantum-Storage Model. 46th Symposium on Foundations of Computer Science (FOCS), 449–458.

5 E. Kiltz, H.U. Simon (2005). Threshold Circuit Lower Bounds on Cryptographic Functions. Journal of Computer and Systems Sciences 71(2), 185–212.

6 M. Abdalla, M. Bellare, D. Catalano, E. Kiltz, T. Kohno, T. Lange, J. Malone-Lee, G. Neven, P. Paillier, H. Shi (2005). Searchable Encryption Revisited: Consistency Properties, Relation to Anonymous IBE, and Extensions. Advances in Cryptology – CRYPTO 2005. LNCS 3621, 205–222.

7 E. Kiltz, A. Mityagin, S. Panjwani, B. Raghavan (2005). Append-Only Signatures, Proceedings of the 32nd International Colloquium on Automata, Languages and Programming ICALP. LNCS 3580, 435–445.

8 E. Kiltz, J. Malone-Lee, G. Leander (2005). Secure Computation of the Mean and Related Statistics. Proceedings of the second Theory of Cryptography Conference TCC. LNCS 3378, 283–302.

9 D. Hofheinz, D. Unruh (2005). Comparing two notions of simulatability. Joe Kilian (ed). Theory of Cryptography, Proceedings of TCC 2005. LNCS 3378, 86–103.

10 D. Hofheinz, J, Müller-Quade, D. Unruh (2005). Polynomial runtime in simulatability definitions. Proceedings of CSFW 2005. IEEE Computer Society, 156–169.

11 D. Hofheinz, J. Müller-Quade, D. Unruh (2005). Universally composable zero-knowledge arguments and commitments from signature cards. 5th Central European Conference on Cryptology. Proceedings of MoraviaCrypt 2005.

12 D. Hofheinz, D. Unruh (2005). On the notion of statistical security in simulatability

definitions. Information Security. Proceedings of ISC 2005. LNCS 3650, 118–133.
13 M. Backes, D. Hofheinz, J. Müller-Quade, D. Unruh (2005). On fairness in simulatability-based cryptographic systems. Proceedings of FMSE 2005. ACM Press, 13–22.
14 K.J. Batenburg (2005). An evolutionary algorithm for discrete tomography. Discrete Applied Mathematics 151, 36–54.
15 K.J. Batenburg (2005). A new algorithm for 3D binary tomography. Proceedings of the Workshop on Discrete Tomography and its Applications. ENDM 20, 247–261.
16 K.J. Batenburg, J.R. Jinschek, C. Kisielowski (2005). Atomic resolution electron tomography on a discrete grid: atom count errors. Proceedings of M&M 2005. Microscopy and Microanalysis. 11(2).
17 K.J. Batenburg and W.A. Kosters. Neural networks for discrete tomography. Proceedings of BNAIC'05, 21–27.

Publications in other journals or proceedings and other scientific output

CWI reports
PNA-R0502
See B.2 on page 201 for complete titles.

Preprints
1 R. Cramer (2005). Algebraic Geometric Secret Sharing and Secure Computation over Small Fields.
2 R. Cramer, S. Fehr, C. Padró (2005). Combinatorial Codes for Detection of Algebraic Manipulation and Their Applications.
3 R. Cramer, R. de Haan (2005). Atomic Secure Multiplication with Low Communication.
4 S. Agarwal, R. Cramer, R. de Haan (2005). Optimal 2-Phase Perfectly Secure Message Transmission.
5 R. Cramer, E. Kiltz, C. Padró (2005). A Note on Secure Computation of the Moore-Penrose Pseudo-Inverse and its Application to Secure Linear Algebra.
6 A. Groch, D. Hofheinz, R. Steinwandt (2005). A practical attack on the root problem in braid groups. IACR ePrint Archive.
7 J. Marti-Farré, Carles Padró (2005). On Secret Sharing Schemes, Matroids and Polymatroids.

Monographs

1 D. Catalano, R. Cramer, I. Damgaard, G. Di Crescenzo, D. Pointcheval, T. Takagi (2005). Contemporary Cryptology. Advanced Courses in Mathematics CRM Barcelona, Birkhauser, 2005 VIII, 237 pages.
2 R. Cramer (ed) (2005). Proceedings of 24th Annual IACR EUROCRYPT. LNCS 3494, 576 pages.

Profesional products

Publications for a broad audience

1 R. Cramer, S. Fehr (2005). Cryptographic Security by Swamping Adversaries with Quantum Information. ERCIM News 63, October.
2 K.J. Batenburg, W.A. Kosters. Neural networks for discrete tomography. SNN Adaptive Intelligence: Lerende oplossingen, 18–19.

Other output

Awards

- R. Cramer. Member, De Jonge Akademie, KNAW (Royal Netherlands Academy of Arts and Sciences).
- S. Fehr. NWO Veni Grant for 'Quantum Cryptography: Achieving Provable Security by Bounding the Attacker's Quantum Memory'.

Grants

- Practical Approaches to Secure Computation (PASC), Sentinels STW, 2004–2009. Jointly with Philips Research and TUE (2 PhD students, 1 postdoc).
- ERCIM Fellowship J. Herranz, 2005/2006.

SOFTWARE ENGINEERING

Principal research area and mission

SEN focuses its research on various aspects of software engineering, evolutionary systems and multimedia applications. Typical research questions deal with analysis and transformation of software systems, verification of embedded systems, component-based development, competitive agents, and multimedia players.

The ambition is to cover the whole range of activities from fundamental concepts and prototype implementations to the application of these concepts in practice. For fundamental research, cooperation with Dutch universities and international partners was continued and further extended. Applications and technology transfer were realized in cooperation with external partners.

In addition to scientific publications, demonstrations and prototype systems are important outcomes of the research in this cluster. These prototypes find their way to researchers worldwide. Our policy is to develop them to the point that real-life applications can be tested and then transfer exploitation to industrial partners.

Cluster staff

Name	**Fte**	**Function**
Prof.dr. P. Klint	0.2	Cluster leader
S.J. van Dam	0.5	Secretary

Research themes

Name		Leader
SEN1	Interactive Software Development and Renovation	Prof.dr. P. Klint
SEN2	Specification and Analysis of Embedded Systems	Dr. J.C. van de Pol
SEN3	Coordination Languages	Prof.dr. J.J.M.M. Rutten
SEN4	Evolutionary Systems and Applied Algorithmics (since July 2005 Computational Intelligence and Multi-agent Games)	Prof.dr.ir. J.A. La Poutré
SEN5	Convergent Media Infrastructures	Dr. D.C.A. Bulterman

SEN1 addresses problems related to the development, understanding and evolution of large software systems. Techniques like parsing, rewriting, relational calculus, and component-based software engineering are used to solve these problems. Research was concentrated in four areas: software renovation, domain-specific languages, generic language technology, and concept-based reasoning.

SEN2 addresses the question how the quality of software in embedded systems (telecommunications, communication protocols) can be improved. Techniques like process algebra, timed automata, and modal logics are used for proof checking, state-space analysis and reduction, simulation and testing of processes and data. Research was focused on two areas: distributed systems and process theory and verification.

SEN3 concentrates on the specification, interaction and dynamic composition of components. Research was focused on three areas: coordination and component-based architectures, formal models for coordination languages and co-algebraic models of computation.

SEN4 aims at the further development of intelligent computation techniques (evolutionary and multi-agent systems, adaptive algorithms, neural networks) and their applications (e-commerce, auctions, optimization, mathematical finance). Research was done in two areas: evolutionary systems, and neural networks and adaptive algorithms.

SEN5 was created as pilot theme (converted to full research theme since January 2006) and looks at mechanisms for the modelling, creation, encoding and distribution of multimedia presentations on devices ranging from from tablet PCs, PDAs, and telephone handsets to consumer audio-video equipment. Apart from case studies, research focused on building an experimental base for future research.

As regards applications, SEN1 focuses on analysis and transformation of administrative and industrial embedded software systems, SEN2 on specification and verification of industrial embedded systems, SEN3 on architectural modelling, SEN4 on e-commerce, trade agents and logistics, and SEN5 on medical applications.

Other items of interest

- M.G.J. van den Brand was appointed as full professor in Software Construction at the TUE.
- 4 PhDs were successfully defended by, respectively, G. Economopoulos, M. Valero Espada, J. Vinju, and P. Zoeteweij.
- 16 SEN members were involved in teaching at universities.
- SEN members participated in the PCs of 87 international workshops and conferences (including several as programme chair or as organizer).
- SEN has cooperations with over 50 national and international companies.
- SEN members act on the editorial board of 9 international journals and book series.
- 11 SEN members hold a part-time position at a university at the level of full or associate professor.
- 10 SEN members appear on CiteSeer's list of ten thousand most cited authors in Computer Science.

Interactive Software Development and Renovation – SEN1

Mission

The development, understanding and evolution of large software systems is a key economic and societal problem and the mission of this theme is to advance the state of the art in these three areas.

The development of large software systems is addressed by generating components on the basis of domain-specific languages, by explicitly describing the cooperation protocols of components, by explicitly packaging subsystems, and by exploring methods for unit testing and daily builds. Key questions are related to capturing the variability of software systems and controlling the process for configuring, building and distributing them. The software implementation activities in this theme form a test bed for these new techniques.

Software understanding is addressed by developing new techniques for the analysis and exploration of software systems. Key questions are how to traverse programs for extracting facts, how to describe the desired analysis, how to collect the results of the analysis and how to visualize them. Real systems use multiple source languages, and fact extraction and analysis should therefore be done in a language-parametric fashion.

The evolution of software systems is approached by applying program analysis techniques to study the evolutionary aspects of a system. The results of program understanding are also used for program transformations that form the basis for fully automatic system renovation. Description and automation of these transformations and finding the commonality in program transformations for different languages are research topics. The correctness of these transformations is also a major concern.

The general research approach is to bring together established fundamental notions such as modularization, term rewriting, and program generation with pragmatic needs such as component-based development and understanding or transforming legacy systems. Formal language definitions play an important role in this approach. They describe the syntax and semantics of a domain-specific or programming language and form the basis for the analysis and transformation of software in existing languages, for the generation of specific tools, and for the development of domain-specific languages. The aim is to realize truly generic language technology that can be applied in many problem areas.

Theme leader

Prof.dr. P. Klint

MSC or CR classification

D.2

Subthemes

Name	Leader
SEN1.1 – Software Evolution	A. van Deursen
SEN1.2 – Software Transformation	J. Heering
SEN1.3 – Generic Language Technology	M.G.J. van den Brand
SEN1.4 – Concept-Based Reasoning and Knowledge Engineering	D.J.N. van Eijck

SEN1.1 aims at developing methods, tools, and techniques to facilitate software maintenance and evolution.

SEN1.2 studies generic, i.e., language-parametric, software transformations for purposes of optimization, refactoring, and computer-aided maintenance.

SEN1.3 aims at developing generic methods, tools and techniques for solving language processing problems, including parsing, analysis, evaluation, generation, and transformation of programs. The results are prototyped in the ASF+SDF Meta-Environment and evaluated in industrial case studies.

SEN1.4 studies cognitive processes using the tools of formal logic, computational linguistics, and formal concept analysis. Application areas are protocol analysis, natural language analysis, and question answering in restricted domains.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. G.C. Ballintijn	1.0	postdoc	2003-07-01 till 2007-06-30	SEN1.3: Deliver
Dr. M.G.J. van den Brand	0.4	researcher, leader SEN1.3	till 2005-12-31	SEN1.2: CaLCE; SEN1.3: ASF+SDF, leading PhD students
Drs. M. Bruntink	1.0	PhD student	2003-10-01 till 2007-09-30	SEN1.1: PhD research, Ideals
Prof.dr. A. van Deursen	1.0	researcher, leader SEN1.1	till 2006-02-28	SEN1.1: DocGen, Ideals, leading PhD students
Drs. G.R. Economopoulos	1.0	PhD student	2005-01-01 till 2007-06-30	SEN1.2: LPPR
Prof. dr. D.J.N. van Eijck	0.4	researcher, leader SEN1.4	indefinite	SEN1.4: leading PhD students
J. Heering	1.0	researcher, leader SEN1.2	indefinite	SEN1.2: CaLCE, LPPR
Drs. H.A. de Jong	1.0	project member, PhD student	2000-01-01 till 2005-12-31	SEN1.2: CaLCE; SEN1.3: PhD research, ASF+SDF
Prof.dr. P. Klint	0.6	cluster/theme leader	indefinite	SEN1.2: CaLCE; SEN1.3: ASF+SDF, Deliver, leading PhD students
Drs. A.T. Kooiker	1.0	project member, PhD student	2004-01-01 till 2007-12-31	SEN1.2: CaLCE; SEN1.3: PhD research, ASF+SDF

continued on next page

continuation from previous page

Ir. A. Mesbah	1.0	project member, PhD student	2005-05-01 till 2006-02-28	SEN1.1: PhD research, SPCI
Drs. T. van der Storm	1.0	PhD student	2003-07-01 till 2007-06-30	SEN1.3: Deliver
Dr. T. Tourwé	1.0	postdoc	2004-01-01 till 2005-12-31	SEN1.1: Ideals
Drs. J.J. Vinju	1.0	project member, PhD student	2002-02-01 till 2008-11-30	SEN1.2: CaLCE; SEN1.3: PhD research, ASF+SDF

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
S. Dzebric (HvA)	0.6	PhD student	2005-11-01 till 2006-08-31	SEN1.3: ASF+SDF
Dr.ir. R. Lämmel (VU)	0.2	project member	till 2005-01-31	SEN1.2: LPPR
Dr. L.M.F. Moonen (TUD)	0.2	postdoc	2003-01-01 till indefinite	SEN1.1: Ideals

Scientific report

Highlights

- M.G.J. van den Brand was appointed as full professor in software engineering at TUE.
- A. van Deursen gave his inaugural lecture The Software Evolution Paradox at TUD on February 23.
- PhD defense J.J. Vinju.
- A. van Deursen received a best reviewer award at the IEEE International Conference on Software Maintenance (ICSM '05).

PhD students

M. Bruntink
H.A. de Jong
A.T. Kooiker
A. Mesbah
T. van der Storm
J.J. Vinju

SEN1.1 – Software Evolution

The objective of the Software Renovation Research Group (SEN1.1) is to develop methods, tools, and techniques that help to make software systems sufficiently flexible.

Title	DocGen – Documentation Generation
Period	1999–indefinite
Leader	A. van Deursen
Funding	(consultancy)
Partner	Software Improvement Group BV

Progress report. No work was done in this project.

Title	Ideals – Idiom Design for Embedded Applications at Large
Period	September 2003–2007
Leader	A. van Deursen
Staff	M. Bruntink, L.M.F. Moonen, T. Tourwé
Funding	SenterNovem
Partners	ASML, ESI, TUE, UT

Progress report. The Ideals project addresses crosscutting concerns in embedded software and, in particular, the opportunities for using aspect-oriented techniques in ASML's 10 million line C code base, which is used to control their wafersteppers. The activities focused on analyzing error handling mechanisms in ASML's code.

Title	SPCI – Single Page Computer Interaction
Period	Januari 2005–December 2006
Leader	A. van Deursen
Staff	A. Mesbah
Funding	SenterNovem
Partners	Backbase BV, TUD

Progress report. This project addresses rich internet applications in which all user interaction goes through a single page. There is a growing demand for more and richer user interaction in web applications, and the emerging Ajax (Asynchronous JavaScript and XML) technologies provide a new way of achieving this.

See also `http://www.cwi.nl/htbin/sen1/twiki/bin/view/SEN1/SoftwareRenovationResearch`.

SEN1.2 – Software Transformation

SEN1.2 studies generic, i.e., language-parametric, software transformations for purposes of optimization, refactoring, and computer-aided maintenance.

Title	LPPR – Language-Parametric Program Restructuring
Period	April 2004–March 2008
Leader	J. Heering
Staff	G.R. Econompoulos, R. Lämmel (until January 31)
Funding	NWO
Partner	VU

Progress report. As of January 1, Economopoulos was appointed in the position left by the departure of L. Grunske in 2004. Lämmel left for Microsoft Redmond. As a consequence, his joint work with J. Heering on the classification of language-parametric software transformations was discontinued. A paper by Lämmel jointly with Klint and C. Verhoef (VU) on the need for so-called grammarware engineering, including grammarware transformation, as a separate theme in software engineering was published in *ACM Transactions on Software Engineering and Methodology*.

A survey paper by Heering jointly with M. Mernik (Univ. of Maribor, Slovenia) and A.M. Sloane (Macquarie Univ., Sydney) on when and how to develop domain-specific languages was published in *ACM Computing Surveys*. Heering and Mernik started a joint project to write a book on this subject.

Economopoulos finished his PhD thesis on generalized LR-parsing and obtained his degree from the Univ. of London on January 9, 2006. He focused on refactoring the implementation of the scannerless generalized LR (SGLR) parser within the ASF+SDF Meta-Environment. The goal of this work was to improve the flexibility and performance of the individual packages and to allow easier comparisons between different generalised parsing algorithms. As part of the refactoring he also aimed to improve the error reporting of SGLR. This has involved researching current error detection and correction techniques used by standard bottom-up parsers and considering their applicability in GLR-style parsing algorithms. He also investigated the correctness and applicability of the filtering and disambiguation techniques used by the SGLR parser. This research uncovered problems in the current implementation of the reject filtering which he subsequently resolved. In addition to this work he also investigated the applicability of performing limited ambiguity detection on grammars with an aim of locating possibly ambiguous constructs.

Title	CaLCE – Computer-aided Life Cycle Enabling of software assets
Period	September 2003–August 2006
Leader	J. Heering
Staff	M.G.J. van den Brand, D.J.N. van Eijck, H.A. de Jong, P. Klint, A.T. Kooiker, J.J. Vinju
Funding	SenterNovem
Partners	Getronics PinkRoccade BV, Software Improvement Group BV, VU

Progress report. This project aims at improving the software maintenance process by applying more powerful tools to it. CWI is involved in the CaLCE work packages on Generic Language Technology, Static Analysis and Software Transformation. The latter will be used for software refactoring as well as to perform software modifications in a controlled 'semantics aware' way rather than by unsafe edit scripts.

Vinju successfully defended his PhD thesis 'Analysis and Transformation of Source Code by Parsing and Rewriting'. As part of his PhD research he developed prototypes of ASF interpreters and compilers for the purpose of executing 'high-fidelity' source-to-source transformations that are layout preserving and, more generally, stay maximally close to the original source code. ASF was extended so as to be able to rewrite lexicals down to the character level. Using these prototypes, he implemented a tool to analyze the source code comments of a large C system and check them for consistency and correctness. As part of this work, a grammar for ANSI-C with GNU extensions including (limited but sufficient) support for the C preprocessor was written in a slightly generalized version of the syntax definition formalism SDF2. Apart from this, to facilitate a type-driven approach to concrete meta programming, the scannerless generalized LR (SGLR) parser of the ASF+SDF Meta-Environment was extended to cyclic grammars.

Van den Brand, De Jong, Kooiker, and Vinju worked on a better modularization of the ASF+SDF Meta-Environment with a more highly integrated GUI. These two almost con-

tradictory goals have led to a plugin architecture on the GUI level, and an 'onion design' on the component composition level. This work will continue in 2006. As a side-effect, reusing open-source implementations of popular GUI elements, the user experience of the environment was greatly improved. For instance, a language parametric syntax high-lighter based on the standard Java Swing editor kit was added.

SEN1.3 – Generic Language Technology

SEN1.3 aims at developing generic methods, tools and techniques for solving language processing problems, including parsing, analysis, evaluation, generation, and transformation of programs. The results are prototyped in the ASF+SDF Meta-Environment and evaluated in industrial case studies.

Title	ASF+SDF
Period	1998– indefinite
Leader	M.G.J. van den Brand
Staff	H.A. de Jong, P. Klint, A.T. Kooiker, J.J. Vinju
Funding	CWI
Partners	UvA, VU, Software Improvement Group BV

Progress report. ASF+SDF progress is reported under the CaLCE (SEN1.2) and LPPR (SEN1.2) projects.

Title	Deliver – Intelligent software knowledge management and delivery
Period	July 2003–November 2007
Leader	P. Klint
Staff	G.C. Ballintijn, T. van der Storm
Funding	NWO (Jacquard, UU)
Partners	Baan (until November 2003

Progress report. At the start of the year, R.L. Jansen moved to UU and continued his PhD research in the group of S. Brinkkemper. He has continued his cooperation with the Deliver group, however. The first event of the year was the Jacquard Conference in Zeist. The project presented itself using a poster, a presentation by Ballintijn, and a discussion session on release, delivery, and deployment led by Klint. In addition, Van der Storm presented a technical paper. The project also presented itself at the SIREN 2005 symposium in Eindhoven. In the context of the Jacquard Voucher program, the Deliver project was approached by CreditComfort BV with a request for assistance with the initial stages of the development of a new information system. An exploratory meeting was held with representatives of CreditComfort, and Ballintijn has subsequently worked on an architectural prototype of the system. Ballintijn also presented the paper 'A Case Study of the Release Management of a Health-care Information System', at the 21st International Conference on Software Maintenance (ICSM '05) in Budapest.

Van der Storm continued his work on composing configurable components. He extended his feature-oriented component interfaces with an abstract language for binding variation points, and performed experiments with these extended interfaces, using Java and AspectJ as an implementation platform. Van der Storm further used relational calculus to formalize component composition and configuration, and subsequently model the evolution of software components. By precisely analyzing the versions and dependencies of components, it becomes possible to automate the build, release, and delivery processes in a way that is both incremental and continuous. Every time a component is changed it is rebuilt, tested and released. The use of precise version information derived from the version control system ensures that customer installations are linked to the sources of the software system. This traceability is crucial to enable incremental updates and precise feedback. Van der Storm presented these ideas in his paper 'Continuous Release and Upgrade of Component-Based Software' at the 12th Software Configuration Management workshop (SCM-12) in Lisbon. To validate this model, he developed the Sisyphus continuous integration system, which is used by the SEN1.3 team to develop and support the ASF+SDF Meta-Environment.

Title	Study of the effects of allowing patent claims for computer-implemented inventions
Period	March 2004–March 2007
Leader	P. Klint
Staff	J.A. Bergstra (seconded from UU)
Funding	European Commission
Partners	MERIT (UM), CIER (UU), COIT (Univ. Politécnica de Madrid), CESPRI (Bocconi Univ., Milan)

Progress report. Bergstra and Klint studied the

impact of intellectual property rights (IPR) on the software engineering life cycle and made an initial study of so-called 'trivial' patents (report SEN-R0517). This has resulted in an active discussion with the open source movement (via the Holland Open Platform) and with patent lawyers from various companies (Microsoft, Philips). On October 20, the symposium *IPR on software: The road ahead* was organized at CWI.

Title	Software Engineering Amsterdam (Hefboom)
Period	December 2005–November 2008
Leader	J.J. Vinju
Funding	NWO Hefboom

Progress report. This project started on December 1. Progress will be reported next year.

SEN1.4 – Concept-Based Reasoning and Knowledge Engineering

SEN1.4 studies cognitive processes using the tools of formal logic, computational linguistics, and formal concept analysis. Application areas are protocol analysis, natural language analysis, and question answering in restricted domains.

Title	Concept-based reasoning and knowledge engineering
Period	2004–indefinite
Leader	D.J.N. van Eijck
Funding	CWI

Progress report. Van Eijck worked on so-called natural logic for natural language (shallow inference mechanisms based on monotonicity properties of quantifiers), and reported on this at a workshop on Logic and Computation in Tbilisi (Georgia). A paper on earlier work on quantification patterns appeared in *Journal of Logic and Computation*.

Together with J. van Benthem and B. Kooi, Van Eijck continued work on logics of communication and change. A paper on this topic was presented at TARK (Singapore), and a more extensive journal paper was finished and accepted for publication in *Information and Computation*.

Van Eijck and S.M.Orzan (SEN2, TUE) collaborated on uses of epistemic modeling for protocol analysis, and reported on their work in the Trends in Functional Programming workshop (Tallinn). A sequel to this work was presented in an invited talk for the De Morgan Workshop (London).

Together with A. Visser, Van Eijck wrote a textbook on mathematical thinking entitled Inzien en Bewijzen (Insight and Proof) that was published by Amsterdam University Press.

Together with R. Verbrugge, Van Eijck applied for a NIAS project grant for a half-year project on the theme 'Games, Action and Social Software' which was accepted and will start in September 2006.

Societal aspects and knowledge transfer

External contacts

Aarhus Univ., ASML, ATOS Origin, Backbase BV, Belastingdienst, Chipsoft, Datasiel SpA, DoCoMo Research Laboratories Munich, Elsevier Science, ESI, Free Univ. Bolzano, Exact Software, HvA, INRIA/LORIA Nancy, Kent State Univ., Lehigh Univ., Microsoft Research, Ministerie van Sociale Zaken en Werkgelegenheid, Nokia Research Helsinki, NWO Exacte Wetenschappen, PinkRoccade Public BV, Planon, Polytechnic Valencia, SERC, Software Engineering Institute, Software Improvement Group BV, Sogeti, Technical Univ. Munich, TUD, TUE, Univ. Alberta, Univ. Bergen, Univ. Cagliari, Univ. Durham, Univ. Mons-Hainaut, Univ. Namur, Univ. Sheffield, Univ. Stuttgart, Univ. Queensland, Univ. Victoria, UT, UU, UvA, Vrije Univ. Brussel, Vanenburg Group, VU.

Projects with partners in public and private sector

- ASF+SDF; see page 71.
- CaLCE; see page 70.
- Deliver; see page 71.
- Ideals; see page 69.
- LPPR; see page 70.
- Patents; see page 71.
- SPCI; see page 69.

Teaching at university

- Joint HvA, UvA, and VU masters program software engineering: M.G.J. van den Brand (Courses: software construction, software evolution), D.J.N. van Eijck (Organization, course: testing), P. Klint (Courses: software construction, software evolution), J.J. Vinju (Organization).
- Software Testing and Quality Engineering, TUD computer science bachelor education: A. van Deursen.

- Logical Methods in Linguistics, Uil-OTS, Utrecht: D.J.N. van Eijck.
- Epistemic Logic for AI, bachelor course computer science and AI, Utrecht, December: D.J.N. van Eijck.
- Programming Environments, UvA: P. Klint, T. van der Storm (assistant).
- Algorithms and Datastructures, Vrije Universiteit Brussel: T. Tourwé.

Spin-offs

- Software Improvement Group BV (SIG)

Organization of conferences, workshops, courses, meetings

- Workshop on Linking Aspect Technology and Evolution (LATE) held in conjunction with the 4th International Conference on Aspect-Oriented Software Development (AOSD), Chicago, March 14: T. Tourwé (main organizer).
- Transformation Techniques in Software Engineering, Dagstuhl Seminar 05161, Dagstuhl, April 17–22: R. Lämmel (co-organizer).
- Third Belgian-Netherlands Evolution Workshop (BENEVOL), Eindhoven, May 26–27: T. Tourwé (co-organizer).
- Workshop on Reflection, AOP and Metadata for Software Evolution (RAM-SE) held in conjunction with the European Conference on Object-Oriented Programming (ECOOP), Glasgow, July 25: T. Tourwé (co-organizer).
- Workshop on Monotonicity, Language and Cognition, Utrecht, October 14: D.J.N. van Eijck (co-organizer).
- Symposium IPR on software: The road ahead, CWI, October 20: P. Klint (co-organizer).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- National Functional Programming Day, Groningen, January 7: D.J.N. van Eijck (Lecture: Relational Analysis of Software Systems).
- Nationale Wiskunde Dagen (NWD), Noordwijkerhout, February 4: D.J.N. van Eijck (Lecture: Inzien en Bewijzen).
- Jacquard 2005, Zeist, February 3: G. Ballintijn, M. Bruntink (Lecture: Does an AOSD-based approach improve software quality?), A. van Deursen, P. Klint, T. van der Storm (Lecture: Composing configurable Java components).
- 4th International Conference on Aspect-Oriented Software Development (AOSD '05) and Workshop on Linking Aspect Technology and Evolution (LATE), Chicago, March 14–18: T. Tourwé.
- IPA Spring Days on Software Architecture, Made, March 31: A. van Deursen. (Lecture: Symphony: View-driven software architecture reconstruction), T. van der Storm (Lecture: Composing configurable Java components).
- ETAPS '05 including LDTA '05, Edinburgh, April 2–10: M.G.J. van den Brand, G.R. Economopoulos, J.J. Vinju (Lecture: TIDE — A generic debugging framework).
- Transformation Techniques in Software Engineering, Dagstuhl Seminar 05161, Dagstuhl, April 17–22: M.G.J. van den Brand, R. Lämmel, J.J. Vinju (Lecture: Generic language technology).
- ASML Technology Conference, Veldhoven, May 25: M. Bruntink, A.van Deursen, T. Tourwé (Lecture: Chasing 30 000 error linking violations).
- Third Belgian-Netherlands Evolution Workshop (BENEVOL), Eindhoven, May 26–27: T. Tourwé.
- Summer School in Program Analysis and Transformation (PAT), Copenhagen, June 5–12: M. Bruntink.
- Calculus workshop, Amsterdam, June 27: D.J.N. van Eijck (System demonstration: DEMO, lecture: Jaspars' Telelogica).
- Summer School on Generative and Transformational Techniques in Software Engineering (GTTSE '05), Braga, Portugal, July 4–8: M.G.J. van den Brand (System demonstration: Applications of the ASF+SDF Meta-Environment), J.J. Vinju (Lectures: Generic language technology — Components for automated transformations, How to make a bridge between transformation and analysis technologies.)
- Workshop on Reflection, AOP and Metadata for Software Evolution (RAM-SE), Glasgow, July 25: T. Tourwé.
- Symposium on Embedded Software Quality, Amsterdam, August 31: A. van Deursen (Lec-

ture: Improving embedded systems quality with aspect-oriented programming), P. Klint.
- 12th International Workshop on Software Configuration Management, Lisbon, September 5–6: T. van der Storm (Lecture: Continuous release and upgrade of component-based software).
- 2nd International Workshop on Rapid Integration of Software Engineering techniques (RISE '05), Heraklion, Crete, September 8–9: P. Klint, J.J. Vinju (Lecture: Type-driven automatic quotation of concrete object code in meta programs).
- 6th Tbilisi International Symposium on Language, Logic and Computation, Batumi, Georgia, September 15: D.J.N. van Eijck (Lecture: Natural Logic for Natural Language).
- Symposium on Trends in Functional Programming, Tallinn, Estonia, September 23–24: D.J.N. van Eijck (Lecture: (Modeling the epistemics of communication with functional programming).
- 21st IEEE International Conference on Software Maintenance (ICSM '05), Budapest, September 25–30: G. Ballintijn (Lecture: A case study of the release management of a health-care information system), M. Bruntink (Lecture: Isolating cross-cutting concerns), A. van Deursen (Panelist), A.T. Kooiker (Lecture: An architecture for context-sensitive formatting), A. Mesbah, T. Tourwé, J.J. Vinju.
- 7th IEEE International Symposium on Web Site Evolution (WSE '05), Budapest, 26 september: A. van Deursen, A. Mesbah (Lecture: Crosscutting concerns in J2EE applications).
- Fifth IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '05), Budapest, September 30–October 1: M. Bruntink, A.T. Kooiker, J.J. Vinju.
- Scientific ICT Research Event Netherlands (SIREN '05), Eindhoven, October 6: G. Ballintijn (Poster presentation of the Deliver project).
- 7th August de Morgan Workshop, London, November 4: D.J.N. van Eijck (Invited lecture: Checking communication protocols with dynamic epistemic logic).
- Beyond Program Slicing, Dagstuhl Seminar 05451, November 6–11: M. Bruntink (Lecture: Domain-specific slices), T. Tourwé (Lecture: Concern slicing).
- Landelijk Architectuur Congres (LAC '05), Nieuwegein, November 23–24: G. Ballintijn, T. van der Storm.
- Workshop on Distributed Embedded Systems, Lorentz Center, Leiden, November 21: A. van Deursen (Invited lecture: Isolating crosscutting concerns in embedded systems).
- Computational Linguistics (CLIN '05), Amsterdam, December 16: D.J.N. van Eijck (Lecture: Monotonicity, syllogistics and natural Reasoning).

Working visits

- IRIT, Toulouse, May 29–June 1: M.G.J. van den Brand (Lecture: Generic language technology for (automated) transformations).
- Rostock Univ., Rostock, June 22–24: M.G.J. van den Brand (Lecture: Generic language technology for (automated) transformations).
- Univ. of Canterbury, Canterbury, October 10–11: M.G.J. van den Brand (Lecture: Generic language technology for (automated) transformations).
- Univ. of Maribor (M. Mernik), November 15-17: J. Heering.

Project meetings

- Ideals partner meeting, Eindhoven, March 30: A. van Deursen (Lecture: Crosscutting concerns in the ASML code base), P. Klint.
- Ideals partner meeting, Eindhoven, April 10: A. van Deursen (Lecture: Refactoring and analysis), P. Klint, M. Bruntink, T. Tourwé.
- CaLCE meeting, VU, Amsterdam, October 4: M.G.J. van den Brand, A.T. Kooiker, H.A. de Jong, J.J. Vinju (Lecture: High-fidelity source-to-source transformations).

Other lectures

- 'Logics for epistemic updating', Zuidelijk Intercity Colloquium, TUE, March 8: D.J.N. van Eijck.
- 'Parsing with sequentially indexed grammars' and 'Quantifier decomposition', Signes Seminar, Univ. Michel de Montaigne, Bordeaux, March 14: D.J.N. van Eijck.
- 'Isolating Crosscutting Concerns in System Software', Philips Research Colloquium, Eindhoven, April 27: A. van Deursen.
- 'Monotonicity in natural reasoning', TF Lunch Seminar, Utrecht, June 28: D.J.N. van Eijck.
- 'Informatica studeren waarom niet?', alumnus talk, UvA, August 30: J.J. Vinju.
- 'Software als blokkendoos?', Impetus lecture, HvA, December 21: P. Klint.

Visitors

- D. Wieringa, Deloitte & Touche, January 20. Host: J.J. Vinju.
- J. Pleiter, Backbase BV, February 2. Host: A. van Deursen.
- R. Heller, ChessIT, May 19. Host: J.J. Vinju.
- J.R. Cordy, Queens Univ., Canada, November 15. Host: P. Klint.

Memberships of committees and other professional activities

M.G.J. van den Brand

- Member programme committee 9th European Conference on Software Maintenance and Reengineering (CSMR '05).
- Member programme committee 6th International Workshop on Rule-Based Programming (RULE '05).
- Member programme committee VLDB Workshop on Trends in Enterprise Application Architecture (TEAA '05).
- Copromotor J.J. Vinju, UvA, November 15.

A. van Deursen

- Member programme committee WCRE '05 Workshop on Reengineering Towards Product Lines (R2PL '05).
- Member programme committee 12th Working Conference on Reverse Engineering (WCRE '05).
- Member programme committee 21st International Conference on Software Maintenance (ICSM '05).
- Member programme committee 5th IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '05).
- Member programme committee First International Workshop on the Modeling and Analysis of Concerns in Software (MACS '05).
- Member programme committee 13th International Workshop on Program Comprehension (IWPC '05).
- Member programme committee 27th International Conference on Software Engineering (ICSE '05).
- Member programme committee 9th European Conference on Software Maintenance and Reengineering (CSMR '05).
- Member programme committee IASTED International Conference on Software Engineering (SE '05).
- Member beoordelingscommissie NWO's Informatica Open Competitie.
- Member programme committee NWO's Jacquard research programme.
- Editor special issue on reverse engineering *IEEE Transactions on Software Engineering* **31** (2).
- Editor Science of Computer Programming.
- Editor, Special Issue on Language Definitions and Tool Generation, IEE Proceedings, Vol. 152, Number 2, April 2005.
- Editor special issue on reverse engineering *Journal of Systems and Software* **77** (3).

D.J.N. van Eijck

- Member of the board Dutch Graduate School in Logic (OzsL).
- Member of the European Network in Computational Logic.
- Member programme committee 6th International Workshop on Computational Semantics.
- Member programme committee 2nd Workshop on Lambda Calculus, Type Theory and Natural Language.
- Member PhD committee R. Mastop.
- Member PhD committee O. Koornwinder.

J. Heering

- Member programme committee 6th Workshop on Language Definitions Tools and Applications (LDTA '06).

P. Klint

- Member programme committee 5th Workshop on Language Definitions Tools and Applications (LDTA '05).
- Member programme committee 2nd International Workshop on Rapid Integration of Software Engineering techniques (RISE '05).
- President European Association for Programming Languages and Systems (EAPLS).
- Member Scientific Directorate Schloss Dagstuhl.
- Member steering committee ETAPS.
- Chair Adviescommissie Informatica (ACI).
- Chair Informaticaonderzoek Platform Nederland (IPN).
- Member programme committee NWO Jacquard.
- Member of the Board Institute for Programming and Algorithms (IPA).
- Member programme board Lorentz Center.

- External examiner, PhD defense J. Iversen, Aarhus Univ., May 12.
- Member PhD committee G. Delen, UvA, May 17.
- PhD committee Peter Zoeteweij, UvA, November 29.

Academic publications

Publications in refereed journals or proceedings

1 G. Ballintijn (2005). A case study of the release management of a health-care information system. Proceedings of the IEEE International Conference on Software Maintenance (ICSM '05, Industrial track), September, 34–43.

2 J. van Benthem, J. van Eijck, B. Kooi (2005). Common knowledge in update logics. R. van de Meyden (ed). Theoretical Aspects of Rationality and Knowledge. Proceedings of the Tenth Conference, National Univ. of Singapore, 253–261.

3 M.G. J. van de Brand, A.T. Kooiker, J.J. Vinju, N.P. Veerman (2005). An architecture for context-sensitive formatting. Proceedings 21st IEEE International Conference on Software Maintenance (ICSM '05), IEEE Computer Society, 631–634.

4 M. van de Brand, P.-E. Moreau, J. Vinju (2005). A generator of efficient strongly typed abstract syntax trees in Java. IEEE Proceedings — Software 152(2), 70–79.

5 M. Bravenboer, R. Vermaas, J. Vinju, E. Visser (2005). Generalized type-based disambiguation of meta programs with concrete object syntax. R. Glück and M. Lowry (eds). Generative Programming and Component Engineering (GPCE '05), LNCS 3676, 157–172.

6 M. Bruntink, A. van Deursen, R. van Engelen, T. Tourwé (2005). On the use of clone detection for identifying crosscutting concern code. IEEE Transactions on Software Engineering 31(10), 804–818,

7 M. Bruntink, A. van Deursen, T. Tourwé (2005). Isolating idiomatic crosscutting concerns. Proceedings International Conference on Software Maintenance (ICSM '05), 37–46. IEEE Computer Society.

8 M. Ceccato, M. Marin, K. Mens, L. Moonen, P. Tonella, T. Tourwé (2005). A qualitative comparison of three aspect mining techniques. Proceedings International Workshop on Program Comprehension (IWPC).

9 A. van Deursen, E. Burd (2005). Guest editorial: Software reverse engineering. Journal of Systems and Software 77(3), 209–211.

10 A. van Deursen, M. Marin, L. Moonen (2005). A JHotDraw: A showcase for refactoring to aspects. Proceedings AOSD Workshop on Linking Aspect Technology and Evolution (LATE).

11 A. van Deursen, E. Stroulia (2005). Guest editors' introduction: 10th WCRE Working Conference on Reverse Engineering. IEEE Transactions on Software Engineering 31(2), 97–98.

12 J. van Eijck (2005). Normal forms for characteristic functions on n-ary relations. Journal of Logic and Computation (15), 85–98.

13 J. van Eijck, S. Orzan (2005). Modelling the epistemics of communication with functional programming. M. van Eekelen (ed). Sixth Symposium on Trends in Functional Programming TFP '05, Institute of Cybernetics, Tallinn Technical Univ., 44–59.

14 B. Graaf, H. van Dijk, A. van Deursen (2005). Evaluating an embedded software reference architecture: Experience report. Proceedings 9th European Conference on Software Maintenance and Reengineering (CSMR '05), 354–363. IEEE Computer Society.

15 S. Jansen, S. Brinkkemper, G. Ballintijn (2005). A process model and typology for software product updaters. Proceedings of the 9th European Conference on Software Maintenance and Reengineering (CSMR '05), Manchester, UK, March, 265–274.

16 S. Jansen, S. Brinkkemper, G. Ballintijn, A. van Nieuwland (2005). Integrated development and maintenance of software products to support efficient updating of customer configurations: A case study in mass market erp software. Proceedings of the IEEE International Conference on Software Maintenance (ICSM '05, Research track), Budapest, Hungary, September. 10 pages.

17 H.A. de Jong, A.T. Kooiker (2005). My favorite editor anywhere. N. Guelfi (ed). Rapid Integration of Software Engineering Techniques '04, LNCS 3475, 122–131.

18 P. Klint, R. Lämmel, C. Verhoef (2005). Toward an engineering discipline for grammarware. ACM Transactions on Software

Engineering and Methodology 14(3), 331–380.

19 P. Klint, T. van der Storm, J. J. Vinju (2005). Term rewriting meets aspect oriented programming. A. Middeldorp, V. van Oostrom, F. van Raamsdonk, R. C. de Vrijer (eds). Processes, Terms and Cycles: Steps on the Road to Infinity, Essays Dedicated to Jan Willem Klop, on the Occasion of His 60th Birthday, LNCS 3838, 88–105.

20 M. Lormans, A. van Deursen (2005). Reconstructing requirements coverage views from design and test using traceability recovery via LSI. Proceedings of the 3d ASE International Workshop on Traceability in Emerging Forms of Software Engineering. ACM, November.

21 M. Marin, L. Moonen, A. van Deursen (2005). An approach to aspect refactoring based on crosscutting concern types. Proceedings of the ICSE 2005 First International Workshop on the Modeling and Analysis of Concerns in Software (MACS). ACM, 2005. SIGSOFT Software Engineering Notes 30(4).

22 M. Marin, L. Moonen, A. van Deursen (2005). A classification of crosscutting concerns and the implications for aspect-oriented refactoring. Proceedings International Conference on Software Maintenance (ICSM '05), 673–677.

23 M. Mernik, J. Heering, A. Sloane (2005). When and how to develop domain-specific languages. ACM Computing Surveys 37(4), 316–344.

24 A. Mesbah, A. van Deursen (2005). Crosscutting concerns in J2EE applications. Proceedings 7th IEEE International Symposium on Web Site Evolution (WSE '05), 14–21.

25 M. van den Brand, B. Cornelissen, P. Olivier, J. Vinju (2005). TIDE: (a) generic debugging framework. J. Boyland, G. Hedin (eds). Language Design Tools and Applications ENTCS 141, 161–165.

26 T. van der Storm (2005). Continuous release and upgrade of component-based software. Proceedings of the 12th International Workshop on Software Configuration Management (SCM-12), Lisbon, Portugal, September.

Publications in other journals or proceedings and other scientific output

CWI reports

SEN-E0502, SEN-R0503, SEN-E0504, SEN-R0504, SEN-E0506, SEN-E0507, SEN-R0507, SEN-R0510, SEN-R0512, SEN-R0513, SEN-R0515, SEN-R0517, SEN-E0517.

See B.3 on page 202 for complete titels.

Software developed

1 M. Marin, A. van Deursen, L. Moonen (2005). AJHotDraw. SourceForge. Aspect-oriented re-implementation of JHotDraw.

2 M. Marin, A. van Deursen, L. Moonen (2005). FINT. Eclipse plugin offering aspect-mining capabilities by means of fan-in analysis.

3 T. van de Storm (2005). Sisyphus. Continuous integration system.

Monographs

1 J. van Eijck, A. Visser (2005). Inzien en Bewijzen. Amsterdam University Press, 2005.

2 J. van Eijck, A. Visser (2005). Inzien en Bewijzen — Docentenhandleiding. Exact in Context. Amsterdam University Press, 2005.

PhD theses

1 J.J. Vinju (2005). Analysis and Transformation of Source Code by Parsing and Rewriting. UvA, November 15. Advisor: P. Klint, co-advisor: M.G.J. van den Brand.

Professional products

Publications for a broad audience

1 A. van Deursen interview: Kim Loohuis. Fouten in C en C++ oorzaak beveiligingsproblemen. Computable 48(2).

2 A. van Deursen (2005). De Software-Evolutieparadox. TUD, February 23. Inaugural Lecture.

3 A. van Deursen (2005). Uiteindelijk loopt elk systeem vast. Automatisering Gids, 38(10).

4 A. van Deursen radio-interview in VPRO Noorderlicht, March 15.

5 P. Klint, Onderzoekscentrum West, Aflevering 45, column, I/O Magazine van het Informaticaonderzoek Platform Nederland 2(1).

6 P. Klint, Meten van wetenschap, column, I/O Magazine van het Informaticaonderzoek Platform Nederland 2(2).

7 P. Klint, Ban op spam, column, I/O Magazine van het Informaticaonderzoek Platform Nederland 2(3).

8 P. Klint, Emigreren of blijven?, column, I/O Magazine van het Informaticaonderzoek Platform Nederland 2(4).

9 P. Klint interview: Andrew Wools-King and Steven Keeping, Should software be patentable?, Philips Research Passport Magazine, Issue 25.

10 P. Klint interview: Peter Steeman, Huidige software patenten ouderwets, Computable, December 2.

11 P. Klint interview: Christian Jongeneel, Informatici moeten keuzes maken, *Computable*, December 23.

12 P. Klint, Computerstoring trekt wissel op relatie reiziger, NS en ProRail, Tros Nieuwsshow, Radio 1, April 9.

13 M. Lormans, H. van Dijk, A. van Deursen, E. Nöcker, A. de Zeeuw (2005). Omgaan met veranderende requirements in outsourcing-projecten. Informatie, December.

14 J.J. Vinju, Nieuwe programmeertechnologie behoudt kwaliteit software, *Computable*, November 11.

Other output

Awards

A. van Deursen received a best reviewer award at the IEEE International Conference on Software Maintenance (ICSM '05).

Specification and Analysis of Embedded Systems – SEN2

Mission

The research of this theme concentrates on techniques for improving the quality of software components typically found in embedded systems. For this purpose we study and develop formal techniques for the unambiguous description, design and documentation of full software systems. An important vehicle is the language μCRL: micro Common Representation Language; others are timed automata and modal logic. We work with a wide range of analysis techniques and resources to prove that programmed systems exhibit their expected functionality. We employ methods from algebra and logics, as well as term rewriting. Dedicated tools for proof checking, state-space analysis and reduction, simulation, and testing are used for the analysis of systems. To assess the viability of various techniques and tools, we carry out experiments in the realm of fundamental distributed algorithms, embedded and hybrid control systems, and network protocols. Industrial application of our techniques, in the form of case studies, is an important activity.

Theme leader

Dr. J.C. van de Pol

MSC or CR classification

C.2.2, D.2.4, F.3.1

Subthemes

Name	Leader
SEN2.1 – Distributed Systems	J.C. van de Pol
SEN2.2 – Process Theory and Verification	W.J. Fokkink

SEN2.1 is devoted to the study of specification, analysis and testing techniques for computer controlled systems, allowing to design and build these more efficiently, and with fewer embedded faults. This is achieved by developing and implementing algorithms for the analysis and verification of distributed systems for the μCRL toolset. The techniques and algorithms are assessed and improved via case studies in various application domains, such as railway safety (also: network protocols, embedded controllers, etc.). Central issues are (1) State space reduction for model checking (by abstraction and theo-

rem proving); (2) distributed algorithms that run model generation, reduction and checking on a cluster of computers, and (3) test generation and execution.

SEN2.2 deals with the development of methods for proof checking as a means to improve the quality of mathematical proofs. Furthermore, it is concerned with the fundamental study of process theory and term rewriting. Within this theme, theory and methods are developed that are applied in SEN2.1. Central issues are process algebra, symbolic verification techniques, automated deduction, and modeling and (semi-)automated verification of security protocols.

SEN2 has a long-term collaboration with the group Vasy (systems validation) in INRIA Rhône-Alpes, in the framework of the bilateral project SENVA. The project organized several workshops and research visits, and fosters synergy and software bridges between the μCRL and CADP toolsets. This recently resulted in a joint European project proposal (NEST-Pathfinder).

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. B. Badban	0.79	PhD student	2001-10-16 till 2005-10-15	SEN2.2: IT-VDS
Dr. S.C.C. Blom	0.17	project member	2000-03-01 till 2005-02-28	SEN2.1: TT-Medal
Drs. J. Calamé	1.0	PhD student	2004-07-01 till 2008-06-30	SEN2.1: TT-Medal
Drs. T. Chen	0.5	PhD student	2005-07-01 till 2009-06-30	SEN2.2: Bricks
Drs. M. Dashti	1.0	PhD student	2004-01-01 till 2007-12-31	SEN 2.2: Account
Prof.dr. W.J. Fokkink	0.2	leader SEN 2.2	indefinite	SEN2.1: PROGRESS,TT-Medal; SEN2.2: TIPSy
Dr. N. Goga	0.55	Postdoc	2005-02-01 till 2005-12-31	SEN2.1: TT-Medal
Dr.Dipl.ing. N. Ioustinova	1.0	project member	2001-10-01 till 2007-10-15	SEN2.1: TT-Medal, MoveBP
Prof.dr. J.W. Klop	0.4	CWI Fellow	indefinite	SEN2.2
Drs. B. Lisser	1.0	programmer	indefinite	SEN2.1: TT-Medal
Dr. J.C. van de Pol	1.0	theme leader, leader SEN2.1	indefinite	SEN2.1: PROGRESS, TT-Medal; SEN2.2: IT-VDS
Drs. M.A. Valero Espada	0.17	PhD student	2001-03-01 till 2005-02-28	SEN2.1: PROGRESS
Dr. M. Weber	0.17	Postdoc	2005-11-01 till 2008-10-31	SEN2.1: VeriGEM
Drs.ing. A.J. Wijs	1.0	PhD student	2003-07-01 till 2007-06-30	SEN2.2: TIPSy

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr.ir. J.F. Groote (TUE)	0.1	researcher	indefinite	SEN2.1
Dr. S.P. Luttik (TUE)	0.2	researcher	2004-05-01 till 2007-04-30	SEN2.1
Dr. S. Mauw (TUE)	0.1	researcher	indefinite	SEN2.2
Dr. S.M. Orzan (TUE)	0.2	guest researcher	till	SEN2.1

Scientific report

Highlights

- On October 14, the TT-Medal project on Testing with TTCN-3 had its final demonstration in Helsinki. Its six demos, of which CWI/SEN2 presented the application to the railway domain, delivered TT-Medal the ITEA

Achievement Award 2005.

- The NWO/Focus project VeriGEM (Verification GRID for Enhanced Model Checking) was awarded by a grant of three postdocs for three years (CWI/SEN2, UT, TUE).
- On December 5, M. Valero successfully defended his thesis at VU, see page 89 thereby finishing the STW/Progress project on shared data spaces.
- On December 19, the 60th birthday of J.W. Klop was celebrated, as well as his 25 years connection with CWI. A symposium with 9 international speakers was organized on *Processes, terms, and cycles: steps on the road to infinity*, followed by a reception.

PhD students

B. Badban
J. Calamé
T. Chen
M. Dashti
M.A. Valero Espada
A.J. Wijs

SEN2.1 – Distributed Systems

Title	CES.5009 – Formal design, tooling, and prototype implementation of a real-time distributed shared data space
Period	2000-06-01–2005-02-28
Leader	J.C. van de Pol
Staff	S.M. Orzan, M.A. Valero Espada
Funding	PROGRESS
Partner	J. Hooman (RU), 4TEC, ThalesNL

Progress report. Valero defended his thesis, see 1 on page 89 It has contributed to the understanding of shared dataspaces (Splice, JavaSpaces and general frameworks), to the abstraction of system specifications, in order to reduce state spaces for model checking, and to distributed algorithms for state space reduction and model checking. Fruitful collaborations with the former PhD students Valero and S. Orzan exist and will be continued.

Title	TT-Medal – Testing and test methodologies with advanced languages
Period	2004-01-01–2005-12-31
Leader	J.C. van de Pol
Staff	S.C.C. Blom, J. Calamé, N. Goga, N. Ioustinova, B. Lisser
Funding	ITEA/SenterNovem
Partners	LogicaCMG, ProRail, Improve QS, Fokus, DaimlerChrysler, Nokia, VTT, Conformiq, Nethawk

Progress report. Calamé finished the systematic description of the test generator TGV. In collaboration with Van de Pol and Ioustinova, he furthermore refined the approach for a test generation process based on data abstraction and constraint-solving. Calamé developed the tool support and evaluated the approach of test generation with data abstraction on the case study CEPS (Common Electronic Purse Specifications), showing the automatic generation of parameterizable test cases in TTCN-3.

Ioustinova, in cooperation with S. Blom (Univ. Innsbruck), T. Deiss (Nokia), Axel Rennoch (FOCUS), Van de Pol (CWI) and N. Sidorova (TUE), provided a semantics for *host-based testing* with *simulated time*, and showed which kind of timing constraints can be adequately tested with simulated time. She also provided a simulated-time solution for *distributed* testing with TTCN. The concept of simulated time and the proposed solution have been applied to test software for Vital Processor Interlocking in the realm of Railway Safety.

Goga was part time working at CWI and part time at TUE. At CWI, Goga performed the actual Railway case study, in collaboration with S. Blom, Ioustinova, and Lisser. He tested the VPI code of an interlocking system of Pro-Rail. The testing efforts led to the discovery of an error, that was previously found by ProRail engineers, but not by earlier verification activities at CWI. At TUE the research mainly focussed on the ISO/IEEE 1073 family of standards for medical equipment.

Title	VeriGEM – A Verification GRID for Enhanced Model Checking
Period	2000-06-01–2005-02-28
Leader	Prof. B.R. Haverkort (UT)
Staff	M. Weber
Funding	NWO-Focus
Partner	Haverkort (UT), Groote (TUE)

Progress report. Weber started a postdoc position on November 1, 2005. He is working on parallel and distributed algorithms for state space generation. He is collaborating with J.F. Groote (TUE) to advance and extend parallel mu-calculus model checking (with data).

Furthermore, he is part of a collaboration with Masaryk Univ. Brno and TU Munich in the DivSPIN project. Its goal is to specify and develop components for practically competitive distributed model checkers, culminating in the development of a distributed SPIN-compatible model checker.

Title	FACS – Facilitating the Advancement of Computational Science
Period	2003-10-01–2008-10-01
Leader	N. Nes (INS1)
Staff	S.C.C. Blom, M. Weber, B. Lisser
Funding	NWO-k
Partners	INS1, SEN4

Progress report. After the departure of S. Blom, Lisser took over the development of distributed model checking and reduction software, as well as the maintenance of this software on the FACS cluster and also at the TUE. He will continue to do so, now also in collaboration with Weber on the VeriGEM project.

Other activities. Van de Pol supervised four PhD students daily (Badban, Valero, Calamé, Wijs) and three postdocs (Goga, Ioustinova, Weber). He was involved in several project proposals, among which the Focus project VeriGEM, which was awarded, and the preparation of a European proposal (STREP in NEST Pathfinder). Other proposals still pending are NWO/open, STW/open and NWO/Focus. His research was devoted to (1) abstraction for model checking, in particular on adding accelarated transitions (with Valero); (2) theorem proving, in particular combining DPLL, BDDs and decision procedures (with Badban, Tveretina (Univ. of Cork), Zantema (TUE), M. Schuijers (Master Student TUE) and Luttik (TUE); (3) distributed model checking, in collaboration with S. Orzan (TUE), S. Blom (Univ. Innsbruck), and Weber. He also actively participated in joint meetings with the SENVA team in Grenoble, H. Garavel, F. Lang, R. Mateescu and W. Serwe (Inria Rhône-Alpes).

J.F. Groote directed his effort mainly to the development of μCRL2, a successor of μCRL. μCRL2 contains a rich set of datatypes, including functions and sets, and the possibility to deal with multi-actions. Both features make it easier to concisely model and analyse system behaviour. However, the redesign of the language turned out to require the reformulation of its basic theory and reprogramming the tools (esp. the introductions of functions turn out to be cumbersome). The estimate is that the transformation of the μCRL toolset in μCRL2 is now halfway completed.

SEN2.2 – Process Theory and Verification

Title	IT-VDS – Integrating Techniques for the Verification of Distributed Systems
Period	2001-10-16–2005-10-15
Leader	J.C. van de Pol
Staff	B. Badban
Funding	NWO
Partner	H. Zantema (TUE)

Progress report. Badban finished her research in verifying logical formulas with data by means of generalized BDD procedures and DPLL procedures. With Luttik, she finalized the Generalized DPLL procedure to algebras with constructors and recognizers. Badban also verified a Sliding Window Protocol with Piggybacking in μCRL. She finished writing the manuscript of her thesis ($> 95\%$) which will be submitted soon.

Title	TIPSy – Performance analysis and system verification
Period	2003-07-01–2007-06-30
Leader	J.C. van de Pol
Staff	A.J. Wijs
Funding	NWO
Partners	J.C.M. Baeten (TUE), K. Rooda (TUE)

Progress report. Wijs continued work on the scheduling problem of the chemical analyser case study, in collaboration with Van de Pol and E. Bortnik from TUE. Guidelines were described how to specify a model of a system in untimed process algebra in order to find shortest schedules. Besides an on-the-fly search algorithm to find optimal schedules, a distributed version was implemented joint with Bert Lisser and is integrated with the μCRL toolset. Wijs also adopted beam search algorithms and implemented them in the μCRL toolset to optimize the search for (near)optimal schedules

The translation scheme from Chi to μCRL was updated by Wijs to deal with the latest version of Chi. Next an implementation of the scheme should be created. The work on the turntable has been officially published as a jour-

nal paper. Luttik is co-author of the same paper, and is involved in a similar translation of Chi to SPIN.

Finally, Wijs collaborated with Fokkink and Pang on research on Timed Branching Bisimilarity. It was checked whether or not this relation is actually an equivalence, which it proved to be when dealing with discrete time. In a continuous time setting though, the existing definition needed to be updated.

Title	Account – Accountability in electronic commerce protocols
Period	2004-01-01–2007-12-31
Leader	W.J. Fokkink
Staff	M. Dashti
Funding	NWO
Partners	Crispo (VU), Etalle (UT)

Progress report. Dashti has been working on the formalization of a model of intruder for verifying liveness properties in security protocols. To get a better understanding of how in verification practice this model can be used, two case studies have been undertaken. The first one, published in ICICS'05, studies non-repudiation protocols and the second one, still in progress, looks at fairness requirements in digital right management (DRM) protocols.

Title	Bsik/BRICKS PDC 1.3
Period	2005–2009
Leader	W.J. Fokkink
Staff	T. Chen
Funding	NWO
Partners	TUE, Siemens

Progress report. Chen started his PhD programme from July, 2005. With Fokkink and H. Jonker he was working on developing a formal model for the Siemens project and proposed some blueprint for the redesign. Moreover, he is now studying the axiomatization problem for process algebra and has got some results. More work on diverse theoretical open problems and security algorithms is still in progress.

Other activities. Klop completed a paper on Iterative Lexicographic Path orders (ILPO) together with V. van Oostrom and R. de Vrijer (VU). With R. de Vrijer he wrote a paper on infinite normalization. With Luttik and Clemens Grabmayer (VU) he started work on a geometric view on process algebra, reported in a paper presented at the conference in Bertinoro, Italy about *25 years of process algebra*. Klop further worked on starting up the project INFINITY, a three year NWO project in the framework of FOCUS/BRICKS, with partners VU, CWI, UU.

Fokkink graduated Valero and participated in the security projects, by supervising Dashti and Chen. He also proofread the manuscript of Badban. His main research activity is on distributed algorithms. He continues research on axiomatizations of process algebra and structural operational semantics. With Wijs he studies timed process semantics.

Luttik participated in the NWO project TIPSy, supervising N. Trcka (TUE), and in the project Tangram of the Embedded Systems Institute, supervising M. van Osch (TUE). He worked with Badban on extending DPLL to ground term algebras with recognizers. With C. Grabmayer (VU) and Klop he started work in the NWO project GeoProc, developing a geometric view on process algebra. He also continued collaboration with L. Aceto, A. Ingolfsdottir (both Reykjavik Univ.) and Fokkink on finding suitable axiomatisations of process algebras.

Societal aspects and knowledge transfer

External contacts

- Companies: LogicaCMG, Prorail, Improve QS, Nokia (Germany, Finland), Daimler-Chrysler, Add-Controls, 4TEC, Thales, TNO-FEL, Dutch Aerospace Laboratory, Siemens NL, ASML, ESI, Philips Natlab, Philips Medical, Conformiq (Finland), Ericsson, AT&T Bell Labs, etc.
- Academic: INRIA Rhône-Alpes, TUE (depts. CS, EE, ME), UT, VU, UvA, RU, UU, Univ. Innsbruck, Univ. Cork, Univ. Masaryk, LMU Munich, Univ. Complutense Madrid, Univ. Oldenburg, RWTH Aachen, Fraunhofer/Fokus, VTT Finland, Univ. Sheffield, etc.

Projects with partners in public and private sector

- Thales NL and 4TEC are partners of PROGRESS project CES.5009.
- ASML is involved in the NWO project TIPSy.
- TT-Medal is a joint project with a.o. LogicaCMG, ProRail, Improve QS (NL), DaimlerChrysler, Nokia (Germany), Conformiq,

Nokia (Finland)
- Siemens is partner in the BRICKS/PDC 1.3 project.

Teaching at university

- Fokkink teaches courses on protocol validation and on formal language theory and distributed algorithms at VU.
- Groote teaches the master's course RADV at TUE, on using the μCRL toolset for requirements analysis, design and verification.
- Van de Pol started an advanced masters course Algorithms for Model Checking at the TUE. He also supervized the MSc student M. Monteban (VU/CWI, October 12), M. Schuijers (TUE) and was in the MSc committee of J. van de Wulp (TUE, August 19).
- Luttik teaches bachelor courses on Semantics of Programming Languages and Logic and Set Theory at TUE.
- S. Mauw teaches (bachelor and masters) at the TUE on Information security, Verification of security protocols., Semantics, and Logic and sets.

Courses, tutorials

- FOSAD'05, Milan, September: S. Mauw (Tutorial: Foundations of attack trees).
- IPA Herfstdagen on Security, Zwartsluis, Netherlands, November: 21–25. S. Mauw (Tutorial: Foundations of attack trees).

Organization of conferences, workshops, courses, meetings

- Seminar Process Algebra Meetings, CWI, weekly: Ioustinova (organizer).
- 11th Theory Day of the NVTI, (Nederlandse Vereniging voor Theoretische Informatica), Utrecht, March 4: Van de Pol (organizer).
- The First Dutch Workshop on Formal Testing Techniques (DWFTT 2005), CWI, Amsterdam, June 21: Ioustinova (organizer with M. Stoelinga, UT).
- The workshop PDMC 2005 co-located with ICALP, Lisbon, Portugal, July 10: Van de Pol (organizer with M. Leucker, LMU Munich).
- organized The Symposium on Embedded Software Quality, CWI, August 31: Ioustinova and Van de Pol with C. Willcock (Nokia), Rini van Solingen (LogicaCMG) organizer).
- The Symposium Processes, terms, and cycles: steps on the road to infinity in honour of Jan Willem Klop (JWK 60 year + 25 years at CWI). CWI, December 19: Van de Pol (organizer with Van Dam, Van Oostrom, Van Raamsdonk, De Vrijer, VU).
- The 5th International Conference Integrated Formal Methods, TUE, November 29–December 2: Van de Pol (organizer with J. Romijn TUE, and G. Smith, Queensland, Australia).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- 22nd Meeting of the German Computer Society SIG Test, Analyse, Verifikation, Bremen/Germany, February 17–18: J. Calamé.
- 11th NVTI Theoriedag, Utrecht, March 4: J. van de Pol (organizer), M. Dashti, A. Wijs.
- Joint Mathemetical BeNeLuxFra conference, Gent, Belgium, May 20–22: Jan Willem Klop (Lecture: Kaleidoscope of Process Algebra).
- TTCN-3 User Conference, Sophia-Antipolis/France, June 6–8: J. Calamé, J. van de Pol. N. Ioustinova (Lecture: Testing Railway Interlockings with TTCN-3, Outstanding Presentation Award from ETSI).
- 10th Conference on Engineering of Complex Computer Systems (IEEE), Shanghai/China, June 16–20: A. Wijs (Lecture: From χ to μCRL: Combining Performance and Functional Analysis).
- 1st Dutch Workshop on Formal Testing Techniques, Amsterdam/Netherlands, June 21. N. Ioustinova, J. van de Pol; J. Calamé (Lecture: Test Generation with Abstraction and Concretization).
- Workshop on Structural Operational Semantics 2005, Lisbon, Portugal, July 10: W. Fokkink (Lecture: Divide and congruence applied to η-bisimulation).
- Workshop on Parallel and Distributed Methods in VerifiCation 2005, Lisbon, Portugal, July 10: J. van de Pol (co-chair).
- International Colloquium on Algorithms, Languages and Programming 2005, Lisbon, Portugal, July 11–15: W. Fokkink (Lecture: A finite basis for failure semantics).

- Workshop: 25 years of process algebra. Bertinoro, Italy, August 3: W. Fokkink (organizer), J.F. Groote (Lecture: Rationale behind μCRL2), J.W. Klop (Lecture: Reflections on a Geometry of Processes), B. Luttik (Lecture: What is algebraic in process theory?).
- Symposium on Embedded Software Quality, CWI, August 31: N. Ioustinova, J. van de Pol (organizers), M. Dashti.
- International Conference on Algebra and Coalgebra in Computer Science, 2005, Swansea, Wales, September 3–6: W. Fokkink (Lecture: Bisimilarity is not finitely based over BPA with interrupt).
- 10th International Workshop on Formal Methods for Industrial Critical Systems (ACM), Lisbon/Portugal, September 5–6: J. van de Pol, A. Wijs (Lecture: Solving Scheduling Problems by Untimed Model Checking).
- 3rd Conference on Formal Modelling and Analysis of Timed Systems, Uppsala/Sweden, September 26–28: A. Wijs (Lecture: Is Timed Branching Bisimilarity and Equivalence Indeed?).
- Scientific ICT Research Event Netherlands (SIREN) workshop: Eindhoven, October 6: A. Wijs, J. van de Pol etal. (Poster presentation: Tools and Techniques for Integrating Performance Analysis and System Verification: TIPSY).
- 6th ITEA Symposium, Helsinki, Finland, October 14: N. Ioustinova (Poster and demonstrator: Testing Railway Interlockings with TTCN-3). ITEA Achievement Award 2005.
- CWI in Bedrijf, October 20: J. Calamé, N. Ioustinova, J. van de Pol. (Poster presentation: Testing of railway safety with TTCN-3).
- FMCO 2005, CWI, November 2: J.F. Groote (Lecture: μCRL2: a language for behavioural modelling and analysis), W. Fokkink (Lecture: Divide and congruence).
- 11de Nederlandse Testdag, Enschede, November 11: J. Calamé, N. Ioustinova (Lecture: Testing Railway Interlockings with TTCN-3).
- 2nd European Symposium on Verification and Validation of Software Systems and Testing (VVSS), Laquso, Eindhoven, November 24: J. van de Pol.
- 5th International Conferences on Integrated Formal Methods, Eindhoven, November 29–December 2: J. van de Pol (co-chair), A. Wijs, J. Calamé (Lecture: Student Symposium: An Automated Test Generation Process from UML Models to TTCN-3), M. Dashti (Lecture: Student Symposium: A passive Dolev-Yao intruder that reads xor).
- ICISC'05, Seoul, December: S. Mauw (Lecture: Foundations of attack trees).
- Münchner Model Checking Tag 2005, München, Germany, December 9: M. Weber (Lecture: Parallel Model Checking (Issues and some Solutions).
- 12th Asia-Pacific Software Engineering Conference (IEEE)), Taipei/Taiwan, December 14–17: J. Calamé (Lecture: Data Abstraction and Constraint Solving for Conformance Testing).
- 25th International Conference Foundations of Software Technology and Theoretical Computer Science (FSTTCS'05): Hyderabad, India, December 15–18: T. Chen (Lecture: On the Bisimulation Congruence in chi-Calculus.)

Working visits

- TNO-FEL H. Jense, January 17: J. van de Pol.
- L. Aceto, A. Ingolfsdottir, Reykjavik Univ., Iceland, December 10–17: B. Luttik.
- L. Brim, ParaDiSe Labs, Masaryk Univ., Brno, Czech Republic, December 12–16: M. Weber.

Project meetings

- TT-Medal Meeting NL consortium, Nieuwegein, February 17, May 25, August 17: J. van de Pol.
- TIPSy Meetings, TUE, January 28, February 18, May 20, June 17, July 7, September 9, November 4, December 20: J. van de Pol, A. Wijs.
- TT-Medal Meeting, Saariselkä/Finland, March 1–5: N. Ioustinova. J. Calamé (Lecture: Abstraction and Concretization for Test Generation).
- SENVA audioconference, April 13: J. van de Pol, B. Lisser, A. Wijs, H. Garavel, F. Lang, R. Mateescu, W. Serwe.
- SENVA Meeting, St Pierre de Chartreuse, May 30–June 1: A. Wijs (Lecture: Solving Scheduling Problems by Untimed Model Checking - The Clinical Chemical Analyser Case Study), J. van de Pol (Lecture: Accelerated must-transitions to get more progress), W. Fokkink (Lecture: Is Timed Branching Bisimilarity an Equivalence Indeed?), M. Weber (Lecture: Parallel Model Checking.)
- TT-Medal Meeting, Sophia Antipolis, France, June 9–10: J. van de Pol.

- TT-Medal Meeting, Amsterdam, August 31–September 2: J. Calamé (Lecture: Generation of TTCN-3 from Abstracted Test Cases).
- TT-Medal Meeting and Final Review, Berlin, September 27–28: J. van de Pol, N. Ioustinova.
- SENVA Meeting on Clusters and Grids for Verification and Performance Evaluation, INRIA Rhône-Alpes - Montbonnot (Isère), France, November 16–17: M. Weber (Lecture: DivSPIN: A SPIN Compatible Distributed Model Checker.), J. van de Pol (Lecture: Distributed State Space Generation and Minimization), S. Orzan (Lecture: Detecting Strongly Connected Components in Large Distributed State Spaces.)
- VeriGEM meeting, UT, Enschede, November 25: J. van de Pol and M. Weber visited (A. Belinfante, A. Rensink, M. Stoelinga, B. Haverkort UT, J. van Ossenbruggen (BRICKS), M. de Boer (NWO).

Other lectures

(Lectures at the local PAM seminar have been omitted)

- KiviNiria RADKNIT avondlezing, Utrecht, April 12: J. van de Pol (Lecture: Automated error detection in Software Intensive Systems).
- KNAW June 20: J.W. Klop (Lecture: Rekenen met Acties en Communicaties).
- Cryptography and Formal Methods, RISC seminar, CWI, October 24: M. Dashti (Lecture: A passive Dolev-Yao intruder that reads xor).

Courses

- Leeuwendaal course MIOO: Management in Research Organisations: J.C. van de Pol.
- IPA Lentedagen on Software Architecture, Made/The Netherlands, March 20–April 1: A. Wijs, M. Dashti.
- Summer school, Marktoberdorf Germany, August 2–14: M. Dashti.
- English writing course, CWI, October–December: T. Chen.
- IPA Herfstdagen on Security, Zwartsluis, November 21–25: J. Calamé, T. Chen, M. Dashti (Lecture: Dashti: Wanted: Safe or Alive).

Visitors

- A. Huima, Conformiq Finland (TT-Medal), January 11–12. Host: J. van de Pol.
- M.J. Gabbay, Heriot-Watt Univ., Edinburgh, UK, March 2. Host: J. van de Pol.
- D. Maurer, George Washington Univ., Washington, USA, April 20. Host: N. Ioustinova.
- R. van Glabbeek, Kensington Research Laboratory, Sydney, Australia. June 15. Host: W. Fokkink.
- W. Serwe, Frederic Lang, SENVA, Inria Rhône-Alpes, September 10–15. Host: J. van de Pol.
- D. Dams, AT& T Bell Labs, USA, October 31. Host: J. van de Pol.
- A. Huima, Conformiq Finland, December 13–14. Hosts: N. Ioustinova, J. van de Pol.

Memberships of committees and other professional activities

J.C. van de Pol

- Themeleader SEN2, CWI.
- Senior Lecturer (0.2 fte) TUE.
- Vice-chair ERCIM Working Group FMICS.
- Secretary NVTI, Dutch Association for Theoretical Computer Science.
- PC-member: FMICS 2005, TACAS 2006, AMAST 2006, WRS 2006.
- Co-chair of IFM 2005, PDMC 2005, PDMC 2006.
- Co-advisor: M. Valero, VU, December 5.
- PhD committee: O. Tveretina, TUE, June 26.
- Editor special issues/proceedings: STTT and LNCS 3771.

W.J. Fokkink

- Professor of Computer Science, VU.
- Member science council, computer science department, VU.
- Member science committee IPA.
- Member programme/review committee NWO open competition CS, SENTINELS, SAFE-NL, PROGRESS.
- Co-organizer: Workshop on Algebraic Process Calculi: The First 25 Years and Beyond, Bertinoro, Italy, August 1–5.
- PC-member: EXPRESS'2005, PDMC'2005, ICTAC'2005, GT-VC'05, MT-Coord'05, SOS'05, 11th Dutch Testing Day.

- Advisor: M. Valero Espada, Modal Abstraction and Replication of Processes with Data, VU, December 5.
- PhD reading committee: C. Grabmayer, VU, March, H. Gao, RUG, April, O. Tveretina, TUE, June, G. Lenzini, UT, June, M. Mousavi, TUE, September.
- Editor Special Issues TCS 335(2-3) and Proceedings SOS 2004.

J.F. Groote

- Professor of Computer Science, TUE, chair Ontwerp en Analyse van Systemen (OAS).
- Director of Education, bachelor/masters Computer Science curriculum, TUE.
- NIRICT Coordination committee for long term challenges.
- Chair of the Informaticakamer, VSNU.
- Board member of the Eindhoven Embedded Systems Institute.
- Member of the IFIP working group WG1.8 on concurrency theory (2005-. . .).
- Reviewer Zentralblatt für Mathematik (1995-present).
- PC-member: PSI06, ICALP06.
- Moderator of the concurrency mailing list (appr. 1000 subscribers).
- Advisor: O. Tveretina, Decision Procedures for Equality Logic with Uninterpreted Functions, TUE. M. Mousavi, Structuring Structural Operational Semantics, TUE.
- Co-advisor: H. Gao, Design and Verification of Lock-free Parallel Algorithms, RUG. F. van Ham, Interactive visualisation of large graphs, TUE.
- PhD committees: M. Valero Espada, G. Freshe.

J.W. Klop

- Professor of Computer Science, VU.
- Head of Theoretical Computer Science, VU.
- Member editorial board CWI Tracts and Syllabi.
- Board member Dutch Association for Theoretical Computer Science (NVTI).
- PhD committee member of M. Valero Espada.

S. Mauw

- Member steering committee ERCIM Working Group on Security and Trust Mangagement (STM).
- PC member ARSPA'05, STM'05 (Co-chair), SAPS'05, CISC'05, IPA Fall days on security 2005.
- PhD committees: V. Nikov, H.M.A. Van Beek (co-advisor).
- Editor special issue: Proceedings CIM 05.

S.P. Luttik

- PhD reading committee: C. Grabmayer, VU, March.

Academic publications

Publications in refereed journals or proceedings

1 L. Aceto, W. Fokkink, A. Ingólfsdóttir, Z. Ésik (2005). Guest editors' foreword: Process Algebra. Theor. Comput. Sci. 335(2-3), 127–129.

2 L. Aceto, W. Fokkink, A. Ingólfsdóttir, B. Luttik (2005). CCS with Hennessy's merge has no finite-equational axiomatization. Theor. Comput. Sci. 330(3), 377–405.

3 L. Aceto, W. Fokkink, A. Ingólfsdóttir, B. Luttik (2005). Finite equational bases in process algebra: Results and open questions. A. Middeldorp, V. van Oostrom, F. van Raamsdonk, R. C. de Vrijer (eds). Processes, Terms and Cycles: Steps on the Road to Infinity, Essays Dedicated to Jan Willem Klop, on the Occasion of His 60th Birthday, LNCS 3838, , 338–367.

4 L. Aceto, W. Fokkink, A. Ingólfsdóttir, B. Luttik (2005). Split-2 bisimilarity has a finite axiomatization over CCS with Hennessy's merge. Logical Methods in Computer Science 1(1-3), 12.

5 L. Aceto, W. Fokkink, A. Ingólfsdóttir, S. Nain (2005). Bisimilarity is not finitely based over BPA with interrupt. J.L. Fiadeiro, N. Harman, M. Roggenbach, J.J.M.M. Rutten (eds). Proceedings, LNCS 3629, Algebra and Coalgebra in Computer Science: First International Conference, CALCO 2005, 52–66.

6 L. Aceto, W. Fokkink, I. Ulidowski (2005). Preface. Proceedings of SOS'2004. ENTCS 128(1), 1.

7 Z. M. Ariola, S. Blom (2005). Skew and *mega*-skew confluence and abstract böhm semantics. A. Middeldorp, V. van Oostrom, F. van Raamsdonk, R. C. de Vrijer (eds). Processes, Terms and Cycles: Steps on the

Road to Infinity, Essays Dedicated to Jan Willem Klop, on the Occasion of His 60th Birthday, LNCS 3838, , 368–403.

8 T. Arts, J. van de Pol (2005). Introductory paper. STTT 7(3), 195–196.

9 B. Badban, W. Fokkink, J. F. Groote, J. Pang, J. van de Pol (2005). Verification of a sliding window protocol in μCRL and PVS. Formal Asp. Comput., 17(3), 342–388.

10 B. Badban, J. van de Pol (2005). Zero, successor and equality in BDDs. Ann. Pure Appl. Logic, 133(1-3), 101–123.

11 S. Blom, J. F. Groote, S. Mauw, A. Serebrenik (2005). Analysing the BKE-security protocol with μCRL. Proceedings ARTS'2004. ENTCS 139(1), 49–90.

12 S. Blom, S. Orzan (2005). A distributed algorithm for strong bisimulation reduction of state spaces. STTT 7(1), 74–86.

13 S. Blom, S. Orzan (2005). Distributed state space minimization. STTT 7(3), 280–291.

14 E. Bortnik, N. Trcka, A.J. Wijs, B. Luttik, J.C.B. Asia van de Mortel-Fronczak, W. J. Fokkink, K. Rooda (2005). Analyzing a χ-model of a turntable system using Spin, CADP and UPPAAL. Journal of Logic and Algebraic Programming 65(2), 51–104.

15 J.R. Calamé, N. Ioustinova, J. v. d. Pol, N. Sidorova (2005). Data Abstraction and Constraint Solving for Conformance Testing. Proceedings 12th Asia-Pacific Software Engineering Conference (APSEC'05), 541–548.

16 J.G. Cederquist, M.T. Dashti (2005). Formal analysis of a fair payment protocol. T. Dimitrakos, F. Martinelli (eds). 2nd Int. Workshop on Formal Aspect of Security and Trust (FAST), Toulouse, France, IFIP 173, 41–54.

17 T. Chen, T. Han, J. Lu (2005). Analysis of a leader election algorithm in μCRL. Fifth International Conference on Computer and Information Technology (CIT 2005), 841–847.

18 T. Chen, T. Han, J. Lu (2005). On the bisimulation congruence in *chi*-calculus. Proceedings FSTTCS 2005: Foundations of Software Technology and Theoretical Computer Science, LNCS 3821, 128–139.

19 C. Cremers, V. Issarny, S. Mauw (eds) (2005). STM'05, Proceedings of the First International Workshop on Security and Trust Management 15, Elsevier.

20 C. Cremers, S. Mauw (2005). Operational semantics of security protocols. S. Leue, T. Systä (eds). Scenarios: models, transformations and tools, international workshop, Dagstuhl castle, Germany, LNCS 3466.

21 C.J.F. Cremers, S. Mauw (2005). Checking secrecy by means of partial order reduction. D. Amyot, A.W. Williams (eds). SAM 2004: Security Analysis and Modelling, LNCS 3319, 177–194.

22 C.J.F. Cremers, S. Mauw, E.P. de Vink (2005). A syntactic criterion for injectivity of authentication protocols. Proceedings of ARSPA'2005. ENTCS 135(1), 23–38.

23 W. Fokkink, J.-H. Hoepman, J. Pang (2005). A note on K-state self-stabilization in a ring with K=N. Nordic Journal of Computing, 12(1), 18–26.

24 W. Fokkink, S. Nain (2005). A finite basis for failure semantics. L. Caires, G. F. Italiano, L. Monteiro, C. Palamidessi, M. Yung (eds). Proceedings Automata, Languages and Programming, 32nd International Colloquium, ICALP 2005, LNCS 3580, 755–765.

25 W. Fokkink, J. Pang (2005). Formal verification of timed systems using cones and foci. Proceedings of ARTS'2004. ENTCS 139(1), 105–122.

26 W. Fokkink, J. Pang (2005). Simplifying Itai-Rodeh leader election for anonymous rings. Proceedings of AVOCS'2004. ENTCS 128(6), 53–68.

27 W. Fokkink, J. van de Pol, S. Vijay (2005). Which two-sorted algebras of booleans and naturals have a finite basis? Algebra Universalis 52(4), 469–485.

28 W. J. Fokkink, J. Pang, A. J. Wijs (2005). Is timed branching bisimilarity and equivalence indeed? Proceedings of the 3rd Conference on Formal Modelling and Analysis of Timed Systems (FORMATS'05), LNCS 3829, 258–272.

29 H. Gao, J. F. Groote, W. H. Hesselink (2005). Lock-free dynamic hash tables with open addressing. Distributed Computing 18(1), 21–42.

30 H. Gao, J. F. Groote, W. H. Hesselink (2005). Lock-free parallel garbage collection, 263–274.

31 N. Goga, F. Moldoveanu (2005). Bit boundary testing coverage. Proceedings of the 18th Canadian Conference on Electrical and

Computer Engineering (CCECE 2005), 408–411.

32 J.F. Groote, M. Keinänen (2005). A subquadratic algorithm for conjunctive and disjunctive boolean equation systems. Dang Van Hung, M. Wirsing (eds). Theoretical Aspects of Computing - ICTAC 2005, Second International Colloquium, Proceedings. LNCS 3722, 532–545.

33 J.F. Groote, F. Monin, J. Springintveld (2005). A computer checked algebraic verification of a distributed summation algorithm. FAC 17(1), 19–37.

34 J.F. Groote, T.A.C. Willemse (2005). Model-checking processes with data. SCP 56(3), 251–273.

35 J.F. Groote, T.A.C. Willemse (2005). Parameterised boolean equation systems. TCS 343(3), 332–369.

36 J. Hooman, J. van de Pol (2005). Semantic models of a timed distributed dataspace architecture. TCS 331(2-3), 291–323.

37 J. Ketema, J. W. Klop, V. van Oostrom (2005). Vicious circles in orthogonal term rewriting systems. Proceedings WRS'2004. ENTCS 124(2), 65–77.

38 J. Klop, R. de Vrijer (2005). Infinitary normalization. S. Artemov, H. Barringer, A. d'Avila Garcez, L. Lamb, J. Woods (eds). We Will Show Them: Essays in Honour of Dov Gabbay 2, 169–192.

39 B. Luttik, N. Trcka (2005). Stuttering congruence for χ. P. Godefroid (ed). Proceedings SPIN 2005, LNCS 3639 185–199.

40 B. Luttik, V. van Oostrom (2005). Decomposition orders another generalisation of the fundamental theorem of arithmetic. TCS 335(2-3), 147–186.

41 A.J. Mooij, N. Goga (2005). Dealing with non-local choice in IEEE 1073.2's standard for remote control. D. Amyot, A.W. Williams (eds). Proceedings of the 4th international SDL and MSC Workshop on System Analysis and Modeling (SAM 2004), LNCS 3319, 257–270.

42 A. J. Mooij, N. Goga, J. Romijn (2005). Non-local choice and beyond: Intricacies of MSC choice nodes. M. Cerioli (ed). (2005). Proceedings Fundamental Approaches to Software Engineering, 8th International Conference, FASE 2005, Part of ETAPS 2005, LNCS 3442, 273–288.

43 M. R. Mousavi, M. A. Reniers, J. F. Groote (2005). Notions of bisimulation and congruence formats for SOS with data. Inf. Comput, 200(1), 107–147.

44 M. R. Mousavi, M. A. Reniers, J. F. Groote (2005). A syntactic commutativity format for SOS. Inf. Process. Lett. 93(5), 217–223.

45 G. Nair, A. Gopalakrishnan, S. Mauw, E. Moll (2005). XML security in the next generation optical disc context. W. Jonker, M. Petkovic (eds). Secure Data Management, Second VLDB Workshop, SDM 2005, Proceedings, LNCS 3674, , 217–233.

46 S. Orzan, J. van de Pol, M. V. Espada (2005). A state space distribution policy based on abstract interpretation. Proceedings of PDMC'2004. ENTCS 128(3), 35–45.

47 Y. Pan, D. Chen, M. Guo, J. Cao, J. Dongarra (eds) (2005). Parallel and Distributed Processing and Applications, Proceedings Third International Symposium, ISPA 2005. LNCS 3758.

48 J. van de Pol, M.V. Espada (2005). An abstract interpretation toolkit for μCRL. Proceedings of FMICS'2004. ENTCS 133, 295–313.

49 J. van de Pol, O. Tveretina (2005). A BDD-representation for the logic of equality and uninterpreted functions. Proceedings of Mathematical Foundations in Computer Science (MFCS'05), 769–780.

50 J. van de Pol, H. Zantema (2005). Generalized innermost rewriting. J. Giesl (ed). Proceedings Term Rewriting and Applications, 16th International Conference, RTA 2005, LNCS 3467, 2–16.

51 J. Romijn, G. Smith, J. van de Pol (eds) (2005). Proceedings Integrated Formal Methods, 5th International Conference, IFM 2005. LNCS 3771.

52 W. Wesselink, N. Goga, A.J. Mooij, R. Spronk (2005). Formal methods impact on ANSI standard HL7/IM: filling gaps in MSC theory. Proceedings of the 18th Canadian Conference on Electrical and Computer Engineering (CCECE 2005), 1656–1659.

53 A. J. Wijs, W.J. Fokkink (2005). From χ to μCRL: Combining performance and functional analysis. Proceedings of the 10th Conference on Engineering of Complex Computer Systems (ICECCS'05), 184–193.

54 A.J. Wijs, J.C. van de Pol, E. Bortnik (2005). Solving scheduling problems by untimed model checking. Proceedings of the 10th International Workshop on Formal Methods for Industrial Critical Systems (FMICS'05), 54–61.

Publication in other journals or proceedings and other scientific output

CWI reports

SEN-E0501, SEN-E0503, SEN-R0508, SEN-R0509, SEN-R0516.
See page B.3 on page 202 for complete titles.

Technical reports published elsewhere

1 M.T.D. J. Cederquist (2005). An intruder model for verifying termination in security protocols. Technical Report TR-CTIT-05-29, UT.

2 M.T.D. J. Cederquist, R. Corin (2005). On the quest for impartiality: Design and analysis of a fair non-repudiation protocol. Technical Report TR-CTIT-05-32, UT.

Software developed

- B. Lisser implemented a distributed tool for breadth-first state space generation. It is possible to stop the system at any time, at which the state space generated so far will be dumped, so that the state space generation can be continued later.
- B. Lisser participated in programming several tools for TT-MEDAL, Tipsy, etc, and mainained the distributed software for FACS.
- J. Calamé (a) object-oriented layer library for the μCRL library, (b) object-oriented AST library for Aldébaran LTSs, (c) μCRL specification abstractor (reengineering based on (a)), (d) abstract test trace selector (based on (b)), (e) test data constraint generator, several versions (current version under construction based on (a) and (b)), (f) TTCN-3 test case generator (based on (a) and (b)),
(g) KDE-based test generation GUI for (c), (d), (e), (f) and the TGV test generator.
- A. Wijs implemented several beam search algorithms in the μCRL toolset

Deliverables for projects

1 TT-Medal D.1.2-1: W.J. Fokkink, P.H. Deussen, N. Ioustinova, J.Seubers, J.van de Pol. Towards model-based test generation and validation for TTCN3.

2 TT-Medal D.1.2-2: J. Calamé, Zhen Ru Dai, N. Ioustinova, J. van de Pol, R. Swinkels. Definition of methods for automated test generation for TTCN3 based test systems.

3 TT-Medal D.4.1.D4_1: S.C.C. Blom, W.J. Fokkink, D. van der Meij. Requirements specification for testing methodology and tooling. Domain specific requirements.

4 TT-Medal D.4.2.D4_4: S.C.C. Blom. Domain Specific Test Systems.

Book chapters

1 C. A. Grabmayer, J. W. Klop, S. P. Luttik (2005). Reflections on a geometry of processes. L. Aceto, A.D. Gordon (eds). Algebraic Process Calculi: The First Twenty Five Years and Beyond, number NS-05-3 in BRICS Notes Series, 118–125, June 2005.

2 J. Groote, M. van Weerdenburg, A. Mathijssen, Y. Usenko (2005). From μcrl to mcrl2. motivation and outline. L. Aceto, A. D. Gordon (eds). Algebraic Process Calculi: The First Twenty Five Years and Beyond, NS-05-3 BRICS, 126–131, June 2005.

3 Y. U. Senko, J.F. Groote, M.A. Reniers (2005). Discretization of timed automata in timed μcrl à la regions and zones. L. Aceto, A.D. Gordon (eds). Algebraic Process Calculi: The First Twenty Five Years and Beyond, NS-05-3 BRICS, 132–136, June 2005.

PhD theses

1 M. Valero Espada (2005). Modal Abstraction and Replication of Processes with Data. PhD thesis, VU, December 5. Thesis advisor: W.J. Fokkink. Co-advisor: J. van de Pol.

Coordination Languages – SEN3

Mission

SEN3 aims to provide the technology for coordination and dynamic composition of concurrent systems, based on solid mathematical foundations. Systems of special interest include long-lasting distributed applications, component based systems, and service oriented computing. Adaptation and mobility frequently arise as requirements in this context, necessitating dynamic reconfiguration. Building such concurrent systems by composition of independent components and services involves coordination of their mutual interactions. It is advantageous to isolate coordination concerns into explicit connectors, separate from the components and services that they compose. Among other things, this simplifies validation of systems through modular validation of their individual connectors, components, and services. Reliable tools for validation of such connectors require a solid mathematical foundation to support compositional operational models of (observable) behaviour (of services and components). The activity in SEN3, therefore, spans from mathematical models of behaviour and computation to experimental systems and demonstrator applications.

Theme leader

Prof.dr. J.J.M.M. Rutten

MSC or CR classification

D.1, D.2, D.3, F.1, F.3, F.4

Subthemes

Name	Leader
SEN3.1 – Coordination and Component-Based Architectures	F. Arbab
SEN3.2 – Formal Methods for Coordination Languages	F.S. de Boer
SEN3.3 – Coalgebraic Models of Computation	J.J.M.M. Rutten

SEN3.1 deals with models, languages, and tools for coordination and compositional construction of component-based software systems for parallel, distributed, and mobile platforms. SEN3.2 is concerned with the development and application of formal methods for concurrent systems including coordination languages for component-based systems. SEN3.3 is concerned with the study of coalgebra and coinduction as a general theory of various dynamical and computational systems.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. F. Arbab	1.0	Leader SEN3.1	indefinite	SEN3.1: EU Trust4All, NWO CBCS, SenterNovem CIM, Adaptive Planet, B.V.; SEN3.2: Mobi-J, SEN3.3: NWO C-Quattro
Drs. F. Atanassow	1.0	researcher	2005-10-15 till 2007-05-31	SEN3.1: EU Trust4All
Drs. C.L. Blom	1.0	programmer	indefinite	SEN3.1: NWO CBCS
Dr. F.S. de Boer	0.8	leader SEN3.2	indefinite	SEN3.1: EU Trust4All; SEN3.2: NWO Mobi-J; EU Omega; SEN3.3: NWO C-Quattro

continued on next page

continuation from previous page

F.J. Burger	0.6	programmer	indefinite	SEN3.1
Dr. D. Clarke	1.0	postdoc	2004-04-01 till 2008-03-31	SEN3.1; SEN3.3: NWO C-Quattro
Dr. T. Chothia	1.0	postdoc	2005-12-01 till 2007-05-31	SEN3.1: EU Trust4All
Drs. D. Costa	1.0	PhD student	2003-12-01 till 2007-12-01	SEN3.1; SEN3.3
Dr. N.K. Diakov	1.0	postdoc	2003-07-01 till 2006-06-30	SEN3.1: SenterNovem CIM
Drs. C.T.H. Everaars	1.0	programmer	indefinite	SEN3.1: SenterNovem CIM
Drs. J.V. Guillen Scholten	1.0	PhD student	2001-07-01 till 2005-06-30	SEN3.1: Mobi-J
Drs. J.F. Jacob	1.0	project member	2002-03-01 till 2006-02-28	SEN3.2: EU Omega
Prof.dr. J.J.M.M. Rutten	1.0	theme leader, leader SEN3.3	indefinite	SEN3.1: EU Trust4All, SenterNovem CIM; SEN3.2; SEN3.3: NWO PROMACS, NWO COCON, NWO COMOLO, NWO C-Quattro
Dr. L.W.N. van der Torre	1.0	postdoc	2002-12-01 till 2005-12-01	SEN3.1
Ir. P. Zoeteweij	1.0	PhD student	2001-04-01 till 2005-03-31	SEN3.1: NWO CBCS

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. M.M. Bonsangue (UL)	0.2	senior researcher	indefinite	SEN3.2: NWO Mobi-J
Prof.dr. J.N. Kok (UL)	p.m.	advisor	until 1 July	SEN3.1; SEN3.2; SEN3.3
Drs. H.H. Hansen (VU)	0.4	PhD student	2004-09-01 till 2008-09-01	SEN3.3: NWO C-Quattro
Drs. C. Kupke (UvA)	0.4	PhD student	2002-02-01 till 2006-02-01	SEN3.3: NWO COMOLO
Drs. C. Pierik (UU)	0.1	PhD student	2002-01-01 till 2006-01-01	SEN3.2: NWO Mobi-J
Drs. M. Kyas (CAU[1])	0.1	PhD student	2002-01-01 till 2006-01-01	SEN3.2: NWO Mobi-J

Scientific report

Highlights

- Organization of CALCO 2005: first international Conference on Algebra and Coalgebra in computer science.
- Organization of FMCO 2005, fourth international conference on Formal Methods for Components and Objects.
- PhD thesis of P. Zoeteweij. See PhD theses.

PhD students

D. Costa
J.V. Guillen Scholten
H.H. Hansen
A. HeydarNoori (external, Waterloo)
C. Kupke
M. Kyas
C. Pierik
P. Zoeteweij

SEN3.1 – Coordination and Component-Based Architectures

The research in this subtheme is focused on the development of formal models for components and component-based software that enable construction of systems by composition of exogenously coordinated software components, allow compositional derivation of the properties of a system from those of its constituent components, and support notions of distribution and mobility. The objective of this work is to use the models and formalisms we develop as the

[1]CAU, Christian-Albrechts-Universität zu Kiel, Germany

foundation for our implementation of practical component-based and service-oriented software engineering tools and support environments.

Title	Trust4All
Period	July 2005–July 2007
Leader	F. Arbab
Staff	F. Arbab, F. Atanassow, F.S. de Boer, T. Chothia
Funding	SenterNovem
Partners	Philips Research, TUE, LIACS, Oce Technologies, Telematica Instituut; Nokia (Finland), VTT Technical Research Center (Finland), Robotiker (Spain), Visual Tools (Spain), ESI (Spain), Solid Information Technology (Finland), Fagor (Spain), Ikerlan (Spain).

Progress report. The Trust4All project is aimed at developing a programming environment that includes a notion of trust values. Within this project SEN3 plans to develop a model of components with the same kind of trust values, which can be machine checked. Rather than the usual aim of 'proving' that a model based on a certain application is correct, we hope to be able to use our model to automatically generate test data for the original application.

We have investigated a number of automata component models; these include Interface automata, Team automata, Constraint automata and I/O automata, from which we have identified Interface automata as a useful starting point. We have also identified the semi-ring model of Montanari et al. as a good way of formalising a wide range of trust and quality values.

Combining both these ideas, we proposed to add semi-ring style values to an automata to make the base of our model of Trust4ALL programs. Further work will involve finalising this automata model and then selecting and adapting an existing model checker to find error traces. We hope to be able to automatically generate test data for real applications from these error traces.

Title	CBCS – Coordination Based Constraint Solvers
Period	2000–2005
Leader	F. Arbab
Staff	F. Arbab, C.L. Blom, P. Zoeteweij
Funding	NWO
Partners	PNA1 (K.R. Apt), Univ. Nantes (E. Monfroy)

Progress report. In 2005, Zoeteweij completed his work on the OpenSolver configurable constraint solver. He finished the writing of his thesis and successfully defended it in November at UvA.

Title	Reo – Compositional connectors for coordination of components
Period	2002–2005
Leader	F. Arbab
Staff	F. Arbab, F.S. de Boer, M.M. Bonsangue, F. Burger, D. Clarke, D. Costa, N.K. Diakov, C.T.H. Everaars, J.J.M.M. Rutten, J.V. Guillen Scholten
Funding	CWI
Partners	LIACS; Univ. Bonn, Germany; Univ. Tehran, Iran

Progress report. A master degree student has built a simulator for Constraint Automata and has successfully defended his degree in October 2005 in Delft. One of the innovations of this tool allows using CAs as coordinators for Java or Python components. Two other master students used Reo for specification of an e-business process model for PayPal online payment process, and specification of behavior in software architectures. They successfully obtained their degrees in August 2005 in Leiden.

Guillen Scholten worked on a π-calculus-based formalization of MoCha, called MoCha-pi, as a coordination middleware. He also worked on a model for composition of channels into connectors based on the notion of coordination components. The advantage of this model is that the semantics of its connectors are the parallel composition of the MoCha-pi calculus semantics of its constituents. Also, since we implemented both the mobile channels and the coordination components in the MoCha middleware, the connectors of our model are immediately implementable. Furthermore, our model easily implements a subset of Reo; the subset involves those Reo connectors where there is little or no propagation of synchronization.

Everaars implemented a prototype of the distributed version of the colouring algorithm. Diakov investigated the Eclipse tool development framework as a possible platform for CIM/SEN3 tools. The framework shows excellent potential and we have started working on a

Web Services composition tools in Eclipse.

Title	CIM – Cybernetic Incident Management
Period	2003–2005
Leader	F. Arbab
Staff	F. Arbab, N.K. Diakov, C.T.H. Everaars, J.J.M.M. Rutten,
Funding	SenterNovem
Partners	SEN4, TUD, VU, Almende, CMotions, Falck

Progress report. The workpackages involving requirements and evaluation of technologies, and basic concepts and terminology were completerd and delivered. We continued our work on the application of Reo in this project. Specifically, we started to adapt a prototype of Reo to coordinate compositions of WebServices. This prototype developed in SEN3 is based on a new 'connector colouring' algorithm for distributed computation of the behaviour of Reo circuits.

Our investigation of the integration of commercial-off-the-shelf components shows that the notion of synchrony in Reo relates closely with the term 'business transaction'. We implemented a prototype of a special 'f-channel' to investigate practical issues in integrating third-party models using Reo connectors. We may use such channels when applying the MoCha C++ middleware in a CIM demonstrator we work on together with Almende.

Considering the technological requirements of our industrial partners within CIM, we have completed porting the Java-based MoCha mobile channel middleware to C++ on a Linux platform. In addition we enhanced the MoCha C++ with an XML configuration mechanism and improved the distributed locking scheme.

SEN3.2 – Formal Methods for Coordination Languages

The research in this subtheme concerns the development and application of formal methods for dynamically reconfigurable systems with special emphasis on coordination languages and object-oriented programming languages like Java.

Within the Trust4All project SEN3.1 and SEN3.2 are currently in the process of transferring a distributed implementation of mobile channels (developed in SEN3) which will form the basis for an extension of the Trust4All component model. For this new component model we are developing a tool for testing the trustworthiness of component-based systems.

The collaboration with the Intelligent Systems group of UU has resulted in the PhD thesis *Validation techniques for object-oriented proof outlines* of C. Pierik (date of the defense is May 3 , 2006). Supervision of the PhD student B. Riemsdijk (UU) has resulted in a dynamic logic for plan revision in intelligent agents. Collaboration with M. Dastani (UU) has resulted in an application of Reo in modelling the coordination of multi agent systems.

Other work pursued in SEN3.2 concerns the continued collaboration with M. Sirjani on the actor-based language REBECCA.

A major effort of SEN3.2 has been the development and submission of a new EU IST STREP project Credo (*Modeling and analysis of evolutionary structures for distributed services*), coordinated by De Boer. According to the Dutch National Contact Point in the corresponding activity (IST-2005-2.5.5- Software and Services) Credo acquired 88,3% of the points and was ranked on place 6 of the 15 retained proposals (out of a total of aprox. 200 submissions). Currently we are expecting an invitation to start the negotiations.

Title	OMEGA – Correct development of real-time embedded systems in UML (Unified Modelling Language)
Period	January 2002–March 2005
Leader	F.S. de Boer
Staff	F.S. de Boer, M.M. Bonsangue, J.F. Jacob
Funding	EU project IST-2001-33522
Partners	Verimag (Sifakis), CAU (De Roever), RU (Hooman), Weizmann Institute (Pnueli, Harel), OFFIS (Damm), EADS Launch Vehicles, France Télécom R&D, Israeli Aircraft Industries, National Aerospace Laboratory

Progress report. The OMEGA project was successfully terminated.

Title	Mobi-J: Assertional methods for mobile asynchronous channels in Java
Period	September 2005– September 2008
Leader	F.S. de Boer
Staff	F. Arbab, F.S. de Boer, M.M. Bonsangue, J.V. Guillen Scholten, J.F. Jacob
Funding	NWO
Partners	LIACS (Bonsangue), CAU (De Roever)

Progress report. In the continuation of the MobiJ project we aim at a further integration of component and objects. In the context of the MobiJ project de Boer and Bonsangue have already organized the fourth international symposium on Formal Methods for Components and Objects (FMCO 2005), Amsterdam (CWI), November 1–4 (see `http://fmco.liacs.nl/fmco05.html`). Furthermore, collaboration with CAU has resulted in the thesis *verifying OCL specifications of UML models* of Marcel Kyas (date of the defense is April 4, 2006).

Title	BRICKS -AFM3– Formal methods for active networking
Period	January 2005–January 2009
Leader	F.S. de Boer
Staff	F.S. de Boer, S. Kemper
Funding	Bsik
Partners	TUE (J. Baeten, E. de Vink)

Progress report. PhD student Kemper will start in February 2006.

SEN3.3 – Coalgebraic Models of Computation

In this subtheme we study coalgebra as a unifying mathematical framework for computational systems and programming paradigms with emphasis on infinite behaviour. The application of the coinductive calculus of streams to sequential digital circuits has resulted in an efficient algorithm for the construction of minimal Mealy automata (and consequently, memory-minimal digital circuits) from algebraic specifications. A Haskell implementation has been constructed by Hansen and Costa.

Title	COMOLO - Coalgebra and Modal Logic
Period	February 2002–January 2006
Leader	J.J.M.M. Rutten
Staff	C. Kupke, J.J.M.M. Rutten
Funding	NWO
Partners	UvA (Venema), RU (Jacobs)

Progress report. Kupke spent the last year of his PhD programme to conclude his research on finitary coalgebraic logics, and to finish the writing of his thesis. He is expected to defend his thesis, which by now has been approved by the PhD Committee, on 23 March 2006 at UvA.

Title	C-Quattro - Compositional construction of component connectors
Period	April 2004– September 2008
Leader	F. Arbab, J.J.M.M. Rutten
Staff	F. Arbab, D. Clarke, H.H. Hansen, J.J.M.M. Rutten
Funding	NWO
Partner	VU

Progress report. Hansen has studied in detail various normal forms of algebraic expressions denoting functions on bitstreams. These are needed for the exact formulation and implementation of the algorithm for the construction of Mealy automata mentioned above. Together with Costa, Clarke has developed various so-called colouring models for the coordination language Reo, as a basis for its distributed implementation. He has also developed a prototype implementation of a subset of Reo, which can serve as the basis for an application to web services composition.

Title	Formal methods for Reo
Period	December 2003– December 2007
Leader	F. Arbab, J.J.M.M. Rutten
Staff	F. Arbab, D. Costa, J.J.M.M. Rutten
Funding	FCT (Portugal)
Partner	VU

Progress report. Together with Clarke, Costa has finished editing a compendium of Reo circuits, intended as a reference for Reo users. He has developed distributed computational models for Reo that take into account the context dependence of Reo circuits. Together with Hansen, he has finished the implementation (in Haskell) of an arithmetic tool automating Rutten's differential calculus of bitstreams.

Societal aspects and knowledge transfer

External contacts

UL (J.N. Kok), RU (B. Jacobs), UvA (Y. Venema), VU (Klop, Grabmayer), UU (J.J. Meyer), Univ. Tehran (M. Sirjani), Univ. Waterloo (F. Mavaddat), Univ. Leicester (J. Fiadeiro, A. Kurz), Univ. Oslo (E. Broch Johnson), Univ. Minho (L. Barbosa), Univ. Bonn (C. Baier), CAU, Kiel (W.-P. de Roever).

Projects with partners in public and private sector

- CIM, Omega, Trust4All.

Teaching at university

- LaPP-Top course: Design with Software Components, LIACS, UL, January 18, 25: F. Arbab.
- Coordination and Component Composition, LIACS, UL, February 4–May 27: F. Arbab.
- Concepts of Programming Languages, LIACS, UL, September 9–December 2: F. Arbab.
- Logica, LIACS, UL, Feberuari 10–May 27: F.S. de Boer.
- Proof theory of object-oriented programs, LIACS, UL, September 9–December 2: F.S. de Boer.

Other external contacts

See Working Visits (on the next page).

Organization of conferences, workshops, courses, meetings

- IPM International Workshop on Foundations of Software Engineering (FSEN 2005), October 1–3, Tehran, Iran. Co-organized with the School of Computer Science, Institute for Studies in Theoretical Physics and Mathematics (IPM), Iran.
- Formal Methods for Components and Objects (FMCO 2005), Amsterdam, November 1–4.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- IPA Basic Course on Algorithms and Complexity January 31–February 4, Eindhoven, Netherlands: H. Hansen.
- Univ. Bologna, Italy, February 1–July 31: M.M. Bonsangue.
- GAMES Spring School March 15–19, Bonn, Germany: H. Hansen.
- ACM Symposium on Applied Computing (SAC 2005), Santa Fe, New Mexico, USA, March 13–17: J.V. Guillen Scholten (Talk: MoCha-pi, an Exogenous Coordination Calculus based on Mobile Channels).
- IEEE International Conference on e-Technology, e-Commerce and e-Service, Hong-Kong, China, March 29–April 1: N.K. Diakov (Presented paper: Composition of Negotiation Protocols for E-Commerce Applications).
- FInCo 2005 (ETAPS workshop), Edinburgh, UK, April 8: F. Arbab (Invited panel member), L. van der Torre (Lecture: coordination in normative multiagent systems).
- Coordination 2005, Namur, Belgium, April 17–23: F. Arbab (Talk: Synthesis of Reo Circuits for Implementation of Component-Connector Automata Specifications), J.V. Guillen Scholten (MoCha poster presentation).
- CoOrg 2005 at COORD 2005, Namur, Belgium, April 20–22: L. van der Torre (Talk: coordination and organisation).
- OOPSLA 2005, PC Meeting, San Francisco, USA, April 28–30: D. Clarke.
- FOSSACS 2005, Edinburgh, UK, May 4–7: M.M. Bonsangue (Talk: Duality for logics of transition systems).
- Marktoberdorf Summer School 2005 August 2–14, Marktoberdorf, Germany: H. Hansen.
- FM 2005, Newcastle, UK, July 18–22: F. de Boer.
- The Second International Workshop on Coordination and Adaptation of Software Entities, W-CAT'2005, Glasgow, UK, July 27: N.K. Diakov (Presented paper: Adaptation of Software Entities for Synchronous Exogenous Coordination: An Initial Approach).
- IJCAI 2005, Edinburgh, UK, August 1–5: L. van der Torre (Talk: Non-monotonic reasoning with various kinds of preferences).
- FOCLASA 2005, San Francisco, California, August 27: F. Arbab (Talk: Modeling the Exogenous Coordination of Mobile Channel based Systems with Petri Nets), D. Costa (Talk: Connector Colouring I: Synchronisation and Context Dependency).
- IFIP Working Group 2.2, Skagen, Denmark, August 31–September 3: F. de Boer.
- CALCO 2005, Swansea, Wales, September 2–6: D. Costa, H. Hansen, C. Kupke, J. Rutten.
- IFIP Working Group 1.3, Swansea, Wales, September 7–8: J. Rutten (Invited observer).
- Workshop on Predictable Assembly, Manchester, UK, September 12: F. Arbab.
- FSEN 2005, Tehran, Iran, September 1–October 3: D. Clarke (Talk: Reasoning About

Connector Reconfiguration II: Basic Reconfiguration Logic).
- FSEN 2005, Tehran, Iran, September 27–October 2, 2005. M.M. Bonsangue (Talk: A calculus for component-oriented programming).
- COSOLV 2005 workshop on Cooperative Solvers in Constraint Programming, held in conjunction with CP 2005, Sitges, Spain, October: P. Zoeteweij (Talk: Towards Component-Based Cooperative Constraint Solving).
- FSEN 2005, Tehran, Iran, October 1–3: F. Arbab, J. Rutten, D. Clarke.
- ICTAC 2005, Hanoi, Vietnam, October 17–21: F. Arbab (Invited lecture: A Calculus of Interaction for Software Composition), F.S. de Boer.
- FACS 2005, Macau, China, October 24–25: F. Arbab (Invited lecture: Reo: A Coordination Model for Component Composition), F. de Boer, J. Rutten (Talk: Algebraic specification and coalgebraic synthesis of Mealy automata).
- Intel Multi-core Workshop, Portland, Oregon, December 8–9: F. Arbab.
- CALCO 2005, 1st Conference on Algebra and Coalgebra in Computer Science September 1–7, Swansea, Wales: H. Hansen.
- IPA Herfstdagen on Security November 21–25, Zwartsluis, Netherlands: H. Hansen.

Working visits

- F. Mavaddat, School of Computer Science, Univ. Waterloo, Ontario, Canada, February 8–11: F. Arbab.
- Prof.dr. C. Diamantini, Univ. Ancona, Italy, June 23–25: M.M. Bonsangue (Lecture: ArchiMate: an architecture description language).
- Prof.dr. R. de Nicola, Univ. Firenze, Italy, June 29: M.M. Bonsangue (Lecture: Full abstraction of UML components).
- S. Drossopoulou, Imperial College, London, UK, June 27–July 1: D. Clarke.
- AAMAS 2005, Utrecht, The Netherlands, July 27–30: L. van der Torre (Lecture: Enforceable Social Laws).
- T. Wrigstad, Stockholm Univ., Sweden, August 8–12: D. Clarke.
- Y. Gurevich, Microsoft Research, Redmond, Washington, USA, August 12: F. Arbab.
- E. Lee, EECS department, UC Berkeley, Berkeley, California, USA, August 25: F. Arbab.
- C. Talcott, SRI International, Palo Alto, California, USA, August 26: F. Arbab.
- S. Drossopoulou, Imperial College, London, November 25–28: D. Clarke.

Project meetings

- Various meetings of NWO/DFG project Mobi-J.
- Meetings for preparation of Credo project proposal.
- Trust4All project meeting, Eindhoven, June 23: F. Arbab, F.S. de Boer.
- Trust4All project meeting, Amsterdam, September 5–7: F. Arbab, F.S. de Boer.
- Trust4All informal project meeting, CWI, November 17: F. Atanassow (Topic: Mapping Reo to Robocop).
- Trust4All project meeting, Vitoria, Spain, November 21–22: F. Arbab, F.S. de Boer, F. Atanassow.
- Trust4All informal project meeting, LIACS, Leiden, December 15: F. Atanassow (Topic: Integrating Robocop with C-semiring constraint model).
- Trust4All informal project meeting, Philips, Eindhoven, December 23: F. Atanassow (Topic: Robocop and quality attributes).

Other lectures

- Reo: a coordination model for component composition, School of Computer Science, Univ. Waterloo, Ontario, Canada, February 10: F. Arbab.
- Reo: a coordination model for component composition, Computer Science Department, Univ. Luxembourg, Luxembourg, June 20: F. Arbab.
- Component Coordination Through Distributed Connector Circuits, Microsoft Research, Redmond, Washington, USA, August 12: F. Arbab.
- Connector Circuits for Coordinated Component Composition, Aeorspace Corp., El Segundo, California, USA, August 22: F. Arbab.
- Coordinated Component Composition, EECS department, UC Berkeley, Berkeley, California, USA, August 25: F. Arbab.
- Connector Circuits for Coordinated Component Composition, SRI International, Palo Alto, California, USA, August 26: F. Arbab.
- Connector Circuits for Coordinated Component Composition, Tutorial lecture, FSEN 2005, Tehran, Iran, October 1: F. Arbab.

- Algebra and Coalgebra of Streams, Automata and Circuits, Tutorial lecture, FSEN 2005, Tehran, Iran, October 2: J. Rutten.

Visitors

- A. Silva, Univ. Minho, Portugal, March 15. (Lecture: Innovation in the Practice of Computer Science Education to follow Bologna Trends: a Case Study). J. Proenca, Univ. Minho, Portugal, March 15. (Lecture: Pointwise-Pointfree Transformations). Host: D. Costa.
- D. Goldin, Univ. Connecticut, USA, June 7. (Lecture: Interaction: conjectures, results, myths). Host: F. Arbab.
- M. Sirjani, Univ. Tehran, June 14. (Lecture: Reactive objects as components on Reo circuits). Host: J.J.M.M. Rutten.
- F. Mavaddat, School of Computer Science, Univ. Waterloo, Ontario, Canada, September–December. Host: F. Arbab.
- Alex Potainin, Victoria Univ. Wellington, NZ, July 25–30: Host: D. Clarke.

Memberships of committees and other professional activities

F. Arbab

- Leiden University Foundation Professor of Computer Science, Chair of Software Composition, Leiden Institute for Advanced Computer Science, UL, since June 2004.
- Adjunct professor of Computer Science, School of Computer Science, Univ. Waterloo, Ontario, Canada, since September 2004.
- Member Association for Computing Machinery.
- Member IEEE Computer Society.
- Member IPA, Dutch Graduate School Institute for Programming and Algorithmics.
- (Co)project leader of NWO/EW research projects C-Quattro (developing a compositional calculus of component connectors) and coordination-based parallel constraint solving.
- PhD committee member, T. Gelsema, UL, November 8.
- PhD advisor (with K. Apt at UvA), P. Zoeteweij, November 29.
- Member programme committee, Workshop on the Foundations of Interactive Computation (FInCo 2005), Satellite workshop of ETAPS, Edinburgh, UK, April 9.
- Member programme committee, Coordination 2005, Seventh International Conference on Coordination Models and Languages, Namur, Belgium, 19–22 April.
- Member programme committee, Coordination and Organization workshop (CoOrg) 2005, Namur, Belgium, 21 April.
- Member programme committee, Third Int. Workshop on Distributed and Mobile Collaboration (DMC 2005), Linköping, Sweden, June 13–15.
- Evaluator for the EU IST project ArchWare, the EC, June 17.
- Member programme committee Fourth International Workshop on Foundations of Coordination Languages and Software Architectures (FOCLASA 2005), San Francisco, California, August 27.
- MSc thesis supervisor for Yongzhi Li and Min Xie, LIACS, August 31.
- PhD committee member for J. Eggermont, UL, September 14.
- Programme committee chair, IPM International Workshop on Foundations of Software Engineering (FSEN 2005), Tehran, Iran, October 1–3.
- MSc Thesis supervisor for Hok-Kwan Kan, Delft, October 31.
- Member programme committee, Seventh International Conference on Formal Engineering Methods (ICFEM 2005), Manchester, UK, November 1–4.
- Member programme committee, International Workshop on Formal Aspects of Component Software (FACS 2005), Macao, China, October 24–25.
- Member programme committee, Third European Conference on Web Services (ECOWS 2005), Vaxjo, Sweden, November 14–16.
- Member scientific committee, Fifth IEEE International Symposium and School on Advance Distributed Systems (ISSADS 2005), Guadalajara, Jalisco, Mexico, January 24–28.
- Member programme committee, Eighth International Conference on Parallel Computing Technologies (PaCT-2005), Krasnoyarsk, Russia, September 5-9.

- Member programme committee Second Ubiquitous Mobile Information and Collaboration Systems (UMICS 2005) workshop at the CAiSE - 17th International Conference on Advanced Information Systems Engineering, Porto, Portugal, June 13–14.
- Member advisory board EuroPar 2005, Lisbon, Portugal, September.

F.S. de Boer

- Associate professor at the Leiden Institute for Advanced Computer Science, UL, since September 2003.
- Member of the IFIP Working Group 2.2 Formal Description of Programming Concepts.
- Member of the Dutch research schools IPA (Institute for Programming research and Algorithmics) and SIKS (School voor Informatie- en KennisSystemen).
- Member programme committee of the Third IEEE International Conference on Software Engineering and Formal Methods, Koblenz, Germany.
- Member programme committee of the Third Workshop on Quantitative Aspects of Programming Languages, Edinburgh, Scotland (Satellite Event of ETAPS 2005).
- Member programme committee of the workshop on Coordination and Organization (satelite event of Coordination 2005).
- Member programme committee of the workshop on Foundations of Interface Technologies (satelite event of Concur 2005).
- Organizer of the fourth International Symposium of Formal Methods for Components and Objects (FMCO 2005).
- Editor of proceedings of the third International Symposium on Formal Methods for Components and Objects (FMCO 2004), LNCS 3657.
- Editor of Formal Methods for Components and Objects (Special issue of Theoretical Computer Science, Vol. 331).
- Editor of Formal Methods for Components and Objects: Pragmatic aspects and applications (Special issue of Science of Computer Programming, Vol. 55.

M.M. Bonsangue

- Fellow of the Royal Netherlands Academy of Arts and Sciences (KNAW).
- Member of the Dutch Architectural Forum (NAF).
- Member of the programme committee of the 2005 IEEE International Conference on Information Reuse and Integration (IRI 2005), Las Vegas, Nevada, USA. August 15–17.
- Member of the programme commitee of the main track on Component-based Software Engineering and the special track on Component Models for Dependable Systems at the 31st EuroMicro Conference on Software Engineering and Advanced Applications (SEAA), Porto, Portugal, August 30–September 3.
- Member of the programme committee of the 3rd IEEE International Conference on Software Engineering and Formal Methods (SEFM 2005), Koblenz, Germany, September 6–7.
- Member of the programme commitee of the 2nd international workshop on Formal Aspect of Component Software (FACS 2005), Macau, October 24–25.
- Member of the programme committe of the 7th international conference on Formal Engineering Methods (ICFEM 2005), Manchester, United Kingdom, November 1–4.
- Member of the programme committe of the first IPM International Workshop on Foundations of Software Engineering (FSEN 2005), Teheran, Iran, October 1–3.
- Co-organizer of the 4th International Symposium on Formal Methods for Components and Objects (FMCO 2005).
- Co-editor of proceedings of the 3rd International Symposium on Formal Methods for Components and Objects (FMCO 2004), LNCS 3657, Springer.
- Co-editor of the volumes 343(3) and 331(2–3) of Theoretical Computer Science, Elsevier Science.
- Co-editor of the volume 55(1–2) of Science of Computer Programming, Elsevier Science.

D. Clarke

- PC Member of 20th Conference on Object-oriented Programming Languages, Systems and Applications (OOPSLA).
- Project member of NWO project CQuattro.

J.J.M.M. Rutten

- Professor of Theoretical Computer Science (bijzonder hoogleraar: Foundations of Computer Science, esp. Coalgebra), VU, since December 2001.
- (Co)project leader of NWO/EW research projects: COMOLO (Coalgebra and modal logic), C-Quattro (developing a compositional calculus of component connectors).
- Project member of SenterNovem research project CIM (Cybernetic incident management), EU project Trust4All, NWO project Infinity.
- Editor of proceedings series Electronic Notes in Theoretical Computer Science (ENTCS); guest editor of journal Theoretical Computer Science (TCS); editor of book series Semantic structures in computation, Kluwer Academic Press Publishers; editor of electronic journal Logical Methods in Computer Science (LMCS).
- Chairman of the steering committee of the Coalgebraic Methods in Computer Science (CMCS) workshop series; chairman of the steering committee of the Conferences on Algebra and Coalgebra (CALCO); member of the programme committee of CALCO 2005, Swansea.
- Member of Research Schools IPA and OzsL.
- Member PhD committee C. Grabmayer (VUA), A. Sokolova (TUE), P. Zoeteweij (UvA).

L.W.N. van der Torre

- PC co-chair. First international symposium on Normative Multiagent Systems (NorMAS 2005), part of AISB convention 2005. Hatfield, England,x April 12–13.
- PC co-chair. First international Workshop on Coordination and Organisation (CoOrg 2005), co-located with International Conference on Coordination COORD2005. Namur, Belgium, April 19.
- Member programme committee Eight European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU-2005). Barcelona, Spain, July 6–8.
- Member programme committee Game Theoretic and Decision Theoretic Agents (GTDT 2005) workshop held at International Joint Conference on AI (IJCAI 2005), Edinburgh, UK, July 30.
- Member programme committee The Third International Workshop on Programming Multi-Agent Systems: Languages, frameworks, techniques and tools (PROMAS 2005) held at Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2005), Utrecht, The Netherlands, July 26.
- Member programme committee 2005 IEEE / WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT 2005). Compiegne, France, September 19–22.
- Member programme committee Sixth International Workshop on Engineering Societies in the Agents' World (ESAW 2005). Kusadaci, Turkey, October 26–28.
- PC co-chair. AAAI 2005 Fall Symposium Roles, an interdisciplinary Perspective. Arlington, Virginia, USA, November 4–6.

Academic publications

Publications in refereed journals or proceedings

1 E. Abraham, F. de Boer, W.P. de Roever, M. Steffen (2005). An assertion-based proof system for multithreaded Java. Theoretical Computer Science 331(2–3), 251–290.

2 F. Arbab, F. de Boer, M. Bonsangue, L. van der Torre (2005). M. Lankhorst (ed.). Enterprise Architecture at Work: Modeling, Communication and Analysis. Springer (contributing authors).

3 F. Arbab (2005). Abstract Behavior Types: a foundation model for components and their composition. Science of Computer Programming 55(1-3), 3–52.

4 F. Arbab, C. Baier, F.S. de Boer, J.J.M.M. Rutten, M. Sirjani (2005). Synthesis of Reo Circuits for Implementation of Component-Connector Automata Specifications, Coordination Models and Languages. J.M. Jacquet and G. P. Picco (eds). 7th International Conference, COORDINATION 2005, Proceedings, LNCS 3454, 236–251.

5 G. Boella, J. Hulstijn, L. van der Torre (2005). Argumentation for access control. S. Bandini, S. Manzoni (eds). AI*IA 2005: Advances in Artificial Intelligence, Proceedings. LNCS 3673, 86–97.

6 G. Boella, J. Hulstijn, L. van der Torre (2005). Virtual Organizations as Normative Multiagent Systems. Proceedings of 38th Hawaii Intern. Conference on System Sciences (HICSS'05). 9 pages.
7 G. Boella, J. Hulstijn, L. van der Torre (2005). Argument games for interactive access control. Proceedings of WI05. 4 pages.
8 G. Boella, J. Hulstijn, and L. van der Torre (2005). A Synthesis Between Mental Attitudes and Social Commitments in Agent Communication Languages. Proceedings of IAT05. 7 pages.
9 G. Boella, J. Hulstijn, L. van der Torre (2005). Admissible Agreements among Goal-directed Agents. Proceedings of IAT05. 7 pages.
10 G. Boella, L. van der Torre (2005). Role-based Rights in Artificial Social Systems. Proceedings of IAT05. 4 pages.
11 G. Boella, L. van der Torre (2005). From the Theory of Mind to the Construction of Social Reality. Proceedings of CogSci05. 6 pages.
12 G. Boella, L. van der Torre (2005). Enforceable Social Laws. M. Pechoucek, D. Steiner, S. Thompson (eds). 4rd International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS 2005), 682–689.
13 G. Boella, L. van der Torre (2005). Organizations as Socially Constructed Agents in the Agent Oriented Paradigm. M.P. Gleizes, A. Omicini, F. Zambonelli (eds). Engineering Societies in the Agents World V, 5th International Workshop, ESAW 2004, Toulouse, France, October 20–22, 2004, Revised Selected and Invited Papers. LNCS 3451, 1–13.
14 G. Boella, L. van der Torre (2005). Permission and Authorization in Policies for Virtual Communities of Agents. G. Moro, S. Bergamaschi, K. Aberer (eds). Agents and Peer-to-Peer Computing: Third International Workshop, AP2PC 2004, LNCS 3601, 86–97.
15 G. Boella, L. van der Torre (2005). Normative Multiagent Systems and Trust Dynamics. R. Falcone, K.S. Barber, J. Sabater-Mir, M.P. Singh (eds). Trusting Agents for Trusting Electronic Societies, Theory and Applications in HCI and E-Commerce. LNCS 3577, 1–17.
16 F. de Boer, M.M. Bonsangue, S. Graf, W.-P. de Roever (eds) (2005). Proceedings of FMCO 2004 - revised lectures. LNCS 3657, 329 pages.
17 F.S de Boer, M.M. Bonsangue (eds) (2005). Formal Methods for Components and Objects - A theoretical perspective. Theoretical Computer Science 331 (2–3), 249–486.
18 F.S. de Boer, M.M. Bonsangue (eds) (2005). Formal Methods for Components and Objects - Pragmatic aspects and applications. Science of Comp. Programming 55(1–2), 1–290.
19 F.S. de Boer, M.M. Bonsangue (eds) (2005). Formal Methods on Components and Objects (FMCO 2003). Theoretical Computer Science 343(3), 283–530.
20 F.S. de Boer, M.M. Bonsangue, M. Steffen, E. Abraham (2005). A fully abstract semantics for UML Components. F. de Boer, M.M. Bonsangue, S. Graf and W.P. de Roever (eds). Proceedings of FMCO 2004 - revised lectures, LNCS 3167, 49–69.
21 F. de Boer, M. Bonsangue, L. Groenewegen, A. Stam, S. Stevens, L. van der Torre (2005). Change Impact Analysis of Enterprise Architecture. Proceedings of IEEE International Conference on Information Reuse and Integration (IRI'05). 5 pages.
22 F. de Boer, M. Bonsangue, J. Jacob, A. Stam and L. van der Torre (2005). Enterprise Architecture Analysis with XML. Proceedings of 38th Hawaii International Conference on System Sciences (HICSS'05). 11 pages.
23 M.M. Bonsangue, A. Kurz (2005). Dualities for Logics of Transition Systems. Proceedings of the European Joint Conferences on Theory and Practice of Software (ETAPS 2005), LNCS 3441, 455–469.
24 J. Broersen, M. Dastani, L. van der Torre (2005). Beliefs, Obligations, Intentions and Desires as components in an agent architecture. International Journal of Intelligent Systems 20(9), 893–919.
25 M. Dastani, F. Arbab, F. de Boer (2005). Coordination and composition in multi-agent systems. Proceedings of the fourth international joint conference on Autonomous agents and multi-agent systems, 439–446.
26 M. Dastani, J. Hulstijn, L. van der Torre (2005). How to decide what to do? European Journal of Operations Research 160(3), 762–784.

27 M. Dastani, G. Governatori, A. Rotolo, L. van der Torre (2005). Programming Cognitive Agents in Defeasible Logic. Proceedings LPAR'05, LNAI 3487, 144–160.

28 M. Dastani, G. Governatori, A. Rotolo, L. van der Torre (2005). Preferences of Agents in Defeasible Logic. Proceedings AI'05, LNAI.

29 M. Dastani, A. Herzig, J. Hulstijn, L. van der Torre (2005). Inferring trust. J.A. Leite, P. Torroni (eds). Computational Logic in Multi-Agent Systems, 5th International Workshop, CLIMA V, LNCS 3487, 144–160.

30 N. Diakov, F. Arbab (2005). Adaptation of Software Entities for Synchronous Exogenous Coordination - An Initial Approach. S. Becker, C. Canal, J.M. Murillo, P. Poizat, M. Tivoli (eds). 2nd International Workshop on Coordination and Adaptation Techniques for Software Entities (WCAT05), 39–46, satellite workshop of ECOOP 2005.

31 N.K. Diakov, F. Arbab (2005). Adaptation of Software Entities for Synchronous Exogenous Coordination: An Initial Approach. Proceedings of The Second International Workshop on Coordination and Adaptation of Software Entities, W-CAT'2005.

32 N. Diakov, Z. Zlatev, S. Pokraev (2005). Composition of Negotiation Protocols for E-Commerce Applications. Proceedings of the 2005 IEEE International Conference on e-Technology, e-Commerce and e-Service, William Cheung, Jane Hsu, IEEE Computer Society, 418–423.

33 J.L. Fiadeiro, N. Harman, M. Roggenbach, J.J.M.M. Rutten (eds) (2005). Proceedings of First International Conference on Algebra and Coalgebra in Computer Science (CALCO 2005) LNCS 3629, 457 pages.

34 J.V. Guillen-Scholten, F. Arbab, F.S. de Boer, M.M. Bonsangue (2005). MoCha-pi, an Exogenous Coordination Calculus based on Mobile Channels. Proceedings of the 20th ACM Symposium on Applied Computing (SAC 2005), ACM press.

35 J. Guillen-Scholten, F. Arbab, F.S de Boer, M.M. Bonsangue (2005). Modeling the Exogenous Coordination of Mobile Channel based Systems with Petri Nets. Proceedings FoCLaSA2005, ENTCS.

36 J. Guillen-Scholten, F. Arbab, F. de Boer, M. Bonsangue (2005). An Exogenous Coordination Calculus Based on Mobile Channels. Proceedings of the 20th ACM Symposium on Applied Computing (SAC 2005), 436–442.

37 S. Kaci, L. van der Torre (2005). Algorithms for a No monotonic Logic of Preferences. L. Godo (ed). Proceedings Symbolic and Quantitative Approaches to Reasoning with Uncertainty, 8th European Conference, ECSQARU 2005, LNCS 3571, 281–292.

38 J. Kok, F. Arbab (guest editors) (2005). Compositional Construction and Reasoning Techniques for Software. Special issue of the Journal of Universal Computer Science 11(10).

39 C. Kupke, Y. Venema (2005). Closure properties of coalgebra automata. 20th Annual IEEE Symposium on Logic in Computer Science (LICS 2005), 199–208.

40 C. Kupke, A. Kurz, D. Pattinson (2005). Ultrafilter extensions for coalgebras. Algebra and Coalgebra in Computer Science, LNCS 3629, 263–277.

41 M. Kyas, F. de Boer, W.-P. de Roever (2005). A Compositional Trace Logic For Behavioral Interface Specifications. Nordic Journal of Computing 12(2), 116–132.

42 Marcel Kyas, Harald Fecher, Frank S. de Boer, Joost Jacob, Jozef Hooman, Mark van der Zwaag, Tamarah Arons, Hillel Kugler (2005). Formalizing UML Models and OCL Constraints in PVS. ENTCS 115, 39–47.

43 C. Pierik, F. de Boer (2005). A proof outline logic for object-oriented programming. Theoretical Computer Science 343(3), 413–442.

44 Cees Pierik, Dave Clarke, Frank S. de Boer (2005). Controlling Object Allocation Using Creation Guards. Proceedings of Formal Methods, International Symposium of Formal Methods Europe, LNCS 3582, 59–74.

45 J.J.M.M. Rutten (2005). A tutorial on coinductive stream calculus and signal flow graphs. Theoretical Computer Science Volume 343(3), 443–481.

46 J.J.M.M. Rutten (2005). A coinductive calculus of streams. Mathematical Structures in Computer Science, 15, 93–147.

47 J.J.M.M. Rutten (2005). Algebra, bitstreams, and circuits Contributions to General Algebra 16, 231–250.

48 M. Sirjani, A. Movaghar, A. Shali, F. de Boer (2005). Model Checking, Automated Abstraction, and Compositional Verification of Rebeca Models. Journal of Universal Computer Science 11(6), 1054–1082.
49 Marjan Sirjani, Frank S. de Boer, Ali Movaghar, Amin Shali (2005). Extended Rebeca: A Component-Based Actor Language with Synchronous Message Passing, ACSD, 212–221.
50 M. Steffen, A. Gruner, E. Abraham, M.M. Bonsangue, F.S. de Boer (2005). Observability, connectivity, and replay in a sequential calculus of classes. F. de Boer, M.M. Bonsangue, S. Graf and W.P. de Roever (eds). Proceedings of FMCO 2004 revised lectures, LNCS 3167, 301–321.
51 P. Wegner, F. Arbab, D.Q. Goldin, P. McBurney, M. Luck, D. Robertson (2005). The Role of Agent Interaction in Models of Computing: Panelist Reviews. ENTCS 141(5), 181–198.

Publications in other journals or proceedings and other scientific output

CWI reports

SEN-R0501, SEN-R0502, SEN-R0505, SEN-R0506, SEN-E0508, SEN-E0509, SEN-E0510, SEN-E0511, SEN-E0512, SEN-E0514, SEN-R0514, SEN-E0515, SEN-E0516.
See B.3 on page 202 for complete titles.

Software developed

- Visual editor and simulators for Constraint Automata, H.K. Kan.

PhD theses

1 P. Zoeteweij (2005). Composing constraint solvers, UvA, November 29. Thesis advisors: K. Apt and F. Arbab.

Professional products

Publications for a broad audience

- Composition by Interaction, Innaugural lecture, Leiden Univ., October 28: F. Arbab.

Computational Intelligence and Multi-agent Games – SEN4

Until June 2005: Evolutionary Systems and Applied Algorithmics

Mission

The theme works on the combination of two areas, consisting of computer science techniques and focus fields:

1. Intelligent algorithms, like evolutionary algorithms, adaptive algorithms, neural networks, graphical models, and hybrid heuristics.
2. Competitive games in multiagent systems and optimization.

Games in multi-agent systems: e-business and economics

Interactions between self-interested agents in a multi-agent system are often modeled by games, like negotiations, auctions (competitive games), and market mechanisms (economic games). Important multi-agent systems occur in computer science as well as economics. A prominent feature for an agent is the skill of learning. This is a growing field of research, for both agent technology (how to build a really-learning agent) and economics (how to simulate learning agents).

In the SEN4 theme group, intelligent algorithms are investigated, in order to build the internals of learning agents participating in games (in e-business applications) as well as to simulate market mechanisms (economics and e-business agent systems).

Focus areas are among others the following:

1. Intelligent algorithms and adaptive strategies for agents participating in competitive games (game theory), like in negotiations, auctions, and dynamic pricing,

2. Design and/or simulation of market mechanisms (market games) in multi-agent systems (for e-business applications or economics simulations).

Competitive games in multi-agent systems can be used in applications like e-business, logistics, and economics.

Intelligent Algorithms

Fundamental research on intelligent algorithms is also performed in the more conventional problem domains of optimization and classification. Here, the emphasis is on the mere development of these techniques, which in addition facilitates other research activities, like for multi-agent systems.

Special attention is given to a novel type of neural networks, consisting of spiking neurons. Research aspects include learning rules, classification, binding, and credit assignment in neural networks via appropriate market mechanisms.

Research is also performed for improving and analyzing the performance of evolutionary algorithms and adaptive discrete algorithms, like for dynamic and online optimization problems, as well as novel types of optimization problems arising from multi-agent systems applications.

Theme leader

Prof.dr.ir. J.A. La Poutré

MSC or CR classification

I.2, I.5, I.6, J.4, F.2, G.1, 91H

Subthemes

Name	Leader
SEN4.1 – Evolutionary Systems	J.A. La Poutré
SEN4.2 – Neural Networks and Discrete Algorithms	J.A. La Poutré

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr.ir. J.A. La Poutré (0.2 fte seconded to TUE)	1.0	theme leader	indefinite	SEN4.1; SEN4.2: DEAL, FREA, FRNN, MIA, CIM
Dr. S.M. Bohte (0.2 fte seconded to TUD)	1.0	researcher	indefinite	SEN4.2; SEN4.1: SCANN, FRNN, MIA
Dr. P. Bosman	1.0	postdoc	2004-12-01 till 2006-11-30	SEN4.1: DEAL, FREA
Dr. ir. P.J. 't Hoen	1.0	postdoc	2001-03-01 till 2007-02-28	SEN4.1: DEAL, FRNN
Dr. T.B. Klos	1.0	postdoc	2003-02-01 till 2007-02-01	SEN4.1: CIM, FREA
Drs. V. Robu	1.0	PhD student	2003-10-01 till 2007-09-30	SEN4.1: DEAL, FREA
Dr. D.J.A. Somefun	1.0	postdoc	2001-01-01 till 2006-12-31	SEN4.1: FREA, MIA
Drs. I.B. Vermeulen	1.0	PhD student	2004-02-01 till 2008-02-01	SEN4.1: MIA

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof. Dr. H.M. Amman (TUE)	0.1	advisor	till 2006-09-01	SEN4.1: FREA
Prof.dr. J.N. Kok (UL)	0.05	advisor	till 2005-07-01	SEN4.2: FRNN
Dr. C. Witteveen (TUD)	0.2	researcher	2004-01-01 till 2006-01-01	SEN4.1: FREA, CIM, DEAL
Dr. M. De Weerdt (TUD)	0.2	researcher	2005-01-01 till 2007-01-01	SEN4.1: FREA, CIM, DEAL
Drs. A. Hutzschenreuter (TUE)	0.0	PhD student	2005-04-01 till 2009-03-01	SEN4.1: FREA
Drs. J. van Luin (TUE)	0.0	PhD student	2005-01-01 till 2008-01-01	SEN4.1: FREA

Scientific report

Highlights

- The name of the group has been changed into 'Computational Intelligence and Multi-agent Games', which better reflects the research interests of the theme group.
- The theme group has again been evaluated as 'excellent' in the six-yearly evaluation of the CWI by NWO, similarly like in 1999.
- An NWO grant for a joint project with TUD has been awarded: 'Task Coordination for Non-Cooperative Agents'.
- Research activities on patient logistics in health care have increased, in cooperation with hospitals like the AMC.
- Software demo's have been developed and are available on `http://homepages.cwi.nl/~han/SEN4Demos/`

PhD students

V. Robu
I.B. Vermeulen
A.K. Hutzschenreuter
J. van Luin

SEN 4.1 – Evolutionary Systems

In SEN4.1, the following projects were carried out.

Title	DEAL – Distributed Engine for Advanced Logistics
Period	May 2002–2006
Leader	J.A. La Poutré
Staff	P.J. 't Hoen, P. Bosman, V. Robu, D.J.A. Somefun
Funding	E.E.T. (SenterNovem)
Partners	Almende, EUR, VU, Vos Logistics, Post Kogeko Transport Group, Groeneveld Group

Progress report. In the project, research focused on strategies to increase the effectiveness of logistical decision making, such as through dynamic (re-)scheduling of routes and loads.

In a spot market approach, each truck in a network continually participates in auctions to increase, change and augment the loads the truck carries. Research was performed to evaluate the effectiveness of rescheduling loads via contract decommitment ('t Hoen, G. Redekar (IIT), Robu, La Poutré).

Fundamental research to facilitate smart logistical software agents has focused on coordination aspects of Multi-Agent Systems, from the cooperative as well as for the competitive aspect. For cooperative systems, work has focused on agents learning when the agents should cooperate on joint actions. This approach allows for agents to start with a restricted state space and limited observations. Agents learn through experience when they should expand their initial compact representation to more effective coordinated joint actions as required by the domain (N. Kok (UvA), 't Hoen, B. Bakker (UvA), N. Vlassis (UvA)).

The competitive research has focused on two forms of strategic behavior. First of all, work has investigated the impact of strategic bidding for agents bidding in sequential auctions for goods where bundles of such goods have complementarities, i.e. the value of the bundle is more than the sum of the value of the individual items. Results show that individual agents have a strong incentive to exploit the expected future profits. ('t Hoen and La Poutré)

Research on multi-agent reinforcement learning has shown that improved policies can be found by agents that take into account how an opponent will likely react to the choice of

play. ('t Hoen, Bohte, La Poutré).

Also, research has been carried out on using utility graphs for modeling high-dimensional automated negotiations over multiple, interdependent issues. We showed that in such settings, it is possible to exploit the decomposable structure of complex utility functions (represented in graphical form) in order to reach more efficient (i.e. Pareto-optimal) agreements. Furthermore, we show that in e-commerce settings, it is possible to use techniques inspired from collaborative filtering of aggregate buyer preferences in order to reduce the number of negotiation steps needed to find an efficient agreement (Robu, Somefun, La Poutré).

More applied work focused on a case study application of negotiation techniques, together with our industrial partner, VOS Logistics, Nijmegen (a large European provider of transportation logistics solutions). The business case studied focused mostly on modeling complex negotiations over the distribution of transportation orders within a 'closed group' composed of several transportation companies (S. van der Putten, Robu, La Poutré).

Work was carried out on extending a visualization for negotiation and market techniques previously developed in this project (Robu, 't Hoen, Somefun, Noot).

Title	CIM – Cybernetic Incident Management
Period	2004–2007
Leader	J.A. La Poutré
Staff	T.B. Klos, C. Witteveen, M. de Weerdt
Funding	SenterNovem (CIC)
Partners	Almende, VU, TUD, Group4Falck, CMotions

Progress report. Work was carried out on computational reputation-based trust modeling. Specifically, we have investigated and compared a variety of ways of combining different agents' reputations, when a binary decision needs to be made about which those agents contribute possibly conflicting observations. (Klos, La Poutré).

Contribution were made to the design and development of the Agent Reputation and Trust (ART) Test-bed, which serves as a standardized environment for experimenting with and comparing different computational trust models—the first competition between different researchers' trust models is scheduled to occur at the fifth AAMAS conference in Japan in May 2006. (Klos et al.).

We have applied a reputation-based trust model developed earlier to an e-commerce setting, where consumer agents form and update reputation assessments of suppliers—either producers, or intermediating agents buying from producers. When consumer agents base their decisions on their suppliers' reputation, then for a variety of producers' pricing strategies, intermediaries are able to retain some market share by accumulating a base of loyal consumer-agents who are willing to pay the intermediaries markup in exchange for the intermediating agents protection against the dynamics of the market place—even if consumers have the option of purchasing from producers directly. (Klos, F. Alkemade (UU)).

We studied reputation in task allocation. We consider a situation where agents have different capabilities, and some agents would like to have some tasks done that require many of these capabilities. We assume that these agents are socially situated, meaning that they have a network of friends who they can request to participate in fulfilling their task. On these friends they have some notion of reputation information. How can this information be used? What is the influence of the structure of this network on the results? Currently, we are working on an implementation. (De Weerdt, Klos)

We developed and implemented a system in which self-interested agents can (i) construct their plans themselves, (ii) coordinate their actions during planning, and do so while (iii) maintaining their privacy. The first experiments with this system have been published at two conferences (De Weerdt, R. van der Krogt (TUD)).

We studied the application of Model Based Diagnosis in agent-based planning. We model a plan as a system to be diagnosed and assume that agents can monitor the execution of the plan by making partial observations during plan execution. These observations are used by the agents to explain plan deviations (errors) by qualifying some action instances as behaving abnormally. We prefer those qualifications that are maximum informative, i.e. explain as much as possible. Since in a plan several instances of the same action might occur, an error occurring in one instance might be used to predict the occurrence of the same error in an action

instance to be executed later on. Next, we consider the multi-agent perspective where each agent is responsible for a part of the total plan, we show how plan-diagnoses of these partial plans are related to diagnoses of the total plan and how global diagnoses can be obtained in a distributed way. (Witteveen, N. Roos (TUD))

We discuss task planning problems where a number of agents have to work on a joint planning problem that consists of a set of interdependent, hierarchically ordered tasks. Each agent is assigned a subset of tasks to perform for which it has to construct a plan. The agents are non-cooperative in that they insist on planning autonomously and do not want to revise their individual plans when a joint plan has to be assembled. The aim is twofold: first of all to present a general formal framework to study some computational aspects of this non-cooperative coordination problem, and secondly to establish some complexity results and to identify some of the factors that contribute to the complexity of this problem. (Ter Mors (TUD), Valk (TUD), Witteveen)

As part of an international collaboration effort, a competition test bed for trusting agents was co-designed. This test bed is intended to serve as both a competition and a benchmark test-bed for trust and reputation solutions in multi-agent systems. (Klos, K.K. Fullam, K.S. Barber (Univ. Texas at Austin, USA), G. Muller, L. Vercouter (École Nationale Supérieure des Mines, Saint-Étienne, France), J. Sabater (National Research Council (CNR), Rome, Italy), A. Schlosser, M. Voss (Darmstadt Univ. Technology, Germany) Z. Topol, J. Rosenschein (Hebrew Univ., Israel)).

Title	MIA – Medical Information Agents
Period	2004–2008
Leader	J.A. La Poutré
Staff	I.B. Vermeulen, S.M. Bohte, D.J.A. Somefun
Funding	NWO
Partners	UM, AMC, TUE

Progress report. For the ToKeN2000 project MIA (medical information agent) research activities include literature research, modeling, and computer experiments. This project researches a distributed and dynamic approach to hospital patient (re)scheduling. Scheduling the complex treatment plans of patients requires coordination between all the different autonomous departments involved. Due to the dynamic nature of a hospital, any approach must be efficient, online, and flexible. In cooperation with logistic health care experts we are investigating the use of autonomous software agents negotiating with each other in order to make (or reschedule) appointments for patient treatment. We developed a multi-agent system, capturing local resource constraints and individual patient properties, to solve this online scheduling problem (Vermeulen, Bohte, Somefun, La Poutré).

A project plan was developed to study and improve the actual hospital patient scheduling problem at the Amsterdam Medical Center's CT-Scanners (Vermeulen, Bohte, La Poutré, Bakker (AMC)).

Title	FREA – Fundamental research on economic agents and on evolutionary algorithms
Period	undefined
Leader	J.A. La Poutré
Staff	D.J.A. Somefun, P.J. 't Hoen, A.K. Hutzschenreuter, J. van Luin, P. Bosman, C. Witteveen
Funding	basic

Progress report. On bundling and bilateral negotiation: We developed a procedure a seller can use to quickly learn through bargaining which subset a particular customer likes best, from all goods being offered. Moreover, starting with no prior knowledge we developed an on-line and scalable learning scheme that significantly speeds up the process of finding the best bundle. (Somefun, La Poutré).

Research in designing algorithms for dynamic optimization was performed, specifically on evolutionary algorithms. The focus has been on dealing with the influence that decisions taken now have on future events and situations. The research has led to the design of a framework to tackle this problem and a successful proof-of-principle experimentation on two dynamic optimization problems. The ultimate application of this research lies in the dynamical problems that occur in the DEAL project. (Bosman, La Poutré)

Fundamental research was carried out to study estimation-of-distribution algorithms for numerical optimization and applications thereof. One successful application has been the

optimization of parameters in a medical simulation. By replacing the existing analytical optimization algorithm in a simulation for guide wire propagation with a hybrid EDA we were able to obtain faster and more reliable simulations. Recent advances in fundamental research has led to a significant improvement of the current state-of-the-art in continuous estimation-of-distribution algorithms by introducing a robust adaptive method for scaling variances in the estimation procedure.(Bosman)

A literature study was carried out on agent-based coordination mechanisms and on decentralized scheduling methods in the application area of health care. Contacts were established for a case study in cooperation with the Catharina Ziekenhuis in Eindhoven. And the topic for a case study was determined: intelligent agent-based planning in operating theatres. Furthermore, work was carried out on queueing models for outpatient appointment scheduling. (Hutzschenreuter, La Poutré).

Also, fundamental research was performed on areas and problems occurring in other (externally financed) projects, like the DEAL project. In the FREA project, the more fundamental parts were addressed. These subjects therefore coincide with those mentioned there and are described in these projects.

SEN 4.2 – Neural Networks and Discrete Algorithms

Title	FRNN – Fundamental Research on Neural Networks
Period	1998–2005
Leader	J.A. La Poutré
Staff	S.M. Bohte, J.N. Kok, P.J. 't Hoen
Funding	basic (project funding)
Partner	UL

Progress report. Fundamental research on the subject of Spiking Neural Networks was carried out within the SCANN and DEAL projects (see the respective project reports).

Title	SCANN – Scalable Architectures for spiking Neural Networks
Period	2004–2008
Leader	S.M. Bohte
Funding	NWO Veni (project funding)

Progress report. Research was carried out on applying policy gradient techniques to spiking neurons. Given the spike-response model, a spiking neuron model that very closely mimics the behavior of real neurons, we found that maximizing the log-likelihood of the neuron's response to presented stimuli (input spikes) yields a learning rule that very closely resembles the spike-timing dependent plasticity learning rule observed in real neurons. Our model further makes predictions about the shape and time-course of such a learning rule under different conditions. We showed how the model can be extended to the experimentally applied method of 'current injection', without significant changes to the outcomes of the experiments. (S.M. Bohte and M.C. Mozer (Univ. Colorado, Boulder)).

Methods for large scale simulation of asynchronous spiking neural networks on clustered computers were investigated. Given the emergence of very high-speed interconnects, we investigated whether asynchronous simulations would be possible, thus avoiding the performance penalty of synchronous simulations that prevent efficient scaling of network simulations to very large networked computers. Work was carried out to evaluate the currently available parallel computing software, like MPI, for this purpose (Hoogewoning, Bohte).

Societal aspects and knowledge transfer

Other external contacts

Contacts exist with, among others, TUD; TUE; UM; UvA, AMC Academic Medical Centre, Amsterdam; Freiburg Univ., Germany; Carnegie Mellon Univ., USA; Univ. Bielefeld, Germany; Napier Univ., Edinburg, UK; the Free Univ. Brussels, Belgium; Univ. Southampton, UK; Univ. Essex, UK; Univ. of Colorado, Boulder, USA; CERCO, France.

Projects with partners in public and private sector

- DEAL, see page 104.
- FRNN, see page 107.
- FREA, see page 106.
- CIM, see page 105.
- MIA, see page 106.
- SCANN, see page 107

Teaching at university

- Course Distributed Software Architectures, on multi-agent systems, TUE: J.A. La Poutré.
- SIKS Course on Logic and Agents: J.A. La Poutré (Lecture: Mechanism Design and Auctions).
- Course Seminarium Computational Complexity and 'Seminarium Multi-Agent Systems', TUD: S.M. Bohte.
- PhD course Basic Course Algorithms and Complexity, IPA research school: P.A.N. Bosman, J.A. La Poutré (both lectured).

Organization of conferences, workshops, courses, and meetings

- SEN4 seminars:
  - W. Wiechers, Simulating the Establishment of Trust Infrastructures in Multi-Agent Systems, January 18.
  - Design and Application of Iterated-Density Estimation Evolutionary Algorithms, P.A.N. Bosman, February 15.
  - Utile Coordination: Learning Interdependencies among Cooperative Agents. J. Kok, March 15.
  - Repeated Auctions with Complementarities, P.J. 't Hoen, April 12.
  - Dynamic Inter-organizational Business Process Management: Application of MAS and SOC Technology. P. Grefen, May 10.
  - Modelling Complex Multi-Issue Negotiations over Using Utility Graphs. V. Robu, June 14.
  - Repeated Patterns in Linear and Tree Genetic Programming. B. Langdon, June 21.
  - Evolving problem instances to evaluate combinatorial algorithms. J. van Hemert, September 15.
  - Discounting and Combining Evidence in Bayesian Reputation Systems. T. Klos, September 27.
  - A Scalable Method for Online Learning of Non-linear Preferences Based on Anonymous Negotiation Data, K. Somefun, October 25.
  - Reducing Spike Train Variability: A Computational Theory Of Spike-Timing Dependent Plasticity. Sander Bohte, November 22.
- SEN4 Journal Club meetings (monthly).
- The 7th International Workshop on Agent-Mediated Electronic Commerce (AMEC VII), Utrecht, July 25: J.A. La Poutré, co-organizer with N.M. Sadeh (Carnegie Mellon Univ., USA).
- The first International workshop on Learning and Adaptation in MAS (LAMAS) In connection with the fourth International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS '05), Utrecht, the Netherlands, July 26: P.J. 't Hoen (co-organizer).
- International Conference on Management Science, CWI, Amsterdam, May 2006: D.J.A. Somefun, J.A. La Poutré, H. Amman, F. Alkemade (co-organizers).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Computing and Markets, Dagstuhl, Germany, January 3–7: La Poutré (Lecture: Negotiation over Bundles and Prices Using Online Aggregate Knowledge).
- Computational Intelligence SIKS course, Zeist, February 17–18: V. Robu, I.B. Vermeulen.
- ToKeN2000 Symposium, March 18: I. Vermeulen (Poster: Efficient Patient Treatment).
- Stochastic Programming, LNMB course, Utrecht, April–June: V. Robu, I.B. Vermeulen.
- Optimization by Building and Using Probabilistic Models (OBUPM) workshop at the Genetic and Evolutionary Computation Conference (GECCO), June 24: P.A.N. Bosman (Invited lecture: Numerical Optimization with Real-Valued Estimation-of-Distribution Algorithms).
- The Genetic and Evolutionary Computation Conference - GECCO-2005, Washington D.C., USA, June 25–29: P.A.N. Bosman (Lectures: 'Exploiting Gradient Information in Numerical Multi-Objective Evolutionary Optimization', 'Learning, Anticipation and Time-Deception in Evolutionary Online Dynamic

Optimization', 'Evolutionary Algorithms for Medical Simulations — A Case Study in Minimally-Invasive Vascular Interventions').
- Data Mining, SIKS course, Maastricht, 27 June–1 July: V. Robu.
- International Workhop on Agent-Based Models for Economic Policy Design (ACEPOL'05), Center for Interdisciplinary Studies (ZIF), Bielefeld, Germany, June 30–July 2: J.A. La Poutré (Invited lecture: On Social Learning and Robust Evolutionary Algorithm Design in Economic Games).
- European Agent Systems Summer School (EASS'05), Utrecht, July 18–22: V. Robu.
- Workshop on Learning Agents in Multi-Agent Systems at the AAMAS 2005 conference, July 25: S.M. Bohte, P.J. 't Hoen.
- Workshop on Trust in Agent Societies at the AAMAS 2005 conference, July 25: T.B. Klos.
- Workshop on Agents and Peer-to-Peer Computing at the AAMAS 2005 conference, July 26: T.B. Klos.
- Workshop on Agent Mediated Electronic Commerce VII at AAMAS 2005, July 26: S.M. Bohte, D.J.A. Somefun, J.A. La Poutré, P.J. 't Hoen (Lecture: Repeated Auctions with Complementarities).
- Autonomous Agents and Multi-Agent Systems (AAMAS) Conference 2005, Utrecht, July 27–29: J.A. La Poutré, V. Robu (Lectures: Automated Multi-Attribute Negotiation with Efficient Use of Incomplete Preference Information; Software Demonstration: Simulation and Visualization of a Market-Based Model for Logistics Management in Transportation), H. Noot, D.J.A. Somefun, T.B. Klos (Presented: Trusted Intermediating Agents in Electronic Trade Networks), S.M. Bohte, P.J. 't Hoen.
- Advanced Issues in Neurocomputing, ASCI course, Amsterdam-Nijmegen, August: V. Robu.
- IEEE Conference on Evolutionary Computation, Edinburgh, Scotland, September 2–5: J.A. La Poutré (Lecture: On Social Learning and Robust Evolutionary Algorithm Design in Economic Games).
- Third Agentlink Technical Forum on Multi-Agent Resource Allocation (TFG-MARA), Budapest, Hungary, September 15–17: V. Robu.
- Seventeenth Belgium Netherlands Conference on Artificial Intelligence (BNAIC), Brussels, October 17–18: P.J. 't Hoen, J.A. La Poutré, S.M. Bohte, V. Robu, T.B. Klos, C. Witteveen, P. Bosman (lectures and software demonstrations).
- SIKS-day: SIKS: School voor Informatie- en Kennissystemen, November 11: J.A. La Poutré (Invited lecture: Computational Intelligence in Multi-Agent Games).
- SNN Symposium on 'Lerende Oplossingen', Nijmegen, November 16: D.J.A. Somefun, T. Klos, S.M. Bohte, J.A. La Poutré, P.J. 't Hoen.
- The 3^{rd} European Workhop on Multiagent Systems (EUMAS), Brussels, Belgium, December 7–8: J.A. La Poutré (Invited lecture: Action-Reaction in Multi-agent Games).

Working visits

- VU Brussel, Brussels, Belgium, March 11: J.A. La Poutré.
- I.W.T. (Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen), Brussels, Belgium, November 23: J.A. La Poutré.

Project meetings

- DEAL Steering group meetings, Rotterdam: J.A. La Poutré.
- DEAL Working group meetings, Rotterdam/Amsterdam: P.J. 't Hoen, V. Robu, P.A.N. Bosman, H. Noot.
- CIM project meetings (Cybernetic Incident Management): J.A. La Poutré, T.B. Klos (every 4 months).
- MIA project meetings: I.B. Vermeulen, S.M. Bohte, D.J.A. Somefun, H. Noot, J.A. La Poutré, irregularly scheduled.

Other lectures

- ESHL, Brussels, Belgium, March 16: D.J.A. Somefun (Lecture: Bringing Haggling Back to the Market Place: How to Combine Bundling, Fairness and Win-Win).
- ISAS Lab, UvA, Amsterdam, May 10: S.M. Bohte (Lecture: Information Theoretic Derivation of Stochastic Gradient Learning in Spiking Neurons).

Visitors

- See 'SEN4-seminars', on the preceding page.

Memberships of committees and other professional activities

S.M. Bohte

- Guest editor for special issue of Information Processing Letters on Applications of Spiking Neural Networks (with J.N. Kok).
- Member programme committee BNAIC 2005.
- Member programme committee Workshop on Learning Agents and Multi-Agent Systems 2005 (LAMAS'05).
- Reviewer for Neural Computation, TCS, Neurocomputing, Control & Intelligent Systems (CIS), Information Processing Letters. ICANN 2005, BNAIC 2005, ICML 2005, LAMAS 2005, Kluwer Scientific Publishing.

P.A.N. Bosman

- Session chair for the EDA track of the Genetic and Evolutionary Computation Conference GECCO-2005.
- Member programme committee of the Congress on Evolutionary Computation CEC-2005 .
- Member programne committee of Genetic and Evolutionary Computation Conference GECCO-2005.
- Reviewer for IEEE Transactions on Systems, Man, and Cybernetics; IEEE Transactions on Evolutionary Computation, Natural Computing, European Journal of Operational Research, Evolutionary Computation, Computational Economics.

P.J. 't Hoen

- Co-chair of The first International workshop on Learning and Adaptation in MAS (LAMAS) In connection with the fourth International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS '05). July 26, Utrecht, the Netherlands.
- Reviewer for the BNAIC 2005.

T.B. Klos

- Reviewer for Computational Economics, Journal of Economic Behavior and Organization Journal of e-JEMED, and Journal of Management Science, Seventh International Workshop on Agent-Mediated Electronic Commerce: Designing Mechanisms and Systems, Information Technology for Economics and Management.

J.A. La Poutré

- Member editorial boards of Netnomics, Computational Management Science (CMS), and e-JEMED, the Electronic Journal of Evolutionary Modeling and Economic Dynamics.
- Chair of the BNVKI, the Belgium-Netherlands Association for Artificial Intelligence.
- Member PhD committees of A.M.L. Liekens: 'Evolution of Finite Populations in Dynamic Environments' (TUE), and J.M. Valk: 'Coordination among Autonomous Planners' (TUD).
- Member programme committees of the Workhop on Agent-Based Models for Economic Policy Design (June–July, Bielefeld, Germany), Member programme committees of IEEE/WIC/ACM International Conference on Web Intelligence (WI-2005) (September, Compiègne, France); ICSC Symposium on Advanced Computing in Financial Markets (ACFM'2005) (December, Istanbul, Turkey); Fourth International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS) (July, Utrecht); and Fifth International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS) (May 2006, Hakodate, Japan).
- Member of the selection-committee for IWT specialization grants (November 23; IWT: Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen, Belgium): committee 'Artificial Intelligence and Operational Research'.
- Programme co-chair of the 7th International Workshop on Agent-Mediated Electronic Commerce (AMEC VII) (July, Utrecht).
- Member IEEE Technical Committee of Computational Finance and Economics (CFETC) of the IEEE's Computational Intelligence Society (CIS).
- Member of the research schools SIKS, BETA and IPA.

V. Robu

- Co-supervision of S. van der Putten (Master student)
- Auxiliary Reviewer for AAMAS 2005.

M.M. de Weerdt

- Research fellow of SIKS and TRAIL research school.
- Reviewer for IJCAI'05, CLIMA'05, EUMAS'05, AAMAS'05 (non programme committee member).

- Organizer of Agent colloquium (by TUD, CWI, UU).
- Presenter of tutorial on Multi-agent Planning at European Agent Systems Summer School.

C. Witteveen

- Member programme board TRAIL research school.
- Member programme board Computer Science of the Lorentz Center.
- Member jury committee STW.
- Member board BNVKI (treasurer), the Belgium-Netherlands Association for Artificial Intelligence.
- Reviewer for Journal of Artificial Intelligence, Mathematical Reviews, IEEE Transactions on Knowledge and Data Engineering, AMAI, Zentralblatt fuer Mathematik, Transportation and management.
- Member programme committee for BNAIC'05, ESQUARU'05, CLIMA'05, PROMAS'05, AAMAS'05, EUMAS'05.

Academic publications

Publications in refereed journals or proceedings

1 F. Alkemade, C. Castaldi (2005). Strategies for the diffusion of innovations on social networks. Computational Economics 25(1), 3–23.

2 F. Alkemade, J. La Poutré, H. Amman (2005). On social learning and robust evolutionary algorithm design in economic games. Proceedings of the 2005 IEEE Congress on Evolutionary Computation (CEC 2005), 2445–2452.

3 F. Alkemade, D. van Bragt, J. La Poutré (2005). Stabilization of tag-mediated interaction by sexual reproduction in an evolutionary agent system. Information Sciences 170, 101–119.

4 S. Bohte, J. Kok (2005). Applications of spiking neural networks. Information Processing Letters 95, 519–520.

5 S. Bohte, M. Mozer (2005). Reducing spike-train variability: A computational theory of spike-timing dependent plasticity. K. Verbeeck, K. Tuyls, A. Nowé, B. Manderick, B. Kuijpers (eds). Proceedings of the Seventeenth Belgium-Netherlands Conference on Artificial Intelligence (BNAIC), 319–320.

6 S.M. Bohte, M. C. Mozer (2005). Reducing spike train variability: A computational theory of spike-timing dependent plasticity. L.K. Saul, Y. Weiss, L. Bottou (eds). Advances in Neural Information Processing Systems (NIPS) 17, 201–208.

7 P. Bosman (2005). Learning, anticipation and time-deception in evolutionary online dynamic optimization. K. Verbeeck, K. Tuyls, A. Nowé, B. Manderick, B. Kuijpers, (eds). Proceedings of the Seventeenth Belgium-Netherlands Conference on Artificial Intelligence (BNAIC), 321–322.

8 P.A.N. Bosman (2005). Learning, anticipation and time-deception in evolutionary online dynamic optimization. S. Yang, J. Branke (eds). Proceedings of the Evolutionary Algorithms for Dynamic Optimization Problems (EvoDOP) Workshop at the Genetic and Evolutionary Computation Conference (GECCO) 2005, 39–47.

9 P.A.N. Bosman, T. Alderliesten (2005). Evolutionary algorithms for medical simulations — a case study in minimally-invasive vascular interventions. S.L. Smithi, S. Cagnoni (eds). Proceedings of the Medical Applications of Genetic and Evolutionary Computation MedGEC Workshop at the Genetic and Evolutionary Computation Conference (GECCO), 125–132.

10 P.A.N. Bosman, E.D. de Jong (2005). Exploiting gradient information in numerical multi-objective evolutionary optimization. H.-G. Beyer, U.-M. O'Reilly, D.V. Arnold, W. Banzhaf, C. Blum, E.W. Bonabeau, E. Cantú-Paz, D. Dasgupta, K. Deb, J.A. Foster, E.D. de Jong, H. Lipson, X. Llora, S. Mancoridis, M. Pelikan, G.R. Raidl, T. Soule, A. M. Tyrrell, J.-P. Watson, E. Zitzler (eds). Proceedings of the Genetic and Evolutionary Computation Conference (GECCO), 755–762.

11 P.A.N. Bosman, D. Thierens (2005). The naive MIDEA: a baseline multi-objective EA. C. A. C. Coello, A. H. Aguirre, and E. Zitzler (eds). Evolutionary Multi-Criterion Optimization (EMO) 2005 LNCS 3410, 428–442.

12 T. Bosse, C. Jonker, L. van der Meij, V. Robu, J. Treur (2005). A system for analysis of multi-issue negotiation. M. Calisti, M. Klusch, R. Unland (eds). Software

Agent-Based Applications, Platforms and Development Kits, 253–280.

13 L. Epstein, R. van Stee (2005). Online bin packing with resource augmentation. Proceedings of the 2nd Workshop on Approximation and Online Algorithms (WAOA 2004), LNCS 3351, 23–35.

14 L. Epstein, R. van Stee (2005). Online square and cube packing. Acta Informatica 41(9), 595–606.

15 L. Epstein, R. van Stee (2005). Optimal online algorithms for multidimensional packing problems. SIAM Journal on Computing 35(2), 431–448.

16 L. Epstein, R. van Stee (2005). This side up! Proceedings of the 2nd Workshop on Approximation and Online Algorithms (WAOA 2004), LNCS 3351, 48–60.

17 K. Fullam, T. Klos, G. Muller, J. Sabater-Mir, A. Schlosser, Z. Topol, S. Barber, J. Rosenschein, L. Vercouter, M. Voss (2005). A specification of the agent reputation and trust (art) testbed: Experimentation and competition for trust in agent societies. F. Dignum, V. Dignum, S. Koenig, S. Kraus, M. Singh, M. Wooldridge (eds). Proceedings Fourth International Conference on Autonomous Agents and Multi-Agent Systems 2, 512–518.

18 K. Fullam, T. Klos, G. Muller, J. Sabater-Mir, Z. Topol, S. Barber, J. Rosenschein, L. Vercouter (2005). The agent reputation and trust (art) testbed architecture. P.R. B.López, J. Meléndez, J. Vitrià (eds). Artificial Intelligence Research and Development, FAIAA 131, 389–396.

19 K. Fullam, T. Klos, G. Muller, J. Sabater-Mir, Z. Topol, S. Barber, J. Rosenschein, L. Vercouter (2005). A demonstration of the agent reputation and trust (art) testbed for experimentation and competition. M. Pechoucek, D. Steiner, S. Thompson (eds). Proceedings Fourth International Conference on Autonomous Agents and Multi-Agent Systems, volume Industry Track, 151–152.

20 E. Gerding, D. Somefun, J. La Poutré (2005). Multi-attribute bilateral bargaining in a one-to-many setting. Proceedings of the 6th Workshop on Agent Mediated Electronic Commerce (AMEC-VI), LNAI 3435.

21 P. 't Hoen, J. La Poutré (2005). Repeated auctions with complementarities: Extended abstract. K. Verbeeck, K. Tuyls, A. Nowé, B. Manderick, B. Kuijpers, (eds). Proceedings of the Seventeenth Belgium-Netherlands Conference on Artificial Intelligence (BNAIC), 313–314.

22 P. 't Hoen, G. Redekar, V. Robu, J. La Poutré (2005). Decommitment in a competitive multi-agent transportation setting. M. Calisti, M. Klusch, R. Unland (eds). Software Agent-Based Applications, Platforms and Development Kits, 409–433.

23 P.J. 't Hoen, S.M. Bohte, J.A. La Poutré (2005). Action-reaction in multi-agent games. Proceedings of the Third European Multi-Agent Systems Conference (EUMAS), 18–24.

24 K. Jansen, R. van Stee (2005). On strip packing with rotations. Proceedings of the thirty-seventh annual ACM symposium on Theory of computing (STOC), 755–761.

25 A. Kesselman, Y. Mansour, R. van Stee (2005). Improved competitive guarantees for QoS buffering. Algorithmica 43(1–2), 63–80.

26 T. Klos, F. Alkemade (2005). Trusted intermediating agents in electronic trade networks. F. Dignum, V. Dignum, S. Koenig, S. Kraus, M. Singh, M. Wooldridge (eds). Proceedings Fourth International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS '05) 3, 1249–1250.

27 T. Klos, H. La Poutré (2005). Decentralized reputation-based trust for assessing agent reliability under aggregate feedback. K. Verbeeck, K. Tuyls, A. Nowé, B. Manderick, B. Kuijpers, (eds). Proceedings of the Seventeenth Belgium-Netherlands Conference on Artificial Intelligence (BNAIC), 357–358.

28 T. Klos, H. La Poutré (2005). Decentralized reputation-based trust for assessing agent reliability under aggregate feedback. R. Falcone, S. Barber, J. Sabater-Mir, M. Singh (eds). Trusting Agents for Trusting Electronic Societies: Theory and Applications in HCI and E-Commerce, LNACS 3577, 110–128.

29 J.R. Kok, P.J. 't Hoen, B. Bakker, N. Vlassis (2005). Utile coordination: Learning interdependencies among cooperative agents. Proceedings of the IEEE Symposium on Computational Intelligence and Games (CIG'05), 29–36.

30 R. van der Krogt, M. de Weerdt (2005). Coordination through plan repair. Gelbukh, de Albornoz, and Terashima-Marin (eds). Mexican International Conference on AI (MICAI) 2005: Advances in Artificial Intelligence, LNAI 3789 264–274.
31 R. van der Krogt, M. de Weerdt (2005). Self-interested planning agents using plan repair. Proceedings of the International Conference on Automated Planning and Scheduling (ICAPS) 2005 Workshop on Multiagent Planning and Scheduling, 36–44.
32 A. ter Mors, J. Valk, C. Witteveen (2005). Complexity of task coordination for non cooperative planning agents. M. Pechoucek, P. Petta, L.Z. Varga (eds). Proceedings of the Multi-Agent Systems and Applications IV, 4th International Central and Eastern European Conference on Multi-Agent Systems (CEEMAS 2005), LNCS 3690, 600–603.
33 V. Robu (2005). Market-based task allocation and control for distributed logistics. Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS'05), 1383.
34 V. Robu, D. Somefun, J. La Poutré (2005). Modeling bilateral negotiations over multiple, interdependent issues using utility graphs. K. Verbeeck, K. Tuyls, A. Nowé, B. Manderick, B. Kuijpers, (eds). Proceedings of the Seventeenth Belgium-Netherlands Conference on Artificial Intelligence (BNAIC), 377–378.
35 V. Robu, D. Somefun, J. La Poutré (2005). Modeling complex multi-issue negotiations using utility graphs. Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS'05), 280–287.
36 N. Roos, C. Witteveen (2005). Diagnosis of plan execution and the executing agent. U. Furbach (ed.) Proceedings of the 28th German Conference on Artificial Intelligence (KI 2005), LNCS 3698, 161–175.
37 G. Silaghi, V. Robu (2005). An agent strategy for automated stock market trading combining price and order book information. Proceedings of the ICSC Congress on Computational Intelligence Methods and Applications (CIMA 2005), Track: Advanced Computing in Financial Markets. CD-rom.
38 R. van Stee, J. La Poutré (2005). Minimizing the total completion time on-line on a single machine, using restarts. Journal of Algorithms, 57(2), 95–129.
39 C. Witteveen, N. Roos, R. van der Krogt, M. de Weerdt (2005). Diagnosis of single and multi-agent plans. Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS '05), 805–812.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals

1 L. Epstein, R. van Stee (2005). Buffer management problems Signet NEWS 35(3), 58–66.

CWI reports

SEN-E0513, SEN-E0505.
See B.3 on page 202 for complete titles.

Software developed

In the DEAL project (see page 104), software was further developed for simulation and visualization of a market-based model for logistics management in transportation: Demo 'Bidding with decommitment in a multi-agent transportation model' ('t Hoen, Noot, Robu, La Poutré).

A generic visualization package was developed for 2-agent bargaining. This package has been applied to the demonstrators 'Automated Negotiation and Bundling of Information Goods' (Noot, Somefun) and 'Using Utility Graphs to Model Complex Multi-Issue Negotiations' (Noot, Robu).

Detailed documentation was created for the general EA software packages originally developed by E.H. Gerding en D.D.B van Bragt (Noot).

Deliverables for projects

Several deliverables have been produced for the DEAL and CIM project, in the form of technical reports. These are mostly submitted to or published at conferences and journals. In addition, see also the section Software developed.

Professional products

Publications for a broad audience

1 S. Bohte, M. Breitenbach, G. Grudic (2005). Fast and easy classification: the polynomial

mpmc cascade. SNN Adaptive Intelligence: Lerende Oplossingen, November 16.

2 S. Bohte, J. La Poutré (2005). Agents@CWI. BNVKI Newsletter, August.

3 T. Klos, J. La Poutré (2005). Using reputation information to learn agent reliability. SNN Adaptive Intelligence: Lerende Oplossingen, November 16.

4 J. La Poutré (2005). Evolutionary systems and applied algorithmics. SNN Adaptive Intelligence: Lerende Oplossingen, November 16.

5 J. Lenstra, R. Cramer, J. La Poutré (2005). De kracht van het grensvlak, (interview). I/O InformaticaOnderzoek, March.

6 D. Somefun, J. La Poutré (2005). Online learning of preferences while negotiating over price and bundle. SNN Adaptive Intelligence: Lerende Oplossingen, November 16.

7 P. 't Hoen, J. La Poutré (2005). Repeated auctions with complementarities: Bidding for profitable bundles. SNN Adaptive Intelligence: Lerende Oplossingen, November 16.

Other output

Grants

- NWO Grant for the project 'Task Coordination for Non-Cooperative Agents', a joint project with TUD (Witteveen, La Poutré).

Convergent Media Infrastructures - SEN5

As of January 1 2006: Distributed Multimedia Languages and Infrastructures

Mission

The continued convergence of digital media production and distribution devices presents a host of new problems related to the creating, distribution, adaptation and rendering of multimedia on a range of dissimilar devices. This pilot theme studies fundamental problems related to media distribution and modelling (in the BRICKS PDC-3 project), media encoding and creating (in the Passepartout project) and platform agnostic distribution (in the Ambulant project). The output consists of research papers, implementation languages and software implementations.

Theme leader

Dr. D.C.A. Bulterman

MSC or CR classification

H.4.3, H.5.1, I.7.2

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. D.C.A. Bulterman	1.0	theme leader	indefinite	BRICKS-PDC3, Ambulant-II, Passepartout
Drs. C.L. Blom	1.0	programmer	indefinite	Ambulant-II, Passepartout
Drs. D. Benden (seconded ITF)	0.2	programmer	2003-02-01 till 2006-01-31	Ambulant- II
Dr. P.S. Cesar	1.0	postdoc	2005-11-01 till 2007-12-31	BRICKS-PDC3
A.J. Jansen	0.8	programmer	indefinite	Ambulant-II, Passepartout

Scientific report

Highlights

- Successful Evaluation of Convergent Media Infrastructures Pilot and conversion into the research theme Distributed Multimedia Languages and Infrastructures.
- Start of the ITEA Project Passepartout.
- Release of the W3C SMIL 2.1 Recommendation.
- Release of Ambulant 1.6 Player, for Mobile SMIL 2.1 and the full SMIL 2.1 Language.
- Staff Expansion for the BRICKS-PDC3 Project.
- Publication of one journal article, three international specifications.
- Presentation of three conference keynotes and invited presentations.

Project reports

Title	P2521: BRICKS PDC-3
Period	January 2004–December 2008
Leader	D.C.A. Bulterman
Staff	D.C.A. Bulterman, P.S. Cesar
Funding	Bsik (project funding)
Partner	PUC-Rio (Brasil)

Progress report. The BRICKS PDC-3 project studies the end-to-end modelling of distribution networks for the efficient transfer of multimedia media information in a heterogeneous environment. After modelling initial results in 2004, the project expanded its scope in 2005 with the attraction of two new staff members: a new postdoc, who started near the end of 2005, and a new OIO, who is expected to start in early 2006.

The focus of our activities in 2005 was the definition of an experimental environment upon which performance analysis can be built. This environment is centered around a home media server system, with multiple external links (for broadcast, conventional IP services and a peer-to-peer infrastructure) and a distributed, scaled home distribution network of thin and expanded clients (ranging from television sets, though tablet-based personal computers, to mobile devices), all connected via fixed and wireless systems.

The architecture defined in this project capitalizes on work performed in the Passepartout and the Ambulant-II projects.

Title	P2522: Ambulant reference players
Period	October 2004–September 2006
Leader	D.C.A. Bulterman
Staff	D.C.A. Bulterman, A.J. Jansen, C.L. Blom, D. Benden
Funding	NLnet (project funding)
Partner	W3C

Progress report. The Ambulant-II project studies the specification and implementation of a new generation of media players based on the needs of the mobile and high-end production communities. The Ambulant-II project allows us to further develop the open-source Ambulant Player to align with the results of the W3C Synchronized Multimedia and Timed Text working group. The project started in October 2004.

The work in this project has allowed us to participate in the SMIL 2.1 international standardization activities via W3C. We have been able to provide substantial language additions (being the editors of three out of the five new specification sections), and the development of the SMIL 2.1 reference architecture and mobile players has attracted substantial visibility and the ability to join new project consortia.

Title	P2523: ITEA Passepartout
Period	January 2005–May 2007
Leader	D.C.A. Bulterman
Staff	D.C.A. Bulterman, A.J. Jansen, C.L. Blom, D. Benden
Funding	ITEA/Senter (project funding)
Partners	CWI-INS2, Philips Research, Stoneroos, V2_

Progress report. The ITEA/Passepartout project is a 30-month research project that studies media interfaces and delivery for interactive TV (iTV) peer-to-peer home applications. The project coordinator is Philips Research. The main contribution of the SEN-5 group is the development of an interactive interface that provides differentiated graphical annotations to media content for sharing in a local and global P2P framework.

During 2005, we contributed as workpackage leader of two packages within the project. We edited a project technical report on content adaptation techiques, we contributed a demonstrator specification and we defined the initial architecture of an end-user content personalization system.

Societal aspects and knowledge transfer

Standardization activities

- Member of the W3C SMIL Working Group: D.C.A. Bulterman, A.J. Jansen.
- Member of the W3C Timed Text Working Group: D.C.A. Bulterman, C.L. Blom.

Organization of conferences, workshops, courses, and meetings

- ITEA Passepartout Meeting, September 13–14: D.C.A. Bulterman and A.J. Jansen.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Workshop on Content Generation and Augmentation, Pisa, Italy, February 22: D.C.A. Bulterman.
- W3C Technical Plenary Meeting, Boston, February: D.C.A. Bulterman, K.S. Mullender.
- Dagstuhl Workshop on Future Directions in Multimedia, March: D.C.A. Bulterman.
- Workshop on DAISY-API Support, Tokyo Japan, May 18–20: D.C.A. Bulterman, A.J. Jansen.
- Workshop on Disaster Preparation Technologies, Urakawa, Japan, May 22–23: A.J. Jansen.
- HOSC, Amsterdam, May 30–31: D.C.A. Bulterman (paper), K.S. Mullender.
- HOSC, Amsterdam, May 30–31, demo presentation: C.L. Blom, A. J. Jansen, D. Benden
- MS-Asia Multimedia Research Strategic Directions Workshop, Beijing, China, July 23: D.C.A. Bulterman (paper).
- CoNext Symposium on Computer Networking, Toulouse, FR, October 27–28: D.C.A. Bulterman (Invited presentation).
- ACM Document Engineering 2005, Bristol, UK, November 2–4: D.C.A. Bulterman (Invited Keynote).
- ACM Multimedia 2005, Singapore, November 14–16: D.C.A. Bulterman (Session presentations).
- W3C SYMM Working Group Meeting, December 7–9: D.C.A. Bulterman, A.J. Jansen, C.L. Blom.

Working visits

- Philips Research, Briarcliff Manor, Medical Multimedia, May 6 May: D.C.A. Bulterman.
- NRCD, Tokyo, Japan, May 17–20: D.C.A. Bulterman, A.J. Jansen.
- Urakawa Project Meeting, Urakawa, Japan, May 21–24: A.J. Jansen.
- FNB, Grave (NL), July 1: D.C.A. Bulterman, A.J. Jansen.
- WMC, Enschede (NL), July 5: D.C.A. Bulterman, C.L. Blom, A.J. Jansen
- Brown Univ., USA, Interactive Multimedia Interfaces, July: D.C.A. Bulterman.
- INT/ARTEMIS, Evry, France, September 26: D.C.A. Bulterman.
- INRIA, Paris, France, November 15–17: D.C.A. Bulterman.
- NOKIA, Amsterdam, December 1: D.C.A. Bulterman, A.J. Jansen.
- FNB, Amsterdam, December 20: D.C.A. Bulterman, A.J. Jansen.

Project meetings

- NL-Passepartout Meeting, Hilversum, January 11: D.C.A. Bulterman, A.J. Jansen.
- W3C SYMM WG, Boston, February 22–23: D.C.A. Bulterman, K.S. Mullender.
- W3C TimedText WG, Boston, February 24: D.C.A. Bulterman.
- AMBULANT Meeting, Amsterdam, January 20, March 29, June 21, September 29, December 15: D.C.A. Bulterman, A.J. Jansen, K. Blom, D. Benden.
- Passepartout Meeting, Brussels, March 23: D.C.A. Bulterman, A.J. Jansen.
- BRICKS PDC-3 meeting, Amsterdam, April 19, June 27, July 5, September 21, November 11: D.C.A. Bulterman, A.J. Jansen.
- SAI WG, Tokyo, May 17–20: D.C.A. Bulterman, A.J. Jansen.
- Urawaka WG, Japan, May 21–24: A.J. Jansen.
- W3C SYMM WG, Helsinki, June 1–2: D.C.A. Bulterman, K.S. Mullender. D.C.A. Bulterman, A.J. Jansen.
- Passepartout Meeting, Luxembourg, June 7: D.C.A. Bulterman.
- NL-Passepartout Meeting, Eindhoven, June 22: D.C.A. Bulterman.

- NL-Passepartout Meeting, Amsterdam, September 13: D.C.A. Bulterman, A.J. Jansen.
- Passepartout Meeting, Amsterdam, September 13–14: D.C.A. Bulterman, A.J. Jansen.
- W3C SYMM WG, Tokyo, September 15–16: D.C.A. Bulterman, K.S. Mullender.
- Passepartout Meeting, Paris, September 26: D.C.A. Bulterman.
- Passepartout Meeting, Paris, November 29–30: D.C.A. Bulterman, P.S. Cesar.
- W3C SYMM WG, Amsterdam, December 7–8: D.C.A. Bulterman, K.S. Mullender.
- NL-Passepartout Meeting, Eindhoven, December 15: D.C.A. Bulterman, P.S. Cesar.

Memberships of committees and other professional activities

D.C.A. Bulterman

- Associate editor, ACM Transactions of ACM Transaction on Multimedia Computing, Communications, and Applications (TOMCCAP).
- Associate editor, ACM/Springer Multimedia Systems Journal.
- Member of editorial board, Multimedia Tools and Applications, Kluwer.
- Member of the W3C SMIL Working Group.
- Member of the W3C Timed Text Working Group.
- Brave New Topics co-chair, ACM Multimedia 2005, Singapore.

A.J. Jansen

- Member of NLUUG executive board.
- Member of the W3C SMIL Working Group.
- Member of the SAI.

C.L. Blom

- Member of the W3C Timed Text Working Group.

Academic publications

Publications in refereed journals or proceedings

1 D.C.A. Bulterman, L. Hardman (2005). Structured Multimedia Authoring. ACM Trans. on Multimedia Computing, Communications and Applications (TOMCCAP) 1(1), 89–119.

2 D.C.A. Bulterman (2005). An Open XML Language for Modelling Environment Capabilities in SMIL-Based Media Players. Holland Open Software Conference, Amsterdam.

3 D.C.A. Bulterman (2005). Engineering Information in Documents: Leaving Room for Uncertainty. Proceedings ACM DocumentEngineering 2005, 94.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 A.J. Jansen (2005). Distaster Preperation in the Netherlands. Urawaka SAI Seminar, Japan, May 21.

2 D.C.A. Bulterman (2005). Transforming Infrastructure for Media Sharing: From Producer to Consumer Control. Invited Presentation, MS-ASIA, Beijing, July.

3 D.C.A. Bulterman (2005). Rethinking Media Distribution and Sharing to Empahsize CONTENT. Invited talk, CoNext, Toulouse, FR, October.

4 D.C.A. Bulterman (2005). Network Infrastructure Support for Convergent Interactive Media, BRICKS Seminar, November 11.

5 D.C.A. Bulterman (2005). New Media Distribution and Control: Producer and Consumer Issues. KKA Seminar, Amsterdam, November.

6 D.C.A. Bulterman, D. Zucker (eds) (2005). SMIL 2.1 Extended Mobile Profile, SMIL 2.1 Recommendation, W3C, December 13.

7 D.C.A. Bulterman, G. Gassel, D. Zucker (eds) (2005). SMIL 2.1 Mobile Profile, SMIL 2.1 Recommendation, W3C, December 13.

8 D.C.A. Bulterman (2005). SMIL 2.1 Layout Module Functional Specification, SMIL 2.1 Recommendation, W3C, December 13.

9 D.C.A. Bulterman (2005). SMIL 2.1 Media Module Functional Specification, SMIL 2.1 Recommendation, W3C, December 13.

Software developed

1 D.C.A. Bulterman, A.J. Jansen, Ambulant 1.6 player for SMIL 2.0, Win32, WinCE, Linux, Mac OS X version. All versions available from `http://www.ambulantPlayer.org/`

MODELLING, ANALYSIS AND SIMULATION

Principal research area and mission

The principal research area of cluster MAS is *Applied and Numerical Mathematics and System and Control Theory*. For applied and numerical mathematics the emphasis lies on partial differential equations with mathematical analysis, numerical analysis and scientific computing as major activities. Application areas include biology, oceanography and climatology from the natural sciences, and fluid dynamics, electromagnetics and electric discharge problems from the technical sciences and from physics. For control and system theory the emphasis lies on control of discrete event systems, hybrid systems, nonlinear stochastic systems, and on modelling, realization and control of rational positive systems. Here the application areas include biology and medicine, mathematical finance, engineering and networks of computer systems. A small sized activity with a theoretical bias concerns asymptotics and special functions. Our principal mission is to contribute to advanced modelling, analysis and simulation with applied and computational mathematics at the center of interest. The cluster policy is to maintain a good balance between long-lasting discipline oriented and more short term applied research, with in particular an enduring attention for new challenges from applications.

Cluster staff

Name	Fte	Function
Prof.dr. J.G. Verwer	0.2	Cluster leader
Drs. J. Kok	0.4	Computer support
N. Mitrovic	0.6	Secretary
Dr. N.M. Temme	0.2	Management support (till May 31)

Research themes

Name		Leader
MAS1	Nonlinear PDEs: Analysis and Scientific Computing	Prof.dr. A. Doelman
MAS2	Computing and Control	Prof.dr.ir. B. Koren
MAS3	Nonlinear Dynamics and Complex Systems	Prof.dr. U.M. Ebert

Other items of interest

May 27 Dr. Nico Temme left cluster MAS and went into retirement, after a highly successful career of 37 years at CWI. Officially this also marks the end at CWI of Temme's research field 'Asymptotics and Special Functions'. Temme will however continue his research for a number of years, amongst others for writing a book on numerical aspects of special functions, which will be published by SIAM.

Nonlinear PDEs: Analysis and Scientific Computing – MAS1

Mission

Within the MAS scope of Applied and Numerical Mathematics, theme MAS1 focuses on (i) mathematical analysis of nonlinear PDEs and dynamical systems theory, (ii) numerical analysis in these areas with

a strong focus on evolutionary advection-diffusion-reaction equations and wave equations from continuum mechanics, and (iii) asymptotics and special functions.

The research ranges from fundamental to practical with a considerable part being application driven. Typically, MAS1 applications come from the natural sciences: life sciences (biology and medicine) for which mathematical modelling and scientific computing rapidly become more and more important; and more recently atmospheric and climate dynamics and mathematical modelling in oceanography.

Theme leader

Prof.dr. A. Doelman

MSC or CR classification

33, 34, 35, 65, 86, 92

Subthemes

Name	Leader
MAS1.1 – Scientific Computing in the Life Sciences	J.G. Blom & B.P. Sommeijer
MAS1.2 – Nonlinear Dynamics of Natural Systems	A. Doelman
MAS1.3 – Numerical Modelling in Atmosphere and Ocean	J.E. Frank & J.G. Verwer
MAS1.4 – Asymptotics and Special Functions	N.M. Temme

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
M. Ashyraliyev, MSc	1.0	PhD student (NWO)	2004-09-01 till 2008-08-31	MAS1.1
Drs. J.G. Blom	1.0	leader MAS1.1	indefinite	MAS1.1
M. Dobrzynski, MSc	1.0	PhD student (NWO)	2004-08-01 till 2008-07-31	MAS1.1
Prof.dr. A. Doelman	0.8	theme leader, leader MAS1.2	indefinite, since 2004-09-01	MAS1.1; MAS1.2
S. Dubinkina, MSc	1.0	PhD student (NWO)	2005-08-01 till 2009-07-31	MAS1.3
Dr. L. Ferracina	1.0	postdoc (NWO)	2005-11-1 till 2007-10-31	MAS1.1
Dr.ir. J.E. Frank	1.0	leader MAS1.3	indefinite	MAS1.1; MAS1.3
Y. Habib, MSc	1.0	PhD student (NWO)	2004-04-01 till 2005-07-31	MAS1.1
Drs. P.J.A. van Heijster	1.0	PhD student (NWO)	2005-05-01 till 2009-04-30	MAS1.2
Ir. J.K. Krottje	1.0	PhD student (NWO)	2001-04-01 till 2005-03-31	MAS1.1
N.N. Pham Thi, MSc	1.0	PhD student (NWO)	2002-09-01 till 2006-08-31	MAS1.1
Dr. ir. M.H. van Raalte	1.0	postdoc (NWO)	2005-03-01 till 2008-02-29	MAS1.1
Dr. B.P. Sommeijer	1.0	leader MAS1.1	indefinite	MAS1.1
Dr. N.M. Temme	0.8	leader MAS1.4	retired 2005-05-31	MAS1.4

continued on next page

continuation from previous page

Prof.dr. J.G. Verwer	0.6	cluster leader, leader MAS1.3	indefinite	MAS1.1; MAS1.3
Dr. A. Zagaris	1.0	postdoc (NWO)	2005-05-01 till 2006-04-30	MAS1.2

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. J. Hulshof (VU)	0.2	researcher	2002-09-01 till 2005-03-31	MAS1.2
Prof.dr.ir. L.A. Peletier (UL)	p.m.	advisor	2004-09-01 till 2006-09-01	MAS1.2
Prof.dr. H.E. de Swart (UU)	0.6	sabbatical visitor	2005-03-01 till 2005-06-01	MAS1.2
Prof.dr. S. Verduyn Lunel (UL)	p.m.	guest researcher	2005-05-01 till 2007-05-01	MAS1.2
Prof.dr. H.A. van der Vorst (UU)	p.m.	advisor	2005-11-01 till 2007-11-01	MAS

Scientific report

Highlights

- The national NWO-funded cluster 'Nonlinear Dynamics of Natural Systems$^+$' (NDNS$^+$), developed by A. Doelman in collaboration with H. Broer (Groningen), A. van der Vaart (VU) and S. Verduyn Lunel (Leiden) officially started on April 21. In the context of this cluster two new permanent positions of tenure track type have been created within MAS, and many other activities will be initiated.
- Acceptance by *Nature* of the paper 'Reduced mixing generates oscillations and chaos in the oceanic deep chlorophyll maximum' by N.N. Pham Thi, B.P. Sommeijer and others.
- PhD defenses of R. Planqué and J. Krottje. See on page 131
- 3 postdocs and 2 new PhD students joined MAS 1.
- A. Doelman co-organized the kick-off meeting of the NDNS$^+$-cluster 'Mathematics of Life Sciences'.
- On May 27, CWI organized the symposium From Here to Infinity on the occasion of N.M. Temme's retirement. See also page 126

PhD students

M. Ashyraliyev
M. Dobrzynski
S. Dubinkina
Y. Habib
P.J.A. van Heijster
J.K. Krottje
N.N. Pham Thi
R. Planqué

MAS1.1 – Scientific Computing in the Life Sciences

Within theme MAS1 this subtheme is the largest and is primarily application driven. The objective is mathematical modelling, mathematical and numerical analysis and numerical simulation, for life science applications. The subtheme comprises several projects on applications from biology and medicine.

Title	Cell biology, the silicon cell
Period	1999–end of theme
Leader	J.G. Blom
Staff	J.G. Blom, A. Doelman, J.G. Verwer
Funding	CWI
Partners	J.H. van Schuppen (MAS2.3), J.A. Kaandorp (UvA/SCS); UvA (SILS), VU (IMBW)

Progress report. The research in this project is conducted in the framework of the Silicon Cell Initiative Amsterdam, which is a joint effort of research groups from IMBW(VU), SILS(UvA), SCS(UvA), and CWI. The long-term goal is the computation of life at the cellular level. In MAS1 research focuses on the mathematical modelling and simulation of biochemical processes and the dynamic architecture of living cells. Currently the focus is on the following three projects.

Title	Cell biology, Mesoscale simulation paradigms
Period	2004–2008
Leader	J.G. Blom
Staff	Y. Habib, L. Ferracina, J.G. Blom, J.G. Verwer
Funding	NWO (Wiskunde Toegepast)
Partner	J.A. Kaandorp (UvA/SCS)

Progress report. Reaction-diffusion phenomena in the cell can be studied with various simulation paradigms. Depending on the cellular phenomenon considered, models of appropriate spatial scales need to be used: ODEs for homogeneous systems; for moderate spatial variability PDEs of the reaction-diffusion type; and particle models describing the interaction of individual molecules. In collaboration with researchers from SCS (UvA) we want to compare different mesoscale simulation paradigms for reaction and diffusion—PDEs (MAS1.1) and Lattice-Boltzmann/Lattice Gas (SCS)—on biologically relevant problems. The CWI project concerns the development of numerical methods and software for an adaptive method for reaction-diffusion PDE systems with irregular, dynamically changing, interfaces. Special to the model is that the reaction-diffusion PDE systems inside the domain (cell) are coupled with lower-dimensional reaction-diffusion PDE systems on the boundary of the domain (the membrane of the cell). As a start a variable order, variable mesh size Finite Element method is studied for this problem in 2D.

Title	Cell biology, Mathematics and computation for the system biology of cells
Period	2004–2008
Leader	J.G. Blom
Staff	M. Dobrzynski, J.G. Blom, J.G. Verwer
Funding	NWO (Computational Life Sciences)
Partners	J.A. Kaandorp (UvA/SCS), M.A. Peletier (TUE/Math&Comp.Sc.), J.H. van Schuppen (CWI, MAS2.3), H.V Westerhoff (VU/IMBW)

Progress report. In collaboration with IMBW (VU), SCS (UvA), and MAS2.3 mathematical and computational techniques for the systems biology of the cell are developed, implemented and validated. The research focus in the PhD project of Dobrzynski is the development of multi-adaptive numerical methods for the efficient solving of reaction-diffusion phenomena with varying spatial and temporal scales, and space dependent chemical schemes; and the development of methods that allow the integration of PDE-based and particle-based methods into a single simulation.

Title	Cell biology, Modelling of developmental regulatory networks
Period	2004–2008
Leader	J.G. Blom
Staff	M. Ashyraliyev, J.G. Blom, J.G. Verwer
Funding	NWO (Computational Life Sciences), NWO/RFBR (Dutch Russian Research Cooperation)
Partners	J.A. Kaandorp (UvA/SCS), A.M. Samsonov (Ioffe Inst., St.Petersburg)

Progress report. In collaboration with SCS (UvA) models are developed for the genetic regulation of the development of organisms. The models range from systems of PDEs - describing the transport of environmental nutrients, the regulatory network, and the growth of an organism - to a hybrid continuum-discrete model for simulating developmental regulatory networks that can be used to study the formation of spatial and temporal expression patterns of gene products during development in systems with moving cells. A major issue are correct estimations of the parameter settings in the network models (the regulatory weight factors). Therefore, the models will be used in combination with optimization algorithms (genetic algorithms and simulated annealing) to explore large parameter spaces of regulatory networks and to select specific spatial and temporal expression patterns (work to be done at SCS(UvA)).

In the PhD project of Ashyraliyev the main issues are the mathematical aspects and the efficient implementation of the hybrid discrete-continuum model, both important in view of the fact that the model will be used as the core of the optimization algorithms.

Title	Cell biology, rods and DNA
Period	2000–2004
Leader	M.A. Peletier
Staff	M.A. Peletier, R. Planqué
Funding	CWI (Crossroads)
Partner	G.H. van der Heijden (Univ. College London)

Progress report. In bacteria, DNA is present in closed loops with a torsional loading (the link number is non-zero). As a result these loops twist into the knot-like structures that are well-

known from telephone cords. Various numerical simulations have provided insight in the relationship between the imposed link number and the resulting three-dimensional form; eventually we will investigate this analytically. In preparation of the full three-dimensional problem, Planqué (PhD research) and Peletier are concentrating on a model problem of lower dimension: A twisted rod that is forced to lie on a cylinder.

Planqué received his PhD on April 7.

Title	Phytoplankton dynamics
Period	2002–2006
Leader	B.P. Sommeijer
Staff	N.N. Pham Thi, B.P. Sommeijer, J.G. Verwer
Funding	NWO (Computational Science Programme)
Partners	J. Huisman (Inst. of Biodiversity and Ecosystems Dynamics, UvA), D. Karl (Univ. of Hawaii), W. Hundsdorfer (MAS3)

Progress report. In the previous years, models have been studied in which the light availability was assumed to be the only factor limiting phytoplankton growth. In some parts of the oceans, however, this assumption is not valid and nutrients (like nitrogen, phosphorus, iron) form a restrictive resource as well. Moreover, light and nutrients cause contrasting gradients since light supply is from above, whereas nutrients are supplied from the bottom. Therefore, the model has been extended with equations for the nutrients, and efficient solution techniques for this combined model have been studied. So far, nutrient limitation of phytoplankton growth is thought to lead to a stable equilibrium. However, a surprising result is that the biomass may exhibit oscillatory behaviour in a low mixing regime. As all climate models predict, global warming strengthens the stratification of the oceans and thereby reduces the upward mixing of nutrients. Hence, these fluctuations in the plankton, caused by global warming, may result into a decline of oceanic production and reduced sequestration of the greenhouse gas carbon dioxide into the oceans. These findings will appear as a publication in Nature, Vol. 439 (January 2006).
Furthermore, we have studied the concept of positivity. Since a positive numerical solution is a prerequisite for phytoplankton concentrations, the following question is relevant: 'what conditions on the time step have to be imposed to guarantee that the time integration process yields a positive solution, given a positive initial value?' Jointly with Hundsdorfer, positivity results are derived for explicit two-step methods formulated in linear multistep form and in one-leg form. It turns out that the latter formulation allows a slightly larger step size with respect to positivity. This result appeared as preprint MAS-E0522 and has been submitted for publication.

Title	Numerical algorithms for bio-informatics
Period	2004–2008
Leader	J.G. Blom
Staff	J.G. Blom, A. Doelman, J.E. Frank, B.P. Sommeijer, J.G. Verwer
Funding	Bsik/BRICKS
Partners	UU (H.A. van der Vorst, O. Diekmann, A. Dijkstra), UvA (J. Huisman, J.A. Kaandorp, P.M.A. Sloot, R. van Driel), VU (S.A.L.M. Kooijman, H.V. Westerhoff)

Progress report. This project concerns mathematical and numerical analysis with a special focus on applications in biology. Background research for the PhD projects on Cell Biology and Phytoplankton Dynamics. Cf. also the project Runge-Kutta-Chebyshev methods.

Title	Neurobiology, modelling of axon growth
Period	2001–2005
Leader	J.G. Verwer
Staff	J.K. Krottje, J.G. Verwer
Funding	NWO (Wiskunde Toegepast)
Partners	A. van Ooyen (VU and Netherlands Institute for Brain Research, NIH/KNAW), J. van Pelt (NIH)

Progress report. Krottje has successfully completed his PhD research with the defence of his thesis 'On the numerical solution of diffusion systems with localized, gradient-driven, moving sources' at UvA, November 17. The PhD project concerned the development of numerical methods for a class of differential equations modelling the outgrowth of axons in the nervous system. The broader modelling aim has been to better understand the biochemical mechanisms which govern outgrowth and regeneration of connections in the nervous system. The model at hand has been suggested by

A. van Ooyen and J. van Pelt from the Netherlands Institute for Brain Research. It consists of parabolic systems coupled to gradient equations based on the hypothesis that axon growth is partly governed by concentration gradients of biochemical molecules in extracellular space. The numerical methods developed by Krottje are mesh free, adaptive in space and use Voronoi meshes. A sequel to this project is currently considered.

Title	Understanding the 'organic carbon pump' in meso-scale ocean flows
Period	2005–2008
Leader	B.P. Sommeijer
Staff	M.H. van Raalte, B.P. Sommeijer
Funding	NWO (Computational Life Sciences)
Partners	S.A.L.M. Kooijman, B.W. Kooi (VU), H.A. Dijkstra (IMAU, Utrecht), H. Burchard (Warnemünde, Germany)

Progress report. The 'organic carbon pump' is the rate at which algae bind atmospheric carbon dioxide, and transport it to deep waters. In this multidisciplinary project, a systematic 'first principle' approach is followed to determine the effect of transport properties of oceanic meso-scale flows to the efficiency of the organic carbon pump. We do so by combining a realistic algal physiology model, based on the Dynamic Energy Budget theory, with simulations in a high-resolution ocean model. The simulation results will be tested against in-situ data obtained by satellites. This multidisciplinary project combines (i) the biological model which contains explicit energy and nutrient balances, while biomass composition is variable (VU-part), (ii) the high-resolution ocean model to simulate flows details of the meso-scale flows (IMAU-part), and (iii) the advanced numerical methods used for determining the transport properties of nutrients and biomass (CWI-part).

As a first joint activity we have studied time integration methods for biochemical systems. Special attention was paid to positivity and mass-conservation. The resulting publication has been accepted by *Applied Numerical Mathematics* and will appear in 2006.

Title	Runge-Kutta-Chebyshev methods
Period	2004–2008
Leader	J.G. Verwer, B.P. Sommeijer
Staff	J.G. Verwer, B.P. Sommeijer
Funding	Bsik/BRICKS
Partners	L.F. Shampine (Dallas, Texas), W. Hundsdorfer (MAS3)

Progress report. Runge-Kutta-Chebyshev methods (RKC) have a long history at CWI. Semidiscretized, multi-dimensional diffusion-reaction equations exemplify the problems for which RKC was originally designed. However, an efficient use of RKC is restricted to problems where (i) the reaction terms are mildly stiff so as to keep the number of stages at a manageable level, (ii) the eigenvalues of the Jacobian are close to the negative real axis (diffusion-dominated).

To avoid these limitations, we have extended RKC in two directions: With respect to (i), we constructed an implicit-explicit (IMEX) version for diffusion-reaction equations with severely stiff reaction terms. The IMEX scheme treats these reaction terms implicitly and the diffusion terms explicitly. Within the setting of linear stability theory, the new IMEX scheme is unconditionally stable for the reaction terms (having negative eigenvalues in the Jacobian). For the diffusion terms the stability characteristics are the same as in RKC.
This work has been published in *SISC*, 25, 1824–1835. Jointly with L.F. Shampine, we implemented the IMEX-RKC method in a Fortran 90 code, called IRKC. This automatic ODE-slover is publicly available through Netlib and the accompanying paper will be published in JCAM (2006).
The second extension concerns the incorporation of advection terms (in the explicit part of the IMEX approach). A proper choice of RKC parameters results in a stability region that allows eigenvalues with larger imaginary part, caused by advection terms. This extension was joint work with Hundsdorfer and has been published in *Journal Computational Physics*, 201, 61–79.

MAS1.2 – Nonlinear Dynamics of Natural Systems

In recent years, important new insights into the behaviour of PDEs and FDEs (Functional DEs) have been obtained by interpreting these systems as infinite-dimensional (semi-)dynamical

systems. At present, there is a strong and stimulating interaction between the theory of (low-dimensional) dynamical systems, and that of PDEs and FDEs, in which an important role is played by intermediate high dimensional systems such as network and lattice equations. These developments are in a crucial way driven by challenges posed to the field by the life and earth sciences. At the same time, the mathematical approach yields insights into fundamental mechanisms in the natural sciences. This fast-developing field is in the focus of international attention. The MAS1 team is one of the major players in a far-reaching initiative of various teams at Dutch mathematical institutes that has succeeded in building a national research cluster 'Nonlinear Dynamics of Natural Systems'.

This subtheme also encompasses the one-day per week secondments at CWI of professors J. Hulshof (VU), L.A. Peletier (UL, advisor), H.E. de Swart (UU, sabbatical) and S. Verduyn Lunel (UL). The main goal is to generate a concentrated research group in the analysis of PDEs and nonlinear dynamical systems, and their applications in the earth and life sciences at CWI that acts as a 'hot spot' within the Dutch research community. By the beginning of 2006, dr. G.M. Hek (UvA), dr. V. Rottschäfer and prof. dr. H.E. de Swart will become advisors in the context of the 'Nonlinear Dynamics of Natural Systems' cluster.

Title	The interactions of localized structures
Period	2002–2009
Leader	A. Doelman
Staff	A. Doelman, L.A. Peletier
Funding	CWI/NWO
Partners	T.J. Kaper (Boston), K. Promislow (Michigan)

Progress report. In the last decades, the existence and stability theory of travelling pulse and front solutions of nonlinear partial differential equations has developed significantly. However, these methods cannot be applied to interacting pulses or fronts. As a consequence, the most intriguing aspects of pulse interactions, including the phenomenon of self-replicating pulses, cannot be understood, yet. In the context of the present project, new methods are developed by which these interactions can be studied. In May, Van Heijster started as a PhD-student with an NWO-funded project on this subject.

Title	Tidal dynamics, internal waves and the morphology of basins
Period	2004–2010
Leader	A. Doelman
Staff	A. Doelman
Funding	CWI/FOM
Partners	L.R.M. Maas (NIOZ, Texel), H.E. de Swart (IMAU, Utrecht)

Progress report. This is an ongoing cooperation project between Doelman, several PhD students, and colleagues at Delft Hydraulics, IMAU, NIOZ, and Rijkswaterstaat. In 2005, FOM-funded PhD student G.M. Terra has graduate on a thesis on the subtle relation between the morphology of a coastal zone and the tidal dynamics within the basin ('Nonlinear Tidal Resonance). De Swart spent a sabbatical at CWI in the spring of 2005 to work with Doelman on this project. The proposal 'Internal Wave Patterns in 3D' has been successfully submitted by L.R.M. Maas (NIOZ) and Doelman within the FOM/NWO programme 'Dynamics of Patterns'. A PhD student – J. Hazewinkel – will start working on this project in February 2006.

Title	Defects in periodic media
Period	2001–2005
Leader	A. Doelman
Staff	A. Doelman
Funding	CWI/NWO/UvA
Partners	D. Iron (Irvine/Halifax), Y. Nishiura (Sapporo), B. Sandstede (Surrey), A. Scheel (Minnesota), G. Schneider (Karlsruhe)

Progress report. The long term goal of this project is to obtain a mathematical understanding of the dynamics of defects in a 'background' with a spatially periodic structure. Such patterns occur very naturally in (bio-)chemical reactions, hydrodynamics (convection), oceanography, etc. In June, the NWO funded PhD student H. van der Ploeg defended his thesis 'Singular Pulse Patterns in the Gierer-Meinhardt Equation' on periodic and aperiodic patterns in singularly perturbed reaction-diffusion equations. Most recently, the validity of the Burgers equation for the dynamics of defects of the 'sink' type in reaction-diffusion problems has been established.

Title	Reduction methods for high-dimensional systems
Period	2004–2008
Leader	A. Doelman
Staff	A. Zagaris
Funding	NWO
Partners	C.W. Gear (Princeton), T.J. Kaper (Boston), H.G. Kaper (Argonne/NSF), I.G. Kevrekidis (Princeton)

Progress report. Zagaris is an NWO-funded postdoc in the 'Nonlinear Dynamics of Natural Systems' cluster. He did his PhD (May 2005, Boston) on reduction methods for ODEs. At CWI he works on reduction models for PDEs and in the context of equation free models (with C.W. Gear and I.G. Kevrekidis from Princeton). Zagaris will submit in Veni grant proposal titled 'Reduced Models for Multi-Scale Reaction-Diffusion Models' in January 2006.

Title	Stabilization by slow diffusion
Period	2001–2006
Leader	A. Doelman
Staff	A. Doelman
Funding	CWI/UvA
Partner	G.M. Hek (UvA/Lausanne)

Progress report. In this project, the behaviour of systems with interaction stability mechanisms – near criticality described by coupled modulation equations of Ginzburg-Landau type – is studied. A main theme of the research is the surprising stabilizing effects of neutrally stable modes, which are described by (slow) diffusion equations. UvA funds a PhD student that is working on this project and that will graduate in 2006.

Title	Two-phase flow in porous media
Period	2002–2005
Leader	L.A. Peletier
Staff	C.J. van Duijn, L.A. Peletier
Funding	CWI
Partner	I.S. Pop (Eindhoven)

Progress report. An extension of the Buckley-Leverett (BL) equation describing two-phase flow in porous media is studied, and existence conditions for travelling wave solutions are derived. In this way non-monotone weak solutions of the BL problem consisting of steady states separated by shocks are obtained. These results confirm experimentally observed phenomena.

Title	Travelling waves in free boundary problems
Period	2003–2007
Leader	J. Hulshof
Staff	J. Hulshof, A. Doelman
Funding	NWO/CWI
Partners	C.M. Brauner (Bordeaux), A. Lunardi (Parma), J.F. Ripoll (Stanford)

Progress report. Free boundary problems (FBPs) for partial differential equations appear in many applications in the exact sciences. The classical example is the Stefan problem for water-ice. Other applications involve cell boundaries, contact lines in thin film flows, and flame fronts in combustion models. On the latter subject, a PhD project funded by NWO through the open competition started in 2003.

MAS1.3 – Numerical Modelling in Atmosphere and Ocean

Numerical simulation of large scale flows in the atmosphere and ocean on time scales of relevance to climate and weather prediction calls for advanced methods to give simulation data suitable for statistical analysis in the absence of strict numerical accuracy in the classical, asymptotic sense. This subtheme comprises three projects, one directly addressing geophysical flows, one addressing wave equations more generally, and one studying modern techniques for error control.

Title	Geometric numerical methods for continuum mechanics
Period	2002–2005
Leader	J.E. Frank
Staff	J.E. Frank
Funding	NWO Innovative Research Grant (Veni)
Partner	S. Reich (Imperial College London)

Progress report. This project, funded by a *Vernieuwingsimpuls Veni* grant, was concluded in August 2005. The project focused on geometric numerical methods applied to wave equations in general and geophysical fluid dynamics in particular. The discipline of geometric integration is concerned with the design and analysis of methods, for simulating ordinary and partial differential equations, that retain the underlying mathematical/physical structure of a given system being modelled. In the last year of the project, one article appeared in *Atmospheric Science Letters* describing a regularization of the shallow water equations and its relation to a

semi-implicit time differencing. Additionally two new articles were submitted, one has been accepted to *SIAM J. on Scientific Computing*, and the second is still under consideration. Both articles address the use of symmetric Runge-Kutta methods to discretize the spatial derivatives of wave equations. In the first article, it was shown that such methods have the unique feature that energy always flows in the correct direction. The second article considers the conservation of wave action by such methods in PDEs with varying coefficients.

This project had already generated one successful follow-up proposal in 2004. In 2005, two new proposals were submitted on related topics. One of these, a joint proposal with O. Bokhove of UT, received funding in the NWO/ALW Climate Variability programme. The other, submitted to NWO/EW Open Competition, is momentarily awaiting a decision.

Title	Symplectic Integration of Atmospheric Dynamics
Period	2005–2009
Leader	J.E. Frank
Staff	S.B. Dubinkina, J.E. Frank, J.G. Verwer
Funding	NWO/ALW Climate Variability Program
Partner	S. Reich (Imperial College London)

Progress report. The mathematical equations modelling atmospheric flows are chaotic, and yet must be integrated over long time intervals for weather prediction and climate simulations. This calls for advanced numerical methods that produce statistically accurate solutions in the absence of traditional numerical accuracy. Work has begun to extend the Hamiltonian Particle-Mesh method—a Lagrangian-based method that is symplectic, and conserves mass, energy and circulation—to hydrostatic flows with topography. Additionally, the implications of symplectic discretization for long-time ensemble simulations, will be studied.

Title	Global error estimation and control for initial-value problems
Period	2003–2006
Leader	J.G. Verwer
Staff	J.G. Verwer
Funding	CWI
Partner	J. Lang (Darmstadt)

Progress report. In this project we study global error estimation and control for initial value problems for ordinary differential equations. A comparison study has been completed, focusing on a novel estimation approach based on the adjoint method combined with a small sample statistical initialization (proposed by Cao & Petzold, *SISC '04*, 26, 359–374) and the classical approach based on the first variational equation. Control is achieved through tolerance proportionality. Both approaches were found to work well and to enable estimation and control in a reliable manner. However, the novel approach was not found to be competitive with the classical approach, while it also demands a huge storage for truly large problems compared to the classical approach. The results have been published in the preprint MAS-E0531 and have been submitted for publication.

MAS1.4 – Asymptotics and Special Functions

Title	Asymptotics and special functions
Period	1995–2005
Leader	N.M. Temme
Staff	N.M. Temme
Funding	CWI, NIST (Washington)
Partners	J.B. Sanders (FOM-Amolf), J.L. López (Pamplona), A. Gil and J. Segura (Madrid), H. A. Carteret (Calgary), B. Richmond (Waterloo).

Progress report. The research on 3D singular perturbation problems for elliptic equations (with J.L. López) resulted in two submitted papers.

The joint work with A. Gil and J. Segura on numerical aspects of special functions continued with the writing of a book on this topic (to be published in 2006). A second paper on recurrence relations for hypergeometric functions and two papers on the computation of parabolic cylinder functions have been accepted for publication.

Temme participated in the NIST DLMF project, the complete revision of the *Handbook of Mathematical Functions*, Abramowitz and Stegun (revision of earlier written chapters and editorial work).

On May 27, CWI organized the symposium From Here to Infinity on the occasion of Temme's retirement.

A conference Special Functions: Asymptotic Analysis and Computation organized to celebrate Temme's 65th birthday, Santander, July 4–7.

Societal aspects and knowledge transfer

External contacts

MAS1.1
National: UvA (SILS, IvI, IBED-Aquatic Microbiology), VU (IMBW, Theor. Biology), TUE (Wiskunde, BMT), RUG (Biophysical Chemistry), NIBR (Netherlands Institute for Brain Research).
International: the groups of Samsonov (Ioffe Institute, St Petersburg), Samsonova (St Petersburg State Polytechnical Institute), Reinitz (Stony Brook Univ., USA), Shampine (Southern Methodist University, Dallas), Karl (Univ. Hawaii), Burchard (Warnemünde, Germany).
MAS1.2
National: S. van Gils (Twente), L.R.M. Maas (NIOZ), Schielen (Rijkswaterstaat), H.E. de Swart (IMAU), J.L. van den Berg (VU).
International: Derks (Surrey), T.J. Kaper (Boston), Y. Nishiura (Hokkaido), Promislow (Michigan), C.W. Gear (Pinceton), I.G. Kevrekidis (Princeton), H.G. Kaper (Argonne/NSF), B. Sandstede (Ohio), A. Scheel (Minneapolis), G. Schneider (Karlsruhe), G.I. Sivashinsky (Tel Aviv), C.M. Brauner (Bordeaux), M. Frankel (Indianapolis).
MAS1.3
National: O. Bokhove (Twente), L.R.M. Maas (NIOZ), W. Verkleij (KNMI). International: S. Reich (Potsdam), B. Leimkuhler (Leicester), J. Lang (Darmstadt).
MAS1.4
National: J.B. Sanders (FOM-Amolf).
International: J.J. Segura (Univ. Cantabria, Santander, Spain), J.L. López (Univ. Navarra, Pamplona, Spain), A. Gil (Univ. Autónoma de Madrid, Spain).

Projects with partners in public and private sector

Contract research

- DLMF project (NIST), see MAS1.4.

Teaching at university

- Numerical Analysis II, UvA: J.E. Frank with W. Hoffmann.
- Special Course on Numerical Methods for Stiff Problems: An Introduction to the Numerical Solution of Advection-Diffusion-Reaction Problems, Otto-von-Guericke-Universitaet Magdeburg, April 11–12, 10 one-hour lectures: J.G. Verwer.
- Partial Differential Equations, Dutch National Master: A. Doelman with S. van Gils, J. Hulshof.
- Organization MRI/Stieltjes Master Class 'Finite and Infinite Dimensional Dynamical Systems': A. Doelman with H. Broer (RUG), S. van Gils (UT).

Organization of conferences, workshops, courses, meetings

- Mathematics, Computer Science and Climate Research, lectures and discussions, January 10. Organizers: G. Burgers, A. Doelman, L. Wolters.
- CLS Systems Biology weekend Nederhemert, February 25–27. Organizer: J.G. Blom.
- Minisymposium on Geometric Methods for PDEs, SciCADE 05 International Conference on Scientific Computation and Differential Equations, Nagoya, Japan, May 23–27. Organizer: J.E. Frank.
- MAS Scientific Computing seminar series (every 3 weeks, organized by J.E. Frank, B. Koren, W. Hundsdorfer); external speakers: K. Oosterlee (TUD), H. van Brummelen (TUD), L. Ferracina (UL), T. Gerkema (NIOZ), E. Vollebregt (VORtech Computing, Delft), A. Swart (Utrecht), B. Braams (Emory Univ. Atlanta), B. van Leer (Univ. Michigan), H. van der Vorst (Utrecht), A. Mourik (VU), A. Verhoeven (TUE/Philips), J.-P. Boeuf & G. Hagelaar (Univ. Toulouse).
- Nonlinearity in Amsterdam (monthly, co-organized by groups at CWI, UvA and VU); external speakers: H. Meijer (Utrecht), L. Lorenzi (Parma), M. Peletier (Eindhoven), F. Otto (Bonn), H. de Swart (IMAU, Utrecht), L. Maas (NIOZ, Texel), A. Morozov (Leiden), T. Kolokolnikov (Brussel).
- Mathematics of Life Sciences, Groningen, October 10–13. Kick-off bijeenkomst NDNS+ cluster. Organizers: H.W. Broer, A. Doelman, A. van der Vaart, S. Verduyn Lunel.
  See: http://www.ndns.nl/mathematics-of-life-sciences
- 2005 Conference of the Dutch-Flemish Numerical Analysis Communities, October 12–14, Woudschoten Conference Centre, Zeist. Organizer: J. Kok

- Dynamics of Patterns, Leiden, November 14–18. Organizers: O. Diekmann, A. Doelman, J. Hulshof, B. Mulder, W. van de Water, W. van Saarloos.
  See http://www.lc.leidenuniv.nl/lc/

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- One-day NWO Meeting 'Mathematics, Computer Science and Climate Research', CWI, January 10: J.G. Verwer (Lecture: Transient dynamics, multiple scales and geometric integration).
- Programme Computational Science Meeting, Oegstgeest, January 12–13: N.N. Pham Thi and B.P. Sommeijer (Lecture: Oscillating behaviour in phytoplankton-nutrient dynamics).
- NWO Computational Life Science programme day, Utrecht, February 25: M. Ashyraliyev (Poster: Modelling Developmental Regulatory Networks), J.G. Blom, M. Dobrzynski (Poster: Multiscale Computational Methods for Silicon Cell), Y. Habib.
- Stability Criteria for Multi-Dimensional Waves and Patterns, American Institute of Mathematics, Palo Alto, California USA, May 16–20: A. Doelman.
- SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah USA, May 22–26: A. Doelman (Lecture: The Dynamics of Modulated Wave Trains & The Stability of Periodic Patterns in Singular Perturbed Reaction-Diffusion Equations), A. Zagaris (Lecture: A Unifying Framework for Reduction Methods).
- 2nd International Symposium on Networks in Bioinformatics, Amsterdam. May 23–25: M. Ashyraliyev (Poster: Modelling Developmental Regulatory Networks), J.G. Blom.
- SciCADE 05 International Conference on Scientific Computation and Differential Equations, Nagoya, Japan, May 23–27: J.E. Frank (Lecture: Conservative discretizations of wave equations: group velocity signature and nonphysical reflections).
- Symposium 'Towards a Philosophy of Systems Biology' VU, Amsterdam. June 2–3: J.G. Blom, M. Dobrzynski.
- The Second International Conference on Abstract and Applied Analysis 2005, Quy Nhon, Vietnam, June 4–9: B.P. Sommeijer (Lecture: RKC: a numerical time integrator for PDEs).
- BioCentrum Science Day, BioCentrum, Amsterdam, June 9: N.N. Pham Thi (Lecture: Oscillatory behaviour in a phytoplankton-nutrient model).
- Programme Computational Life Sciences Meetings, VU/IMAU, July 7, September 21, December 8: M.H. van Raalte, B.P. Sommeijer.
- Foundations of Computational Mathematics (FoCM), Santander, Spain, June 30–July 9. Workshop on Geometric Numerical Integration: J.E. Frank (Lecture: Dispersion properties of conservative discretizations for wave equations).
- Fifth EUROMECH Nonlinear Dynamics Conference, Eindhoven, the Netherlands, August 8–12: A. Doelman.
- Model Reduction and Coarse Graining for Multiscale Phenomena, Leicester UK, August 24–26: A. Zagaris.
- Potsdam Workshop on Numerical Methods in Climate and Weather Prediction, Potsdam, Germany, September 28–October 1: S.B. Dubinkina, J.E. Frank (Lecture: Some really exotic conservation laws, a method that preserves them all, and considerations for nonuniform grids).
- 2005 Conference of the Dutch-Flemish Numerical Analysis Communities, Woudschoten, Zeist, the Netherlands, October 12–14: M. Ashyralyev, M. Dobrzynski, S. Dubinkina, J. Kok, N.N. Pham Thi, M.H. van Raalte, B.P. Sommeijer, J.G. Verwer.
- Seminar on Algorithms and Processes in Life Sciences, CWI, Amsterdam, November 29: M. Ashyraliyev (Lecture: Modelling developmental regulatory networks), J.G. Blom, M. Dobrzynski (Lecture: Modelling of multiscale and noisy life systems), N.N. Pham Thi, B.P. Sommeijer (Lecture: Numerical simulation of phytoplankton dynamics).
- Kick-off meeting national mathematics cluster 'Nonlinear Dynamics of Natural Systems', RUG, October 10–13: J.G. Blom, M. Dobrzynski (Lecture: On modelling of multiscale and noisy life systems), A. Doelman, J.G. Verwer (Lecture: Numerical life and earth sciences research at CWI), A. Zagaris (Lecture: Analysis of reduction methods for multiscale problems).

- NWO-RFBR Workshop 'Robust Numerical Methods for Singularly Perturbed and Multiscale Problems', CWI, Amsterdam, November 3–4: B.P. Sommeijer, M.H. van Raalte (Lecture: Discontinuous Galerkin methods for advection schemes and for embedded boundary conditions).
- Dynamics of Patterns workshop, Lorentz Leiden. November 7–11. J.G. Blom, A. Doelman, P. van Heijster, A. Zagaris.
- Workshop Informatics in Neuroscience, ZonMw, The Hague, December 9: J.G. Verwer (Lecture: A scientific computing framework for studying axon guidance).
- Workshop 'Fast Numerical Solution of Partial Differential Equations', UU, December 20–22: M.H. van Raalte (Lecture: Embedded Boundary Conditions for Discontinuous Galerkin Discretization).

Working visits

- Univ. of Zaragoza, Spain, February 27–March 12: B.P. Sommeijer (Lecture1: Extensions to the Runge-Kutta-Chebyshev method; Lecture2: Numerical simulation of phytoplankton dynamics).
- Univ. of Surrey, Guildford, UK, March 14–19: A. Doelman (Lecture: The Stability of Spatially Periodic Patterns).
- Michigan State Univ., Lansing USA, September 6–14: A. Doelman (Lecture: The Stability of Spatially Periodic Patterns).
- Newton Institute for Mathematical Sciences, Cambridge Univ., UK, Program 'Pattern Formation in Large Domains', October 15–25: A. Doelman (Lecture: The Stability of Singular Patterns).
- Darmstadt Univ. of Technology, Germany, October 30–November 3: J.G. Verwer (Lecture: Numerical life and earth sciences research at CWI).
- Bristol Univ., UK, November 28–December 1: A. Doelman (external examiner PhD D. Lloyd).
- Heriot-Watt Univ., Edinburgh, UK, December 1-3: A. Doelman (Lecture: The Stability of Spatially Periodic Patterns).
- International Univ. of Bremen, Germany, December 6–7: J.E. Frank (Lecture: Symplectic discretization of atmospheric flows).
- Johannes Gutenberg Univ., Mainz, December 12–16: J.G. Blom.

Project meetings

- Project meetings CellMath (Mathematics and computation for the system biology of cells), Jan. 25, CWI and June 28, VU: M. Dobrzynski, J.G. Blom (organization).

Visitors

- F. Otto, Stieltjes professor, Univ. Bonn, Germany, February 7–March 4. Host: A. Doelman.
- T. Kaper, Boston Univ., USA, March 6–13. Host: A. Doelman.
- J. Lang, Darmstadt Univ., Germany, April 19–May 13 and November 16–18. Host: J.G. Verwer.
- S. Kopecz, Univ. Kassel, Germany, August 1–December 31. Host: J.E. Frank.
- S. Reich, Potsdam Univ., Germany, November 10–12. Host: J.E. Frank.
- M. Beck, Boston Univ., USA, July 25–30. Host: A. Doelman.
- T. Kaper, Boston Univ., USA, August 15–21. Host: A. Doelman.

Memberships of committees and other professional activities

A. Doelman

- Professor of Applied Analysis, Korteweg-de Vries Institute, UvA.
- Coordinating editor of Physica D.
- Member of the board of 'Nonlinear Dynamics of natural Systems^{+}' NWO Mathematics cluster.
- Programme manager NWO-EW/FOM programme 'Dynamics of Patterns', together with W. van Saarloos (Leiden).
- Member programme committee NWO-ALW programme 'Climate Variability'.
- Member Council for Mathematics ('Academie Raad'), Royal Dutch Academy of Sciences (KNAW).
- Member programme board for mathematics, Lorentz Center Leiden.
- Member Mathematics Council ('Kamer') of the Association of Dutch Universities (VSNU).
- Member governing board Stieltjes Institute Research School.

- Co-programme leader Stieltjes research programme 'Differential Equations, Dynamical Systems and Numerical Analysis' with C.J. van Duijn.
- Member of 'Stieltjesprijs' committee.
- Member of various PhD committees and of several hiring committees at the level of full professor.
- Thesis advisor of N.H. Khanh (February 1), H. van der Ploeg (June 22), G.M. Terra (October 27).

B.P. Sommeijer

- Editor Journal of Computational and Applied Mathematics (JCAM).
- Co-organizer 11th Seminar NUMDIFF on Numerical Solution of Differential and Differential-Algebraic Equations, Halle, Germany, September 4–8, 2006.
- Committee member PhD thesis of L. Ferracina, Monotonicity and boundedness in general Runge-Kutta methods, UL, September 6.

N.M. Temme

- Editor Zeitschrift für Mathematik und Physik, since 1988.
- Editor Mathematics of Computation, since 1990.
- Editor DLMF project, the revision of the Handbook of Mathematical Functions (Abramowitz and Stegun), since 1998.
- Member of the evaluation committee for a grant of the Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen (IWT) (February 23, 2004).
- Member of the governing board of the Stieltjes Institute for Mathematics and CWI-coordinator for the Dutch research schools in mathematics and computer science, since 1990.
- Organizer of the CWI general monthly seminar CWI Scientific Meetings, since 1997.
- Review work for Zentralblatt für Mathematik.

J.G. Verwer

- Professor of Numerical Analysis, Korteweg-de Vries Institute, UvA.
- Senior editor APNUM (Applied Numerical Mathematics).
- Associate editor TOMS (ACM Transactions on Mathematical Software).
- Co-organizer 11th Seminar NUMDIFF on Numerical Solution of Differential and Differential-Algebraic Equations, Halle, Germany, September 4–8, 2006.
- CWI contact for the Flemish Research Network on Advanced Numerical Methods for Mathematical Modelling (WOG).
- Member scientific committee 3rd International Conference on Air Pollution Modelling and Simulation APMS 2005, February 21–25, Paris.
- Member WCW committee Systembiology.
- Member KNAW committee 'Verkenning Biowiskunde'.
- Advisor (second) PhD thesis L. Ferracina, Monotonicity and boundedness in general Runge-Kutta methods, UL, September 6. First advisor M.N. Spijker.
- Advisor PhD thesis J.K. Krottje, On the numerical solution of diffusion systems with localized, gradient driven moving sources, UvA, November 17.
- Committee member PhD thesis of G. Terra, Nonlinear tidal resonance, UvA, October 27.
- Committee member PhD thesis of C. Montijn, Adaptive grid simulations of negative streamers in nitrogen, TUE, December 20.

Academic publications

Publications in refereed journals or proceedings

1 S. Angenent, J. Hulshof (2005). Singularities at $t = \infty$ in equivariant harmonic map flow. pp 1–15 in Geometric evolution equations, Contemp. Math. 367, Amer. Math. Soc.

2 C.-M. Brauner, M. Frankel, J. Hulshof, G.I. Sivashinsky (2005). Weakly nonlinear asymptotics of the κ-θ model of cellular flames: the Q-S equation, Interfaces Free Bound. 7, 131–146.

3 X. Brusset, N.M. Temme (2005). Impact of information and coordination on transport procurement. R. de Koster, W. Delfmann (eds). Supply Chain Management – European Perspectives Copenhagen Business School Press, Denmark, 239–261.

4 H.A. Carteret, B. Richmond, N.M. Temme (2005). Evanescene in coined quantum walks, J. Phys. A: Math. Gen. 38, 8641–8665.

5 A. Doelman, D. Iron, Y. Nishiura (2005). Edge bifurcations in singularly perturbed reaction-diffusion equations: a case study, EQUADIFF03 International Conference on Differential Equations. F. Dumortier, H. Broer, J. Mahwin, A. Vanderbauwhede, S. Verduyn Lunel (eds). World Scientific, Singapore etc. 783–788.
6 C. Ferreira, J. López, E. Mainar, N.M. Temme (2005). Asymptotic approximations of integrals: An introduction, with recent developements and applications to orthogonal polynomials. ETNA 19, 58–83.
7 J. Frank, S. Reich, A. Staniforth, A. White, N. Wood (2005). Analysis of a regularized, time-staggered discretization method and its link to the semi-implicit method, Atmospheric Science Letters 6, 97–104.
8 C.W. Gear, T.J. Kaper, I.G. Kevrekidis, A. Zagaris (2005). Projecting to a slow manifold: Singularly perturbed systems and legacy codes, SIAM Appl. Dyn. Syst. 4, 711–732.
9 G.M. Hek, N. Valkhoff, A. Doelman (2005). Stabilization of pulses by competing instability mechanisms'. Proceedings ENOC-2005, 2353–2361.
10 B.P. Sommeijer, J.G. Verwer, K. Strehmel, R. Weiner (eds) (2005). Tenth seminar on the numerical solution of differential and differential-algebraic equations (proceedings NUMDIFF-10), Applied Numerical Mathematics 53 (2–4), 89–545.
11 N.N. Pham Thi, J. Huisman, B.P. Sommeijer (2005). Simulation of 3D phytoplankton dynamics: competition in light-limited environments, J. Comput. Appl. Math. 174, 57–77.
12 N.N. Pham Thi (2005). On positive solutions in a phytoplankton-nutrient model, J. Comput. Appl. Math. 177, 467–473.
13 H. van der Ploeg , A. Doelman (2005). Stability of spatially periodic pulse patterns in a class of singularly perturbed reaction-diffusion equations, Indiana Univ. Math. J. 54(5) 1219–1301.
14 J.B. Sanders, N.M. Temme (2005). On the temporal order of first-passage times in one-dimensional lattice random walks, J. Comp. Appl. Math. 182, 134–149.
15 A. Zagaris, H.G. Kaper, T.J. Kaper (2005). Two perspectives on reduction of ordinary differential equations, Math. Nach. 278, 1629–1642.

Publications in other journals or proceedings and other scientific output

CWI reports

MAS-E0503, MAS-E0504, MAS-E0507, MAS-E0508, MAS-E0509, MAS-E0510, MAS-E0512, MAS-E0513, MAS-E0518, MAS-E0519, MAS-E0520, MAS-E0522, MAS-E0523, MAS-E0527, MAS-E0531

See B.4 on page 203 for complete titles.

PhD theses

1 J.K. Krottje (2005). On the numerical solution of diffusion systems with localized, gradient-driven, moving sources. UvA, November 17. Thesis advisor: J.G. Verwer.
2 R. Planqué (2005). Constraints in applied mathematics: Rods, membranes, and cuckoos, TUE, April 7. Thesis advisor: M.A. Peletier. Co-advisor G.H.M. van der Heijden (UCL, London).

Professional products

Publications for a broad audience

1 J.G. Blom, A. Kik (2005). Modelling a Living Cell - Mathematics to Model Metabolic Pathways. ERCIM News 60, January.
2 J. Frank (2005). Better Weather Forecasts with Use of Conservation Laws. ERCIM News 61, April.

Other output

Grants

- H. Broer, A. Doelman, A. van der Vaart, S. Verduyn Lunel, NWO 'Wiskunde clusters', Nonlinear Dynamics of Natural Systems$^+$.
- A. Doelman, L. Maas, NWO/FOM 'Dynamics of Patterns', Internal Wave Patterns in 3D.
- J.E. Frank, NWO/ALW Climate Variability, (co-applicant with O. Bokhove, UT, main-applicant), Hamiltonian-based numerical methods for forced-dissipative climate prediction, (jointly with S. Reich (Potsdam) and J.J.W. van der Vegt (UT)).

Computing and Control – MAS2

Mission

The theme Computing and Control is concerned with the numerical and system-theoretic analysis of complex applications in science and engineering, as well as with their simulation and control. Numerical simulation enables the investigation of phenomena that are too dangerous, too expensive, too difficult, or simply impossible to be studied by real experiments. Control and system theory is a major factor in the effective functioning of technological systems (motorway networks, aircraft, air-traffic control, cars, communication networks, power networks, chemical plants, and mechanical systems) and in modelling of life systems (modelling of toxic substances, modelling and control of metabolic, signalling, and gene regulatory networks). Because there is no end in sight yet for the growth of computing power and algorithmic improvements in numerical mathematics and system theory, the potential benefits of computing and control are enormous. The challenge is the simulation, control, design and optimization of ever more realistic problems.

The current research in this theme is directed towards applications of fluid dynamics, electromagnetics, and control and system theory. Advanced computational fluid-dynamics techniques are developed for ship hydrodynamics, and for aircraft and spacecraft aerodynamics. The primary objective of the computational electromagnetics research is to improve the existing electromagnetic design techniques. Current work concerns combining the computational expediency of analytical and even empirical engineering models with the accuracy of finite-element discretizations of the Maxwell equations. Research in control and system theory is currently primarily motivated by control problems from engineering and biology (mechanical systems, manufacturing systems, cars, communication networks, and biochemical reaction networks). It is focused on fundamental control and realization problems for hybrid systems, discrete-event systems, nonlinear systems, rational positive systems, and nonlinear stochastic systems.

Theme leader

Prof.dr.ir. B. Koren

MSC or CR classification

35-xx, 39-xx, 41-xx, 65-xx, 76-xx, 78-xx, 93-xx, 94A12

Subthemes

Name	Leader
MAS2.1 – Computational Fluid Dynamics and Computational Electromagnetics	B. Koren
MAS2.2 – Control and System Theory	J.H. van Schuppen

MAS2.1 is concerned with research issues related to the computation of fluid flows and electromagnetic fields for various complex (mostly industrial) applications. In 2005, emphasis was placed on the development of:

- efficient solution methods for steady, incompressible two-fluid Navier-Stokes flows,
- discontinuous Galerkin methods and level-set methods for compressible two-fluid Euler flows,
- immersed boundary methods for incompressible Navier-Stokes flows around complex geometries,
- computational techniques for optimization problems in magnetic shape design,
- stochastic methods for field computations in electromagnetic compatibility problems,
- parallelization of software for fluid-structure interaction.

MAS2.2 carries out research on synthesis of control laws for control systems and on modelling, realization, and system identification of dynamic phenomena by dynamic systems. In the year 2005 the research focus included:

- control of piecewise-affine hybrid systems on polytopes,
- control of discrete-event systems, including decentralized control and modular control,
- control of nonlinear stochastic systems motivated by problems of mathematical finance, and
- modelling, realization, and control of rational positive systems.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. P.J. Collins	1.0	researcher	2005-04-01 till 2010-04-01	MAS2.2: CTSC, CHS
J. Duchoňová, MSc	1.0	PhD student	2005-11-01 till 2009-11-01	MAS2.2: RATPOS
Drs.ir. D. Echeverría	1.0	PhD student	2003-04-01 till 2007-04-01	MAS2.1: IOP-EMVT1
Prof.dr. P.W. Hemker	0.8	CWI Fellow	indefinite	MAS2.1: NWO1, NWO2, IOP-EMVT1, IOP-EMVT2
Prof.dr.ir. B. Koren	0.8	theme leader, leader MAS2.1	indefinite	MAS2.1: BRICKS-MSV1.6, IOP-EMVT1, NWO1, NCF
Drs. A. Kuut	1.0	PhD student	2003-03-01 till 2007-03-01	MAS2.1: NWO1, CHS
Dr. D. Lahaye	1.0	postdoc	2003-09-01 till 2007-09-01	MAS2.1: IOP-EMVT1, IOP-EMVT2
Drs. M. Nool	0.6	programmer	indefinite	MAS2.1: BRICKS-MSV1.6, IOP-EMVT1, NCF; MAS2.2: CC, CHS
Drs. M. Petreczky	1.0	PhD student	2002-08-01 till 2006-08-01	MAS2.2: CHS
Prof.dr.ir. J.H. van Schuppen	0.8	leader MAS2.2	indefinite	MAS2.2: CHS, CDES, CC, RESI, RATPOS, LIFESYSTEMS, CTSC
Mr. L. Sella, MSc	1.0	PhD student	2005-10-01 till 2009-10-01	MAS2.2: CTSC
Ir. J. Wackers	1.0	PhD student	2003-07-01 till 2007-07-01	MAS2.1: BRICKS-MSV1.6

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr.ir. L.C.G.J.M. Habets (TUE)	0.2	researcher	1999-12-01 till 2007-12-31	MAS2.2: CHS, CC, RESI
Ms. H. Härdin (VU/FALW)	0.2	PhD student	2005-04-01 till 2009-04-01	MAS2.2: LIFESYSTEMS
Prof.dr. B. van Leer (Univ. Michigan)	p.m.	advisor	indefinite	MAS2.1: BRICKS-MSV1.6
R. vander Meûlen (TUD)	1.0	trainee	2005-04-01 till 2006-01-31	MAS2.1: BRICKS-MSV1.6
J. Naber (TUD)	1.0	trainee	2005-02-01 till 2005-12-31	MAS2.1: BRICKS-MSV1.6, NWO1
Prof.dr. G.I. Shishkin (IMM Ekaterinburg)	p.m.	visitor	2004-01-01 till 2006-12-31	MAS2.1: NWO2
Prof.dr.ir. P. Wesseling (TUD)	p.m.	advisor	indefinite	MAS2.1

Scientific report

Highlights

- Van Raalte (former PhD student) received the 'Best PhD thesis of the Year Award'. See Awards on page 148.
- Naber graduated with honours on his MSc work performed at CWI.
- Hemker and Koren were invited to be two of the Dutch academics of which all publications were made publicly available by the Digital Academic Repositories (www.creamofscience.org).
- Koren was invited to become member of the Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte.
- Van Schuppen was asked to be a member of the INRIA Panel of Experts for the biology and medicine programme; of an evaluation committee of the INRIA/IRISA institute; of the Department of Business Mathematics and Informatics of North-West Univ. in Potchefstroom, South Africa; and of a project financed by the European Commission.

PhD students

J. Duchoňová
D. Echeverría
H. Härdin
A. Kuut
M. Petreczky
L. Sella
J. Wackers

MAS2.1 – Computational Fluid Dynamics and Computational Electromagnetics

Computational Fluid Dynamics (CFD) and Computational Electromagnetics (CEM) are of crucial importance to many processes in science and engineering. Still very fruitful application areas of CFD are aircraft and spacecraft aerodynamics, and ship hydrodynamics.

At present, CFD cooperates with other disciplines such as solid mechanics (computational fluid-structure interactions) and electromagnetism (computational magnetohydrodynamics). Much fundamental research is still required in these new, challenging cooperations.

Electromagnetic engineering is a very active area (mobile telecommunication, magnetic resonance imaging, electromechanics, magnetohydrodynamic power generation, tokamak reactors). Computational techniques for electromagnetics are less far developed than those for fluid dynamics. Here exist excellent opportunities for fruitful knowledge transfer. E.g., it is of great industrial importance to improve the existing computational electromagnetic design techniques. Many of these techniques are time-consuming 'trial-and-error' methods which inhibit the use of the engineer's intuition and, so, hamper the generation of new knowledge. One of the challenges is to properly combine the computational expediency of analytical and even empirical engineering models with the accuracy of sophisticated numerical treatments of Maxwell's equations.

Title	BRICKS-MSV1.6 – Two-fluid Navier-Stokes solvers for water-air flows around ships
Period	July 2003–July 2007
Leader	B. Koren
Staff	B. Koren, B. van Leer, R. vander Meûlen, J. Naber, M. Nool, J. Wackers
Funding	ICES-KIS 3
Partners	MARIN; Faculty of Aerospace Engineering, TUD; Delft Centre for Computational Science and Engineering; Department of Aerospace Engineering, Univ. Michigan, Ann Arbor

Progress report. This year, Wackers and Koren completed the first part of their work on the efficient solution of surface capturing models for water flow with a free surface (like the flow around ships). In surface capturing models, the water surface is modelled as a (slightly smeared out) discontinuity, that can move freely through the computational grid. Therefore, the grid does not have to be deformed to fit the water surface, which makes capturing methods very flexible and robust. However, existing solution techniques for the computation of steady flow problems with surface capturing models are very slow and inefficient. The research of Wackers and Koren showed that it is possible to combine surface capturing with fast solution techniques. A discretisation of the Navier-Stokes equations with surface capturing was developed that can be combined with the proven multigrid technique. The multigrid technique was combined with a line smoother, that is very suitable for convection-dominated problems like water flow. Test problems showed that the

new solver usually is more than 50 times faster than existing solution techniques.

In the second part of the year, work was started on the upgrading of the surface capturing algorithm to second-order accuracy. Special discretisations can be used here to get a very good resolution of the water surface. Initial tests showed that the quality of the solutions is much improved over the original model. Especially the water surface is captured much sharper. Also, research was started on the incorporation of a RANS turbulence model in the flow equations. Nearly all water flow is turbulent, so a turbulence model is essential for the simulation of realistic water flow problems. From a mathematical point of view, the turbulence model makes the line smoothing much more difficult: its stability is no longer guaranteed. This problem was analyzed and adaptations of the smoother were suggested.

In the framework of his MSc work from TUD, Vander Meûlen worked with Koren and Wackers on Immersed Boundary Methods (IBMs) for the steady, incompressible Navier-Stokes equations. A literature study was made, and a simple 1D channel-flow and 2D full Navier-Stokes flows were computed. The 1D Poiseuille flow study allowed us to calculate the exact error made by the IBMs. The 2D Navier-Stokes study gave us the opportunity to test some of the findings from the 1D study in a higher dimension. A lot of effort was put in constructing the pre-processor, which creates the Cartesian grid and determines the intersections of the grid lines with the immersed boundary. Three IBMs were successfully implemented in the 2D Navier-Stokes code. They were tested on a backward-facing step flow, a circular cylinder flow and a multi-element airfoil flow. The results confirmed that IBMs are able to treat complex geometries in a satisfactory manner. The flows were resolved quite accurately. Grid generation appeared to be very straightforward and fast for the multi-element airfoil.

In the framework of his MSc work from TUD, Naber worked with Koren on an accurate numerical method for unsteady, compressible two-fluid flows described by 2D Euler equations. The method is based on the level-set (LS) approach for tracking the two-fluid interface. The novelty of the method was the application of an accurate Runge-Kutta discontinuous Galerkin (RKDG) method for the temporal and spatial discretization of the Euler equations. A RKDG discretization and the LS approach combine the accuracy of the former with the efficiency and easy implementation of the latter. It was shown that the LS equation has to be used in its advective form since this approach, as opposed to the frequently used conservative form, does not generate an erroneous off-set in the interface location. A simple fix was applied to prevent the solution from becoming oscillatory near the two-fluid interface. Application of this fix requires the development of a special two-fluid slope limiter for the RKDG method. Numerical results of several discriminating 1D and 2D flow problems show the competence of the developed method. December 23, Naber defended his MSc work, and graduated with honours.

Title	IOP-EMVT1 – Space-mapping and related techniques for inverse problems in magnetic shape design, with application to an electric actuator
Period	April 2003–April 2007
Leader	P.W. Hemker
Staff	D. Echeverría, P.W. Hemker, B. Koren, D. Lahaye, M. Nool
Funding	IOP-EMVT
Partner	Group Electromechanics and Power Electronics TUE

Progress report. The space mapping technique was evaluated by application on two model problems. Numerical results that confirm its efficiency were published in a first paper. The thorough analysis of the method revealed several relations between space mapping and the well-known defect correction technique. Using the correspondence a new improved algorithm, now called 'manifold-mapping', could be developed. Manifold-mapping yields more accurate solutions than space-mapping at the same efficiency. These theoretical results, together with the description of the new algorithm were the subject of a second published paper.

In close collaboration with the section EPE of the department of Electrical Engineering at TUE, manifold-mapping was applied in optimization problems of practical relevance. A third paper shows its computational advantages in the design of linear actuators.

The modelling of linear actuators involves the computation of magnetic forces. This issue received special attention during the course of

the project and the novel eggshell method was implemented for that purpose. The promising results obtained with this technique on a series of model problems have been published in a CWI technical report by Nool and Lahaye. Lahaye finished his activities in the project on August 31th.

Part of the research on space-mapping was carried out by Echeverría during a summer internship at the Lawrence Livermore National Laboratory.

Title	IOP-EMVT2 - Stochastic methods for field computations in EMC problems
Period	2004–2007
Leader	P.W. Hemker
Staff	P.W. Hemker, D. Lahaye (since September 1)
Funding	SenterNovem
Partner	TUE

Progress report. The project studies electromagnetic compatibility (EMC) of a device by computing its EMC response, taking into account possible variations of the configuration. Computational methods were studied that may take into account the stochastics of the source and target in scattering problems. In a first phase of the project, relevant integro-differential equations and solution techniques for scattering by thin wires have been studied. Several numerical methods to solve Hallén's and Pocklington's integral equations were compared. D. Lahaye started his activities on this project on September 1st.

Title	NWO1 – hp-Adaptive methods for 3D convection dominated flows
Period	February 2003–February 2007
Leader	P.W. Hemker
Staff	A. Kuut, P.W. Hemker, B. Koren, J. Naber
Funding	NWO
Partner	UvA

Progress report. While a report on an h-adaptive refinement algorithm was in preparation, Kuut became ill and had to stop his activities in this project. For this reason the main course of activities in this project came to a halt for a while. In the conference season dr. D. Vasileva, former member of the team, presented the paper 'An adaptive multigrid strategy for convection-diffusion problems' by Vasileva, Kuut and Hemker, at the Fifth International Conference on Large-Scale Scientific Computing, Sozopol, Bulgaria, June 7–9.

In December the plan for the project was adapted to the new situation. The emphasis of the research became the combination of (i) a hierarchical adaptive discretization technique, and (ii) an immersed boundary method for the solution of the incompressible Navier-Stokes equations. Naber was found prepared to execute the adapted project for the remaining 14 months. Koren will take part in the supervision of the project.

Title	NWO2 – Robust numerical methods and computational technologies for singularly perturbed multiscale problems
Period	January 2004–December 2006
Leader	P.W. Hemker
Staff	P.W. Hemker, G.I. Shishkin
Funding	NWO
Partners	TUE; Institute for Mathematics and Mechanics, Ekaterinburg, Russia; Moscow State Univ., Russia

Progress report. The work on methods for convection dominated and singularly perturbed problems was continued, according to the planned activities A4, B3, C5 and D4 in the research cooperation programme NWO-RFBR 047.016.008. This also implied research on discontinuous Galerkin methods, local defect correction and hp-refinement for multiscale problems. For this purpose prof. G.I. Shishkin and dr. L.P. Shishkina visited CWI during the month November.

Further, in the framework of this project an 'NWO-RFBR Workshop on Robust Numerical Methods for Singularly Perturbed and Multiscale Problems' was organized at CWI, November 3-4. Invited speakers were, besides prof. Shishkin and dr. Shishkina: prof. H-G. Roos (Dresden, Germany), dr. W. Hundsdorfer (CWI), dr. M.H. van Raalte (CWI), prof.dr. G. Lube (Göttingen, Germany), prof.dr. M. Stynes (Cork, Ireland), prof.dr. O'Riordan (Dublin, Ireland), ir. J. Naber (CWI), prof.dr. L. Tobiska (Magdeburg, Germany), ir. J. Wackers (CWI) and dr. J. Maubach (TUE).

Title	NCF – Grant for Parallel Implementation of a Coupling Interface for Fluid-Structure Interaction
Period	September 1, 2005–September 1, 2006
Leader	B. Koren
Staff	H. Bijl, A. de Boer, B. Koren, E.J. Lingen, M. Nool
Funding	NWO
Partners	TUD (H. Bijl and A. de Boer); Habanera Numerical Software (E.J. Lingen)

Progress report. The Faculty of Aerospace Engineering of TUD has started a project to develop a generic, open-source coupling shell, named FLECS, that can be used to join two or more arbitrary solvers. The aim is not to achieve the best possible efficiency or to support a large feature set, but to provide a flexible platform for developing new data transfer algorithms and coupling schemes. This means that existing flow and structure solvers can be reused and that the efforts that have been made in developing these solvers can be exploited. Each solver deals with one particular physical domain, applying the numerical algorithms that are most efficient for that domain. The solvers regularly exchange data to take into account the effects of the other domains. The discrete meshes used in the different domains do not have to match at their common interface, especially when different physical fields are involved. A detailed study on coupling methods has been done by A. de Boer. In FLECS a coupling method, based on the use of spline functions, will be inserted because of their high accuracy and efficiency. This method does not require orthogonal projections or a search algorithm. The computation involves the inversion of a small matrix only. In the future, we intend to admit other coupling methods. The initial implementation of FLECS will be based on `MPI-2`, applying dynamic process management and supporting mixed-language programming.

MAS2.2 – Control and System Theory

Research on fundamental problems of control and system theory for various dynamic systems is motivated by control problems of engineering and cell biology. The fundamental problems are: (1) Control synthesis: The determination of a control law for a control system such that the closed-loop system satisfies a-priori specified control objectives. (2) Realization problem: Characterize when a pair of observed signals can be represented as the input-output signals of a dynamic system in a prespecified class of systems; and classify of such dynamical systems all the minimal ones. The CWI research focus is on the following classes of dynamic systems: Hybrid systems (motivated by the control of engineering systems by computers); discrete-event systems (motivated by the use of computers for networks); nonlinear stochastic systems described by stochastic differential equations (motivated by mathematical finance and engineering); and positive systems (motivated by research in biology and medicine).

In 2005 the CWI research was directed at:

- Control of piecewise-affine hybrid systems with emphasis on the hybrid character.
- Supervisory control of modular discrete-event systems.
- Modelling, realization, and control of rational positive systems with applications to model of molecular cell biology.
- Control of the capital adequacy ratio of banks.

Title	CHS – Control of hybrid systems
Period	December 1998–February 2007
Leader	J.H. van Schuppen
Staff	P.J. Collins, L.C.G.J.M. Habets, A. Kuut, M. Nool, M. Petreczky, J.H. van Schuppen
Funding	CWI
Partners	Parades, UCB

Progress report. Petreczky continued his research on realization theory of hybrid systems. Research efforts were mostly focused on hybrid systems without guards, i.e., hybrid systems without autonomous switching. The previous results on linear and bilinear hybrid systems were further extended and were published as CWI technical reports and in conference proceedings. A journal article on the topic is in preparation. An abstract algebraic framework for realization theory of linear and bilinear hybrid systems was developed. The proposed framework combines theory of formal power series with automata theory and provides a suitable framework for studying hybrid systems. A paper on this topic was submitted for publication in the proceedings of the Int. Symp. on Mathematics of Networks and Systems, 2006 (MTNS2006), to be held in Kyoto, Japan.

Results on linear and bilinear switched systems were further extended, the results were

submitted for publication in a journal (ESAIM Control, Optimization and Calculus of Variations). A technical report and an article in a conference proceedings were published too. Computational aspects and partial realization theory of hybrid systems without guards were investigated, a journal article on the topic is in preparation.

Progress was made in realization theory of piecewise-affine hybrid systems. Preliminary results on realization theory of piecewise-affine hybrid systems in discrete-time were obtained and the results were submitted for publication in the proceedings of MTNS2006.

Petreczky stayed as a Marie Curie Control Training Site Fellow at INRIA Sophia-Antipolis in the period October 23–December 5. There he worked under supervision of J.-B. Pomet on realization theory of nonlinear hybrid systems. During that period some preliminary results on realization theory of nonlinear hybrid systems were obtained. A paper is in preparation on the topic. The proposed solution uses the theory of Hopf-algebras, which is quite novel in the context of control theory.

Petreczky's current affiliation with CWI ends on July 31, 2006. Around that time he is expected to get his PhD degree and thus a significant amount of time was spent on writing his thesis.

Habets and Van Schuppen continued their cooperation on control of hybrid systems. After April 1 Collins joined them. A piecewise-affine control law for the reachability of a terminal state for a piecewise-affine hybrid system was derived using the control-to-facet approach. A paper on this has been accepted for publication and will appear in 2006. A second paper was presented at the Conference on Decision and Control. That paper concerned a generalization where there is only one control law per polytope rather than per simplex.

Control design for piecewise-affine hybrid systems benefits from a software package. For the particular approach developed at CWI based on the control-to-facet control law, the software package ConPAHS is under development. The program package has been developed by the programmer Nool. In the last two months she was assisted by Kuut. The functional specification was written by Van Schuppen. Petreczky has helped with the object-oriented program design and the overall structure of the program. Habets, Collins, and Van Schuppen have participated in the formulation of the theory on which the package is based. The development will be continued in 2006.

Title	CDES – Control of discrete-event systems
Period	December 1998–February 2007
Leader	J.H. van Schuppen
Staff	J.H. van Schuppen
Funding	CWI
Partners	CZ.AS.IM.Brno, Univ. Michigan (Ann Arbor), UIUC, Ghent Univ.

Progress report. Van Schuppen and J. Komenda (Brno) have continued their cooperation on control of modular discrete-event systems. Sufficient conditions for modular control synthesis to equal global control synthesis were formulated both for the case of complete observations and for the case of partial observations. At the IFAC World Congress a paper was presented and at the Conference on Decision and Control two papers were presented. At the Symposium on Formal Methods for Components and Objects an overview was presented on control of modular and decentralized discrete-event systems. Research was carried out on coordination control of discrete-event systems that will be continued in 2006.

Title	CC – Computation and Control
Period	January 2002–May 2005
Leader	J.H. van Schuppen
Staff	L.C.G.J.M. Habets, M. Nool, J.H. van Schuppen
Funding	European Commission (EU.IST.CC)
Partners	Verimag, Parades, ETH Zürich, Lund Univ. of Technology, EDF, ABB

Progress report. The project was originally scheduled for termination at January 1 but was finally extended till May 1.

There was no research effort for this project in 2005.

The development of the software package ConPAHS reported in project CHS was started in project CC and a considerable amount of activity was completed in the latter project.

Title	RATPOS – Realization and Control of Rational Positive Systems
Period	November 2005–November 2009
Leader	J.H. van Schuppen
Staff	J. Duchoňová, J.H. van Schuppen
Funding	NWO Open Competitie
Partner	VU Dept. of Economics

Progress report. The project has started with the arrival at CWI of the PhD student Duchoňová on November 1. Duchoňová has taken a course of the graduate school DISC and is reading papers on positive systems with her research advisor.

Title	RESI – Realization and System Identification
Period	indefinite
Leader	J.H. van Schuppen
Staff	L.C.G.J.M. Habets, J.H. van Schuppen
Funding	CWI
Partner	VU Dept. of Economics

Progress report. Van Schuppen has carried out research on modelling and control of rational positive systems. Several lectures were presented during the year. Part of this research will be transferred to project RATPOS in 2006.

Title	LIFESYSTEMS – Control and system theory for biology
Period	2001–2009
Leader	J.H. van Schuppen
Staff	H. Härdin, J.H. van Schuppen
Funding	NWO Computational Life Sciences, CWI
Partners	VU Dept. of Life Sciences, Dept. of Economics

Progress report. Härdin started her PhD studies on April 1. She has taken a course on positive systems and DISC courses in model reduction and system identification. She has read books and articles on system theory, kinetics, and cell biology. A first approach to model reduction of biochemical systems, the main subject of her PhD research, was initiated. An already existing model reduction method for linear systems was used after linearization of rational positive systems of biochemical reactions.

Theory on observers for positive systems has been developed by Van Schuppen. This includes theorems for decomposition of matrices into irreducible submatrices and the existence of observers for special cases of systems with irreducible system matrices. The development of the theorems is motivated by their use for biochemical systems. Härdin illustrated this by using the theory on a model of the glycolysis in yeast. An article about this was submitted at the end of the year.

Härdin and Van Schuppen participated in conferences and workshops on system theory as well as systems biology and bioinformatics. Contact with system biologists at KTH in Stockholm has been established.

Title	CTSC – Computational Topology for Systems and Control
Period	2005-04-01–2010-03-31
Leader	P.J. Collins
Staff	P.J. Collins, L. Sella
Funding	NWO Vidi Grant
Partners	Parades (T. Villa, A. Casagrande), Univ. Patras (J. Lygeros), Univ. Kyoto (H. Kokubu). U.C. Merced (K. Mitchell)

Progress report. From April 1, Collins is working on computability theory and computational topology for dynamical and control systems. The goal of this project is to combine formal notions of effective representation and computation from computer science with advanced tools of algebraic topology for the rigorous numerical study of dynamic systems. These methods can be expected to be particularly important for nonlinear and hybrid systems, and in applications where verification of controllers and safety properties is important.

Results on reachable, viable and invariant sets have been obtained for semicontinuous multivalued maps. In the context of control theory, these results can be interpreted as semicomputability results for safety verification and controller design. Optimal semicomputable approximations for uncomputable operators have also been derived. These results have been extended to hybrid systems, defined as impulse differential inclusions, with J. Lygeros.

Work has also been carried out on the dynamics of surface diffeomorphisms relative to periodic and homo/heteroclinic orbits. Results have been obtained with K. Mitchell on duality in automorphisms of surface-embedded graphs, and their relations with homotopy groups and surface dynamics.

From October 1, Sella followed courses of the Mathematical Research Institute's Master Class programme on Finite and Infinite Dimensional Dynamical Systems and has been study-

ing computable analysis and algebraic topology.
Tools. Collins has worked with T. Villa and A. Casagrande (Parades) on the specification and development of the tool Ariadne, for set-based analysis and the verification of nonlinear and hybrid systems.
Collins has continued work on the development of the tool Tangle for analysis of the dynamical properties of surface diffeomorphisms forced by braids and trellises.

Societal aspects and knowledge transfer

External contacts

P.J. Collins

- Parades, Rome, Italy, Control Department. (page 139).
- Univ. Bristol, United Kingdom, Department of Engineering Mathematics.

P.W. Hemker

- UvA, Korteweg-de Vries Institute for Mathematics, Dynamical Systems and Numerical Analysis group (page 136).
- TUE, Faculty of Electrical Engineering, Electromechanics and Power Electronics Group, EPE (page 135).
- TUE, Faculty of Electrical Engineering, Electromagnetics Group, EM (page 136).
- CARIM, Cardiovascular Research Institute Maastricht, UM.
- Institute of Mathematics and Mechanics, Ural Branch Russian Academy of Sciences, Ekaterinburg, Russia. (page 136).

B. Koren

- TUD, Faculty of Aerospace Engineering (page 134 and page 136).
- Univ. Michigan, Department of Aerospace Engineering, W.M. Keck Foundation Laboratory for Computational Fluid Dynamics (page 134).
- MARIN, Wageningen (page 134).
- Shell Global Solutions - Fluid Flow and Thermodynamics (page 134).
- ETH Zürich, Institut für Fluiddynamik.

J.H. van Schuppen

- Univ. California at Berkeley, Dept. EECS, CA, U.S.A. (page 137).
- Czech Academy of Sciences, Institute of Mathematics, Brno Branch, Brno, Czech Republic. (page 138).
- Ghent Univ., Department of Systems, Belgium. (page 138).
- Parades, Rome, Italy, Control Department. (page 138).
- VU, Department of Mathematics (page 138 and page 139).
- VU, Department of Molecular Cell Physiology (page 139).

Projects with partners in public and private sector

- BRICKS-MSV1.6 (page 134)
- CC (page 138)
- CDES (page 138)
- CHS (page 137)
- CTSC (page 139)
- IOP-EMVT1 (page 135)
- IOP-EMVT2 (page 136)
- LIFESYSTEMS (page 139)
- NCF (page 136)
- NWO1 (page 136)
- NWO2 (page 136)
- RATPOS (page 138)
- RESI (page 139)

Teaching at university

- Computational Fluid Dynamics, UvA, January–June: P.W. Hemker.
- Scientific Computing, Advanced, UvA, September–December: P.W. Hemker.
- Computational Fluid Dynamics II, TUD, January–June: B. Koren.
- Advanced Numerical Techniques for Fluid Flow and Structural Engineering, TUD, January–June: B. Koren (jointly with TUD colleagues).
- Computational Fluid and Solid Mechanics, TUD, September–November: B. Koren (jointly with TUD colleagues).
- Control and system theory of positive systems, VU, April–May: J.H. van Schuppen.
- Control and system theory of stochastic systems in continuous time, VU, September–December: J.H. van Schuppen.

Organization of conferences, workshops, courses, meetings

- BRICKS Scientific Computing Meeting, CWI, April 20: B. Koren.
- NWO-RFBR Workshop 'Robust Numerical Methods for Singularly Perturbed and Multiscale Problems', CWI, November 3–4: P.W. Hemker.
- MAS Scientific Computing Seminar at CWI (approximately tri-weekly): B. Koren, jointly with J.E. Frank and W.H. Hundsdorfer.
- CWI Seminar Control and System Theory (bi-weekly): J.H. van Schuppen.
- CWI Colloquium Control and System Theory (irregularly): J.H. van Schuppen and P.J. Collins.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- NWO Computational Science Seminar, Oud Poelgeest, January 13: P.W. Hemker.
- Boderc Symposium of Embedded Systems Institute (EESI) at TUE, Eindhoven, February 24: J.H. van Schuppen.
- Workshop of the NWO Computational Life Sciences Program, Utrecht, February 25: H. Härdin, J.H. van Schuppen.
- Seminar Shape Optimization for elliptic free boundary problems by Karsten Eppler (WIAS, Berlin), UU, March 1: D. Echeverría, D. Lahaye.
- Oberwolfach Tagung Regelungstheorie, Oberwolfach, Germany, February 28–March 4: J.H. van Schuppen. (Lecture: Control and realization of piecewise-affine hybrid systems).
- CC Review Workshop Zürich, Switzerland, March 12: J.H. van Schuppen. (Lecture: Control synthesis for piecewise-affine hybrid systems on polytopes).
- Benelux Meeting on Systems and Control, Houffalize, Belgium, March 23–24: M. Petreczky (Lecture: Realization theory of linear hybrid systems), J.H. van Schuppen.
- Symposium Delft Centre for Computational Science and Engineering, TUD, April 8: B. Koren, J. Naber, M. Nool, J. Wackers.
- BRICKS Scientific Computing Meeting, CWI, April 20: B. Koren, M. Nool, J. Wackers (Lecture: Efficient computation of steady water waves).
- Opening 'Cream of Science' of Digital Academic Repositories, Royal Netherlands Academy of Arts and Sciences, Amsterdam, May 10: P.W. Hemker, B. Koren.
- Mini-symposium Space mapping: a knowledge-based engineering modeling and optimization methodology exploiting surrogates during the 8th SIAM Optimization Conference on Optimization, Stockholm, Sweden, May 15–18: D. Echeverría (Lecture May 18: Multi-Level optimization with the space-mapping technique), D. Lahaye (Lecture May 18: Space-mapping applied to linear actuator design).
- 2nd International Symposium Network in Bioinformatics, Amsterdam, May 23–25: H. Härdin, J.H. van Schuppen.
- The 6th World Congress on Structural and Multidisciplinary Optimization (WCSMO6), Rio de Janeiro, Brazil, May 30–June 3: D. Lahaye (Lecture June 1: Geometry optimization of electromagnetic linear actuators).
- Third International Conference on Advanced Computational Methods in Engineering (ACOMEN 2005), Gent, Belgium, May 30–June 2: J. Wackers (Lecture: A surface capturing method for the efficient computation of steady water waves).
- 10th International Conference Mathematical Modelling and Analysis and 2nd International Conference Computational Methods in Applied Mathematics June 1–5, Trakai, Lithuania: P.W. Hemker (Invited presentation: Space mapping and defect correction).
- Symposium Philosophy of Systems Biology, Amsterdam, June 2–3: P.J. Collins, H. Härdin, M. Petreczky, J.H. van Schuppen.
- Computability in Europe 2005: New computational paradigms, Amsterdam, June 8–12: P.J. Collins (Lecture: Computable analysis in systems and control), M. Petreczky.
- Bio Centrum Amsterdam Science Day, UvA, Amsterdam, June 9: J.H. van Schuppen.
- Mathematics Colloquium, UU, June 17: B. Koren (Invited presentation: Peter Lax – 2005 Abel Prize recipient – an outline of his numerical work and biography).
- 15th Conference on the Computation of Electromagnetic Fields (COMPUMAG2005),

Shenyang, China, June 26–30: D. Echeverría (Poster presentation June 29: Manifold-mapping optimization applied to linear actuator design).

- International Conference on Computational Methods in Marine Engineering (MARINE 2005), Oslo, Norway, June 27–29: J. Wackers (Lecture: A surface capturing method for the efficient computation of steady water waves).
- IFAC World Congress, Prague, Czech Republic, July 4–8: J.H. van Schuppen (Lecture: Modular antipermissive control of discrete-event systems).
- Sixth SIAM Conference on Control and Its Applications, New Orleans, USA, July 11–14: M. Petreczky (Lecture: Realization Theory for linear hybrid systems).
- ENUMATH 2005, Sixth European Conference on Numerical Mathematics and Advanced Applications, Santiago de Compostela, Spain, July 18–22: P.W. Hemker.
- 11th IEEE International Conference Methods and Models Automation and Robotics (MMAR.2005), Miedzyzdroje, Poland, August 29–September 2: M. Petreczky (Lecture: Realization theory for bilinear hybrid systems); J.H. van Schuppen (Invited plenary lecture: Realization and control problems for biochemical reaction networks).
- Lorentz Center, Workshop on Model order reduction, coupled problems and optimization. September 19–23: P.W. Hemker (Invited presentation September 21: Space mapping and defect correction), D. Lahaye (Invited presentation September 22: Space mapping applied to linear actuator design), D. Echeverría, M. Nool.
- ERNSI Workshop System Identification 2005, Louvain-la-Neuve, Belgium, September 19–23: P.J. Collins (Lecture: Computability of system properties), H. Härdin, M. Petreczky, J.H. van Schuppen (Lecture: Problems of control and system biology motivated by systems biology).
- Seminar Delft Centre for Computational Science and Engineering, TUD, September 23: B. Koren.
- EMG2005, 8th European Multigrid Conference (EMG2005), Scheveningen, The Netherlands, September 27–30: D. Echeverría (Lecture September 29: Multilevel optimization: the space mapping technique), P.W. Hemker, D. Lahaye, J. Wackers (Lecture September 27: A multigrid method for the computation of steady water waves).
- Philips Research Numerical Mathematics Working Party 106 (NMWP106), Eindhoven, The Netherlands, October 4: D. Echeverría (Lecture: Manifold-mapping optimization).
- First meeting of the BIOSIM network, Mallorca, Spain, October 6–8: H. Härdin.
- NDNS+ Workshop Mathematics of the Life Sciences, Groningen, October 10–13: P.J. Collins, M. Petreczky, J.H. van Schuppen (Lecture: Realization and control problems for biochemical reaction networks).
- 30th Conference of the Dutch-Flemish Numerical Analysis Communities, Zeist, The Netherlands, October 12–14: D. Echeverría (Poster: Manifold-mapping optimization applied to linear actuator design), P.W. Hemker, B. Koren, D. Lahaye, M. Nool (Poster: The eggshell method for magnetic force computation), B. van Leer (Presentation: DG for diffusion), J. Naber, J. Wackers (Poster: Efficient computation of steady water waves).
- Fourth International Symposium on Formal Methods for Components and Objects (FMCO.2005), Amsterdam, November 1–4: J.H. van Schuppen. (Invited lecture: Decentralized and modular control of discrete-event systems).
- FEMLAB Users Conference, Frankfurt, Germany, November 2–4: D. Lahaye (Lecture November 3: The eggshell method for magnetic force computation).
- NWO-RFBR Workshop 'Robust Numerical Methods for Singularly Perturbed and Multiscale Problems', CWI, November 3–4: P.W. Hemker, B. Koren, J. Naber (Lecture: A Runge-Kutta discontinuous Galerkin level-set method for unsteady compressible two-fluid flow), J. Wackers (Lecture: Efficient computation of steady water flow with gravity waves).
- Conference Biological Dynamics; from molecules to cells, Amsterdam, November 7–9: H. Härdin.
- 22th SARA Superdag 'High-end on demand', November 29, Amsterdam: M. Nool.
- Conference on Decision and Control, combined with the European Control Conference (ECC.CDC.2005), Seville, Spain, December 12–15: P.J. Collins (Lectures: Computability of finite-time reachable sets for hybrid systems; On the computability of reachable and

invariant sets), M. Petreczky (Lecture: Realization theory for bilinear hybrid systems), J.H. van Schuppen (Lectures: Supremal languages of general specification languages arising in modular control of discrete-event systems; Modular supervisory control with general indecomposable specification languages, Control to facet problems for affine systems on simplices and polytopes - With applications to control of hybrid systems).
- Second International Conference on Scientific Computing and Partial Differential Equations, and First East Asia SIAM Symposium, Hong Kong, December 12–16: B. Koren (Invited presentation: Multigrid solution of incompressible water-air flows with gravity waves).
- Workshop 'Fast Numerical Solution of Partial Differential Equations', UU, December 20–22: P.W. Hemker.

Working visits

- Department of Mathematics, TUD, Delft, January 20: J.H. van Schuppen.
- Department of Business Mathematics and Informatics, North-West Univ., Potchefstroom, South Africa, January 31–February 20: J.H. van Schuppen.
- Department of Mathematics, Univ. of the Western Cape, Cape Town, South Africa, February 7: J.H. van Schuppen. (Lecture: Stochastic control of pension funds).
- Department of Biochemistry, Univ. Stellenbosch, Stellenbosch, South Africa, February 8: J.H. van Schuppen. (Lecture: Rational positive systems for cell reaction networks).
- Department of Electrical Engineering, Univ. of Pretoria, Pretoria, South Africa, February 16: J.H. van Schuppen. (Lecture: Control and realization of piecewise-affine hybrid systems).
- Department of Electrotechnical Engineering, Free Univ. Brussels, Belgium, March 5: D. Lahaye.
- Dipartimento di Ingegneria Elettrica Industriale, Politecnico Torino, Italy, March 31–April 1 and December 1: D. Lahaye.
- Faculty of Aerospace Engineering, TUD, April 14, August 25, September 6, November 22: B. Koren.
- Department of Engineering, Univ. Cambridge, United Kingdom, April 22: P.J. Collins (Lecture: Continuity and computability of reachable sets).
- FEMLAB, Stockholm, Sweden, May 17: D. Lahaye. (Lecture: Geometry optimization of electromagnetic linear actuators).
- Synapse BV, UM, June 28: P.W. Hemker.
- Department of Control Theory, KTH, Stockholm, Sweden, June 8–10, December 21: H. Härdin (Seminar December 21: Model reduction of biochemical systems).
- MARIN, Wageningen, June 22: B. Koren, J. Wackers (Presentation: Efficient computation of steady water flow).
- STW Utrecht, Meeting about valorization of research results, June 23: B. Koren.
- Internship under supervision of Charles Tong in the Center for Applied Scientific Computing (CASC) at the Lawrence Livermore National Laboratory (LLNL), July 6–September 16, Livermore, CA, USA: D. Echeverría.
- Department of Electrical Engineering, Univ. Cyprus, Nikosia, Cyprus, July 21: J.H. van Schuppen (Lecture: Control of piecewise-affine hybrid systems).
- TUD, Delft Centre for Systems Identification and Control, October 16: M. Petreczky (Presentation: Realization theory for hybrid systems).
- INRIA Sophia-Antipolis, October 23–December 5, Marie Curie Control Training Site Fellow: M. Petreczky.
- Fakultät für Theoretische Mathematik, Univ. Siegen, Germany, October 27: P.J. Collins (Lecture: Continuity and computability in nonlinear systems).
- Department of Mechanical Engineering, TUE, Eindhoven, October 3: M. Petreczky and J.H. van Schuppen; November 7: P.J. Collins (Lecture: Computability of reachable and invariant sets), J.H.van Schuppen (Lecture: Control of piecewise-affine hybrid systems).
- Fakultät für Elektrotechnik, Informatik und Mathematik, Univ. Paderborn, Germany, October 28: P.J. Collins (Lecture: Continuity and computability in nonlinear systems).
- Institute for Electrical Machines, RWTH Aachen Univ., Germany, October 31: D. Lahaye (Lecture: Geometry optimization of electromagnetic linear actuators).
- Institut für Theorie Electromagnetischer Felder, TU Darmstadt, Germany, November 1: D. Lahaye.
- Department of Computer Science, TUE, Eindhoven, November 7: J.H. van Schuppen.

- Department of Applied Mathematics, UT, Enschede, November 17: J.H. van Schuppen.
- IRISA, Rennes, France, December 1–2: J.H. van Schuppen.
- Corus, IJmuiden, December 2: J. Wackers.

Project meetings

- BRICKS project board meeting, CWI, February 25: B. Koren.
- Meeting for the CellMath Project, Nederhemert, February 26–27: H. Härdin.
- Biannual IOP-EMVT meeting. TUE, March 25: D. Echeverría, P.W. Hemker, D. Lahaye.
- Meetings with the EPE research group of TUE related to the IOP-EMVT project Space-Mapping and Related Techniques for Inverse Problems in Magnetic Shape Design, with Application to an Electric Actuator, Amsterdam, on February 28, October 10, December 12, and in Eindhoven, The Netherlands, on February 1 and April 4. D. Echeverría, P.W. Hemker, D. Lahaye.
- Meetings executive committee Delft Centre for Computational Science and Engineering, TUD, March 11, April 21, June 2, August 25, September 22: B. Koren.
- Meetings local organizing committee ECCOMAS 2006 CFD Conference, TUD, April 21, November 3: B. Koren.
- Meeting board of project leaders J.M. Burgers Centre, TUD, May 20: B. Koren.
- Meetings with the research group EM of TUE, related to the IOP-EMVT project Stochastic Methods for Field Computations in EMC Problems, P.W. Hemker (September 11, December 13), D. Lahaye (December 13).
- STW users meeting, STW-project Flight Simulation Models Based on Computational Fluid Dynamics and Flight Test Identification, TUD, October 27: B. Koren.
- Biannual IOP-EMVT meeting, TUD, November 7: D. Echeverría, P.W. Hemker, D. Lahaye.

Other lectures

- MAS Scientific Computing Seminar, CWI, March 15: D. Lahaye (Lecture: Space-mapping applied to a one-dimensional voice-coil actuator problem).
- MAS Scientific Computing Seminar, CWI, June 21: D. Lahaye (Lecture: Sensitivity analysis for PDE constrained optimization problems).
- Presentation about MAS2 for Visiting Committee, CWI, March 24: B. Koren.
- CWI BRICKS Day, Amsterdam, November 29: D. Duchoňová, H. Härdin, P.J. Collins, M. Nool, J.H. van Schuppen (Lecture: Control and system theory for biochemical reaction networks).

Visitors

- G. Hegemans (COMSOL), January 28, February 18, July 7, September 1, October 6, December 9. Host: D. Lahaye.
- A. Almendral (TUD), April 20. (Lecture: Free boundaries and integro-differential equations in finance). Host: B. Koren.
- R.A.W.M. Henkes (Shell Global Solutions, Amsterdam), April 20. (Lecture: Dynamic simulations of oil and gas transport through pipelines). Host: B. Koren.
- J. van der Mullen (TUE), April 20. (Lecture: Modelling plasma dynamics with the PLASIMO-MD2D platform). Host: B. Koren.
- T.L. van Noorden (TUE), April 20. (Lecture: Crystal dissolution and precipitation in porous media). Host: B. Koren.
- J. Rommes (UU), April 20. (Lecture: Generalized eigenvalue problems and purification). Host: B. Koren.
- W.H.A. Schilders (TUE, Philips), April 20. (Lecture: Numerical methods in the electronics industry). Host: B. Koren.
- J.J.W. van der Vegt (UT), April 20. (Lecture: Residual based a posteriori error estimates for edge element discretizations of the time-harmonic Maxwell equations). Host: B. Koren.
- M. Gerritsen (Stanford Univ.), June 10. (Lectures: Coastal ocean modeling and The Pterosaur flight project). Host: B. Koren.
- H. Gluesing-Luerssen (RUG), June 20. (Lecture: The weight adjacency matrix of a convolutional code.) Host: J.H. van Schuppen.
- H. Fouché (North-West Univ., Potchefstroom, South Africa), July 9–12. Host: J.H. van Schuppen.
- J. Delos (College of William and Mary, Williamsburg, VA, USA), July 19–20. (Lecture: Chaos and fractals in the ionization of hydrogen in fields.) Host: P.J. Collins.
- K. Mitchell (Univ. California at Merced, USA), August 15–19. Host: P.J. Collins.

- K.M.T. Helmholt-Kleefsman (RUG), August 29. Host: B. Koren
- X.G. Tielrooy (TUD), August 30 (Lecture: CFD analysis of the aerodynamic properties of the Spyker C8 Spyder sports car). Host: B. Koren
- B. Braams, Emory Univ., Atlanta, Georgia (August 30–September 2, September 19–23, October 3–7). Host: B. Koren.
- P.G. Bakker (TUD), October 10. Host: B. Koren.
- M. van Lent (Philips), October 24. Host: B. Koren.
- G. Lube (Univ. Göttingen, Germany), November 2–5, (Lecture: From wall functions to resolution of boundary layers in incompressible flows). Host: P.W. Hemker.
- E. O'Riordan (Dublin City Univ., Ireland), November 2–5, (Lecture: Solution decompositions for singularly perturbed elliptic problems). Host: P.W. Hemker.
- H.-G. Roos (Univ. Dresden, Germany), November 2–5, (Lecture: Superconvergence in finite element methods on layer adapted meshes). Host: P.W. Hemker.
- M. Stynes (Univ. Cork, Ireland), November 2–5, (Lecture: ELLAM: the Eulerian-Lagrangian local adjoint method for time-dependent convection-diffusion problems). Host: P.W. Hemker.
- L. Tobiska (Univ. Magdeburg, Germany). November 2–5, (Lecture: A new stabilized method for higher order finite elements applied to convection-diffusion problems in 1D). Host: P.W. Hemker.
- G.I. Shishkin (Institute for Mathematics and Mechanics, UBRAS, Ekaterinburg, Russia) November 1–30, (Lecture: Discrete approximations of the solution and derivative for a singularly perturbed parabolic convection-diffusion equation with nonsmooth initial condition). Host: P.W. Hemker.
- L.P. Shishkina (Institute for Mathematics and Mechanics, UBRAS, Ekaterinburg, Russia) November 1–30, (Lecture: A difference scheme of improved accuracy for a quasilinear singularly perturbed elliptic convection-diffusion equation). Host: P.W. Hemker.
- J. Maubach (TUE) (Lecture: On the left/right preconditioning of convection diffusion problems). Host: P.W. Hemker.
- J.J. Sudirham (UT), December 1 (Lecture: Space-time discontinuous Galerkin methods for convection-diffusion problems. Application to wet-chemical etching). Host: P.W. Hemker.

Memberships of committees and other professional activities

P.J. Collins

- Member of Graduate School Dutch Institute for Systems and Control (DISC).

P.W. Hemker

- Full professor Scientific Computing, UvA.
- Member Koninklijke Hollandsche Maatschappij der Wetenschappen.
- Vice-chair Working Group 2.5 on Numerical Software, IFIP.
- Chair Beoordelingcommissie Toegepaste Wiskunde, NWO.
- Member evaluation panel, The Higher Education and Training Awards Council, Ireland, March 30–31.
- Member Numerical Algorithms Group, NAG Inc.
- Editor Computational Methods in Applied Mathematics.
- Member PhD committees D. Vidović, TUD, February 14, H. van der Ploeg, UvA, June 22, J. Kroot, TUE, June 23, I. Hernandez-Ramirez, UT, September 16, J.K. Krottje, UvA, November 17, J.J. Sudirham, UT, December 8.
- Member MSc committee H. van der Weij, UvA, November 23.

B. Koren

- Full professor Computational Fluid Dynamics, TUD, Faculty of Aerospace Engineering.
- Member Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte.
- Senior member American Institute for Aeronautics and Astronautics.
- Member scientific committee and local organizing committee ECCOMAS CFD Conference, Egmond aan Zee, 2006.
- Member executive committee and leader project Computational Aerodynamics, Delft Centre for Computational Science and Engineering.
- Member board of project leaders J.M. Burgers Centre, Research School for Fluid Mechanics.

- Member advisory committee STW-project Flight Simulation Models Based on Computational Fluid Dynamics and Flight Test Identification, TUD, Faculty of Aerospace Engineering.
- Coordinator BRICKS project Scientific Computing (MSV1)
- Member CWI library committee.
- Member jury of FOM programme Turbulence.
- Editor Mathematics and Computers in Simulation.
- Member PhD committees D. Vidovic, TUD, February 14, C. Michler, TUD, June 14, M.E.N. Wisse, TUD, June 21, J.K. Krottje, UvA, November 17, K.M.T. Helmholt-Kleefsman, RUG, November 18, S.P. van der Pijl, TUD, November 22, J.J. Sudirham, UT, December 8, C. Montijn, TUE, December 20.
- Chairman MSc committees E.D. Nennie, TUD, June 2, A. Galvão, TUD, June 9, S. Bosscher, TUD, June 13, G.J.A. Loeven, TUD, December 1. J. Naber, TUD, December 23.
- Member MSc committees T. Verbruggen, TUD, August 31, X.G. Tielrooy, TUD, September 2, P. Noël, TUD, October 29.

M. Nool

- Member CWI library committee.

J.H. van Schuppen

- Full Professor in Applied Analysis at the Department of Mathematics, Faculty of Exact Sciences, VU, since 2000.
- Editor-in-Chief, Mathematics of Control, Signals, and Systems, since 1994.
- Co-Editor of Springer's Communication and Control Engineering Series, Springer Verlag London Ltd., since January 2002.
- Member of the Council of the European Union Control Association, as of September 2003.
- Member of Graduate School Dutch Institute for Systems and Control (DISC).
- Member of Graduate School Thomas Stieltjes Institute of Mathematics.
- Member of the Directorium of the graduate school Bio Centrum Amsterdam (since September 2005).
- Member of the Panel of Experts of the INRIA Program on biology and medicine, April.
- Member of a Visiting Committee of IRISA, December.
- Member of the Evaluation Committee of North-West Univ., Potchefstroom, South Africa.
- Member of an appointment committee of the Department of Electrical Engineering of the University of Cyprus, Nikosia, Cyprus.
- Member of the programme coordination committee of EU.IST.CC project.
- Chairman of the Curatorium of the special chair in mathematical system theory and linear analysis at VU.
- CWI contact person for system biology.
- Member of users committee of the STW project 'Stochastic network analysis for the design of self-optimising cellular mobile communication systems' (TWI.4412), September 12.
- Member of programme committee of the Workshop on Hybrid Systems - Computation and Control, Zürich, Switzerland, March 9–11.
- Member of programme committee of the IFAC World Congress Prague, Czech Republic, July 5–9.
- Associate editor of the European Control Conference/Conference on Decision and Control, Seville, Spain, December.
- Member of the programme committee of the IFAC Symposium System Identification April 2006, Newcastle Australia.
- Member of the programme committee of the International Symposium on the Mathematical Theory of Networks and Systems, Kyoto, Japan, July 24–28.
- Member of the programme committee of the International Workshop on Control of Discrete Event Systems, Ann Arbor, Michigan, July 10–12.
- Member of PhD committee F. Bruggeman, VU, July 1.
- Member of PhD committee S. Strubbe, UT, December 8.

Academic publications

Publications in refereed journals or proceedings

1 Eugene Asarin, Pieter Collins (2005). Noisy Turing Machines. Proceedings of the 32nd International Colloquium on Automata, Languages and Programming, 1031–1042.

2 Pieter Collins (2005). Dynamics of surface diffeomorphisms relative to homoclinic and heteroclinic orbits, Dyn. Syst.x, 19(1), 1–39.

3 Pieter Collins (2005). Forcing Relations for Homoclinic Orbits of the Smale Horseshoe Map, Experiment. Math. 14(1), 75–86.

4 Pieter Collins (2005). Continuity and computability of reachable sets, Theor. Comput. Sci. 341, 162–195.

5 Pieter Collins (2005). Entropy-minimizing models of surface diffeomorphisms relative to homoclinic and heteroclinic orbits, Dyn. Syst. 20(4), 369–400.

6 Pieter Collins (2005). On the Computability of Reachable and Invariant Sets, Proceedings of the 45th IEEE Conference on Decision and Control and the European Control Conference, 4187–4192.

7 Pieter Collins, John Lygeros (2005). Computability of finite-time reachable sets for hybrid systems, Proceedings of the 45th IEEE Conference on Decision and Control and the European Control Conference, 4688–4693.

8 G.F. Duivesteijn, H. Bijl, B. Koren, E.H. van Brummelen (2005). On the adjoint solution of the quasi-1D Euler equations: the effect of boundary conditions and the numerical flux function. International Journal for Numerical Methods in Fluids, 47, 987–993.

9 D. Echeverría, P.W. Hemker (2005). Space mapping and defect correction. Comp. Methods in Appl. Math. 5, 107–136.

10 D. Echeverría, D. Lahaye, L. Encica, P.W. Hemker (2005). Optimization in Electromagnetics with the Space-Mapping Technique. COMPEL 24 (3), 952-966.

11 L.C.G.J.M. Habets, J.H. van Schuppen (2005). Control to facet problems for affine systems on simplices and polytopes - with applications to control of hybrid systems. Proceedings Conference on Decision and Control combined with the European Control Conference, Seville, Spain, 4175–4180.

12 P.W. Hemker, M.H. van Raalte (2005). Two-level multigrid analysis for the convection-diffusion equation discretized by a discontinuous Galerkin method. Numerical Linear Algebra with Applications 12, 563–584.

13 H.C. Hemker, E. De Smedt, P.W. Hemker (2005). During coagulation thrombin generation shifts from chemical to diffusion control. Journal of Thrombosis and Haemostasis 3, 2399–2400.

14 Jan Komenda, Jan H. van Schuppen (2005). Supremal Sublanguages of General Specification Languages Arising in Modular Control of Discrete-Event Systems. Proceedings Conference on Decision and Control combined with the European Control Conference, 2775–2780.

15 Jan Komenda, Jan H. van Schuppen, Benoit Gaudin, Hervé Marchand (2005). Modular supervisory control with general indecomposable specification languages. Proceedings Conference on Decision and Control combined with the European Control Conference, 3474–3479.

16 Jan Komenda, Jan H. van Schuppen (2005). Control of discrete-event systems with partial observations using coalgebra and coinduction. J. Discrete Event Dynamic Systems 15, 257–315.

17 M. Nool, M.J.J. Proot (2005). A parallel least-squares spectral element solver for incompressible flow problems on unstructured grids. Parallel Computing 31, 414–438.

18 Mihaly Petreczky (2005). Realization theory for bilinear hybrid systems. Proceedings 11th IEEE Conference on Methods and Models in Automation and Robotics (CD-ROM).

19 Mihaly Petreczky (2005). Realization theory for bilinear switched systems. Proceedings of 44th IEEE Conference on Decision and Control. (CD-ROM).

20 Jan H. van Schuppen (2005). Realization and control problems for biochemical reaction networks. S. Domek and R. Kaszyński (eds). Proceedings of the 11th International IEEE Conference on Methods and Models of Automation and Robotics (MMAR.2005), 1–4, (CD-ROM).

21 J. Wackers, B. Koren (2005). A fully conservative model for compressible two-fluid flow, International Journal for Numerical Methods in Fluids 47, 1337–1343.

22 J. Wackers, B. Koren (2005). A surface capturing method for the efficient computation of steady water waves. P. Bergan, J. Garcia, E. Onate, T. Kvamsdal (eds). Proceedings of the International Conference on Computational Methods in Marine Engineering (MARINE 2005), 419–428.

23 J.A.S. Witteveen, P.G. Bakker, B. Koren (2005). An improved front tracking method for the Euler equations. Proceedings of the 17th AIAA Computational Fluid Dynamics Conference, AIAA-paper 2005-5335, American Institute of Aeronautics and Astronautics, Reston, VA.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 L. Encica, D. Echeverría, E.A. Lomonova, A.J.A. Vandenput, P.W. Hemker, D. Lahaye (2005). Efficient Optimal Design of Electromagnetic Actuators Using Space-Mapping. Proceedings of the 6th World Congress on Structural and Multidisciplinary Optimization (WCSMO6), paper 5631, 10 pages on CDROM (ISBN: 85-285-0070-5).
2 D. Echeverría, D. Lahaye, L. Encica, E.A. Lomonova, P.W. Hemker, A.J.A. Vandenput (2005). Space-Mapping Applied to Linear Actuator Designs. Proceedings of the 15th Conference on the Computation of Electromagnetic Fields (COMPUMAG2005) III, 18–19.
3 M. Nool, D. Lahaye (2005). The Eggshell Method for Magnetic Field Computations. Proceedings of the FEMLAB Users Conference, 303–308.
4 B. Koren (2005). Hyperbolic and elliptic problems. Lecture notes in course Computational Fluid and Structural Mechanics, Faculty of Aerospace Engineering, TUD.
5 Jan H. van Schuppen (2005). Control and realization of piecewise-affine hybrid systems. Oberwolfach Reports (Oberwolfach Tagung Regelungstheorie).
6 Jan H. van Schuppen (2005). Preface of the book: Chuan Ma and W. Murray Wonham (2005). Nonblocking supervisory control of state tree structures, Lecture Notes in Control and Information Sciences 317, Springer, Berlin, v–vi.

CWI reports

MAS-E0501, MAS-E0502, MAS-E0505, MAS-E0506, MAS-E0514, MAS-E0517, MAS-E0524, MAS-E0533, MAS-E0534, MAS-E0535, MAS-R0502, MAS-R0501.
See B.4 on page 203 for complete titles.

Preprints

1 Jan Komenda, Jan H. van Schuppen (2005). Modular antipermissive control of discrete-event systems. Preprints IFAC World Congress, Pergamon, London (CD-ROM).
2 Kurt R. Rohloff, Jan H. van Schuppen (2005). Approximating minimal communicated event sets for decentralized supervisory control. Preprints IFAC World Congress, Pergamon, London. (CD-ROM).

Other output

Awards

- Van Raalte (former PhD student of Hemker) was awarded the prize for the 'Best PhD thesis in mathematics of the year 2004' by the Stieltjes Institute for Mathematics, for his thesis 'Multigrid Analysis and Embedded Boundary Conditions for Discontinuous Galerkin Discretization'.

Grants

- B. Koren, NCF grant for project Parallel Implementation of a Coupling Interface for Fluid-Structure Interaction. Programmer: M. Nool. Partners: TUD (H. Bijl) and Habanera Numerical Software (E.J. Lingen).
- B. Koren, NCF grant in project for Design of High-Performance Airfoils for Low-Speed Applications. Partner: TUD (A. Dushyn).

Nonlinear Dynamics and Complex Systems – MAS3

Mission

We investigate nonlinear dynamics and pattern formation in spatially extended systems. Mathematically speaking, patterns are generic solutions of (sets of) nonlinear PDEs which appropriately describe many phenomena in nature on a meso- and macroscopic level (cf. MAS1 and MAS2), i.e., on the scales that are directly accessible to human senses and activities. On the methodological side, we concentrate on analytical and numerical solutions mainly of nonlinear PDE's, but also of Monte Carlo models on

a smaller scale and moving boundary approximations on a larger scale, on their hierachical relation in a series of model reductions as well as on their hybrid coupling in computations. Fundamental numerical mathematics research focuses, in particular, on convection-diffusion equations, with emphasis on monotone numerical schemes and grid refinements in space and time. On the application side, we presently concentrate on the initial electric breakdown in sparks and lightning, that is described by reaction-advection-diffusion models coupled to the Poisson equation of electrostatics. Electric breakdown is ubiquitous in nature and technology, but much less investigated than, e.g., the Navier-Stokes equation of fluid dynamics.

Theme leader

Prof.dr. U. Ebert

MSC or CR classification

65, 35, 41, 58, 82, 92

Subthemes

None. W. Hundsdorfer supervises the projects and project aspects concerned with numerical analysis, while U. Ebert is in charge of the aspects of modelling and nonlinear analysis.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. F. Brau	1.0	postdoc	2005-10-01 till 2008-09-31	MAS3
Drs. Li Chao (C. Li)	1.0	PhD student	2005-02-01 till 2009-01-31	MAS3
Prof.dr. U. Ebert	0.8	theme leader	indefinite	MAS3
Dr. W. Hundsdorfer	1.0	project leader	indefinite	MAS3
Dr. A. Luque	1.0	postdoc	2005-08-01 till 2008-07-31	MAS3
Drs. B.J. Meulenbroek	1.0	PhD student	2001-11-01 till 2006-04-30	MAS3
Ir. C.S. Montijn	1.0	PhD student	2001-10-01 till 2006-03-31	MAS3
Drs. V. Savcenco	1.0	PhD student	2004-02-01 till 2008-01-31	MAS3

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Ir. T. Briels (TUE/STW)	0.2	PhD student	2003-05-01 till 2007-05-01	MAS3
Dr. W. Brok (TUE/BRICKS)	0.1	postdoc	2005-11-01 till 2007-10-31	MAS3
Drs. L. Portero (Univ. Navarra)	1.0	PhD student, 4 months' guest	2005-07-01 till 2005-10-31	MAS3

Scientific report

Highlights

- In 2005, three new projects started, a project within the NWO-EW/FOM-programme 'Dynamics of Patterns', a large project within the Open Competitie STW headed by CWI with participance of the faculties of physics and electroengineering of TUE, and the BRICKS-

project. On all three projects, very good collaborators could be hired.

- The PhD projects of Montijn and Meulenbroek have been very fruitful at their final stages delivering an adaptive grid refinement code for pulled streamer fronts and analytical solutions for an intricate moving boundary problem.
- Furthermore, 2005 was a very active year for conference organization, conference participation and presentations for a general public.

PhD students

T. Briels (mainly at TUE)
Li Chao
B.J. Meulenbroek
C.S. Montijn
L. Portero (guest from Univ. Navarra)
V. Savcenco

Project reports

Title	STREAMERS-STW
Period	2004–2008
Leader	U. Ebert
Staff	T. Briels, A. Luque, C.S. Montijn, W. Hundsdorfer
Funding	STW, NWO-RFBR
Partners	E. van Veldhuizen, G.M.W. Kroesen, G. Pemen, B. van Heesch (TUE)

Progress report. In November 2004, a large STW-project on streamer physics was granted. Ebert coordinates the project that takes place at CWI (3 years postdoc Luque) and the departments of physics (oio Briels) and of electroengineering (2 years postdoc Winands) of TUE. Ebert directly supervises the planning and interpretation of experiments of Briels at physics at TUE, and also the modelling and numerical work of Luque at CWI. The supervision of experimental methods is in the hands of E. van Veldhuizen and of numerical methods in the hands of Hundsdorfer. Luque builds on the PhD project of Montijn (see NUMLED). Since his start in August 2005, he has learned the subject, and he has studied numerical strategies to parallelize the solution of the Poisson equation in three spatial dimensions with grid refinement, a very hard problem, and the bottleneck for streamer computations. Furthermore, he has developed an efficient scheme to include photoionization into the model and is busy with the inclusion of nontrivial electrodes. Together with the experimental work of Briels and master student J. Kos in Eindhoven, this should lead to a quantitative comparison of experimental and theoretical results.

In the same scientific context, we also mention the international workshop at the Lorentz Center in Leiden organized by Ebert in May 2005, the workshop at the ICPIG 2005 in July 2005, the Dutch-Russian NWO-RFBR-project on streamers and the EU-COST-action on lightning.

Title	STREAMER-MBA
Period	2001–2008
Leader	U. Ebert
Staff	F. Brau, B. Meulenbroek
Funding	NWO/FOM (Dynamics of Patterns) and CWI

Progress report. In 2005, a proposal within the NWO-EW/FOM-programme 'Dynamics of patterns' was granted. In October, postdoc Brau started on a three years postdoc position within this project. It follows onto the PhD thesis of Meulenbroek that he will defend in April 2006. Major progress could be made on the derivation of a moving boundary approximation for streamer fronts and full analytical solutions of the resulting moving boundary problem. For details I refer to publication 5 in *Phys. Rev. Lett.* and to Meulenbroek's thesis. The work already lead to three invitations to international conferences in 2006, a number of more extended papers are in progress. Brau will, in particular, investigate the moving boundary problem with finite conductivity in the interior of the streamer body.

Title	NUMLED
Period	2001–2006
Leader	W. Hundsdorfer
Staff	C.S. Montijn, U. Ebert
Funding	NWO/FOM (Computational Science)

Progress report. The research in this project is focused on the numerical solution of pulled fronts and streamer propagation for gas discharges (see also project STREAMERS-STW). In a streamer, there are small spatial regions with steep ionization fronts. For a correct numerical solution these regions need fine grids. Standard methods for adaptive grids and local grid refinements, however, are not applicable directly to these problems. This is due to the unstable character of the equations ahead of the fronts.

Fine grids are therefore not only needed in the ionization front itself but also in regions ahead of the front. Another complication is formed by the need for fast Poisson solvers to update the electric fields. For the elecric field and potential different grids are required than for the electron and ion densities.

In this project we have developed a numerical code with grid refinements for the simulation of negative streamers. With this code it has become possible, for the first time, to study streamer development in high and low background fields in detail, and, in particular, to study the onset of branching of the streamer head with a saturation of the branching time using sufficiently fine grids. Furthermore, in 2005, Montijn wrote and successfully defended her PhD thesis.

Title	STREAMERS-MC
Period	2004–2008
Leader	U. Ebert, W. Hundsdorfer
Staff	C. Li
Funding	BRICKS
Partners	W. Broks, J. van der Mullen (TUE) within BRICKS-MSV1

Progress report. Mathematical models for streamer propagation (see also project STREAMERS-STW and NUMLED) can be based on partial differential equations (PDEs) or on particle models. For a proper PDE description one needs fluid assumptions and local field approximations. With particle models the physical descriptions can be much more refined, but simulations of such models by Monte Carlo (MC) techniques are extremely expensive in terms of computer time and memory.

In this project, combinations of PDE models and MC models are studied. The aim is to apply the PDE description in parts of the spatial domain, where the densities are large and the state is near-equilibrium, and to use a particle description in the regions with (very) low densities. Compared to a full particle model, this will involve only a modest number of particles.

In 2005, Monte Carlo techniques for impact ionizations have been examined for 'swarm models' in constant electric fields. A full Monte Carlo model was implemented for planar fronts, allowing detailed studies for energy distributions in the streamer developments. These results, of interest on their own, will be used for the coupling with PDE models.

Title	MRPDE
Period	2004–2008
Leader	W. Hundsdorfer
Staff	V. Savcenco
Funding	NWO-EW Open Competitie

Progress report. In this project, multirate schemes for stiff ordinary differential equations and time-dependent partial differential equations are investigated. With multirate schemes different parts of the spatial domain, or different solution components, are treated with appropriate temporal step sizes, adapted to the local level of activity.

In 2005 a multirate strategy was developed and tested for parabolic model problems in one spatial dimension with fixed spatial grids. The multirate scheme is based on Rosenbrock methods of order two or four. The temporal stepsizes and refinements are based on local error estimates. Good results with significant speedups were obtained for problems with moving fronts.

Spatial refinements have been examined with a regridding after a complete time step. Combination with the multirate approach was not entirely successful so far, mainly due to the large basic time steps that are taken in the scheme, and during these time steps the grid is not adapted. A more taylored approach is to be examined in the future.

Initial experiments with stiff ordinary differential equations, on the other hand, were much more promising. Contacts with Philips (J. ter Maten, A. Verhoeven) will be intensified.

Title	NSADR
Period	Indefinite
Staff	W. Hundsdorfer, J.G. Verwer (MAS1)
Funding	CWI
Partners	S.J. Ruuth (Simon Fraser Univ., Canada)

Progress report. Research cooperation with Ruuth is continued on the analysis and construction of numerical time integration methods with monotonicity or boundedness properties, such as TVD (total variation diminishing) and TVB (total variation boundedness) properties. The research in this project has shown that there are many linear multistep methods that satisfy favourable boundedness properties when com-

bined with starting procedures.

In 2005, there was also cooperation with B. Sommeijer and Pham Thi (MAS1) on a related topic: postivity properties of two-step schemes. These schemes are used in phyto-plankton simulations.

Societal aspects and knowledge transfer

See projects, visits and visitors, and, in particular, the presentations for a general public.

Organization of conferences, workshops, courses, meetings

- MAS Seminars Scientific Computing, tri-weekly seminar, CWI: J. Frank, W. Hundsdorfer, B. Koren.
- CWI Scientific Meetings, bi-monthly general CWI seminar, CWI: S. Bohte, W. Hundsdorfer.
- Colloquium and workshop on 'Polymers and complex matter', `http://top10.physik.uni-freiburg.de/~ferber/LS05/`, in honour of L. Schäfer, Univ. Essen, Germany, January 26: C. von Ferber (Freiburg), U. Ebert.
- International workshop on 'The multiscale nature of spark precursors and high altitude lightning', http://www.lc.leidenuniv.nl/lc/web/2005/20050509/info.php3?wsid=155, Lorentz Center, Leiden, May 9–13: U. Ebert, M. Füllekrug (Bath), P.F. Williams (Nebraska).
- The XXVII'th bi-annual International Conference on Phenomena in Ionized Gases (ICPIG), http://www.icpig2005.nl , Veldhoven, July 17–22: U. Ebert (member organizing committee), and workshop 'Transient phenomena in discharges' within ICPIG 2005: U. Ebert (principal organizer).
- World Year of Physics 2005, http://www.wyp2005.nl, U. Ebert (member of national organizing committee).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Annual meeting NWO Computational Science, Leiden, January 12–13: C. Montijn (Poster: Numerical simulations of negative discharge channels.), W. Hundsdorfer, U. Ebert.
- International Symposium in honour of the 60th birthday of Prof.dr. L. Schäfer, Univ. Essen, Germany, January 26: U. Ebert (Talk: Sparks and high altitude lightning: the dynamics of electric breakdown).
- Kick-off of Graduiertenkolleg Tieftemperatur-Plasmaphysik, Univ. Bochum, Germany, February 21: U. Ebert (Talk: Sparks and high altitude lightning: the dynamics of electric breakdown).
- 17th NNV/CPS symposium for Plasma Physics and Radiation Technology, Lunteren, March 1–2: C. Montijn (Talk: Propagation and branching of negative streamers: a numerical investigation using local uniform grid refinements).
- International Symposium 'Windows to Complexity', Münster, Germany, March 4–6: U. Ebert (Invited talk: The multiscale nature of spark precursors and high altitude lightning).
- DSCE Sympsium (Delft Centre for Computational Science and Engineering), Delft, April 8: C. Li.
- Workshop 'Analysis and Numerics of Kinetic and Hydrodynamic Modelling for the Environment and the Economy', Castiglione della Pescaia, Italy, May 5–7: W. Hundsdorfer (Invited main talk: Monotonicity results for implicit and explicit multistep methods).
- International workshop on 'The multiscale nature of spark prescursors and high altitiude lightning', Lorentz Center, Leiden, May 9–13: U. Ebert (Principal organizer, short introduction: A few remarks on the scales in streamers), T. Briels (Talk: Experimental investigation and nanosecond imaging of streamers), B. Meulenbroek (Talk: Streamer ionization fronts as moving boundaries: analytical results with conformal mapping methods), C. Montijn (Talk: PDE simulations with adaptive grid refinement for negative streamers in nitrogen), F. Brau, W. Hundsdorfer, C. Li, A. Luque.
- SIAM Conference on Applications of Dynamical Systems, Snowbird, Utah, May 22–26: U. Ebert.
- Conference SciCADE05, Nagoya, Japan, May 23–27: W. Hundsdorfer (Invited plenary talk: Monotonicity and boundedness properties of linear multistep methods).

- 21st Biennial Conference on Numerical Analysis, Dundee, Scotland, June 28–July 1: W. Hundsdorfer (Talk: Flux limiting for diffusion equations).
- 27th International conference on phenomena in ionized gases, Veldhoven, July 17–22: U. Ebert (Invited talk: The multiscale nature of streamers: theory and experiment), T. Briels (Poster: Experiments on the diameter of positive streamers in air), C. Montijn (Poster: Adaptive grid simulations of negative streamers in nitrogen in under- and overvolted gaps).
- Summer school on 'Low temperature plasma physics: basics and applications', Bad Honnef, Germany, October 8–13: C. Li.
- NDNS kick-off workshop 'Mathematics of Life Sciences', Groningen, October 10–13: B. Meulenbroek (Talk: A regularized moving boundary problem: solutions and stability), U. Ebert, F. Brau.
- Woudschoten Conference of the Dutch-Flemish Numerical Analysis Communities, October 12–14: W. Hundsdorfer, V. Savcenco (Poster: A multirate time-stepping strategy for PDEs).
- Workshop Dynamic of Patterns, Lorentz Center, Leiden, November 7–11: U. Ebert (Talk: The patterns of growing sparks: some firm answers and many questions), B. Meulenbroek (Poster: A regularized moving boundary problem: solutions and stability), C. Montijn (Poster: Adaptive Grid Simulations of Negative Streamers in Nitrogen), F. Brau.
- NWO-RFBR Workshop on Robust Methods for Singularly Perturbed and Multiscale Problems, Amsterdam, November 3–4: W. Hundsdorfer (Talk: RKC time stepping for advection-diffusion-reaction problems).
- 8th Euroregional workshop on the exploration of low temperature plasma physics, Kerkrade, November 24–25: C. Montijn (Talk: An adaptive grid refinement strategy for the simulation of negative streamers in nitrogen).
- Annual scientific meeting FOM-decemberdagen, Veldhoven, December 13–14: U. Ebert (Talk: Ionization front dynamics: conformal mapping, regularization and exact results), A. Luque and C. Montijn (Poster: Multiscale 3D simulations of spark formation through streamers), C. Li (Poster: Towards hybrid calculations of spark or streamer growth — the Monte Carlo part), F. Brau.

Project meetings

- BRICKS meeting, April 20, CWI: U. Ebert, W. Hundsdorfer, C. Li.
- STW-meeting, TUE, March 10: U. Ebert, T. Briels (Talk: Overview over experimental streamer results) C. Li, C. Montijn.
- Meeting of EU-COST action on Lightning, Brussels, June 24: U. Ebert.
- STW-meeting, TUE, September 30: U. Ebert, F. Brau, T. Briels (Talk: Thick and thin streamers), C. Li, A. Luque, C. Montijn (Talk: Adaptive Grid Simulations of Negative Streamers in Nitrogen).
- NWO-RFBR-project on streamers, visits to Moscow, T. Briels (working visit October 4–25, talk), U. Ebert (working visit October 15–18, Talk: A personal overview on streamer physics),

Other lectures

- W. Hundsdorfer, January 11, MAS Scientific Computing Seminar, CWI: Limiting for Diffusion Discretizations.
- U. Ebert, February 23, Ehrenfest-Kolloquium, UL: Sparks and high altitude lightning: the dynamics of electric breakdown.
- C. Montijn, April 26, MAS Scientific computing seminar, CWI: Adaptive grid simulations of propagating and branching negative streamers.
- V. Savcenco, June 21, MAS Scientific Computing Seminar, CWI: A multirate time-stepping strategy for PDEs.
- V. Savcenco, June 28, Computational Science Seminar, Philips Research Laboratories, Eindhoven: A multirate time-stepping strategy for PDEs.
- U. Ebert, July 5, talk at Sonderforschungsbereich 'Singuläre Phänomene und Skalierung in mathematischen Modellen', Univ. Bonn: The multiscale nature of spark formation: experiments, simulations and an associated regularized free boundary problem with exact solutions
- C. Montijn, November 25, CWI Scientific meeting: Numerical simulations of growing and branching spark channels.

Presentations for a general public

- U. Ebert, April 15, congres van de Nederlandse Vereniging voor Onderwijs in de Natuurwetenschappen (NVON), Wageningen: Vonken en 'opwaartse bliksem': hoe geleidende kanalen groeien en vertakken.
- U. Ebert, April 15, Natuurkundig Gezelschap te Middelburg: Vonken en 'opwaartse bliksem': hoe geleidende kanalen groeien en vertakken.
- U. Ebert, June 10, Jury Techniek Toernooi voor basisscholieren in Het Land van Ooit within World Year of Physics 2005, Den Bosch.
- U. Ebert, C. Montijn, June 15–19: daily presentations with experiments on 'Het geheim van de bliksem' for children from 6 to 12 years at 'Science Unlimited' at Science Museum Nemo, main event of the World Year of Physics 2005 in The Netherlands.
- U. Ebert, September 30, scientific guest of the day with an interview of 20 minutes within Theater ad hoc, gaslab TUE.
- U. Ebert (Lecture: Hoe banen bliksems zich een weg), C. Li, A. Luque, October 22, stand at Open Dag CWI.

Visitors

- L. Portero, Univ. Pública de Navarra, Pamplona, Spain, July 10–October 31. (Talk: Fractional Step Runge-Kutta methods and some of their applications). Host: W. Hundsdorfer.
- G. Derks, Surrey, UK, August 17–24. Host: U. Ebert.
- J.-P. Boeuf and G. Hagelaar, CPAT, Toulouse, December 19–20. (Talk: Low temperature plasmas and applications: some modeling problems). Host: U. Ebert.

Memberships of committees and other professional activities

U. Ebert

- Part-time professor of physics at TUE.
- Member of steering committee of research school 'Centrum voor Plasmafysica en Stralingstechnologie' (CPS).
- Member national organizing committee for the World Year of Physics 2005.
- Member PhD committee Wouter Brok, October 5, TUE.

W. Hundsdorfer

- Member of the NWO programme committee Computational Science.
- Member of the reading and PhD committee Luca Ferracina, September 6, UL.

F. Brau

- Copy editor of Journal of Nonlinear Mathematical Physics.

Academic publications

Publications in refereed journals or proceedings

1 T.M.P. Briels, E.M. van Veldhuizen, U. Ebert (2005). Branching of positive discharge streamers in air at varying pressures, IEEE Trans. Plasma Science 33, 264-265.

2 T.M.P. Briels, E.M. van Veldhuizen, U. Ebert (2005). Experiments on the diameter of positive streamers in air, ref. Proceedings of the XXVII'th Int. Conf. on Phenomena in Ionized Gases (ICPIG) (4 pages).

3 W. Hundsdorfer, S.J. Ruuth (2005). On monotonicity and boundedness properties of linear multistep methods. Math. Comp., E-Pub S0025-5718(05)01794-1.

4 A. Luque, H. Schamel (2005). Electrostatic trapping as a key to the dynamics of plasmas, fluids and other collective systems, Phys. Rep. 415, 261–359.

5 A. Luque, H. Schamel, B. Eliasson, P.K. Shukla (2005). Nonlinear instability and saturation of linearly stable current-carrying pair plasmas, Phys. Plasmas 12, 122307 (6 pages).

6 B. Meulenbroek, U. Ebert, L. Schäfer (2005). Regularization of moving boundaries in a Laplacian field by a mixed Dirichlet-Neumann boundary condition: exact results, Phys. Rev. Lett. 95, 195004 (4 pages).

7 C. Montijn, U. Ebert, W. Hundsdorfer (2005). Adaptive grid simulations of negative streamers in nitrogen in under- and overvolted gaps, ref. Proceedings of the XXVII'th Int. Conf. on Phenomena in Ionized Gases (ICPIG) (5 pages).

8 C. Montijn, B. Meulenbroek, U. Ebert, W. Hundsdorfer (2005). Numerical simulations and conformal mapping analysis of growing and branching negative discharge streamers. IEEE Trans. Plasma Sci. 33, 260–261.

9 S.J. Ruuth, W. Hundsdorfer (2005). High-Order Linear Multistep Methods with General Monotonicity and Boundedness Properties, J. Comput. Physics 209, 226–248.
10 D.D. Sijacic, U. Ebert, I. Rafatov (2005). Oscillations in DC driven 'barrier' discharges: numerical solutions, stability analysis and phase diagram, Phys. Rev. E 71, 066402 (12 pages).
11 E.M. van Veldhuizen, T.M.P. Briels, L.R. Grabowskii, A.J.M. Pemen, U. Ebert (2005). Influences of the pulsed power supply on corona streamer appearance, ref. Proceedings of the 2nd Workshop on Cold Atmospheric Pressure Plasmas: Sources and Applications (CAPPSA) (4 pages).

Publications in other journals or proceedings and other scientific output

CWI reports

MAS-E0511, MAS-E0515, MAS-E0516, MAS-E0521, MAS-E0522, MAS-E0525, MAS-E0526, MAS-E0528, MAS-E0529, MAS-E0530, MAS-E0532.

See B.4 on page 203 for complete titles.

PhD Theses

1 C. Montijn (2005). Evolution of negative streamers in nitrogen: a numerical investigation on adaptive grids, TUE, December 20. Thesis advisor: U. Ebert, co-advisor: W. Hundsdorfer.

Professional products

Publications for a broad audience

1 U. Ebert, F. van der Lijn (2005). Bliksem boven bliksem. Zenit, January, 12–15.
2 M. Persson (2005). Mysteries van omhoog flitsende engelen, Volkskrant, May 7, half a page.
3 U. Ebert (2005). Een gemeenschap voor 'fenomenologische' theorie, opiniestuk in FOMexpres, December.
4 B. van Wayenburg (2005). Bliksem onder de loep, Natuurwetenschap & Techniek 16, June.

Other output

New grants in 2005

- U. Ebert, 3 years postdoc project within NWO-EW/FOM-programme 'Dynamics of Patterns'.
- U. Ebert/MAS3, member NWO-wiskunde cluster 'Nonlinear Dynamics of Natural Systems'.
- U. Ebert, member EU-COST-action on Lightning.

INFORMATION SYSTEMS

Principal research area and mission

The research activities are focused on various aspects of information systems: From theory inspired investigation into the nature of new computing paradigms; prototyping novel visualization techniques on concrete applications and devices; methods and models for narrative story telling over multimedia stores, to management of large multimedia datastores with probabilistic query processing features.

All research activities seek a balance between application inspired problems, the accompanying software architectures and experimentation, and the scientific modelling and analysis of the solutions invented.

An important output of the work in this cluster is the development of prototypes for demonstrating and experimenting with solutions. Many of these prototypes are used by affiliated research groups, find their way through partners in (inter)national consortia, and can be picked up from the open-source software repositories. The policy regarding their construction is to develop them up to the point that real applications can be built and exercised.

The themes foster transfer of research to its business liaisons. In INS1, and INS2 this is largely formalized in the context of the MultimediaN and Token program. Another important outlet of the knowledge acquired is through active participation in International Standardization committees as organized in the context of the World Wide Web Consortium (W3C). The work in INS3 is multidisciplinary and highly experimentally driven research taken place in the context of large programs such as VLE and NWO grants. Fundamental research in INS1 and INS4 are funded through the Bricks program, EU projects and personal grants. In 2005 we set steps to spin-off a company to market and sell the Personal Space Station developed in recent years in INS3.

Some highlights of 2005 include major software distributions in the public scene, recognition of personal science potential with a Veni, Vidi, Vici grant accumulated in a single group, and enlarged external visibility in the public media.

The INS senior researchers participate in the National Research Schools (ASCI, SIKS, OzsL, IPA), broadly disseminate their research results in the international scene, and hold faculty positions at universities.

Cluster staff

Name	Fte	Function
Prof.dr. M.L. Kersten	0.2	Cluster leader
M.W.A. Hegt	0.7	Secretary

Research themes

Name		Leader
INS0	Standardization and Knowledge Transfer	Prof.dr. M.L. Kersten
INS1	Database Architectures and Information Access	Prof.dr. M.L. Kersten
INS2	Multimedia and Human-Computer Interaction	Prof.dr. H.L. Hardman
INS3	Visualization and 3D Interfaces	Prof.dr.ir. R. van Liere
INS4	Quantum Computing and Advanced Systems Research	Prof.dr. H.M. Buhrman

Standardization and Knowledge Transfer – INS0

Mission

The mission of the group is to stimulate dissemination and take-up scientific results through concerted actions with e.g., standardization committees.

Theme leader

Prof.dr. M.L. Kersten

MSC or CR classification

H5, 68T30, 68T50, I.2.3, I.2.4, I.2.7, F.3.1, F.3.2, F.4.1, F.4.2, D.2.11, H.1.2, H.2.4, H.2, E.1, E.5

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. I. Herman	1.0	researcher	indefinite	W3C activities
Prof.dr. M.L. Kersten	p.m	theme leader	indefinite	INS0
S. Pemberton	1.0	researcher	indefinite	W3C activities

Lectures, conferences, courses, project meetings, working visits

Lectures

- A Decade of Webdesign, Amsterdam, January 21: S. Pemberton (Invited Talk: Ineluctable Modality of the Visible).
- Semantic Web Seminar organized by the W3C Benelux Office and ISOC Belgium, Antwerpen, Belgium, February 16: I. Herman (Tutorial: Semantic Web Technologies).
- W3C Technical Plenary, Boston, MA, USA, March 3: S. Pemberton (Talk: Revolution or Evolution).
- Web3D2005 Symposium, Bangor, Wales, UK, March 29: I. Herman (with D.A. Duce and F.R.A. Hopgood, Oxford Brooks Univ., UK) (Tutorial on SVG).
- Semantic Web Symposium, Hong Kong, China, April 12: I. Herman (Tutorial on Semantic Web Technologies).
- W3C Technology Forum in Gouagzhou, China, April 14: I. Herman (Tutorial on Semantic Web Technologies).
- Sankt Augustin, Germany, April 19: S. Pemberton (XHTML2 and XForms).
- The 14th International World Wide Web Conference (WWW2005), Chiba, Japan, May 13: S. Pemberton (with Mark Birbeck) (Talk: The Semantic Browser: Improving the User Experience).
- WWW 2005 Developers' Day, Chiba, Japan, May 14: S. Pemberton (with TV Raman) (Talk: XHTML2 and XForms).
- XTech2005 Conference, Amsterdam, May 24: I. Herman (Tutorial on Semantic Web Technologies).
- News Standards Summit 2005, Amsterdam, May 24: S. Pemberton (Keynote: Metadata in XHTML2).
- XTech 2005, Amsterdam, May 26: S. Pemberton (with Mark Birbeck) (Talk: XHTML2: Accessible, Usable, Device Independent and Semantic).
- 40th Annual General Meeting of the International Press Telecommunications Council, London, UK, June 7: S. Pemberton (Invited talk: Metadata in XHTML2).
- W3C Semantic Web Day, Vienna, Austria, June 20: I. Herman (Keynote: Questions (and Answers) on the Semantic Web).
- EuroPython 2005, Göteborg, Sweden, June 28: S. Pemberton (Keynote: Hypothesis: Programmers are Humans too).
- The First Euro Conference on Mobile Government, Brighton, UK, July 10: S. Pemberton (Talk: W3C XForms: improving the user experience with accessible, device-independent e-forms).

- Interact 2005, Rome, Italy, September 16: S. Pemberton (Keynote: The Future of Web Interfaces).
- W3C Benelux and ISOC Belgium, Antwerp, Belgium, October 3: S. Pemberton (Tutorial: XHTML and XForms).
- Semantic Web Days, München, Germany, October 10: I. Herman (Keynote: Questions (and Answers) on the Semantic Web).
- W3C Germany and Austria, Munich, Germany, October 21: S. Pemberton (Tutorial: XHTML and XForms).
- User Experience 2005, Boston, USA, 27–28 October; London, UK, November 17–: S. Pemberton (Tutorials: Styling the New Web Advanced CSS Design).
- International Conference/Workshop on Web Technologies, New Delhi, India, November 10: I. Herman (Talk: Introduction to SVG); November 11: I. Herman (Tutorial: Semantic Web
- Fundamentos Web 2005 (Web Foundations 2005), Gijon, Asturias, Spain, November 24: S. Pemberton (Invited talk: Usability, Accessibility and Markup Languages).
- Fundamentos Web 2005 (Web Foundations 2005), Oviedo, Asturias, Spain, November 25: S. Pemberton (Tutorial: XHTML and XForms).
- W3C Advisory Committee Meeting, Montréal, Canada, December 1: S. Pemberton (Talk: The Power of Declarative Thinking).
- 2nd Italian Semantic Web Workshop on Semantic Web Applications and Perspectives (SWAP 2005), Trento, Italy, December 14: I. Herman (Tutorial: Introduction to the Semantic Web).

Visits to Conferences, Workshops, Symposia

- A Decade of Webdesign, Amsterdam, January 21–22: S. Pemberton.
- Semantic Web Symposium, Hong Kong, China, April 12: I. Herman.
- W3C Technology Forum, Gouagzhou, China, April 14: I. Herman.
- The 14th International World Wide Web Conference (WWW2005), Chiba, Japan, May 10–13: I. Herman, S. Pemberton.
- WWW 2005 Developers' Day, Chiba, Japan, May 14: S. Pemberton.
- News Standards Summit 2005, Amsterdam, May 24: S. Pemberton.
- XTech 2005, Amsterdam, (with Mark Birbeck), May 25–27: I. Herman, S. Pemberton.
- 40th Annual General Meeting of the International Press Telecommunications Council, London, June 7: S. Pemberton.
- EuroPython 2005, Goeteborg, Sweden, June 27–29: S. Pemberton.
- The First Euro Conference on Mobile Government, Brighton, UK, July 10–12: S. Pemberton.
- Interact 2005, Rome, Italy, September 14–16: S. Pemberton.
- Semantic Web Days, in Munchen, Germany, October 10–12: I. Herman:
- User Experience 2005, Boston, USA, October 27, and London, UK, November 17: S. Pemberton.
- International Conference/Workshop on Web Technologies, Delhi, India, November 10–11: I. Herman.
- Fundamentos Web 2005 (Web Foundations 2005), Oviedo, Asturias, Spain, November 22–23: S. Pemberton.
- 2nd Italian Semantic Web Workshop on Semantic Web Applications and Perspectives (SWAP 2005), Trento, Italy, December 14–17: I. Herman.

Project meetings

- W3C Offices' face-to-face meeting, Sophia Antipolis, France, January 10–12: I. Herman.
- W3C Technical Plenary, Boston, USA, March 3: I. Herman, S. Pemberton.
- IW3C2 Conference Commitee meeting, Chiba, Japan, May: I. Herman.
- W3C Advisory Committee Meeting, Mandelieu, France, June: I. Herman.
- IW3C2 Conference Commitee meeting, Calgary, Canada, October: I. Herman.
- W3C Advisory Committee Meeting, Montréal, Canada, December: I. Herman, S. Pemberton.
- HTML Working Group face-to-face, Boston, MA, USA, March 3–4: S. Pemberton.
- HTML Working Group face-to-face, Amsterdam, June 13–15: S. Pemberton.
- HTML Working Group face-to-face, Raleigh, NC, USA, September 6–8: S. Pemberton.
- HTML Working Group face-to-face, Antwerp, Belgium, November 7-9: S. Pemberton.

- XForms Working Group face-to-face, Cambridge, MA, USA, February 28–March 1: S. Pemberton
- XForms Working Group face-to-face, Amsterdam, June 15–17: S. Pemberton.
- XForms Working Group face-to-face, Raleigh, NC, USA, September 8–10: S. Pemberton
- XForms Working Group face-to-face, Antwerp, Belgium, November 9–11: S. Pemberton.

Memberships of committees and other professional activities

I. Herman

- Member of International World Wide Web Conference Committee (IW3C2).
- Member of the editorial board of the journal Computer Graphics Forum.
- Member of the industrial track programme committee of the 4th International Semantic Web Conference 2005 (ISWC2005).
- Reviewer for the web programme (Technical Track) of SIGGRAPH 2005.
- Member of the international programme committee of the SVGOpen 2005 Conference, Enschede, the Netherlands.
- Reviewer (on behalf of the European Commission) of the EU 5th Framework Projects SPIRIT, SCULPTEUR, and SPACEMANTIX.
- International programme committee member of the 2nd Italian Semantic Web Workshop 2005 (SWAP 2005).
- Board member of the foundation 'Stichting Bartiméus Accessibility'.
- Member of the subcommittee on Electronic Publishing of the European Mathematical Society (EMS).
- Member of the IFIP TC6 Working group on Internet Applications Engineering.

S. Pemberton

- Editorial board member, ACM/interactions.
- Chair, W3C HTML Working Group.
- Chair, W3C Forms Working Group.
- Programme committee member, XTech 2005
- Programme committee member, Advanced Visual Interfaces, AVI 2006

Academic publications

Publications in refereed journals or proceedings

1 D.J. Duke, K.W. Brodlie, D.A. Duce, I. Herman (2005). Do You See What I Mean? IEEE Computer Graphics and Applications, 25(3), 6–9.

Publications in other journals or proceeeding and other scientific output

Technical reports published elsewhere

1 Steven Pemberton, Masayasu Ishikawa (eds) (2005). W3C XFrames, `http://www.w3.org/TR/2005/WD-xframes-20051012`.

Software developed

1 I. Herman (2005). sparql-p, a SPARQL API implementation for the Python RDF Environment RDFLib.

Professional products

Publications for a broad audience

1 ABC Programmer's Handbook, L. Geurts, L. Meertens, S. Pemberton, Bosko Books, ISBN 0954723945 (republished in 2005).

Database Architectures and Information Access – INS1

Mission

The work carried out in the research team INS1 is focused on bridging the gap between database architectures developed for applications in a peer-2-peer (P2P) setting and the need to scale algorithms for multimedia information retrieval beyond a few thousand elements. Such a multidisciplinary approach is considered pivotal to make progress in both scientific fields.

The research line on multimedia information retrieval aims at developing a multimedia database system, which can offer a high level of abstraction to both developers of end-user applications and researchers working on content analysis techniques. At the core of such a system we envision a sound and flexible probabilistic model to steer the retrieval process, integrated with query optimise's and ker-

nel functionality.

The advanced database architectures research thread is focused on the key challenges posed by P2P networks as a platform for distributed and heterogeneous datamanagement. This involves research in all architectural components of a contemporary DBMS to assess, enrich, or replace it to cope with the ad-hoc nature of said networks. A key scientific challenge is to find the proper balance between theoretical optimal solutions in the context of hard resource limitations and application demands.

Both research lines are supported by activities geared at bridging the technology gap itself using our MonetDB experimentation platform. This involves research into novel ways (algorithms, datastructures and software stack) to exploit the potential power of custom hardware and research in query optimisation (language specific, adaptive, cost-models) to achieve a more modular solution. The system is widely distributed to provide others a sound and modern database platform, but also to import user experiences on the choices made.

Theme leader

Prof.dr. M.L. Kersten

MSC or CR classification

H.3.1, H.3.3, H.2.4, H.2, E.1, E.5, H.2.8, I.1.5

Subthemes

Name	Leader
INS1.1 – Multimedia Databases	A.P. de Vries
INS1.2 – Database Architectures	P.A. Boncz
INS1.3 – Query Languages & Optimisation	S. Manegold
INS1.4 – MonetDB Dissemination	N.J. Nes
INS1.5 – Organic Database Architectures	M.L. Kersten

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. A.R. van Ballegooij	1.0	PhD student	1999-10-01 till 2005-09-30	INS1.1
Dr. P.A. Boncz	1.0	researcher, leader INS1.2	indefinite	INS1.2; INS1.3; INS1.4
R. Cornacchia, MSc	1.0	PhD student	2003-10-01 till 2007-09-30	INS1.1
Drs. F. Groffen	1.0	PhD student	2004-09-01 till 2008-08-31	INS1.5
Drs. S. Héman	0.7	PhD student	2005-06-01 till 2009-05-31	INS1.2
S. Idreos, MSc	0.25	PhD student	2005-10-01 till 2009-09-30	INS1.5
Prof.dr. M.L. Kersten	0.6	theme leader	indefinite	INS1.1; INS1.2; INS1.3; INS1.4; INS1.5
Dr. S. Manegold	1.0	researcher, leader INS1.3	indefinite	INS1.2; INS1.3; INS1.4; INS1.5
Drs. K.S. Mullender	1.0	programmer	indefinite	INS1.3; INS1.4

continued on next page

continuation from previous page

Dr. N.J. Nes	1.0	researcher, leader INS1.4	indefinite	INS1.2; INS1.3; INS1.4; INS1.5
G. Ramírez i Camps, MSc	1.0	PhD student	2003-01-01 till 2007-02-28	INS1.1
Dr.ir. A.P. de Vries	1.0	researcher, leader INS1.1	indefinite	INS1.1
Dr.ir. T.H.W. Westerveld	1.0	postdoc	2002-09-01 till 2007-08-31	INS1.1
Drs. Y. Zhang	0.9	PhD student	2005-02-01 till 2009-01-31	INS1.2
M. Zukowski, MSc	1.0	PhD student	2003-11-01 till 2007-10-31	INS1.2

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
W. Alink (UvA)	0.75	MSc student	2005-02-01 till 2005-10-31	INS1.3
S. Héman (UvA)	0.4	MSc student	2004-09-01 till 2005-06-01	INS1.2
Prof.dr. A.P.J.M. Siebes (UU)	1.0	advisor	indefinite	

Scientific report

Highlights

The first official MonetDB/XQuery version on SourceForge was realized, generating several thousands of downloads and an increased international developers team. We contributed to the database community by leading the database core-track of VLDB 2005.

PhD students

A.R. van Ballegooij
R. Cornacchia
F. Groffen
S. Héman
S. Idreos
G. Ramírez i Camps
Y. Zhang
M. Zukowski

INS1.1 – Multimedia Databases

Title	MASE: Multimedia Access by Sense and Expression
Period	1999–2003
Leader	A.P. de Vries
Staff	A.P. de Vries, M.L. Kersten, A.R. van Ballegooij G. Ramírez i Camps, R. Cornacchia
Funding	MultimediaN
Partners	CTIT, UvA, Philips Research, Data Distilleries

Progress report. The Multimedia Information Retrieval research is carried out in the context of the MultimediaN N5 (semantic access) and CIRQUID projects. Ongoing research with M. van Doorn (Philips Research) has resulted in a publication on ambient narratives.

Title	MultimediaN N5 (semantic access)
Period	July 2004–June 2008
Leader	A.P. de Vries
Staff	A.P. de Vries, T.H.W. Westerveld, A.R. van Ballegooij, R. Cornacchia
Funding	Bsik
Partners	CTIT, UvA, Van Dale, Beeld en Geluid

Progress report. MultimediaN project N5 develops a parameterised search engine generator, for which we bring together our experience in video retrieval, XML-IR, and integration of information retrieval and databases. The group participates on a regular basis in international information retrieval benchmark activities, and this year's experiments for TREC, TRECVID, and INEX have all been performed using an early prototype, demonstrating feasibility of such an integration of databases and information retrieval.

Cornacchia and De Vries have extended our current approach to array processing in databases (relational array management, RAM) to handle sparse arrays, providing a runtime environment for retrieval models expressed in

Roelleke et al.'s Matrix Framework for information retrieval. Early results will be published as a poster at ECIR 2006. Westerveld and Cornacchia have integrated the dense array processing system with the scored region algebra back-end, to enable joint image and text retrieval for the INEX evaluation (using the Lonely Planet collection).

De Vries has worked together with T. Roelleke (QMUL) to derive new instantiations of the classic probabilistic model of IR, resulting in a SIGIR publication on improved effectiveness obtained by using a different estimation for the inverse document frequency. This led to a visit to MSRC.

Title	CIRQUID
Period	June 2003–December 2007
Leader	A.P. de Vries
Staff	A.P. de Vries, G. Ramírez i Camps
Funding	NWO
Partner	CTIT

Progress report. The CIRQUID project (Complex Information Retrieval Queries in a Database) researches the integration of databases and information retrieval to improve structured document retrieval. The CIRQUID research contributes heavily to the foundations of the Semantic Access project. Ramírez and de Vries have concentrated on the different strategies of using structure to improve information retrieval effectiveness. Ramírez published her PhD research proposal at the ECDL doctoral consortium, and preliminary experiments on a corpus of IEEE documents at the SIGIR workshop on context in IR. Results on structural relevance feedback have been published at CIKM.

INS1.2 – Database Architectures

Title	X100
Period	February 2002–2008
Leader	P.A. Boncz
Staff	P.A. Boncz, M.L. Kersten, M. Zukowski, N.J. Nes, S. Manegold, S. Héman
Funding	MultimediaN
Partners	SPSS, Textkernel B.V.

Progress report. The X100 project seeks to evolve the MonetDB system to better support intensive analysis applications (such as video retrieval) on massive data volumes. It falls in line with our multi-year goal to improve database processing on modern hardware (e.g., exploiting CPU caches, generating high IPC code for deeply pipelined super-scalar CPUs).

Zukowski made good progress by publishing two papers (one at the CIDR conference, one invited at the DEBULL journal) on the X100 project, as well as successfully present his PhD project at two PhD forums (at BNCOD and VLDB). He then expanded his network and capabilities during a three-month visit at Microsoft SQLserver database group.

Héman finished his MSc project on Super-Scalar RAM-CPU Cache Compression. Left-over funds from the MultimediaN project allowed the group to hire him on-the-spot as a PhD student. His work on CPU conscious database compression directly resulted in a publication at the IEEE ICDE Conference.

The research relationship with SPSS Amsterdam (formerly known as Data Distilleries) was formalized in MultimediaN by CWI, MultimediaN, and SPSS signing of a first-user contract. Similar contacts were established with the Dutch technology firm Textkernel B.V. that delivers high-performance IR solutions.

INS1.3 – AmbientDB & XQuery & Optimisation

Title	Pathfinder
Period	2004–2008
Leader	S. Manegold
Staff	P.A. Boncz, S. Manegold, K.S. Mullender, N.J. Nes, Y. Zhang, W. Alink
Funding	MultimediaN
Partners	TU Munich, UT, UvA, NFI

Progress report. The successful cooperation with the Univ. Konstanz database research group (which re-located to Technical Univ. Munich) on the Pathfinder XQuery compiler on top of MonetDB was continued and led to a major open-source release of MonetDB/XQuery. Its ability to translate the XQuery language into optimized relational algebra provides this CWI open-source system with a strong performance lead on all other currently available XQuery systems.

In 2005 the decision to re-align the AmbientDB project to use MonetDB/XQuery technology (rather than X100, above) was made. It was done so because of the previously unanticipated success of MonetDB/XQuery, combined with

the advantages of using web-standards (such as W3C XQuery and XML) in constructing P2P systems on a WAN scale (e.g., better support for heterogeneous computing environments).

Finally, we started using XML databases, in particular XML annotations. This work was triggered by Alink (UT MSc student, co-advised by De Vries) at the Dutch forensic institute NFI. At NFI, a wide array of hard-disk and file analysis tools are used to annotate confiscated hard disk data with derived metadata. Such annotations provide multiple metadata views on the underlying data, which do not necessarily form a strict hierarchy, rather a forest of hierarchies correlated by byte offsets. Alink showed that NFI's need for a technology to query this diverse metadata in a uniform data management framework, could be provided by MonetDB/XQuery extended with a number of new XPath steps that allow to traverse hierarchy forests. Similar multi-hierarchy annotation problems also arise in multimedia analysis (e.g., video scene detection, speech recognition), as well as natural language processing (multiple potential parse trees), and spawned a cooperation with the NLP group at UvA (Prof. de Rijke), as well as a followup research proposal with NFI.

INS1.4 – MonetDB Dissemination

Title	MonetDB
Period	1993–indefinite
Leader	N.J. Nes
Staff	M.L. Kersten, P.A. Boncz, S. Manegold, K.S. Mullender, F. Groffen
Funding	MultimediaN
Partners	UT, SPSS, UMass Amherst, TU Munich

Progress report. Nes visited ASTRON during the summer to investigate opportunities for deployment of MonetDB in the context of LOFAR. Two astronomical surveys, NVSS (NRAO VLA Sky Survey) and WENSS (Westerbork Northern Sky Survey) were identified for such a project. For this exercise the FITS module has been added to MonetDB.

During the fall we participated in the c't Magazine benchmark for database systems. This experiment uncovered quite a number of weaknesses in the handling of client-server interaction. They have led to a redesign and implementation of both the SQL catalogue management part and the application interface libraries.

The responsibilities for code-maintenance and improvement are shared by the members of the group with Nes responsible for SQL and kernel, Manegold took care of automatic testing and XQuery kernel support, Mullender maintains ODBC and took care of portability to Windows platforms, Groffen acted as first-line end-user support and maintains the JDBC. Boncz, Kersten worked on various components in preparation of MonetDB/x100 and MonetDB/Five.

The MonetDB source code is available from sourceforge.net and a large number of RPM mirrors. In 2005 there were around 7000 downloads from SourceForge alone.

INS1.5 – Organic Database Architectures

Title	Databases for personalized ubiquitous intelligent devices
Period	2004–2008
Leader	M.L. Kersten
Staff	S. Manegold, N.J. Nes, F. Groffen, S. Idreos
Funding	BRICKS/IS1 and BRICKS/IS2
Partners	UU, UT

Progress report. Within the context of the Bsik/BRICKS the project on organic database architectures is finally getting of the ground. Kersten published the preliminary results of adaptive storage management, called *cracking*, based on the hypothesis that index maintenance can (and should be) based on actual query use.

Groffen and Idreos have been hired as PhD students. Groffen, Manegold and Kersten studied the data distribution aspects amongst autonomous sources, which has led to a first model for distributed data managements based on data block lineage. Idreos is challenged to find novel ways to break database queries into meaningful pieces to enable incremental execution in a distributed setting.

MonetDB/Five is the main vehicle foreseen to support this research line. In 2005, Groffen realized the JDBC module, and Nes finalized the SQL compiler.

Kersten spent six weeks at Microsoft Research (Seattle) on pursuing the development of a benchmark suite for measuring the capabilities of a database system on query sequences.

Societal aspects and knowledge transfer

- Consultation meetings on modern database technology with NedStat from June till August: M.L. Kersten, A.P.J.M. Siebes.
- Weekly scientific meetings of the sub-groups: A.P. de Vries, P.A. Boncz.

External contacts

- Research advisor M. van Doorn, Philips Natlab: A.P. de Vries.
- Research advisor A. Sinitsyn, Philips Natlab: P.A. Boncz.

Projects with partners in public and private sector

- AmbientDB; see `http://homepages.cwi.nl/~boncz/ambientdb.html`
- CIRQUID; see page 162.
- MonetDB; see `http://monetdb.cwi.nl`.

Teaching at university

- MSc Course Advanced Database Techniques, UvA: M.L. Kersten.
- Course Database Techniques, UvA: P.A. Boncz, S. Manegold.
- MSc Course IN4144, Multimedia Data Management, TUD: A.P. de Vries.
- MSc Course Information Retrieval, UT: A.P. de Vries (2 lectures).

Courses, tutorials

- Siks Basic Course, Information Retrieval: A.P. de Vries (1 lecture).

Spin-offs

The research is conducted in close cooperation with groups abroad, e.g., Univ. Massachusetts, Amherst (USA), Technical Univ. Munich (Germany), UT, Philips Research, and SPSS.

Organization of conferences, workshops, courses, meetings

- First International Workshop on Data Management on New Hardware (DaMoN 2005), Baltimore, MD, USA, June 12: A. Ailamaki (CMU), P.A. Boncz, S. Manegold.
- ICME 2005, Amsterdam, July 6–8: M.L. Kersten (Local organizing chair).
- 31th Conference on Very Large Databases, chairman Core-database track, Trondheim, Norway, Augustus 30–September 2: M.L. Kersten.
- Dutch-Belgian Database Day, CWI, October 30: P.A. Boncz, M. van Keulen.
- MultimediaN AmbientDB Workshop, CWI, November 1: P.A. Boncz, M. van Keulen (UT).
- MRE workshop, CWI, November 24: T.H.W. Westerveld, A.P. de Vries, F. de Jong (UT).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- CIDR 2005, Asilomar (USA), January 4–7: P.A. Boncz, M. Zukowski (Talk: MonetDB/X100: Hyper-Pipelining Query Execution), M.L. Kersten (Talk: Cracking a Database Store).
- Dutch Information Retrieval, January 10–11, Utrecht: A.P. de Vries, G. Ramírez i Camps, T.H.W. Westerveld.
- Multimedia Research: where do we need to go tomorrow, Schloss Dagstuhl, Wadern, Germany, March 1–4: A.P. de Vries (Talk: Multimedia Retrieval is 'just' IR).
- Database Congres 2005, Leiden, March 10–11: M.L. Kersten (Talk: Some Dutch Database Technology).
- DELOS workshop 'Future Digital Library Management Systems (System Architecture & Information Access)', Schloss Dagstuhl, Wadern, Germany, March 29–April 1: F. Groffen, S. Manegold.
- ICDE Conference Tokyo (Japan), April 5–8: M.L. Kersten (Panel: Paradigm Shift to New DBMS Architectures: Research Issues and Market Needs).
- An Event to Celebrate the 70th Year of Karen Spärck Jones, Cambridge, UK, April 5: A.P. de Vries.
- Holland Open Software Conference, Amsterdam, May 31: M.L. Kersten, S. Manegold (Talk: MonetDB/XQuery: A scalable open-source XQuery processor).
- Simply 4U, Delft, June 3: A.P. de Vries (Invited talk: Multimedia Retrieval is 'just' Information Retrieval!).

- XIME-P workshop, Baltimore (USA), June 18: S. Manegold (Talk: Purely Relational FLWORs),

  P.A. Boncz (Talk: Updating the Pre/Post Plane in MonetDB/XQuery).
- ICME, Amsterdam, July 5–8: M.L. Kersten, T.H.W. Westerveld, A.P. de Vries, S. Manegold, P.A. Boncz (Demos: BOND: Branch and Bound on Decomposed Data and MonetDB/XQuery).
- BNCOD Doctoral Consortium, Sunderland (UK), July 7: M. Zukowski (Talk: Improving I/O Bandwidth for Data-Intensive Applications).
- IR Theory Workshop, Glasgow, UK, July 25: A.P. de Vries (Invited talk: IR Models in Multimedia and Other Applications).
- ESF Exploratory Workshop on IR in Context (IRiX), Glasgow, UK, July 26–27: A.P. de Vries.
- AMR, Jul 28–29, Glasgow, UK, July 28–29: A.P. de Vries, T.H.W. Westerveld (Talk: Surface Features in Video Retrieval).
- INEX 2005 Workshop on Element Retrieval Methodology, Glasgow, UK, July 30: A.P. de Vries, T.H.W. Westerveld.
- What the Hack Conference 2005, Liempde, the Netherlands, August 8: S. Héman (Talk: Database Compression Between RAM and CPU-Cache — Hacking the Memory Hierarchy).
- ACM SIGIR'05, Salvador, Brazil, August 15–18: A.P. de Vries (Talk: Relevance Information: A Loss of Entropy but a Gain for IDF?), G. Ramírez i Camps, T.H.W. Westerveld.
- SIGIR Workshop IRiX 2005, Salvador, Brazil, August 19: G. Ramírez i Camps.
- SIGIR Workshop MMIR , Salvador, Brazil, August 19: T.H.W. Westerveld (Talk: TRECVID as a Re-Usable Test-Collection for Video Retrieval).
- Electra workshop, Salvador, Brazil, August 19: A.P. de Vries.
- DEXA 2005, Copenhagen, Denmark, August 22–26: R. Cornacchia (Talk: Distribution Rules for Array Database Queries).
- ECDL'05 and ECDL'05 Doctoral Symposium , Vienna, Austria, September 19–21: G. Ramírez (Talk: Search Tasks and Strategies in Structured Information Retrieval).
- VLDB 2006, Trondheim, Norway, August 30–September 2: M.L. Kersten, S. Idreos.
- VLDB 2006 PhD Workshop, Trondheim, Norway, August 29: M. Zukowski (Talk: Hardware-Conscious DBMS Architecture for Data-Intensive Applications).
- Dagstuhl 'workshop Data always and everywhere: management of mobile, ubiquitous, pervasive and sensor data', Schloss Dagstuhl, Wadern, Germany, October 17–20: M.L. Kersten (Talk: MonetDB/Datacell Database Technology for The Ambient Home), P.A. Boncz (Talk: AmbientDB: database middleware for ubiquitous computing).
- CIKM'05, Bremen, Germany, October 31–November 5: G. Ramírez i Camps, (Poster: Structural Features in Content-Oriented XML Retrieval).
- DBDBD, Amsterdam, October 31: S. Héman (Talk: Super-scalar Database Compression between RAM and CPU Cache), W. Alink (Talk: XIRAF — an XML-IR Approach to digital Forensics).
- AmbientDB workshop, Amsterdam, November 1: All, Y. Zhang (Talk: P2P Query processing on top of MonetDB/XQuery), S. Manegold (Talk: MonetDB/XQuery — Consistent Efficient Updates on the Pre/Post Plane).
- TRECVID 2005, NIST, Gaithersburg MA, USA November 14–15: A.P. de Vries.
- TREC 2005, NIST, Gaithersburg MA, USA, November 16–18: A.P. de Vries.
- Astrowise workshop, Leiden, November 16: M.L. Kersten, N.J. Nes.
- INEX 2005, Schloss Dagstuhl, Wadern, Germany, November 28–30: A.P. de Vries (Talk: Entity Ranking in INEX), G. Ramírez i Camps (Talk: TIJAH Scratches INEX 2005: Vague Element Selection, Overlap, Image Search, Relevance Feedback, and Users), T.H.W. Westerveld (Talk: MM Track Discussion).
- CWI Scientific meeting, November 25: T.H.W. Westerveld (Talk: Generative probabilistic models for multimedia retrieval).
- Nationaal Innovatie Event, Maarsen, December 7: M.L. Kersten.
- NWO Workshop on Informatics in Neuroscience, Den Haag, December 9: M.L. Kersten (Talk: Neuroscience, a database expedition).

Working visits

- Microsoft Research, Seattle, USA, January 10: P.A. Boncz (Talk: MonetDB/Pathfinder: XQuery on top of a relational DBMS), M. Zukowski.
- Microsoft SQLserver Group, Seattle, USA, January 10: P.A. Boncz (Talk: MonetDB/X100: Hyper-Pipelining Query Execution), M. Zukowski
- Oracle Database Kernel Group, Redwood Shores, USA, January 13: P.A. Boncz (Talk: MonetDB/X100: Hyper-Pipelining Query Execution).
- Oracle XQuery group, Redwood Shores, USA, January 13: P.A. Boncz, (Talk: MonetDB/Pathfinder: XQuery on top of a relational DBMS).
- IBM Database Research Group, San Jose, January 14: P.A. Boncz (Talks: MonetDB/X100: Hyper-Pipelining Query Execution, MonetDB/Pathfinder: XQuery on top of a relational DBMS).
- Microsoft Research, Seattle, January 10–February 15: M.L. Kersten (Talks: Cracking the database store, SQL Server: Lessons from a Novice).
- Queen Mary Univ., London, UK, April 6: A.P. de Vries.
- Microsoft Cambridge, UK, April 4, July 13–14, October 24, July 13–14, October 24: A.P. de Vries.
- TUD, May 10: P.A. Boncz (Talk: MonetDB/Xquery: state-of-the-art in XML Databases).
- Columbia Univ., New York, June 22: S. Manegold.
- Microsoft Cambridge, UK, July 13–14: A.P. de Vries.
- ASTRON, Dwingelo, August 14–28: N.J. Nes.
- Microsoft Cambridge, UK, October 24: A.P. de Vries.
- INL, Leiden, October 27: A.P. de Vries, S. Manegold.

Project meetings

- MultimediaN project M meeting, TNO Delft, January 24: K.S. Mullender, N.J. Nes.
- SYMM Face 2 Face, Boston, USA, February 28–March 2: K.S. Mullender.
- MultimediaN N5 meeting, Enschede, March 7: A.P. de Vries, T.H.W. Westerveld, K.S. Mullender.
- MultimediaN project M meeting, TI Enschede, March 21: K.S. Mullender, N.J. Nes.
- MultimediaN N5 meeting on Philips Sensor Data, Eindhoven, March 29: A.P. de Vries.
- Waterland meeting, Hilversum, June 29, September 27: A.P. de Vries, T.H.W. Westerveld.
- SYMM Face 2 Face, Helsinki, Finland, May 31–June 2: K.S. Mullender.
- Cirquid, Meeden, June 13–14: A.P. de Vries, G. Ramírez i Camps, T.H.W. Westerveld.
- MultimediaN project M meeting, CWI, June 10: K.S. Mullender, N.J. Nes.
- MultimediaN N5 meeting, Amsterdam, June 15: A.P. de Vries, T.H.W. Westerveld.
- Astro-wise meeting, RUG, Groningen, July 7: N.J. Nes.
- SYMM Face 2 Face, Tokyo, Japan, September 13–16: K.S. Mullender.
- CWI-Astron meeting, CWI, September 21: N.J. Nes, E. Pauwels.
- MultimediaN N5 meeting, Hilversum, September 27: A.P. de Vries, T.H.W. Westerveld.
- MultimediaN N5 meeting on Philips and StreetTIVO demo, Amsterdam, OctobeR 11: A.P. de Vries.
- AmbientDB meeting, Amsterdam, November 1: A.P. de Vries (Talk: StreetTIVO).
- SYMM Face 2 Face, CWI, December 7–8: K.S. Mullender.
- CWI-Astron meeting, CWI, December 7: N.J. Nes, S. Bohte.
- MultimediaN project management meetings (3-weekly): M.L. Kersten.
- MultimediaN project visits September/October: M.L. Kersten.

Visitors

- J. Rittinger, Univ. Konstanz, Germany, May 29. Host: S. Manegold.
- S. Idreos, TU Crete, Greece, June 25. Host: M.L. Kersten.
- A. Schmidt, Univ. Aarlborg, Denmark, October 12. Host: S. Manegold.
- H. Philippi, UU, November 6–10. Host: S. Manegold.
- P. Bosch, ATT, USA, November 10. Host: M.L. Kersten.
- M. Ivanova, Uppsala Univ. Sweden. Host: M.L. Kersten.
- C. Tryfonopoulos, TU Crete, Greece, Host: M.L. Kersten.

Memberships of committees and other professional activities

P.A. Boncz

- Organizer SIGMOD/DaMoN 2005 workshop, Baltimore, USA.
- Organizer AmbientDB workshop, Amsterdam.
- Organizer Dutch Belgian Database Day, Amsterdam.
- Member programme committee DBIS P2P Workshop VLDB 2005, Trondheim, Norway.
- Member programme committee PhD Workshop VLDB 2005, Trondheim, Norway.
- Member programme committee VLDB 2005 Trondheim, Norway.
- Member programme committee ICDE 2005 Tokyo, Japan.
- Reviewer VLDB Journal, SIGMOD 2006.

R. Cornacchia

- Reviewer conferences: ICDE 2005, EDBT 2006.

F. Groffen

- Reviewer conferences: VLDB 2005, ICDE 2005.
- Reviewer Electronic journal on Web-Services.

S. Héman

- Reviewer conferences: EDBT 2006.

M.L. Kersten

- Professor of computer science at UvA
- Member programme committee DELOS workshop on Architectures for DL, Dagstuhl (Germany); SIGMOD/DaMoN workshop, Baltimore (USA); WISE 2005, New York (USA); ICME 2005, Amsterdam; CIKM 2005, Bremen (Germany); EDBT 2006, Munich (Germany); ICDE 2006, Atlanta (USA).
- Programme chair Core track VLDB 2005, Trondheim, Norway; Industrial tack VLDB 2006, Seoul, Korea.
- Scientific co-director Bsik/MultimediaN.
- Scientific advisor Philips Research.
- Member ToKeN2000 research programme committee, NWO.
- Member scientific advisory board Helsinki Institute for Information Technology.
- Member scientific advisory board GMD IPSI, Darmstadt, Germany.
- Reviewer committee FET-OPEN, EU FP-6.
- Member research school SIKS.
- Board member of ANMA, Amsterdam New-Media Association.
- Reviewer VLDB journal, ACM Transactions on Office Information Systems, Journal Data and Knowledge Engineering.

S. Manegold

- Organizer SIGMOD/DaMoN 2005 workshop, Baltimore, USA.
- Member programme committee VLDB 2005, Trondheim, Norway.
- Member programme committee DASFAA 2006, Singapore.
- Member programme committee EDBT/QLQP 2006 workshop, Munich, Germany.
- Member programme committee EDBT 2006 PhD workshop, Munich, Germany.
- Reviewer: ICDE 2005, SIGMOD 2006, ACM TOIS, Information Systems.

G. Ramírez i Camps

- Reviewer for VLDB 2005, CIKM 2005, ECIR 2005.

A.P. de Vries

- Co-organizer of DIR 2005 (Dutch-Belgium Information Retrieval workshop).
- Demonstrations programme chair (Europe) for ICDE 2006.
- Coordinator of the new TREC Enterprise Search track 2005.
- Member of the INEX Metrics Working Group.
- Programme committee member of the IMIX research programme (NWO).
- Programme committee member for INFOSCALE 2006, ECIR 2006, CIKM 2005, SIGIR 2005, CIVR 2005, ECIR 2005, MMIR 2005, INEX 2005 Workshop on Element Retrieval Methodology, CBMI 2005, AMR 2005, IDDI'05.
- Reviewed for MMTAP, ACM TOIS, Information Retrieval journals, and NWO and EC FW6 funding organisations.
- Panelist in the AMR 2005 panel on Adaptive Content-Based Image Retrieval, and in the Enterprise Search panel of the Gilbane conference (on content management).
- General (co-)chair for ACM SIGIR 2007.

T.H.W. Westerveld

- Local organization chair ICME.
- Coordinator INEX multimedia track 2006.
- Programme committee member for ICME 2005, CIVR 2005, ACM/SIGIR 2005, ECIR 2006.
- Reviewer for CIKM 2005, JASIST, ACM TOMCAP, ACM MMS journal.

M. Zukowski

- Reviewer conferences: VLDB 2005, ICDE 2005.

Academic publications

Publications in refereed journals or proceedings

1 S. Abiteboul, R. Agrawal, P.A. Bernstein, M.J. Carey, S. Ceri, W.B. Croft, D.J. DeWitt, M.J. Franklin, H. Garcia-Molina, D. Gawlick, J. Gray, L.M. Haas, A.Y. Halevy, J.M. Hellerstein, Y.E. Ioannidis, M.L. Kersten, M.J. Pazzani, M. Lesk, D. Maier, J.F. Naughton, H.-J. Schek, T.K. Sellis, A. Silberschatz, M. Stonebraker, R.T. Snodgrass, J.D. Ullman, G. Weikum, J. Widom, S. B. Zdonik (2005). The lowell database research self-assessment. Commun. ACM 48(5), 111–118.

2 K. Böhm, C.S. Jensen, L.M. Haas, M.L. Kersten, P.-Å. Larson, B.C. Ooi (eds). (2005). Proceedings of the 31st International Conference on Very Large Data Bases, August 30–September 2, ACM.

3 P.A. Boncz, T. Grust, M. van Keulen, S. Manegold, J. Rittinger, J. Teubner (2005). Pathfinder: XQuery-The Relational Way. Proceedings of the International Conference on Very Large Data Bases (VLDB), September. (Demo).

4 P.A. Boncz, S. Manegold, J. Rittinger (2005). Updating the Pre/Post Plane in MonetDB/XQuery. Proceedings of the International Workshop on XQuery Implementation, Experience and Perspectives (XIME-P), June.

5 P.A. Boncz, M. Zukowski, N.J. Nes (2005). MonetDB/X100: Hyper-Pipelining Query Execution. Proceedings of the Biennial Conference on Innovative Data Systems Research (CIDR), January.

6 A.P. de Vries, T. Roelleke (2005). Relevance information: A loss of entropy but a gain for idf? Proceedings of the 28th annual international ACM SIGIR conference on Research and development in information retrieval, 282–289.

7 G. Kazai, M. Lalmas, A.P. de Vries (2005). Reliability tests for the xcg and inex-2002 metrics. Third Workshop of the INitiative for the Evaluation of XML Retrieval INEX 2004, Advances in XML Information Retrieval LNCS 3493, 60–72.

8 M.L. Kersten, S. Manegold (2005). Cracking the Database Store. Proceedings of the Biennial Conference on Innovative Data Systems Research (CIDR), January.

9 J. List, V. Mihajlovic, G. Ramírez, A.P. de Vries, D. Hiemstra, H.E. Blok (2005). TIJAH: Embracing IR Methods in XML Database. Information Retrieval 8(4), 547–570. The original publication is available in LINK, (c) Springer-Verlag.

10 K.F. Lubbers, A.P. de Vries, T.W.C. Huibers, P.E. van der Vet (2005). A probabilistic approach to the medical retrieval task. Workshop of the Cross-Language Evaluation Forum (CLEF 2004), LNCS/LNAI. Springer-Verlag.

11 V. Mihajlovic, G. Ramírez, A.P. de Vries, D. Hiemstra, H.E. Blok (2005). TIJAH at INEX 2004: Modeling Phrases and Relevance Feedback. N. Fuhr, M. Lalmas, S. Malik, Z. Szlávik (eds). Advances in XML Information Retrieval. Third Workshop of the INitiative for the Evaluation of XML Retrieval (INEX 2004), LNCS 3493/LNAI. Springer-Verlag.

12 G. Ramírez (2005). User Needs and Strategies in Structured Information Retrieval. ECDL 2005 Doctoral Symposium.

13 G. Ramírez, A.P. de Vries (2005). XML and Context: Structural Features Relevant to Search Tasks. Proceedings of the ACM SIGIR 2005 Workshop on Information Retrieval in Context, IRiX, 24–26.

14 G. Ramírez, T.H.W. Westerveld, A.P. de Vries (2005). Structural features in content oriented XML retrieval. CIKM '05: Proceedings of the 14th ACM international conference on Information and knowledge management, 291–292, ACM Press.

15 A.R. Schmidt, S. Manegold, M.L. Kersten (2005). Storing XML Documents in Databases. L.C. Rivero, J.H. Doorn, and V.E.

Ferraggine (eds). Encyclopedia of Database Technologies and Applications. Idea Group Publishing, 2005.
16 A.R. van Ballegooij, R. Cornacchia, A.P. de Vries, M.L. Kersten (2005). Distribution Rules for Array Database Queries. Proceedings of the International Workshop on Database and Expert Systems Application, 55–64.
17 T. H. W. Westerveld (2005). Using generative probabilistic models for multimedia retrieval. SIGIR Forum 39, 69.
18 T. H. W. Westerveld, A. P. de Vries (2005). Generative probabilistic models for multimedia retrieval: query generation versus document generation. Proceedings - Vision, Image and Signal Processing 152, 852–858.
19 T. H. W. Westerveld, A. P. de Vries, G. Ramírez (2005). Surface features in video retrieval. 3rd International Workshop on Adaptive Multimedia Retrieval.
20 M. A. Windhouwer, M. L. Kersten (2005). Digital Media Warehouses. L. C. Rivero, J. H. Doorn, V. E. Ferraggine (eds). Encyclopedia of Database Technologies and Applications. Idea Group Publishing.
21 M. Zukowski (2005). Hardware-Conscious DBMS Architecture for Data-Intensive Applications. Proceedings of the International Conference on Very Large Data Bases, August. PhD Workshop.
22 M. Zukowski (2005). Improving I/O Bandwidth for Data-Intensive Applications. Proceedings of the British National Conference on Databases. PhD Workshop.
23 M. Zukowski, P. A. Boncz, N. J. Nes, S. Heman (2005). MonetDB/X100 - A DBMS In The CPU Cache. IEEE Data Engineering Bulletin 28(2), 17–22.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 V. Mihajlovic, G. Ramirez, T. H. W. Westerveld, D. Hiemstra, H. E. Blok, A. P. de Vries (2005). TIJAH Scratches INEX 2005. Vague Element Selection, Overlap, Image Search, Relevance Feedback, and Users. Proceedings of the Fourth Workshop of the INitiative for the Evaluation of XML Retrieval, INEX 2005. Notebook paper.
2 H. Rode, G. Ramirez, T. H. W. Westerveld, D. Hiemstra, A. P. de Vries (2005). The Lowlands' TREC Experiments 2005. Proceedings of the 14th Text REtrieval Conference, TREC 2005. Notebook paper.
3 R. van Zwol, A. P. de Vries, D. Hiemstra (2005). Number 1 in Journal of Digital Information Management 1–2.
4 T. H. W. Westerveld, A. P. de Vries, F. M. G. de Jong (2005). Workshop on the evaluation of multimedia retrieval. SIGIR Forum 39, 34–36.
5 T. H. W. Westerveld, J. C. van Gemert, R. Cornacchia, D. Hiemstra, A. P. de Vries (2005). An integrated approach to text and image retrieval - The Lowlands Team at Trecvid. Trec Video Retrieval Evaluation Online Proceedings.

CWI reports

INS-E0503, INS-E0506, INS-E0507, INS-E0508, INS-E010, INS-E0511.
See page B.5 on page 204 for complete titles.

Software developed

In 2005 two major software releases were announced. In February a release, called Valentijn, was sent out including functional improvements for SQL. End of May we delivered a full-functional XQuery front-end for MonetDB. It was developed in close cooperation with UT (Van Keulen) and Technical Univ. Munich (T. Grust).

Professional products

Publications for a broad audience

1 Exposure of PhD Thesis T.H.W. Westerveld in Informatie Professional, February 2005 and BNVKI newsletter, February 2005.
2 Issue 4/2005 of the Dutch 'Linux Magazine' (http://www.linuxmag.nl/) features an article written by R. van Rein, 'MonetDB: optimaal en dynamisch' ('MonetDB: optimal and dynamic'; in Dutch).
3 R. van Rein (2005). 'MonetDB keert een DBMS binnenste-buiten'. Database Magazine 4.

Semantic Media Interfaces – INS2

Mission

We see the technological basis for storing human knowledge as switching from document processing to knowledge representation. The human process of making new information available is thus evolving from creating documents putting the information in a fixed document to placing it in a more generally structured knowledge store from which many different presentation documents can derive. These generated presentations each cater to its current user, giving the user much flexibility in controlling each presentation's structure and style. The author also gains expressive power, being able to store each new piece of knowledge once in its most generalized conceptual form rather than in one or more static documents for specific contexts.

To provide this power to authors and users, we aim to make the systems that lie between them meet the following challenge: to let the user specify and guide the automated process of finding relevant content and building instructive document structure around it. The current simultaneous emergence and adoption of Semantic Web technologies and several media metadata formats bring about a substantial basis for both implementation and empirical evaluation of this progression.

Theme leader

Prof.dr. L. Hardman

MSC or CR classification

H.5.4, H.5.1, I.2.4, I.4, I.7.2, I.3.7, J.4, J.5

Subthemes

None.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
A.K. Amin, MSc	1.0	PhD student	2005-10-01 till 2009-09-30	MultimediaN
Ir. S. Bocconi	1.0	PhD student	2000-01-01 till 2005-12-31	I^2RP
K.I. Falkovych, MSc	1.0	PhD student	2002-11-01 till 2006-10-31	CHIME
Drs.ing. J.P.T.M. Geurts	1.0	PhD student	2002-06-01 till 2006-05-31	NASH
Prof.dr. L. Hardman (0.2 TUE)	0.8	theme leader, leader INS2.1	indefinite	NASH, I^2RP, CHIME, MultimediaN, Passepartout
Drs. M. Hildebrand	1.0	PhD student	2005-11-01 till 2009-10-31	MultimediaN
Dr. Z. Huang	1.0	researcher	2005-10-01 till 2006-04-15	I^2RP
Dr. F.-M. Nack	1.0	researcher	2000-02-01 till 2006-12-31	CHIME, Passepartout
Dr. J.R. van Ossenbruggen	1.0	project leader, researcher	indefinite	NASH, MultimediaN

continued on next page

continuation from previous page

Dr. L.W. Rutledge	1.0	researcher	indefinite	Passepartout, CHIP
K. Schwarz	0.2	researcher	2003-01-09 till 2005-08-31	

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. L. Aroyo	0.2	researcher	2005-05-01 till 2006-04-30	INS2: CHIME, Passepartout, CHIP
Dr. R. Troncy	1.0	researcher	2005-01-09 till 2006-05-31	ERCIM Fellow

Scientific report

PhD students

A. Amin
S. Bocconi
K.I. Falkovych
J.P.T.M. Geurts
M. Hildebrand

INS2.1 – Semantics and Hypermedia Processing

Title	NASH – Networked Adaptive Structured Hypermedia
Period	May 1, 2002–April 30, 2006
Leader	J.R. van Ossenbruggen
Staff	J.P.T.M. Geurts, L. Hardman, J.R. van Ossenbruggen
Funding	NWO
Partner	TUE

Progress report. This project is in its final stages, from INS2 only one PhD (Geurts) is still involved with the project. NASH is a combined project with TUE and aims at improving structured adaptive hypermedia presentations on the Web by combining Semantic Web and Adaptive Hypermedia technology. Geurts worked on his thesis and on deploying Semantic Web technology to multimedia annotation and the Cuypers presentation generation engine.

Title	CHIME – Cultural Heritage in an Interactive Multimedia Environment
Period	September 1, 2002–August 31, 2006
Leader	L. Hardman
Staff	L. Hardman, K.I. Falkovych, F.-M. Nack
Funding	NWO ToKeN2000
Partner	TUE, VU

Progress report. The goal of the CHIME project is to investigate the use of semantic models for tailoring the presentation of cultural information to different types of users. The research in the project concentrates on creating semantic models based on domain semantics and discourse semantics that also take into account user modeling aspects.

The initial prototype of the multimedia presentation authoring environment Samp*L*e (2004) enabled media retrieval and composition of discourse structures based on explicit discourse knowledge. Falkovych has extended the functionality of Samp*L*e by accounting for multiple workflows in the multimedia presentation authoring process. Falkovych has produced a set of requirements for modeling discourse knowledge and has developed an approach to support discourse structure composition for currently unsupported genres. The proposed approach also allows the generation of discourse structures that are adapted to specific user needs.

Title	I^2RP – Intelligent Information Retrieval and Presentation in public historical multimedia databases
Period	January 1, 2002–January 1, 2006
Leader	L. Schomaker
Staff	L. Hardman, S. Bocconi, Z. Huang
Funding	NWO ToKeN2000
Partners	Rijksmuseum Amsterdam, KI/RUG, IKAT/UM, UL

Progress report. INS2 is participating with a PhD (Bocconi) and a senior (Huang) in this project. The project aims at improving Web-based presentations by using natural language processing (UL), cognitive user modeling (Groningen) and discourse modeling (INS2).

Bocconi has worked on his thesis and on the development of the VoxPopuli software that deploys explicit rhetorics to automatically edit documentary film footage, and demonstrated this in the domain of video interviews. Huang has worked on modeling time, time ontologies,

temporal and event-based reasoning in intelligent presentation generation software. He has also demonstrated the applicability of his work in the context of the MultimediaN/N9C demonstrator.

Title	MultimediaN N9C Eculture project
Period	January 1 2004–1 January, 2010
Leader	G. Schreiber (VU); J.R. van Ossenbruggen (Assistent leader)
Staff	L. Hardman, J. van Ossenbruggen, Z. Huang, A. Amin, M. Hildebrand
Funding	Bsik
Partners	VU, UvA, Stichting Digitaal Erfgoed Nederland (DEN)

Progress report. INS2 is participating with two new PhDs (Amin and Hildebrand) and two seniors (Hardman and Van Ossenbruggen) in this project. The project aims at improving Web-based access to heterogeneous collections from the Dutch cultural heritage domain. It focuses on improving the current state of the art in metadata modeling, manual and semi-automatic annotation and metadata-based reasoning. Within the project, INS2 is responsible for developing intelligent user-specific and perspective-specific search and browsing interfaces. The project works closely with the NWO/ToKeN CHIME and I^2RP projects and the various NWO/CATCH projects.

While the project started at the beginning of 2005, the PhDs only started in the final quarter of the year. The first year has mainly been devoted to establishing contacts in the Dutch cultural heritage community and designing and developing the infrastructure for the project's demonstrator. The same software is also used as an experimentation platform for the PhDs. A first prototype came on-line at the end of 2005, see `http://e-culture.multimedian.nl/`, and was demonstrated at the EWIMT workshop in London.

Van Ossenbruggen developed the initial semantic time-line software for the time-perspective interface and worked on the semantic clustering search results. Amin has worked on improving the usability of the current interface, based on an informal user study at the end of the year. Hildebrand improved the time-line software and began developing an initial version of the facet-perspective interface.

Title	Passepartout
Period	January 1, 2005–January 1, 2007
Leader	A. Kaptein (Stoneroos B.V., Hilversum)
Staff	L. Hardman, F.-M. Nack
Funding	SENTER
Partners	NL: Philips PDSL, Stoneroos, CharToon Software, TUE, V2_ and European partners

Progress report. The ITEA project Passepartout aims at coupling home media-centers to home networks for rendering scalable content from high definition television (HDTV) to lower definitions in a seamless fashion. CWI (together with V2_ Institute for the Unstable Media, Rotterdam) began their investigation of specific techniques with respect to the specification of the technology for the cushion demonstrator as outlined in WP2 of the ETA International Passepartout description. CWI INS2 has started with the technical specification (modeling) of the key processes, namely signal identification and interpretation, decision making about soft or hard adaptation of content or environment, and actual application of the adaptation strategy. Results have been presented at 2005 ACM MM Workshop: ACM Workshop on Multimedia for Human Communication – From Capture to Convey, `http://homepages.cwi.nl/ media /conferences/mhc05/mhc05.html`, organised by INS2.

Title	CHIP
Period	May 1, 2005 – April 30, 2008
Leader	P. de Bra, TUE
Staff	L.W. Rutledge
Funding	NWO/ TI
Partners	TUE, Telematica Instituut, Rijksmuseum Amsterdam

Progress report. The CHIP project aims to personalize access to cultural heritage represented with Semantic Web technology. In its first seven months, CHIP's primary accomplishment is its pilot demo, which recommends topics to browse based on user rating of museum artefact images. It also developed a renewed RDF representation of the Rijksmuseum Amsterdam ARIA database.

Title	W3C AC – World Wide Web Consortium Advisory Committee
Period	indefinite
Leader	L.W. Rutledge
Staff	L.W. Rutledge
Funding	CWI

Progress report. This representation of CWI within the W3C's Activity Committee helps ensure CWI's position in the forefront of emerging web technologies. We have maintained close involvement with the W3C as a whole, tracked particular developing technologies relevant to CWI research and helped bridge web developments with the Dutch Web technology community. This was performed in close cooperation with the INS0-hosted W3C staff.

Title	ERCIM Fellowship
Period	September 1, 2005 – May 31, 2006
Staff	R. Troncy
Funding	ERCIM

Progress report. In his ERCIM fellowship, Troncy has investigated how Semantic Web technologies can be used for better describing, retrieving, processing or even generating multimedia content. More precisely, he studied a number of multimedia and audio-visual ontologies that have already been proposed for annotating collections of images or videos, and investigated better ways to fuse and link them. This work is conducted within the 'Multimedia and Semantic Web' task force of the W3C 'Semantic Web Best Practices' group, and an ad-hoc group initiated from the EU Integrated Project 'aceMedia'.

Societal aspects and knowledge transfer

Projects with partners in public and private sector

- CHIME, page 171.
- I^{2}RP, page 171.
- MultimediaN, page 172.
- Passepartout, page 172.

Teaching at university

- Invited class 'Structured Documents on the Web', VU, WBKR course, March 21: J.R. van Ossenbruggen.
- Invited class on SMIL for 'Interactive Multimedia Systems' at UvA, April 6: L. Rutledge.
- Teacher of 'Web Information Systems (21120)' at TUE, Fall: L. Hardman.
- Lectures and assisted grading for course 'Web Information Systems (21120)' at TUE, Fall: L.W. Rutledge.

Courses, tutorials

- Ricoh Innovations, Menlo Park, USA, January 26: F.-M. Nack (Invited talk: The Discrete Charm of Media Annotations).
- CWI Scientific Friday, 'Presenting knowledge – Bridging the World Wide and Semantic Webs', January 28: L.W. Rutledge.
- NII, Tokyo, Japan, May 16: L. Hardman (Invited talk: Presenting Knowledge on the Semantic Web).
- National Technological Univ. Athens, June 30: J.R. van Ossenbruggen (Invited talk: Multimedia Documents on the Semantic Web).
- CWI Open Day, October 22: S. Bocconi (Poster and demo Vox Populi).
- ACM MM2005 full day tutorial 'Media Semantics and the Statistical Foundations for Understanding It', Hilton, Singapore, November 7: F.-M. Nack.
- Rijksmuseum Amsterdam Kunsthistorisch Lunch, Rijksmuseum Amsterdam, November 17: L.W. Rutledge (The CHIP Project – Personalized Access to Cultures).
- CS department, Bogazici Univ., Istanbul, Turkey, November 28: L. Hardman (Invited talk: Presenting Knowledge on the Semantic Web).

Knowledge transfer

- Coordinator of the Multimedia Task Force of the W3C Working Group on Semantic Web Best Practices and Deployment (SWBPD): J.R. van Ossenbruggen.
- Multimedia Task Force of the W3C Working Group on Semantic Web Best Practices and Deployment (SWBPD): R. Troncy.
- Co-editor of Image annotation on the Semantic Web, Public Working Draft, `http://www.w3.org/2001/sw/BestPractices/MM/image_annotation.html` : R. Troncy

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- The Fifth Dutch-Belgian Information Retrieval Workshop (DIR'05), Utrecht, January 10–11: L.W. Rutledge.
- AKT workshop, Southampton, UK, January 25–26: L. Hardman, L.W. Rutledge (Talk: Presenting knowledge – Bridging the World Wide and Semantic Webs).
- Invited participants in Dagstuhl seminar 'Multimedia Research – where do we need to go tomorrow', Dagstuhl, Germany, March 1–4: L. Hardman (Making Aesthetics Explicit in Semantic Multmedia Documents), F.-M. Nack (Media Meta Data Is Not Dead But Aware), L.W. Rutledge (The Multi is the Message).
- ToKeN2000 Symposium, March 18: S. Bocconi (Poster: Rhetorical Video Editing), K.I. Falkovych (Poster: Multimedia Authoring Support in Four Phases: harmonizing domain and discourse knowledge), L. Hardman, J.R. van Ossenbruggen.
- The Fifth Creativity and Cognition Conference, Hosted by Goldsmiths College, London, UK, April 12–15: K.I. Falkovych, L. Hardman.
- MindShare, Telematica Instituut, April 14: L.W. Rutledge (Invited Talk: Browsing Semantics).
- International Cross-Disciplinary Workshop on Web Accessibility at WWW2005, May 5: L. Hardman.
- The 14th World Wide Web Conference (WWW_2005), Tokyo, Japan, May 10–14: L. Hardman, J.R. van Ossenbruggen, L.W. Rutledge (Paper: Making RDF Presentable – Global and Local Semantic Web Browsing).
- Digitainment Information Technology for Future Entertainment, Leiden, May 11: S. Bocconi, K.I. Falkovych.
- Multimedia and the Semantic Web, one day workshop, Heraklion, Crete, May 29: J.P.T.M. Geurts (Paper: Requirements for Practical Multimedia Annotation).
- The 2nd Annual European Semantic Web Conference (ESWC2005), Heraklion, Crete, May 29–June 1: J.P.T.M. Geurts.
- PhD Career Event, Beurs van Berlage, June 14: S. Bocconi, J.P.T.M. Geurts.
- IEEE International Conference on Multimedia & Expo (ICME2005), Amsterdam, July 6–8: S. Bocconi (Paper: Using Rhetorical Annotations for Generating Video Documentaries), F. Nack, L.W. Rutledge (Poster: Personalized Presentation and Navigation in Cultural Heritage Content).
- Invited to ESF Exploratory Workshop on Information Retrieval in Context (IRiX), Glasgow, UK, July 26–27: L. Hardman.
- Workshop on Narrative, Musical, Cinematic and Gaming Hyperstructure, at HT2005, Salzburg, Austria, September 6: S. Bocconi, K.I. Falkovych (Paper: Creating a semantic-based discourse model for hypermedia presentations: (un)discovered problems), F.-M. Nack (Paper: Generating Media Stories – Play it again, Sam), L.W. Rutledge.
- The Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9: S. Bocconi (Paper: Supporting the Generation of Argument Structure within Video Sequences), K.I. Falkovych, F. Nack, L.W. Rutledge (Poster: Generalized Semantics-to-Document Derivation, Demo: Cruising the Semantic Web with Noadster).
- Enlightening Science Congress, WTCW, September 21: J.R. van Ossenbruggen (Presentation).
- The Scientific ICT Research Event Netherlands (SIREN 2005), TUE, Eindhoven, October 6: A. Amin, J.P.T.M. Geurts, L. Hardman, J.R. van Ossenbruggen, L.W. Rutledge (Poster: CATCH/CHIP Project – Personalized Presentation and Navigation of Cultural Heritage Content).
- BNAIC2005, Brussels, Belgium, October 17: Z. Huang (Presentation: Reasoning with Inconsistent Ontologies).
- The Fourth International Semantic Web Conference (ISWC2005), Galway, Ireland, November 3–10: Z. Huang (Paper: Reasoning with Multi-version Ontologies: a Temporal Logic Approach), J.R. van Ossenbruggen, L.W. Rutledge, R. Troncy.
- End User Semantic Web Interaction workshop at ISWC2005, Galway, Ireland, November 7: L.W. Rutledge (Position Paper: Recommending Topics from Rated Object).
- SWCASE, Colocated with ISWC2005, Galway, Ireland, November 7: J.R. van Ossenbruggen (Paper: Multimedia Annotations and the Semantic Web).

- ACM Multimedia (ACM MM2005), Hilton, Singapore, November 6–11: L. Hardman, F.-M. Nack.
- ACM Workshop on Multimedia for Human Communication – From Capture to Convey, at ACM MM2005, November 11: L. Hardman (Paper: Canonical Processes of Media Production), F.-M. Nack (Paper: Capture and Transfer of Metadata During Video Production).
- Conferentie Informatiewetenschap, Antwerp, Belgium, November 18: S. Bocconi (Presentation: Using Rhetorical Annotations for Generating Video Documentaries), L. Hardman, M. Hildebrand, F.-M. Nack, L.W. Rutledge (Talk: Making RDF Presentable).
- International Conference on Web Information Systems Engineering (WISE2005), New York, USA, November 20–22, R. Troncy (Paper: oMAP: Combining Classifiers for Aligning OWL Ontologies).
- European Workshop on the Integration of Knowledge, Semantic and Digital Media Technologies (EWIMT2005), London, UK, November 30–December 1: L. Hardman, J.R. van Ossenbruggen (Poster presentation: Semantic Timeline Interfaces for Annotated Multimedia Assets), R. Troncy.

Working visits

- Garage Cinema Research Group, School of Information Management and Systems (SIMS), Univ. California at Berkeley. Position: Invited Visiting Scholar, Design of the data model for the Media Streams Metadata Exchange project (MSMDX), January 5–April 28: F.-M. Nack.
- A. Dekker, Montevideo project: Video Jokey, Amsterdam, January 12, May 9: S. Bocconi.
- A. Dekker, Montevideo project, Amsterdam, March 1: S. Bocconi.
- Yahoo Media group, Sunnyvale, CA, talking about collaboration with the new Yahoo Media Lab in Berkeley, June 21–23: F.-M. Nack.
- NTUA, Athens, June 29–July 1: J.R. van Ossenbruggen.
- A. de Waard, collaboration on the Casimir project, ELSEVIER, Amsterdam, August 10: K.I. Falkovych.
- U. Straccia, CNR, Pisa, Italy, October 18–21: R. Troncy.
- A. Nijholt and P. van der Vet, UT, December 13: L.W. Rutledge.

Project meetings

- I^2RP project meeting, CWI, January 21: S. Bocconi, L. Hardman.
- ToKeN2000 user group meeting, CWI, January 21: S. Bocconi, L. Hardman.
- NWO meeting with M. Kas and M. de Boer, January 25: J.P.T.M. Geurts.
- Digitalisering en Informatisering, NWO, Den Haag, February 1: L. Hardman.
- Passepartout meeting, Philips Labs, Eindhoven, February 1: L.W. Rutledge.
- MultimediaN N9C Project meeting, VU, February 2: L. Hardman, J.R. van Ossenbruggen.
- Bsik/BRICKS projectboard meeting, CWI, February 10: J.R. van Ossenbruggen.
- CHIME project meeting, CWI, February 22: K.I. Falkovych, L. Hardman.
- Passepartout Meeting, CWI, February 25: L. Hardman, F.-M. Nack, L.W. Rutledge.
- MultimediaN N9C Project Meeting, VU, March 10: J.R. van Ossenbruggen.
- Passepartout EU Kickoff Meeting, Brussels, March 10–11: L.W. Rutledge.
- Passepartout project meeting, V2_, March 15: L. Hardman.
- CHIP project candidate interviews, Rijksmuseum Amsterdam, March 31, May 2: L.W. Rutledge.
- BRICKS/OC&W overleg, Den Haag, April 4: J.R. van Ossenbruggen.
- Passepartout project meeting, CWI, April 21: L. Hardman, L.W. Rutledge.
- Bsik/BRICKS advisoryboard meeting, CWI, April 22, November 11: J.R. van Ossenbruggen.
- CHIP planning meeting, Rijksmuseum Amsterdam, April 27: L. Hardman, J.R. van Ossenbruggen, L.W. Rutledge.
- CHIP project candidate interviews, Rijksmuseum Amsterdam, May 2: L.W. Rutledge.
- CHIP brainstorm meeting, Rijksmuseum Amsterdam, May 4: L. Hardman, L.W. Rutledge.
- Passepartout project meeting, CWI, May 19: L. Hardman, F.-M. Nack.
- Passepartout project meeting, V2_, June 12–13: F.-M. Nack.
- Passepartout project meeting, TUE, June 22: L. Hardman.

- Bsik Koepeloverleg, July 5: J.R. van Ossenbruggen.
- Bsik/BRICKS Project meeting, Utrecht, July 11: J.R. van Ossenbruggen.
- WGI, Utrecht, August 4: L. Hardman.
- EMMA project meeting, CWI, August 25-26 : F.-M. Nack.
- CHIME project meeting, VU, September 1: K.I. Falkovych, L. Hardman.
- MultimediaN N9C Project meeting, CWI, September 8: L. Hardman, J.R. van Ossenbruggen.
- Passepartout project meeting, CWI, September 12-14: L. Hardman, F.-M. Nack.
- CATCH project meeting, NWO, September 13: L.W. Rutledge.
- MultimediaN N9C Project meeting, UvA, September 22: L. Hardman, J.R. van Ossenbruggen.
- Passepartout project meeting, V2_,i Every, Paris, September 22, September 26–27, November 28–29: F.-M. Nack.
- I^2RP Project meeting, Groningen, October 26: S. Bocconi, L. Hardman, Z. Huang (Presentation: Temporal Aspects of Intelligent Multimedia Retrieval and Presentation).
- CHIP project meeting, CWI, October 27: L.W. Rutledge.
- CHIME site visit, CWI, October 28: K.I. Falkovych, L. Hardman.
- MultimediaN N9C Project Meeting, CWI, November 3: A. Amin, M. Hildebrand, J.R. van Ossenbruggen.
- MultimediaN N9C Project Meeting, Antwerp, November 18: A. Amin, J.R. van Ossenbruggen.
- MultimediaN N9C Project Meeting, CWI, November 24: A. Amin, M. Hildebrand, J.R. van Ossenbruggen.
- CATCH project meeting, Koninklijke Bibliotheek, Den Haag, November 25: L.W. Rutledge.
- FOCUS project meeting, TU Twente, November 25: J.R. van Ossenbruggen.
- Bsik Knowledge transfer meeting, Amsterdam, December 6: J.R. van Ossenbruggen.
- MultimediaN N9C Project Meeting, UvA, December 8: A. Amin, L. Hardman, M. Hildebrand, J.R. van Ossenbruggen.
- Passepartout project meeting, Philips, December 14: L. Hardman.
- MultimediaN N9C Project Meeting, CWI, December 16: A. Amin.
- MultimediaN N9C Project Meeting, CWI, December 20: A. Amin, L. Hardman, M. Hildebrand, J.R. van Ossenbruggen.
- MultimediaN N9C Annotation Meeting, CWI, December 20: A. Amin, L. Hardman, M. Hildebrand, J.R. van Ossenbruggen.

Courses

- Presentation course, CWI, February 11–April 15: K.I. Falkovych, J.P.T.M. Geurts.
- Technical writing course, CWI, October 7–December 9: A. Amin.

Visitors

- L.J.B. Nixon, Free Univ. Berlin, February 2. (Talk: SWeMPS: A framework for a Semantic Web-enabled Multimedia Presentation System). Host: J.P.T.M. Geurts.
- M. Davis, Garage Cinema Research, Univ. California, Berkeley, February 27. (Talk: Mobile Media Metadata: The Future of Mobile Imaging). Host: J.P.T.M. Geurts, L. Hardman.
- A. Bouwer, Human-Computer Studies Lab, Faculty of Science (FNWI), UvA, April 28. (PhD thesis presentation: ' Knowledge-based Simulation Models in Education'). Host: L. Hardman.
- H. Takeda, I. Ohmukai (NII), Y. Matsuo, J. Mori (AIST), June 6–7. Host: L. Hardman.
- S. Pfeiffer, ICT Centre in Marsfield, CSIRO, Sydney, July 5. (Talk: The Continuous Media Web). Host: F.-M. Nack.
- A. de Waard, ELSEVIER, July 6. (Talk: Science Publishing And The Web, Or: Why Are You Reading This Paper). Host: F.-M. Nack
- C. Mancini, Knowledge Media Institute, The Open Univ., July 13. (Talk: Cinematic Hypertext. Investigating a New Paradigm). Host: F.-M. Nack.
- F. Hendrickx (Multimedia Research Lab of IMEC), Peter Soetens, Matthias Degeyter, Bjorn Muylaert, Nico Oorts (VRT), Tom Beckers (XMT) Belgium, July 26. Host: J.R. van Ossenbruggen.
- P. Dolog, L3S Research Center, September 29 (Talk: User Centered Adaptation on the (Semantic) Web). Host: L. Hardman.
- F. Cena, Univ. Torino, September 1–December 24. Host: L. Hardman.

- G. Mallen, System Simulation Ltd, London, UK, September 29. (Talk: Reflections on Gordon Pask's Adaptive Teaching Concepts and their Relevance to Modern Knowledge Systems). Host: F.-M. Nack.
- C. Mellish, Department of Computing Science Univ. Aberdeen, October 7. Host: L. Hardman.
- Z. Obrenovic, Univ. Belgrade, November 2. (Talk: Designing Interactive Systems). Host: L. Hardman.
- G. Anadiotis, Univ. Athens, November 17. Host: L. Hardman.
- E. Hyvonen, Helsinki Univ. of Technology, November 24. Host: L. Hardman.
- L. Concole, Univ. di Torino, December 1. Host: L. Hardman.
- L. Manovich, Univ. California, San Diego, December 14. Host: S. Bocconi.
- J.Z. Pan, Information Management Group, School of Computer Science, Univ. Manchester, December 21. (Talk: Description Logics and Semantic Web Language Extensions). Host: J.R. van Ossenbruggen.

Memberships of committees and other professional activities

A. Amin

- Member of the WGI.
- Member of the SIGCHI and SIGCHI.NL.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).

S. Bocconi

- Programme committee member for the IEEE International Conference on Multimedia & Expo (ICME2005), Amsterdam, July 6–8.
- Assisted reviewing for the Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9.
- Assisted reviewing for the 9th European Conference on Research and Advanced Technology for Digital Libraries (ECDL 2005), Vienna, Austria, September 18–23.
- Reviewer for the Computational Linguistics in the Netherlands Conference (CLIN2005), December 17.
- Member of the Vereniging Werkgemeenschap Informatiewetenschap.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).

K.I. Falkovych

- Programme committee member for the IEEE International Conference on Multimedia & Expo (ICME2005), Amsterdam, July 6–8.
- Assisted reviewing for the Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9.
- Assisted reviewing for the 9th European Conference on Research and Advanced Technology for Digital Libraries (ECDL 2005), Vienna, Austria, September 18-23.
- Assisted reviewing for the Semantic Web track of the 15th International World Wide Web Conference, Edinburgh, Scotland, May 23-26.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).

J.P.T.M. Geurts

- Reviewer for the one day workshop on Multimedia and the Semantic Web, Heraklion, Crete, May 29.
- Programme committee member for the IEEE International Conference on Multimedia & Expo (ICME2005), Amsterdam, July 6–8.
- Assisted reviewing for the Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).

L. Hardman

- Professor in computer science at TUE, since 2001.
- Supervision of A. Amin (PhD student since October 2005).
- Supervision of S. Bocconi (PhD student since January 2002).
- Supervision of K.I. Falkovych (PhD student since November 2002).
- Supervision of J.P.T.M. Geurts (PhD student since June 2002).
- Supervision of M. Hildebrand (PhD student since November 2005).
- Supervision of S. Loeber (PhD student since March 2000) as part of cooperation with TUE.
- Supervision of A. Nigten (PhD student at Central St. Martin's Institute, London since 2002) in collaboration with V2_ (Institute for the Instable Media, Rotterdam).

- Co-supervision of MSc thesis at CWI for J. Salas, (Ontologies in Information Integration within Multimedia Presentation Generation), May 26.
- Co-supervision of MSc thesis for K. Schwarz, (Domain model enhanced search – A comparison of taxonomy, thesaurus and ontology in Information Integration within Multimedia Presentation Generation), June 16.
- Member PhD defense committee of H. van Beek, TUE.
- Member of NWO Veni committee.
- Committee member of the Vereniging Werkgemeenschap Informatiewetenschap.
- Member editorial board for the New Review of Hypermedia and Multimedia (NRHM).
- Member editorial board for the Journal of Web Semantics.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).
- Assisted reviewing for the Semantic Web track of the 15th International World Wide Web Conference, Edinburgh, Scotland, May 23–26.
- Programme committee member for the Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9.
- Reviewer for the International Workshop of Web Semantics.
- Reviewer for the 17th European Summer School in Logic, Language and Information, student session.
- Reviewer for the Informatiewetenschap conference, November 18, Antwerp.
- Reviewer for the New Review of Hypermedia and Multimedia.
- Reviewer for the Journal of Web Semantics.
- Reviewer for the IEEE International Conference on Multimedia & Expo, Amsterdam, July 6–8.
- Reviewer for the 7th International Workshop of the EU Network of Excellence DELOS on Audio-Visual Content and Information Visualization in Digital Libraries (AVIVDiLib'05), Cortona, Italy, May 4–6.
- Reviewer for the Multimedia and the Semantic Web Workshop at the 2nd European Semantic Web Conference (ESWC2005), Heraklion, Crete, May 29.
- Reviewer for the End User Semantic Web Interaction Workshop at the 4th International Semantic Web Conference, Galway, Ireland, November 7.
- Programme committee member for the ACM MM Workshop on Multimedia for Human Communication – From Capture to Convey (MHC 05), Singapore, November 11.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb), Multimedia (SIGMM) and Computer-Human Interaction (SIGCHI).
- Member of the British Computing Society (BCS).

Z. Huang

- Programme committee member of the European Simulation and Modelling Conference (ESM2005), Porto, Portugal, October 24–26.
- Reviewer for the First International Workshop on Workflow systems in e-Science – WSES06, at the International Conference of Computational Science (ICCS06),
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).

F.-M. Nack

- Organizer of ACM MM Workshop ACM Workshop on Multimedia for Human Communication – From Capture to Convey (MHC 05), Hilton Hotel, Singapore, November 11.
- Co-organizer of ACM MM full day Tutorial Media Semantics and the Statistical Foundations for Understanding It, Hilton Hotel, Singapore, November 7.
- Programme committee member of ACM MM 05: Application track, Singapore, November 6–12.
- Co-Chair of ACM MM 05 Video Program, Singapore, November 6–12.
- Programme committee member of ACM MM 05 Art track, Singapore, November 6–12.
- Programme committee member of ACM MM 05 Short paper track, Singapore, November 6–12.
- MSc thesis examiner of K. Han: A semi-automated system to repair anomalies in video footage, The Univ. of York, UK, November.
- PhD thesis examiner of Edward Harteley: Automating Video Annotation, Lancaster Univ., Lancaster, UK, October.

- Reviewer for ACM Multimedia Systems.
- Reviewer for ACM Transactions on Multimedia Computing, Communications and Applications (TOMCCAP).
- Reviewer for Information Retrieval Journal.
- Reviewer for IEEE Intelligent Systems magazine.
- Reviewer for IEEE Multimedia.
- Programme committee member of ACM Multimedia (ACM MM2005), Singapore, November 6–11.
- Programme committee member of IEEE International Conference on Multimedia & Expo (ICME2005), Amsterdam, July 6–8.
- Member of the Advisory Board of V2_, Institute for the Unstable Media, Rotterdam.
- Reviewer for the EU MEDIA programme (Media Program TAO Training)
- Reviewer for the EU MEDIA sagasnet series.
- Reviewer for EPSRC, UK.
- Editor of the Media Impact Column of IEEE MM journal.
- Associate editor in chief for IEEE Multimedia.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb), Multimedia (SIGMM) and Computer-Human Interaction (SIGCHI).
- Member WGI (Vereniging Werkgemeenschap Informatiewetenschap).

J.R. van Ossenbruggen

- Member PhD defense committee of J. Broekstra, July 4.
- Co-supervision of MSc thesis at CWI for J. Salas, (Ontologies in Information Integration within Multimedia Presentation Generation), May 26.
- Affiliate member of the Institute of Electrical and Electronics Engineers (IEEE) Computer Society.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb), Multimedia (SIGMM) and Computer-Human Interaction (SIGCHI).
- Member of the Belgium-Netherlands Association for Artificial Intelligence
- Reviewer for the 15th World Wide Web Conference (WWW2006), Edinburgh, Scotland, May 23–26.
- Programme committee member for the Sixteenth ACM Conference on Hypertext and Hypermedia (HT2005), Salzburg, Austria, September 6–9.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).
- Member of the Semantic Web Best Practices and Deployment (SWBPD) W3C working group.

L.W. Rutledge

- Member of committee for MSc Thesis at TUD for A. Kapoerchan 'Topic Maps for the StatLine database', July 12.
- Programme committee vice chair responsible for the Hypermedia and Multimedia Track of The Fifteenth International World Wide Web Conference (WWW2006), Edinburgh, Scotland, May 23–26.
- Programme committee co-chair responsible for the Time and Synchronisation in Hypermedia theme of the Sixteenth ACM conference on Hypertext and Hypermedia (HT05), Salzburg, Austria, September 6–9.
- Publicity co-chair for ACM Multimedia 2005, Singapore, November 6–11.
- Reviewer for IEEE Transactions on Multimedia.
- Reviewer for the New Review of Hypermedia and Multimedia (NRHM).
- Reviewer for the Journal of Digital Information (JoDI).
- Reviewer for Document Engineering (DocEng 2005), Bristol, UK, November 2–4.
- Reviewer for the Tenth International Conference on Multi-Media Modeling (MMM 2005), Melbourne, Australia, January 12–14.
- Reviewer for the Ninth European Conference on Research and Advanced Technology for Digital Libraries (ECDL 2005), Vienna, Austria, September 18–23.
- Reviewer for The First International Workshop of the EU Network of Excellence DELOS on Audio-Visual Content and Information Visualization in Digital Libraries (AVIVDiLib'05), Cortona, Italy, May 4–6.
- Member of the Dutch research school for Information and Knowledge Systems (SIKS).
- Member of the Vereniging Werkgemeenschap Informatiewetenschap.

- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb), Multimedia (SIGMM) and Computer-Human Interaction (SIGCHI).

K. Schwarz

- Member of the Vereniging Werkgemeenschap Informatiewetenschap.
- Maintainer of the website of the Vereniging Werkgemeenschap Informatiewetenschap.

R. Troncy

- Programme committee member of the Fourth International Semantic Web Conference (ISWC2005), Galway, Ireland, November 3–10.
- Workshop co-organizer 'Systéme d'Information Audiovisuel' – AudioVisual Information Systems (SIAV'06), Fribourg, Switzerland, September 18–22.
- Workshop co-organizer Semantic Web Annotations for Multimedia (SWAMM'06), Edinburgh, Scotland, May 22.
- Member of the Semantic Web Best Practices and Deployment (SWBPD) W3C working group.

Academic publications

Publications in refereed journals or proceedings

1 S. Bocconi, F. Nack, L. Hardman (2005). Supporting the Generation of Argument Structure within Video Sequences. Proceedings of the sixteenth ACM Conference on Hypertext and Hypermedia 2005, 75–84.

2 D. C. Bulterman, L. Hardman (2005). Structured Multimedia Authoring. ACM Trans. Multimedia Comput. Commun. Appl. 1(1), 89–109.

3 F. Nack, J. van Ossenbruggen, L. Hardman (2005). That Obscure Object of Desire: Multimedia Metadata on the Web (Part II). IEEE Multimedia 12(1), 54–63. Based on CWI report INS-E0309.

4 J. van Ossenbruggen, L. Hardman, L. Rutledge (2005). Combining RDF Semantics with XML Document Transformations. International Journal of Web Engineering and Technology (IJWET), 2(2/3), 248–263. IJWET Special Issue on Semantic Web Technologies for Data Integration and Multimedia Presentation. Flavius Frasincar, Geert-Jan Houben and Jacco van Ossenbruggen (guest editors). Article is a revised version of INS-E0303.

5 L. Rutledge, J. van Ossenbruggen, L. Hardman (2005). Making RDF Presentable. Integrated Global and Local Semantic Web Browsing, Proceedings WWW2005, 199–206.

6 K. Schwarz, T. Kouwenhoven, V. Dignum, J. van Ossenbruggen (2005). Supporting the decision process for the choice of a domain modeling scheme. Formal Ontologies Meet Industry (FOM/2005), 6 pages.

Publications in other journals or proceedings and other scientific output

Unrefereed (electronic) journals or proceedings

1 S. Bocconi, F. Nack, L. Hardman (2005). Using Rhetorical Annotations for Generating Video Documentaries. Proceedings of the Conferentie Informatiewetenschap 2005. Already published at ICME 2005.

2 K. Falkovych, S. Bocconi (2005). Creating a Semantic-based Discourse Model for Hypermedia Presentations: (Un)discovered Problems. HT 05 Workshop on Narrative, Musical, Cinematic and Gaming Hyperstructure, 5 pages.

3 J. Geurts, J. van Ossenbruggen, L. Hardman (2005). Requirements for practical multimedia annotation. BSWC 2005 Workshop on Multimedia and the Semantic Web, 4–11.

4 F. Nack (2005). Capture and Transfer of Metadata During Video Production. Proceedings of the ACM Workshop on Multimedia for Human Communication – From Capture to Convey (MHC 05), 4 pages.

5 F. Nack, S. Bocconi (2005). Generating Media Stories – Play It Again, Sam. HT 05 Workshop on Narrative, Musical, Cinematic and Gaming Hyperstructure, 3 pages.

6 L. Rutledge, L. Aroyo, P. Gorgels, N. Stash, M. Veenstra, R. Brussee (2005). Recommending Topics from Rated Objects. End User Semantic Web Interaction Workshop (colocated with ISWC 2005), Galway, Ireland, 2 pages. Short position paper.

7 L. Rutledge, M. Alberink, L. Hardman, M. Veenstra (2005). Generalized Semantics-to-Document Derivation. ACM Hypertext, 284–285, Poster.

8 L. Rutledge, J. van Ossenbruggen (2005). Cruising the Semantic Web with Noadster. ACM Hypertext, 290–291, Poster.
9 U. Straccia, R. Troncy (2005). oMAP: An Implemented Framework for Automatically Aligning OWL Ontologies. Proceedings of the 2nd Italian Semantic Web Applications and Perspectives Workshop (SWAP 05), 14 pages.
10 U. Straccia, R. Troncy (2005). oMAP: Results of the Ontology Alignment Contest. Proceedings of the K-Cap Workshop on Integrating Ontologies (IntOnt 05), 5 pages.
11 J. van Ossenbruggen, L. Hardman (2005). Semantic Timeline Interfaces for Annotated Multimedia Assets. The 2nd European Workshop on the Integration of Knowledge, Semantic and Digital Media Technologies (EWIMT), November 30–December 1, Poster presentation.
12 J. van Ossenbruggen, G. Stamou, J. Z. Pan (2005). Multimedia Annotations and the Semantic Web. Semantic Web Case Studies and Best Practices for eBusiness, 4 pages. Workshop colocated with ISWC 2005.

MSc theses

1 K. Schwarz (2005). Domain model enhanced search – A comparison of taxonomy, thesaurus and ontology. Master Thesis Content and Knowledge Engineering, UU.

CWI reports

INS-E0501, INS-E0502, INS-E0504, INS-E0505, INS-E0509, INS-E0512, INS-E0513, INS-E0514, INS-E0515, INS-E0516, INS-E0517.
See page B.5 on page 204 for the complete titles.

Software developed

1 In the context of the MultimediaN project van Ossenbruggen co-developed the first version of Eculture MultimediaN demostrator. Further developments on the demo included Amin's work on interface issues. Amin purposed a set of user profiles and conducted the first internal evaluation on the Eculture demo at the MultimediaN Annotation Meeting. Hildebrand explored the possibilities of semantic presentation generation using multiple facets, including time and space. He updated the existing MultimediaN Eculture demo in two ways: improved visualization of the semantic timeline and added a natural language sentence generator for cluster headers.
2 In the context of the I^2RP project, Bocconi extended the previous implementation of the Vox Populi demo. He improved underlying argumentation structure to allow for generation of extended video sequences. Bocconi also improved the user interface with possibilities to set user preferences regarding interview participants in the presented videos.
3 In the context of the CHIME project, Falkovych further developed a prototype of the SampLe system, which supports authors of multimedia presentations by allowing them to carry out their tasks in different workflows. The system currently supports the creation of discourse structures for various presentation genres and provides adaptation of discourse structures to specific user characteristics.
4 In the context of the NASH project, Geurts maintained software which generated the Media Streams ontology. He also integrated and adopted Semantic Web technology into the Cuypers framework. Furthermore the design rules within the system were extended to use modality knowledge to improve the presentation of media items.
5 Rutledge developed the Noadster Demo, which exercises Semantic Web browsing with automatic generation of document structure around search results.
6 Troncy developed oMAP: an ontology alignment tool available at: `http://homepages.cwi.nl/troncy/oMAP/`.

Visualization and 3D Interfaces – INS3

Mission

Visualization and 3D user interfaces have rapidly become an important research area. It clearly has a multidisciplinary character, intersecting various disciplines in computer science (in particular com-

puter graphics and user interfaces) and mathematics (in particular numerical mathematics and statistics), and also has connections with research in perception and industrial design.

Until recently, research in scientific visualization and 3D user interfaces was oriented toward the ad hoc development of working prototypes. In the excitement over the obvious benefits, few questions were asked about the nature of perceived information and how well the human visual system actually performs. Because visualization and virtual reality are new, emerging disciplines, the lack of structure is not surprising, but their development is necessary and offers significant opportunities.

The mission of the theme 'Visualization and 3D Interfaces' is to obtain a better understanding of the methodologies and formalisms involved in building and engineering interactive visualization systems. An important aspect is the application and evaluation of these systems in real world applications.

Theme leader

Prof.dr.ir. R. van Liere

MSC or CR classification

I.3.2, I.3.3, I.3.2.6

Subthemes

Name	Leader
INS3.1 – Data Visualization	R. van Liere
INS3.2 – 3D User Interfaces	R. van Liere

INS3.1 is concerned with researching interactive scientific visualization issues in the area of time-dependent data sets and the exploration of multidimensional information spaces. This research is combined with the development of algorithms arising in projects from the Dutch living cell initiative.

INS3.2 is concerned with applying virtual reality technology to cost-effective and ergonomical 3D desktop user interfaces. 3D visual and tangible interfaces are the key research focus. This research is combined with the engineering of prototype desktop solutions together with several affiliated research groups.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Ir. A. Broersen	1.0	PhD student	2004-02-01 till 2008-02-01	INS3.1
Drs. B.R. Boschker	0.5	PhD student	2002-11-01 till 2005-06-01	INS3.2
Drs. W. Burakiew	0.83	PhD student	2005-05-01 till 2009-05-01	INS3.1
Drs. K.J. Kruszynski	1.0	PhD student	2004-03-01 till 2008-03-01	INS3.1
Dr.ir. W.C. de Leeuw	1.0	researcher	indefinite	INS3.1
Prof.dr.ir. R. van Liere	0.8	theme leader	indefinite	INS3.1; INS3.2
Dr. J.D. Mulder	1.0	researcher	2005-05-01 till 2007-05-01	INS3.2
D.Q.A. Nguyen	0.75	MSc student	2004-12-01 till 2005-09-01	INS3.2

continued on next page

continuation from previous page

Ir. A.J. van Rhijn	1.0	PhD student	2002-03-01 till 2006-03-01	INS3.2
Drs. F. Smit	0.25	PhD student	2005-09-01 till 2009-09-01	INS3.2

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. J.J. van Wijk (TUE)	p.m.	advisor	indefinite	INS3.2

Scientific report

Highlights

- NWO VIEW 'QUASID' project granted.
- Spin-off company Personal Space Technologies initiated.

PhD students

A. Broersen
B.R. Boschker
W. Burakiew
K.J.Kruszynski
A.J. van Rhijn
F. Smit

INS3.1 – Data Visualization

Microscopy has always been an essential component in biological and biomedical research. Confocal and deconvolution microscopes now are routine equipment in many laboratories. The application of interactive graphics techniques allow for the analysis of high-volume 3D-images of biological objects, such as protein, cells and tissues. These imaging techniques will continue to evolve, as a broad field of bioscientists are now moving into the imaging of living cells. The research of De Leeuw addresses the problems arising when visualizing time dependent data sets of living cells acquired by confocal microscopes.

Title	Modelbased visualization of chromatin dynamics
Period	January 2004–April 2008
Leader	R. van Liere
Staff	W.C. de Leeuw, R. van Liere
Funding	Bsik VL-e
Partner	SILS

Progress report. De Leeuw continued research on the modelling simulation of 30 nanometer fibers. The results of this research will be used for enhanced extraction and visualization techniques of chromatin dynamics from three dimensional confocal imaging data. Methods were developed to provide visual presentations of structural characteristics of cell data. New algorithms were developed to determine image attributes and the classification of data sets based on multidimensional attribute vectors. Two multi-disciplinary journal papers on this subject have been published in 2005. These results have been integrated in the software package *Argos*.

The research in the project is coordinated by Van Liere, in collaboration with Prof. R. van Driel at the Swammerdam Institute for Life Sciences.

Title	3D visualization of large scale mass-spectroscopy data
Period	January 2004–April 2008
Leader	R. van Liere
Staff	A. Broersen, R. van Liere
Funding	Bsik VL-e
Partner	AMOLF

Progress report. Broersen continued research on the visualization of mass-spectroscopy data. Novel 3D methods will be developed for interactive analysis of very large data sets. These methods use interactive principle component analysis for the interactive analysis of the spectral component in the data and are implented on the GRID to achieve the required performance. In 2005, this research has resulted in two conferences papers.

The research in the project is coordinated by Van Liere, in collaboration with Prof. R. Heeren (AMOLF).

Title	Visualization of Particle Dynamics
Period	May 2005–May 2008
Leader	R. van Liere
Staff	W. Burakiew, R. van Liere
Funding	Bsik VL-e
Partner	AMOLF

Progress report. Burakiew initiated research on the visualization of complex particle dynamics. Algorithms will been developed that visualize particle dynamics at a high-level semantical level. These algorithms will be applied to obtain insight in ion cloud dynamics and ion-ion interactions.

The research in the project is coordinated by Van Liere, in collaboration with Prof. R. Heeren (AMOLF).

Title	Quantitative visualization of complex Bio-medical objects
Period	January 2004–April 2008
Leader	R. van Liere
Staff	K.J. Kruszynski, R. van Liere
Funding	Bsik VL-e
Partner	AMOLF

Progress report. Kruszynski continued research on the quantitative visualization of complex bio-medical objects. Various skeleton extraction algorithms have been quantitatively compared based on morphological metrics. In 2005, this research has resulted in one conferences paper.

The research in the project is coordinated by Van Liere, in collaboration with Dr. J. Kaandorp (UvA).

INS3.2 – 3D User Interfaces

The 3D interfaces project researches how new interface paradigms and a better understanding of underlying perceptual issues will create new opportunities for interacting with 3D worlds. 3D interfaces raise various new research questions, e.g., what, where and why are potential gains of exploring scientific data in the 3D environments and what is the role of direct interaction in these environments.

The experimental environments used in the 3D interface project are the in-house developed Personal Space Station environment. This environment uses a mirror for creating a input workspace and optical tracking allowing for interaction tasks. Fiducial marker tracking will enable the connection between the physical and computational representations, and thus provide the basis for tangible interfaces. During the course of the project this environment and the developed software has been disseminated to several affiliated national research groups.

In 2005 the NWO VIEW QUASID project was initiated. This project seeks to develop a more quantitative approach to the design of spatial interaction techniques. The approach will be applied and tested in the design of new spatial interaction techniques for mixed-reality desktop environments.

Title	PSS – Personal Space Station
Period	April 2001–April 2005
Leader	R. van Liere
Staff	J.D. Mulder, B. Boschker, A.J. van Rhijn, R. van Liere
Funding	ICES-KIS II
Partners	SILS, TUE

Progress report. The research of Van Rhijn is focused on the study of 3D interactive techniques in a near field virtual reality environment. Current research is aimed at the low level technical requirements in a Personal Space Station environment.

Van Rhijn developed an optical tracker based on the model estimation and tracking of point clouds. Inter-point connections can be rigid or have six degrees of freedon.. This work has led to publications at the IEEE VR conference in 2005 and Eurographics Symposium on Virtual Environments 2005.

Mulder conducted a study on realistic occlusion in augmented reality environments. In 2005, this work has led to a publication at the IEEE VR conference in 2005.

Mulder conducted a study on menu selection in virtual reality environments. In 2005, this work has led to a publication at the Central European Multimedia and Virtual Reality Conference.

Boschker and Mulder worked on a study that compares collaborative construction techniques in a mixed reality envrironment.

Title	QUASID : Quantitative Design of Spatial Interaction Techniques for Desktop Mixed-Reality Environments
Period	June 2005–June 2009
Leader	R. van Liere
Staff	F. Smit, R. van Liere
Funding	NWO
Partners	TUE

Progress report. The research of Smit is focused on the study of tangible interaction on scientific data. The aim is to generalize and improve the process of integrating tangible models into mixed reality environments and to study the effectiveness of these tangible interfaces.

Smit initiated work on a new optical tracker for determining the pose of input props. The approach is based on the projective invariant topology of graph structures. In this way the point correspondence problem by a subgraph matching algorithm between the detected 2D image graph and the model graph can be solved.

Societal aspects and knowledge transfer

External contacts

- TUE
- TUD
- VU
- AMOLF
- UvA CAPS

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- IEEE VR 2005, Bonn, Germany, March 27–31: R. van Liere, J.D. Mulder, A. van Rhijn.
- Central European Multimedia and Virtual Reality Conference, Prague, Czech Republic, June 8–10: R. van Liere, A. van Rhijn, J.D. Mulder.
- 3D genome workshop, Heidelberg, May 31: W. de Leeuw.
- Dagstuhl Seminar No 05231 Scientific Visualization: Challenges for the Future, June 5: W. de Leeuw.
- Eurographics / IEEE EUROVis, Leeds, UK, May 28–31: A. Broersen.
- VIIP, Benidorm, Spain, September 6–9: A. Broersen, C. Kruzynski.
- Eurographics Symposium on Virtual Environments, Aalborg, Denemark, October 8–9: A. van Rhijn, J.D. Mulder, R. van Liere.

Memberships of committees and other professional activities

R. van Liere

- Full professor at TUE, one day/week.
- Member executive committee, Eurographics Association Benelux region.
- Member programme committee NWO-VIEW.
- IPC IEEE Virtual Reality 2006.
- IPC Eurographics/IEEE Visualization Symposium 2006.
- IPC Eurographics Symposium on Virtual Environments 2006.
- IPC Workshop on Advanced Collaborative Environments.
- IPC IASTED, VIIP 2005.
- IPC IEEE Visualization 2005.

J.D. Mulder

- IPC IEEE Virtual Reality 2005.
- IPC Eurographics Symposium on Virtual Environments 2006.

Academic publications

Publications in refereed journals or proceedings

1 P.J. Verschure, I. van der Kraan, W. de Leeuw, J. van der Vlag, A.E. Carpenter, A.S. Belmont, R. van Driel (2005). In vivo HP1 targeting causes large-scale chromatin condensation and enhanced histone lysine methylation. Molecular and Cellular Biology 25, 4552–4564.

2 A. Broersen, R. van Liere (2005). Transfer Functions for Imaging Spectroscopy Data using Principle Component Analysis. Proceedings of Eurographics / IEEE VGTC Symposium on Visualization, 117–123.

3 A. Broersen, R. van Liere, R.M.A. Heeren (2005). Comparing three PCA-based Methods for the 3D Visualization of Imaging Spectroscopy Data. Proceedings of IASTED International Conference on Visualization, Imaging and Image Processing, 540–545.

4 A. van Rhijn, J.D. Mulder (2005). Optical Tracking and Calibration of Tangible Interaction Devices, Proceedings of the Eurographics Symposium on Virtual Environments 2005, 41–50.

5 A. van Rhijn, R. van Liere, J.D. Mulder (2005). An Analysis of Orientation Prediction and Filtering Methods for VR/AR. Proceedings of the IEEE Virtual Reality Conference 2005, 67–74.

6 J.D. Mulder (2005). Realistic Occlusion Effects in Mirror-Based Co-Located Augmented Reality Systems. Proceedings of the IEEE Virtual Reality Conference 2005, 203–208.

7 J.D. Mulder (2005). Menu Selection in Desktop Virtual Reality. Proceedings of the Central European Multimedia and Virtual Reality Conference 2005, 121–128.

8 B.R. Boschker, J.D. Mulder (2005). Evaluation of Collaborative Construction in Mixed Reality. Proceedings of the Eurographics Symposium on Virtual Environments 2005, 171–179.

9 R. van Liere, A. Kok, J.-B. Martens, M. van Tienen (2005). Interacting with Molecular Structures: User Performance versus System Complexity. R. Blach, E. Kjems (eds). Proceedings of the IPT / EGVE 2005, 147–156.

10 A. Kok, R. van Liere (2005). A Multimodal Virtual Reality Interface for VTK. E.V. Zudilova-Seinstra, T. Adriaansen (eds). Proceedings of Multimodal Interaction for the Visualization of Scientific Data, 35–42.

Publications in other journals or proceedings and other scientific output

Software developed

- Argos: software for the analysis and visualization of collections of confocal data sets and associated image attributes.
- PVR: a portable desktop VR system. The PVR system includes functionality for managing the 3D workspaces and optical tracking algorithms. The software is installed and used daily at six universities.

Professional products

Publications for a broad audience

1 'Beleven met een machine', by H. Klomp, NRC, February 15,

Other output

Grants

NWO VIEW project QUASID : Quantitative Design of Spatial Interaction Techniques for Desktop Mixed-Reality Environments.

Quantum Computing and Advanced Systems Research – INS4

Mission

There is great progress and opportunity in nonclassical computational technologies and algorithmics by exploiting novel computational aspects of physical phenomena, using nonclassical algorithms, or using classical algorithms in a nonclassical manner. Key issues are Feasibility of Technology and Efficiency of Algorithms, and Theoretical Basics. Novel technologies comprise coherent quantum mechanical and reversible low-energy computing.

Quantum information processing is the intersection of quantum mechanics and computer science. It tries to improve on classical computers and classical complexity bounds by making use of quantum mechanical phenomena. After Peter Shor's 1994 discovery of efficient quantum algorithms for factoring and the discrete log (threatening current 'classical' cryptography), the field has grown explosively and is now one of the hottest subfields of both computer science and physics.

Novel aspects of classical algorithms include distributed networking, security, genomics algorithmics and automatic learning by compression.

The work programme in quantum algorithmics includes the design and analysis of new algorithms in communication and the 'black box' model, and development of new tools to establish complexity bounds of such algorithms. We plan to test such algorithms collaborating with experimental groups in the USA and recently also in the EU (viz., the RESQ project). In reversible computing we develop new reversible simulations that use less time and memory simultaneously than any currently known algorithm. In machine learning we continue our work on algorithmic minimal sufficient statistics and minimal description length learning (MDL). Applications of algorithmic information theory (also known as Kolmogorov complexity) in mathematics and algorithms are investigated and consolidated. A new

research strain (for the moment part of INS4.3) is planned in theoretical analysis and applications of computational genomics. In particular in sequencing, analyzing genomic material in secondary and tertiary structure. For more information, see `http://www.cwi.nl/ins4`.

Theme leader

Prof.dr. H.M. Buhrman

MSC or CR classification

E.4, F.1, F.2, H.3, I.2, I.5

Subthemes

Name	Leader(s)
INS4.1 – Quantum Computing	H.M. Buhrman
INS4.2 – MDL Learning and Algorithmic Statistics	P.D. Grünwald, P.M.B. Vitányi
INS4.3 – Advanced Algorithms, Systems and Genomics	H.M. Buhrman, P.M.B. Vitányi

INS4.1 studies algorithms and systems based on quantum mechanical principles. This work is exploratory research dealing with quantum algorithmics, quantum communication complexity, quantum information theory. Together with similar groups in Europe and the USA, CWI's work is aimed at making the realization of practical quantum computation possible.

INS 4.2 addresses a range of issues related to machine learning and statistical inference, both theoretically and practically. It studies the relation between data compression and generalization properties and prediction, for example in the sense of the 'minimum description length' paradigm – basically a formal version of Occam's Razor.

INS 4.3 develops principles and algorithms for distributed and parallel systems. Moreover, it identifies limitations and possibilities of future systems by exploiting fundamental mathematical techniques of complexity theory. A major part of the work is on computational genomics, phylogeny, and clustering.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. H.M. Buhrman	0.8	theme leader, leader INS4.1, co-leader INS4.3	indefinite	INS4.1: RESQ, NWO, Vici; INS4.3
R.L.C. Cilibrasi, BSc (Caltech)	1.0	PhD student	2002-09-01 till 2006-09-01	INS4.2: PASCAL; INS4.3: ACAA
Dr. P.D. Grünwald	1.0	co-leader INS4.2	indefinite	INS4.2: UL, PASCAL, Vidi
Dr. M. Koucky	1.0	postdoc	2005-01-01 till 2005-12-31	INS4.1, 4.3 : Vici
Dr. Z. Lotker	1.0	postdoc	2004-12-01 till 2006-12-01	INS4.1, 4.3: NWO project
Drs. S. de Rooij	1.0	PhD student	2003-10-01 till 2007-10-01	INS4.2:PASCAL; INS4.3: NWO
Drs. R.S. Špalek	1.0	PhD student	2002-09-01 till 2006-09-01	INS4.1; REQ
Dr. J.T. Tromp	1.0	researcher	indefinite	INS4.2; INS4.3: BSI
Drs. F.P. Unger	1.0	PhD student	2004-01-04 till 2008-01-04	INS4.1: RESQ, Vici

continued on next page

continuation from previous page

Prof.dr.ir. P.M.B. Vitányi	0.8	INS4.2, INS4.3	indefinite	INS4.1; INS4.2; INS4.3; collaboration with several people
Drs. S.D.C. Wehner	0.67	PhD student	2004-05-01 till 2008-05-01	INS4.1: RESQ, Vici
Dr. R.M. de Wolf	1.0	postdoc	2002-09-01 till 2006-09-01	INS4.1: RESQ, NWO, Vici

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
T.J. Lee, BSc (UvA)	1.0	PhD student	2002-01-01 till 2006-02-01	INS4.1; INS4.3: RESQ
T. van Erven	1.0	trainee	2005-07-01 till 2006-04-01	INS4.2
J. van Woudenberg	1.0	trainee	2004-11-01 till 2005-06-01	INS4.2

Scientific report

Highlights

- Paradiso lecture quantum computing (Buhrman).
- Lecture in Diligentia Den Haag (Buhrman).
- Vitányi appointed 'Hoogleraar 1' at UvA.
- Vitányi adjunct Professor Computer Science, Univ. Waterloo, Ontario, Canada.
- Peter Grünwald starts Vidi project.
- Book 'Advances in Minimum Description Length: theory and applications' published by MIT Press. Book is co-edited by Grünwald, who also wrote the first two introductory chapters.
- The paper 'Generalization to Unseen Cases' (co-authored by Grünwald) wins the best paper award at BNAIC 2005 (Annual Belgium-Netherlands AI Conference).
See also on page 200.

PhD students

R.L.C. Cilibrasi
T.J. Lee
S. de Rooij
R.S. Špalek
F.P. Unger
S.D.C. Wehner

INS4.1 – Quantum Computing

There is great progress and opportunities in nonclassical computational technologies and algorithmics by exploiting novel computational aspects of physical phenomena, using nonclassical algorithms, or using classical algorithmics in a nonclassical manner. Novel technologies comprise coherent quantum mechanical and reversible low-energy computing. Here, we focus on exploratory research dealing with quantum algorithmics, quantum communication complexity, quantum information theory, and quantum information retrieval algorithms. This work is part of a strong international effort aimed at solving the grand challenge of finding applications and limitations of quantum computing.

Title	Vici grant – Quantum information processing
Period	2004–2009
Leader	H.M. Buhrman
Staff	H.M. Buhrman, S.D.C. Wehner, F.P. Unger
Funding	NWO (Project 639.023.302)

Title	RESQ – Resources for Quantum Computing
Period	2003–2005
Leader	H.M. Buhrman
Staff	H.M. Buhrman, R.S. Špalek, S. Wehner, R.M. de Wolf, F. Unger
Funding	EU (Project IST-001-37559)

Title	QC – Quantum Computing
Period	1998–2005
Leader	P.M.B. Vitányi
Staff	H.P. Röhrig, postdoc vacancy
Funding	NWO (Grant 612.015.001)

Title	QIP – Quantum Information Processing
Period	1999–2005
Leader	H.M. Buhrman
Staff	R.S. Špalek, R.M. de Wolf
Funding	NWO (Grant 612.055.001)
Partners	RESQ partners

Joint progress report of above projects. N. Brassard (Montréal), Buhrman, G. Linden (Bristol), A. Methot (Montréal), A. Tapp (Montréal), Unger studied limits on nonlocality. Bell proved that quantum entanglement enables two space-like separated parties to exhibit classically impossible correlations. Even though these correlations are stronger than anything classically achievable, they cannot be harnessed to make instantaneous (faster than light) communication possible. Yet, Popescu and Rohrlich have shown that even stronger correlations can be defined, under which instantaneous communication remains impossible. This raises the question: Why are the correlations achievable by quantum mechanics not maximal among those that preserve causality? We give a partial answer to this question by showing that slightly stronger correlations would result in a world in which communication complexity becomes trivial.

Using the above mentioned approach Buhrman, R. Cleve (Waterloo), Laurent (PNA1), N. Linden (Bristol), Schrijver (PNA1), and Unger were able to derive the best known upper bound on the noise for fault tolerant quantum computation. In particular we show that quantum circuits cannot be made fault-tolerant against a depolarizing noise level of noise = $(6 - 2\sqrt{2})/7\ 45\%$, thereby improving on a previous bound of 50% (due to Razborov). Our precise quantum circuit model enables perfect gates from the Clifford group and arbitrary additional one-qubit gates that are subject to depolarizing noise of roughly 45We prove that this set of gates cannot be universal for arbitrary (even classical) computation, from which the upper bound on the noise threshold for fault-tolerant quantum computation follows

Buhrman, M. Christandl (Cambridge), Unger, Wehner, A. Winter (Bristol) studied Implications of Superstrong Nonlocality for Cryptography. Non-local boxes are hypothetical machines that give rise to superstrong non-local correlations, leading to a stronger violation of Bell/CHSH inequalities than is possible within the framework of quantum mechanics. We show how non-local boxes can be used to perform any two-party secure computation. We first construct a protocol for bit commitment and then show how to achieve oblivious transfer using non-local boxes. Both have been shown to be impossible using quantum mechanics alone.

Buhrman, M. Christandl (Cambridge), P. Hayden (Montréal), H.-K. Lo (Toronto), Wehner studied the (Im)possibility of Quantum String Commitment. Unconditionally secure non-relativistic bit commitment is known to be impossible in both the classical and quantum worlds. However, when committing to a string of n bits at once, how far can we stretch the quantum limits? We consider quantum schemes where Alice commits a string of n bits to Bob, in such a way that she can only cheat on a bits and Bob can learn at most b bits of 'information' before the reveal phase. We show a negative and a positive result, depending on how we measure Bob's information. If we use the Holevo quantity, no good schemes exist: $a + b$ is at least n. If, however, we use accessible information, there exists a scheme where $a = 4 \log n + O(1)$ and $b = 4$. This is classically impossible. Our protocol is not efficient, however, we also exhibit an efficient scheme when Bob's measurement circuit is restricted to polynomial size. Our scheme also implies a protocol for n simultaneous coin flips which achieves higher entropy of the resulting string than any previously known protocol.

INS4.2 – MDL Learning and Algorithmic Statistics

Applications and implementations of MDL include automatic grammar generation from large text corpora, pattern recognition (learning optimal model granularity) and comparative evaluation of predictive accuracy of MDL and new forms of stochastic complexity. Furthermore, basic research into the 'algorithmic' sufficient statistic, an individual statistic that summarizes all relevant information in the individual data. We also apply our methods to resolve, and elucidate, problems in in cognitive psychology.

Title	PASCAL–Pattern Analysis, Statistical Modelling and Computational Learning
Period	2003–2007
Leader	P.D. Grünwald
Staff	J.T. Tromp, R.L.C. Cilibrasi, S. de Rooij, P.M.B. Vitányi
Funding	EU Network of Excellence
Partners	Univ. Southampton, 57 more sites

Title	Vidi grant–Learning when all Models are Wrong
Period	2005–2010
Leader	P.D. Grünwald
Staff	P.D. Grünwald, T. van Erven (to start 1-2-2006)
Funding	NWO (Project 639.022.402)

Joint progress report of above projects.
Grünwald published an extensive 80-page tutorial on the Minimum Description Length Principle. This appeared as the first two chapters of the book *Advances in Minimum Description Length: theory and applications* (MIT Press, April 2005), edited by Grünwald, I.J. Myung, M.A. Pitt (Ohio State Univ.).

Grünwald, T. Roos, P. Myllymäki, H. Tirri (all Univ. Helsinki) studied generalization bounds for the so-called *off-training set* classification error. In contrast to the ordinary $0/1$ or classification error, this error measure is defined as the probability of making a wrong prediction, given that the X-value on which the prediction is based *has not been seen before*. For the ordinary classification error, there exist various learning bounds that bound the probability of error of learning algorithms in terms of their performance on the training set. These can be based on Vapnik-Chervonenkis dimension, PAC-Bayes analysis or other trade-offs between fit on training data and complexity of hypothesis space. It has been claimed (but never proven) that no such learning bounds can be established for off-training set error. We show that this is not true: we derive data-dependent learning bounds for off-training set error. Our method uses the idea of Good-Turing estimation, originally mostly applied in the language learning community. Based on our results, we show the incorrectness of some stated (but never proved) implications of the so-called 'No Free Lunch' theorems of machine learning. We presented this work at NIPS 2005. An early version of the paper won the best paper award at the BNAIC 2005 conference.

Grünwald, J. Langford (TTI, Chicago) continued work on inconsistency of Bayesian and MDL inference. From a purely probabilistic point of view, our first main result (2004) can be restated as 'if none of the models under consideration is 'correct' (coincides with the data generating distribution), but the set of models under consideration nevertheless contains some quite good approximations to the data generating distribution, then these approximations may never be found by Bayesian/MDL learning algorithms, no matter how many data are provided'. In 2005, this was work was extended to characterize the worst-case behaviour of Bayesian methods in classification problems. Amazingly, it was found that classification based on the Bayes' decision rule taken relative to the Bayesian posterior distribution can be much worse than random guessing.

Grünwald, R. Gill (UU) gave an algorithmic and a geometric characterization of the so-called CAR (Coarsening at Random) condition for conditional probability distributions. This condition plays a fundamental role in updating probability distributions in the light of new information: if the condition holds for the (set of) distributions under consideration, then one does not need to distinguish between observing an event and discovering that it is true. Grünwald and Gill provide a simple probabilistic algorithm that can simulate all, and only, CAR distributions, thereby solving an open problem posed by Gill, van der Laan and Robins in 1997. They also show that the set of conditional CAR distributions for a given finite sample space is a convex polytope, and they provide a precise characterization of the extreme points of this polytope.

Title	UL – Universal Learning
Period	2002–2006
Leader	P.M.B. Vitányi
Staff	P.D. Grünwald, S. de Rooij
Funding	NWO (project 612.052.004)
Partners	HIIT Helsinki, Univ. College London

Progress report. Vitányi, Vereshchagin (Moscow State Univ.) propose and develop rate-distortion theory in the Kolmogorov complexity setting. This gives a theory of lossy compression of individual data objects, using the computable regularities of the data. They show that a lossily compressed representation that realizes least distortion of the source object at a given rate also captures an appropriate part of the 'essence' or 'meaning' of that object. This essential property cannot even be expressed in the standard rate distortion theory based on Shannon's concepts. This is applied to Euclidean distortion, Hamming distortion. De Rooij worked at the following items:

1. The Prequential Maximum Likelihood

code, a particular type of universal code that we found exhibits unexpected behaviour. Our findings are published and presented as detailed below.
2. An interesting case in which the MDL principle may be expected to lead to underfitting. Work in progress, joint work with Peter Grünwald and Tim van Erven.
3. An attempt to study in a practical setting the the notion of lossy data compression within the theoretical framework of Kolmogorov Complexity (the so-called Kolmogorov Structure Function.)

This is work together with Vitanyi.

INS4.3 – Complexity Theory advanced Algorithms, Systems, and Genomics

The project develops principles and algorithms for distributed and parallel systems. Moreover, it identifies limitations and possibilities of future systems by exploiting fundamental mathematical techniques of complexity theory. We study the descriptional complexity, leading to both the 'incompressibility method' and 'learning by compression.' Central question in this research area are the P versus NP question and other computational complexity related issues.

Title	ACAA – Average-Case Analysis of Algorithms
Period	2000–2006
Leader	P.M.B. Vitányi
Staff	R.L.C. Cilibrasi
Funding	NWO (project 612.55.002)
Partners	Univ. Waterloo, BSI

Progress report. Cilibrasi and Vitányi continued research in a new method for clustering based on compression. The method doesn't use subject-specific features or background knowledge, C. It is based on a parameter-free, universal, similarity distance, the normalized compression distance or NCD, computed from the lengths of compressed data files (singly and in pairwise concatenation). The NCD is not restricted to a specific application area, and works across application area boundaries. We have developed the theory based on the new notion of 'normal' compressors, and shown that the method is universal The method is implemented and available as public software, and is robust under choice of different compressors. It was published in *IEEE Transactions Information Theory* and presented at ITW2005 - IEEE ITSOC Information Theory Workshop 2005 on Coding and Complexity, Augustus 29–September 1, Rotorua, New Zealand.

Cilibrasi and Vitanyi have developed a new method to extract a hierarchy of clusters from the distance matrix, a variant of 'quartet-puzzling' which is is a sensitive computational biology phylogeny method. We show the method is NP hard, and give a randomized hill-climbing parallel genetic programming method as a a fast heuristic to implement it. The method is capable of handling up to 60–80 objects in a matter of hours, while no existing quartet heuristic can directly compute a quartet tree of more than about 20–30 objects without running for years. The method is implemented and available as public software at www.complearn.org. We present applications in many areas like music, literature, bird-flu (H5N1) virus clustering, and automatic meaning discovery using Google. The method was presented at EU-PASCAL Statistics and Optimization of Clustering Workshop, July 5–6, London, UK.

Cilibrasi and Vitanyi continued work on a method to automatically extract the meaning of words and phrases from the world-wide-web using Google page counts. This work is part of a a new area of parameter-free similarity distance measures useful in data-mining, pattern recognition, learning and automatic semantics extraction. The method is implemented and available as public software at www.complearn.org. It was presented at ITW2005 - IEEE ITSOC Information Theory Workshop 2005 on Coding and Complexity, August 29–September 1, Rotorua, New Zealand, and reported in an article in the New Scientist, newspapers around the globe, about a 1000 weblogs, and Dutch TROS Radio.

Cilibrasi and A. Cruz continued to implement the CompLearn Toolkit: open source software system at http://www.complearn.org/ It implements the above theories making them a practical data-mining tool that can also extract semantics from the web. CompLearn is described in New Scientist and Technology Research News. CompLearn was developed at the National Research Institute CWI in Amsterdam, written by Cilibrasi. The improvements include: * cleaner repackaging and installation with C-only core library and separated ruby

binding * completed C-language API documentation first draft inline doc system* better experimntal reporting, verification, and smart layout features for improved accuracy * online demo using NGD with interactive experiment builder * complearn surpassed 1000 downloads and 100,000 page views, and is still growing

Cilibrasi, T. Roos, T. Heikki, P. Myllymaki (HIIT Helsinki) have applied the above NCD to Stematology research. They determined the causal relations between transcriptions of mediaeval manuscripts in Latin and Swedish concerning the national patron saint, St Henry, of Finland, to com to a phylogeny of the documents. This work appeared preliminary as: T. Roos, T. Heikki, Cilibrasi, P. Myllymaki, (2005). Compression-based Stemmatology: A Study of the Legend of St. Henry of Finland, Technical report HIIT-2005-3.

Cilibrasi, Tromp, L. van Iersel (TUE), and S.M. Kelk (PNA1) did research on the complexity of several haplotyping problems and algorithms in Bioinformatics, which was reported in the 5th International Workshop, WABI 2005, Mallorca, Spain.

See on page 200 at Software developed for more information.

Title	Computational complexity theory and its applications
Period	1999–2003
Leader	H.M. Buhrman
Staff	H.M. Buhrman, T.J. Lee, J.T. Tromp, F. Unger, P.M.B. Vitányi
Funding	CWI (basic funding)
Partners	L. Fortnow (Univ. Chicago). E. Allender (Rutgers), D. van Melkebeek (Univ. Wisconsin), M. Li (Univ. Waterloo, Canada), T. Jiang (UC Riverside, USA)

Progress report. Buhrman, L. Torenvliet (UvA) and Unger started working on the question what the complexity of sparse and selfreducible sets is. They defined a useful and new notion called tree-self-reducibility and proved that sparse tree-tt-self-reducible sets are in $P^{NP[log]}$. This upper bound seems to be tight since we can exhibit a sparse tt-self-reducible set which is in but not lower than $P^{NP[log]}$ in some relativized world. They also finally proved that log-sparse btt-self-reducible sets are in P. Their paper was accepted for STACS 2006. Together with Vereshchaging we have constructed an oracle under which the following holds. There is a sparse self-reducible set outside $P^{NP[n]}$. Lozano and Toran have shown that every sparse self-reducible set is in $P^{NP[poly(n)]}$. Our result thus shows that Lozano and Toran's result cannot be improved using relativized techniques. A joint paper is in preparation.

Unger finalized his work done in his masters thesis and showed that NP and other classes of the polynomial hierarchy probably do not have super-sparse hard leaf languages, for otherwise the polynomial hierarchy would collapse. The paper was accepted for MFCS'05

Koucky, P. Pudlak, D. Therien develop a new method to analyze the flow of communication in constant-depth circuits and we use it to show lower-bounds on the size of constant-depth circuits. This allows us to exhibit an explicit examples for separation of two circuit size measures: the number of wires and the number of gates. We also exhibit a correspondence between an algebraic classification of regular languages and the size of circuits computing these languages.

A. Gal, Koucky, P. McKenzie prove that the class of functions expressible by first order formulas with only two variables coincide with the class of functions computable by AC0 circuits with a linear number of gates. We then investigate the feasibility of using Ehrenfeucht-Fraisse games to prove lower bounds for that class of circuits, as well as for general AC0 circuits.

Koucky, C. Lautemann, S. Poloczek, D. Therien propose a new model of restricted branching programs which we call incremental branching programs. We show that syntactic incremental branching programs capture previously studied structured models of computation, namely marking machines Cook (1974) and Poon's extension of jumping automata on graphs. We then prove exponential size lower bounds for our syntactic incremental model, and for some other restricted branching program models as well.

Buhrman, Koucky and N.K. Vereshchagin have constructed a 3-round two parties polynomial time protocol with communication length $2n$ outputting an n-bit string with Shannon entropy at least $3n/4 - O(1)$ provided at least one of the parties is honest (obeies the protocol). Previously, the best known lower bound of entropy for constant round $O(n)$-communication protocols was $n/2$.

B. Awerbuch, Y. Azar, Z. Lotker, B. Patt-Shamir, and Mark R. consider a model with

n players and m objects. Each player has an unknown grade for each object, modeled by a 'preference vector' of length m. A player can learn his grade for an object by probing that object, but performing a probe incurs cost. The goal of the players is to learn their own evaluations of objects with minimal cost, by adopting the results of probes performed by other players. To facilitate communication, we assume that players collaborate by posting their grades for objects on a shared billboard: reading from the billboard is free. We consider players whose preference vectors are popular, i.e., players whose preferences are common to many other players. We present distributed and sequential algorithms to solve the problem with logarithmic cost overhead.

Z. Lotker, B. Patt-Shamir, M. Tuttle consider a model with a shared register (a billboard), a stream of readers (customers) that arrive at a constant rate in the time interval [0,1], and a set of writers (advertisers) that each write to the shared register one time. If we interpret the value of the shared register as an advertisement, or a pointer a reader can follow to an interesting resource, then each writer's goal is to maximize the time its value is in the register. We analyze this scenario as a strategic timing game. Each player i chooses a point x_i in[0,1]. The utility to player i is the distance from its point x_i to the next larger point, or to 1 if x_i is the largest, and each player's goal is to maximize the length of this interval. We fully characterize the Nash equilibrium for the two-player, continuous-action game, and we give an efficient algorithm to compute the symmetric Nash equilibrium for the n-player, discrete-action game. In both cases, we show the (symmetric) equilibrium is unique. Our algorithmic approach to the n-player game is an interesting one, since equilibria to two-player games can usually be found by solving differential equations, but equilibria to n-player games often involve systems of partial differential equations that are much harder to solve.

R. Klasing, Z. Lotker, A. Navarra, S. Pérennes, consider the following problem. Place n points on the vertices of G independently and uniformly at random. Once the points are placed, relocate them using a bijection from the points to the vertices that minimizes the maximum distance between the random place of the points and their target vertices. We look for an upper bound on this maximum relocation distance that holds with high probability (over the initial placements of the points). For general graphs, we prove the #P-hardness of the problem and that the maximum relocation distance is $O(\sqrt{n})$ with high probability. We also present a Fully Polynomial Randomized Approximation Scheme when the input graph admits a polynomial-size family of witness cuts while for trees we provide a 2-approximation algorithm.

A common assumption in sensor networks is that the sensors are located in a uniform random distribution. In this paper Z. Lotker, A. Navarra show that uniform random points on the two dimensional unit square are almost a 'grid'. In particular for a synchronous geographic sensor network we give a protocol that emulates any grid protocol in the random sensors network, with high probability. This suggests the following framework. In order to solve a problem on a random sensor network we solve the same problem on the grid. Then we use our emulation to translate the solution to the random sensor network. We analyze the cost of the emulation in terms of consumed energy and time. Finally we provide three examples that illustrate our method.

Societal aspects and knowledge transfer

Projects with partners in public and private sector

- ACAA; see on page 191.
- PASCAL; see on page 189.
- QC; see on page 188.
- QIP; see on page 188.
- RESQ; see on page 188.
- UL; see on page 190.

Teaching at university

- Course Quantum Computing, UvA, February–May: H.M. Buhrman, R.S. Špalek.
- Course Minimum Description Length Learning, UvA, February–May: P.D. Grünwald, S. de Rooij

Courses, tutorials

- Course (2 lectures) at Spring School, Montangac, France, May 30–June 3: H.M. Buhrman (Talk: Quantum Computing).

- Tutorial (3 lectures) at Computing in Europe, Amsterdam, The Netherlands, June 8–10: H.M. Buhrman (Talk: Quantum Computing).
- Advanced SIKS Course 'Computational Intelligence', Zeist, February 17–18: P.D. Grünwald (Tutorial: 'Introduction to MDL').
- Seminar Max Planck Institute, Garching, Germany, May 24: H.M. Buhrman (Talk: Quantum string commitment).

Organization of conferences, workshops, courses, meetings

- P.D. Grünwald was co-organizer of the PASCAL workshop on 'Modelling in Classification and Statistical Learning', EURANDOM, Eindhoven, October 30–5. (Jointly with Prof.dr. R.D. Gill (UU/EURANDOM) and Dr. L. Mohammadi (UL/EURANDOM).)

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- QIP conference, Steering committee meeting. Boston, USA, January 13–17: H.M. Buhrman.
- QIP'05, Boston, USA, January 14–17: S. Wehner (Talk: Quantum Anonymous Transmissions), T.J. Lee (Poster).
- QIP 05 conference, MIT, Boston, January 17: R. de Wolf (Talk: Direct product theorems and optimal time-space tradeoffs).
- STOC Programme committee meeting, San Jose USA, January 21–22: H.M. Buhrman.
- IPA course, Eindhoven, The Netherlands, February 3: H.M. Buhrman (Talk: Quantum Computing).
- Presentation for Technet, TUD, February 7: H.M. Buhrman (Talk: Quantum Computing).
- Workshop on Computational Compl., Barbados, February 27–March 5: M. Koucky (Title: Bounded-depth circuits: separating wires from gates).
- Workshop/Meeting for chapter authors of the Handbook of the Philosophy of Information, Amsterdam, March 9–10: P.D. Grünwald (Talk: Algorithmic Information Theory/Kolmogorov's structure function).
- Meeting National ICT Regieorgaan, March 29: P.M.B. Vitányi (Learning Meaning from the Web Using Google).
- Ischia, Italy, May 4–6: P.M.B. Vitányi (Talk: Time, Space, and Energy in Reversible Computing).
- 26th Symposium on Information Theory in the Benelux,ULB, Brussels, Belgium, May 19–20: P.M.B. Vitányi (Plenary invited talk: Algorithmic Rate Distortion Theory).
- Baltimore, STOC, May 21–24: M. Koucky (Talk: Bounded-depth circuits: separating wires from gates).
- Annual Graybill Conference on Statistics in Information Technology, Fort Collins, CO, USA, June 2–3: P.D. Grünwald (Talk: Suboptimality of MDL and Bayes in Classification under Misspecification).
- Conference on Computational Complexity, San Jose, California, June 12: T.J. Lee (Talk: The quantum adversary method and formula size lower bounds).
- COLT conference, Bertinoro, Italy, June 27–30: S. de Rooij.
- Eighteenth Annual Conference on Learning Theory (COLT 2005), Bertinoro, Italy, June 27–30: P.D. Grünwald (Impromptu) (Talk: Generalization to Unseen Cases).
- EU-PASCAL Statistics and Optimization of Clustering Workshop, London, UK, July 5–6: R.L.C. Cilibrasi (Talk: A New Quartet Tree Heuristic for Hierarchical Clustering).
- ICALP'05, Lisabon, Portugal, July 11–15: R.S. Špalek (Talk: All quantum adversaries are equivalent).
- ICALP'05, Lisbon, Portugal, July 16–17: S. Wehner (Talk: Improved Lower Bounds for Locally Decodables Codes and Private Information Retrieval).
- Univ. Waterloo, July 24–August 4: R.S. Špalek (Talk: All quantum adversaries are equivalent).
- The 4th International Conference on Web-based Learning (ICWL 2005), Hong Kong SAR, China, July 31–August 3: P.M.B. Vitanyi (Invited Keynote talk: Automatic Meaning Discovery Using Google).
- 2 talks at 5th Canadian Summer School on quantum computing, Univ. de Montréal, Canada, August 4–5: R.M. de Wolf (Talk: Quantum lower bounds).

- ITW2005 - IEEE ITSOC Information Theory Workshop 2005 on Coding and Complexity, Rotorua, New Zealand, August 29–September 1: P.M.B. Vitányi (Invited Speaker: Universal Similarity).
- MFCS 2005, Gdansk, Poland, August 29–September 2: F. Unger (On small hard leaf languages).
- ERATO conference, Tokyo, Japan, August 26–30: H.M. Buhrman (Talk: Quantum string commitment).
- ERATO office, Kyoto, Japan, September 2: H.M. Buhrman (Talk: Non local boxes, communication complexity and fault tolerant computing).
- ISIT conference, Adelaide, Australia, September 4–9: S. de Rooij.
- CWI Crypto day, Amsterdam, The Netherlands, September 6: H.M. Buhrman (Talk: Quantum string commitment).
- EURANDOM Alumni Day, EURANDOM, Eindhoven, September 25: P.D. Grünwald (Talk: Updating Probabilities).
- PASCAL Workshop on Modelling in Classification and Statistical Learning, EURANDOM, Eindhoven, October 3–5: P.D. Grünwald (Talk: 'Suboptimality of MDL and Bayes in Classification under Misspecification').
- Symposium zum Gedenken an Prof.dr. Clemens Lautemann, Mainz, Gutenberg Univ., October 6–7: M. Koucky.
- 2005 Belgium-Netherlands conference on Artificial Intelligence (BNAIC 2005), Bruxelles, Belgium, October 17–18: P.D. Grünwald (Talk: Generalization to Unseen Cases, (best paper award)).
- CWI science day, Amsterdam, The Netherlands, October 22: H.M. Buhrman (Talk: Quantum Computing).
- Philips NatLab, Eindhoven, October 26: R.M. de Wolf (Talk: Quantum computing: Algorithms and proofs).
- Information beyond Shannon Workshop, Orlando, FL, October 27–28: P.M.B. Vitányi (Invited Plenary talk: Algorithmic Rate Distortion Theory and Lossy Compression).
- CWI, Amsterdam, November: R.S. Špalek (Talk: Quantum Algorithms for Matching and Network Flows).
- CWI seminar, Amsterdam, November 10: R.M. de Wolf (Talk: Bounded-error quantum state identification with applications).
- EIDMA Congress for DIAMANT, Mierloo, The Netherlands November 16–18: H.M. Buhrman (Talk: Quantum Computing).
- Beta congress UL, Leiden, The Netherlands, November 23: H.M. Buhrman (Talk: Quantum Computing and Communication complexity).
- LRI, Paris, December: R.S. Špalek (Talk: Quantum Time-Space Tradeoffs for Deciding Systems of Linear Inequalities).
- NATO ASI on Quantum Computing: S. Wehner (Talk: Implications of Superstrong Nonlocality for Crytptography).
- ASIACRYPT 2005, Madras, India, December 4–8: S. Wehner (Talk: Quantum Anonymous Transmissions).
- Quantum Comput RESQ meeting, Budapest, May 12–14: F. Unger (Talk: Communication Complexity and Thresholds for fault-tolerant).
- Eighteenth Conference on Neural Information Processing Systems (NIPS 2005). Vancouver/Whistler, BC, Canada, December 5–10: P.D. Grünwald (Poster: Generalization to Unseen Cases; Talk: (at NIPS Systems (NIPS 2005)).
- NIPS Satellite Workshop on Value of Information, December 5–10: P.D. Grünwald (Poster: Generalization to Unseen Cases; Talk: When ignorance is bliss).
- In SPAA 2005. Z. Lotker: (Talk: Collaborate With Strangers To Find Own Preferences).
- In Disc 2005. Z. Lotker: (Talk: Timing Games and Shared).
- ISAAC 2005. Z. Lotker: (Talk: From Balls and Bins to Points and Vertices).
- Problem, IEEE International Workshop on Foundations and Algorithms for Wireless Networking. Z. Lotker (Talk: Unbalanced Points and Vertices).
- Prague, mini-conference STTI'05 - Soucasne trendy teoreticke informatiky (Current trends in TCS), May 13–14: M. Koucky (Talk: Bounded-depth circuits: separating wires from gates).

Working visits

- M. Szegedy, Rutgers, USA, January 17–28 February: T.J. Lee.
- Computer Science Dept., City Univ. Hong Kong, January 22: P.M.B. Vitányi (Talk: Automatic Meaning Discovery using Google).

- Computer Science Dept., Univ. Helsinki, related to the EU PASCAL NoE, February-April: R.L.C. Cilibrasi.
- Computer Science Dept., Univ. Hong Kong, February 23: P.M.B. Vitányi (The Similarity Metric and Parameter-Free Data-Mining).
- Gutenberg Univ., Mainz, April 4–7: M. Koucky (Talk: Circuit lower-bounds via Ehrenfeucht-Fraisse games).
- D. Therien, Montréal, McGill Univ., May 16–20: M. Koucky.
- Three-day visit, hosted by Professor J. Halpern, Cornell Univ., Department of Computer Science, Ithaca, NY, USA, May 31: P.D. Grünwald (Talk: Suboptimality of MDL and Bayes in Classification under Misspecification).
- Univ. de Montréal, Canada, July 28: R.M. de Wolf (Talks: Lower bounds on matrix rigidity via a quantum argument; Quantum computing workshop).
- Univ. Calgary, August 5–31: R.S. Špalek (Talks: All quantum adversaries are equivalent; Quantum and classical strong direct product theorems and optimal time-space tradeoffs).
- UU, Utrecht, The Netherlands, September 27: H.M. Buhrman (Talk: Non local boxes, communication complexity and fault tolerant computing).
- Charles Univ., Prague, October: R.S. Špalek (Talks: Quantum random walk algorithms, Quantum search and network flows).
- Seminar Talk, Univ. of South Paris, Orsay France, October 5: T.J. Lee (Talk: Beyond the adversary method for formula size lower bounds).
- School of Computer Science, Univ. of Waterloo, Waterloo, Ontario, Canada, November 2: P.M.B. Vitányi (Talk: Rate-distortion theory for individual sequences).
- One-day visit, hosted by Prof.dr. B. Kappen, RU, Nijmegen, November 3: P.D. Grünwald (Talk: Suboptimality of MDL and Bayes in Classification under Misspecification).
- School of Computer Science, Univ. Waterloo, Waterloo, Ontario, Canada, October 3–November 4: P.M.B. Vitányi (Talk on October 14: Automatic meaning discovery using Google).
- McGill Univ., Montréal, November 6–11: M. Koucky.
- Univ. of Queensland, November: S. Wehner (Talks: Semidefinite Programming and Tsirelson Bounds; Entanglement in Interactie Proof Systems with Binary Answers).
- National Univ. Singapore, December: S. Wehner (Talk: Semidefinite Programming and Tsirelson Bounds).

Project meetings

- BRICKS Meeting Advisory Committee, April 22: P.M.B. Vitányi (Talk: Learning Meaning from the Web Using Google).
- RESQ meeting, Budapest, May 12–14: R.S. Špalek (Talk: All quantum adversaries are equivalent).
- BRICKS bijeenkomst, November 29: P.M.B. Vitányi (Talk: Universal Similarity).
- Quantum Computing Seminar, CWI, June 14: F. Unger (Talk: Communication Complexity and Thresholds for fault-tolerant).

Other lectures

- Paradiso lecture for general public, Amsterdam, The Netherlands, March 4: H.M. Buhrman (Talk: Quantum Computing).
- Presentation for Diligentia, The Hague, March 14: H.M. Buhrman (Talk: Quantum Computing).
- CWI Scientific Meeting, Amsterdam, March 18: R.M. de Wolf (Talk: Quantum proofs for classical theorems).

Visitors

- N.K. Vereshchagin, Moscow State Univ., January 6–February 6 and September 28–February 4 2006. Host: P.M.B. Vitányi.
- D. van Melkebeek (Univ. Wisconsin), January 10–14. Host: H.M. Buhrman.
- T. Roos, Helsinki, March 1–April 30. Hosts: H.M. Buhrman, T.J. Lee.
- L. Fortnow, Chicago, March 14–18. Host: H. Buhrman.
- P. Myllymäki and H. Wettigi, Helsinki, April 6–9. Host: P.D. Grunwald, P.M.B. Vitányi.
- M. Christandl, Cambridge, April 18–22, November 31–December 7. Host: H.M. Buhrman.
- A. Ambainis, Waterloo, May 16–20, September 5–10. Host: H.M. Buhrman.
- S. Aaronson, IAS Princeton, May 27–June 3. Host: H.M. Buhrman.

- L. Antunes, Porto, June 8–17. Host: H.M. Buhrman.
- J. Kempe (LRI Paris), and O. Regev (Tel Aviv), June 11–July 16. Host: H.M. Buhrman.
- D. Preda, Berkeley, June 15–27. Host: H.M. Buhrman.
- A. Nayak, Waterloo, June 28–30. Host: H.M. Buhrman.
- E. Viola, Harvard, July 3–17. Host: H.M. Buhrman.
- M. Mosca, Waterloo, September 5–22. Host: H.M. Buhrman.
- S. Massar, Brussels, September 28. Host: H.M. Buhrman.
- P. Myllymäki and T. Roos, Helsinki, October 14–16. Host: P.D Grunwald, P.M.B. Vitányi.
- M. Christandl, Cambridge, November 31–December 7. Host: H.M. Buhrman.

Memberships of committees and other professional activities

H.M. Buhrman

- Professor at UvA.
- Member of programme committee Symposium on Theory of Computation (STOC) 2005.
- Member of programme committee QIP 2006.
- Member of programme committee TAMC'2006.
- Member of board of the Dutch Association for Theoretical Computer Science (NVTI).
- Member steering committee Conference on Computation Complexity (CCC).
- Member steering committee Quantum Information Processing (QIP).
- Editor of Theory of Computing Systems TOCS, and Journal Computational Complexity.
- Guest editor JCSS special issue for Conference on Computational Complexity 2003.
- Member ESF steering committee ESF Forward Look: Nano Sciences and the long term evolution of Information Technology (NSIT).
- Chiar of programme board for Computer Sciences, Lorentz Center.
- Member library committee CWI.
- Member PhD committee M. Mahlla.
- Member Habilitation committee of S. Laplante, Paris.
- Member of PhD committee of Th. Pedersen, Aarhus.
- PhD advisor of R.S. Špalek, T.J. Lee, S. Wehner, F. Unger.
- Member steering committee RESQ.
- Member steering committee QUEROPE
- Member of the board Dutch Institute for Logic, Language, and Computation (ILLC).
- Member Dutch Institute for Programming and Algorithmics (IPA).
- Member Onderzoeksschool Logica (OzL).

P.D. Grünwald

- PASCAL workshop on 'Modelling in Classification and Statistical Learning', EURANDOM, Eindhoven, The Netherlands, October 3–5.
- Member of the organizing committee (with Prof.dr. R.D. Gill (UU/EURANDOM) and Dr. L. Mohammad, UL/EURANDOM)). Funded by the EU 6th framework PASCAL network.
- PC member Tenth International Workshop on Artificial Intelligence and Statistics (AISTATS '05).
- PC member Fourth International Symposium on Imprecise Probabilities and Their Applications (ISIPTA '05)
- Member of the PhD committee of G. Infante-Lopez UvA, April 2005.
- Member of MS committee of B. Leskes, UvA, April 2005.
- Member of MS committee member F. Oliehoek, UvA September 2005.
- Supervision and MS committee of J. van Woudenberg, UvA, October 2005.
- PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning). EU N.E since 12/2003. Member of the steering committee; Coordinator of the Conference and Workshop Organization Programme.
- FoLLI (The European Association for Logic, Language and Information) (member).
- ISBA (International Society for Bayesian Analysis) (member).
- Member 'CWI-60' committee.

Z. Lotker

- Member programme committee Dynamo workshop Random sensor networks.
- Member programme committee IEEE International Workshop on 'Foundation and Algorithms for Wireless Networking 2006'.

P.M.B. Vitányi

- Full Professor at UvA.
- Information Processing Letters, North-Holland/Elsevier.
- Theory of Computing Systems (TOCS formerly Mathematical Systems Theory), Springer Verlag.
- 'Parallel Processing Letters', World Scientific Publishers, Singapore.
- 'International Journal of Foundations of Computer Science (IJFCS)', World Scientific Publishers, Singapore.
- Guest editor 'Journal of Computer and System Sciences', special issue on selected papers from EuroCOLT'95.
- 'Journal of New Generation Computer Systems', (Akademie-Verlag, Berlin)
- 'Frontiers in Computing Systems Research', Plenum Annual Review Book Series, Plenum Press.
- Member of the Scientific Board, 'Encyclopaedia of Mathematics', Reidel (updated and annotated translation of the Soviet 'Mathematical Encyclopaedia'.)
- Goedel Prize Committee.
- Member programme committee 26th IEEE International Conference on Distributed Computing Systems (ICDCS-26), Lisboa, Portugal, July 4–7, 2006. `http://icdcs2006.di.fc.ul.pt`
- TPC membership for the International Conference on Applied Practice and Theory on Computation and Control Tahiti, French Polynesia, October 23–28.
- Member programme committee ADMA 2005 (Advanced Data Mining and Applications), Wuhan, China.
- Member programme committee The First International. Workshop on Reversible Computing A Key Challenge for 21st Century Computing; a special session at ACM Computing Frontiers 2005 (CF'05) Ischia, Italy, May 4–6.
- Member programme committee 16th European Conference on Machine Learning (ECML) and the 9th European Conference on Principles and Practice of Knowledge Discovery in Databases (PKDD), Porto, Portugal, October 2–7.
- Vice chairman Steering committee of the Annual Conference on Distributed Computing (DISC) 2004–2006.
- Member of: ESF QiT programmme, EU NeuroCOLT II Working Group EP 27150, EU NoE PASCAL, Netherlands Bsik/BRICKS project.
- Project Leader NWO Projects: 612.015.001 Quantum Computation 612.055.002 Average-Case Analysis of Algorithms 612.052.004 Universal Learning.

Academic publications

Publications in refereed journals or proceedings

1 B. Awerbuch, Y. Azar, Z. Lotker, B. Patt-Shamir, M.R. Tuttle (2005). Collaborate With Strangers To Find Own Preferences. SPAA 2005, 263–269.

2 H. Buhrman, C. Dürr, M. Heiligman, P. Høyer, F. Magniez, M. Santha, R. de Wolf (2005). Quantum Algorithms for Element Distinctness. SIAM Journal on Computing 34(6), 1324–1330.

3 H. Buhrman, S. Massar (2005). Causality and Tsirelson's bounds, Physical Review A 72 (5), Art. No. 052103.7 pages.

4 H. Buhrman, I. Newman, H. Röhrig, R. de Wolf (2005). Robust Quantum Algorithms and Polynomials. STACS 2005, LNCS 3404, 593–604. quant-ph/0309220.

5 H. Buhrman, L. Fortnow, I. Newman, N.K. Vereshchagin (2005). Increasing Kolmogorov Complexity. STACS 2005, 412–421.

6 H. Buhrman, L. Torenvliet (2005). A Post's Program for Complexity Theory. Bulletin of the EATCS 85, 41–51.

7 H. Buhrman, A. Panconesi, R. Silvestri, P. Vitányi (2005). On the importance of having an identity or, is consensus really Universal? Distributed Computing, Published online: March 10.

8 H. Buhrman, L. Fortnow, A. Pavan (2005). Some Results on Derandomization. Theory Comput. Syst. 38(2), 211–227.

9 H. Buhrman, T. Lee, D. van Melkebeek (2005). Language compression and pseudorandom generators. Computational Complexity 14, 247–274.

10 R. Cilibrasi, L. van Iersel, S. Kelk, J. Tromp (2005). On the Complexity of Several Haplotyping Problems, Rita Casadio, Gene Myers (eds). Proceedings of the Workshop on Algorithms in Bioinformatics. 5th International Workshop, LNCS 3692, 128–139, Springer.

11 R. Cilibrasi, P.M.B. Vitányi (2005). Clustering by compression. IEEE Trans. Information Theory 51(4), 1523–1545.
12 M. Christandl, S. Wehner (2005). Quantum Anonymous Transmissions, ASIACRYPT.
13 W. van Dam, R.D. Gill, P.D. Grünwald (2005). The statistical strength of nonlocality proofs. IEEE Transactions on Information Theory 51(8), 2812–2835.
14 P. Grünwald, S. de Rooij (2005). Asymptotic log-loss of prequential maximum likelihood codes. Proceedings of the Eighteenth Annual Conference on Learning Theory (COLT 2005), 652–667.
15 P. Grünwald, I.J. Myung, M.A. Pitt (eds) (2005). Advances in Minimum Description Length: Theory and Applications, 452, MIT Press, ISBN.
16 S. Laplante, T. Lee, M. Szegedy (2005). The quantum adversary method and classical formula size lower bounds. Complexity, 76–90.
17 P. Høyer, R. Špalek (2005). Quantum Fan-out is Powerful. Theory of Computing 1(5), 83–101. quant-ph/0208043.
18 P. Høyer, R. Špalek (2005). Lower Bounds on Quantum Query Complexity. EATCS Bulletin 87, 78–103. quant-ph/0509153.
19 R. Klasing, Z. Lotker, A. Navarra, S. Pérennes (2005). From Balls and Bins to Points and Vertices, Proceedings ISAAC 2005, 757–766.
20 M. Koucky, P. Pudlak, D. Therien (2005). Bounded-depth Circuits: Separating Wires from Gates. Proceedings of the 37th Annual ACM Symposium on Theory of Computing (STOC), 257–265.
21 T. Lee, A. Romashchenko (2005). On polynomial time bounded symmetry of information. Theoretical Computer Science, 345 (2-3), 386–405.
22 Z. Lotker, B. Patt-Shamir, M. Tuttle (2005). Timing Games and Shared Memory, Disc 2005, 507–508.
23 S. de Rooij, P.D. Grünwald (2005). MDL model selection using the ML plug-in code. Proceedings of the 2005 IEEE International Symposium on Information Theory (ISIT 2005).
24 T. Roos, H. Wettig, P. Grünwald, P. Myllymäki, H. Tirri (2005). On discriminative Bayesian Network classifiers and logistic regression. Machine Learning Journal 59(3), 267–296.
25 R. Špalek, M. Szegedy (2005). All Quantum Adversary Methods are Equivalent. ICALP 2005, LNCS 3580, 1299–1311.
26 P.M.B. Vitányi (2005). Universal Similarity, Proceedings ITW2005 - IEEE ITSOC Information Theory Workshop 2005 on Coding and Complexity.
27 P. Vitányi (2005). Time, Space, and Energy in Reversible Computing. Proceedings 2005 ACM International Conference on Computing Frontiers, 435–444.
28 P. Vitányi (2005). Distortion-rate theory for individuel data. J. Cardinal, N. Cerf, O. Delgrange, O. Markowitch (eds)., Proceedings 26th Symp. Information Theory in the Benelux, 319–320.
29 S. Wehner, R. de Wolf (2005). Improved Lower Bounds for Locally Decodable Codes and Private Information Retrieval, ICALP 2005, 1424.

Publications in other journals or proceedings and other scientific output

Technical reports published elsewhere

1 T. Roos, T. Heikki, R. Cilibrasi, P. Myllymaki, (2005). Compression-based Stemmatology: A Study of the Legend of St. Henry of Finland, Technical report HIIT-2005-3.

Preprints

1 A. Ambainis, R. Špalek, R. de Wolf (2005). Quantum Direct Product Theorems for Symmetric Functions and Time-Space Tradeoffs. quant-ph/0511200.
2 H. Buhrman, M. Christandl, P. Hayden, H.-K. Lo, S. Wehner (2005). On the (Im)possibility of Quantum String Commitment. quant-ph/0504078.
3 H. Buhrman, M. Koucky, N. Vereschchagin (2005). Randomized Individual Communication Complexity.
4 H. Buhrman, L. Fortnow, M. Koucky, J. D. Rogers, N. Vereshchagin (2005). Inverting Onto Functions Might Not Be Hard.
5 D. Gavinsky, J. Kempe, O. Regev, R. de Wolf (2005). Bounded-Error Quantum State Identification and Exponential Separations in Communication Complexity. quant-ph/0511013
6 D. Gavinsky, J. Kempe, R. de Wolf (2005). Strengths and weaknesses of quantum fingerprinting, quant-ph/0511013.

7 R.D. Gill, P.D. Grünwald (2005). An algorithmic and a geometric characterization of Coarsening at Random. Placed on ArXiv math.ST/0510276.

8 P. Høyer, R. Špalek (2005). Tight adversary bounds for composite functions. quant-ph/0509067.

9 M. Koucky, C. Lautemann, S. Poloczek, D. Therien (2005). Circuit lower bounds via Ehrenfeucht-Fraisse games.

10 S. Wehner (2005). Tsirelson Bounds for Generalized CHSH inequalities. quant-ph/0510076.

11 R. de Wolf (2005). Lower Bounds on Matrix Rigidity via a Quantum Argument. quant-ph/0505188.

Software developed

- CompLearn Toolkit: Machine Learning Via Compression. Available at `http://complearn.sourceforge.net/`

  CompLearn was written by R.L.C. Cilibrasi. The CompLearn Toolkit is a suite of simple-to-use utilities that you can use to apply compression techniques to the process of discovering and learning patterns. The compression-based approach used is powerful because it can mine patterns in completely different domains. It can classify musical styles of pieces of music and identify unknown composers. It can identify the language of bodies of text. It can discover the relationships between species of life and even the origin of new unknown viruses such as SARS. Other uncharted areas are up to you to explore. In fact, this method is so general that it requires no background knowledge about any particular classification. There are no domain-specific parameters to set and only a handful of general settings.

Book chapters

1 P. Grünwald (2005). A Tutorial Introduction to the Minimum Description Length Principle. P. Grünwald, I.J. Myung, M.A. Pitt (eds). Chapters 1 and 2 of Advances in Minimum Description Length: Theory and Applications.

2 P.M.B. Vitányi (2005). Algorithmic statistics and Kolmogorov's Structure Functions. Advances in Minimum Description Length: Theory and Applications, P.D. Grünwald, I.J. Myung, M.A. Pitt (eds). MIT Press, 151–174.

Professional products

Publications for a broad audience

- R. Cilibrasi, P. Vitányi (2005). Google Teaches Computers the Meaning of Words, ERCIM News 61, 48–49.
- Interview with de Wolf in the Volkskrant.
- Vitányi: A search for meaning, New Scientist, 21, by Duncan Graham-Rowe.
- Vitányi: Discussion in Slashdot— News for nerds, Stuff that matters, January 29.
- Computer ergooglen die Bedeutung von Worten, F. Rötzer, Heise on line, Telepolis, January 27.
- Google helpt computer snappen, De Volkskrant, February 12.

Contributions to documentaries or radio or TV broadcasting

- Radio interview with Buhrman, VPRO Noorderlicht!
- Radio interview with Vitányi, Tros Radio online.

Other output

Awards

- P. Grünwald received the NWO Vidi Award 2005.
- Grünwald, jointly with T. Roos, P. Myllymäki and H. Tirri of the Univ. Helsinki received the *Best Paper Award* for the paper 'generalization to unseen cases', presented at the 2005 Belgium-Netherlands AI Conference. The paper is a preliminary version of the paper that was presented as a poster at the 2005 NIPS conference. It has been accepted for publication in the NIPS proceedings, which will appear early 2006.

APPENDICES

A Statistics of CWI publications

	2002	2003	2004	2005
Refereed journals or proceedings	260	316	308	391
Other journals or proceedings	28	27	22	37
Monographs	9	6	5	5
Book chapters	12	10	14	10
PhD Theses	17	9	12	11
CWI reports	71	105	114	113
Professional products and other output	116	138	94	131
Total	513	611	569	698

Publications and other scientific output 2002–2005

B CWI reports

CWI reports can be downloaded from
`http://db.cwi.nl/rapporten/index.php`

B.1 Downloads of CWI reports 2000–2005

Year	# of reports downloaded	Total # of hits
2005	2508	1318192
2004	1636	1111495
2003	1164	832112
2002	1065	486002
2001	967	279008
2000	853	149416

B.2 PNA reports

E series (electronic only)

1 PNA-E0501. M.R.H. Mandjes, J. Timmer. A duopoly model with heterogeneous congestion-sensitive customers.

2 PNA-E0502. N.D. van Foreest, M.R.H. Mandjes, J.C.W. van Ommeren, W.R.W. Scheinhardt. A tandem queue with server slow-down and blocking.

3 PNA-E0503. W.R.W. Scheinhardt, N.D. van Foreest, M.R.H. Mandjes. Continuous feedback fluid queues.

4 PNA-E0504. J.W.H. Tangelder. Survey of 2D face recognition methods for robust identification by smart devices.

5 PNA-E0505. A.B. Dieker. Applications of factorization embeddings for Lévy processes.

6 PNA-E0506. P.M. de Zeeuw. The multigrid image transform.

7 PNA-E0507. K.G. Dębicki, M.J.G. van Uitert. Large buffer asymptotics for generalized processor sharing queues with Gaussian inputs.

8 PNA-E0508. U. Ayesta. A unifying conservation law for single server queues.

9 PNA-E0509. S. Aalto, U. Ayesta. On the non-optimality of the FB discipline within the service time distribution class IMRL.

10 PNA-E0510. K.O. Dzhaparidze. Representations of isotropic random fields with homogeneous increments, with applications to spacial fractional Brownian motion.

11 PNA-E0511. O. Kella, O.J. Boxma, M.R.H. Mandjes. A Lévy process reflected at a Poisson age process.

12 PNA-E0512. M.R.H. Mandjes, I. Saniee, A.L. Stolyar. Load characterization and anomaly detection for voice over IP traffic.

13 PNA-E0513. I.M. Verloop, S.C. Borst, R. Núñez Queija. Stability of size-based scheduling disciplines in resource-sharing networks.

14 PNA-E0514. R. Bekker, S.C. Borst. Optimal admission control in queues with workload-dependent service rates.

15 PNA-E0515. R.M. Brouwer. A modified version of frozen percolation on the binary tree.

16 PNA-E0516. M.R.H. Mandjes. Analysis of jitter due to call-level fluctuations.

17 PNA-E0517. K.G. Dębicki, A.B. Dieker, T. Rolski. Quasi-product forms for Lévy-driven fluid networks.

18 PNA-E0518. R. Malhotra, R. van Haalen, M.R.H. Mandjes, R. Núñez Queija. Modeling the interaction of IEEE 802.3x hop-by-hop flow control and TCP end-to-end flow control.
19 PNA-E0519. K.O. Dzhaparidze, J.H. van Zanten, P. Zareba. Representations of isotropic random fields with homogeneous increments.
20 PNA-E0520. R.M. Brouwer, J. Pennanen. The cluster size distribution for a forest-fire process on Z.

R series

1 PNA-R0501. M.N.M. van Lieshout. Markovianity in space and time.
2 PNA-R0502. J. van de Lune, H.J.J. te Riele. On some conjectural inequalities and their consequences.
3 PNA-R0503. M.N.M. van Lieshout. Maximum likelihood estimation for random sequential adsorption.
4 PNA-R0504. R. Bekker, S.C. Borst, R. Núñez Queija. Performance of TCP-friendly streaming sessions in the presence of heavy-tailed elastic flows.
5 PNA-R0505. V. Shcherbakov. On a model of sequential point patterns.
6 PNA-R0506. V. Shcherbakov. Gaussian fluctuations of random point measures generated by cooperative sequantial adsorption.

B.3 SEN reports

E series (electronic only)

1 SEN-E0501. S.M. Orzan, J.C. van de Pol. Detecting strongly connected components in large distributed state spaces.
2 SEN-E0502. T. Tourwé, M. Bruntink, A.M. Marin, D. Shepherd. Proceedings of the 1st workshop on aspect reverse-engineering.
3 SEN-E0503. S.C.C. Blom, I. Ioustinova, J.V. van de Pol, N. Sidorova. Simulated time for testing railway interlockings with TTCN-3.
4 SEN-E0504. R.L. Jansen, G. Ballintijn, S. Brinkkemper. Release and deployment at Planon: a case study.
5 SEN-E0505. S.M. Bohte, M.C. Mozer. A computational theory of spike-timing dependent plasticity: achieving robust neural responses via conditional entropy minimization.
6 SEN-E0506. G. Ballintijn. A case study report on the development, release, and deployment processes of ChipSoft.
7 SEN-E0507. J.J. Vinju. A type-driven approach to concrete meta programming.
8 SEN-E0508. C.L. Blom, M. Hazewinkel. Identification clouds: aspects of the implementation.
9 SEN-E0509. Y. Li. Specification of coordination behaviors in software architecture using the Reo coordination language.
10 SEN-E0510. M. Xie. Specification of e-business process model for PayPal online payment process using Reo.
11 SEN-E0511. F.S. de Boer, J.V. Guillen Scholten, J.F. Jacob. The unified coordination language UnCL.
12 SEN-E0512. H.K. Kan. Design and implementation of an editor and simulators for constraint automata in the context of Reo.
13 SEN-E0513. P.J. 't Hoen, S.M. Bohte, J.A. La Poutré. Learning from induced changes in opponent (re)actions in multi-agent games.
14 SEN-E0514. L.W.N. van der Torre, M.M. Lankhorst, H. ter Doest, J. Campschroer, F. Arbab. Landscape maps for enterprise architectures.
15 SEN-E0515. F. Arbab, F.S. de Boer, M.M. Bonsangue, M.M. Lankhorst, H.A. Proper, L.W.N. van der Torre. Integrating architectural models.
16 SEN-E0516. F. Arbab, L.W.N. van der Torre. Interactive visualization of dynamic models.
17 SEN-E0517. M. Mernik, J. Heering, A.M. Sloane. When and how to develop domain-specific languages.

R series

1 SEN-R0501. N.K. Diakov, Z.V. Zlatev, S.V. Pokraev. Composition of negotiation protocols for E-commerce applications.
2 SEN-R0502. J.J.M.M. Rutten. Algebra, bitstreams, and circuits.
3 SEN-R0503. T. van der Storm. Composing configurable Java components.
4 SEN-R0504. M. Bruntink, A. van Deursen, T. Tourwé. Isolating crosscutting concerns in system software.
5 SEN-R0505. M. Sirjani, F.S. de Boer, A. Movaghar, A. Shali. Extending Rebeca with synchronous messages and reusable components.

6 SEN-R0506. D.G. Clarke. Reasoning about connector reconfiguration I: Equivalence of constructions.
7 SEN-R0507. A. van Deursen, A.M. Marin, L.M.F. Moonen. A systematic aspect-oriented refactoring and testing strategy, and its application to JhotDraw.
8 SEN-R0508. J.R. Calamé. Specification-based test generation with TGV.
9 SEN-R0509. J.C. van de Pol, O. Tveretina. A BDD-representation for the logic of equality and uninterpreted functions (a full version with proofs).
10 SEN-R0510. M.G.J. van den Brand, A.T. Kooiker, N.P. Veerman, J.J. Vinju. An industrial application of context-sensitive formatting.
11 SEN-R0511. G. Alberts, A. van den Boogaard, M. Campbell-Kelly, F. Veraart. History of the software industry: the challenge.
12 SEN-R0512. D.J.N. van Eijck. Syllogistics = monotonicity + symmetry + existential import.
13 SEN-R0513. A. Mesbah, A. van Deursen. Crosscutting concerns in J2EE applications.
14 SEN-R0514. J.J.M.M. Rutten. Algebraic specification and coalgebraic synthesis of Mealy automata.
15 SEN-R0515. M. Bruntink, A. van Deursen, T. Tourwé. Discovering faults in idiom-based exception handling.
16 SEN-R0516. J.W. Klop, R. de Vrijer. Infinitary normalization.
17 SEN-R0517. About 'trivial' software patents: the IsNot case. J.A. Bergstra, P. Klint.

B.4 MAS reports

E series (electronic only)

1 MAS-E0501. D.E.A. van Odyck. Exact Riemann solver for RMHD in the case of shocks only.
2 MAS-E0502. J. Naber. Building your own shock tube.
3 MAS-E0503. C.J. van Duijn, L.A. Peletier, I.S. Pop. A new class of entropy solutions of the Buckley-Leverett equation.
4 MAS-E0504. A. Doelman, B. Sandstede, A. Scheel, G. Schneider. The dynamics of modulated wave trains.
5 MAS-E0505. J. Naber. Numerical solver for compressible two-fluid flow.
6 MAS-E0506. D. Echeverría, P.W. Hemker. Space mapping and defect correction.
7 MAS-E0507. H. van der Ploeg, A. Doelman. Stability of spatially periodic pulse patterns in a class of singularly perturbed reaction-diffusion equations.
8 MAS-E0508. Integral representations for computing real parabolic cylinder functions. A. Gil, J. Segura, N.M. Temme.
9 MAS-E0509. A. Gil, J. Segura, N.M. Temme. The ABC of hyper recursions.
10 MAS-E0510. J. Huisman, N.N. Pham Thi, D.M. Karl, B.P. Sommeijer. Reduced mixing generates oscillations and chaos in the deep chlorophyll maximum.
11 MAS-E0511. B.J. Meulenbroek, U. Ebert, L. Schaefer. Regularization of moving boundaries in a Laplacian field by a mixed Dirichlet-Neumann boundary condition – exact results.
12 MAS-E0512. M. Ashyraliyev, J.G. Blom, J.G. Verwer. On the numerical solution of diffusion-reaction equations with singular source terms.
13 MAS-E0513. L.F. Shampine, B.P. Sommeijer, J.G. Verwer. IRKC: an IMEX solver for stiff diffusion-reaction PDEs.
14 MAS-E0514. M. Nool, D. Lahaye. The Eggshell method in a nutshell.
15 MAS-E0515. C. Montijn, U. Ebert. Diffusion correction to the avalanche-to-streamer transition.
16 MAS-E0516. V. Savcenco, W. Hundsdorfer, J.G. Verwer. A multirate time stepping strategy for parabolic PDE.
17 MAS-E0517. M. Petreczky. Realization theory for linear and bilinear switched systems: a formal power series approach.
18 MAS-E0518. J.L. López; E. Pérez Sinusía, N.M. Temme. First order approximation of an elliptic 3D singular perturbation problem.
19 MAS-E0519. M. Beck, A. Doelman, T.J. Kaper. A geometric construction of traveling waves in a bioremediation.
20 MAS-E0520. M. Ashyraliyev. Generalizations of Gronwall's integral inequality and their discrete analogies.
21 MAS-E0521. W. Hundsdorfer, L. Portero. A note on iterated splitting schemes.

22 MAS-E0522. H.A. Carteret, B. Richmond, N.M. Temme. Positivity for explicit two-step methods in linear multistep and one-leg form.
23 MAS-E0523. H.A. Carteret, B. Richmond, N.M. Temme. Evanescence in coined quantum walks.
24 MAS-E0524. L.P. Shishkina, G.I. Shishkin. A difference scheme of improved accuracy for a quasilinear singularly perturbed elliptic convection-diffusion equation.
25 MAS-E0525. T.M.P. Briels, E.M. van Veldhuizen, U. Ebert. Experiments on the diameter of positive streamers in air.
26 MAS-E0526. E.M. van Veldhuizen, T.M.P. Briels, L.R. Grabowski, A.J.M. Pemen, U. Ebert. Influences of the pulsed power supply on corona streamer appearance.
27 MAS-E0527. A. Doelman, T.J. Kaper, K. Promislow. Nonlinear asymptotic stability of the semi-strong pulse dynamics in a regularized Gierer-Meinhardt model.
28 MAS-E0528. C. Montijn, U. Ebert, W. Hundsdorfer. Adaptive grid simulations of negative streamers in nitrogen in under- and overvolted gaps.
29 MAS-E0529. U. Ebert, C. Montijn, T.M.P. Briels, W. Hundsdorfer, B.J. Meulenbroek, A. Rocco, E.M. van Veldhuizen. The multiscale nature of streamers.
30 MAS-E0530. C. Montijn. Vroege vonken onder de virtuele microscoop.
31 MAS-E0531. J. Lang, J.G. Verwer. On global error estimation and control for initial value problems.
32 MAS-E0532. C. Montijn, W. Hundsdorfer, U. Ebert. An adaptive grid refinement strategy for the simulation of negative streamers.
33 MAS-E0533. G.F. Duivesteijn, H. Bijl, B. Koren, E.H. van Brummelen. On the adjoint solution of the quasi-1D Euler equations: the effect of boundary conditions and the numerical flux function.
34 MAS-E0534. J. Wackers, B. Koren. A fully conservative model for compressible two-fluid flow.
35 MAS-E0535. J. Wackers, B. Koren. A surface capturing method for the efficient computation of steady water waves.

R series

1 MAS-R0501. P.J. Collins. Hybrid trajectory spaces.
2 MAS-R0502. M. Petreczky. Realization theory for linear and bilinear hybrid systems.

B.5 INS reports

E series (electronic only)

1 INS-E0501. S. Bocconi, F.-M. Nack, L. Hardman. Using rhetorical annotations for generating video documentaries.
2 INS-E0502. K.I. Falkovych, F.-M. Nack. Context aware guidance for multimedia authoring: harmonizing domain and discourse knowledge.
3 INS-E0503. P.A. Boncz, T. Grust, S. Manegold, J. Rittinger, J. Teubner. Pathfinder: relational XQuery over multi-gigabyte XML inputs in interactive time.
4 INS-E0504. S. Bocconi, F.-M. Nack, L. Hardman. Supporting the generation of argument structure within video sequences.
5 INS-E0505. L.W. Rutledge, J.R. van Ossenbruggen, L. Hardman. Making RDF presentable: integrated global and local Semantic Web browsing.
6 INS-E0506. P.A. Boncz, S. Manegold, J. Rittinger. Updating the pre/post plane in MonetDB/Xquery.
7 INS-E0507. A.R. van Ballegooij, R. Cornacchia, A.P. de Vries. Automatic optimization of array queries.
8 INS-E0508. G. Ramírez, T.H.W. Westerveld, A.P. de Vries. Structural features in content oriented XML retrieval.
9 INS-E0509. M.W. Kauw-A-Tjoe. Generation of abstract geometric art based on exact aesthetics, gestalt theory and graphic design principles.
10 INS-E0510. P.A. Boncz, T. Grust, M. van Keulen, S. Manegold, J. Rittinger, J. Teubner. Loop-lifted staircase join: from XPath to Xquery.
11 INS-E0511. M. Zukowski, S. Héman, N. Nes, P.A. Boncz. Super-scalar RAM-CPU cache compression.
12 INS-E0512. L. Hardman. Canonical processes of media production.
13 INS-E0513. F.-M. Nack. Capture and transfer of metadata during video production.
14 INS-E0514. K. Schwarz. Domain model enhanced search – A comparison of taxonomy, thesaurus and ontology.

15 INS-E0515. J. Salas Enrech. Ontologies in information integration within multimedia presentation generation.
16 INS-E0516. K.I. Falkovych, F.-M. Nack. Composing discourse based on genre semantics.
17 INS-E0517. J. Werner. Investigation of methods for user adapted visualisation of information in a hypermedia generation system.

C Publications outside the research clusters

M.W. Mettrop, P. Nieuwenhuysen, H. Smulders (2004). Clustering of search engine results by Google. C. Nixon, J. Burmood (eds). Proceedings of Internet Librarian International 2004, October 11–12, 2004, London, UK, Information Today Inc, Medford, New Jersey, 2004, 112–121.

D ERCIM Fellows

(to be upgraded)

Name	**Research theme**	**Period**
Dr. R. Péteri	PNA4	2004-10-01–2005-06-30
Dr. U. Ayesta	PNA2	2005-01-16–2005-10-15
Dr. R. Troncy	INS2	2005-07-01–2006-03-31

E Acronyms of universities in the Netherlands

Acronym	Name of university	Acronym	Name of university
EUR	Erasmus University Rotterdam	UT	University of Twente
RU	Radboud University Nijmegen	UU	Utrecht University
RUG	University of Groningen	UvA	Universiteit van Amsterdam
TUD	Delft University of Technology	UvT	Tilburg University
TUE	Technische Universiteit Eindhoven	VU	Vrije Universiteit Amsterdam
UL	Universiteit Leiden	WUR	Wageningen University and Research
UM	Maastricht University		

F PhD theses

Author
Date, University
Title
Thesis (co-)advisor(s)

E. Abraham-Mumm
January 20, UL
An Assertional Proof
W.-P. de Roever (Carl-Albrechts-Universität zu Kiel), J.N. Kok

R. Planqué
April 7, TUE
Constraints in Applied Mathematics: Rods, Membranes, and Cuckoos
M.A. Peletier, G.H.M. van der Heijden (UCL, London, co-advisor)

W.J. van Hoeve
April 19, UvA
Operations Research Techniques in Constraint Programming
K.R. Apt

D.C. Gijswijt
September 22, UvA
Matrix Algebras and Semidefinite Programming Techniques for Codes
A. Schrijver

R. Brouwer
October 6, VU
Percolation, Forest-fires and Monomer-dimers (or the hunt for self-organised criticality)
J. van den Berg

J.J. Vinju
November 15, UvA
Analysis and Transformation of Source Code by Parsing and Rewriting
P. Klint, M.G.J. van den Brand (co-advisor)

J. Krottje
November 17, UvA
On the Numerical Solution of Diffusion Systems with Localized, Gradient Driven, Moving Sources
J.G. Verwer

P. Zoeteweij
November 29, UvA
Composing Constraint Solvers
K.R. Apt, F. Arbab

J.A. Valero Espada
December 5, VU
Modal Abstraction and Replication of Processes with Data
W.J. Fokkink, J.C. van de Pol (co-advisor)

R. Bekker
December 12, TUE
Queues with State-dependent Rates
O.J. Boxma, S.C. Borst

C. Montijn
December 20, TUE
Evolution of Negative Streamers in Nitrogen: a Numerical Investigation on Adaptive Grids
U. Ebert, W. Hundsdorfer (co-advisor)