Overview Research Activities 2003

Final text 25th June 2004

CWI is the national research institute for mathematics and computer science. It is sponsored by the Netherlands Organization for Scientific Research (NWO). CWI is a founding member of ERCIM, the European Research Consortium for Informatics and Mathematics. It participates in the Telematics Institute and the Amsterdam Science Technology Centre (WTCW). CWI is a Member of the World Wide Web Consortium (W3C) and runs the W3C Office in the Benelux.

General Director

Gerard van Oortmerssen
(till May 1)
Wim Hutter
(May–September, ad interim)
Jan Karel Lenstra
(starting October 1)

Colophon

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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
- Jaarverslag (Dutch), a supplement containing the social and financial report and the works council report

They can be ordered at the Communication and Publication Department (cpd@cwi.nl)

PREFACE

This overview

This overview is a comprehensive report of the CWI research activities in 2003 and is a supplement to *CWI Annual Report 2003*, 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 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 has a staff of 210 fte (full time equivalent), 160 of whom are scientific staff. It operates on an annual budget of M€ 13.

CWI's research entities

CWI's scientific research is organized in four scientific clusters, each consisting of 3 to 5 scientific research themes.

PNA – Probability, Networks and Algorithms

Research themes:

- PNA1 – Networks and Logic – Optimization and Programming
- PNA2 – Advanced Communication Networks
- PNA3 – Stochastics
- PNA4 – Signals and Images

SEN – Software Engineering

Research themes:

- SEN0 – Biography of Aad van Wijngaarden
- SEN1 – Interactive Software Development and Renovation
- SEN2 – Specification and Analysis of Embedded Systems
- SEN3 – Coordination Languages
- SEN4 – Evolutionary Systems and Applied Algorithmics

MAS – Modelling, Analysis and Simulation

Research themes:

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

INS – Information Systems

Research themes:

- INS0 – Standardization and Knowledge Transfer
- INS1 – Data Mining and Knowledge Discovery (renamed Database Architectures and Information Access by 2004)
- INS2 – Multimedia and Human-Computer Interaction
- 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
- Six appendices:

  A Statistics of CWI publications
  B CWI reports
  C Publications of CWI outside the research entities
  D ERCIM Fellows and Indian Institute of Technology Summer Internships
  E PhD theses
  F Acronyms of universities in the Netherlands

Items per cluster

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

Items per theme

- Name of theme + acronym
- Mission of theme
- Theme leader
- MSC or CR classification of theme
- 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, etc.
- Organization of conferences, workshops, courses, etc.
- Lectures, conferences, courses, project meetings, working visits
- Visitors
- Memberships of committees and other professional activities
- Academic publications (papers in refereed journals, books and 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, and optimization (with analysis, discrete mathematics, game theory, logic, operations research, and stochastics as prime tools), and on their applications in technology, management, trade, and biology, in particular in information technology, operations management, finance, transport, communication, combinatorial and computational biology, medicine, textile trade, and the environment.

PNA's first and foremost research objective is to make fundamental and applied contributions to problems and techniques in the above themes. Testing and implementing new techniques for practical use and developing algorithms also belong to the objectives, as exemplified by participation in several externally funded application-oriented projects and a considerable number of consultancies. As for consultancies, it is PNA's policy not to compete with other parties in the service sector, but rather to complement them by developing innovative scientific techniques, and implementing and testing them.

Much of PNA's research is on the borderline of mathematics and computer science. A few examples are found in the projects on computational logic, computer-intensive methods in stochastics, computational complexity, automatic algorithms for coding of still images, wavelet signal analysis, and performance and control of computer-communication networks.

The pilot-theme PNA2 has proved to be very successful, both scientifically and as to project-financing. Therefore, from January 2004 PNA2 will continue as a regular theme.

A new theme in PNA is PNA0 Mathematical Statistics, focusing on saddlepoint approximations, Poisson intensity functions, Edgeworth expansions and bootstrap resampling. The leading researcher of this group is Dr. R. Helmers.

PNA aims to maintain strong ties with academia and industry, both in the Netherlands and abroad. Members of PNA play an active role in several Dutch research schools and networks (DISC, EIDMA, OZSL, MRI, and Stieltjes), and in the graduate networks of Operations Research and Stochastics. Apt is a research team leader in the proposal for the Research School 'A Center of Excellence for Logic'. Apt, Van den Berg, Borst, Gerards, Mandjes, and Schrijver hold part-time professorships at TUE, UT, UvA, and VU. Other associations exist with UvA and the Catholic University in Brussels. Also, associations with EURANDOM enable PNA-members to exchange knowledge and to supervise PhD students and post-docs at EURANDOM. Next to that, researchers in PNA2 have part-time positions at Bell Laboratories.

PNA receives financial support from NWO, ERCIM, EU, ACM, and international programmes with Indonesia and Hungary, for several research positions for PhD students and post-docs. The Fifth Framework Programme of the European Union supports the project EUROPHLUKES of PNA4. PNA is further involved in a number of new 'Network of Excellence' proposals, and serves as coordinator for the MUSCLE programme (Multimedia Understanding through Semantics, Computation and Learning). In addition, the EU supports PNA by the Training and Mobility of Researchers (TMR) Programme in the project 'Discrete Optimization Network' and by 'Research and Training Network' Programme in the projects AMORE (railway planning) and DYNSTOCH (financial statistics). Other new projects include BASIS (Biometrics Authentication Supporting Invisible Security) in the IOP programme, the project 'Sequential point processes' supported by STW, and EQUANET (End-to-End Quality of Service in Next-Generation Networks) supported by SENTER.

PNA has industrial contacts and performs consultancies in transportation (Dutch Rail), information technology (IBM, Microsoft), communication (KPN, AT&T, Lucent Technologies, UUNet/WorldCom, Libertel, Ericsson, Surfnet, France Télécom), biology (through BASIS), public health (hospitals), environment (RIVM, Ministry of Transport and Public Works (North Sea)), seismology (Shell, KNMI), and finance (Limperg Institute).

Cluster staff

Name	Fte	Function
Prof.dr. A. Schrijver	0.2	Cluster leader
S.J. van Dam	0.4	Secretary
Dr. R. Helmers	0.2	Senior researcher, leader PNA0

Research themes

Name	Leader
PNA1 – Networks and Logic – Optimization and Programming	Prof.dr.ir. A.M.H. Gerards
PNA2 – Advanced Communication Networks	Prof.dr. M.R.H. Mandjes
PNA3 – Stochastics	Prof.dr. J. van den Berg
PNA4 – Signals and Images	Dr.ir. H.J.A.M. Heijmans

Networks and Logic – Optimization and Programming – PNA1

Mission

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

Theme leader

Prof.dr.ir. A.M.H. Gerards

MSC or CR classification

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

Subthemes

Name	Leader
PNA1.1 – Networks and Optimization	A.M.H. Gerards, M. Laurent, A. Schrijver
PNA1.2 – Constraint and Integer Programming	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. K.R. Apt (0.2 UvA)	0.8	leader PNA1.2	indefinite	PNA1.2: CIP, FDP
S. Brand, Dipl.-Inform.	1.0	PhD student (NWO)	2000-09-01 till 2004-09-01	PNA1.2: CIP
Dr. S. Etalle (0.9 UT)	0.1	senior researcher (NWO)	2000-07-15 till 2004-07-15	PNA1.2: FDP
Prof.dr.ir. A.M.H. Gerards (0.2 TUE)	0.8	leader PNA1.1	indefinite	PNA1.1: N&O, AMORE PNA1.2: CIP
Ir. W.J. van Hoeve	0.8	PhD student	2000-10-01 till 2005-04-01	PNA1.2: CIP
Dr. D. Jibetean	1.0	post-doc (NWO)	2003-10-01 till 2004-10-01	PNA1.1: SPCO
Dr. M. Laurent	0.7	leader PNA1.1	indefinite	PNA1.1: N&O, SPCO
Prof.dr. J.K. Lenstra	p.m.		indefinite	PNA1.1: N&O
S.G.E. Maróti, MSc	1.0	PhD student (EU)	2001-02-01 till 2005-02-01	PNA1.1: N&O, AMORE
Dr. M. Peeters	0.25	post-doc (EU)	2002-10-01 till 2003-10-01	PNA1.1: AMORE
Prof.dr. A. Schrijver (0.2 UvA)	0.8	leader PNA1.1	indefinite	PNA1.1: N&O
A.G. Steenbeek (0.4 PNA4)	0.6	programmer	indefinite	PNA1.1: STAGESPOREN
Dr. C.F.M. Vermeulen	1.0	post-doc (NWO)	2001-06-01 till 2003-08-01	PNA1.2: FDP

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. M.R. Cerioli	0.1	guest researcher	2003-02-15 till 2004-03-15	PNA1.1: N&O
Dr. R. Gennari (0.55 UvA)	0.45	ERCIM Fellow	2002-07-16 till 2003-04-01	PNA1.2: CIP
Drs. D.C. Gijswijt (0.6 UvA)	0.4	PhD student (NWO)	2002-01-01 till 2005-09-01	PNA1.1: N&O
Dr. B. Guenin	0.1	guest researcher	2003-01-01 till 2003-04-01, 2003-09-01 till 2004-01-01	PNA1.1: N&O
Dr. L. Stougie (0.8 TUE)	0.2	leader PNA1.3	2000-01-01 till 2005-03-01	PNA1.3: ACMB PNA1.1: N&O

Scientific report

Highlights

- K.R. Apt finished his book Principles of Constraint Programming that was published by Cambridge University Press. The book discusses various aspects of constraint programming in a systematic way. It focuses on the fundamental notions of constraint satisfaction problems, local consistency, constraint propagation, complete and incomplete constraint solvers, and various search methods.
- A. Schrijver published his book Combinatorial Optimization – Polyhedra and Efficiency with Springer-Verlag. It offers an in-depth overview of polyhedral methods and efficient algorithms in Combinatorial Optimization.
- A. Schrijver received the George B. Dantzig prize of the Mathematical Programming Society and the Society for Industrial and Applied Mathematics SIAM for his complete work in optimization.
- A.M.H. Gerards received, together with J.F. Geelen (Univ. Waterloo, Ontario) and A. Kapoor (Realization, San Jose, CA) the Delbert Ray Fulkerson prize of the American Mathematical Society and the Mathematical Programming Society for their paper: The ex-

cluded minors for GF(4)-representable matroids, Journal of Combinatorial Theory (B), 2000.

- A. Schrijver received the Delbert Ray Fulkerson prize of the American Mathematical Society and the Mathematical Programming Society for his paper: A combinatorial algorithm minimizing submodular functions in strongly polynomial time, Journal of Combinatorial Theory (B), 2000.
- J.K. Lenstra was 2003 IFORS Distinguished Lecturer at the INFORMS Annual Meeting, Atlanta, USA on October 21.

PhD students

S. Brand
D.C. Gijswijt
W.J. van Hoeve
S.G.E. Maróti

PNA1.1 – Networks and Optimization

Title	Network and Optimization Techniques (N&O)
Period	January 2002–January 2007
Leaders	A.M.H. Gerards, M. Laurent, A. Schrijver
Staff	M.R. Cerioli, D.C. Gijswijt, B. Guenin, J.K. Lenstra, L. Stougie
Funding	CWI
Partners	TUE, UvA, UU, Philips Research Laboratories, Karel Univ. Prague, Ecole Normale Supérieure Paris, IBM Research (Yorktown Heights, NY), Lucent Technologies (Murray Hill, NJ), Microsoft Research (Seattle, WA), McGill Univ. (Montreal, Quebec), Ohio State Univ. (Columbus, Ohio), Princeton Univ. (Princeton, NJ), Rice Univ. (Houston, TX), Simon Fraser Univ. (Vancouver, BC), Univ. Waterloo (Ontario), Victoria Univ. (Wellington, New Zealand)

Progress report. State graph parameters: With M.H. Freedman and L. Lovász (Microsoft Research), Schrijver characterized by means of reflection positivity which graph parameters represent so-called partition functions of states in quantum statistical mechanics.

Matroid structure and representability: Research by Gerards, J.F. Geelen (Univ. Waterloo, Ont.) and G. Whittle (Victoria Univ., Wellington, New Zealand) on the structure of matroids has been continued: the occurence of grids in matroids represented over finite fields is better understood now (yielding as a side result a matroid extension (for q-ary matroids) of Erdös-Pósa's theorem for vertex disjoint circuits in graphs); the interplay between 'tangles' and grid minors as described for graphs by Robertson and Seymour has been extended to matroids over finite fields; towards Rota's conjecture it has been proved that excluded minors for q-ary matroids do not contain large projective geometries as minor; a polynomial length certificate for nonrepresentability of a matroid (given by an independence oracle) over a given finite field has been derived.

Packing paths: Gerards derived together with M. Chudnovski, M. Lohman, P. Seymour (all Princeton Univ.), J.F. Geelen (Univ. Waterloo, Ont.), and L. Goddyn (Simon Fraser Univ., Vancouver, BC) a min max relation for the maximum number of disjoint nonzero A-paths in group labelled graphs (extending Mader's S-paths theorem).

Graph colouring: Gerards proved with J.F. Geelen (Univ. Waterloo, Ont.), L. Goddyn (Simon Fraser Univ., Vancouver, BC), P. Seymour (Princeton Univ.) and B.A. Reed and A. Vetta (both McGill Univ., Montreal, Quebec), that graphs with no large cliques as an 'odd minor' have low chromatic number, thus proving a qualitative relaxation of the conjecture by Gerards and P. Seymour that k-chromatic graphs have k-clique as an 'odd minor'.

Polyhedral combinatorics: Gijswijt showed that the integer hull of a polyhedron determined by a circular-ones matrix has the integer decomposition property. As an application, this gives a polynomial-time algorithm for a packet scheduling problem for smart antennas. Stougie and G. Brightwell (LSE, London, UK) improved Stougie's strongly polynomial bound on the diameter of the transportation polytope to a linear bound.

Routing: Lenstra and Stougie finished together with W.E. de Paepe (TUE), J. Sgall (Czech Academy of Sciences) and R.A. Sitters (TUE), a paper on complexity classification of dial-a-ride problems. Stougie and Sitters (TUE) simplified the proof of competitiveness of the general two-server problem, through deriving a general competitiveness characterization for met-

rical service systems. At the same time they improved the competitive ratio considerably.

Network design: Stougie, C.A.J. Hurkens and J. Keijsper (TUE), worked on a conjecture concerning so-called virtual private networks. They proved the conjecture for circuit networks.

Scheduling: Stougie, N. Megow (TU-Berlin) and R.A. Sitters (TUE), worked on on-line minimization of weighted latency in a scheduling problem on parallel identical machines. They proved competitiveness of the natural algorithm for this problem and designed an algorithm with a so far best competitive ratio for a preemptive version of the problem.

Stochastic programming: Together with M. Dyer (Univ. Leeds), Stougie finished a paper on the complexity of stochastic programming problems. Together with M.H. van der Vlerk (RUG), Stougie finished a chapter on approximation algorithms in stochastic programming for a handbook on approximation algorithms. Together with M. Dye (Canterbury Univ., New Zealand) and A. Tomasgard (NTNU, Trondheim) approximation algorithms were designed for a resource service-provision problem originating from the telecommunication industry.

Title	Semidefinite Programming and Combinatorial Optimization (SPCO)
Period	June 2001–January 2008
Leader	M. Laurent
Staff	D. Jibetean
Funding	CWI and NWO-Vidi project
Partners	LAAS-CNRS (Toulouse), Univ. Klagenfurt (Austria), Univ. Rennes (France), TUD

Progress report. Semidefinite programming and polynomials: Laurent studied algebraic approximations for the minimization of a polynomial function over a semi-algebraic set. In the case of optimization over the simplex, she proved in collaboration with E. de Klerk (Univ. Waterloo, Ont.) and P. Parrilo (ETH, Zürich, Switzerland) that the two approaches based on the theorems of Pólya and of Schmüdgen-Putinar are in fact equivalent.

Laurent gave a new proof for two results of Curto and Fialkow dealing with positive semidefinite moment matrices, which is elementary and algebraic in nature while the original proof uses more advanced operator theoretic tools.

Jibetean has worked together with Laurent on a new method for computing converging bounds for the problem of global polynomial optimization. Jibetean has continued previous work with Van Schuppen (MAS2) on model reduction with respect to the divergence rate criterion.

Title	Algorithmic Methods for the Optimization of the Railways in Europe (AMORE)
Period	April 2000–March 2004
Leader	A.M.H. Gerards
Staff	S.G.E. Maróti, M. Peeters
Funding	EU (Research training network)
Partners	EUR, NS Reizigers, Univ. Konstanz, ETH (Zürich), Technical Univ. Denmark (Lyngby), Univ. Sapienza (Rome), Univ. degli Studi dell'Aquila (Italy), Computer Technology Institute (Patras, Greece)

Progress report. Peeters has worked on railway optimization problems in close collaboration with the NS Reizigers, the main Dutch operator of passenger trains.

Maróti derived theoretical complexity results for the maintenance routing problem and made computational experiments with implementations of two models for this problem.

Maróti and Schrijver developed and implemented a model for rolling stock scheduling problems of NS Reizigers.

Externally financed networks

Title	Dutch-Hungarian cooperation project: Combinatorial and Algebraic Structures and Algorithms
Period	January 2001–December 2003
Leader	A.M.H. Gerards
Funding	NWO (networking)
Partners	TUE, Eötvös Loránd Univ. (Budapest)

Title	Discrete Optimization Network (DONET)
Period	March 1998–February 2003
Leaders	A.M.H. Gerards, A. Schrijver
Funding	EU (Research training network)
Partners	Univ. Cath. Louvain (Belgium), RFW Univ. (Bonn), Univ. Pierre et Marie Curie (Paris), IASI (Rome), Univ. Lisbon, Ecole Polytechnique Fédérale de Lausanne, London School of Economics and Political Sciences, TUE, UM, UvA, Univ. Padova, Univ. Köln, Univ. Grenoble

PNA1.2 – Constraint and Integer Programming

Title	Constraint and Integer Programming Techniques (CIP)
Period	January 2002–January 2007
Leader	K.R. Apt
Staff	S. Brand, R. Gennari, W.J. van Hoeve
Funding	CWI; NWO-project
Partners	ERCIM WG Constraints, Univ. Victoria (Canada), Univ. Singapore, Brooklyn College (USA)

Progress report. Apt worked on a number of aspects of constraint programming. He worked with P. Zoeteweij (SEN3) on the subject of arithmetic constraints on integer intervals. A number of approaches to implement constraint propagation for arithmetic constraints on integer intervals were studied and compared using a set of benchmarks. They were explained in a uniform way using integer interval arithmetic and appropriate proof rules.

Apt and Brand prepared a full version of a paper on efficient schedulers and redundancy avoidance for a class of rules that naturally arise in the context of rule-based constraint programming. The paper will eventually appear in Theory and Practice of Logic Programming.

Gennari, Brand and M. de Rijke (UvA) worked on constraint methods for modal satisfiability, exploring to what extent and how efficiently existing constraint programming (CP) methods can be used in the context of automated reasoning for modal and modal-like logics: Modal satisfiability problems were modelled as (layers of) constraint satisfaction problems with non-boolean domains, together with suitable constraints to reason about these values; encoding optimizations can be done very elegantly and compactly by using constraints.

Van Hoeve investigated the use of semidefinite relaxations in constraint programming and together with M. Milano (Univ. Bologna) he also worked on search strategies for constraint programming.

Title	Foundations of Declarative Programming (FDP)
Period	January 2002–January 2007
Leader	K.R. Apt
Staff	S. Etalle, C.F.M. Vermeulen
Funding	CWI; NWO project
Partners	UT, VU

Progress report. Vermeulen worked on denotational semantics of first order logic, in particular on: further investigation into the axiomatics of the semantics; options for the extension of the expressive power of the semantics; the possibility to combine the denotational semantics with search routines. Written reports on each of these issues were completed.

PNA1.3 – Algorithmic and Combinatorial Methods for Molecular Biology

Title	Algorithmic and Combinatorial Techniques in Molecular Biology (ACMB)
Period	January 2001–January 2006
Leader	L. Stougie
Funding	CWI
Partners	TUE, UU, VU, WUR, Georgia Tech., Univ. Iceland, Carnegie Mellon. Univ., Celena Genomics

Progress report. Research on the interface of mathematics and biology has been continued. Together with T. Boekhout (CBS KNAW), E. Kuramae (BBS KNAW), V. Robert (CBS KNAW), R. Cilibrasi (INS4), J. Tromp (INS4) and P. Vitányi (INS4), Stougie worked on constructing phylogenetic trees for fungi species. The trees were built using genome and whole mitochondrial DNA-data.

Societal aspects and knowledge transfer

External contacts

K.M.J. de Bontridder (Siemens, Eindhoven), G. Brightwell (LSE, London, UK), T. Boekhout (Centraal Bureau voor Schimmelcultures, KNAW, Utrecht), M. Chudnovsky (Princeton Univ., NJ), M. Conforti (Univ. Padova, Italy), B. Daniel (Dash, UK), S. Dye (Univ. Canterbury, New Zealand), M.E. Dyer (Leeds Univ., UK), M. van Emden (Univ. Victoria, Canada), A. Frank (Eötvös Univ. Budapest, Hungary), M.H. Freedman (Microsoft Research), J.F. Geelen (Univ. Waterloo, Waterloo, Ont.), M. Goemans (MIT, Cambridge, MA, USA), L. Goddyn (Simon Fraser Univ., Vancoucer, BC), B. Hanzon (UL), M. Henz (National Univ. Singapore), J. van den Heuvel (LSE, London, UK), J. Jaffar (National Univ. Singapore), M. Junger (Univ. Köln, Germany), E. de Klerk (Univ. Waterloo, Ont.), L.G. Kroon (NS Reizigers), S. Krumke (ZIB, Berlin, Germany), E. Kuramae (Centraal Bureau voor Schimmelcultures, KNAW, Utrecht), S. Leonardi (La Sapienza, Rome, Italy), T. Liebling (EPFL, Lausanne, Switzerland), A. Lodi (Univ. Bologna, Italy), M. Lohman (Princeton Univ., NJ), L. Lovász (Microsoft Research), X. Lu (Univ. East China, Shanghai, China), A. Marchetti Spaccamela (La Sapienza, Rome, Italy), N. Megow (TU Berlin, Germany), M. Milano (Univ. Bologna, Italy), B. Mohar (Ljubljana Univ.), E. Monfroy (Univ. Nantes, France), P. Mutzel (TU Wien, Austria), P. Parrilo (ETH, Zürich, Switzerland), D. Poensgen (ZIB, Berlin, Germany), F. Rendl (Univ. Klagenfurt, Austria), B.A. Reed (McGill Univ., Montreal, Quebec), M. de Rijke (UvA), G. Rinaldi (CNR/IASI, Rome, Italy), V. Robert (Centraal Bureau voor Schimmelcultures, KNAW, Utrecht), A. Sebő (Laboratoire Leibniz, IMAG, Grenoble, France), P.D. Seymour (Princeton Univ., NJ), J. Sgall (Czech Academy of Sciences, Prague, Czechia), M. Skutella (Max Planck Inst., Saarbrücken, Germany), A. Tomasgard (NTUT Trondheim, Norway), A.P.A. Vestjens (CQM, Eindhoven), A. Vetta (McGill Univ. Montreal, Quebec), R. Weismantel (Univ. Magdeburg, Germany), G. Whittle (Victoria Univ., Wellington, New Zealand), G.J. Woeginger (UT), L. Wolsey (Univ. Cath. Louvain, Belgium), R. Yap (National Univ. Singapore).

Projects with partners in public and private sector

- N&0 (page 9).
- AMORE (page 10).
- ACMB (page 11).
- DONET (page 11).
- Eigenvalue methods for graphs (Microsoft Research).
- Optimum stock circulation (NS Reizigers).
- Planning of railway yards (NS Reizigers).

Contract research

- A. Schrijver continued the consultancy projects 'Optimum stock circulation' and 'Planning of railway yards' for NS Reizigers (Dutch Rail) on the optimum circulation of rolling stock on the Intercity-lines between the Randstad and the Northern and Eastern parts of the Netherlands.
- A.G. Steenbeek develops and maintains software for the VU and for the UM to route medical students along trainee posts in hospitals.

Teaching at university

- Courses on logic and constraint programming, National Univ. Singapore: K.R. Apt.
- Programming with constraints, within the Graduate Programme in Logic, organized by the Institute for Logic, Language and Computation (ILLC) of the UvA: S. Brand.
- Constraint logic programming, Operating systems and Distributed e-business techniques, UT: S. Etalle.
- Graphs and algorithms, TUE: A.M.H. Gerards.
- Graph theory, UvA: D.C. Gijswijt.
- Sequencing and scheduling, TUE: J.K. Lenstra.
- Combinatorial optimization, UvA: A. Schrijver.

Courses, tutorials

- LNMB graduate-course Combinatorial optimization: A.M.H. Gerards and M. Laurent.
- Semidefinite programming and combinatorial optimization, summer school Doctoral courses in discrete optimization, CORE, Louvain-La-Neuve: M. Laurent.
- LNMB-graduate course Randomized algorithms: L. Stougie.

Organization of conferences, workshops, courses, meetings

- Tagung 'Graph Theory', Mathematisches Forschungsinstitut Oberwolfach, January 12–18: A. Schrijver (organizer).
- 8th International Workshop on High Performance Optimization Techniques (HPOPT 2004), June 23–25, 2004, CWI, Amsterdam: D. Jibetean (member organizing committee), M. Laurent (member organizing committee).
- 8th Annual Workshop of the ERCIM Working Group on Constraints and the CoLogNET area on Constraint and Logic Programming, Budapest, Hungary, June 30–July 2: K.R. Apt (co-organizer).
- EIDMA-Minicourse Approximation schemes for NP-hard geometric problems by S. Arora, TUE, September 1–5: L. Stougie (organizer).
- International Workshop on Software Verification and Validation (SVV03), Bombay, India, December 14: S. Etalle (co-organizer and editor).
- Winterschool on Mathematics and Biology, Wageningen, The Netherlands, December 17–19: L. Stougie (member organizing committee).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Tagung 'Graph Theory', Mathematisches Forschungsinstitut Oberwolfach, January 12–18: A.M.H. Gerards (Lecture: On the excluded minors for matroids with branch-width k), A. Schrijver.
- 28-th LNMB conference on the mathematics of operations research, Lunteren, January 14–16: W.J. van Hoeve, S.G.E. Maróti.
- ETAPS 2003, Warsaw, Poland, March 5–10: S. Etalle.
- ACM Symposium on Applied Computing (SAC), Melbourne, Florida, USA, March 9–12: S. Brand (Lecture: Schedulers for Rule-Based Constraint Programming).
- Workshop on Combinatorial Optimization, Aussois, France, March 9–15: S.G.E. Maróti.
- WITS 2003, Warsaw, Poland, March 10: S. Etalle (Lecture).
- APPOL Workshop, Bertinoro, Italy, March 22–28: L. Stougie (Lecture: A strongly polynomial bound on the diameter of the transportation polytope).
- Optimization Days, Montreal, Canada, May 5–7: W.J. van Hoeve (Lecture: A hybrid constraint programming and semidefinite programming approach for the stable set problem).
- CPAIOR'03, international workshop on the integration of constraint programming, artificial intelligence and operations research techniques, Montreal, Canada, May 8–10: W.J. van Hoeve (Lecture: A hybrid constraint programming and semidefinite programming approach for the stable set problem).
- AMORE Internal Meeting, L'Aquila, Italy, May 8–10: S.G.E. Maróti (Lecture: Rolling stock rostering: The 'Noordoost case'), M. Peeters (Lecture: Circulation of railway rolling stock: a branch-and-price approach).
- 2nd Cologne Twente Workshop on Graphs and Combinatorial Optimization, UT, May 14–16: M.R. Cerioli (Lecture: Clique graphs and edge-clique graphs).
- Cryptographic Security Aspects of Smart-Cards and the Internet, Amsterdam, May 20–23: S. Etalle (Invited Lecturer).
- 1st Dutch-Hungarian Workshop on Combinatorial Optimization, Budapest, Hungary, May 23–25: D.C. Gijswijt, S.G.E. Maróti, A. Schrijver (Invited Lecture: Permanents, edge-colouring, dimers).
- 4th International Workshop on Rule-Based Programming (RULE), Valencia, Spain, June 9: S. Brand (Lecture: Deductive generation of constraint propagation rules).
- 29th Workshop on Graph Theoretic Concepts in Computer Science, WG2003, June 19–21, Elspeet: M.R. Cerioli, A. Schrijver (Keynote lecture: Matchings, edge-colouring, dimers).
- High Performance Methods for Mathematical Optimization, Tilburg, June 23: M. Laurent.
- Princeton/Oxford workshop, Oxford Univ., Oxford, UK, June 25–29: A.M.H. Gerards (Lecture: Excluding a planar graph from a q-ary matroid).
- TACO Day: Treewidth and Combinatorial Optimization, Utrecht, June 26: M.R. Cerioli.
- Joint Annual Workshop of the ERCIM Working Group on Constraints and the CoLogNET area on Constraint and Logic Programming,

Budapest, Hungary, June 30–July 2: S. Brand (Lecture: Modelling modal satisfiability in constraint logic programming), W.J. van Hoeve.

- EURO/INFORMS Istanbul 2003, Istanbul, Turkey, July 6–10: M. Peeters (Lecture: Circulation of railway rolling stock: a branch-and-price approach).
- Structural Graph Theory Meeting, PIMS, Vancouver, Canada, July 9–19: A.M.H. Gerards.
- 18th International Symposium on Mathematical Programming, Copenhagen, August 18–22: A.M.H. Gerards, M. Laurent (Invited lecture: Semidefinite representation for finite varieties), A. Schrijver.
- Computer Science Logic 2003, Vienna, Austria, August 25–30: C.F.M. Vermeulen, (Lecture: More computation power for a denotational semantics for first order logic).
- EUROCOMB 2003, Prague, Czech Republic, September 6–11: A.M.H. Gerards (Invited plenary lecture: On the structure of matrices and matroids).
- ESA 2003, Budapest, Hungary, September 15–21: L. Stougie.
- PWC2003: 8th international conference on personal wireless communication, Venice, Italy, September 23–25: S. Etalle (Lecture).
- 9th International Conference on Principles and Practice of Constraint Programming (CP), Kinsale, County Cork, Ireland, September 29–October 3: K.R. Apt, S. Brand (Poster presentation: Constraint programming for modelling and solving modal satisfiability), W.J. van Hoeve (Lecture: Hybrid constraint programming and semidefinite programming approach for the stable set problem).
- INFORMS Annual Meeting, Atlanta, USA, October 19–22: J.K. Lenstra (Semi-plenary lecture: Minimum test sets).
- Nineteenth International Conference on Logic Programming Mumbai, Bombay, India, December 8–13: K.R. Apt, S. Etalle.
- Advances in Graph and Matroid Theory (conference in honour of Neil Robertson's 65th birthday), Ohio State Univ., Columbus, Ohio, USA, December 13–16: A.M.H. Gerards (Lecture: Excluding a planar graph from a q-ary matroid).
- SVV03 International Workshop on Software Verification and Validation, Bombay, India, December 14: S. Etalle (Lecture: A trace logic for local security properties).

Working visits

- National Univ. Singapore, January 1–December 31: K.R. Apt.
- Leeds Univ., Leeds, UK, January 19–22: L. Stougie.
- Univ. Bologna, January 29–February 7: W.J. van Hoeve (Lecture: Semidefinite relaxations in constraint programming).
- Univ. La Sapienza, Rome, Italy, March 15–22: L. Stougie.
- Victoria Univ., Wellington, New Zealand, May 6–June 1: A.M.H. Gerards.
- Univ. La Sapienza, Rome, Italy, May 20–23: L. Stougie.
- Eötvös Loránd Univ., Budapest, May 21–23: A. Schrijver.
- ESA 2003 Programme Committee, Rome, Italy, May 23–25: L. Stougie.
- Univ. Bologna, July 6–24: W.J. van Hoeve.
- Department of Combinatorics & Optimization, Waterloo Univ., Waterloo, Canada, July 20–28: A.M.H. Gerards.
- Microsoft Research, Redmond, Washington, USA, September 21–October 10: A. Schrijver (Lecture: Hein van der Holst's work on linkless embeddings of graphs).
- Bentley Historical Library, Univ. Michigan, Ann Arbor, USA, October 26–November 7: J.K. Lenstra (for research of the history of the traveling salesman problem).
- School of Computing, National Univ. Singapore, November 17–December 3: S. Brand, W.J. van Hoeve.
- Technische Univ. Berlin, Berlin, Germany, November 25–28: L. Stougie.
- Department of Combinatorics & Optimization, Waterloo Univ., Waterloo, Canada, November 30–December 11: A.M.H. Gerards.
- Laboratoire Leibniz, IMAG, Département de Mathématiques Discrètes, Grenoble, France, December 1–3: M.R. Cerioli (Lecture: Edge-clique graphs).
- UL, December 4: D. Jibetean.
- Univ. Pierre et Marie Curie (Paris 6), Equipe Combinatoire et Optimisation, Paris, France, December 4–5: M.R. Cerioli (Lecture: Edge-clique graphs).

Project meetings

- Initiating meeting EU-RTN Proposal ADONET, IASI, Rome, Italy, January 26–28: A.M.H. Gerards.

Other lectures

- EIDMA Combinatorial Optimization Seminar, TUE, January 6: L. Stougie (Lecture: A strongly polynomial bound on the diameter of the transportation polytope).
- UM, June 23: L. Stougie (Lecture: A quadratic bound on the diameter of the transportation polytope).
- Philips NatLab, Eindhoven, June 25: A. Schrijver (Lecture: Matching, colouring, scheduling, and Ising).
- EIDMA Seminar Combinatorial Theory, TUE, November 19: A.M.H. Gerards (Lecture: On the structure of matrices and matroids).
- UM, November 21: L. Stougie (Lecture: A linear bound on the diameter of the transportation polytope).

Courses

- LNMB Course 'Randomized algorithms': S.G.E. Maróti.
- EIDMA Minicourse Approximation schemes for NP-hard geometric problems by S. Arora, TUE, September 1–5: M.R. Cerioli, D.C. Gijswijt, S.G.E. Maróti, L. Stougie.
- Management Development Program, Univ. Michigan, Ann Arbor, USA, October 26–November 7: J.K. Lenstra.

Visitors

- G. Whittle (Victoria Univ., Wellington, New Zealand), January 18–23. Host: A.M.H. Gerards.
- M. Schweighofer (Univ. Rennes), March 19–21. Host: M. Laurent.
- A. Sebő (Laboratoire Leibniz, IMAG, Département de Mathématiques Discrètes, Grenoble, France), March 27–30. Hosts: A.M.H. Gerards and A. Schrijver.
- B. Hanzon (UL), December 16. Host: D. Jibetean.

Memberships of committees and other professional activities

K.R. Apt

- Editor Journal of Logic and Computation, since 1989.
- Editor Theory and Practice of Logic Programming (TPLP), since 2001.
- External reviewer for the PhD thesis of Yuanlin Zhang, National Univ. Singapore, December 2003.
- Founder and editor-in-chief ACM Transactions on Computational Logic (TOCL), since 1999.
- Member of the Board of the International Federation for Computational Logic (IFCoLoG), since 1999.
- Member of Constraint Programming Organizing Committee, since 2003.
- Member of the executive committee of the Association for Logic Programming, 1991–1994 and since 2001.
- Member programme committee Joint Annual Workshop of the ERCIM Working Group on Constraints and the CoLogNET area on Constraint and Logic Programming, Budapest, Hungary, June 30–July 2, 2003.
- Member programme committee 9th International Conference on Principles and Practice of Constraint Programme, Kinsale, Ireland, September 29–October 3, 2003.
- Member programme committee Workshop on Software Verification and Validation (SVV 2003), Mumbay, India, December 14, 2003.

S. Etalle

- Editor of the ALP Newsletter, since May 2001.
- External reviewer for the PhD thesis of David Matthew Overton, Univ. Melbourne, Australia.
- Member of programme committee 1st International Conference on Virtual Goods 2003.
- Member of programme committee ICLP 2003, International Conference on Logic Programming, Bombay, India.
- Member of programme committee WFLP'03, the twelfth International Workshop on Functional and (Constraint) Logic Programming, Valencia, Spain, June 12–13, 2003.

- Member of programme committee IWFM 2003, the Sixth International Workshop in Formal Methods, Dublin City Univ., Dublin, Ireland.
- Member of programme committee FAST 2003, Workshop on Formal Aspects in Security & Trust, Pisa, Italy, September 8, 2003.

R. Gennari

- Member programme committee IJCAI-03, Acapulco, Mexico, August 9–15.

A.M.H. Gerards

- Associate editor Mathematical Programming, Series A, 1999–2003.
- Board member Landelijk Netwerk Mathematische Besliskunde, since 2001.
- Co-editor Mathematical Programming, Series A, since 2003.
- Editor CWI Tracts, CWI Syllabi, since 1999.
- Editor SIAM Journal on Discrete Mathematics, since 1999.
- Member IPCO steering committee, Mathematical Programming Society, since 2002.
- Member-at-large of the Council of the Mathematical Programming Society, since 2003.
- Member of programme committee IPCO 2004, New York, USA, June 9–11, 2004.

M. Laurent

- Associate editor Mathematics of Operations Research, since 2001.
- Editor SIAM Journal on Optimization, since 2001.
- Member-at-large of the Council of the Mathematical Programming Society, 2000–2003.
- Member of the editorial board of the MPS-SIAM book series on Optimization, since August 2003.
- Programme committee 8^{th} International Workshop on High Performance Optimization Techniques (HPOPT 2004), CWI, Amsterdam, June 23–25, 2004.

J.K. Lenstra

- Member Editorial Board CWI Monographs, 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 MPS-SIAM Series on Optimization, since 1999.
- Member PhD committee (advisor) Maarten Lipmann, TUE, June 30.
- Member programme committee (co-chair track A) ICALP 2003, International Conference on Automata, Languages and Programming, TUE, June 30–July 4, 2003.
- Member Editorial Board Princeton Applied Mathematics Series, Princeton Univ. Press, since 2000.
- Member Advisory Board SCIMA Special Series, since 1979.
- Advisory editor Wiley-Interscience Series in Discrete Mathematics and Optimization, since 1982.
- 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.
- Area editor for Design and Analysis of Algorithms, INFORMS Journal on Computing, 1987–2003.
- 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.

A. Schrijver

- Advisory editor Journal of Combinatorial Optimization, since 1996.
- Advisory editor North-Holland Mathematical Library, since 1995.
- Associate editor Mathematics of Operations Research, since 1987.
- 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 Program Board for Mathematics, Lorentz Center Leiden, since 2003.
- Member programme committee Netwerken, NWO, since 2000.
- Member Raad van Advies voor de Wiskunde, TUE, since 2000.
- Member Science council Stieltjes Institute for Mathematics, since 1992.

L. Stougie

- Member of the programme committee of European Symposium on Algorithms (ESA) 2003, Budapest, Hungary, September 16–19.
- Member PhD committee Sammani Danwawu Abdullahi, Univ. Leeds, UK, January 20.
- Member PhD committee Ovidiu Listes, EUR, June 12.
- Member PhD committee (co-advisor) Maarten Lipmann, TUE, June 30.
- Member PhD committee Alexander Grigoriev, UM, November 20.

Academic publications

Publications in refereed journals

1. K.M.J. De Bontridder, B.V. Halldórsson, M.M. Halldórsson, C.A.J. Hurkens, J.K. Lenstra, R. Ravi, L. Stougie (2003). Approximation algorithms for the test cover problem. Mathematical Programming Series B 98, 477–492.
2. S. Dye, L. Stougie, A. Tomasgard (2003). Approximation algorithms and relaxations for a service provision problem on a telecommunication network. Discrete Applied Mathematics 129, 63–81.
3. S. Dye, L. Stougie, A. Tomasgard (2003). The stochastic single resource service provision problem. Naval Research Logistics Quarterly 50, 869–887.
4. E. Feuerstein, M. Mydlarz, L. Stougie (2003). On-line multi-threaded scheduling. Journal of Scheduling, 167–181.
5. J.F. Geelen, A.M.H. Gerards, N. Robertson, G.P. Whittle (2003). On the excluded minors for the matroids of branch-width k. Journal of Combinatorial Theory, Series B 88, 261–265.
6. J.F. Geelen, A.M.H. Gerards, G. Whittle (2003). Disjoint cocircuits in matroids with large rank. Journal of Combinatorial Theory, Series B 87, 270–279.
7. A.M.H. Gerards, S.G.E. Maróti, A. Schrijver (2003). Note on: N.E. Aguilera, M.S. Escalante, G.L. Nasini, A generalization of the perfect graph theorem under the disjunctive index. Mathematics of Operations Research 28, 884–885.
8. D.C. Gijswijt, A. Schrijver (2003). On the b-stable set polytope of graphs without bad K_4. SIAM Journal on Discrete Mathematics 16, 511–516.
9. S.O. Krumke, W.E. de Paepe, D. Poensgen, L. Stougie (2003). News from the online traveling repairman. Theoretical Computer Science 295, 279–294.
10. M. Laurent (2003). Lower bound for the number of iterations in semidefinite relaxations for the cut polytope. Mathematics of Operations Research 28(4), 871–883.
11. M. Laurent (2003). A comparison of the Sherali-Adams, Lovász-Schrijver and Lasserre relaxations for 0-1 programming. Mathematics of Operations Research, 28(3), 470–496.
12. X. Lu, R.A. Sitters, L. Stougie (2003). A class of on-line scheduling algorithms to minimize total completion time. Operations Research Letters 31, 232–236.
13. B. Mohar, A. Schrijver (2003). Blocking nonorientability of a surface. Journal of Combinatorial Theory, Series B 87, 2–16.
14. T. Vredeveld, J.K. Lenstra (2003). On local search for the generalized graph coloring problem. Operations Research Letters 31, 28–34.

Publications in other journals and other scientific output

Conference proceedings

1. K.R. Apt, S. Brand (2003). Schedulers for Rule-based Constraint Programming. Proceedings of the ACM Symposium on Applied Computing (SAC 2003), 14–21.
2. K.R. Apt, P. Zoeteweij (2003). A comparative study of arithmetic constraints on integer intervals. Proceedings of the 2003 ERCIM/Colognet Workshop on Constraints, MTA SZTAKI, Budapest, Hungary, 1–23.
3. J.C.M. Baeten, J.K. Lenstra, J. Parrow, G.J. Woeginger (eds) (2003). Automata, Languages and Programming. Proceedings of the 30th International Colloquium ICALP TUE, June 30–July 4, LNCS 2719, Springer-Verlag, Berlin, 1199.
4. S. Brand (2003). A Note on Redundant Rules in Rule-Based Constraint Programming. Barry O'Sullivan (ed.). Recent Advances in Constraints, LNAI, 2627, Springer, 109–120.
5. S. Brand, R. Gennari, M. de Rijke (2003). Modelling Modal Satisfiability Constraint Programming. On-line proceedings of the 2003 ERCIM-Colognet workshop, available via `http://ws.ailab.sztaki.hu/Program.html`
6. S. Brand, R. Gennari, M. de Rijke (2003). Modelling Modal Satisfiability in Constraint Logic Programming, K.R. Apt, F. Fages, F. Rossi, P. Váncza (eds). Proceedings of 8th Workshop of the ERCIM Working Group on Constraints, 193–207.
7. S. Brand, R. Gennari, M. de Rijke (2003). Constraint Programming for Modelling and Solving Modal Satisfiability. F. Rossi (ed.). Proceedings of Principles and Practice of Constraint Programming (CP'03), LNCS 2833, Springer, 795–800.
8. S. Brand, R. Gennari, M. de Rijke (2003). Finite CSP Solvers for Modal Satisfiability. Proceedings of 3rd Workshop Methods for Modalities (M4M-3), 45–60.
9. S. Brand, E. Monfroy (2003). Deductive Generation of Constraint Propagation Rules. Jean-Louis Giavitto and Pierre-Etienne Moreau (eds). Proceedings of 4th International Workshop on Rule-Based Programming, 86, 2, ENTCS, Elsevier.
10. M.R. Cerioli (2003). Clique graphs and Edge-clique graphs. 2nd Cologne. Workshop on Graphs and Combinatorial Optimization, UT, May 14–16.
    Electronic Notes in Discrete Mathematics, 13, Elsevier Science. Online publication date: April 2003. Guest Editors: H. Broersma, U. Faigle, J. Hurink, S. Pickl and G. Woeginger. `http://www.elsevier.com/gej-ng/31/29/24/72/show/Products/notes/cover.htt`
11. M.R. Cerioli, T.O. Ferreira, F. Protti (2003). Conjunto Independente e Cobertura por Cliques em Grafos de Disco Unitario e Moeda Unitaria. XXVI CNMAC – Congresso Nacional de Matematica Aplicada e Computacional São José do Rio Preto, Brazil. Proceedings on CD.
12. C.N. Chong, R. Corin, S. Etalle, P.H. Hartel, Y.W. Law (2003). LicenseScript: A Novel Digital Rights Language.
    R. Grimm, J. Nitzel (eds). Proceedings of the IFIP TC6 WG 6.11 International Workshop for Technology, Economy, Social and Legal Aspects of Virtual Goods, Ilmenau, Germany, May, TU Ilmenau, 104–115.
13. C.N. Chong, R. Corin, S. Etalle, P.H. Hartel, W. Jonker, Y.W. Law (2003). LicenseScript: A Novel Digital Rights Language and its Semantics. K. Ng, C. Busch, P. Nesi (eds). Proceedings of the 3rd Int. Conf. on Web Delivering of Music (WEDELMUSIC), Leeds, UK, September, IEEE Computer Society Press, Los Alamitos, California, 122–129.
14. C.N. Chong, S. Etalle, P.H. Hartel (2003). Comparing Logic-based and XML-based Rights Expression Languages. R. Meersman, Z. Tari (eds). Proceedings of the Confederated Int. Workshops: On The Move to Meaningful Internet Systems (OTM), Catania, Sicily, Italy, November, LNCS 2889, Springer-Verlag, Berlin, 779–792.
15. C.N. Chong, S. Etalle, P.H. Hartel, Y.W. Law (2003). Approximating Fair Use in LicenseScript. M.T. Tengku, H.B. Sembok, H. Zaman (eds). Proceedings of the 6th Int. Conf. of Asian Digital Libraries (ICADL), Kuala Lumpur, Malaysia, December, LNCS 2911. Springer-Verlag, Berlin, 432–443.
16. R. Corin, S. Etalle, P.H. Hartel, A. Mader (2003). On Modelling Real-time and Secu-

rity properties of Distributed Systems. 5th Plenary Cabernet Workshop, Porto Santo, Madeira Archipelago, Portugal, November, unrefereed.
17. R. Corin, S. Malladi, J. Alves-Foss, S. Etalle (2003). Guess what? Here is a new tool that finds some new guessing attacks (Extended Abstract). R. Gorrieri, R. Lucchi (eds). Proceedings of the IFIP WG 1.7 and ACM SIGPLAN Workshop on Issues in the Theory of Security (WITS), Warsaw, Poland, April, Dipartamento di Scienze dell'Informazione Univ. Bologna, Italy, 62–71.
18. M. Cryan, M. Dyer, H. Müller, L. Stougie (2003). Random walks on the vertices of transportation polytopes with constant number of sources. Proceedings of the 13th ACM-SIAM Annual Symposium on Discrete Algorithms, 330–339.
19. R. Di Pietro, L.V. Mancini, Y.W. Law, S. Etalle, P.J.M. Havinga (2003). LKHW: A Directed Diffusion-Based Secure Multicast Scheme for Wireless Sensor Networks. C.-H. Huang, J. Ramanujam (eds). Proceedings of the 32nd Int. Conf. on Parallel Processing Workshops (ICPP), Kaohsiung, Taiwan, October, IEEE Computer Society Press, Los Alamitos, California, 397–406.
20. P.J.M. Havinga, S. Etalle, H. Karl, C. Petrioli, M. Zorzi, H. Kip, T. Lentsch (2003). EYES – Energy Efficient Sensor Networks, 4th IFIP TC6/WG6.8. M. Conti, S. Giordano, E. Gregori, S. Olariu (eds). Proceedings of the Int. Conf on Personal Wireless Communications (PWC), Venice, Italy, September, LNCS 2775, Springer-Verlag, Heidelberg, 198–201.
21. W.J. van Hoeve (2003). A hybrid constraint programming and semidefinite programming approach for the stable set problem. Proceedings of the Ninth International Conference on Principles and Practice of Constraint Programming (CP'03), LNCS 2833, Springer-Verlag, 407–421.
22. W.J. van Hoeve (2003). A hybrid constraint programming and semidefinite programming approach for the stable set problem. Proceedings Fifth International Workshop on Integration of AI and OR Techniques in Constraint Programming for Combinatorial Optimization Problems (CP-AI-OR'03), 3–16.
23. Y.W. Law, S. Etalle, P.H. Hartel (2003). Assessing Security-Critical Energy-Efficient Sensor Networks. D. Gritzalis, S. De Capitani di Vimercati, P. Samarati, S.K. Katsikas (eds). Proceedings of the 18th IFIP TC11 Int. Conf. on Information Security, Security and Privacy in the Age of Uncertainty (SEC), Athens, Greece, May, Kluwer Academic Publishers, Boston, 459–463.
24. Y.W. Law, R. Corin, S. Etalle, P.H. Hartel (2003). A Formally Verified Decentralized Key Management Architecture for Wireless Sensor Networks. M. Conti, S. Giordano, E. Gregori, S. Olariu (eds). Proceedings of the 4th IFIP TC6/WG6.8 Int. Conf. on Personal Wireless Communications (PWC), Venice, Italy, September, LNCS 2775, Springer-Verlag, Berlin, 27–39.
25. W.E. de Paepe, R.A. Sitters, L. Stougie (2003). A competitive algorithm for the general 2-server problem. Proceedings of the 30th International Conference on Automata, Languages and Programs ICALP, LNCS 2719, Springer-Verlag, 624–636.
26. A. Schrijver (2003). Matching, edge-colouring, dimers, Graph-Theoretic Concepts in Computer Science, H.L. Bodlaender (ed.). Lecture Notes in Computer Science 2880, Springer-Verlag, Berlin, 13–22.
27. C.F.M. Vermeulen (2003). More Computation Power for a Denotational Semantics for First Order Logic. M. Baaz, J.A. Mokowsky (eds). Computer Science Logic. Lecture Notes in Computer Science 2803, Springer 530–543.

Technical reports published elsewhere

1. G. Brightwell, J. van den Heuvel, L. Stougie (2003). A linear bound on the diameter of the transportation polytope. SPOR-report 2003-12, TUE.
2. R. Brinkman, L. Feng, S. Etalle, P.H. Hartel, W. Jonker (2003). Experimenting with linear search in encrypted data. Centre for Telematics and Information Technology, TR-CTIT-03-43, UT.
3. R. Corin, C.N. Chong, S. Etalle, P.H. Hartel (2003). How to pay in LicenseScript. Centre for Telematics and Information Technology, TR-CTIT-03-31, TUE.
4. R. Corin, J. Doumen, S. Etalle (2003). Analysing Password Protocol Security

Against Off-line Dictionary Attacks. Centre for Telematics and Information Technology, TR-CTIT-03-52, TUE.

5. S. Dye, L. Stougie, A. Tomasgard (2003). The stochastic single resource service-provision problem. SPOR-report 2003-13, TUE.
6. M.E. Dyer, L. Stougie (2003). Complexity of stochastic programming problems. SPOR-report 2003-20, TUE.
7. J.F. Geelen, A.M.H. Gerards, N. Robertson, G. Whittle (2003). Obstruction to Branch-Decomposition of Matroids. Research Report 03-2 School of Mathematical and Computing Series, Victoria Univ. Wellington.
8. J. Geelen, B. Gerards, G. Whittle (2003). Excluding a Planar Graph from $GF(q)$-Representable Matroids. Research Report 03-4 School of Mathematical and Computing Series, Victoria Univ. Wellington.
9. W.J. van Hoeve, M. Milano (2003). Decomposition Based Search – A theoretical and experimental evaluation. LIA00203, LIA Technical Report, Univ. Bologna.
10. D. Huisman, R. Jans, M. Peeters, A.P.M. Wagelmans (2003). Combining Column Generation and Lagrangian Relaxation. Report EI2003-47, Econometric Institute, EUR.
11. S.O. Krumke, L. Laura, M. Lipmann, A. Marchetti Spaccamela, W.E. de Paepe, D. Poensgen, L. Stougie (2003). Minimizing the Maximum Flow Time in the Online-TSP on the real line. SPOR-Report 2003-01, TUE.
12. Y.W. Law, C.N. Chong, S. Etalle, P.H. Hartel, R. Corin (2003). Licensing Structured Data with Ease. Centre for Telematics and Information Technology, TR-CTIT-03-33, UT.
13. W.E. de Paepe, J.K. Lenstra, J. Sgall, R.A. Sitters, L. Stougie (2003). Computer-aided complexity classification of dial-a-ride problems. SPOR-report 2003-07, TUE.
14. M. Peeters, L. Kroon (2003). Circulation of Railway Rolling Stock: a Branch-and-Price Approach. ERIM Report Series Research in Management, ERS-2003-055-LIS, TUE.
15. L. Stougie, M.H. van der Vlerk (2003). Approximation in stochastic integer programming. SPOR-report 2003-14, TUE.
16. R.A. Sitters, L. Stougie (2003). The general 2-server problem. SPOR-report 2003-23, TUE.

Software developed

- C.N. Chong, R. Corin, Y.W. Law, S. Etalle. License Interpreter, Manager and Interface for LicenseScript, Centre for Telematics and Information Technology, UT, July.

Deliverables for projects

- A. Schrijver, Report Planning van Materieelomlopen, January (for NS Reizigers).
- A. Schrijver, Report Planning van Opstelsporen, July (for NS Reizigers).

Monographs

1. K.R. Apt (2003). Principles of Constraint Programming, Cambridge Univ. Press, 407 + xiv pages.
2. A. Schrijver (2003). Combinatorial Optimization – Polyhedra and Efficiency, Springer-Verlag, Berlin, 1882 pages.

Professional products

Contracts

- DONET(ERB-FMRX-CT98-2002): EU-Research training network, finalized March 31. Contractors: CWI, European Community, Univ. Catholique de Louvain (Louvain-La-Neuve, Belgium), Rheinische Friedrich-Wilhelms-Univ. (Bonn, Germany), Univ. Pierre et Marie Curie (Paris, France), IASI (Rome, Italy), Univ. Lisbon, Ecole Polytechnique Fédérale de Lausanne, London School of Economics and Political Sciences.
- AMORE(HPRN-CT-1999-00104): EU-Research training network, till 2004: Contractors: CWI, European Community, EUR, NS Reizigers & Univ. Konstanz (Germany), Eidgenössische Technische Hochschule (Zürich, Switzerland), Technical Univ. Denmark (Lyngby, Denmark), Univ. La Sapienza (Rome, Italy), Univ. degli Studi dell'Aquila (Italy), Computer Technology Institute (Patras, Greece).
- Long-term contract research for software devellopment. Contractors: CWI and Faculteit Geneeskunde, UM.
- Maintenance contract softwarepacket 'automatische verwerking co-schappen'. Contractors: CWI and VU.

- Research contract for development of railway optimization software. Contractors: CWI and NS Reizigers.

Other output

Awards

- A.M.H. Gerards received, together with J.F. Geelen (Univ. Waterloo, Ontario) and A. Kapoor (Realization, San Jose, CA) the Delbert Ray Fulkerson prize of the American Mathematical Society and the Mathematical Programming Society for their paper 'The excluded minors for GF(4)-representable matroids'. Journal of Combinatorial Theory (B), 2000.
- J.K. Lenstra was 2003 IFORS Distinguished Lecturer at the INFORMS Annual Meeting, Atlanta, USA, October 21.
- A. Schrijver received the George B. Dantzig prize of the Mathematical Programming Society and the Society for Industrial and Applied Mathematics (SIAM) for his complete work in optimization.
- A. Schrijver received the Delbert Ray Fulkerson prize of the American Mathematical Society and the MPS for his paper 'A combinatorial algorithm minimizing submodular functions in strongly polynomial time'. Journal of Combinatorial Theory (B), 2000.

Grants

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

Advanced Communication Networks – PNA2

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 emergence 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 both wireline and wireless systems;
- Network traffic analysis (heavy tails, long-range dependence, and their impact on system performance);
- Network economics (pricing and cost allocation issues in communication networks).

Theme leader

Prof.dr. M.R.H. Mandjes

MSC or CR classification

60K25, 68M20, 90B18, 90B22

Subthemes

Name	Leader
PNA2.1 – Wireline Networks, TCP/IP	M.R.H. Mandjes
PNA2.2 – Wireless Networks, UMTS	S.C. Borst
PNA2.3 – Network Economics	M.R.H. Mandjes

PNA2.1: The research objective is to develop queueing-theoretic models, methods, and algorithms for studying congestion phenomena in communication networks. The research is motivated by the application of advanced technology in communication and computer networks. In 2003 there was a focus on issues related to service integration and quality differentiation in communication networks. Also emphasis was on feedback-based flow-control protocols, e.g., TCP (Transmission Control Protocol). The role of long-tailed phenomena, and the impact on network performance remained a prominent subject of research.

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 develop. To accommodate future expansion, next-generation mobile communication systems are being 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: On an abstract level, a communication network can be considered as a set of resources, for which an extensive set of users is competing. With economic models this competition can be described and analyzed. The key problem is the search for mechanisms that allocate the available resources (bandwidth, buffer space) to the population of heterogeneous users in an economically sound way. More specific problems are: (1) charging network users based on their contribution to congestion, by packet marking, (2) allocation of bandwidth through auctions, (3) models that allocate cost among network users, in conjunction with network measurements.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. R. Bekker (0.6 fte at TUE)	0.4	PhD student	2001-10-01 till 2005-09-30	PNA2.1: FLOW, 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, QFN-IS/PS; PNA2.2: BANCA, PROMO
Dr. K.G. Dębicki (NWO)	1.0	post-doc	2001-04-01 till 2003-03-31	PNA2.1: EQUIP, LT
Drs. A.B. Dieker	1.0	PhD student	2002-04-01 till 2006-03-31	PNA2.1: EQUIP, LT
Dr. N. Hegde	1.0	post-doc	2003-05-01 till 2003-12-31	PNA2.2: BANCA, PROMO
Prof.dr. M.R.H. Mandjes (0.4 fte at UT)	0.6	theme leader, subtheme leader PNA2.1 and PNA2.3	indefinite	PNA2.1: EQUIP, FLOW, QFN-PS, LT; PNA2.3: COST, PRICE
Dr. R. Núñez Queija (0.5 fte at TUE)	0.5	researcher	1999-08-01 till 2005-03-31	PNA2.1: FLOW, QFN-IS/PS; PNA2.3: COST, PRICE
Drs. M.J.G. van Uitert	1.0	PhD student	1999-05-01 till 2003-09-30	PNA2.1: QFN-PS

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. R.J. Boucherie (UT)	0.2	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 2004-09–30	PNA2.1: FLOW, LT, QFN-PS
Drs. S.K. Cheung (UT)	0.2	PhD student	2002-12-01 till 2006-11-30	PNA2.2: BANCA, PROMO
Drs. R. Litjens (TNO Telecom)	0.2	PhD student	2002-12-01 till 2003-08-31	PNA2.2: BANCA, PROMO
Drs. D.T.M.B. van Ooteghem (TUE)	0.2	PhD student	2001-09-01 till 2005-08-31	PNA2.1: QFN-PS
Dr.ir. W.R.W. Scheinhardt (UT, exchange with M.R.H. Mandjes)	0.2	researcher	2000-09-01 till 2005-09-30	EQUIP, FLOW, LT
Dr. A.P. Zwart (TUE)	0.2	researcher	2002-08-01 till 2005-07-31	PNA2.1: EQUIP, LT, QFN-IS/PS

Scientific report

Highlights

- S.C. Borst received the Infocom 2003 best-paper award.
- A.B. Dieker was runner-up for the thesis award of the Netherlands Society for Statistics and Operations Research (VVS).
- M.J.G. van Uitert completed and successfully defended her PhD thesis titled 'Generalized Processor Sharing Queues', which was nominated for the ASML prize for the best thesis in fundamental science at the TUE in 2003.
- A.P. Zwart received the Gijs de Leve prize for the best thesis in Mathematics of Operations Research in the Netherlands during the period 2000–2002.
- EU Network of Excellence proposal EURO-NGI was granted.
- TI M2C-QoS proposal was granted.
- NWO Van Gogh project with INRIA Sophia Antipolis was granted.
- NWO Open Competitie proposal 'Rare-Event Analysis of Processor-Sharing Systems' was granted.

PhD students

R. Bekker
A.B. Dieker
D.T.M.B. van Ooteghem
M.J.G van Uitert

PNA2.1 – Wireline Networks, TCP/IP

Title	EQUIP – Large-deviations asymptotics and fast simulation
Period	April 2002–April 2006
Leader	M.R.H. Mandjes
Staff	P.T. de Boer (UT), K.G. Dębicki, A.B. Dieker, T. Igonina (UT), M.R.H. Mandjes, V.F. Nicola (UT), W.R.W. Scheinhardt, A.P. Zwart
Funding	CWI (basic funding), NWO
Partner	UT

Progress report. Together with C. Bahadoran and A. Benassi (Clermont-Ferrand Univ.), Dębicki finished the work on operator self-similar Gaussian processes. They classified representations of this class of processes, and obtained a wavelet decomposition and identification theorem.

Dębicki, Mandjes and Van Uitert continued work on the tandem queue. 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.

Dieker and Mandjes finished work on the simulation of large-deviation probabilities with importance sampling by an exponential change of measure. They derived necessary and sufficient conditions for efficiency of the simulation scheme, and showed that these conditions are 'tight' in the sense that they coincide under a weak condition.

Dieker and Mandjes started work on the simulation of a queue fed by many Gaussian sources with stationary increments. The theoretical properties of three different simulation methods are investigated. These methods are all based on importance sampling, but only two are asymptotically efficient. A detailed numerical comparison is made.

D.P. Kroese (Univ. Queensland), Scheinhardt and P.G. Taylor (Univ. Melbourne) studied the decay rate for the stationary distribution of the second queue in an M/M/1 tandem queue, viewed as a Quasi-Birth-and-Death process with infinitely many phases.

Title	FLOW – End-to-end congestion-based flow control mechanisms
Period	2001–2005
Leader	S.C. Borst
Staff	R. Bekker, S.C. Borst, O.J. Boxma, M.R.H. Mandjes, R. Núñez Queija, W.R.W. Scheinhardt
Funding	CWI (basic funding), Philips, SENTER (EQUANET)
Partners	Lucent, Philips, TNO Telecom, TUE, UT

Progress report. Together with D. Abendroth (Univ. Hamburg-Harburg and UT) and J.L. van den Berg (UT and TNO Telecom), Mandjes developed models for assessing the impact of user heterogeneity on TCP performance. An integrated packet/flow-level model was developed, and iteratively solved (packet-level by a fixed-point approach; flow-level by simulation).

Bekker, Borst, Boxma and Kella (Hebrew Univ. Jerusalem) finished work on queues with workload-dependent service and arrival rates. In the M/G/1 case, they obtained equivalence relations for the workload distribution between two closely related queues. Also, some fundamental relations between the workload just before arrival instants and the workload at arbitrary epochs in time are derived for the G/G/1 queue with general state-dependent release rate.

Bekker and Zwart studied the loss probability of a customer in a single-server queue with finite buffer and partial rejection, and showed that it can be identified with the tail distribution of the cycle maximum of the associated infinite buffer-queue.

N.D. van Foreest (UT), Mandjes and Scheinhardt have continued working on (Markov) fluid models with feedback. Earlier work concentrated on 'threshold-feedback', i.e., as a function of the buffer level, both the traffic rates and generator are step functions. The resulting models were applied for modelling TCP. Their earlier work on a Markov-chain modelling of TCP has been tested and extended by using a Petri-net representation. Recent research focuses on a model in which this function is continuous. For this continuous-feedback model, the buffer content distribution is given as the solution of a number of differential equations (Kolmogorov equations).

N.D. van Foreest (UT), Mandjes and Scheinhardt examined so-called back-pressure models, in which congestion in downstream queues determines the service rate of the upstream queues. Together with P.E. Lassila (Helsinki Univ. Technology), Mandjes studied the flow-level dynamics, again with the purpose of quantifying the impact of user-heterogeneity.

R. Malhotra (Lucent Technologies, Bell Labs Innovations), Mandjes, Núñez Queija and F. Panken (Lucent Technologies, Bell Labs Innovations) started an investigation of the back-pressure mechanism for Ethernet. Back-pressure allows to control congestion in the network by sending congestion signals upstream when the buffers fill beyond a pre-specified threshold level. Although several simulation studies have addressed the impact of this mechanism on performance of both delay-critical and elastic traffic flows, its functionality is still not well understood. The aim of this work is to construct a model that allows for numerical evaluation of the relevant performance measures (loss probability and throughput). Simulation studies suggest that the effect of back-pressure on TCP's throughput may be both positive and negative, depending on the parameter settings.

Núñez Queija, J.A.C. Resing (TUE) and Scheinhardt initiated a study to estimate the bandwidth shares of heterogeneous TCP sources as a function of the number of active sources and their characteristics (round-trip times and packet loss probabilities). This work provides a link between earlier packet level studies of TCP and modelling of flow level dynamics (using, for instance, Discriminatory Processor-Sharing (DPS) queues). Partial results are obtained in various limiting regimes (e.g., for large population sizes), supporting the DPS model under certain scenarios. In the framework of the joint Van Gogh project with INRIA

Sophia Antipolis, this investigation is also parallelled through ns-simulations of dynamic TCP connections (Núñez Queija with K. Avrachenkov and B. Prabhu).

Title	LT – Performance analysis of communication networks; focus on long-tailed traffic characteristics and fluid queues
Period	1996–2003
Leader	M.R.H. Mandjes
Staff	S.C. Borst, O.J. Boxma, K.G. Dębicki, A.B. Dieker, M.R.H. Mandjes, W.R.W. Scheinhardt, A.P. Zwart
Funding	CWI (basic funding), NWO
Partners	Columbia Univ., EURANDOM, Lucent, TUE, Univ. Wrocław, UT

Progress report. Borst, Dębicki and Zwart analyzed the tail asymptotics of the supremum of the superposition of two stochastic processes, of which at least one has subexponential characteristics. Canonical examples of such processes include Levy processes and random walks with subexponential jumps, On-Off processes with subexponential activity periods, and Gaussian processes exhibiting long-range dependence; these processes routinely arise in queueing and risk theory. They gave necessary as well as sufficient conditions for a so-called reduced-load equivalence to hold. In this case, one of the two processes can be replaced by its mean. It is shown that this property holds whenever certain structural properties are satisfied. If the reduced-load equivalence does not hold, then the asymptotics are qualitatively different. This is illustrated by a number of examples, which show that the well-behaved process may contribute to the asymptotics by its moderate deviations, large deviations, or oscillatory behaviour.

Dieker worked on conditional limit theorems for queues with Gaussian input. Using metric entropy techniques, he derived a weak-convergence result for Gaussian processes with stationary increments. With this convergence, he obtained logarithmic asymptotics and conditional limit theorems for both the probability of a high buffer content and a large busy period.

Dieker started to work on extremes of Gaussian processes. He derived exact asymptotics for the probability of a high buffer content if a queue is fed by stationary or self-similar Gaussian sources. Special cases are fractional Brownian motion and Gaussian integrated processes (both with short- and long-range dependent characteristics).

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

Progress report. Bekker, Borst and Núñez Queija studied the situation where a fixed number of streaming sessions share a bottleneck link with a dynamic population of elastic flows.

Mandjes has examined two extensions of traditional single-node packet-scale queueing models: tandem networks and (strict) priority systems. Two generic input processes are considered: periodic and Poisson arrivals. For the two-node tandem, he derived an exact expression for the joint distribution of the total queue length, and the queue length of the first queue, implicitly determining the distribution of the second queue. Similarly, he derives the distribution of the low-priority queue in a two-class priority system. He also provides explicit approximations based on the Brownian bridge.

Title	QFN-PS – Quality-of-service in future networks; emphasis on packet scheduling algorithms
Period	1999–2004
Leader	S.C. Borst
Staff	S.C. Borst, O.J. Boxma, M.R.H. Mandjes, R. Núñez Queija, D.T.M.B. van Ooteghem, M.J.G. van Uitert, A.P. Zwart
Funding	CWI (basic funding), SENTER (EQUANET)
Partners	Lucent, Philips, TNO Telecom, TUE

Progress report. U. Ayesta, K. Avrachenkov (both INRIA Sophia Antipolis), P. Brown (France Télécom) and Núñez Queija initiated an investigation of the conditional delay distribution in the Discriminatory Processor-Sharing queue. The aim of this work is to further specify the delay of users with large service requirements, in particular as a function of the discrimination weights. Part of the analysis is based on a mod-

ification of Kleinrock's conservation law for delays.

Borst, Van Ooteghem and Zwart derived the sojourn time asymptotics for a multi-class G/G/1 queue with regularly varying service requirements operating under the Discriminatory Processor-Sharing (DPS) discipline.

Dębicki and Van Uitert continued work on large-buffer asymptotics for a two-class GPS model. Both classes are assumed to have Gaussian characteristics with different variance structure. The asymptotics depend on the dominating variance function.

G. van Kessel (TUE) and Núñez Queija studied the Discriminatory Processor-Sharing model (with Poisson arrivals) under two limiting regimes.

Mandjes and K. Kumaran (Exxon-Mobil Research) have started comparing different scheduling disciplines, e.g., priority, GPS, and resource partitioning.

Mandjes, P. Mannersalo (EPFL, VTT), I. Norros (VTT) and Van Uitert continued work on queues fed by a large number of fractional Brownian motion input processes.

Mandjes and Van Uitert finished work on the Generalized Processor Sharing (GPS) mechanism serving two classes of independent identically distributed Gaussian flows. They show how to use the results in choosing the values of the GPS weights.

Mandjes and Zwart consider large deviations for the steady-state waiting-time distribution in the GI/G/1 PS queue, under light-tailed service requests. Interestingly, the asymptotics coincide with those of long busy periods. Mandjes and M. Nuyens (UvA) found that the same asymptotics also apply under the foreground-background discipline.

PNA2.2 – Wireless Networks, UMTS

Title	BANCA – Effective bandwidth calculations for integrated-services wireless networks
Period	2002–2005
Leader	S.C. Borst
Staff	S.C. Borst, R.J. Boucherie, N. Hegde, R. Litjens
Funding	CWI (basic funding), France Télécom (FLORIN)
Partners	France Télécom, Lucent, TNO Telecom, TUE, UT

Progress report. Borst and Hegde started 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.

Title	PROMO – Processor-sharing models for best-effort wireless services
Period	2002–2005
Leader	S.C. Borst
Staff	S.C. Borst, R.J. Boucherie, N. Hegde, R. Litjens
Funding	CWI (basic funding), France Télécom (FLORIN)
Partners	France Télécom, Lucent, TNO Telecom, TUE, UT

Progress report. T. Bonald (France Télécom R&D), Borst, Hegde and A. Proutière (France Télécom R&D) investigated the performance of wireless downlink data channels in multi-cell scenarios. They considered a network of base stations offering downlink data transfers to users in a dynamic setting, with random arrivals and departures of data flows. They obtain two types of bounds for the flow-level performance, first-degree bounds that assume minimum and maximum interference on the cell under consideration, and second-degree bounds that assume minimum and maximum interference experienced by the neighbouring cells, but allow the cell under consideration to be influenced by its neighbours. The closer second-degree bounds correspond to a Processor-Sharing queue in a time-varying environment, and cannot be calculated analytically. Thus, they obtain performance measures at two limiting regimes, termed fluid and quasi-stationary, where the time-varying environment evolves on a very fast and a very slow time scale, respectively. The performance in these regimes is insensitive, and they provide explicit formulas for the distribution of the number of active flows, the mean transfer delays, and the flow throughputs.

In the past few years, the potential for exploiting rate variations to improve the performance of wireless data networks by opportunistic scheduling has been extensively studied at the packet level. T. Bonald (France Télécom

R&D), Borst and A. Proutière (France Télécom R&D) examined how slower, mobility-induced rate variations impact the performance at the flow level, accounting for the dynamic number of users sharing the transmission resource. They identified two limit regimes, termed fluid regime and quasi-stationary regime, where the rate variations occur on an infinitely fast and an infinitely slow time scale, respectively. Using stochastic comparison techniques, they showed that these limit regimes provide simple, insensitive performance bounds that only depend on easily calculated load factors. Additionally, they proved that for a broad class of Markov-type fading processes, the performance varies monotonically with the time scale of the rate variations.

PNA2.3 – Network Economics

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
Funding	CWI (basic funding), Telematics Institute
Partners	Microsoft Research, Telematics Institute, TNO Telecom, UT

Progress report. Together with R. van de Meent, A. Pras (both UT), J.L. van den Berg (TNO Telecom and UT) and F. Roijers (TNO Telecom), Mandjes 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. Apart from its simplicity, the dimensioning formula has a number of attractive features, viz. its insensitivity and robustness (as just the load ρ is needed), and its transparency.

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. The main result of this study describes the relation between the shape of this function, and the correlation structure. More specifically, it is shown that the curve is convex at some buffer size b if and only if there are negative correlations on the time scale at which the overflow takes place. Interestingly, it is possible to retrieve the variance function of the Gaussian sources by observing (i.e., measuring) the buffer content distribution. Recent work with R. van de Meent (UT) empirically shows the validity of this 'inversion' approach.

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 (basic funding), Telematics Institute
Partners	Microsoft Research, Telematics Institute, TNO Telecom, UT

Progress report. J.L. van den Berg (TNO Telecom and UT), Mandjes and Núñez Queija extended their study of price setting in a scenario with two best-effort classes. Users choose the service class depending on the file size, prices and the expected transfer times, in each service class. Users may also choose not to join the system (balking). Thus, the load on each of the service classes depends on the prices. The operator of the system is supposed to be a revenue-maximizing agent. Given a static allocation of traffic to both service classes, the high-priority class experiences an ordinary M/G/1 Processor-Sharing (PS) system and the low-priority class sees an M/G/1 PS queue that is subject to random service interruptions. In the revenue-optimizing Nash equilibrium, short files use the (more expensive) premium service and long files join the low-priority service. Users with medium-sized files are the first to balk.

Mandjes and J. Timmer (UT) have studied Paris Metro Pricing (PMP) as a mechanism for offering differentiated QoS. In PMP providers divide their networks into logically separated subnetworks, all of them 'best-effort' but having different prices. The cheapest network being the most attractive, it will have the highest congestion level, and hence the worst performance. It is unclear what happens if there are multiple competing providers offering PMP. Earlier re-

sults showed that under specific assumptions the providers do not have any incentive to split their network. Mandjes and Timmer have developed a game-theoretic framework to systematically examine this issue. Importantly, it is shown that the providers' willingness to split their resources into subnetworks critically relies on the specific assumptions made.

Societal aspects and knowledge transfer

External contacts

- Carnegie Mellon Univ., Pittsburgh, USA (M. Harchol-Balter).
- Columbia Univ., New York, USA (P.R. Jelenković).
- France Télécom R&D, Paris, France (J.W. Roberts, T. Bonald, A. Proutière).
- 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 Sophia Antipolis, France (E. Altman, U. Ayesta, C. Barakat, K. Avrachenkov, Ph. Nain).
- Lucent Technologies, Bell Labs Innovations, Hilversum (E. Meeuwissen, F. Panken).
- Lucent Technologies, Bell Labs Innovations, Murray Hill (D.M. Andrews, D. Mitra, I. Saniee, A.L. Stolyar, P.A. Whiting).
- Microsoft Research, Cambridge, UK (A. Ganesh, P. Key, L. Massoulié).
- Statistical Laboratory, Univ. Cambridge, UK (F.P. Kelly, D.J. Wischik).
- VTT, Helsinki, Finland (P. Mannersalo, I. Norros).

Projects with partners in public and private sector

- EQUANET.
- EURO-NGI.
- M2C-QoS.
- Van Gogh.

Contract research

- FLORIN, France Télécom R&D, Paris, December 2002–December 2003: S.C. Borst, N. Hegde, M.R.H. Mandjes, R. Núñez Queija.

Teaching at university

- Exercises Wiskunde 1 voor ST, TUE: R. Bekker.
- Stochastic Performance Modeling, TUE: O.J. Boxma, R. Núñez Queija.
- Queueing Networks, TUE: S.C. Borst, R. Núñez Queija.
- Bachelor case, Applied Mathematics, UT, December: M.R.H. Mandjes.
- Stochastic Decision Theory, TUE: R. Núñez Queija.
- Linear Algebra and Linear Programming, TUE: D.T.M.B. van Ooteghem.
- Stochastic Processes 1, TUE: D.T.M.B. van Ooteghem.
- Exercises Wachttijd- en Stagnatieproblemen, TUE, March–June: M.J.G. van Uitert.

Courses, tutorials

- Course Stochastic Models for Telecommunications, UT, May–June: M.R.H. Mandjes.
- Tutorial Heavy Tails: Performance Models and Scheduling Disciplines, ITC-18, Berlin, Germany, August 31: S.C. Borst, O.J. Boxma, R. Núñez Queija.

Organization of conferences, workshops, courses, meetings

- Benelux Performance Workshop, EURANDOM, Eindhoven, March 13–14: S.C. Borst, O.J. Boxma.
- Queueing Colloquium, June 23, November 26: M.R.H. Mandjes, R. Núñez Queija.
- Reading Seminar, CWI, January 10, February 7, March 7, April 11, September 26, November 7, December 19: R. Bekker, A.B. Dieker, R. Núñez Queija, M.J.G. van Uitert.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- 28th Annual Mathematics of Operations Research Conference, Lunteren, January 14–16: R. Bekker (Talk: Queues with workload-dependent arrival and service rates), S.C. Borst, O.J. Boxma, K.G. Dębicki, A.B. Dieker (Talk: On asymptotically efficient simulation

of large deviation probabilities), M.R.H. Mandjes, R. Núñez Queija, W.R.W. Scheinhardt, M.J.G. van Uitert, A.P. Zwart.
- ITC-18, Berlin, Germany, September 1–5: R. Bekker, S.C. Borst (talk, accepted for proceedings, joint work with R. Núñez Queija, A.P. Zwart), O.J. Boxma, M.R.H. Mandjes (Talk, accepted for proceedings, joint work with N. van Foreest, W.R.W. Scheinhardt; talk, accepted for proceedings, joint work with M.J.G. van Uitert), R. Núñez Queija (Talk, accepted for proceedings, joint work with S.C. Borst, A.P. Zwart), D.T.M.B. van Ooteghem, M.J.G. van Uitert (Talk, accepted for proceedings, joint work with M.R.H. Mandjes).
- Benelux Performance Workshop, EURANDOM, Eindhoven, March 13–14: R. Bekker, S.C. Borst, O.J. Boxma, M.R.H. Mandjes (Invited talk: Performance analysis of queues with Gaussian input), D.T.M.B. van Ooteghem.
- Infocom 2003, San Francisco, USA, April 1–3: S.C. Borst (Talk: User-level performance of channel-aware scheduling algorithms in wireless data networks: accepted for proceedings), M.R.H. Mandjes (Talk: Pricing strategies and service differentiation, accepted for proceedings).
- Workshop on Applied Probability and Advanced Communication Networks, Będlewo, Poland, May 26–30: O.J. Boxma, K.G. Dębicki, M.R.H. Mandjes (Invited talk: Sample-path large deviations for tandem queues with Gaussian input), M.J.G. van Uitert, A.P. Zwart.
- Stochastic Processes and its Applications, Angra dos Reis, Brazil, August 3–9: A.B. Dieker (Talk: On asymptotically efficient simulation of large deviation probabilities), A.P. Zwart.
- Workshop on Heavy-Traffic Analysis of Stochastic Networks, EURANDOM, Eindhoven, September 8–12: R. Bekker, S.C. Borst, O.J. Boxma, A.B. Dieker, N. Hegde, M.R.H. Mandjes, R. Núñez Queija, D.T.M.B van Ooteghem, A.P. Zwart.
- TCP Workshop, UT, September 12: M.R.H. Mandjes, R. Núñez Queija.

Working visits

- INRIA Sophia Antipolis, France, March 10–14: R. Núñez Queija.
- Hewlett-Packard Laboratories (A. van Moorsel), Palo Alto, USA, March 31: M.R.H. Mandjes.
- INRIA Sophia Antipolis, France, May 12–16: W.R.W. Scheinhardt.
- Wrocław Univ. (T. Rolski, K.G. Dębicki), June 1–5: M.R.H. Mandjes, M.J.G. van Uitert.
- France Télécom R&D (T. Bonald, A. Proutière, J.W. Roberts), Paris, France, July: N. Hegde.
- UT, September 12, 18: R. Núñez Queija.
- Yale Univ., New Haven, USA, November 12: S.C. Borst.

Project meetings

- EQUANET project meetings, Lucent Technologies, Bell Labs Innovations, Hilversum: February 21: M.R.H. Mandjes, R. Núñez Queija; March 5, 21: M.R.H. Mandjes, R. Núñez Queija; April 2: R. Núñez Queija (lecture); April 25: M.R.H. Mandjes; May 2: M.R.H. Mandjes; May 22: R. Núñez Queija; June 20: R. Núñez Queija; August 20: R. Núñez Queija; September 19, 22: M.R.H. Mandjes, R. Núñez Queija; November 7: R. Núñez Queija; December 5: M.R.H. Mandjes, R. Núñez Queija.
- EQUANET project meetings, TNO KPN Valley / TNO Telecom Leidschendam/Delft: April 14: R. Núñez Queija; March 5, 21: M.R.H. Mandjes, R. Núñez Queija; June 19: R. Núñez Queija; August 26: R. Núñez Queija, December 16: S.C. Borst, M.R.H. Mandjes, R. Núñez Queija, D.T.M.B. van Ooteghem.
- FLORIN project meetings, CWI, January 24: S.C. Borst, M.R.H. Mandjes, R. Núñez Queija; September 8: S.C. Borst, N. Hegde, M.R.H. Mandjes, R. Núñez Queija.
- FLORIN project meeting, France Télécom R&D, Paris, France, April 25: S.C. Borst, N. Hegde, M.R.H. Mandjes.
- M2C-QoS project meeting at Telematics Institute, November 13: M.R.H. Mandjes.
- EU Network of Excellence EURO-NGI kick-off meeting, Paris, France, December 8–9: O.J. Boxma, M.R.H. Mandjes.

Other lectures

- Seminar UvT, January 21: M.R.H. Mandjes (Invited talk: Performance analysis of queues with Gaussian input).
- Reading seminar, CWI, March 7: A.B. Dieker (Talk: Transient properties of many-server queues and related QBD's), S.C. Borst (Talk: Fluid model for a network operating under a fair bandwidth-sharing policy).

- BETA workshop PAPATINT, Ede, March 20: S.C. Borst (Invited talk: Agent staffing in call centers).
- Seminar Hewlett-Packard Laboratories, Palo Alto, USA, March 31: M.R.H. Mandjes (Invited talk: Pricing strategies and service differentiation).
- Reading seminar, CWI, April 11: R. Núñez Queija (Talk: Modelling integration of streaming and data traffic).
- Seminar Korteweg-De Vries Institute, Amsterdam, May 12: M.R.H. Mandjes (Invited talk: Performance analysis of queues with Gaussian input).
- PNA Colloquium, CWI, May 16: M.R.H. Mandjes (Talk: Performance analysis of queues with Gaussian input).
- Seminar Wrocław Univ., Poland, June 3: M.R.H. Mandjes (Invited talk: Performance analysis of queues with Gaussian input).
- Queueing Colloquium, CWI, June 23: N. Hegde (Invited talk: Capacity of Multiservice WCDMA Networks with Variable GoS).
- Scientific Meeting, CWI, June 27: R. Núñez Queija (Talk: Mathematical modelling and performance analysis of TCP-like controlled traffic).
- Reading seminar, CWI, September 26: R. Bekker (Talk: Applications of level crossings).
- EURANDOM seminar, Eindhoven, October 21: R. Núñez Queija (Talk: Perturbation analysis for denumerable Markov chains with applications to queueing models).
- Seminar Yale Univ., New Haven, USA, November 12: S.C. Borst (Talk: Flow-level performance of channel-aware scheduling algorithms in wireless data networks).
- APQ seminar, EURANDOM, Eindhoven, December 16: R. Bekker (Talk: The phase method).
- Reading seminar, CWI, December 19: M.R.H. Mandjes (Talk: Analysis of packet-level queues).

Visitors

- P.A. Whiting, Lucent Technologies, Bell Labs Innovations, March 3–7. Host: S.C. Borst.
- P. Mannersalo, I. Norros, VTT, March 10–21. Host: M.R.H. Mandjes.
- K. Kumaran, Exxon-Mobil Research, June 30–July 4. Host: M.R.H. Mandjes.
- K. Avrachenkov, INRIA Sophia Antipolis, France, November 20–26. (Talk: M/G/1 Processor Sharing with batch arrivals). Host: R. Núñez Queija.

Memberships of committees and other professional activities

R. Bekker

- Referee for Operations Research Letters.

S.C. Borst

- Professor of Stochastic Operations Research (part-time), TUE.
- Advisor of M.J.G. van Uitert (TUE).
- Member PhD committees of D.A. van der Laan (UL), R. Litjens (UT).
- Member of Advisory Board IFIP Working Group 7.3, IFIP Working Group 7.3.
- Member of Board of Directors ACM Sigmetrics.
- Member STW jury committee 191.
- 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 (Modeling and performance analysis of telecommunication systems; project leader: J.P.M. Voeten).
- Area editor Operations Research Letters, associate editor Operations Research, associate editor Performance Evaluation.
- Program committee member HET-NET '03, 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems, Sigmetrics / Performance 2004.
- Referee for The Applied Probability Journals, Electronic Journal of Probability, ICC '04, IEEE Communications Letters, IEEE Transactions on Information Theory, IEEE/ACM Transactions on Networking, IEEE Transactions on Wireless Communications, IEEE Infocom 2004, Operations Research, Operations Research Letters, Performance Evaluation, Queueing Systems, Telecommunication Systems.

R.J. Boucherie

- Assistant advisor of R. Litjens (UT).

K.G. Dębicki

- Assistant professor in Department of Theory of Probability, Mathematical Institute, Univ. Wrocław, Poland.
- Member of Polish Association of Mathematicians.
- Leader 5 P03A 021 20 project 'Analysis of stochastic characteristics in the extreme value theory of stochastic processes' (finally evaluated with mark 'excellent').
- Referee for Stochastic Processes and their Applications, Queueing Systems.

A.B. Dieker

- Referee for Performance Evaluation.

M.R.H. Mandjes

- Professor of Stochastic Operations Research (part-time), UT.
- Member PhD committee of R. Litjens (UT).
- Member project steering committee EQUANET (funded by SENTER; partners: CWI, Lucent Technologies, TNO Telecom, TUE, UT).
- Member project management committee EQUANET (funded by SENTER; partners: CWI, Lucent Technologies, TNO Telecom, TUE, UT).
- 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-18), ITCOM 2003 (Conference on Performance and Control of Next Generation Communication Networks), 16th ITC Specialist Seminar on Performance Evaluation of Wireless and Mobile Systems.
- Referee for ACM Transactions on Modeling and Computer Simulation, Advances in Applied Probability, Annals of Operations Research, Computer Communications, Computer Networks, IEEE Infocom 2004, IEEE/ACM Transactions on Networking, IEEE Communications Letters, ITC-18, Journal of Applied Probability, Mathematics of Operations Research, Performance Evaluation, Probability in the Engineering and Informational Sciences, Queueing Systems, Stochastic Models, Telecommunication Systems.

R. Núñez Queija

- Assistant professor of Stochastic Operations Research (part-time), TUE.
- Member project management committee EQUANET (funded by SENTER; partners: CWI, Lucent Technologies, TNO Telecom, TUE, UT).
- Coordinator NWO Van Gogh project (partner: INRIA Sophia Antipolis, France).
- Referee for IEEE/ACM Transactions on Networking, Mathematics of Operations Research, Performance Evaluation, Probability in the Engineering and Informational Sciences, Stochastic Models.
- Referee for IEEE ICC '04, IEEE Infocom 2004, ITC-18.

W.R.W. Scheinhardt

- Assistant professor of Stochastic Operations Research, UT.
- Referee for Stochastic Models, Stochastic Processes and their Applications, ITC-18.

M.J.G. van Uitert

- Referee for Journal of Applied Probability, ITC-18.

A.P. Zwart

- Assistant professor of Stochastic Operations Research, TUE.
- Referee for The Applied Probability Journals, Bernoulli, Electronic Journal of Probability, Operations Research Letters, Performance Evaluation, Queueing Systems, Stochastic Processes and their Applications, various conferences.

Academic publications

Publications in refereed journals

1. A.A. Borovkov, O.J. Boxma, Z. Palmowski (2003). On the integral of the workload process of the single-server queue. Journal of Applied Probability 40, 200–225.
2. A.A. Borovkov, O.J. Boxma (2003). On large deviation probabilities for random walks with heavy tails. Siberian Advances in Mathematics 13, 1–31.

3. S.C. Borst, O.J. Boxma, J.F. Groote, S. Mauw (2003). Task allocation in a multi-server system. Journal of Scheduling 6, 423–436.
4. S.C. Borst, O.J. Boxma, P.R. Jelenković (2003). Reduced-load equivalence and induced burstiness in GPS queues with long-tailed traffic flows. Queueing Systems 43, 273–306.
5. S.C. Borst, O.J. Boxma, J.A. Morrison, R. Núñez Queija (2003). The equivalence between processor sharing and service in random order. Operations Research Letters 31, 254–262.
6. S.C. Borst, O.J. Boxma, R. Núñez Queija, A.P. Zwart (2003). The impact of the service discipline on delay asymptotics. Performance Evaluation 54, 175–206.
7. S.C. Borst, O.J. Boxma, M.J.G. van Uitert (2003). The asymptotic workload behavior of two coupled queues. Queueing Systems 43, 81–102.
8. S.C. Borst, M. Mandjes, M.J.G. van Uitert (2003). Generalized Processor Sharing queues with heterogeneous traffic classes. Advances in Applied Probability 35, 806–845.
9. S.C. Borst, M. Mandjes, M.J.G. van Uitert (2003). Generalized Processor Sharing queues with light-tailed and heavy-tailed input. IEEE/ACM Transactions on Networking 11, 821–834.
10. S.C. Borst, A.P. Zwart (2003). A reduced-peak equivalence for queues with a mixture of light-tailed and heavy-tailed input flows. Advances in Applied Probability 35, 793–805.
11. O.J. Boxma, D. Denteneer, J.A.C. Resing (2003). Delay models for contention trees in closed populations. Performance Evaluation 53, 169–185.
12. O.J. Boxma, Z. Palmowski, S. Schlegel (2003). A tandem queue with a gate mechanism. Queueing Systems 43, 349–364.
13. O.J. Boxma, T. Takine (2003). The M/G/1 FIFO queue with several customer classes. Queueing Systems 45, 185–189.
14. K.G. Dębicki, M. Mandjes (2003). Exact overflow asymptotics for queues with many Gaussian inputs. Journal of Applied Probability 40, 704–720.
15. A.B. Dieker, M. Mandjes (2003). On spectral simulation of fractional Brownian motion. Probability in the Engineering and Informational Sciences 17, 417–434.
16. N. van Foreest, M. Mandjes, W.R.W. Scheinhardt (2003). Analysis of a feedback fluid model for TCP with heterogeneous sources. Stochastic Models 19, 299–324.
17. K. Kumaran, M. Mandjes, A.L. Stolyar (2003). Convexity properties of loss and overflow functions. Operations Research Letters 31, 95–100.
18. R. Litjens, R.J. Boucherie (2003). Elastic calls in an integrated services network: the greater the call size variability the better the QoS. Performance Evaluation 52, 193–220.
19. M. Mandjes (2003). Pricing strategies under heterogeneous service requirements. Computer Networks 42, 231–249.
20. M. Mandjes, D. Mitra, W.R.W. Scheinhardt (2003). A simple model of network access: feedback adaptation of rates and admission control. Computer Networks 41, 489–504.
21. M. Mandjes, D. Mitra, W.R.W. Scheinhardt (2003). Models of network access using feedback fluid queues. Queueing Systems 44, 365–398.

Publications in other journals and other scientific output

Conference proceedings

1. S.C. Borst (2003). User-level performance of channel-aware scheduling algorithms in wireless data networks. Proceedings Infocom 2003.
2. S.C. Borst, R. Núñez Queija, A.P. Zwart (2003). Bandwidth sharing with heterogeneous service requirements. Providing QoS in Heterogeneous Environments. J. Charzinski, R. Lehnert, P. Tran Gia (eds). Proceedings ITC-18, Berlin, North-Holland, Amsterdam, 501–510.
3. J. Boyer, F. Guillemin, Ph. Robert, A.P. Zwart (2003). Heavy-tailed M/G/1 PS queues with impatience and admission control in packet networks. Proceedings Infocom 2003.
4. M.X. van den Broek, I.J.B.F. Adan, N.S. Shankar, S.C. Borst (2003). Mathematical analysis and evaluation of arrival slot mechanism for contention resolution. Proceedings Infocom 2003.

5. N. van Foreest, M. Mandjes, W.R.W. Scheinhardt (2003). Modelling and fairness aspects of asymmetric TCP sources. Providing QoS in Heterogeneous Environments. J. Charzinksi, R. Lehnert, P. Tran Gia (eds). Proceedings ITC-18, Berlin, North-Holland, Amsterdam, 631–640.
6. P. Lassila, J.L. van den Berg, M. Mandjes, R. Kooij (2003). An integrated packet/flow model for TCP performance analysis. Providing QoS in Heterogeneous Environments. J. Charzinski, R. Lehnert, P. Tran Gia (eds). Proceedings ITC-18, Berlin, North-Holland, Amsterdam, 651–660.
7. M. Mandjes, M.J.G. van Uitert (2003). Sample-path large deviations for tandem queues with Gaussian inputs. Providing QoS in Heterogeneous Environments. J. Charzinski, R. Lehnert, P. Tran Gia (eds). Proceedings ITC-18, Berlin, North-Holland, Amsterdam, 521–530.
8. R. van de Meent, A. Pras, M. Mandjes, J.L. van den Berg, L. Nieuwenhuis (2003). Traffic measurements for link dimensioning – a case study. M. Brunner, A. Keller (eds). Self-managing distributed systems. 14th IFIP/IEEE International Workshop on Distributed Systems Operations and Management, DSOM 2003, Heidelberg, Germany, LNCS, 2867, 106–117.
9. M. Mandjes (2003). Pricing strategies under heterogeneous service requirements. Proceedings Infocom 2003.

CWI reports

PNA-E0302, PNA-R0305, PNA-E0306, PNA-R0308, PNA-R0311, PNA-R0312.
See page 179 for complete titles.

Technical reports published elsewhere

1. H. Albrecher, O.J. Boxma (2003). A ruin model with dependence between claim sizes and claim intervals. EURANDOM Report 2003-23.
2. E. Altman, K. Avrachenkov, R. Núñez Queija (2003). Perturbation analysis for denumerable Marked chains with application to queueing models. INRIA Research Report RR-4713.
3. E. Altman, T. Jiménez, R. Núñez Queija, U. Yechiali (2003). Optimal routing among ./M/1 queues with partial information. INRIA Research Report RR-4985.
4. C. Bahadoran, A. Benassi, K.G. Dębicki (2003). Operator-self-similar Gaussian processes with stationary increments. Report 2003-03, Clermont-Ferrand Univ.
5. R. Bekker, S.C. Borst, O.J. Boxma, O. Kella (2003). Queues with workload-dependent arrival and service rates. SPOR Report 2003-11, TUE.
6. R. Bekker, A.P. Zwart (2003). On an equivalence between loss rates and cycle maxima in queues and dams. SPOR-Report 2003-17, TUE.
7. S.C. Borst, K.L. Clarkson, J.M. Graybeal, H. Viswanathan, P.A. Whiting (2003). User-level QoS and traffic engineering for 3G wireless 1xEV-DO systems. Bell Labs Technical Journal 8, 33–47.
8. S.C. Borst, D.T.B.M. van Ooteghem, A.P. Zwart (2003). Tail asymptotics for Discriminatory Processor-Sharing queues with heavy-tailed service requirements. SPOR-Report 2003-25, TUE.
9. O.J. Boxma, S. Foss, J.-M. Lasgouttes, R. Núñez Queija (2003). Waiting time asymptotics in the single server queue with service in random order. EURANDOM Report 2003-2.
10. O.J. Boxma, H. Kaspi, O. Kella, D. Perry (2003). On/off storage systems with state-dependent input, output and switching rates. EURANDOM Report 2003-38.
11. F. Guillemin, Ph. Robert, A.P. Zwart (2003). Asymptotic results for processor sharing queues. SPOR Report 2003-19, TUE.
12. P. Gupta, P.A. Whiting, S.C. Borst (2003). Channel prediction for 1xEV-DV. Technical Memorandum, Bell Laboratories, Lucent Technologies.
13. R. de Haan, J.L. van den Berg, R.E. Kooij, R.D. van der Mei, A.P. Zwart (2003). Enhancement of an integrated packet/flow model for TCP performance. Stochastics Report 2003-15, VU.
14. D.P. Kroese, W.R.W. Scheinhardt, P.G. Taylor (2003). Spectral properties of the tandem Jackson network, seen as a quasi-birth-and-death process. Memorandum 1691, Department of Applied Mathematics, UT.
15. M. Mandjes, P. Mannersalo, I. Norros, M.J.G. van Uitert (2003). Most probable busy period paths in Gaussian queues. Temporary document, COST-279.

16. W.R.W. Scheinhardt, N.D. van Foreest, M. Mandjes (2003). Continuous feedback fluid queues. Memorandum 1686, Department of Applied Mathematics, UT.
17. M. Vlasiou, I.J.B.F. Adan, O.J. Boxma, J. Wessels (2003). Throughput analysis of two carousels. EURANDOM Report 2003-37.
18. A.P. Zwart (2003). Heavy traffic asymptotics for the single-server queue with random order of service. SPOR Report 2003-26, TUE.
19. A.P. Zwart (2003). Loss rates in the M/G/1 queue with complete rejection. SPOR Report 2003-27, TUE.
20. A.P. Zwart, S.C. Borst, K.G. Dębicki (2003). Subexponential asymptotics of hybrid fluid and ruin models. SPOR-Report 2003-10, TUE.

Deliverables for projects

1. R. Kooij, F. Roijers, F. Panken, M. Mandjes, J.L. van den Berg, R. Núñez Queija (2003). Realistic traffic models for access networks. EQUANET Deliverable D3.1.2.
2. S.C. Borst, G. van Kessel, D.T.M.B. van Ooteghem, R. Núñez Queija (2003). Performance models and analysis of asymmetric flow-level sharing. EQUANET Deliverable D3.3.1.

PhD theses

1. M.J.G. van Uitert (2003). Generalized Processor Sharing Queues. November 24, TUE.

Professional products

Contracts

- End-to-end Quality of Service in Next-generation Networks (EQUANET), funded by SENTER (partners: CWI, Lucent Technologies, TNO Telecom, TUE, UT).
- Flow-level Performance of Integrated 3G CDMA Networks (FLORIN), funded by France Télécom R&D.

Publications for a broad audience

1. O.J. Boxma (2003). Tennis en kansrekening. STAtOR 4(2), 11–12.
2. O.J. Boxma (2003). De kracht van de wachtrijtheorie. STAtOR 4(4), 20–21.
3. A.P. Zwart (2003). Queueing systems with heavy tails. ITW Nieuws, November.

Other output

Awards

- S.C. Borst received the Infocom 2003 best-paper award.
- A.B. Dieker was runner-up for the thesis award of the Netherlands Society for Statistics and Operations Research (VVS).
- A.P. Zwart received the Gijs de Leve prize for the best thesis in Mathematics of OR in the Netherlands during the period 2000–2002.

Grants

- NWO Open Competitie proposal 'Rare-Event Analysis of Processor-Sharing Systems' (S.C. Borst, O.J. Boxma, A.P. Zwart).
- EU Network of Excellence proposal EURO-NGI (S.C. Borst, O.J. Boxma, M.R.H. Mandjes).
- ICES-KIS proposal BRICKS (S.C. Borst, R.J. Boucherie, O.J. Boxma, M.R.H. Mandjes; partners TUE, UT).
- NWO Van Gogh project (R. Núñez Queija, W.R.W. Scheinhardt, A.P. Zwart; partner: INRIA Sophia Antipolis, France).

Stochastics – PNA3

Mission

Rigorous theoretical and applied research in stochastics. One of our goals is to play a substantial role in the development of several important subfields.

Besides doing research on a high level, we consider it as an important duty to detect and study new important international developments and make these known to the Dutch community through lectures, informal discussions and working groups. A good example is our initiative to start a study group on Stochastic Löwner Evolution. This group met frequently in 2003, at CWI. Several mathematicians and physicists from CWI and other Dutch institutes have actively participated. The group will

meet a few more times in the first half of 2004.

The following subjects have our particular attention:

- Percolation phenomena 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 in modern queueing theory. The tools used here are mainly a mixture of probability and analysis (stochastic analysis).

Our activity on statistical estimation of Poisson intensity functions and Edgeworth/saddlepoint/bootstrap based approximations has ended in the first half of 2003, with the departure of R. Helmers and B. Tarigan.

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 – Statistics	R. Helmers
PNA3.3 – Stochastic Analysis	K.O. Dzhaparidze

Remark: The subtheme Statistics has ended mid-2003 with the departure of R. Helmers from PNA3.

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
Drs. R.M. Brouwer	1.0	PhD student	2001-02-01 till 2005-02-01	PNA3.1: NWO-SOC
Dr. K.O. Dzhaparidze	1.0	leader PNA3.3	indefinite	PNA3.3
Dr. R. Helmers	0.55	leader PNA3.2	2003-08-01	PNA3.2
R. van der Horst	0.75	programmer	till 2004-05-01	PNA3
Dr. A. Járai	1.0	post-doc	2002-09-01 till 2004-09-01	PNA3.1: NWO-DPP

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. F. Merkl (UL)	0.05	advisor	2003-06-01 till 2005-12-31	PNA3
Dr. P.J.C. Spreij (UvA)	0.2	senior researcher	2003-12-31	PNA3.3
B. Tarigan, MSc (KNAW)	0.33	PhD student	2000-09-01 till 2003-05-01	PNA3.2: KNAW-SMCS

J.H. van Zanten (VU)	0.05	senior researcher	2003-10-01 till 2007-10-01	PNA3.3: NWO-AGP
P. Zareba (VU-NWO)	0.2	PhD student	2003-10-01 till 2007-10-01	PNA3.3: NWO-AGP

Scientific report

Highlights

- Van den Berg has been appointed full professor (one day per week) at the VU.
- A new project, 'Spectral analysis of processes with stationary increments', supported by NWO (open competition) has started in October.
- The study group on Stochastic Löwner Evolutions has significantly contributed to the introduction of these powerful new techniques in the Dutch scientific community.

PhD students

R.M. Brouwer
B. Tarigan
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 (open competition): salary R.M. Brouwer
Partners	M.S. Keane (Wesleyan and UvA) and R. Meester (VU)

Progress report. A paper on so-called 'self-destructive percolation', motivated by certain models on excitable media (forest-fires, neurons, epidemics, etc.) has been completed and accepted for publication in a special issue (related to a programme at the Isaac Newton Institute in Cambridge) of Random Structures and Algorithms. In the meantime new results have been obtained. In particular we have shown, for a 2-dimensional model where at time 0 every site is 'relaxed', the remarkable fact that (under a percolation-like hypothesis), the probability that before time $t_c + \tau$ more than one excitation 'avalanche' occurs in a given finite region, tends to 0 as (in this order) the system size tends to ∞ and the 'external trigger' intensity tends to 0. Here t_c is the time at which the related system without excitations would 'start to create' an infinite cluster of 'alert' sites, and τ is a positive value arising from the above-mentioned percolation hypothesis.

Title	NWO-DPP: Dynamic percolation phenomena near criticality
Period	2002–2004
Leader	J. van den Berg
Staff	A. Járai
Funding	NWO (open competition): salary A. Járai
Partners	R. van der Hofstad, F. Redig, S. Athreya, A. Sakai and G. Slade

Progress report. Sandpile models: In earlier work, Járai and S. Athreya had shown that in two and more dimensions the stationary distribution of the sandpile model has an infinite-volume limit. Recently, they have proved that (in 5 or more dimensions) the avalanches in this infinite-volume limit remain finite. This result was then used for the construction of an infinite-volume dynamics (cooperation with F. Redig).

Incipient infinite percolation cluster: With R. van der Hofstad, Járai has constructed the incipient infinite cluster for (unoriented) percolation in high dimensions.

Forest fires: Van den Berg and Járai have studied a forest-fire model with self-organized critical behaviour. They have obtained a rigorous proof of a claim in the physics literature about the asymptotic (as the ignition intensity in the model tends to 0) tree density in a 1-dimensional version of the model. They also obtained new results for the dependencies in space and time.

Title	NWO-HONG: Dutch-Hungarian cooperation
Period	2002–2004
Leader	J. van den Berg
Staff	R.M. Brouwer, A. Járai
Funding	NWO, OTKA (Hungary): reciprocal visits, workshops
Partners	Univ. Budapest (B. Tóth and D. Szász), EURANDOM (W.Th.F. den Hollander)

Progress report. Van den Berg, Brouwer and Járai participated in the workshop 'Randomness in space and time', Budapest, June 23–27, and gave a talk.

Further, Járai made a working visit to Budapest, February 24–28, and gave a seminar talk on 'The incipient infinite cluster in $d > 6$ dimensions'. With B. Tóth he discussed a model where a red particle moves in a gas of blue particles with the rule that it can only jump if there is at least one blue particle at its location. They also had discussions on a self-organized critical forest-fire model.

Title	General research in probability theory
Period	indefinite
Leader	J. van den Berg
Staff	R.M. Brouwer, A. Járai, F. Merkl
Funding	CWI
Partners	Cornell Univ. (H. Kesten); Chalmers Univ. (J. Steif); Univ. Milan, (A. Gandolfi); VU (R. Meester); IMPA, Rio de Janeiro (V. Sidoravicius); Rutgers Univ. (J. Kahn)

Progress report. Van den Berg and Kahn (Rutgers Univ. have continued their research on correlation-like inequalities. Extensions of our earlier results to the so-called Fortuin-Kasteleyn random-cluster model with $q \geq 2$ have been obtained. The proof is very different from that for ordinary percolation (which corresponds with $q = 1$), and has a somewhat awkward structure which we hope to improve.

With T. van de Brug (student at VU) and R. Meester (VU) a preliminary study on the connectivity of certain ad-hoc wireless communication networks has been made. A survey-like paper, discussing part of the literature and presenting alternative ideas from percolation, is in preparation.

The study/reading group on Stochastic Löwner Evolution, which started in December 2002, has been quite successful. There were frequent meetings in 2003, and several mathematicians and theoretical physicists from other institutes participated. We think this activity has substantially helped to improve the knowledge in the Netherlands of this exciting new topic. We plan to investigate how these techniques can be used in our own work; in particular we hope they will shed light on the percolation-like hypothesis mentioned in the progress report on the project NWO-SOC above.

With V. Sidoravicius (IMPA, Rio de Janeiro) a peculiar growth model (motivated by certain biological processes) with two types of 'particles' has been investigated. Preliminary results (partly with Y. Peres (Berkeley)) have been obtained.

PNA3.2 – Statistics

This subtheme was terminated due to the departure of Helmers.

PNA3.3 – Stochastic Analysis

Title	EU-DYNSTOCH (European project on statistical methods for dynamical stochastic models)
Period	2000–2004
Leader	K.O. Dzhaparidze
Staff	P.J.C. Spreij
Funding	EU: percentage of expenses
Partners	See project 'General research in Stochastic Analysis'

Progress report. The collaboration with the Helsinki team was continued in two directions. The first subject was fractional Brownian motion. Dzhaparidze and Van Zanten presented their results during their two visits to Helsinki Univ. and discussed the possibilities of further developments. The collaboration was continued at CWI during the visit of E. Valkeila and C. Jost.

Another subject of our joint work is information processes for semimartingale experiments. As an application of our methods, developed in the recent paper in Annals of Probability (2003), 216–243, Dzhaparidze and the members of the Helsinki team, D. Gasbarra and E. Valkeila, started with a new paper with the tentative title Initial enlargement of filtration: Bayesian approach.

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

Progress report. This project, which started in October with the arrival of Zareba, stems from preliminary results obtained by Dzhaparidze and Ferreira and further developed by Dzhaparidze and Van Zanten in a number of papers on fractional Brownian motion (see the project 'General research in stochastic analysis'). Most of the results obtained in these papers are based only on the stationarity property of the increments and therefore seem true in general. The first results confirm our conjectures. The theory of vibrating strings, applied to stationary processes by M.G. Krein, H. Dym and H.P. Mc.Kean, serves us as a guideline.

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

Progress report. Dzhaparidze and Van Zanten started with a draft of a paper on characterization of a fractional Brownian motion as a vibrating string. A fractional Ornstein-Uhlenbeck process will also be studied from a similar point of view.

Societal aspects and knowledge transfer

External contacts

H. Kesten (Cornell Univ.), V. Sidoravicius (IMPA, Rio de Janeiro), J. Kahn (Rutgers Univ.), R. Meester, A. van der Vaart (VU), M.S. Keane (Wesleyan and UvA), B. Nienhuis, W. Kager (Theoretical Physics, UvA), the probability group at EURANDOM/TUE (in particular W.Th.F. den Hollander, F. Redig, R. van der Hofstad), A. van Enter (Groningen, Theoretical Physics), W. Werner (Orsay), S. Shlosman (Marseille), Y. Davidov (Lille), M. Mania (Tbilisi), G. Grimmett (Cambridge), J. Steif, O. Häggström (Gothenburg), B. Tóth, D. Szász (TU Budapest), A. Gandolfi (Milano), M. Aizenman (Princeton), C. Newman (Courant Inst., New York), Y. Peres (Berkely), S. Athreya, G. Slade (Vancouver), E. Valkeila, C. Jost and D. Gasbarra (Helsinki).

Project with partners in public and private sector

- EU-DYNSTOCH

Teaching at university

- Van den Berg teaches one course per academic year (until 2003 at the UvA; since 2003 at the VU), in various subjects.

Courses, tutorials

- Course Mathematical Statistics, UvA: R. Helmers.

Organization of conferences, workshops, courses, meetings

Van den Berg

- Co-organizer (with Bernard Nienhuis, UvA) of a workshop on 'Continuous and discrete random spatial processes', to be held at the Lorentz Centre, Leiden, April 20–29, 2004.
- Organizer of a study/reading group on Stochastic Löwner Evolution at CWI, in which mathematicians and theoretical physicists from several institutes participated.
- Co-organizer (with M.N.M. van Lieshout (PNA4)) of the Spatial Stochastic Seminars at CWI.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Workshop on 'Statistical Mechanics of Polymer Models' May 11–15: (Talk , May 13: High-dimensional graphical networks of self-avoiding walks).
- Dynstoch Meeting, Helsinki, May 22–24: K.O. Dzhaparidze (Talk: Series expansions for the fractional Brownian motion), coauthor H. van Zanten.
- Workshop Randomness in space and time, Budapest, June 23–27: J. van den Berg (Invited talks: Forest fires and self-organized criticality), R.M. Brouwer (Talk: Self-destructive percolation), A. Járai (Talk: The stationary distribution of Abelian sandpile models).

- Conference in Probability theory and Mathematical statistics, Tbilisi, September 21–27: K.O. Dzhaparidze (Invited talk: Reproducing kernel Hilbert space methods in spectral analysis of fractional Brownian motion), coauthor H. van Zanten.
- Mark Kac seminar, Utrecht, November 7: A. Járai (Invited talk: The Abelian sandpile model and the uniform spanning tree).

Working visits

- B. Tóth, Budapest Univ. Technology, February 24–28: A. Járai (Invited talk: The incipient infinite cluster in $d > 6$ dimensions).
- Gordon Slade and Martin Barlow, Univ. British Columbia, Vancouver, May 19–23: A. Járai (Invited talk, May 21: The stationary distribution of Abelian sandpile models).
- Univ. Helsinki, September 29–October 4: K.O. Dzhaparidze.
- Isaac Newton Institute, Cambridge, UK, October 5–25: J. van den Berg (Invited talk: Forest-fires and self-organized criticality).

Other lectures

- Mathematics Colloquium, UL, February 27: J. van den Berg (Invited talk: Percolation and related phenomena).
- Study group on Stochastic Löwner Evolution: Talks by J. van den Berg, January 31, February 21, March 14, June 13; A. Járai, March 28, April 11, November 21, December 12 and F. Merkl, April 25 and September 26; participation by R.M. Brouwer.
- Seminarium Kansrekening en Statistiek, TUD, May 21: J. van den Berg (Invited talk: Stochastic Löwner Evolution and its applications).
- Spatial stochastics seminar, CWI; participation by all PNA3 members; June: R.M. Brouwer (Talk: Self-destructive percolation), October: A. Járai (Talk: The Abelian sandpile model and the uniform spanning tree).
- General Mathematics Colloquium, TUE, November 4: J. van den Berg (Invited talk: Inequalities and random spatial processes).

Courses

- Dutch language course: A. Járai.

Visitors

- E. Valkeila, Univ. Helsinki, December 14–16. Host: K.O. Dzhaparidze.
- C. Jost, Univ. Helsinki, December 15–19. Host: K.O. Dzhaparidze.
- V. Sidoravicius, IMPA (Rio de Janeiro), March 23–April 15. Host: J. van den Berg.

Memberships of committees and other professional activities

J. van den Berg

- Professor at the VU (part-time).
- Co-organizer (with B. Nienhuis) of a workshop on Continuous and Discrete Random Spatial Processes, to be held at the Lorentz Center, Leiden, April 2004.
- Member of the reading committee and thesis committee of D. Znamenski, VU, September 11.
- Organizer of a study/reading group Stochastic Löwner Evolution (with participants from various institutes).

R. Helmers

- Coordinator of the project 'Mathematical Statistics and Applied Probability', which is part of the KNAW cooperation project 'Extended Programme Applied Mathematics 2000-2005'.
- Member of the steering committee Statistical Auditing of the Limperg Institute, The Interuniversity Research Institute for Accountancy in the Netherlands.
- Course Mathematical Statistics at UvA.

P.J.C. Spreij

- Scientist in charge of the Dutch team of the European Research Training Network 'Statistical methods for dynamical stochastic models (DYNSTOCH).

Academic publications

Publications in refereed journals

1. J. van den Berg, A. Járai (2003). The lowest crossing in 2D critical percolation. Ann.Probab. 31, 1241–1253.

2. R. Brouwer (2003). A bicategorical approach to Morita equivalence for von Neumann algebras. Journal of Mathematical Physics 44(5), 2206–2214.
3. K.O. Dzhaparidze, P.J.C. Spreij, E. Valkeila (2003). Information processes for semimartingale experiments. Annals of Probability 31, 216–243.
4. A.J. van Es, P.J.C. Spreij, J.H. van Zanten (2003). Nonparametric Volatility Density Estimation. Bernoulli 9(3), 451–645.
5. R. Helmers, I W. Mangku, R. Zitikis (2003). Consistent estimation of the intensity function of a cyclic Poisson process. Journal of Multivariate Analysis, 84, 19–39.
6. A. Járai (2003). Invasion percolation and the incipient infinite cluster in 2D. Comm.Math.Phys. 236, 311–334.
7. A. Járai (2003). Incipient infinite percolation clusters in 2D. Annals of Probability 31, 444–485.
8. P.J.C. Spreij (2003). On hidden Markov chains and finite stochastic systems. Statistics and Probability Letters 62, 189–201.

Publications in other journals and other scientific output

Unrefereed (electronic) journals

1. R. Helmers, I W. Mangku (2003). On estimating the period of a cyclic Poisson process, IMS Lecture Notes -Monograph Series (42). Marc Moore, Sorana Froda, Christian Leger (eds). Mathematical Statistics and Applications, Festschrift for Constance van Eeden, 345–356.

Conference proceedings

1. R. Helmers, B. Tarigan (2002). Compound sums and their applications in finance. Andonowati & E. van Groesen (eds). Proceedings Institut Teknologi Bandung 34, EPAM General Meeting, July 1–4, 2002, 381–391.

CWI reports

PNA-R0301, PNA-R0302, PNA-R0303, PNA-R0304, PNA-E0304, PNA-R0309, PNA-R0313.
See page 179 for complete titles.

Technical reports published elsewhere

1. Kacha Dzhaparidze, Harry van Zanten (2003). Krein's spectral theory and the Paley-Wiener expansion for fractional Brownian motion. VU report 2003-13.

Book chapters

1. F. Plooij, H.H.C. van de Rijt-Plooij, J.M. van der Stelt, B. van Es, R. Helmers (2003). Illness Peaks During Infancy and Regression Periods. M. Heimann (ed.). Chapter 6 of Regression Periods in Human Infancy, Lawrence Erlbaum Associates, New Jersey, USA, 81–95.
2. F. Plooij, H.H.C. van de Rijt -Plooij, R. Helmers (2003). Multimodal Distribution of SIDS and Regression Periods. M. Heimann (ed.). Chapter 7 of 'Regression Periods in Human Infancy', Lawrence Erlbaum Associates, New Jersey, USA, 97–106.

Professional products

Publications for a broad audience

1. R. Helmers (2003). Review of 'Empirical Processes in M-Estimation' by S. van de Geer. Nieuw Archief voor Wiskunde 5/4(4), 343–344.

Signals and Images – PNA4

Mission

Digital image processing is a multidisciplinary science that borrows principles from diverse fields such as communications theory, optics, surface physics, visual psychophysics, computer science and mathematics. The many applications of image processing include: astronomy, ultrasonic imaging, remote sensing, video communications, industrial inspection, machine vision, medical imaging, and microscopy, among innumerable others. Rapid advances in communications theory and sensor technology and the ever continuing increase of computational power have led to an explosion of visual data. The useful-

ness of such visual resources is largely determined by their accessibility and portability and as such, these data sets present great challenges in terms of coding, transmission, storage, querying, indexing, display and protection. To face such challenges it is not sufficient to develop faster hardware or to design more efficient algorithms. Rather, a deeper understanding of the intrinsic difficulties in visual data representation and analysis is required. This has resulted in a growing demand for sophisticated geometrical and statistical image and signal models, and one of the major goals of the 'Signals and Images' research theme PNA4 is to fall in with these demands. The NWO strategic report *Nieuwe Dimensies, Ruimer Bereik*, published in 2002, explicitly mentions mathematical imaging as one of the challenging research areas in mathematics in the years to come.

Theme leader

Dr.ir. H.J.A.M. Heijmans

MSC or CR classification

42C40, 42A38, 60D05, 60G55, 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 multiresolution 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.

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
Dr.ir. H.J.A.M. Heijmans	1.0	theme leader, leader PNA4.2	indefinite	PNA4.1: EUROPHLUKES; PNA4.2: MASCOT, MRIAS, WA, Watermarking for Multimedia, AMM
Dr.ir. M.J. Huiskes	1.0	researcher	2001-08-01 till 2006-03-01	PNA4.1: FOUNDIT, CBIR, EUROPHLUKES
Drs. L. Kamstra	0.85	PhD student	1999-10-01 till 2004-01-15	PNA4.2: Wavelets and their applications
Dr. M.N.M. van Lieshout	0.8	researcher, leader PNA4.3	indefinite	PNA4.3: See page 46
Dr. E.J.E.M. Pauwels	0.85	researcher, leader PNA4.1	indefinite	PNA4.1: CBIR, FOUNDIT, EUROPHLUKES

G. Piella Fenoy	1.0	PhD student	1999-08-01 till 2003-08-01	PNA4.2: MRIAS
Dr. E.B. Ranguelova	1.0	researcher	2003-01-01 till 2004-09-01	PNA4.1: EUROPHLUKES; PNA4.2: MRIAS
Dr. B.A.M. Schouten	0.4	researcher	2003-05-01 till 2004-05-01	PNA4.1: BIOVISION
A.G. Steenbeek	0.4	programmer	indefinite	PNA4.1; PNA4.2; PNA4.3: Inference for random sets
Dr. P.M. de Zeeuw	0.95	programmer	indefinite	PNA4.1; PNA4.2
Y.-W. Zhan, MSc	1.0	researcher	2001-11-01 till 2003-11-01	PNA4.2: MASCOT, AMM

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. G.C.K. Abhayaratne	1.0	ERCIM Fellow	2002-06-01 till 2003-03-01	PNA4.2: MASCOT
Drs. R. Huele (CML)	p.m.	researcher	p.m.	PNA4.1: EUROPHLUKES
Prof.dr. A.W.M. Smeulders (UvA)	0.2	advisor	till 2003-07-01	PNA4.1, PNA4.2, PNA4.3

Scientific report

Highlights

- Acquisition of FP6 Network of Excellence MUSCLE.
- Acquisition of STW grant Markov sequential point processes for image analysis and statistical physics.
- Completion of EU project MASCOT.
- Completion of EU project FOUNDIT.
- BIOVISION: founding of the European Biometrics Forum, July 2003.
- Completion of PhD theses by G. Piella Fenoy and E.B. Ranguelova.
- Successful EUROPHLUKES test meeting.

PhD students

L. Kamstra
G. Piella Fenoy

PNA4.1 – Image Understanding, Retrieval, and Indexing

The ubiquity and rapid growth of digital multimedia databases has spawned a number of challenging problems regarding the indexing, storage and retrieval of information. These problems are particularly acute for image databases as there is no general set of canonical features that adequately captures the variety and wealth of visual information. In fact, an efficient strategy will often be task-dependent and therefore necessitates its own specific focus, as will transpire from the short overview reported below.

Title	CBIR – Content-Based Image Retrieval
Period	April 1999–July 2004
Leader	E.J.E.M. Pauwels
Staff	M.J. Huiskes
Funding	CWI (basic funding)
Partner	Hogeschool Limburg, Belgium

Progress report. This project focuses on generic methodologies for content-based image retrieval (CBIR) and covers topics such as saliency detection, feature extraction and feature selection, relevance feedback and machine learning applied to image analysis. As such it provides the theoretical underpinning for the more applied projects that are part of the PNA4.1. portfolio. Particular attention has been paid to various aspects of robustness of, and statistical confidence in, feature extraction. This is of paramount importance as the subsequent image retrieval step heavily depends on the mathematical features that are automatically tagged to each image. As a consequence, there is a clear need for cross-validation and feedback between various kinds of feature extractors. The methodology used draws heavily on statistical learning and pattern recognition techniques.

Title	FOUNDIT – Feedback-Operated User Interface for Design and Image Retrieval
Period	September 2001–August 2003
Leader	E.J.E.M. Pauwels
Staff	M.J. Huiskes
Funding	EU (project funding)

Partners	Univ. Gent, Sophis Systems N.V., Pianezza Paolo SNC

Progress report. The goal of this CBIR-related research project was to develop a specialized search engine for decoration designs. In its present implementation the search engine comprises two main modules: (i) a feature extractor that automatically computes the numerical features used to characterize images, and (ii) a search engine that learns from observing examples and counter-examples supplied by the user. The actual learning is achieved by gradually refining a probabilistic model that predicts the relevance of each image in terms of its features. By comparing these predictions to the positive and negative feedback obtained from the user, the model parameters can be tuned, resulting in an enhanced performance. This work was carried out within the framework of the EC-project FOUNDIT and the main effort was focused on robust and perceptually relevant feature extraction and model-based relevance prediction. As an example of the former, we implemented various independent segmentation modules that could compare their outputs in order to assign an internal confidence measure to each result. Our work on relevance prediction used various classification techniques, in particular logistic regression models and radial basis functions.

This project was concluded and the results presented and approved at the final review meeting in Luxembourg in October 2003.

Title	EUROPHLUKES
Period	December 2001–October 2004
Leader	E.J.E.M. Pauwels
Staff	H.J.A.M. Heijmans, M.J. Huiskes, E.B. Rangueleva, A.G. Steenbeek
Funding	EU (project funding)
Partners	CML (UL), MARIS B.V., Sea Watch Foundation, Alnitak, CIRCé, ESPARTE, CEMMA, Museu de Baleia, IMAR, Tethys, Univ. College Cork, Wild Idea, Ecologic, Greenland Inst. of Natural Resources, Oceanopolis, GREC, Projecto Delfim, Whale Watch Azores

Progress report. The contribution of the PNA4.1 research group to EUROPHLUKES concerns three main aspects of image indexing, retrieval and management.

- *Feature Extraction*. A semi-automatic system for feature extraction in a collection of images of sperm whales, humpback whales and dolphins has been developed. For sperm whales the fluke contour is extracted from the image as a pixel string (sequence of image coordinates). For dolphins the contour of the dorsal fin is represented via splines. And for humpbacks pigmentation patches are obtained using supervised segmentation. These features and their geometric characteristics are then stored in a database, and are used by the matching system to find matching individuals on different images.
- *Matching*. The data base created by the Feature Extraction system is searched in order to find all images of the same individual. This is done by computing similarity coefficients between extracted features and compiling a short-list of the most likely matches.
- *Digital Watermarking*. An invisible digital watermark is embedded within an image. This allows image verification and authentication. The key is extracted from the original (source) image. The watermarked image is made public, the source image is kept private. The watermark allows the owner of the original image to proof that the public image originated from the source image.

PNA4.2 – Image Representation and Analysis

Title	MASCOT – Metadata for Advanced Scalable Video Coding Tools
Period	May 2001–April 2003
Leader	H.J.A.M. Heijmans
Staff	G.C.K. Abhayaratne, Y.-W. Zhan
Funding	EU (project funding)
Partners	ENSMP-CMM, ARMINES-CMM, HHI, PUT, LEP, GET-ENST, UPC, VUB

Progress report. MASCOT was a European project in the FET-Open Programme coordinated by Heijmans in which eight European partners collaborated. The goal of MASCOT was to improve the quality and efficiency of video coding systems by exploiting metadata information. Furthermore, it aimed towards the design of an intrinsically scalable video coding scheme providing fully progressive bitstreams by exploiting novel morphological and adap-

tive wavelet decomposition methods, and by the development and optimization of advanced and dedicated prediction schemes. The collaboration with B. Pesquet-Popescu from ENST in Paris was continued. This collaboration concerns, on the one hand, the development of adaptive lifting schemes (see description below), and on the other the investigation of temporal lifting schemes using motion compensation to be used for 3D wavelet coding.

MASCOT was finished on April 30, 2003, with a public demonstration at the Picture Coding Symposium in Saint Malo, France.

Title	BIOVISION
Period	May 2002–April 2003
Leader	B.A.M. Schouten
Funding	EU (project funding)
Partners	A. Albrecht (TTT); M. Behrens (UGF); T. Mansfield (NPL); W. McMeechan (Nationwide); M. Rejman-Greene (Editor, BT); M. Savastano (IBB); P. Statham (CESG); C. Schmidt (TTT); M. Walsh (Daon)

Progress report. The BIOVISION project aims to contribute to a secure, user-friendly, socially acceptable and ethical use of biometrics in Europe. It prepares the grounds for future RTD activities by investigating the likely commercial application of biometrics over the forthcoming 10 years and identifying research challenges, among them technological challenges like improvements in performance and reliability, robustness and scalability are addressed. Focus is placed on how technology can assist in eliminating hindering factors within regulatory, medical and the user perception framework.

The project has been finished with the completion of the roadmap 'Roadmap for Biometrics in Europe till 2010'. This roadmap is also published as CWI report, PNA-E0303. As a result of this project, the European Biometrics Forum was founded in July 2003.

Title	NWO project Wavelet Analysis and Applications
Period	October 1999–September 2003
Leader	H.J.A.M. Heijmans
Staff	L. Kamstra
Funding	NWO
Partners	J.B.T.M. Roerdink (RUG), C.R. Traas (UT), H.G. ter Morsche (TUE)

Progress report. The research of Kamstra initially concerned the investigation of multiresolution decompositions of signals with function values in a finite set that is not necessarily a ring. He has defined a discrete wavelet transform on such finite valued signals and investigated properties of these transforms. His results make it possible to give explicit examples of linear and nonlinear discrete wavelet transforms of binary signals without using the so-called lifting scheme.

In addition, Kamstra developed the composition scheme, a method to construct wavelet transforms with a large support from wavelet transforms with smaller supports. This scheme can also be used to build nonlinear wavelet transforms. Kamstra investigated the capabilities of a large number of linear and nonlinear binary wavelet transforms with respect to binary image compression. It turned out that, in most cases, nonlinear transforms perform significantly better.

Kamstra also made a substantial contribution to the theory of linear binary wavelet transforms. Since linear transforms are more structured and less complicated than nonlinear transform, they are a good starting point to translate useful concepts, like vanishing moments, from the continuous domain to the discrete domain.

The research project was concluded by a collaboration of Heijmans and Kamstra in which they investigated reversible data embedding into images. Reversible data embedding is a fragile watermarking technique that allows one to embed relatively large amounts of information directly into an image in such a way that the original image can be recovered from the watermarked image. Heijmans and Kamstra proposed two new embedding techniques that utilize wavelet techniques. The new techniques were tested on example images and their performance compared favourably to the performance of existing methods.

Title	STW project Multiresolution image analysis and synthesis
Period	October 1999–September 2003
Leader	H.J.A.M. Heijmans
Staff	G. Piella Fenoy, P.M. de Zeeuw
Funding	STW
Partners	TNO-TM, NLR, Thales, RUG

Progress report. In 2003, the work in this project comprised three major ingredients: (i) the design of adaptive lifting schemes for the construction of nonlinear wavelets, (ii) the investigation of multiresolution tools for image fusion, and (iii) the investigation of different region-based and boundary-based methods for image segmentation of 2-D and 3-D image data.

The work on adaptive wavelets has appeared in various journal and conference publications. Piella Fenoy and Heijmans, in collaboration with Pesquet-Popescu (ENST, Paris) have continued their work on issues of quantization and integer-to-integer adaptive lifting schemes and their application in lossy and lossless image and video compression.

The work on image fusion concerned the design and implementation of new region-based multiresolution fusion algorithms. Piella Fenoy and Heijmans have introduced and investigated a new quality measure for image fusion and shown that this measure is consistent with subjective tests. Furthermore, they have started exploring families of multiresolution-based image distance measures.

One of the research directions has been the development of robust methods for difference estimation for synthetic and real images as a continuation of Ranguelova's PhD thesis on 3-D texture segmentation. Two methods have been developed for difference estimation and compensation in 3-D textural imagery which resulted in enhanced segmentation results. The results have been reported in a conference paper. The other research direction has been the application of active contour models (snakes) for boundary extraction.

The work of Piella Fenoy resulted in a PhD thesis which was defended at the UvA on October 30. Currently, the work on adaptive wavelets is being extended by investigating multiple decision criteria.

De Zeeuw investigated the options for integration of numerical methods for the solution of partial differential equations with methods for image fusion. P.J. Oonincx (Royal Netherlands Naval College) and De Zeeuw finalized a paper for the Pattern Recognition journal.

Title	Watermarking for Multimedia
Period	January 2002–p.m.
Leader	H.J.A.M. Heijmans
Staff	L. Kamstra
Funding	CWI (basic funding)
Partner	Philips

Progress report. The ever increasing importance of digital media creates an urgent need for methods that can guarantee protection of copyright ownership. Existing cryptographic systems are only of limited use here; once the data is decrypted it can easily be reproduced without any quality loss. Digital watermarking technology is complementary to cryptography and one of its most important applications is copyright protection. The basic underlying idea is to embed an invisible but robust identification code into the data (e.g., an image). The purpose of this project is to develop new mathematical algorithms in the field of information hiding, watermarking and steganography.

Kamstra (see also description NWO project) and Heijmans have developed some new algorithms for irreversible data hiding into images. Preliminary experiments show that these algorithms outperform existing algorithms in this area. A first paper is in preparation.

Title	Internships from IIT
Period	indefinite
Leader	H.J.A.M. Heijmans
Staff	G. Piella Fenoy, P.M. de Zeeuw, A. Kumar
Funding	CWI (basic funding)
Partner	Indian Institute of Technology, New Delhi

Progress report. The Matlab Image Fusion Toolbox (MATIFUS) has been extended with many facilities for preprocessing and visualization. Documentation is in progress, as well as a documented website.

A prototype of the Matlab fusion toolbox (MATIFUS) is up and running. The toolbox has been furnished with six multiresolution schemes. Kumar (internship from IIT) extended the Matlab image fusion toolbox MATIFUS with a user-friendly and versatile graphical user interface.

Title	Axiomatics of Mathematical Morphology
Period	indefinite
Leader	H.J.A.M. Heijmans
Staff	P.M. de Zeeuw, Y.-W. Zhan
Funding	CWI (basic funding)
Partners	The Johns Hopkins Univ., CSIRO (Sydney), UvA, Univ. Louis Pasteur Strassbourg, Ecole Nationale des Mines de Paris, Hewlett Packard Laboratories (Haifa)

Progress report. This research is concerned with various theoretical and applied aspects of mathematical morphology. During Heijmans' sabbatical at CSIRO in Sydney the work in this project has been taken up again. In collaboration with Buckley and Talbot (both CSIRO) he is exploring a new family of morphological filters based on paths in graphs. Furthermore, Heijmans has started new research on self-dual morphology which should extend and generalize earlier work with Keshet (HP, Haifa).

PNA4.3 – Stochastic Geometry

Title	Shot noise weighted point processes
Period	April–July 2002, July 2003
Leader	M.N.M. van Lieshout
Staff	P. Gregori Huerta
Funding	Univ. Jaume I, Spain
Partner	J. Mateu

Progress report. Dr. Gregori revisited CWI in July to work on generalizations of shot noise weighted and area interaction point processes. The work resulted in two papers, on Modelling generalized area-interaction point processes and on Mixture formulae for shot noise weighted point processes. The first paper concerns statistical inference, the second one explores relationships to multitype pairwise interaction processes.

Title	Marked point processes
Period	indefinite
Leader	M.N.M. van Lieshout
Funding	CWI (basic funding)

Progress report. Van Lieshout and R.S. Stoica (now at Univ. Jaume I, Spain) finished their work on perfect simulation for marked point processes.

A new topic of research is the development of summary statistics as tools in the exploration of marked point pattern data. Attention focuses on generalizations of the J-statistic for classic point processes. The main idea is to compare the distance to the nearest point of the pattern within a certain range from a typical marked point to that from the origin. We prove mixture and representation theorems, give conditions for the existence of densities and hazard rates, study the behaviour under random label allocation, the relationship with the n-point correlation functions and the reduced second moment measure, and work on explicit expressions for various classes of marked point process models.

Societal aspects and knowledge transfer

Projects with partners in public and private sector

- MASCOT; see page 43.
- EUROPHLUKES; see page 43.
- FOUNDIT; see page 43.
- BIOVISION; see page 44.
- STW project; see page 115.
- CBIR; see page 42.
- University Jaume I; see page 46.

Courses, tutorials

- Course 'Economische Sectoren en Technologie' at Katholieke Univ. Brussel (Belgium): E.J.E.M. Pauwels.
- Tutor in digital design, European media Emma, Utrecht School of Art and Technology (USAT): 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): M.N.M. van Lieshout in collaboration with A. Schrijver (cluster leader).
- Co-organizer session Mathematical Statistics, VVS Statistische Dag, UvA, April 15: M.N.M. van Lieshout.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Second Workshop of BioVision, Rome, January 22–23: B.A.M. Schouten (Talk: Research agenda for biometrics in Europe).
- Annual meeting section Mathematical Statistics VVS (Vereniging voor Statistiek en Operationele Research), CWI, January 24: M.N.M. van Lieshout.
- Workshop Multimedia Information Retrieval in Business Applications, Darmstadt, Germany, January 30–31: M.J. Huiskes.
- Fourth European Workshop on Image Analysis for Multimedia Interactive Services (WIAMIS), London, UK, April 9–11: M.J. Huiskes (Invited lecture: FOUNDIT: Searching for decoration designs in digital catalogues).
- VVS Statistische Dag, UvA, April 15: M.N.M. van Lieshout.
- Picture Coding Symposium, Saint Malo, France, April 23–25: H.J.A.M. Heijmans (Public demonstration of MASCOT project).
- Image quality workshop, Philips, Eindhoven, April 23: G. Piella Fenoy.
- NWO conference, UT, May 1: G. Piella Fenoy (Talk: Adaptive wavelet transforms based on seminorms).
- Audio- and Video-Based Biometric Person Authentication (AVBPA), Guildford, UK, June 9–11: B.A.M. Schouten.
- World Textile Conference (Third AUTEX Conference), Gdansk, Poland, June 25–27: M.J. Huiskes (Talk: Metadata for decorative designs: application of MPEG-7 in automatic design interpretation; Poster: Figure-ground segmentation for decorative designs in the textile industry).
- IMACS Computational Engineering in Systems Applications multiconference (CESA), Lille, France, July 9–11: M.J. Huiskes (Talk: Searching and browsing databases of digital decoration designs).
- Foundation of the European Biometrics Forum, Dublin, July 19: B.A.M. Schouten (Keynote lecture: The future of biometrics in Europe).
- SPIE's 48th Annual Meeting 2003, San Diego, USA, August 4–8: G. Piella Fenoy (Poster: Adaptive integer to integer wavelet transforms using update lifting).
- Summerschool on Cognitive Vision, Bonn, Germany, August 25–29: M.J. Huiskes.
- Advanced Concepts for Intelligent Vision Systems, Ghent, Belgium, September 3–5: G. Piella Fenoy (Invited lecture: Multiresolution image fusion guided by a multimodal segmentation).
- ICT Kenniscongres, Den Haag, September 4–5: M.J. Huiskes, E.J.E.M. Pauwels (Demonstration of FOUNDIT project; Invited talk: Eerste ervaringen met Networks of Excellence in KP6).
- ICIP, Barcelona, Spain, September 14–17: L. Kamstra (Poster: The design of linear binary wavelet transforms and their application to binary image compression); G. Piella Fenoy (Talk: A new objective quality measure for image fusion and poster: Quantization of 2D adaptive wavelet decompositions).
- Third International Symposium on Image and Signal Processing and Analysis, Rome, September 18–20: M.J. Huiskes (Talk: Segmentation by color coalition labeling for figure-ground segregation in decoration designs), E.B. Ranguelova (Talk: 3-D methods for difference estimation in volumetric data), Y.-W. Zhan (Talk: On the lifting construction of a class of non-separable 2D orthonormal wavelets).
- CWI in Bedrijf, CWI, October 17: A.G. Steenbeek (demonstration of EUROPHLUKES), P.M. de Zeeuw (demonstration of MATIFUS).
- Bijeenkomst Stochastici, Lunteren, November 17–19: M.N.M. van Lieshout.
- Digital Image Computing - Techniques and Applications, Sydney, December 10–12: H.J.A.M. Heijmans (Invited plenary lecture: Data hiding for image security).

Working visits

- Biovision, London, March 27–28 and May 25–26: B.A.M. Schouten.
- Philips Research, Eindhoven, June 13: M.N.M. van Lieshout (Invited lecture in Wiskunde Colloquium: Locally scaled Markov point processes).
- Pianezza Testing for FOUNDIT project, Azzio, Italy, June 8–17: M.J. Huiskes, E.J.E.M. Pauwels.

- CSIRO Sydney, Sabbatical, August 1, 2003 till March 31, 2004: H.J.A.M. Heijmans.
- Department of Computer Systems, Univ. Technology, Sydney, November 27: H.J.A.M. Heijmans.

Project meetings

- MASCOT 6th Progress Meeting, CWI, January 15–17: G.C.K. Abhayaratne, H.J.A.M. Heijmans and Y.-W. Zhan.
- MASCOT Software integration meeting, CWI, January 16: G.C.K. Abhayaratne.
- IResearch project NWO, Den Haag, January 20: M.N.M. van Lieshout.
- MRIAS 6th meeting users' committee, CWI, January 23: H.J.A.M. Heijmans, G. Piella Fenoy, E.B. Ranguelova, P.M. de Zeeuw.
- FOUNDIT Technical Meeting, Sophis, Wevelgem, Belgium, February 24: M.J. Huiskes and E.J.E.M. Pauwels.
- BioSecure first consortium meeting, Paris, France, February 27–28: B.A.M. Schouten.
- NEMSIP meeting, Bordeaux, France, March 17–18: M.J. Huiskes.
- MASCOT 7th Progress Meeting, PUT Poznan, April 3–4: H.J.A.M. Heijmans, Y.-W. Zhan.
- MultimediaN, Project 6 introduction meeting, UvA, April 4: M.J. Huiskes.
- MASCOT Final Review, Saint Malo, France, April 25: H.J.A.M. Heijmans.
- MRIAS 7th meeting users' committee, CWI, July 2: H.J.A.M. Heijmans, G. Piella Fenoy, E.B. Ranguelova, P.M. de Zeeuw.
- FOUNDIT final review meeting, Luxembourg, October 22: M.J. Huiskes and E.J.E.M. Pauwels.
- EUROPHLUKES test meeting, Leiden, November 12–14: M.J. Huiskes, E.J.E.M. Pauwels, E.B. Ranguelova, A.G. Steenbeek.
- BASIS first consortium meeting, November 18: B.A.M. Schouten.

Other lectures

- PNA Colloquium, CWI, February 28: E.B. Ranguelova (Segmentation of textured volumetric images).
- Colloquium Informatica RUG, March 24: H.J.A.M. Heijmans (Nonlinear wavelets and their applications in image processing).
- Spatial Stochastics Seminar, CWI, May 13: M.N.M. van Lieshout (Non-parametric estimation in generalized Widom-Rowlinson models).
- Signals and Images Seminar, CWI, June 11: Y.-W. Zhan (A kind of biorthogonal nonseparable wavelets); G. Piella Fenoy (Multiresolution image fusion: from pixels to regions).
- KTWeb meeting Brussels, July 10: E.J.E.M. Pauwels.
- CSIRO/CMIS Seminar, Sydney, September 5: H.J.A.M. Heijmans (Self-dual morphology).
- CSIRO/CMIS Seminar, Sydney, September 15: H.J.A.M. Heijmans (Nonlinear and adaptive Wavelets).
- UvA Numerica Seminar, October 6: G. Piella Fenoy (Adaptive wavelet decompositions by update lifting).
- CWI in Bedrijf, CWI, October 17: M.J. Huiskes (Image Retrieval - Keeping ourselves in the loop).
- PNA Colloquium, CWI, October 28: Y.-W. Zhan (Spatio-temporal wavelet transformations in motion sequence compression). Signals and Images Seminar, CWI, November 5: L. Kamstra (Lossless data embedding into images).
- Nederlands Biometrie Forum, November 19: B.A.M. Schouten (The European biometrics forum).

Courses

- Dutch language course CWI: E.B. Ranguelova.

Visitors

- C. Varekampi, Philips Natlab, January 21. Host: H.J.A.M. Heijmans.
- T. Kalkeri, Philips Natlab and TUE, February 5. Host: H.J.A.M. Heijmans.
- R.S. Stoica, Univ. Jaume I, Spain, February 17–18. Host: M.N.M. van Lieshout.
- W. Kruijer, WUR, March 17. Host: M.N.M. van Lieshout.
- P. Gregori Huerta, Univ. Jaume I, Spain, July 1–30. Host: M.N.M. van Lieshout.
- L.S. Mihaylova, Univ. Gent, Belgium, August 14. Host: M.N.M. van Lieshout.
- V.V. Shcherbakov, Univ. Glasgow, UK, August 19–21. Host: M.N.M. van Lieshout. Talk in Signals and Images seminar: see below.
- S. Harding, Springer Verlag London, UK, November 13. Host: M.N.M. van Lieshout.

External speakers for the Signals and Images seminar

- Paul Scheunders, Univ. Antwerp, 'Wavelet Representations of Multivalued Images', Vision Lab, Department of Physics, January 22.
- Ton Kalker, Philips Research and TUE, 'Reversible Data-Hiding Techniques and Limits', February 10.
- Alexei Koloidenko, EURANDOM, 'Robust Acoustic Object Detection', February 19.
- Leo Dorst, 'An Algebraic Approach to Programming Geometry', UvA, March 5.
- Michael van Ginkel, 'Image Analysis using Orientation Space', Pattern recognition group, Department of Applied Physics, TUD, March 19.
- Vincent Schut, 'Using wavelets for image fusion of Ikonos' spectral low-res and panchromatic high-res images', SarVision BV, March 28.
- Maarten Jansen, 'Edge-adaptive multiscale triangulations in 2-d dataanalysis', Faculty of Mathematics and Computer Science, TUE, June 25.
- Vadim Scherbakov, 'Coverage of the whole space and related topics', Department of Statistics, Univ. Glasgow, Augustus 20.
- Joost Batenburg, 'Discrete Tomography', Mathematical Institute, UL, October 27.
- Nicolai Petkov, 'Non-classical receptive field inhibition and contour detection', Institute of Mathematics and Computing Science, RUG, November 27.
- Michael Egmont-Petersen, Institute of Information and Computing Sciences, UU, 'Image processing with neural networks – an overview' December 16.

Memberships of committees and other professional activities

G.C.K. Abhayaratne

- Session chair: Wavelets and multirate filtering session at the Third International Symposium on Image and Signal Processing and Analysis (ISPA) 2003, Rome, Italy, September 18–20.
- Reviewer for IEEE Trans. on Image Processing, IEEE Signal Processing Letters, SPIE Journal on Optical Engineering.
- Member IEEE, SPIE.

H.J.A.M. Heijmans

- Member of editorial board Journal of Mathematical Imaging and Vision.
- Coordination of EU project MASCOT (Metadata for Advanced Scalable Video Coding Tools, finished on April 30).
- Coordinator of MASCOT project (EU 5th FP, May 2001–April 2003).
- Coordinator of large NWO projects Wavelets and their Applications; partners: CWI, RUG, TUE, UT.
- Member of technical committee of IEEE Conference on Image Processing, (ICIP 2003), Barcelona.
- Member of technical committee of 3rd International Symposium on Image and Signal Processing and Analysis, Rome, Italy, September 18–20, 2003.
- Co-advisor Gemma Piella, UvA, October 30.
- Senior member of IEEE.
- Supervision of trainees from IIT New Delhi: (in cooperation with P.M. de Zeeuw).
- Referee for various journals.

M.J. Huiskes

- Reviewer Second International Conference CIVR2003, Urbana-Champaign, IL, USA.

M.N.M. van Lieshout

- Secretary/treasurer of the VVS (Vereniging Voor Statistiek en Operationele Research).
- Member steering committee Statistical Information and Modelling, EURANDOM.
- Member ERCIM Vital Statistics Taskforce.
- Member klankbordgroep IResearch project NWO.
- Member werkgroup Digitaal Archief CWI.
- External examiner of PhD thesis 'Summary statistics in point patterns and their applications' by Jianbao Chen, Curtin Univ. Technology, Perth, Australia, February 2003.
- Referee for a range of journals.
- Member of RSS, Bernoulli Society, NVPHBV, Koninklijk Wiskundig Genootschap, VVS.

E.J.E.M. Pauwels

- Coordination of EU projects FOUNDIT and MUSCLE.
- Reviewer for the International Conference on Image and Video Retrieval CIVR2003

(Urbana-Champaign, USA).

- Reviewer for IEEE Transactions on Pattern Analysis and Machine Intelligence.
- Reviewer for 4th International Conference, Scale-Space 2003.
- Member PhD committee Jerome Fournier (ENSEA, France): Indexation d'images par le contenu et recherche interactive dans les bases generalistes.
- Chairperson of the ERCIM Working Group on Image and Video Understanding.
- Guest editor ERCIM News 55: Special issue on Machine Perception (October 2003).

G. Piella Fenoy

- Member IEEE.
- Member and peer reviewer MERLOT (Multimedia Educational Resource for Learning and Online Teaching).

E.B. Ranguelova

- Member IEEE.

B.A.M. Schouten

- Member Dutch Biometrics Forum. Director of the special interest group on Research and Development.
- Member European Biometrics Forum. Director of the special interest group on Research and Development.
- Evaluator for European Committee. Evaluation of proposals, 6th framework Information Society Technologies.
- Imagine IC. Director Imagine IC. Imagine IC is a centre for the visual representation of identity and cultures in the Netherlands.
- Cinekid. Member of the Jury, 'Kids and Tools'. CineKid Festival for on-line media-education in Arts.
- Coordination of EU project to establish European Biometric Forum.

P.M. de Zeeuw

- Referee of papers for scientific journals.

Y.-W. Zhan

- Member IEEE Signal Processing Society.

Academic publications

Publications in refereed journals

1. U. Hahn, E.B.V. Jensen, M.N.M. van Lieshout, L.S. Nielsen (2003). Inhomogeneous spatial point processes by location-dependent scaling. Advances in Applied Probability (SGSA) 35, 319–336.
2. R. Keshet, H.J.A.M. Heijmans (2003). Adjunctions in pyramids, curve evolution and scale-spaces. International Journal on Computer Vision 52, 139–151.
3. M.N.M. van Lieshout, R.S. Stoica (2003). The Candy model: properties and inference. Statistica Neerlandica 57, 177–206.
4. M.N.M. van Lieshout, E.W. van Zwet (2003). Correction. Exact sampling from conditional Boolean models with applications to maximum likelihood inference. Advances in Applied Probability (SGSA) 35, 362.
5. P.J. Oonincx, P.M. de Zeeuw (2003). Adaptive lifting for shape-based image retrieval. Pattern Recognition 36, 2663–2672.
6. G. Piella (2003). A general framework for multiresolution image fusion: from pixels to regions. Information Fusion, December, 259–280.

Publications in other journals and other scientific output

Unrefereed (electronic) journals

1. P.M. de Zeeuw (2003). Review of 'Ripples in mathematics: the discrete wavelet transform' by A. Jensen and A. la Cour-Harbo. Nieuw Archief voor Wiskunde, 5/4(2), 185–186.

Conference proceedings

1. G.C.K. Abhayaratne (2003). N-point discrete cosine transforms that map integers to integers for lossless image/video coding. Proceedings Picture Coding Symposium (PCS) 2003, St. Malo, France, April 23–25, 417–422.
2. G.C.K. Abhayaratne (2003). Spatially adaptive integer lifting with no side information for lossless video coding. Proceedings Picture Coding Symposium (PCS) 2003, St. Malo, France, April 23–25, 495–500.

3. G.C.K. Abhayaratne (2003). Discrete wavelet transforms with an adaptive low pass filter. Seventh International Symposium on Signal Processing and its Applications (ISSPA) 2003, Paris, France, July 1–4, II, 487–490.
4. G.C.K. Abhayaratne (2003). Orthonormal integer block transforms for lossless coding: design and performance analysis. Visual Communication and Image Processing (VCIP) 2003, Lugano, Switzerland, July 8–11, Proceedings SPIE 5150, 1719–1729.
5. G.C.K. Abhayaratne (2003). Modifying integer wavelet transforms for scalable near-lossless image coding. Visual Communication and Image Processing (VCIP) 2003, Lugano, Switzerland, July 8–11, Proceedings SPIE 5150, 1697–1708.
6. G.C.K. Abhayaratne (2003). Spatially adaptive wavelet transforms: An optimal interpolation approach. Third International Workshop on Spectral Methods and Multirate Signal Processing (SMMSP) 2003, Barcelona, Spain, September 12–13, 155–162.
7. G.C.K. Abhayaratne, H.J.A.M. Heijmans (2003). A novel morphological subband decomposition scheme for 2D+t wavelet video coding. Third International Symposium on Image and Signal Processing and Analysis (ISPA) 2003, Rome, Italy, September 18–20, 1, 239–244.
8. G.C.K. Abhayaratne, G. Piella Fenoy, B. Pesquet-Popescu, H.J.A.M. Heijmans (2003). Adaptive integer to integer wavelet transforms using update lifting. Wavelets: Applications in Signal and Image Processing X, International Symposium on Optical Science and Technology, SPIE's 48th Annual Meeting 2003, San Diego, CA, August 4–8, Proceedings SPIE, 5207, 813–824.
9. G. Frederix, E.J. Pauwels (2003). A statistically principled approach to clustering of one-dimensional data with applications to segmentation. Proceedings of ACIVS 2003, Advanced Concepts for Intelligent Vision Systems, Ghent, Belgium, September 2–5, 9–15.
10. P. Gregori, M.N.M. van Lieshout, J. Mateu (2003). Modelización de procesos area-interacción generalizados (in Spanish). Proceedings 27 Congreso Nacional de Estadística e Investigación Operativa, Lleida (Catalunya), Spain, April 8–11, 11 pages.
11. H.J.A.M. Heijmans, L. Kamstra (2003). Reversible data embedding based on the Haar wavelet decomposition. C. Sun, H. Talbot, S. Ourselin, T. Adriaansen (eds). Proceedings VIIth Digital Image Computing: Techniques and Applications, Sydney, Australia, December, 5–14.
12. M.J. Huiskes, E.J. Pauwels (2003). Segmentation by color coalition labeling for figure-ground segregation in decoration designs. Proceedings of the Third International Symposium on Image and Signal Processing and Analysis (ISPA), Rome, Italy, 84–90.
13. M.J. Huiskes, E.J. Pauwels (2003). Metadata for decorative designs: application of MPEG-7 in automatic design interpretation. Proceedings of the World Textile Conference (Third AUTEX Conference), Gdansk, Poland, Book I, 502–506.
14. M.J. Huiskes, E.J. Pauwels (2003). Figure-ground segmentation for decorative designs in the textile industry. Proceedings of the World Textile Conference (Third AUTEX Conference), Gdansk, Poland, Book II, 150-153.
15. L. Kamstra (2003). The design of linear binary wavelet transforms and their application to binary image compression. Proceedings of ICIP, Barcelona, Spain, September, III, 241–244.
16. E.J. Pauwels, M.J. Huiskes, K. Noonan, P. Bernard, P. Vandenborre, P. Pianezza, M. de Maddalena (2003). FOUNDIT: Searching for decoration designs in digital catalogues. Proceedings of the Fourth European Workshop on Image Analysis for Multimedia Interactive Services (WIAMIS), London, UK, 4 pages.
17. E.J. Pauwels, M.J. Huiskes (2003). Searching and browsing databases of digital decoration designs. Proceedings of IMACS Computational Engineering in Systems Applications multiconference (CESA), Lille, France, 5 pages.
18. B. Pesquet-Popescu, H.J.A.M. Heijmans, G.C.K. Abhayaratne, G. Piella (2003). Quantization of 2D adaptive wavelet decompositions. IEEE International Conference on Image Processing (ICIP),

Barcelona, Spain, September 14–17, III, 209–212.

19. G. Piella Fenoy, H.J.A.M. Heijmans (2003). A new objective quality measure for image fusion. International Conference on Image Processing, Barcelona, Spain, September.
20. M. Nachtegael, H.J.A.M. Heijmans, D. van der Weken, E.E. Kerre (2003). Fuzzy adjunctions in mathematical morphology. Proceedings JCIS.
21. G. Piella Fenoy, H.J.A.M. Heijmans (2003). Multiresolution image fusion guided by a multimodal segmentation. Advanced Concepts for Intelligent Vision Systems, Ghent, Belgium, September.
22. E.B. Ranguelova, A. Quinn (2003). 3-D Methods for difference estimation in volumetric data. Proceedings of the 3rd International Symposium on Image and Signal Processing and Analysis (ISPA03), Rome, Italy, September 18–20, 29–35.
23. C. Tillier, B. Pesquet-Popescu, Y.-W. Zhan, H.J.A.M. Heijmans (2003). Scalable video compression with temporal lifting using 5/3-like filters. Proceedings of Picture Coding Symposium 2003, Saint-Malo, France, April 23–25.
24. Y.-W. Zhan, H.J.A.M. Heijmans (2003). On the lifting construction of a class of non-separable 2D orthonormal wavelets. S. Loncaric, A. Neri, H. Babic (eds). Proceedings 3rd International Symposium on Image and Signal Processing and Analysis, Rome, Italy, September 18–20, 476–481.

CWI reports

PNA-R0301, PNA-R0306, PNA-R0307, PNA-R0310, PNA-E0303, PNA-E0304.
See page 179 for complete titles.

Software developed

- M.J. Huiskes, E.J.E.M. Pauwels. FOUNDIT image retrieval prototype and image understanding toolbox (in progress).
- M.N.M. van Lieshout, A.G. Steenbeek, P. Gregori, R.S. Stoica, K.K. Berthelsen. MPPLIB: a C++ library for marked point patterns (with manual).
- G. Piella Fenoy, P.M. de Zeeuw, H.J.A.M. Heijmans. MATIFUS: a Matlab fusion toolbox.
- E.B. Ranguelova, M.J. Huiskes, E.J.E.M. Pauwels. Europhlukes PhlukePhinder (with manual): Matlab software for segmentation of the phlukes of humback whales .
- A.G. Steenbeek. EUROPHLUKES feature extraction system, matching system and digital watermarking software.

Deliverables for projects

- H.J.A.M. Heijmans, G.C.K. Abhayaratne, other MASCOT members. MASCOT D3.1: New spatio-temporal decompositions.
- H.J.A.M. Heijmans, Y.-W. Zhan, other MASCOT members. Various deliverables.
- M.J. Huiskes, E.J.E.M. Pauwels. FOUNDIT D3.3, part A: The FOUNDIT feature factory – Description of the FOUNDIT feature extraction engine as used for the FOUNDIT extended prototype; Part B: The FOUNDIT inference engine – Figure-ground segregation; Part D: The FOUNDIT inference engine – Linking user feedback and design image features; Part E: The FOUNDIT inference engine – Metadata for decoration designs.
- FOUNDIT D4.1: Report on search engine tests.
- E.J.E.M. Pauwels, M.J. Huiskes. FOUNDIT D6.3: FOUNDIT final report.
- E.J.E.M. Pauwels, M.J. Huiskes. FOUNDIT factsheet KTWeb.
- M. Weber, M. Behrens, B. Schouten. D6.2 BioVision: Paper on the most important technical and economic impacts of biometric identification systems in selected application fields; D6.3 BioVision: Evaluation schemes for biometrical technology and applications; D6.4 BioVision: (Discussion) paper on testing biometrical programs; D6.5 BioVision: Report on technology and application issues for biometrical systems; D6.6 BioVision: Report on a systematic cost-benefit analysis in biometrics.

Book chapters

1. M.N.M. van Lieshout (2003). Probabilistic image modelling. P.J. Green, N.L. Hjort, S. Richardson (eds). Highly structured stochastic systems. Oxford Statistical Science Series 27, Oxford Univ. Press, 323–325.

PhD theses

1. G. Piella Fenoy (2003). Adaptive wavelets and their application to image fusion and

compression. Faculteit der Natuurwetenschappen, Wiskunde en Informatica, UvA, October 30.

Professional products

Publications for a broad audience

1. M.J. Huiskes, E.J. Pauwels (2003). Searching and browsing databases of digital decoration designs. ERCIM News 55, 22–23.
2. M.N.M. van Lieshout (2003). Inference for random sets. Research Highlights, 20–21, CWI Annual Report 2002. ERCIM News 55, 36–37.

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). Other members are M.N.M. van Lieshout and M.W. Brouwer.
- E.J.E.M. Pauwels, H.J.A.M. Heijmans and M.N.M. van Lieshout participate in the ICES-KIS/Bsik project MultimediaN.
- B.A.M. Schouten. IOP project BASIS.
- B.A.M. Schouten and H.J.A.M. Heijmans participate in the ICES-KIS/Bsik project BRICKS.

SOFTWARE ENGINEERING

Principal research area and mission

The research activities in this cluster are focused on various aspects of software engineering. Our 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. The close interactions with our spin-off companies (Software Improvement Group and Adaptive Planet) assure this knowledge transfer.

Cluster staff

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

Research themes

Name	Leader
SEN0 – Biography of Aad van Wijngaarden	Prof.dr. P. Klint
SEN1 – Interactive Software Development and Renovation	Prof.dr. P. Klint
SEN2 – Specification and Analysis of Embedded Systems	Prof.dr. W.J. Fokkink
SEN3 – Coordination Languages	Prof.dr. J.J.M.M. Rutten
SEN4 – Evolutionary Systems and Applied Algorithms	Prof.dr.ir. J.A. La Poutré

The activities in SEN1 are dominated by the question how techniques like parsing, rewriting and component-based software engineering can be applied to the development and renovation of large software systems. Its research was concentrated in three areas: software renovation, domain-specific languages, and generic language technology.

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 discrete algorithms.

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

Other items of interest

- F.S. de Boer was appointed associate professor at the UL.
- M.G.J. van den Brand was appointed lecturer Software Quality at the Hogeschool van Amsterdam.
- A. van Deursen was appointed professor Software Engineering at the TUD.
- S.M. Bohte was awarded a Veni grant.
- Three PhDs: S.M. Bohte, M. de Jonge, and J.M.W. Visser.
- SEN2 and SEN4 participated with INS1 in the acquisition of a cluster of Linux machines (funded by NWO).
- SEN members participated in the PCs of 58 international workshops and conferences.
- 8 SEN members appear on CiteSeer's list of ten thousand most cited authors in Computer Science.
- SEN has cooperations with over 40 national and international companies.

Biography of Aad van Wijngaarden – SEN0

Aad van Wijngaarden (1916–1987), founding father of computer science in the Netherlands and former director of CWI, is the subject of a historical research project. The leading theme in the composition of a scientific biography is 'Mathematical beauty and a taste for language'. In his scholarship Van Wijngaarden, engineer by training, was strongly guided by mathematical beauty. It made him consider scientific computing in its own right (1946), made him turn towards programming languages (1958) and reared his preferences in the design of ALGOL 68.

The project is funded by NWO-EW as 612.057.001 'Biography of Aad van Wijngaarden'.

Theme leader

Prof.dr. P. Klint

MSC or CR classification

01-XX, 65-03, 68-03

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. G. Alberts (seconded NWO)	0.8	researcher	2003-12-31 till 2005–05-01	Biography Van Wijngaarden, history of computing Advising Alberts

Scientific report

In 2003 research was continued by archival searches and interviews in The Netherlands, Germany (Dortmund, Munich) and Austria (Vienna).

Organization of conferences, workshops, courses, meetings

- Colloquium History of Computing; convenor, spring 2003: G. Alberts and A. van den Bogaard (TUD).
- Conference History of Computing, July, CWI, organization: G. Alberts.
- NMC39 GMFW symposium Wiskunde in crisis? Keuzemomenten at the 39th Nederlands Mathematisch Congres, Nijmegen, May 1: G. Alberts (organization and lecture:

'Het pact tussen wiskunde en samenleving').

Lectures, conferences, courses, project meetings, working visits

Working visits

- Nationale Wiskunde Dagen, Noordwijk, January 31–February 1: (Lecture: Het geluid van rekentuig).
- HKRWO symposium IX, Utrecht (Lecture: Oude meesters), May 17.
- V2_ Rotterdam, conference Digital Work, October 11.
- Archives and interviews Dortmund, October 15; Munich, October 27–29; Vienna, October 29–November 2.
- 14th Novembertagung zur Geschichte der modernen Mathematik, Vienna, October 30–November 2.
- Games Research conference Level up, Utrecht, November 3–8.
- Compositio History of Compositio Mathematica, Amsterdam, November 7.
- De KNAW en de Nederlandse wetenschap tussen 1930 en 1960, studiedag, Amsterdam, December 2: (Lecture: Niet Het huis der wetenschap).

Memberships of committees and other professional activities

G. Alberts

- Editor Nieuw Archief voor Wiskunde.
- Secretary GMFW, landelijk werkcontact Geschiedenis en Maatschappelijke Functie van de Wiskunde.
- Advisor to SCEN, Stichting Computer Erfgoed Nederland; acquisition and supervision of project 'Verzamelbeleid Historische Computers' funded by Mondriaan Stichting.
- Member of the Archives Committee of the Koninklijk Wiskundig Genootschap, CPAW, Commissie Persoonlijke Archieven van Wiskundigen.
- Member PhD committee for B. Broekhans (KUN), June 18.
- Member PhD committee and co-advisor D. Beckers (KUN), July 2.
- Head of the Science and Society research programme (KUN).

Professional products

Contributions to documentaries or radio or tv broadcastings

1. G. Alberts (2003). Optreden in uitzending van het TV-programma Andere Tijden over de opkomst van de computer, April 15.

Societal aspects and knowledge transfer

Teaching at university

- Course Computerhistorie, UvA, Computer Science, Spring 2003: G. Alberts with E.H. Dooijes.
- Course Wiskunde als wetenschap, UvA, Mathematics, Spring 2003: G. Alberts.
- De waan van de wetenschap, Honours Programme, KUN, Fall 2003: R. Aerts, H. Jürgens and G. Alberts.

Academic publications

Publications in other journals and other scientific output

1. G. Alberts (2002). Een halve eeuw computers in Nederland: 1. Een willekeurig getal. Nieuwe Wiskrant 22-1, 6–8.
2. G. Alberts (2003). Een halve eeuw computers in Nederland: 2. Het geluid van rekentuig. Nieuwe Wiskrant 22-3, 17–23.
3. G. Alberts, G. Koole, J. Molenaar (2003). Twee seconden is hier een eeuwigheid; de overval 1. Nieuw Archief voor Wiskunde 5/4-3 (2003), 224–228.
4. G. Alberts (2003). Rekenmeisjes en rekentuig. Pythagoras 43, 4–7.

Publications in refereed journals

1. G. Alberts, T. Koetsier, G. Bolten (2003). Snippers met formules; archieven van wiskundigen. Nieuw Archief voor Wiskunde 5/4-1, 46–50.

Interactive Software Development and Renovation – SEN1

Mission

The mission of this theme is to advance the state of the art in development and renovation of large software systems.

The general 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 development of large software systems is addressed by explicitly describing the cooperation protocols of components, by explicitly packaging subsystems, and by using methods for unit testing and daily builds. Key questions are related to controlling the configuration, building and distributing processes and optimizing the description of component interfaces.

The renovation of software systems is addressed by developing new techniques for the analysis and transformation of software systems. Key questions cover traversing programs, describing analysis or transformation, visualizing the results of an analysis, collecting the results of an analysis in a language-independent fashion, using the results of an analysis for program transformations, and showing the correctness of these transformations.

Theme leader

Prof.dr. P. Klint

MSC or CR classification

D.2

Subthemes

Name	Leader
SEN1.1 – Software Renovation	A. van Deursen
SEN1.2 – Domain-Specific Languages	J. Heering
SEN1.3 – Generic Language Technology	M.G.J. van den Brand

SEN1.1 aims at developing methods, tools, and techniques that help to make software systems sufficiently flexible.

SEN1.2 studies the 'when and how' of DSL design and development. More specifically, it studies advanced tools and methods for domain analysis and DSL development in general as well as in particular cases.

SEN1.3 is concerned with the redesign, re-implementation, and improvement of the ASF+SDF Meta-Environment. The primary goal is to develop a flexible and extensible generic environment to be used as infrastructure in domain-specific language prototyping (SEN1.2) and software renovation (SEN1.1).

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Dr. G.C. Ballintijn	1.0	post-doc	2003-07-01 till 2007-06-30	SEN1.3: Deliver

Dr. M.G.J. van den Brand	0.4	researcher, leader SEN1.3	indefinite	SEN1.2: CaLCE, SEN1.3: ASF+SDF, AirCube, GAME, MetaEclipse, 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	indefinite	SEN1.1: DocGen, Ideals, NAME, leading PhD students
J. Heering	1.0	researcher, leader SEN1.2	indefinite	SEN1.2: DSL, CaLCE
Drs. R.L. Jansen	1.0	PhD student	2003-11-01 till 2007-10-31	SEN1.3: PhD research, Deliver
Dr. H.A. de Jong	1.0	project member, PhD student	2000-01-01 till 2006-12-31	SEN1.2: CaLCE, SEN1.3: PhD research, ASF+SDF, AirCube, GAME, MetaEclipse
Dr. M. de Jonge	1.0	project member, PhD student	1999-04-01 till 2003-03-31	SEN1.1: PhD research, SEN1.2: DSL
Prof.dr. P. Klint	0.6	cluster/theme leader	indefinite	SEN1.2: CaLCE, SEN1.3: ASF+SDF, Deliver, MetaEclipse, leading PhD students
Dr. B. Li	1.0	post-doc	2003-04-01 till 2003-12-31	SEN1.3: (ERCIM Fellow)
Dr. V. Marangozova	1.0	post-doc	2003-12-01 till 2004-05-31	SEN1.3 (ERCIM Fellow)
Dr. P.A. Olivier	0.6	post-doc	1999-11-01 till 2003-02-28	SEN1.3: ASF+SDF
Drs. T. van der Storm	1.0	PhD student	2003-07-01 till 2007-06-30	SEN1.3: Deliver
Drs. J.J. Vinju	1.0	project member, PhD student	2002-02-01 till 2006-01-31	SEN1.2: CaLCE, SEN1.3: PhD research, ASF+SDF, AirCube, GAME
Dr. J.M.W. Visser	1.0	project member, PhD student	1999-04-01 till 2003-03-31	SEN1.1: PhD research, SEN1.2: DSL

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. J.A. Bergstra (UvA)	0.1	advisor	indefinite	SEN1.1; SEN1.2; SEN1.3
A. Cleve (Univ. Namur)	1.0	trainee	2003-09-01 till 2003-12-31	SEN1.1: Master's thesis research, DocGen
R. de Haan (UvA)	0.33	trainee	2000-01-01 till 2003-12-31	SEN1.3: Master's thesis research, ASF+SDF
A.T. Kooiker (UvA)	1.0	trainee	2003-05-01 till 2003-12-31	SEN1.3: Master's thesis research, ASF+SDF, MetaEclipse
Dr.ir. R. Lämmel (VU)	0.2	project member	indefinite	SEN1.2: DSL, leading J.M.W. Visser
Drs. L.M.F. Moonen	0.2	project member	2003-01-01 till indefinite	SEN1.1: Ideals, NAME
Dr. P. Strooper (Univ. Queensland)	0.2	project member	2003-03-01 till 2003-06-30	SEN1.1: (software testing)

Scientific report

Highlights

- Appointment of M.G.J. van den Brand as lector Software Quality (HvA).
- Appointment of A. van Deursen as part-time professor Software Engineering (TUD).
- PhD defence M. de Jonge.
- PhD defence J.M.W. Visser.

PhD students

M. Bruntink
R.L. Jansen
H.A. de Jong
M. de Jonge
T. van der Storm
J.J. Vinju
J.M.W. Visser

SEN1.1 – Software Renovation

SEN1.1 addresses methods and techniques supporting software evolution. The group collaborates by means of an exchange programme with the Software Evolution Research Lab (SWERL) at TUD.

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

Progress report. Within this project two MSc projects were carried out. M. Bruntink (UvA) investigated software testability by correlating metrics in Java classes and their corresponding test cases. This work was done at the Software Improvement Group BV. A. Cleve (seconded at CWI from the Univ. of Namur) investigated the use of ASF+SDF for the purpose of program transformations as needed for data reverse engineering.

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

Progress report. The Ideals project addresses crosscutting concerns in embedded software. These concerns are crosscutting in the sense that they are inherently difficult to modularize, possibly affecting all modules. Typical examples include error handling, logging, and tracing. This project aims at (1) finding hand-coded crosscutting concerns automatically in C code; and (2) refactoring this C code by means of generation and weaving technology in order to reduce the code size and increase the system's maintainability. The industrial carrier in this project is ASML with a 10 million lines of embedded C code base. After finishing his MSc work in DocGen (see above), M. Bruntink started his PhD research on the Ideals project by doing initial studies of the relevant literature in program analysis, attending the Working Conference on Reverse Engineering (WCRE), and studying the ASML software development process and code base.

Title	NAME – Network of Agile Methodologies Experience
Period	July 2002–July 2003
Leader	L.M.F. Moonen
Staff	A. van Deursen
Funding	EU (SFT, network)
Partners	Free Univ. Bolzano, Datasiel SpA, Polytechnic Valencia, Technical Univ. Munich, Univ. Cagliari, Univ. Sheffield

Progress report. NAME was a network for evaluating agile methodologies. The project was concluded with an experimental framework to collect, classify, and analyze already existing and new experience in the area of agile methods.

SEN1.2 – Domain-Specific Languages

SEN1.2 studies the 'when and how' of DSL design and development. More specifically, it studies advanced tools and methods for domain analysis and DSL development in general as well as in particular cases. With the acceptance of the NWO-funded Language-Parametric Program Restructuring project (LPPR – to begin in 2004) and the CaLCE project (see below) the subject of SEN1.2 is shifting to software transformation.

Title	DSL – Domain-Specific Languages
Period	1999–December 2003
Leader	J. Heering
Staff	M. de Jonge (until March 31), R. Lämmel, J.M.W. Visser (until March 31)
Funding	CWI
Partners	Univ. Maribor, Macquarie Univ.

Progress report. Heering: A comprehensive sur-

vey of the 'when and how' of domain-specific language development joint with M. Mernik (Univ. Maribor) and A.M. Sloane (Macquarie Univ. Sydney) was finished (CWI report SEN-E0309) and submitted to ACM Computing Surveys. It also discusses DSL design pattern support that might be incorporated in future Language Design Assistants. With the publication of this report, the DSL project was concluded.

Klint: Work on feature diagrams started in 2002 was continued in the context of software configuration management in the SEN1.3 Deliver project.

Lämmel continued work on generic functional programming in collaboration with S. Peyton Jones (Microsoft Research, Cambridge). He also worked on grammarware engineering in collaboration with Klint, S. Klusener (Software Improvement Group BV), W. Schulte (Microsoft Research, Redmond), and C. Verhoef (VU). Furthermore, he worked on programming languages for aspect-oriented programming and in particular on a comparison of adaptive, strategic and aspect-oriented programming with E. Visser (UU) and Visser.

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, P. Klint, J.J. Vinju
Funding	SENTER
Partners	PinkRoccade Public 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.

The CWI and VU teams had a series of meetings to identify potential bottlenecks in the development and use of the ASF+SDF Meta-Environment within CaLCE.

Klint carried out various experiments in using relational calculus for manipulating facts extracted from source code. The result is a simple scripting language 'Rscript': a strongly typed calculus that provides standard relational operators as well as transitive closures and a fixed point operator. This allows the expression of a range of program analyses such as dataflow analysis and program slicing. Initial results were reported at IWPC '03.

Lämmel started work on generic software refactoring.

SEN1.3 – Generic Language Technology

SEN1.3 is concerned with the redesign, reimplementation, and improvement of the ASF+SDF Meta-Environment. The primary goal is to develop a flexible and extensible generic environment to be used as infrastructure in domain-specific language prototyping (SEN1.2) and software renovation (SEN1.1).

Title	ASF+SDF
Period	1998– indefinite
Leader	M.G.J. van den Brand
Staff	H.A. de Jong, P. Klint, P.A. Olivier (until March 1), J.J. Vinju
Funding	CWI
Partners	UvA, VU, First Result, Software Improvement Group BV

Progress report. Van den Brand, De Jong, Klint, and Vinju continued work on on the ASF+SDF Meta-Environment on two fronts: more openness and extensibility to other specification formalisms and usability by specification writers.

Further development of ASF+SDF as a language for source-code analysis and transformation has led to the analysis of a number of shortcomings and their respective solutions, among them dealing with ambiguous syntax definitions (e.g., the C language) and availability of basic datastructures and I/O functionality (the ASF+SDF library). Unused and/or unclear SDF constructs have been removed or replaced by more logical constructs. Also, ASF condition syntax has been improved to facilitate earlier detection of user errors. Static checks for both SDF and ASF specifications have been developed or extended.

ASF+SDF-specific services in the environment have been generalized to improve their reusability, among others in-memory caching of modules, error reporting, and a more configurable GUI. De Jong in collaboration with

Kooiker (masters' student) designed a framework to execute and control editors such as GNU Emacs and (G)Vim in a uniform manner. This generic 'editor multiplexer' facilitated integration of the ASF+SDF Meta Environment and the IBM Eclipse IDE. The button language experiment started with Klint was further generalized and resulted in a mechanism to customize both the editors and the user interface.

Transfer of Meta-Environment technology to other specification languages has been given substance in beta versions of the ELAN4 environment (INRIA/LORIA Nancy) and the Action Notation Environment by J. Iversen from Aarhus Univ.

ApiGen, a tool to generate implementations of abstract syntax trees, was extended with a Java backend to facilitate integration of Java components in the Meta-Environment. It brings Java applications closer to ASF+SDF and makes them easier to communicate with by automatically generating implementations of algebraic datatypes. ApiGen was made available externally and this led to many small improvements as a result of user feedback.

Title	AirCube: Rewrite rules
Period	2001–2003
Leader	M.G.J. van den Brand
Staff	H.A. de Jong, J.J. Vinju
Funding	INRIA/LORIA Nancy
Partner	INRIA/LORIA Nancy

Progress report. The AirCube project was concluded with joint work on the deployment of ApiGen, a tool to generate implementations of abstract syntax trees developed at CWI, in the context of TOM, a pattern-matching compiler developed by P.-E. Moreau (INRIA/LORIA Nancy). The results of this integration are promising. A joint paper was submitted for journal publication.

Title	Deliver – Intelligent Software Knowledge Management and Delivery
Period	July 2003–November 2007
Leader	P. Klint
Staff	G.C. Ballintijn, R.L. Jansen, T. van der Storm
Funding	NWO (Jacquard, UU)
Partners	UU, Exact, Chipsoft

Progress report. The Deliver project addresses the problem that it is becoming more and more difficult for vendors of product software to manage and control the software configurations of all their users at the customer's site. It is labor intensive and error-prone to keep track of detailed lists of the software in use by each customer in a (semi-)automatic way. To alleviate this problem, we propose an Intelligent Software Knowledge Base that contains all facts about all software together with their relevant attributes, relations and constraints. In this way, high-quality software configurations can be determined automatically from a small set of key parameters. It also becomes possible to pose what-if questions about necessary or future upgrades of a customer's configuration. These calculations will form the basis for Web-Based Delivery of full installations and upgrades.

Ballintijn, Jansen, and Van der Storm started the study of the problem area by reading the relevant literature and compiling a list of relevant concepts. To get some practical experience, Ballintijn and Van der Storm also examined the main development and deployment problems encountered by the SEN1.3 ASF+SDF project while developing and maintaining the Meta-Environment software. Van der Storm experimented with feature diagrams as mechanism for expressing the variability in the description of software packages. This work is an extension of earlier work on feature diagrams and binary decision diagrams (BDDs) done by Van Deursen and Klint in SEN1.2.

To develop industrial contacts, Ballintijn and Brinkkemper (UU) visited Exact Software in preparation for a case study on the development and deployment processes at Exact.

Title	GAME – Generic Application Maintenance Environment
Period	June 2003–2007
Leader	M.G.J. van den Brand
Staff	H.A. de Jong, J.J. Vinju
Funding	SENTER
Partners	First Result, IBM Nederland

Progress report. The goal of GAME is an improved software development environment in which users can change generated code without risking loss of their modifications after regeneration. The research activities of De Jong and Vinju have focused on the generational aspect

in the form of ApiGen, a tool to generate implementations of abstract syntax trees.

Title	MetaEclipse – Connecting the ASF+SDF Meta-Environment with Eclipse
Period	2003
Leader	M.G.J. van den Brand
Staff	H.A. de Jong, P. Klint, A.T. Kooiker
Funding	IBM Eclipse Innovation Grant

Progress report. The goal of MetaEclipse was to explore the feasibility of integrating the IBM Eclipse extensible Java IDE and the ASF+SDF Meta-Environment. To this end a number of case studies were carried out. The results were presented at the 2003 Eclipse Technology eXchange. A one year follow-up project (KernelMetaEclipse) was accepted.

Societal aspects and knowledge transfer

External contacts

Aarhus Univ., ASML, ATOS Origin, Belastingdienst, Chipsoft, Datasiel SpA, DoCoMo Research Laboratories Munich, Elsevier Science, ESI, Free Univ. Bolzano, Exact, First Result, HvA, IBM Nederland, INRIA/LORIA Nancy, Kent State Univ., Lehigh Univ., Macquarie Univ., Microsoft Research, Ministerie van Sociale Zaken en Werkgelegenheid, Nokia Research Helsinki, NWO Exacte Wetenschappen, PinkRoccade Public BV, 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. Maribor, Univ. Mons-Hainaut, Univ. Namur, Univ. Sheffield, Univ. of Stuttgart, Univ. Queensland, Univ. Victoria, UT, UU, UvA, Vrije Univ. Brussel, Vanenburg Group, VU.

Projects with partners in public and private sector

- AirCube; see page 61.
- ASF+SDF; see page 60.
- CaLCE; see page 60.
- Deliver; see page 61.
- DSL; see page 59.
- GAME; see page 61.
- Ideals; see page 59.
- NAME; see page 59.

Contract research

- DocGen; see page 59.

Teaching at university

- Course on Software Testing and Quality Engineering, TUD, September–October : A. van Deursen.
- Programmeeromgevingen II masters course, UvA: P. Klint.
- Assistant P. Klint's Programmeeromgevingen II course, UvA: J.J. Vinju.
- Guest lecture 'Meta-programming with Strafunski', Univ. Rostock, May 22: R. Lämmel.
- Guest lecture 'Evolution and Exploration of Software Systems' in E. Visser's Software Engineering course, UU, October 20: L.M.F. Moonen.
- Creation of new one year joint UvA, HvA and VU masters programme in software engineering: M.G.J. van den Brand and P. Klint. They have given the courses Software Evolution and Software Construction.

Organization of conferences, workshops, courses, meetings

- Thirty-sixth Annual Hawaii International Conference on System Sciences (HICSS-36), January 6–8: J. Heering (minitrack organizer with M. Mernik, Univ. Maribor, and A.M. Sloane, Macquarie Univ.).
- Dagstuhl Seminar on Software Architecture Recovery and Modelling (SWARM), February 2–7: A. van Deursen.
- Second Dutch NAME Workshop, April 7: L.M.F. Moonen.
- ASF+SDF Users Day, June 6: J.J. Vinju (with N. Veerman, VU).
- First Belgian-Dutch Software Evolution Workshop (BENEVOL), June 19–20: L.M.F. Moonen.
- Second Annual DesignFest on Visualizing Software For Understanding and Analysis (VISSOFT '03) September 22: A. van Deursen.
- Landelijk Architectuur Congres (LAC '03), November 26–27: A. van Deursen (track organizer with H. Bakker, ATOS Origin, and M. van den Bergh, Sogeti).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Thirty-sixth Annual Hawaii International Conference on System Sciences (HICSS-36), Big Island, Hawaii, January 6–8: J. Heering.
- 5th Symposium on Practical Aspects of Declarative Languages (PADL '03), New Orleans, January 13–14: R. Lämmel (Lecture: A Strafunski application letter).
- 2003 ACM SIGPLAN Workshop on Types in Language Design and Implementation (TLDI '03), New Orleans, January 18: R. Lämmel (Lecture: Scrap your boilerplate: A practical design pattern for generic programming).
- Workshop on Aspect-Oriented Software Development, UT, January 21: R. Lämmel (Lecture: Adding superimposition to a language semantics).
- Dagstuhl Seminar on Software Architecture Recovery and Modelling (SWARM), February 2–7: A. van Deursen, L.M.F. Moonen.
- 3rd German Workshop on Aspect-Oriented Software Development, Essen, Germany, March 4–5: R. Lämmel (Lecture: Parse-tree annotations meet re-engineering concerns).
- Workshop on Foundations of Aspect-Oriented Languages, Boston, March 17: R. Lämmel (Lecture: Adding superimposition to a language semantics).
- Conference on Aspect-Oriented Software Development, Boston, March 20: R. Lämmel (Lecture: Strategic programming meets adaptive programming).
- 7th European Conference on Software Maintenance and Reengineering (CSMR '03), Benevento, Italy, March 26–28: M.G.J. van den Brand.
- European Joint Conferences on Theory and Practice of Software (ETAPS '03), Warsaw, Poland, April 5–13: M.G.J. van den Brand, J.J. Vinju.
- Third Workshop on Language Descriptions, Tools and Applications (LDTA '03), Warsaw, Poland, April 6: M.G.J. van den Brand, J.J. Vinju (Lecture: Generalized parsing and term rewriting – Semantics directed disambiguation).
- Second Dutch NAME Workshop, Amsterdam, April 7: L.M.F. Moonen (Lecture: The NAME research roadmap).
- IEEE International Working Conference on Program Comprehension (IWPC '03), Portland Oregon, May 10–11: P. Klint (Invited speaker: How understanding and restructuring differ from compiling – A rewriting perspective).
- 4th International Conference on eXtreme Programming and Agile Processes in Software Engineering (XP '03), Genova, Italy, May 25–29: L.M.F. Moonen (Lecture: NAME aims and structure).
- Workshop on Software Re-engineering, Bad Honnef, Germany, May 7: R. Lämmel (Lecture: Towards generic refactoring).
- Stratego Users Day, Utrecht, June 5: J.J. Vinju (Lecture: Developments in ATerms and SDF2 at CWI).
- ASF+SDF Users Day, Amsterdam, June 6: M.G.J. van den Brand (Lecture: Opening notes, Transforming LaTex equations to XML), H.A. de Jong, P. Klint (Lecture: Using relational calculus for program querying), J.J. Vinju (Lecture: Future plans for ASF+SDF and the Meta-Environment).
- Federated Conference on Rewriting, Deduction and Programming (RDP), Valencia, Spain, June 8–14: J.J. Vinju (Lecture: Environments for term rewriting engines for free!)
- First Belgian-Dutch Software Evolution Workshop (BENEVOL), Amsterdam, June 19–20: A. van Deursen (Lecture: Source based software risk assessment), L.M.F. Moonen (Lecture: Java quality assurance by detecting code smells).
- ICT Kenniscongres, The Hague, September 4: P. Klint (Lecture: The PRESTO project).
- Software Patents: The Choice Is Yours, Conference organised by the Greens/European Free Alliance in the European Parliament, Brussels, September 17: P. Klint (Invited speaker: Against software patents).
- 19th IEEE International Conference on Software Maintenance (ICSM '03), Amsterdam, September 22–26: A. van Deursen (Lecture: Source based software risk assessment), P. Klint, L.M.F. Moonen (Lecture: Exploring software systems), R. Lämmel (Lecture: Deriving tolerant grammars from a base-line grammar).
- Second Annual DesignFest on Visualizing Software For Understanding and Analysis (VISSOFT '03), Amsterdam, September 22: A. van Deursen.

- Net.ObjectDays 2003, Erfurt, Germany, September 22–25: B. Li (Lecture: Managing dependences in component-based systems based on matrix model).
- 3rd IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '03), Amsterdam, September 26–27: L.M.F. Moonen, R. Lämmel (Lecture: Parse-tree annotations meet re-engineering concerns).
- Seminar Microsoft (meeting with Bill Gates), The Hague, October 14: P. Klint.
- Aspect-Oriented Software Design Meeting, Vlaams Software Platform, Heverlee, Belgium, October 23: M. Bruntink.
- Workshop on Evolution of Algebraic Specifications, Natal, Brazil, October 18–26: J.J. Vinju (Lecture: Environment for algebraic specifications languages for free!, Introduction to ASF+SDF).
- OOPSLA '03 and Eclipse Technology eXchange, Anaheim, USA, October 26–30: H.A. de Jong, A.T. Kooiker (A language development environment for Eclipse).
- First International Workshop on REFactoring: Achievements, Challenges, Effects (REFACE '03), Victoria, Canada, November 13: M. Bruntink, A. van Deursen (Lecture: Aspect mining and refactoring, Refactoring: Emerging trends and open problems), L.M.F. Moonen (Lecture: Aspect mining and refactoring).
- 10th Working Conference on Reverse Engineering (WCRE '03), Victoria, Canada, November 13–16: M. Bruntink, A. van Deursen, L.M.F. Moonen.
- IPA Herfstdagen on Compositional Programming Methods, Beekbergen, November 17–21: A. van Deursen (Lecture: Aspect mining and refactoring), R. Lämmel (Lecture: Components for language-parametric program restructuring).
- Landelijk Architectuur Congres (LAC '03), Nieuwegein, November 26–27: A. van Deursen.
- 9de Nederlandse Testdag, Nijmegen, November 25: M. Bruntink (Lecture: Testability of object-oriented systems: a metrics-based approach).

Working visits

- M. Bezem and M. Haveraaen, Univ. Bergen, March 20–21: J. Heering.
- A. Martins Moreira, D. Deharbe, UFRN Natal, Brazil, October 27–31: J.J. Vinju.
- J.C. Rooda, TUE, November 18: J.J. Vinju.

Project meetings

- AirCube Workshop, Nancy, France, March 3–5: M.G.J. van den Brand, P. Klint, R. Lämmel, J.M.W. Visser, J.J. Vinju.
- NAME final review, September 29, Larnaca, Cyprus: L.M.F. Moonen.
- Ideals Kick Off Meeting, October 31, Embedded Systems Institute, Eindhoven: A. van Deursen, M. Bruntink.
- Ideals Presentation Day, December 10, CWI: M.G.J. van den Brand, A. van Deursen, J. Heering, R.L. Jansen, P. Klint, L.M.F. Moonen, J.J. Vinju.

Visitors

- J. Iversen, Aarhus Univ., January–June. Host: M.G.J. van den Brand.
- J.-L. Hainaut, J. Henrard, Univ. of Namur, January 21. Host: A. van Deursen.
- B. Molenaar, Stichting NLnet, January 22. Host: H.A. de Jong.
- P. Strooper, Univ. Queensland, January 30. Host: L.M.F. Moonen.
- K. Czarnecki, Univ. Waterloo, March 7. Host: P. Klint.
- W. Böhm, Colorado State Univ., June 16. Host: P. Klint.
- F. Tip, IBM T.J. Watson Research Center, June 23. Host: P. Klint.
- R. Hirschfeld, DoCoMo Research Labs, Munich, Germany, August 4–6. Host: R. Lämmel.
- A.M. Sloane, Macquarie Univ., September 1. Host: J. Heering.
- W. Lohmann, Univ. Rostock, Germany, November 5–13. Host: R. Lämmel.
- J. Guyon, P.-E. Moreau, INRIA/LORIA Nancy, November. Host: M.G.J. van den Brand.
- M. Bezem, Univ. Bergen, November 3. Host: J. Heering.

Memberships of committees and other professional activities

M.G.J. van den Brand

- Member organizing committee and programme committee member Third Workshop on Language Descriptions, Tools and Applications (LDTA '03).

- Member programme committee 12th International Conference on Compiler Construction (CC '03).
- Programme committee chair 7th European Conference on Software Maintenance and Reengineering (CSMR '03).
- Member programme committee International Conference on Software Maintenance (ICSM '03).
- Guest co-editor of special issue of Science of Computer Programming (selected papers LDTA '01).

A. van Deursen

- Co-chair programme committee 10th Working Conference on Reverse Engineering (WCRE '03).
- Member programme committee and tutorial chair International Conference on Software Maintenance (ICSM '03).
- Member programme committee Third IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '03).
- Member programme committee First International Workshop on Evolution of Large-scale Industrial Software Applications (ELISA '03).
- Member programme committee International Workshop on the Principles of Software Evolution (IWPSE '03).
- Member programme committee 4th International Conference on Extreme Programming and Agile Processes in Software Engineering (XP '03).
- Publicity chair 11th International Workshop on Programme Comprehension (IWPC '03).
- Member PhD committee L. Breebaart (TUD, June 3).

J. Heering

- External examiner O. Bragge and K.T. Kalleberg (Univ. Bergen, March 20–21).

P. Klint

- Member PhD committee J. Mueller (UvA, May 23).
- Member PhD committee M. Windhouwer (UvA, November 6).
- Member programme committee International Conference on Aspect-Oriented Software Development (AOSD '03).
- Member programme committee Eclipse Technology Exchange (eTX '03).
- Member programme committee International Conference on Software Maintenance (ICSM '03).
- Member programme committee Third Workshop on Language Definitions Tools and Applications (LDTA '03).
- Member programme committee ACM SIGPLAN Workshop on Interpreters, Virtual Machines and Emulators (IVME '03).
- Member programme committee Model Driven Architectures (MDA '03).
- Editor IEE Proceedings – Software.
- Editor Science of Computer Programming.
- President European Association for Programming Languages and Systems (EAPLS).
- Member Scientific Directorate Schloss Dagstuhl.
- Member Adviescommissie Informatica (ACI).
- Member programme committee Jacquard.
- Member Informatica Platform Nederland (IPN).
- Member Board of Institute for Programming and Algorithms (IPA).
- Member Programme Board Lorentz Center.

R. Lämmel

- Member organizing committee International Conference on Software Maintenance (ICSM '03).
- Member programme committee Workshop on Foundations of Aspect-Oriented Languages (FOAL '03).
- Member programme committee Workshop on Unanticipated Software Evolution (USE '03).

L.M.F. Moonen

- Activity session chair 4th International Conference on eXtreme Programming and Agile Processes in Software Engineering (XP '03).
- Local chair 3rd IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '03).
- Member steering committee IEEE International Workshop on Source Code Analysis and Manipulation.
- Member programme committee 7th European Conference on Software Maintenance and Reengineering (CSMR '03).
- Member programme committee 11th International Workshop on Programme Comprehension (IWPC '03).
- Member programme committee International Conference on eXtreme Programming and Agile Processes in Software Engineering (XP '03).

- Member programme committee 10th Working Conference on Reverse Engineering (WCRE '03).
- Member programme committee International Workshop on Meta-Models and Schemas for Reverse Engineering (ateM '03).

J.J. Vinju

- Member Software Risk Assessment Expertise Groep of Software Improvement Group BV.

Academic publications

Publications in refereed journals

1. M.G.J. van den Brand, P. Klint, J.J. Vinju (2003). Term rewriting with traversal functions. ACM Transactions on Software Engineering and Methodology 12, 152–190.

Publications in other journals and other scientific output

Conference proceedings

1. M.G.J. van den Brand, H.A. de Jong, P. Klint, A.T. Kooiker (2003). A language development environment for eclipse. eclipse Technology eXchange (eTX). Proceedings OOPSLA '03, 61–66.
2. M.G.J. van den Brand, A.S. Klusener, L. Moonen, J.J. Vinju (2003). Generalized parsing and term rewriting: Semantics driven disambiguation. Proceedings of the Third Workshop on Language Descriptions, Tools and Applications (LDTA '03). Electronic Notes in Theoretical Computer Science 82, Elsevier.
3. M.G.J. van den Brand, P.-E. Moreau, J.J. Vinju (2003). Environments for term rewriting engines for free! Proceedings of the 14th International Conference on Rewriting Techniques and Applications (RTA '03), LNCS 2706, Springer-Verlag, 424–435.
4. A. van Deursen, T. Kuipers. Source-based software risk assessment. Proceedings of the International Conference on Software Maintenance (ICSM '03), IEEE Computer Society.
5. A. van Deursen, J.-M. Favre, R. Koschke, J. Rilling (2003). Experiences in teaching software evolution and program comprehension. Proceedings of the 11th International Workshop on Program Comprehension (IWPC '03). IEEE Computer Society.
6. A. van Deursen, M. Marin, L. Moonen (2003). Aspect mining and refactoring. Proceedings of the First International Workshop on Refactoring: Achievements, Challenges, Effects (REFACE). Univ. Waterloo.
7. J. Heering (2003). Quantification of structural information: On a question raised by Brooks. ACM SIGSOFT Software Engineering Notes 28(3).
8. H.A. de Jong, P. Klint (2003). ToolBus: the next generation. Formal Methods for Components and Objects, LNCS 2852, Springer-Verlag, 220–241.
9. P. Klint (2003). How understanding and restructuring differ from compiling – A rewriting perspective. Proceedings of the International Workshop on Program Comprehension (IWPC '03), IEEE Computer Society, 2–12.
10. J. Kort, R. Lämmel (2003). Parse-tree annotations meet re-engineering concerns. Proceedings of the Third IEEE International Workshop on Source Code Analysis and Manipulation (SCAM '03), IEEE Computer Society.
11. J. Kort, R. Lämmel (2003). A framework for datatype transformation. Proceedings of the Third Workshop on Language, Descriptions, Tools, and Applications (LDTA '03), Electronic Notes in Theoretical Computer Science 82, Elsevier.
12. A.S. Klusener, R. Lämmel (2003). Deriving tolerant grammars from a base-line grammar. Proceedings of the International Conference on Software Maintenance (ICSM '03), IEEE Computer Society Press.
13. R. Lämmel, E. Visser, J. Visser (2003). Strategic programming meets adaptive programming. Proceedings of the International Conference on Aspect-Oriented Software Development (AOSD '03). ACM Press, 168–177.
14. R. Lämmel, S. Peyton Jones (2003). Scrap your boilerplate: A practical design pattern for generic programming. Proceedings of the 2003 ACM SIGPLAN Workshop on Types in Language Design and Implementation. ACM SIGPLAN Notices, 38(3), 26–37.

15. R. Lämmel, J. Visser (2003). A Strafunski application letter. Proceedings Practical Aspects of Declarative Programming (PADL '03), LNCS 2562, Springer-Verlag, 357–375
16. T. Mens, A. van Deursen (2003). Refactoring: Emerging trends and open problems. Proceedings First International Workshop on Refactoring: Achievements, Challenges, Effects (REFACE), Univ. Waterloo.
17. L. Moonen (2003). Exploring software systems. Proceedings of the International Conference on Software Maintenance (ICSM '03), IEEE Computer Society Press.
18. J. Stuber, M.G.J. van den Brand (2003). Extracting mathematical semantics from LaTeX documents. Principles and Practice of Semantic Web Reasoning International Workshop (PPSWMR '03), LNCS 2901, Springer-Verlag, 160–173.

CWI reports

SEN-E0306, SEN-E0307, SEN-R0307, SEN-E0308, SEN-E0309, SEN-E0310, SEN-E0311, SEN-E0319, SEN-E0320, SEN-E0321, SEN-E0323, SEN-E0324, SEN-E0325, SEN-E0326, SEN-E0327, SEN-E0328.
See page 180 for complete titels.

Software developed

- JJTraveller Java visitor combinator framework and library (new release): A. van Deursen, J.M.W. Visser.
- Releases 1.3, 1.4, and 1.4.1 of the ASF+SDF Meta-Environment: M.G.J. van den Brand, H.A. de Jong, J.J. Vinju, et al.
- Release 1.6 of the ApiGen tool for generating implementations of abstract syntax trees: M.G.J. van den Brand, H.A. de Jong, J.J. Vinju.

Deliverables for projects

- NAME project team, Proposal of the Structure of an Experience Framework for Agile Methodologies, NAME deliverable IST-2001-37482-D.5.1, 2003.
- NAME project team, NAME EF Repository and Schema, NAME deliverable IST-2001-37482-D.5.2, 2003.
- NAME project team, Final Report, NAME deliverable IST-2001-37482-D.1.3, 2003.
- NAME project team, NAME Website, NAME Deliverable IST-2001-37482-D.7.1, 2003.

Book chapters

1. J. Heering, P. Klint (2003). Rewriting-based languages and systems. Terese, Term Rewriting Systems, Cambridge Univ. Press, March, Chapter 15.

PhD theses

1. M. de Jonge (2003). To Reuse or to be Reused. UvA, March 6. (Advisor: P. Klint, co-advisor: A. van Deursen).
2. J.M.W. Visser (2003). Generic Traversal of Typed Source Code Representations. UvA, February 14. (Advisor: P. Klint, Co-advisor: R. Lämmel).

Professional products

Contracts

- Project Computer-Aided Life Cycle Enabling (CALCE) (SENTER).
- Project Intelligent Software Management and Delivery (Deliver) (NWO Jacquard).
- Project Generic Application Maintenance Environment (GAME) (SENTER).
- Project Idiom Design for Embedded Applications on a Large Scale (Ideals) (SENTER).
- Project Language-Parametric Program Restructuring (LPPR) (NWO).

Publications for a broad audience

1. A. van Deursen, P. Klint, et al. (2003). Nederland onderschat belang software ontwikkeling. Automatisering Gids, November 14.
2. A. van Deursen, P. Klint (2003). Henry Ford in software engineering: Op weg naar systematische softwarevariatie. Informatie 45 (April), 50–53.

Other output

Grants

IBM Eclipse Innovation Award: P. Klint.

Specification and Analysis of Embedded Systems – SEN2

Mission

The main 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

Prof.dr. W.J. Fokkink

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. Furthermore, the techniques and algorithms are assessed and improved via case studies in various application domains (network protocols, embedded systems, hybrid systems, etc.). Central issues are theorem proving, model checking, distributed verification algorithms, combining verification with performance analysis, and testing.

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. Within this theme, technology is developed that is applied in SEN2.1. Central issues are process algebra, symbolic verification techniques, automated deduction, and security protocols.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. B. Badban	1.0	PhD student	2002-01-01 till 2005-12-31	SEN2.2: IT-VDS
Dr. S.C.C. Blom	1.0	project member	2000-03-01 till 2006-02-28	SEN2.1
Prof.dr. W.J. Fokkink	0.8	theme leader, leader SEN 2.2	indefinite	SEN2.1: PROGRESS SEN2.2: TIPSy
Dipl.ing. N. Ioustinova	1.0	project member	2001-10-01 till 2004-09-30	SEN2.1

Prof.dr. J.W. Klop	0.4	CWI Fellow	indefinite	SEN2.2
Drs. I.A. van Langevelde	1.0	project member	1998-08-01 till 2003-07-31	SEN2.1
Drs. B. Lisser	1.0	programmer	indefinite	SEN2.1
Drs. S.M. Orzan	1.0	PhD student	2000-06-01 till 2004-05-31	SEN2.1: PROGRESS
Drs. J. Pang	1.0	PhD student	2000-08-01 till 2004-07-31	SEN2.1: PROGRESS
Dr. J.C. van de Pol	1.0	leader SEN2.1	indefinite	SEN2.1: PROGRESS SEN2.2: IT-VDS
Drs. J.A. Valero Espada	1.0	PhD student	2001-03-01 till 2005-02-28	SEN2.1: PROGRESS
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. J.A. Bergstra (UvA)	0.1	advisor	indefinite	SEN2
Prof.dr.ir. J.F. Groote (TUE)	0.1	researcher	indefinite	SEN2.1
Dr. J. Hooman (KUN)	0.2	researcher	2001-01-31 till 2003-02-01	SEN2.1: PROGRESS
Dr. S. Mauw (TUE)	0.1	researcher	indefinite	SEN2.1

Scientific report

Highlights

- Stefan Blom and Simona Orzan received a best paper award for their paper Distributed State Space Minimization at the 8th Workshop on Formal Methods for Industrial Critical Systems.
- Acquisition of the ITEA project Tests & Testing Methodologies with Advanced Languages, as an ICT Doorbraakproject funded by SENTER (joint with LogicaCMG, ProRail and Improve QS).
- Acquisition of the project Modelling and Verification of Business Processes in the NWO Open Competition (joint with TUE).
- Acquisition of the project Accountability in Electronic Commerce Protocols in the NWO Open Competition (joint with TUE and VU).
- Acquisition of a cluster of machines on the project Facilitating the Advancement of Computational Science in the NWO Open Competition (joint with SEN4 and INS1).

PhD students

B. Badban
S.M. Oran
J. Pang
J.A. Valero Espada
A.J. Wijs

SEN2.1 – Distributed Systems

Title	IT-VDS – Integrating Techniques for the Verification of Distributed Systems
Period	2002-01-01–2005-12-31
Leader	J.C. van de Pol
Staff	B. Badban
Funding	NWO
Partner	H. Zantema (TUE)

Progress report. Badban developed an algorithm to verify logical formulas by means of binary decision diagrams with zero, successor and equality, jointly with Van de Pol. She generalized DPLL procedure, which solves the satisfiability problem for decidable fragments of quantifier-free first-order logic, in collaboration with Van de Pol, O. Tveretina (TUE) and H. Zantema. She verified the sliding window protocol in PVS, together with Fokkink, Groote, Pang and Van de Pol.

Title	CES.5008 – Improving the quality of embedded systems by formal design and systematic testing
Period	2000-08-01–2004-07-31
Leader	W.J. Fokkink
Staff	J. Pang
Funding	PROGRESS
Partner	B. Wanschers (Add-Controls)

Progress report. Pang worked on the verification

of the redesign of a lift system of Add-Controls with UPPAAL, together with B. Karstens and Fokkink; mistakes were detected in this analysis, and adaptations of the lift system were proposed, which were included in the ultimate implementation of the lift system. He analyzed Dijkstra's self-stabilizing algorithm for mutual exclusion on a ring, together with Fokkink and J.H. Hoepman. He worked with Fokkink, Groote, Badban, and Van de Pol on the verification of a sliding window protocol with unbounded channels, which was completely checked in PVS. Together with Fokkink he worked on the cones and foci method to verify timed systems. He improved and verified a set of distributed leader election algorithms for unidirectional ring networks with Fokkink.

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, J.A. Valero Espada
Funding	PROGRESS
Partner	J. Hooman (KUN)

Progress report. With Blom, Orzan designed and implemented distributed algorithms for strong bisimulation reduction of state spaces. They also analyzed the theoretical complexities and tested the performance. She defined with Van de Pol a space calculus, where heterogeneous distributed dataspace systems can be described. They gave an operational semantics to this language and implemented tools to assist in the functional and performance analysis of distributed systems. Functional behaviour can be checked by an automatic translation to μCRL and the use of a model checker. Performance analysis can be done using an automatically generated distributed C-prototype.

Valero Espada completed, together with Van de Pol, the theoretical background of abstract interpretation for μCRL specifications. They defined a symbolic transformation for linear specifications which integrates the two main stream techniques of abstraction, homomorphisms and Galois Connections, and that preserves the full μ-calculus. In order to make the theoretical results useful, they also defined a method, which uses standard tools, to perform 3-valued model checking over abstract approximations. Furthermore, they developed a tool to assist in the task of using abstraction during the verification process. Thanks to the tool, the theory has been successfully used to model check different (medium- and large-sized) case studies. For example, liveness and safety properties were proved correct on infinite instances of parameterised shared data spaces (such as JavaSpaces).

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

Progress report. Wijs wrote, together with Fokkink, a translation for (part of) the language χ, which is the specification language that serves as input to a performance analysis tool, to μCRL. Also he verified a small turntable systems, jointly with E. Bortnik and N. Trcka (both TUE).

SEN2.2 – Process Theory and Verification

Fokkink worked on the inaxiomatizability of the Hennessy merge in bisimulation, with L. Aceto, A. Ingólfsdóttir (both Aalborg Univ.) and S.P. Luttik (TUE). He worked on the absence of an omega-complete axiomatization for readiness, ready trace and future worlds semantics, with S. Nain (IIT). He worked on modal decomposition in structural operational semantics, with R.J. van Glabbeek (NICTA, Sydney) and P. de Wind (VU).

The research of Van de Pol focused on the effective verification of the behaviour of large scale systems. Used techniques were : (1) theorem prover techniques for combining equational and propositional reasoning (term rewriting, strategies, extended BDDs, extended DPLL); (2) transformations on linear process equations in process algebra (based on invariants, confluence reduction, control flow analysis); (3) abstract interpretation (modal transition systems, 3-valued logic); (4) effective use of the interactive theorem-prover PVS in process theory and protocol verification.

Blom and Ioustinova, with N. Sidorova (TUE), developed an approach that makes timed ver-

ification in μCRL possible without extending the language; some experimental verification results were obtained on timed communication protocols. Ioustinova, with Bosnacki and Sidorova, developed a verification approach that allows to avoid spurious traces caused by data abstractions introducing non-determinism with self-loops.
Groote was involved in discussions about the μCRL toolset, and its planned extensions, namely the increase of the prover and the extension towards modal logics with datatypes.
Mauw, with H.M.A. van Beek (TUE), extended the formal framework for the testing of distributed systems (as set up by Tretmans et al.) to the domain of Internet applications. Together with J.F. Cremers and E.P. de Vink (both VU) he developed a new definition of authentication for security protocols, called synchronization. They proved that synchronization is stronger than all forms of authentication published until now. Research started on the development of a (hybrid) model checker to verify synchronization and other security properties.

Societal aspects and knowledge transfer

External contacts

- LogicaCMG, Prorail, Improve QS, Nokia and DaimlerChrysler.
- Rijkswaterstaat, Siemens NL and Stelvio.
- Dutch Aerospace Laboratory, Space Systems Finland, Swedisch Space Corporation.
- We actively participate in the SAFE-NL platform, which provides a forum for researchers and practitioners from research institutions, industry and government agencies to exchange ideas on the state of the art in security technology.

Projects with partners in public and private sector

- Add-Controls is a partner of PROGRESS project CES.5008.
- Thales NL and 4TEC are partners of PROGRESS project CES.5009.
- ASML is involved in the NWO project TIPSy.

Organization of conferences, workshops, courses, meetings

- 7th Dutch Proof Tools Day, CWI, April 25: J.C. van de Pol and W.J. Fokkink (organizers).
- Weekly seminar (called PAM) at CWI: I.A. van Langevelde and N. Ioustinova (organizers).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- 22nd Japanese Workshop on Term Rewriting Systems, Yakushima, Japan, March 2–4: J.C. van de Pol (Lectures: Verification of Distributed Systems in the μCRL Toolset / Confluence and LTS Reductions that Preserve Branching Bisimilarity).
- 6th International Conference on Foundations of Software Science and Computation Structures, Warsaw, Poland, April 7–11: J. Pang (Lecture: Cones and Foci for Protocol Verification Revisited).
- 9th International Conference on Tools and Algorithms for the Construction and Analysis of Systems, Warsaw, Poland, April 7–11: J.F. Groote (Lecture: Visualisation of Large State Graphs).
- 17th International Parallel and Distributed Processing Symposium, Nice, France, April 22–26: I.A. van Langevelde (Lecture: Founding FireWire Bridges through Promela Prototyping), J. Pang (Lecture: Model Checking a Cache Coherence Protocol for a Java DSM Implementation).
- 7th Dutch Proof Tools Day, Amsterdam, April 25: B. Badban (Lecture: Zero, Successor and Equality in Binary Decision Diagrams), W.J. Fokkink, S.M. Orzan, J. Pang, J.C. van de Pol, J.A. Valero Espada.
- 8th Workshop on Formal Methods for Industrial Critical Systems, Trondheim, Norway, June 5–7: W.J. Fokkink, S.M. Orzan (Distributed State Space Minimization), J.C. van de Pol (Lecture: New Developments around the μCRL Toolset).
- 4th Workshop Security: Applications, Formal aspects and Environments in the Netherlands (SAFE-NL), Eindhoven, June 13: W.J. Fokkink, S. Mauw (Lecture: Operational Semantics of Security Protocols).

- 3rd International Conference on Application of Concurrency to System Design, Guimaraes, Portugal, 18–20 June: J.A. Valero Espada (Lecture: Verification of JavaSpaces Parallel Programs).
- 30th International Colloquium on Automata, Languages and Programming, Eindhoven, June 30–July 4: W.J. Fokkink, J.F. Groote.
- 1st EEF Global Computing Summer School, Edinburgh, Scotland, July 7–11: J. Pang.
- 15th Computer-Aided Verification Conference, Boulder, Colorado, USA, July 8–12: S.C.C. Blom.
- Andrei Ershov 5th International Conference Perspectives of System Informatics, Novosibirsk, Akademgorodok, Russia, July 9–12: S.M. Orzan (Lecture: Verification of Distributed Dataspace Architectures), N. Ioustinova (Lecture: Timed Verification with μCRL).
- 2nd Workshop on Parallel and Distributed Model Checking, Boulder, Colorado, USA, July 14: S.C.C. Blom (Lectures: Compressed and Distributed File Formats for Labeled Transition Systems / Distributed Branching Bisimulation Reduction of State Spaces).
- 1st Workshop on Process Algebra: Open Problems and Future Directions, Bertinoro, Italy, July 21–25: W.J. Fokkink, J.F. Groote (Lecture: The Need for Proof Methodology).
- ICT Kenniscongres, The Hague, September 4: J.F. Groote (Lecture: Models of Software).
- Dagstuhl Seminar 03371 on Scenarios: Models, Transformations and Tools, Dagstuhl, Germany, September 7–12: S. Mauw (Lecture: Visualizing Security Protocols: An Operational Semantics).
- 4th Advanced Course on Petri Nets, Eichstätt, Germany, September 15–26: N. Ioustinova.
- 4th PROGRESS Seminar on Embedded Systems, Nieuwegein, October 22: S.C.C. Blom (Lecture: Distributed Reduction of Large State Spaces), W.J. Fokkink (Lecture: Analyzing the Redesign of a Distributed Lift System in UPPAAL).
- 2nd International Symposium on Formal Methods for Components and Objects, Leiden, November 3–7: J.F. Groote (Lecture: Visualisation of HUGE State Spaces).
- 5th International Conference on Formal Engineering Methods, Singapore, November 5–7: J. Pang (Lecture: Analyzing the Redesign of a Distributed Lift System in UPPAAL).
- 5th Workshop Security: Applications, Formal aspects and Environments in the NetherLands, Delft, November 21: W.J. Fokkink, S. Mauw.
- 9th Dutch Testing Day, Nijmegen, November 25: W.J. Fokkink.
- 1st Asian Symposium on Programming Languages and Systems, Beijing, China, November 27–29: J. Pang.

Project meetings

- AIST Kansai, Amagasaki, Japan, March 5–13: J.C. van de Pol.
- ASSERT EU-proposal meeting, Noordwijk, March 10–11: W.J. Fokkink.
- ASSERT EU-proposal meeting, Noordwijk, April 28–29; June 24–25: W.J. Fokkink, J.C. van de Pol.
- PROGRESS user meeting, Amersfoort, May 6: W.J. Fokkink, J. Pang.
- FMICS working group meeting, Trondheim, Norway, June 7: W.J. Fokkink, J.C. van de Pol.
- PROGRESS user meeting, Amsterdam, October 1: S.M. Orzan, J.C. van de Pol, J.A. Valero Espada.
- DECOS working group meeting, Luxembourg, November 4: W.J. Fokkink.

Other lectures

- Catholic Univ. Leuven, Belgium, May 16: J.C. van de Pol (Lecture: Formal Analysis of a Distributed Lift System).
- VU, June 3: J.C. van de Pol (Lecture: ARS and LTS Theory in PVS).

Courses

- Courses on distributed algorithms and on formal language theory at the VU: W.J. Fokkink.
- Course on μCRL at the TUE: J.F. Groote.
- Course on process algebra at the KUN: J.W. Klop.

Visitors

- P.R. D'Argenio, Univ. Nacional de Córdoba, Argentina, January 15 (Lecture: Reachability Analysis of Probabilistic Systems by Successive Refinements). Host: I.A. van Langevelde.

- R. Cleaveland, State Univ. Stony Brook, New York, USA, February 19 (Lecture: Crossing Boundaries, Compositionally). Host: I.A. van Langevelde.
- B. Rounds, Univ. Michigan, USA, April 22 (Lecture: The Phi-Calculus - A New Language for Distributed Control of Continuous Reconfigurable Systems). Host: I.A. van Langevelde.
- P. Hegde, IIT Delhi, New Delhi, India, May 15–July 19 (Lecture: Origin Tracking in the μCRL Toolset). Host: S.C.C. Blom.
- H. Ohsaki, AIST Kansai, Amagasaki, Japan, June 16–20 (Lecture: Automated Verification of Network Protocols based on AC-Tree Automata Theory). Host: J.C. van den Pol.
- S. Nain, IIT Delhi, New Delhi, India, June 16–July 19 (Covers - A Simpler View on Process Equations). Host: W.J. Fokkink.
- J. Bradfield, Univ. Edinburgh, Edinburgh, UK, June 25 (Lecture: Independence and Concurrency). Host: S.M. Orzan.
- M.T. Dashti, Univ. Teheran, Teheran, Iran, August 26–28 (Lecture: Formal Verification of Cryptographic Protocols: A Survey). Host: W.J. Fokkink.
- H. Fecher, Univ. Mannheim, Germany, September 9 (Lecture: Event Structures for Interrupt Process Algebras). Host: N. Ioustinova.
- H. Ohsaki, AIST Kansai, Amagasaki, Japan, September 15–16. Host: J.C. van den Pol.
- M. Keinänen, Univ. Helsinki, Finland, September 15–December 23 (Lecture: Solving Disjunctive/Conjunctive Boolean Equation Systems with Alternating Fixed Points). Host: W.J. Fokkink.

Memberships of committees and other professional activities

S.C.C. Blom

- Maintains the NVTI mailing list, an email list on theoretical computer science: 100 subscribers.

W.J. Fokkink

- Professor of Computer Science, VU.
- Member science council, computer science department, VU.
- Coordinator CWI Security Platform.
- Member science committee IPA.
- Member steering committee SAFE-NL.
- Member programme committee NWO open competition.
- Member programme committee PROGRESS.
- Reviewer for IWT-Vlaanderen.
- Program chair FMICS'03, Trondheim, Norway, June 5–7.
- Member programme committee PDMC'03, July 14.
- Member programme committee EXPRESS'03, September 2.
- Member programme committee 9th Dutch Testing Day, November 25.
- Member PhD committee T.A.C. Willemse, TUE, February 20.

J.F. Groote

- Professor of Computer Science, TUE.
- Director of Education, Computer Science curriculum, TUE.
- Board member of the Eindhoven Embedded Systems Institute.
- Member programme committee TACAS'03, Warsaw, Poland, April 7–11.
- Member programme committee PSI'03, Novosibirsk, Russia, July 9–12.
- Member of programme committee LPAR'03, Almaty, Kazachstan, September 22–26.
- Member PhD committee J.J.D. Aerts, TUE, January 16.
- 2nd advisor T.A.C. Willemse, TUE, February 20.

J.W. Klop

- Professor of Computer Science, VU.
- Head of Theoretical Computer Science, VU.
- Member editorial board CWI Tracts and Syllabi.
- Chairman Dutch Association for Theoretical Computer Science (NVTI).

I.A. van Langevelde

- Participated in the 'IEEE P1394.1 Reflector Discussion List', evangelising the need for formal methods in standardization and pointing out weak points in the Draft Standard.

B. Lisser

- Maintained the concurrency mailing list, which is an email forum focusing on concurrent process theory: 900 subscribers.

S. Mauw

- Member programme committee SDL Forum'03, Stuttgart, Germany, July 1–4.
- Member PhD committee T.A.C. Willemse, TUE, February 20.

J.C. van de Pol

- Vice-chair ERCIM working group FMICS.
- Member PhD committee D. Hendriks, UU, October 31.

Academic publications

Publications in refereed journals and proceedings

1. L. Aceto, W.J. Fokkink, A. Ingólfsdóttir (2003). A note on an expressiveness hierarchy for multi-exit iteration. Information Processing Letters 87(1), 17–23.
2. S. Borst, O. Boxma, J.F. Groote, S. Mauw (2003). Task allocation in a multi-server system. Journal of Scheduling, 6(5), 423–436.
3. W.J. Fokkink, T.D. Vu (2003). Structural operational semantics and bounded nondeterminism. Acta Informatica, 39(6/7), 501–516.
4. J.F. Groote, J. Pang, A.G. Wouters (2003). Analysis of a distributed system for lifting trucks. Journal of Logic and Algebraic Programming 55(1-2), 21–56.
5. J.F. Groote, O. Tveretina (2003). Binary decision diagrams for first-order predicate logic. Journal of Logic and Algebraic Programming 57(1-2), 1–22.
6. J.F. Groote, H. Zantema (2003). Resolution and binary decision diagrams cannot simulate each other polynomially. Journal of Discrete Applied Mathematics 130(2), 157–171.

Conference proceedings

1. Th. Arts, W.J. Fokkink (eds) (2003). Proceedings 8th Workshop on Formal Methods for Industrial Critical Systems. Electronic Notes in Theoretical Computer Science 80, Elsevier.
2. H.M.A. van Beek, S. Mauw (2003). Automatic conformance testing of internet applications. Workshop on Formal Approaches to Testing of Software (FATES'03), Montreal, LNCS 2931. Springer, 205–222.
3. S.C.C. Blom, W.J. Fokkink, S. Nain (2003). On the axiomatizability of ready traces, ready simulation and failure traces. Proceedings 30th Colloquium on Automata, Languages and Programming (ICALP'03), Eindhoven, LNCS 2719, Springer, 109–118.
4. S.C.C. Blom, J.F. Groote, I.A. van Langevelde, B. Lisser, J.C. van de Pol (2003). New developments around the μCRL tool set. Proceedings 8th Workshop on Formal Methods for Industrial Critical Systems (FMICS'03), Trondheim. Electronic Notes in Theoretical Computer Science 80, Elsevier 2003.
5. S.C.C. Blom, N. Ioustinova, N. Sidorova (2003). Timed verification with μCRL. Proceedings 5th Conference on Perspectives of System Informatics (PSI'03), Novosibirsk, LNCS 2890, Springer, 178–192.
6. S.C.C. Blom, I.A. van Langevelde, B. Lisser (2003). Compressed and Distributed File Formats for Labeled Transition Systems. Proceedings 2nd Workshop on Parallel and Distributed Model Checking, Boulder, Colorado. Electronic Notes in Theoretical Computer Science 89(1). Elsevier.
7. S.C.C. Blom, S.M. Orzan (2003). Distributed State Space Minimization. Proceedings 8th Workshop on Formal Methods for Industrial Critical Systems (FMICS'03), Trondheim. Electronic Notes in Theoretical Computer Science 80. Elsevier.
8. C.J.F. Cremers, S. Mauw, E.P. de Vink (2003). Defining authentication in a trace model. Proceedings 1st Workshop on Formal Aspects in Security and Trust (FAST'03), Pisa, 131–145.
9. W.J. Fokkink, R.J. van Glabbeek, P. de Wind (2003). Compositionality of Hennessy-Milner logic through structural operational semantics. Proceedings 14th Symposium on Fundamentals of Computation Theory (FCT'03), Malmö, LNCS 2751, Springer, 412–422.

10. W.J. Fokkink, J. Pang (2003). Cones and foci for protocol verification revisited. Proceedings 6th Conference on Foundations of Software Science and Computation Structures (FOSSACS'03), Warsaw, LNCS 2620, 267–281.
11. J.F. Groote, F. van Ham (2003). Large State Space Visualization. Proceedings 9th Conference on Tools and Algorithms for the Construction and Analysis of System (TACAS'03), Warsaw, LNCS 2619, 585–590.
12. J.J.M. Hooman, J.C. van de Pol (2003). Equivalent Semantic Models for a Distributed Dataspace Architecture. Proceedings 1st Symposium on Formal Methods for Components and Objects (FMCO'02), LNCS 2852, 182–201.
13. I.A. van Langevelde, J.M.T. Romijn, N. Goga (2003). Founding FireWire Bridges through Promela Prototyping. Proceedings 8th Workshop on Formal Methods for Parallel Programming: Theory and Applications (FMPPTA'03), Nice, IEEE, CD-rom.
14. S.M. Orzan, J.C. van de Pol (2003). Verification of distributed dataspace architectures. Proceedings 5th Conference on Perspectives of System Informatics (PSI'03), Novosibirsk, LNCS 2890, 192–206.
15. J. Pang, W.J. Fokkink, R. Hofman, R. Veldema (2003). Model checking a cache coherence protocol for a Java DSM implementation. Proceedings 8th Workshop on Formal Methods for Parallel Programming: Theory and Applications (FMPPTA'03), Nice, IEEE, CD-rom.
16. J. Pang, B. Karstens, W.J. Fokkink (2003). Analyzing the redesign of a distributed lift system in UPPAAL. Proceedings 5th Conference on Formal Engineering Methods (ICFEM'03), Singapore, LNCS 2885, 504–522, Springer.
17. J.C. van de Pol, M. Valero Espada (2003). Verification of JavaSpaces Parallel Programs. Proceedings 3rd Conference on Application of Concurrency to System Design (ACSD'03), Guimaraes, IEEE, 196–205.
18. H. Zantema, J.F. Groote (2003). Transforming equality logic to propositional logic. Proceedings 4th Workshop on First-order Theorem Proving (FTP'03), Valencia, Electronic Notes in Theoretical Computer Science 86(1), CD-rom.

CWI reports

SEN-E0312, SEN-E0313, SEN-R0303, SEN-R0308, SEN-R0310.
See page 180 for complete titles.

Technical reports published elsewhere

1. H. Gao, J.F. Groote, W.H. Hesselink (2003). Efficient almost wait-free parallel accessible dynamic hashtables. Technical Report CS-03-03, Computer Science Reports, Department of Mathematics and Computer Science, TUE.
2. J.F. Groote, M. Voorhoeve (2003). Operational semantics for Petri Net components. Technical Report CS-03-08, Computer Science Reports, Department of Mathematics and Computer Science, TUE.

Software developed

- B. Lisser implemented stateview, which as an add-on to the μCRL simulator, displays transition systems of the components of a process. He optimised the μCRL instantiator. He implemented jsim, a Java simulator which allows you to wander through labeled transition systems or linear process equations. He implemented in C and documented the api's vdb.h, tdb.h, fifo.h and ltree.h.
- J.C. van de Pol implemented Unify, a unification library for the ATerm library. Furthermore, he developed TERA, a DPLL based theorem prover for boolean formulas over a term algebra.
- J.C. van de Pol and J.A. Valero Espada developed a tool to use data abstraction in system verification.
- S.M. Orzan and J.C. van de Pol implemented tools to assist in the functional and performance analysis of distributed systems.
- S.C.C. Blom and S.M. Orzan implemented distributed tools for the reduction of state spaces modulo strong/branching bisimulation. developed single-threaded tools for state space reduction modulo $\tau * a$-equivalence and strong/branching/weak bisimulation.
- N. Ioustinova, together with D. Bosnacki and N. Sidorova, implemented her approach for timer abstractions in the DTSpin model checker.
- J.F. Groote implemented mucheck, a symbolic prover to establish modal formulas on linear process equations.

- S. Mauw developed SPDL, a prototype secrecy model checker for security protocols, together with I. Schnitzler.

Professional products

Publications for a broad audience

1. Th. Arts, W.J. Fokkink (2003). 8th Workshop on Formal Methods for Industrial Critical Systems. ERCIM News 54, 4.
2. H. Eertink, W.J. Fokkink, I.A. van Langevelde, H. Hermanns (2003). Systems Validation Centre shows benefits of formal methods. ERCIM News 52, 39–40.
3. H. Eertink, W.J. Fokkink, I.A. van Langevelde, H. Hermanns (2003). The Systems Validation Centre in retrospect. Nieuwsbrief voor de Nederlandse Vereniging voor Theoretische Informatica 7, 33–37.
4. J.F. Groote (2003). Master Course Embedded Systems at TUE. ERCIM News 52, 43.

Coordination Languages – SEN3

Mission

Large systems of distributed, heterogeneous software components play an increasingly important role within our society. The paradigm shift from objects to components in software engineering is necessitated by such societal demands, and is fueled by Internet-driven software development. Using components means understanding how they individually interact with their environment, and specifying how they should engage in mutual, cooperative interactions in order for their composition to behave as a *coordinated* whole. Coordination models and languages address such key issues in Component Based Software Engineering as specification, interaction, and dynamic composition of components. The activity in this theme is focused on: (1) Development of formal models for coordination, components, and component-based software. Development of and experiments with the coordination models and languages, and using them to work on real applications. (2) Development and application of compositional specification and verification methods for dynamically reconfigurable systems of components, and their utilization for semi-automatic verification tools. (3) Study of the foundations of computation, notably operational semantics and coalgebraic methods, and the use of coalgebra and coinduction in formal models for coordination and composition of components.

There is close interaction among the three subthemes of SEN3 on our focal topics of coordination and components, formal methods, and coalgebras. The importance of the symbiosis of experimental and theoretical computer science research is illustrated by our work on Reo. This work involves compositional construction of component connectors which uses coalgebra for its formal model, as well as specification and verification methods for component reconfiguration, involving programming logics.

The theme has continued its cooperation with many partners, both inside CWI and outside (see below). The practical relevance of the work of SEN3 is illustrated by the participation in several projects in which SEN3 cooperates with many industrial partners. In addition to the involvement in two ongoing NWO projects, SEN3 participates in the ArchiMate project in the context of the Telematics Institute, the EU-IST project OMEGA, and the NWO/DFG project MOBIJ. In 2003, the following projects were granted: C-Quattro (NWO), CIM (SENTER), and participation in BRICKS (Bsik).

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
Dr. F. Arbab	1.0	Leader SEN3.1	indefinite	SEN3.1: Tel. Inst. ArchiMate, Adaptive Planet, B.V., NWO CBCS; SEN3.2: Mobi-J; SEN3.3: NWO C-Quattro
Drs. F. Bartels	1.0	PhD student	1999-09-01 till 2003-09-01	SEN3.3: NWO PROMACS
Drs. C.L. Blom	1.0	programmer	indefinite	SEN3.1: NWO CBCS, Tel. Inst. ArchiMate
Dr. F.S. de Boer	0.7	leader SEN3.2	indefinite	SEN3.1: Tel. Inst. ArchiMate; SEN3.2: NWO Mobi-J; EU Omega; SEN3.3: NWO C-Quattro
F.J. Burger	0.6	programmer	indefinite	SEN3.1: Tel. Inst. ArchiMate
Drs. D. Costa	1.0	PhD student	2003-12-01 till 2007-12-01	SEN3.1, SEN3.3
Dr. N.K. Diakov	1.0	post-doc	2003-07-01 till 2006-07-01	SEN3.1: SENTER CIM
Drs. C.T.H. Everaars	1.0	programmer	indefinite	SEN3.1: SENTER CIM
Drs. J.V. Guillen Scholten	1.0	PhD student	2001-07-01 till 2005-06-30	SEN3.1: Mobi-J, SEN3.1: Tel. Inst. ArchiMate
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: Tel. Inst. ArchiMate, SENTER CIM; SEN3.2; SEN3.3: NWO PROMACS, NWO COCON, NWO COMOLO, NWO C-Quattro
Dr. M. Sirjani	1.0	post-doc	2003-02-01 till 2003-11-01	SEN3.1; SEN3.2; SEN3.3: NWO COCON
Dr. L.W.N. van der Torre	1.0	post-doc	2002-12-01 till 2005-12-01	SEN3.1: Tel. Inst. ArchiMate
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
E. Abraham-Mumm (CAU[1])	0.1	PhD student	2000-01-01 till 2004-01-01	SEN3.2

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

Prof.dr. J.W. de Bakker (retired)	p.m.	advisor	2002-01-07 till 2004-01-01	SEN3.1, SEN3.2, SEN3.3
Dr. M.M. Bonsangue (UL)	0.2	senior researcher	indefinite	SEN3.2: NWO Mobi-J
Prof.dr. J.N. Kok (UL)	p.m.	advisor	indefinite	SEN3.1, SEN3.2, SEN3.3
Drs. C. Kupke (UvA)	0.4	PhD student	2002-02-01 till 2006-02-01	SEN3.3: NWO COMOLO
B. Romero Matia (Univ. Catalunya)	1.0	trainee	2002-10-01 till 2003-07-01	SEN3.1
Drs. C. Pierik (UU)	0.1	PhD student	2002-01-01 till 2006-01-01	SEN3.2: NWO Mobi-J

Scientific report

Highlights

- Organization of FMCO 2003, second international conference on Formal Methods for Components and Objects. More than 75 participants from 17 countries (including Canada, USA, and Japan) attended the symposium. This year, the symposium included a rich assortment of activities including a preconference workshop on Assertional Methods for Java and a meeting on real-time UML held by the members of the European IST project OMEGA.
- Acceptance of the NWO project C-Quattro (Compositional Construction of Component Connectors), the largest project accepted in the open competition 2003.
- Appointment associate professor at UL of F.S. de Boer.

PhD students

E. Abraham-Mumm
F. Bartels
D. Costa
J.V. Guillen Scholten
C. Kupke
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 foundation for our implementation of practical component-based software engineering tools and support environments.

Title	ArchiMate – Enterprise Architecture Animation
Period	July 2002–December 2004
Leader	F. Arbab
Staff	F. Arbab, F.S. de Boer, M.M. Bonsangue, F.J. Burger, J.J.M.M. Rutten, L.W.N. van der Torre
Funding	Telematics Institute
Partners	Telematics Institute, Ordina Institute, KUN, UL, ABP, ABN-AMRO, Belastingdienst

Progress report. The goal of the Archimate project is to provide an integration of architectures – principles, methods and models – used in the design and realization of organizational structures, business processes, information systems, and infrastructures. The Archimate consortium covers a broad industrial as well as academic spectrum. The role of CWI in the ArchiMate project is to coordinate visualization and analysis research groups and to participate in the activities of the conceptual modelling research group.

During 2003, the second year of the project, a conceptual model and architectural description language was developed. At CWI interaction techniques for enterprise architectures have been developed and illustrated in a prototype. Moreover, a logical viewpoint on architectures has been developed, which gives a precise meaning to architectural concepts defined in the IEEE 1471-2000 standard, such as architectural description, view and viewpoint. The logical viewpoint is the basis of ArchiLogic, a description logic for enterprise architectures presently under development.

Title	CBCS – Coordination Based Constraint Solvers
Period	2000–2003
Leader	F. Arbab
Staff	F. Arbab, C.L. Blom, P. Zoeteweij
Funding	NWO
Partners	PNA1 (Apt), Univ. Nantes (Monfroy)

Progress report. A configurable constraint solver, called OpenSolver was designed and developed by Zoeteweij as a software component. OpenSolver can be coordinated in several ways. Our research focused on the use of OpenSolver as a building block for a parallel constraint solver, and as a solver for arithmetic constraints on integer variables. For both, working prototypes have been implemented. The intention is to integrate OpenSolver with the Distributed Constraint Environment (DICE).

Title	Reo – Compositional Connectors for Coordination of Components
Period	2002–2005
Leader	F. Arbab
Staff	F. Arbab, F.S. de Boer, M.M. Bonsangue, C.T.H. Everaars, J.J.M.M. Rutten, J.V. Guillen Scholten, B. Romero Matia
Funding	CWI
Partner	LIACS

Progress report. Guillen Scholten's work on further development and implementation of the MoCha middleware continued in 2003. MoCha is a middleware for distributed communication based on mobile channels. As such it serves as the foundation layer for the distributed implementation of Reo. Channels allow anonymous, and point-to-point communication among components, while mobility ensures that the structure of their connections can change over time in arbitrary ways. Currently, there is a fully working beta version of MoCha available, implemented in the Java language using the Remote method invocation package. Together with Pierik, De Boer and Guillen Scholten started to work on formal verification of the Java implementation code of MoCha.

After her departure in June Romero Matia's work on the development and implementation of a visual programming environment for Reo was taken over by Everaars and continued in 2003. Because of its intended application in the CIM project, a part of this development activity was carried out by Diakov under the latter project. We worked on transforming Reo circuit specifications into constraint automata, aiming toward model-checking verification of their behaviour.

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	SENTER
Partners	SEN4, TUD, VU, Almende, CMotions, Falck

Progress report. We produced a conceptual design for the project, including a study of the project context, definition of its refined research objectives, overview of related research fields, and definition of a research perspective on the research objectives. We studied Web Services and their applicability to CIM applications, and elaborated on the application of Reo to service-oriented computing in order to improve the composability of Web Services as in the current Web Services standard. We did a preliminary study on transforming service specification formalisms such as BPEL4WS to Reo. Together with Almende, we developed an initial overall component-based software architecture for the project.

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.

The results of the research carried out in the context of the EU project OMEGA and the bilateral NWO/DFG project Mob-J is described below.

Collaboration with M. Sirjani involved an extension of the actor-based language REBECCA with synchronous signals and supervision of the student Hamed Iravanchi (Univ. Teheran), who developed an actor-based model for security protocols. Collaboration with SEN1 (P. Klint) resulted in a Masters thesis (UvA):

Using ASF+SDF for the Verification of Annotated Java Programs by R. de Haan.

Other work pursued in SEN3.2 concerns collaboration with the Intelligent Systems group at the UU on the design, semantics and proof theory of agent-oriented programming languages.

Title	OMEGA – Correct Development of Real-Time Embedded Systems in UML (Unified Modelling Language)
Period	January 2002–January 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), KUN (Hooman), Weizmann Institute (Pnueli, Harel), OFFIS (Damm), EADS Launch Vehicles, France Télécom R&D, Israeli Aircraft Industries, National Aerospace Laboratory

Progress report. The collaboration with CAU and KUN has resulted in a tool for the verification of UML models. This work has given rise to a Rule based Mark-up Language called RML developed by J.F. Jacob for the transformation of XML data. This tool is currently also applied in the ArchiMate project and in the implementation of REO developed in SEN3.1.

Title	Mobi-J: Assertional methods for mobile asynchronous channels in Java
Period	November 2001–November 2004
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	CWI, Leiden Institute for Advanced Computer Science (LIACS) (Bonsangue), CAU (De Roever)

Progress report. For a sequential subset of Java a sound and (relative) complete proof method and corresponding tool-support has been developed by C. Pierik (under supervision of F.S. de Boer) which covers object-creation, aliasing, (recursive) method calls, inheritance, sub-typing (plus casting) and dynamic binding.

In collaboration with CAU, a sound and (relative) complete method has been developed for proving correctness of multithreaded Java programs which includes exception handling and the monitor concept in Java. The formal foundation of this proof method resulted in a new fully abstract semantics for object-orientation. Currently this proof method is applied to the correctness of MoCha which is an implementation of a coordination language based on mobile channels developed by J.V. Guillen Scholten in the context of SEN3.1.

In the context of Mobi-J we have organized the second international symposium on Formal Methods for Components and Objects (FMCO 2003), Leiden, November 4–7 (see `http://fmco.liacs.nl/fmco03.html`).

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. In collaboration with Arbab, Sirjani, Baier (Univ. Bonn), the semantic modelling of the calculus of component connectors, Reo, has continued with the study of constraint automata. The coinductive calculus of streams has been applied to both signal flow graphs and sequential digital circuits.

Title	COCON – Coalgebra and control
Period	September 2001–September 2003
Leader	J.J.M.M. Rutten
Staff	F. Arbab, M. Sirjani, J.J.M.M. Rutten
Funding	NWO
Partners	MAS2 (Van Schuppen, Komenda)

Progress report. We have used constraint automata as formal semantics of Reo, using it for modelling various Reo circuits, and studying various case studies. Sirjani has furthermore studied the formal relationship between a subset of UML developed in European IST Project Omega (2001-33522) and an extended version of REBECCA (introduced by Sirjani and Movaghar, 2001), as a joint work with De Boer. She also extended REBECCA with synchronous messages and components, and presented its formal SOS-style semantics.

Title	PROMACS - Probabilistic methods for the analysis of continuous systems
Period	September 1999–Augustus 2003
Leader	J.J.M.M. Rutten
Staff	F. Bartels, J.J.M.M. Rutten
Funding	NWO
Partners	TUE (Baeten, Andova)

Progress report. The PhD project was concluded with the thesis titled 'On generalized coinduction and probabilistic specification formats', to be defended in June 2004. The main contributions are the introduction of a categorical presentation of various generalized coinductive definition and proof principles as well as well-behaved specification formats for two types of probabilistic systems. The main tool for the derivation of the formats for probabilistic systems is a decompositional method to analyze natural transformations. In joint work with Ana Sokolova and Erik de Vink from the TUE, coalgebraic techniques were used to arrange various probabilistic system types in an expressiveness hierarchy.

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), KUN (Jacobs, Hughes)

Progress report. Kupke studied the duality between categories of Boolean algebras with operators and categories of coalgebras for an endofunctor over Stone spaces. This duality was used to obtain a better understanding of the connection between modal logic and coalgebras. Furthermore, he studied coalgebraic semantics of different types of modal logics (e.g., monotone modal logic).

Societal aspects and knowledge transfer

External contacts

UL (J.N. Kok), KUN (B. Jacobs), UvA (Y. Venema), VU (Klop, Grabmayer), UU (J.J. Meyer), Univ. Teheran (M. Sirjani), Univ. Waterloo (F. Mavaddat), Univ. Bonn (C. Baier), Univ. Kiel (W.-P. de Roever).

Projects with partners in public and private sector

- ArchiMate, CIM, OMEGA.

Teaching at university

- Automata Theory (exercise class), UvA, Fall 2003: C. Kupke.
- Concurrency Verification, 15th European Summer School in Logic Language and Information (ESSLLI 2003): W.P. de Roever and F.S. de Boer.
- Business Modelling and Software Design, ICT in Business Masters Program at LIACS, UL, January–February: F. Arbab.
- *Algebraic Specification*, VU, April–May: J.J.M.M. Rutten. O2C: A Semantics Thread from Objects to Components.
- Graduate short course for PhD students, Helsinki, Finland, June 12–13: F. Arbab, F. de Boer, M.M. Bonsangue, and J. Kok.

Organization of conferences, workshops, courses, meetings

- Mobi-J meeting, München (Technical Univ.), Februari 5–7: F.S. de Boer, M.M. Bonsangue.
- IFIP WG 2.2 (Formal Description of Programming Concepts) meeting, CWI, May 14–17: F.S. de Boer.
- Mobi-J meeting Kiel, June: F.S. de Boer and M.M. Bonsangue.
- Compositional Verification of UML Models, Workshop at the sixth International Conference on the Unified Modeling Language, San Francisco, USA, October 21: F.S. de Boer, M.M. Bonsangue.
- Second International Symposium on Formal Methods for Components and Objects, FMCO 2003, Leiden, November 4–7: F.S. de Boer, M.M. Bonsangue.

Visits to conferences, workshops, symposia

- ACM Symposium on Applied Computing (SAC), Melbourne, Florida, USA, March 9–12: P. Zoeterweij (Lecture: Coordination-Based Distributed Constraint Solving in DICE).

- APPSEM II workshop, Nottingham, UK, March 26–28: C. Kupke.
- Microsoft Research, Net course in Copenhagen, Denmark, May 12–13: F. Arbab.
- ETAPS CMCS 2003, Warsaw, Poland, April 5–6: C. Kupke, J.J.M.M. Rutten, F. Bartels (Lecture: A Hierarchy of probabilistic system types).
- Microsoft Research, Net course in Copenhagen, Denmark, May 12–13: F. Arbab.
- EEF Foundations School on Concurrency, Heeze, May 19–30: M. Sirjani.
- NASSLLI - North American Summer School in Logic, Language and Information, Bloomington, USA, June 17–21: C. Kupke.
- ERCIM/CologNet Workshop on Constraints, Budapest, Hungary, June 30–July 2: P. Zoeterweij (Lecture: A Comparative Study of Arithmetic Constraints on Integer Intervals).
- IJCAI03 & BDIO-CTL, August 10–20: L.W.N. van der Torre (Presentations: Hidden Uncertainty in the Logical Representation of Desires and Properties of Obligation in Agent Specification Languages).
- AI*IA03, August 22–24: L.W.N. van der Torre (Presentation: Obligations as Social Constructs).
- NSAC 2003, Novisad, Serbia, August 26–29: J.J.M.M. Rutten (Plenary lecture: Concrete coalgebra).
- Second International Workshop on Foundations of Coordination Languages and Software Architectures (FOCLASA 2003), Marseille, France, September 6: F. Arbab, J.J.M.M. Rutten (Lecture: Modeling Component Connectors in Reo by Constraint Automata), M. Sirjani.
- CP 2003 doctoral programme, Kinsale, Ireland, September 29–October 3: P. Zoeterweij (Lecture: OpenSolver: a Coordination-Enabled Abstract Branch-and-Prune Tree Search Engine).
- W3C day on Web Services and their applications, October 8: N.K. Diakov.
- UML 2003, San Francisco, USA, October 21: F.S. de Boer, M.M. Bonsangue, J.F. Jacob.
- Compositional Verification of UML Models Workshop of the UML 2003 Conference, October 21, San Francisco, California, USA: F. Arbab (Lecture: Compositional Construction of Applications From Behavioral Components).
- NWO Talentendag, Slot Zeist, October 23: J.V. Guillen Scholten.
- FMCO 2003, Leiden, November 4–7: J.J.M.M. Rutten (Invited talk: Signal flow graphs for dummies); F. Arbab, F.S. de Boer, M.M. Bonsangue, J.F. Jacob, C. Pierik, J.V. Guillen Scholten, M. Sirjani, L.W.N. van der Torre.
- IAT03 & WI03, November 11–18: L.W.N. van der Torre (Presentations: Norm Governed Multiagent Systems: The delegation of control to autonomous agents and Local Policies for the Control of Virtual Communities).
- IPA Herfstdagen on Compositional Programming Methods, Beekbergen, November 17–21: F. Arbab (Invited talk: Reo: A Coordination Model for Component Composition), J.J.M.M. Rutten (Invited talk: Component connectors and circuits, a formal introduction), P. Zoeteweij.
- Formal Methods for Open Object-based Distributed Systems (FMOODS), Paris, France, November 19–21: F.S. de Boer, C. Pierik.
- BNAIC03, November 24–25: L.W.N. van der Torre (Presentations: Design by contract and Trias Politica).

Working visits

- Univ. Freiburg (E. Abraham-Mumm), January: C. Pierik.
- Univ. München (Prof. M. Broy) February 5–7: F. Arbab, F.S. de Boer, M.M. Bonsangue, J.J.M.M. Rutten, W.P. de Roever (in the context of the Mobi-J project).
- Univ. Leicester, UK (Alexander Kurz), March 23–29: C. Kupke.
- Van Gogh exchange project 'BOID argumentation', Toulouse, France, April 1–21: L.W.N. van der Torre.
- Univ. Torino (G. Boella), June 1–10 and July 1–20: L.W.N. van der Torre.
- Institut für Informatik, Univ. Bonn (Christel Baier) July 13–19: M. Sirjani.
- Microsoft Research, Redmond, Washington, USA (Wolfram Schulte and Yuri Gurevich) August 12: F. Arbab.
- Computer Science Department, Univ. Southern California, Los Angeles, California, USA (Nenad Medvidovic), July 22: F. Arbab.
- School of Computer Science, Univ. Waterloo, Ontario, Canada (Farhad Mavaddat), October 5–7 and October 9–10: F. Arbab.

- Computer Science Department, Brown Univ., Providence, Rhode Island, USA (Peter Wegner and Dina Goldin), October 8: F. Arbab.
- Computer Science Department, Univ. California, San Diego, California, USA (Joseph Goguen), October 16: F. Arbab.
- Department of Electrical Engineering and Computer Science, Univ. California, Berkeley, California, USA (Edward Lee) October 20: F. Arbab.

Project meetings

- EU project OMEGA, January 21–23, Brussels: F.S. de Boer, J.F. Jacob, Februari 22–28, Grenoble: F.S. de Boer, June 26–27, Paris: F.S. de Boer, September 10–11, Brussels: F.S. de Boer, J.F. Jacob. September 30–October 3, Amsterdam: F.S. de Boer, J.F. Jacob.
- Moby-J project workshop, February 4–7 München: J.V. Guillen Scholten (Lecture: A Channel Based Coordination Model for Components), F. Arbab (Reo: A Coordination Model for Component Composition), J.J.M.M. Rutten, F.S. de Boer, M.M. Bonsangue.
- Moby-J project workshop, Leiden, November 3: J.V. Guillen Scholten, F. Arbab.

Other lectures

- Invited observer at the IFIP 2.2 (Formal Description of Programming Concepts) meeting, CWI, May 14–16: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition), J.J.M.M. Rutten (Lecture: A coinductive calculus of component connectors).
- Invited speaker, Computer Science Department, Univ. Southern California, Los Angeles, California, USA, July 22: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition).
- Invited speaker, Microsoft Research, Redmond, Washington, USA, August 12: F. Arbab (Lecture: Reo: A Coordination Model for Component Composition).
- Invited speaker, School of Computer Science, Univ. Waterloo, Ontario, Canada, October 10: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition).
- Invited speaker, Computer Science Department, Brown Univ., Providence, Rhode Island, USA, October 8: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition).
- Invited speaker, Computer Science Department, Univ. California, San Diego, California, USA, October 16: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition).
- Invited speaker, Department of Electrical Engineering and Computer Science, Univ. California, Berkeley, California, USA, October 20: F. Arbab (Lecture: Abstract Behavior Types: A Foundation Model for Components and Their Composition).
- Invited speaker, Computer Science Department, TUE, December 12: F. Arbab (Lecture: Reo: A Coordination Model for Component Composition).

Visitors

- Ana Sokolova, TUE, March 4: (Lecture: A hierarchy of probabilistic system types). Host: F. Bartels.
- Christel Baier, Univ. Bonn, March 23–April 4 (Lecture: Branching Time Relations for Markov Chains). Host: J.J.M.M. Rutten.
- W.P. de Roever and M. Kyas, March 31–April 1. Host: F.S. de Boer (OMEGA meeting).
- Jerome Lang, IRIT Toulouse, June 10–20. Host: L.W.N. van der Torre.
- Robbert de Haan, UvA, April 1 (Lecture: Using ASF+SDF for the Verification of Annotated Java Programs). Host: F.S. de Boer.
- B. Rounds, Univ. Michigan, April 22 (Lecture: The Phi-calculus - a new language for distributed control of continuous reconfigurable systems). Host: J.J.M.M. Rutten.
- Yde Venema, UvA, July 1 (Lecture: Unifying the field of modal logics). Host: J.J.M.M. Rutten.
- Alexander Kurz, Univ. Leicester, July 19–August 9 and November 9–November 19. Host: C. Kupke, J.J.M.M. Rutten.
- Nikunj R. Mehta, Univ. Southern California, September 7–12 (Lecture: Composing Style-Based Software Architectures from Architectural Primitives). Host: F. Arbab.
- W.P. de Roever and M. Kyas (OMEGA meeting), September 8–9. Host: F.S. de Boer (OMEGA meeting).

- Hamed Iravanchi Zadeh, Sharif Univ. Teheran, September 20–27 (Lecture: Verification of Security Protocols with Rebeca). Host: F.S. de Boer, M. Sirjani.
- Christel Baier, Univ. Bonn, November 15–December 5 (Lecture: Reo: Semantics and Tools for Design and Analysis. State-of-the-Art and Future Work). (together with M. Sirjani). Hosts: F. Arbab, M. Sirjani, J. Rutten.
- W.P. de Roever and M. Kyas (OMEGA meeting), December 1–2. Host: F.S. de Boer.
- Andreas Herzig, IRIT Toulouse, December 1–20. Host: L.W.N. van der Torre.
- Harko Verhagen, Univ. Stockholm, December 24. Host: L.W.N. van der Torre.
- E. Abraham-Mumm and M. Steffen, December 8–12. Host: F.S. de Boer (Mob-J meeting).

Memberships of committees and other professional activities

F. Arbab

- Member Association for Computing Machinery.
- Member IEEE Computer Society.
- Member IPA, Dutch Graduate School Institute for Programming and Algorithmics.
- Masters project supervisor, Beatriu Romero Matia, Barcelona School of Informatics, Univ. Polytecnica de Catalunya, Spain.
- (Co)project leader of NWO/EW research projects C-Quattro (developing a compositional calculus of component connectors) and Coordination-based parallel constraint solving.
- Member SENTER research project CIM (Cybernetic incident management) and Telematics Institute research project Archimate (Enterprise architecture animation).
- Editor special issue of the Journal of Supercomputing on Coordination Models and Languages, Kluwer, 24, (2), February.
- Evaluator for the IST project ArchWare, the EC, March 19–20, and November 28.
- Member programme committee, second International Workshop on Foundations of Coordination Languages and Software Architectures (FOCLASA 2003), Marseille, France, September 6.
- Member programme committee, Web Service Engineering session, 29th EuroMicro conference, Antalya, Turkey, September 3–5.
- Member programme committee, PaCT-2003 (Parallel Computing Technologies) International conference in Nizhnii Novgorod, Russia, September 15–19.
- Member programme committee, UMICS '03: Ubiquitous Mobile Information and Collaboration Systems, Klagenfurt/Velden, Austria, June 16–17, 2003 (in conjunction with CAiSE '03).
- Member programme committee member, International Workshop on Distributed and Mobile Collaboration (DMC 2003) June 9–11, Linz, Austria, at WETICE 2003: IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises.
- Member PhD committee outside member for Andrea Bracciali, Univ. Pisa, Italy, January.
- Advisory Board member, EURO-PAR 2003, Klagenfurt, Austria, August 26–29.
- Member programme committee, International Conference on Web Services - Europe 2003 (ICWS-Europe'03), Erfurt, Germany, September 23–24.
- Evaluator for the IST project ArchWare, the EC, March 19–20, and November 28.

F. Bartels

- Member IPA, Dutch Graduate School Institute for Programming and Algorithmics.

F.S. de Boer

- Member programme committee of the second International Joint Conference on Autonomous Agents and Multi-Agent Systems, Melbourne, Australia.
- Member programme committee of the ICALP workshop LCMAS Logic and Communication in Multi-Agent Systems.
- Member programme committee of the ICALP workshop SecCo Security Issues in Coordination Models, Languages and Systems.
- Organizer of the Second International Symposium of Formal Methods for Components and Objects (FMCO 2003).
- Editor of Proceedings of the First International Symposium on Formal Methods for Components and Objects (FMCO 2002), LNCS 2852.
- Coordination of the EU project OMEGA.

M.M. Bonsangue

- Fellow of the Royal Netherlands Academy of Arts and Sciences (KNAW).
- Member of the Dutch Architectural Forum (NAF).
- Co-organizer of the second International Symposium on Formal Methods for Components and Objects, Lorentz Center, UL, The Netherlands, November 3–7.
- Member and co-organizer and of the programme committee of the workshop on Compositional Verification of UML Models, affiliated to the 6th Int. Conference on UML - Modelling Languages and Applications (UML 2003), October 21, Fort Mason Center, San Francisco, USA.

J.V. Guillen Scholten

- Membership IPA, Dutch Graduate School Institute for Programming and Algorithmics.

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: ProMACS (Probabilistic Methods for the Analysis of Continuous Systems), COMOLO (Coalgebra and modal logic), COCON (coalgebra and control), C-Quattro (developing a compositional calculus of component connectors).
- Project member of SENTER research project CIM (Cybernetic incident management) and Telematics Institute research project Archimate (Enterprise architecture animation).
- 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.
- Chairman of the steering committee of the Coalgebraic Methods in Computer Science (CMCS) workshop series.
- Board member of the 'NVTI' (Dutch Association of Theoretical Computer Science). Editor of NVTI's newsletter.
- Member of Research Schools IPA and OzsL.
- Member of the programme committees of the 19th Conference on the Mathematical Foundations of Programming Semantics (MFPS XIX), Montreal; the sixth international workshop on Coalgebraic Methods in Computer Science (CMCS 2003), Warsaw; the 28th international symposium on Mathematical Foundations of Computer Science (MFCS 2003), Bratislava.
- External examiner of PhD thesis of Marco Kick, October 9, Univ. Edinburgh (advisor was G. Plotkin).

L.W.N. van der Torre

- Member programme committee, second International Workshop on Regulated Agent-Based Social Systems: Theories and Applications (RASTA'03) at ICAIL 2003, Edinburgh, UK, June 23.
- Member programme committee, seventh European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU-2003), Aalborg, Denmark, July 2.
- Member programme committee, workshop on Uncertainty, incompleteness, imprecision and conflict in multiple data sources at ECSQARU-2003, Aalborg, Denmark, July 2.
- Member programme committee, Game theoretic and decision theoretic agents (GTDT 2003) workshop held at The Second International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2003), Melbourne, Australia, July 15.
- Member programme committee, The First International Workshop on Programming Multi-Agent Systems: Languages, frameworks, techniques and tools (PROMAS 2003) held at The Second International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2003), Melbourne, Australia, July 15.

P. Zoeteweij

- Member IPA, Dutch Graduate School Institute for Programming research and Algorithmics.

Academic publications

Publications in refereed journals

1. R. Banach, F. Arbab, G.A. Papadopoulos, J.R.W. Glauert (2003). A Multiply Hierarchical Automaton Semantics for the IWIM

Coordination Model. Journal of Universal Computer Science 9(1), 2–33.
2. F. Bartels (2003). Generalized Coinduction. Mathematical Structures in Computer Science 13(2), 321–348.
3. M.M. Bonsangue, J.N. Kok (2003). Infinite intersection types. Information and Computation 186(2), 285–318.
4. R.M. van Eijk, F.S. de Boer, W. van der Hoek, J.-J.Ch. Meyer (2003). A verification framework for agent communication. Autonomous Agents and Multi-Agent Systems (6)2, 185–219.
5. F.S. de Boer, R.M. van Eijk, W. van der Hoek, J.-J.Ch. Meyer (2003). A fully-abstract model for the exchange of information in multi-agent systems. Theoretical Computer Science 290(3), 1753–1773.
6. D. Makinson, L. van der Torre (2003). Permissions from an input/output perspective. Journal of Philosophical Logic 32(4), 391–416.
7. J.J.M.M. Rutten (2003). Behavioural differential equations: a coinductive calculus of streams, automata, and power series. Theoretical Computer Science 308(1–3), 1–53.
8. J.J.M.M. Rutten (2003). Coinductive counting with weighted automata. Journal of Automata, Languages and Combinatorics Volume 8(2), 319–352.
9. L. van der Torre (2003). Contextual Deontic Logic: Normative Agents, Violations and Independence. Annals of Mathematics and Artificial Intelligence, 37 (1–2), 33–63.

Publications in other journals and other scientific output

Unrefereed (electronic) journals

1. R.M. van Eijk, F.S. de Boer, W. van der Hoek, J.-J.Ch. Meyer (2003). Process Algebra for Agent Communication: A General Semantic Approach. Communication in Multiagent Systems 2003, LNCS 2650.
2. J. Guillen-Scholten, F. Arbab, F.S. de Boer, M. Bonsangue (2003). A Channel-based Coordination Model for Components. ENTCS 68, Nr. 3.
3. F. Bartels, A. Sokolova, E. de Vink (2003). A Hierarchy of probabilistic System Types. H.-P. Gumm (ed.). Coalgebraic Methods in Computer Science (CMCS'03), Electronic Notes in Theoretical Computer Science 82(1).
4. C. Kupke, A. Kurz, Y. Venema (2003). Stone Coalgebras. H. Peter Gumm (ed.). Coalgebraic Methods in Computer Science (CMCS'03), Electronic Notes in Theoretical Computer Science 82(1).

Conference proceedings

1. E. Abraham-Mumm, F.S. de Boer, W.P. de Roever, M. Steffen (2003). Inductive Proof Outlines for Monitors in Java. Proceedings of Formal Methods for Open Object-based Distributed Systems (FMOODS), LNCS 2884, 155–169.
2. E. Abraham-Mumm, F.S. de Boer, W.P. de Roever, M. Steffen (2003). A Tool-supported Proof System for Multithreaded Java. Proceedings of the First International Symposium on Formal Methods for Components and Objects (FMCO 2002), LNCS 2852, 1–32.
3. E. Abraham-Mumm, F.S. de Boer, W.P. de Roever, M. Steffen (2003). A Compositional Operational Semantics for JavaMT. Proceedings of the symposium on verification- theory and practice, Festschrift celebrating Zohar Manna's 64th Birthday, LNCS 2772, 290–303.
4. F. Arbab (2003). Abstract Behavior Types: A foundation model for components and their composition. Proceedings of the International Symposium on Formal Methods for Components, Objects, and their Implementation (FMCO 2002), F.S. de Boer, M.M. Bonsangue, S. Graf, W.-P. de Roever (eds). LNCS 2852, Springer-Verlag, 33–70.
5. F. Arbab, C. Baier, J.J.M.M. Rutten, M. Sirjani (2003). Modeling component connectors in Reo by constraint automata. A. Brogi, J.M. Jacquet, E. Pimentel (eds). Proceedings of FOCLASA 2003, ENTCS, Elsevier Science B.V.
6. F. Arbab, J.J.M.M. Rutten (2003). A coinductive calculus of component connectors. M. Wirsing, D. Pattinson, R. Hennicker (eds). Recent Trends in Algebraic Development Techniques. Proceedings of 16th International Workshop on Algebraic Development Techniques (WADT 2002), LNCS 2755, Springer, 35–56.

7. G. Boella, L. van der Torre (2003). Attributing mental attitudes to normative systems. Proceedings of the Second International Joint Conference on Autonomous Agents and Multi Agent Systems (AAMAS'03), 942–943.
8. G. Boella, L. van der Torre (2003). Decentralized control: Obligations and permissions in virtual communities of agents. Ning Zhong, Zbigniew W. Ras, Shusaku Tsumoto, Einoshin Suzuki (eds). Foundations of Intelligent Systems. Proceedings of the Fourteenth International Symposium on Methodologies for Intelligent Systems (ISMIS'03), LNAI 2871, Springer 618–622.
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24. P. Zoeteweij (2003). Coordination-Based Distributed Constraint Solving in DICE. Proceedings of the 2003 ACM Symposium on Applied Computing, Melbourne, Florida, USA, March 9–12, 360–366.
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CWI reports

SEN-E0305, SEN-E0314, SEN-R0304, SEN-R0305, SEN-R0306,SEN-R0309.
See page 180 for complete titles.

Technical reports published elsewhere

1. E. Abraham, M.M. Bonsangue F.S. de Boer, M. Steffen (2003). A Structural Operational Semantics for a Concurrent Class Calculus. Technical Report 0307, Department of Computer Science, Univ. Kiel, August.

Software developed

- Rule Markup Language for the transformation of XML data (developed by J.F. Jacob): see `http://homepages.cwi.nl/~jacob/rml/index.html`
- The UML2PVS tool developed in the context of the EU project OMEGA: see `http://homepages.cwi.nl/~jacob/uml2pvs.html`
- VFT, a verification tool for Java programs, developed by C. Pierik (currently used in a course at the UU on Program Correctness).
- An ASF+SDF tool for the verification of annotated Java programs developed by R. de Haan: see `http://homepages.cwi.nl/~paulk/theses/DeHaan.pdf`

Deliverables for projects

- Deliverables of the EU project OMEGA: D2.2.2. Tool set for system verification, D3.2 General methodology.
- F. de Boer, M. Bonsangue, J. Jacob, 'The OMEGA Component Models'. Omega project, deliverable D1.1.2. Available at `http://www-omega.imag.fr/index.php`, January 2003.
- F. de Boer, M.M. Bonsangue, R. van Buuren, L. Groenewegen, S. Hoppenbrouwers, H. Jonkers, M. Lankhorst, E. Proper, A. Stam. 'Concepts for Architectural Description', ArchiMate project deliverable 2.2.1, Telematics Institute reference TI/RS/2003/007.
- F. de Boer, M.M. Bonsangue, H. ter Doest, L. Groenewegen, H. Jonkers, A. Stam, L. van der Torre. 'Analysis techniques', ArchiMate project deliverable 3.5.1, Telematics Institute reference TI/RS/2003/031.

Book chapters

1. D. Makinson, L. van der Torre (2003). What is Input/Output Logic? B. Löwe, W. Malzkorn, T. Rösch (eds). Foundations of the Formal Sciences II: Applications of Mathematical Logic in Philosophy and Linguistics. Trends in Logic 17, Kluwer.

Other output

Grants

At his UL affiliation, M.M. Bonsangue obtained a two-year extension of his fellowship of the Royal Netherlands Academy of Arts and Sciences (KNAW).

Evolutionary Systems and Applied Algorithmics – SEN4

Mission

The SEN4 group Evolutionary Systems and Applied Algorithmics focuses on fundamental research and development into intelligent and adaptive systems, or computational intelligence. The theme focuses on the combination of two fields, consisting of computer science techniques and application fields:

1. Techniques concern intelligent computation: Evolutionary and multi-agent systems, adaptive algorithms, and neural networks.
2. Application fields concern: Economics, management, and e-societies (like e-business).

Important topics concern markets and market mechanisms (economics), negotiation, auctions, and social aspects (game theory), and optimization and classification (management). We give an overview of the above two distinctions from the viewpoint of agent systems in relation to e-business and economics and from the viewpoint of optimization and classification as applied in the SEN4 theme.

Agent systems: E-business and economics

The concept of software agents in computer science as well as the concept of societies of (human) agents in economics and social sciences yield important areas of research. In both cases, adaptive behavior of agents, based on their own point of view ('bounded rationality') and reactive on their dynamic environment, is essential. An important aspect of adaptivity for an agent is the skill of learning. This is a growing field of research, important for both agent technology (how to build a really-learning agent) and economics (how to simulate learning agents).

In order to allow learning in agent systems, computational learning techniques are necessary. In the SEN4 theme group, especially evolutionary systems, neural networks and adaptive algorithms are investigated, in order to build the internals of learning agents in e-commerce applications as well as to simulate markets and market mechanisms in economics and in e-commerce agent systems.

Focus areas are among others the following:

1. Adaptive strategies for trading, like negotiations, auctions (game theory), and dynamic pricing; this concerns learning behavior, especially for high-frequency trading
2. Design and simulation of market mechanisms for e-commerce
3. Simulation of markets in the fields of ACE and CAS (agent-based computational economics; complex adaptive systems; emergence)

The above three fields are closely interrelated as different levels of abstraction, from microscopic behavior (the learning software of an agent) to macroscopic behaviour (behaviour of markets consisting of adaptive agents).

Optimization and classification

More traditional fields are optimization and classification. In these areas, intelligent computation techniques are important and the subject of much research. Neural networks as well as evolutionary algorithms are particularly investigated with respect to classification problems and active learning. Special attention is given to spiking neural networks, which are novel types of neural networks. Application areas are e.g. remote sensing, data mining, profiling, and agent implementations.

Adaptive discrete algorithms as well as evolutionary algorithms are designed for e.g., decision making in dynamic environments or constraint optimization problems, like, among other, on-line process management or quality of service in information technology.

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, 58J, 60H, 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	1.0	theme leader (0.2 fte seconded to TUE)	indefinite	SEN4.1, SEN4.2; ASTA, EESEM, DEAL, FREA, FRNN, QoSMM
Drs. F. Alkemade	1.0	PhD student	1999-10-01 till 2004-10-01	SEN4.1; EESEM
Dr. S.M. Bohte	0.47	researcher	indefinite	SEN4.1, SEN4.2; FRNN, ASTA
Drs. E.H. Gerding	1.0	PhD student	1999-10-01 till 2004-05-01	SEN4.1; ASTA, FREA
Dr. J.I. van Hemert	0.1	post-doc	2002-12-01 till 2004-12-01	SEN4.1; FREA, DEAL
Dr. ir. P.J. 't Hoen	1.0	post-doc	2001-03-01 till 2005-03-01	SEN4.1; DEAL, ASTA, FRNN
Dr. T.B. Klos	0.83	post-doc	2003-02-01 till 2005-02-01	SEN4.1; ASTA, DEAL
Prof.dr. J.N. Kok (UL)	0.1	advisor	till 2006-09-01	SEN4.2; FRNN
Drs. V. Robu	0.25	PhD student	2003-10-01 till 2007-10-01	SEN4.1; DEAL, FREA
Dr. D.J.A. Somefun	1.0	post-doc	2001-01-01 till 2004-12-31	SEN4.1; ASTA, FREA
Dr. R. van Stee	0.66	post-doc	2003-05-01 till 2005-03-01	SEN4.2; QoSMM
I.B. Vermeulen	0.58	MSc trainee	2003-06-01 till 2004-02-01	SEN4.1; ASTA

Scientific report

Highlights

- S.M. Bohte was awarded a prestigious VENI grant by NWO, for the project Scalable Reinforcement Learning in Asynchronous Spiking Neural Networks.
- A PhD thesis was finished and defended by S.M. Bohte.
- The project 'Autonomous Systems for Trade Agents in E-Commerce (ASTA)' was completed successfully (see page 91).

PhD students

F. Alkemade; see page 91.
S.M. Bohte; see page 93.
E.H. Gerding; see page 91.
V. Robu; see page 92.

SEN 4.1 – Evolutionary Systems

Title	ASTA – Autonomous Systems of Trade Agents in E-Commerce
Period	September 1999 – December 2003
Leader	J.A. La Poutré (also project manager)
Staff	E.H. Gerding, D.J.A. Somefun, I.B. Vermeulen, T.B. Klos and S.M. Bohte
Funding	Telematics Institute (project funding)
Partners	TNO-TPD, ING, KPN Research

Progress report. Research was continued on multi-issue negotiation. Bargaining strategies were decomposed into concession strategies and Pareto-efficient search strategies. A set of Pareto-efficient search strategies for multiple issues, viz., orthogonal and orthogonal-Derivative Follower (DF), was developed. If used by two agents, approximate Pareto-efficient solutions in a setting where a buyer and seller negotiate over a multiple issues can be found. The orthogonal strategy is based on finding the closest point on the momentary iso-utility given the offer of the opponent. The orthogonal-DF strategy speeds up the process of finding an efficient deal by employing a derivative follower in combination with the orthogonal strategy. Somefun, Gerding, Bohte and La Poutré.

Strategies for one-to-many negotiations are further developed and investigated. A setting is investigated where a seller agent bilaterally negotiates with a buyer agent. The auction-inspired strategy seems superior, especially if buyers have time pressure to reach agreements early. Somefun, Gerding, and La Poutré.

Furthermore, research continued on integrating recommendations in a negotiation process. A shop aggregates data on customers' past purchases into knowledge about correlations among customers' interests in the various products the shop offers: which products are often bought together? We applied machine learning techniques to the problem of on-line learning of the bundle combinations that optimizes the revenue of a seller of information goods. When negotiating the shop uses this learned knowledge to recommend alternative, more promising bundlecompositions when the negotiation process about a particular bundle stalls. Extensive simulations with have shown that it performs superior than selected benchmarks. Somefun, Klos and La Poutré.

Lastly, work was done on repeated automated negotiation by agents. We developed an agent that can negotiate repeatedly on behalf of its owner, given some budget. To do so, it only requires general instructions about user preferences and budget constraints, which are given only once. Vermeulen, Somefun and La Poutré.

Earlier work on bargaining with posterior opportunities was extended. The ultimatum game for bilateral bargaining is extended to a market-like setting. In this new settings, sellers and buyers are endowed with several bargaining opportunities. An asymmetric case is investigated, using both an evolutionary simulation and game theory, where sellers and buyers have unequal initial opportunities. An important aspect of the game is the information available to the agents viz., complete or incomplete information about the opponent's number of bargaining opportunities. Furthermore, the effects of search costs are considered and the case where uncertainty exists about future opportunities and a new opponent cannot always be found. Gerding and La Poutré.

The ASTA project was concluded by a workshop (see page 94), where a software prototype (webbased agent platform) was presented and experienced with (see page 98).

Title	EESEM – Evolutionary Exploration Systems for Electronic Markets
Period	October 1999–September 2003
Leader	J.A. La Poutré
Staff	F. Alkemade, H.M. Amman (TUE)
Funding	NWO (project funding)
Partner	TUE

Progress report. Further research was done on the fundamentals of the techniques in agent-based computational economics (ACE). It is shown in further experiments that a relation between economic model (like the Cournot game) and settings of the evolutionary techniques must be sufficiently uncoupled, in order to have the evolutionary algorithms work well and to get robust results. This especially addresses the parameters of the evolutionary techniques versus those of the economic problem. Also, comparison with replicator dynamics are made.

Alternative ways of designing and implementing the relation are given, yielding more robust results. An extensive comparison is made to show this. Alkemade, La Poutré and Amman (TUE).

Also, research was done on the spread of an innovation over consumers networks. The networks consist of agents that are exposed to the introduction of a new product. Consumers decide whether or not to buy the product based on their own preferences and the decisions of their neighbours in the social network. We have used and extended concepts from epidemics and herd behaviour to study this problem. The central question is whether firms can learn about the network structure and consumer characteristics when only limited information is available, to evolve a successful, directed advertising strategy. We have extended existing models to allow for heterogeneous agents and positive, as well as negative externalities. A firm can learn a directed advertising strategy that takes into account both the topology of the social consumer network, and the characteristics of the consumer. Such directed advertising strategies outperforms random advertising. Alkemade and C. Castaldi (Sant'Amma school of advanced studies, Pisa).

In addition, evolution-inspired algorithms that are increasingly used in social simulation were studied. These evolutionary algorithms were originally developed as biologically inspired optimization tools. Although evolutionary simulations often adequately model macro-level phenomena and even mimic empirical data, they do not provide a realistic model of social behaviour on a micro-level. In our research, we develop behaviour-based evolutionary algorithms suitable for social simulation and show some result using those algorithms. Alkemade and B. Rand (Univ. Michigan, USA).

Title	DEAL – Distributed Engine for Advanced Logistics
Period	May 2002–2006
Leader	J.A. La Poutré
Staff	P.J. 't Hoen, J.I. van Hemert, T.B. Klos, and V. Robu
Funding	E.E.T. (Novem) (project funding)
Partners	Almende, EUR, VU, Vos Logistics, Post Kogeko Transport Group, Groeneveld Group

Progress report. Work is in progress on dynamic routing, where the aim is to model both the dynamic aspect of the problem and the ability to incorporate forecasting of prospected loads. By incorporating knowledge about the probabilities of loads occurring in regions we aim at improving upon conventional routing algorithms. Van Hemert and La Poutré.

Furthermore, in routing problems, the underlying network structure may be responsible for the difficulty in solving the routing problem. An investigation was started into how well evolutionary computation can be used to generate network structures that adhere to predefined properties. Van Hemert and N.B. Urquhart (Napier Univ., UK).

Also, further work was performed on the development of robust, distributed market mechanisms as part of Multi-Agent Systems, for usage in the logistics of the transportation sector. In this work, online, decentralized auctions are used as model, where agents (representing trucks) bid for cargo in a MAS logistics setting. Bidding strategies were then studied, which were novel for such a large scale setting. In the setting, agents have the opportunity to unilaterally *decommit* from contracts. In an extended series of computer experiments for the above transportation settings, it is shown that significant increase in performance (profit) can be realized by a company with agents who can decommit loads. As a necessary precondition, decommitment is only a clearly superior strategy if an agent is close to the limit of its capacity. 't Hoen, Van Bragt and La Poutré.

Also, the aspect of shifting organizational forms due to developments in Information and Communication Technology is studied. In the logistics sector certain companies adapt from being a 3rd (3PL) to being a 4th (4PL) party logistics service provider. A literature study was performed and the basics of a model were developed to study which organizational forms firms learn to use, as part of a complex system of multiple adaptive agents. Klos and La Poutré.

Finally, a literature study together with initial research was performed in the area of negotiation by agents, as a start of the PhD research of V. Robu. Robu and La Poutré.

Title	FREA – Fundamental Research on Economic Agents and on Evolutionary Algorithms
Period	undefined
Leader	J.A. La Poutré
Staff	E.H. Gerding, D.J.A. Somefun, P.J. 't Hoen, I.J. van Hemert, F. Alkemade, S.M. Bohte
Funding	basic

Progress report. Evolutionary computation was applied in several settings, as described below.

A new representation for solving the graph colouring problem with evolutionary computation was developed and benchmarked. A comprehensive study was finished on solving binary constraint satisfaction problems with evolutionary computation. A comparative study was conducted between evolutionary computation, ant colony optimization, and constraint programming, where ant colony optimization was found to scale extremely well for solvable problem instances close to the phase transition. Van Hemert.

The robustness of parameter settings for variation operators was tested with respect to effectiveness for evolutionary algorithms that solve binary constraint satisfaction problems. Van Hemert.

Evolutionary computation was successfully used to evolve binary constraint satisfaction problems that are extremely hard to solve for constraint programming techniques. Van Hemert.

Work was carried out on a link between Reinforcement Learning (RL) for Multi-Agent Systems(MASs) and a generalized variant of CoEvolution. We show that typical results for a MAS using Q-learners are reproduced in a transformed MAS where each agent is represented by a separate Evolutionary Algorithm. We show that for specific settings that the problems in MAS RL are encountered in similar form in the Evolutionary Algorithms (EA) approach. We can however show that for a more suitable choice of an EA population model, the EA MAS is able to solve coordination problems not attainable using Q-learners. 't Hoen and K. Tuyls (Univ. Brussels, Belgium).

In addition, it was shown how the COllective INtelligence (COIN) framework of Wolpert et. al. traditionally applied to RL can be successfully applied to the EA approach. COIN is a proved engineering approach for learning of cooperative tasks in MASs. The utilities of the agents are re-engineered to contribute to the global utility. We show how the improved results for MAS RL in COIN can be translated to similar results in EA. 't Hoen.

Research was carried out on using so-called policy gradient reinforcement learning algorithms for creating adaptive software agents that can successfully bid in second-price auctions. As demonstrated in earlier work, second price auctions are a very efficient means for allocating resources, as for instance the efficient placement of personalized advertisements. Thus, learning to bid accurately fast in such an environment is an important issue. Policy-gradient algorithms allow one to specify (parameterized) prior knowledge on the problem domain, which typically allows fast convergence of the algorithm. Bohte, with Dr. G.Z. Grudic (Univ. Colorado, Boulder, USA).

Also, fundamental research was performed on areas and problems occurring in other (externally financed) projects, like ASTA and DEAL. In the FREA project, the more fundamental parts were addressed. These subjects therefore coincide with those mentioned there and are described in these projects.

Finally, some limited, preliminary work has been carried out for the upcoming CIM project Cybernetic Incident Management, which will start in 2004 for SEN4.

SEN 4.2 – Neural Networks and Discrete Algorithms

Title	FRNN – Fundamental Research on Neural Networks
Period	1998–2003
Leader	J.A. La Poutré
Staff	S.M. Bohte, J.N. Kok
Funding	basic (project funding)
Partner	UL

Progress report. The work on Spiking Neural Networks for the PhD thesis of Bohte was concluded in the beginning of 2003.

Research is carried out on applying policy gradient techniques to spiking neurons, showing how learning rules discovered in biological spiking neurons can be explained from gradient learning principles . Bohte and M.C. Mozer (Univ. Colorado, Boulder).

A fast non-parametric machine learning classification algorithm was designed: the Polynomial MPMC Cascade. The important feature of this algorithm is its linear time-complexity in the dimensionality of the classification problem as well as linear time-complexity in the size of the training dataset. Performance of this algorithm was shown to be competitive with state-of-the-art algorithms like SVM and MPMC. Bohte and Grudic (Univ. Colorado, Boulder).

Title	QoSMM – Quality of Service for Multimedia Systems
Period	1999–2004
Leader	J.A. La Poutré
Staff	R. van Stee
Funding	NWO (project funding)
Partners	Philips Research, TUE

Progress report. Research was performed on buffering policies in network switches supporting Quality of Service (QoS). We consider the FIFO model, where packets must be transmitted in the order they arrive. Each packet has an intrinsic value, and the goal is to maximize the total value of transmitted packets. The main contribution is an algorithm for the FIFO model for arbitrary packet values that for the first time achieves a competitive ratio better than 2, namely $2 - \varepsilon$ for a constant $\varepsilon > 0$. Van Stee, A. Kesselman, and Y. Mansour.

Additionally, the problem of integrated document and connection caching was considered. In document caching one has to maintain caches containing Web documents. In connection caching one has to maintain a set of open TCP connections. Previous work investigated these two problems separately while in practice the problems occur together.

In our research, we investigated a first study that integrates document and connection caching. We first consider a very basic FAULT model. We present deterministic and randomized online algorithms that achieve nearly optimal competitive ratios unless the size of the connection cache is extremely small. We then consider a general setting where documents have varying sizes. We investigate a FAULT model in which the loading cost of a document is 1 as well as a BIT model in which the loading cost is equal to the size of the document. Van Stee and S. Albers.

Research continues in the areas of online scheduling in peer-to-peer networks and online bin packing with resource augmentation. Van Stee and L. Epstein.

Societal aspects and knowledge transfer

Other external contacts

Contacts exist with, among others, the Telematics Institute, TUD, TUE, Maastricht Univ., Univ. College London, INRIA, Freiburg Univ., SICS, Cornell Univ., Univ. Lyon, France, Napier Univ., Edinburg, UK, the Univ. Brussel, Belgium and the Univ. Szeged, Hungary, Univ. Carlos III de Madrid, Spain.

Projects with partners in public and private sector

- ASTA, see page 91.
- EESEM, see page 91.
- DEAL, see page 92.
- QoSMM,see page 94.
- FRNN, see page 93.

Teaching at university

- J.A. La Poutré is lecturer of the course 'Distributed Software Architectures', especially for the part concerning agent systems (TUE).

Organization of conferences, workshops, courses, and meetings

- Organization of the workshop FUture of Neural Networks (FUNN) 2003 at the '30^{th} International Colloqium on Automata, Languages and Programming (ICALP)', Eindhoven, The Netherlands, July 9: S.M. Bohte, J.N. Kok (UL, CWI) and M. van Wezel (EUR).
- 6^{th} EvoNet Summer School in Evolutionary Computation, Parma, Italy, August 24–31: J.I. van Hemert (member organising committee).
- SEN4 seminars (February 26, June 3, August 29, November 11, November 27).
- SEN4 Journal Club meetings (monthly).
- ASTA and DEAL technical meetings (as often as needed).
- Demonstration and Closing Workshop for the ASTA project (see pages 91 and 98), ING, Amsterdam, December 16.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Symposium The 2003 Latsis Symposium on Neural Coding and Modeling, EPFL, Lausanne, Switzerland, February 17–19: S.M. Bohte (Lecture: Policy Gradient Reinforcement Learning in Spiking Neurons).
- 6^{th} European Conference on Genetic Programming (EuroGP & Evo Workshops), Essex, UK, 14–16 April: J.I. van Hemert.
- 4th ACM Conference on Electronic Commerce (EC-03), San Diego, June 9–12: J.A. La Poutré (Lecture: Intermediaries in an electronic trade network).
- 30^{th} International Colloquium on Automata, Languages and Programming, Eindhoven, June 30–July 4: R. van Stee (Lecture: A study of integrated document and connection caching).
- Computing in Economics and Finance (CEF2003), Seattle, Washington, USA, July 11–13: F. Alkemade (Lecture: An agent-based model of information contagion in a network of consumers, An evolutionary trade network simulation), D.J.A Somefun (Lecture: Bundling and Pricing for Information Brokerage).
- The Second International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), Melbourne, Australia, July 14–18: P.J. 't Hoen (Lecture: A Decommitment Strategy in a Competitive Multi-Agent Transportation Setting) and E. Gerding.
- Agent Mediated Electronic Commerce V, a workshop of The Second International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), Melbourne, Australia, July 15: P.J. 't Hoen (Lecture: A Decommitment Strategy in a Competitive Multi-Agent Transportation Setting) and E. Gerding (Lecture: Automated negotiation and bundling of information goods).
- Workshop on Collectives and the Design of Complex Systems, Stanford Univ., CA, USA, August 25–28: P.J. 't Hoen (Lecture: COllective INtelligence for Task Asssignment).
- ICT Knowledge Congress, The Hague, September 4: E. Gerding, J.I. van Hemert, P.J. 't Hoen, J.A. La Poutré.
- 11th European Symposium on Algorithms Budapest, Hungary, September 15–20: R. van Stee (Lecture: Improved competitive guarantees for QoS buffering).
- Workshop on Simulation in Economics, EUR, September 17: T.B. Klos.
- European Conference of Machine Learning (ECML) 2003, Dubrovnik, Croatia, September 22–26: P.J. 't Hoen (Lecture: COllective INtelligence with Sequences of Actions).
- First conference of the European Social Simulation Association/International Conference of the European Social Simulation Association (SimSoc/ESSA), Groningen, September 18–21: F. Alkemade (Lecture: A behaviour based evolutionary algorithm for social simulation).
- Kalmãr Workshop on Logic and Computer Science, Szeged, Hungary, October 1–2: J.I. van Hemert (Lecture: A new permutation model for solving the graph k-colouring problem).
- The 2003 IEEE/WIC International Conference on Web Intelligence (WI 2003), Halifax, Canada, October 13–16: D.J.A Somefun (Lecture: Bundling and Pricing for Information Brokerage).
- Fifteenth Belgium Netherlands Conference on Artificial Intelligence (BNAIC), Nijmegen, October 23–24: F. Alkemade (Lecture: Intermediaries in an electronic trade network), E. Gerding (Lecture: Automated Negotiation of Information Goods), P.J. 't Hoen (Lecture: A Decommitment Strategy in a Competitive Multi-Agent Transportation Setting), J.A. La Poutré.
- IEEE 2003 Congress on Evolutionary Computation (CEC'03), Canberra, Australia, December 8–13: J.I. van Hemert (Lecture: Evolving binary constraint satisfaction problem instances that are difficult to solve).

Working visits

- UT, November 4: R. van Stee.
- Centre for Emergent Computing, Napier Univ., Edinburgh, UK, June 18–20 and November 11–13: J.I. van Hemert.
- Univ. Brussel, Brussels, December 8–12: P.J. 't Hoen.

Project meetings

- DEAL plenary meetings, bimonthly until September, Rotterdam: J.A. La Poutré, P.J. 't Hoen, J.I. van Hemert, T.B. Klos.

- DEAL Steering group meetings, bimonthly from September, Rotterdam, J.A. La Poutré, DEAL Working group meetings, biweekly from September, Rotterdam/Amsterdam: P.J. 't Hoen, J.I. van Hemert, T.B. Klos.
- ASTA plenary meetings, monthly, CWI, J.A. La Poutré, E.H. Gerding, D.J.A. Somefun, T.B. Klos.
- CIM project meetings (Cybernatic Incident Management), J.A. La Poutré, T.B. Klos (every 4 months).

Other lectures

- Informatica Colloquium of Philips Research, Philips Research NatLab, Eindhoven, April 2, J.A. La Poutré (Lecture: Market-based Recommendation: Agents that Compete for Consumer Attention).
- Centre for Emergent Computing, Napier Univ., Edinburgh, UK, June 19: J.I. van Hemert. (Lecture: Constraint Satisfaction & Optimisation - Problem Difficulty).
- e-Science als motor van innovatie, Executive Forum Meeting, WTCW Amsterdam, July 3: J.A. La Poutré (Lecture: Self-organisation: logistics and economics).
- Game-theory seminar of CentER, the Business and Economics Research Institute, UvT, September 19: E.H. Gerding (Lecture: Bargaining with Posterior Opportunities: an Evolutionary Social Simulation).
- Belgian-Dutch Artificial Intelligence Symposium for Students (BNAIS), CWI, October 9: E.H. Gerding (Lecture: Geautomatiseerd Onderhandelen in de Informatie Markt), V. Robu (Lecture: Improving the outcome of cooperative negotiations in incomplete information environments).
- In CWI in Bedrijf, CWI, October 17: E.H. Gerding (Lecture: Onderhandelen is ook maar een spel).
- Open Dag Wetenschapsweek, CWI, Amsterdam, October 18: J.A. La Poutré (Lecture: Met intelligent plannen heb je een zorg minder).
- Dutch research school for Information and Knowledge Systems (SIKS) tutorial week Formal methods for Information and Knowledge Systems and Agent Technology, Vught, The Netherlands, December 12: V. Robu, (Lecture: Negotiation in agent systems), J.A. La Poutré and E.H. Gerding (Lecture: Market Mechanisms).

Visitors

- G. Redekar of IIT, Madras, India, May 1–July 31. Host: P.J. 't Hoen. (Presentation: Visualisation of a Multi-Agent Transportation System).
- C. Castaldi, Sant'Anna School of Advanced Studies, Pisa Italy, May 19–May 24. Host: F. Alkemade.
- B. Rand, Computer Science Department/ CSCS, Univ. Michigan, USA, August 1– August 31. Host: F. Alkemade. (Presentation: Statistical Validation of Spatial Patterns in Agent-Based Models).
- K. Tuyls, Univ. Brussels, Belgium, November 24–28. Host: P.J. 't Hoen. (Presentation: Evolutionary Game Theory for Learning in MAS).
- N. B. Urquhart, Napier Univ., Edinburgh, June 2–6. Host: J.I. van Hemert. (Presentation: Using evolutionary algorithms and agents to route postal deliveries).

Memberships of committees and other professional activities

F. Alkemade

- Member programme committee Third international workshop on computational intelligence in economics and finance (CIEF2003).
- Reviewer Computational Economics, JEDC, and Evolutionary Economics.

S.M. Bohte

- Member of the organization committee of the workshop on the Future of Neural Networks (FUNN) 2003 at ICALP 2003, with Prof. J.N. Kok (LIACS, UL) and Dr. M. van Wezel (EUR).
- Referee for proposals of the EPSRC.
- Reviewer for IEEE Trans. Neural Networks, Conference ICANN 2003.

J.I. van Hemert

- Member of the organizing committee of the Sixth EvoNet Summer School, Parma, Italy, August 24–31.
- Member of the programme committees of European Conference on Evolutionary Computation in Combinatorial Optimization,

Hawaii, International Conference on System Sciences, and Genetic and Evolutionary Computation Conference.
- Reviewer for the journals Journal on Evolutionary Computation, IEEE Transactions on Evolutionary Computation, IEEE Transactions on Systems, Man, and Cybernetics, Information Processing Letters, and Electronic Journal of Evolutionary Modeling and Economic Dynamics.

P.J. 't Hoen
- Supervisor MSc IIT trainee G. Redekar.

T.B. Klos
- Reviewer of Journal of e-JEMED, and Journal of Management Science.

J.A. La Poutré
- Member of the 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 of the PhD committees of Dr. J.J.D. Aerts: 'Random Redundant Storage for Video on Demand', and Dr. M. Lipmann, 'On-line Routing', and Dr. L. Maruster: 'A Machine Learning Approach to Understand Business Processes' (all TUE).
- Member of the reading and PhD committees of Dr. P.A.N. Bosman: 'Design and Application of Interated Density-Estimation Evolutionary algorithms' (UU).
- Member of the programme committees of TAEN'04 workshop: Theory and Applications of e-Negotiations (April 2004, Poland), 12th International World Wide Web Conference (WWW2003), section E-Commerce, proceedings: ACM Press (May 2003, Budapest), IJCAI workshop on Trading Agent Design and Analysis (TADA) (August 2003, Acapulco, Mexico), AAMAS Workshop on Evolutionary Game Theory for Learning in MAS (EGTMAS) (July 2003, Melbourne, Australië), and Belgium-Netherlands Conference on Artificial Intelligence (BNAIC) (October 2003, Nijmegen).
- Reviewer for Journal of Economic Dynamics and Control (JEDC), Journal of Autonomous Agents and Multi-Agent Systems.
- Supervisor MSc student I.B. Vermeulen.

D.J.A. Somefun
- Supervisor MSc student I.B. Vermeulen.

R. van Stee
- Reviewer for Theoretical Computer Science, Journal of Algorithms, Operations Research Letters, and Symposium on Discrete Algorithms.

Academic publications

Publications in refereed journals

1. E. Bach, J. Boyar, L. Epstein, L.M. Favhroldt, T. Jiang, K.S. Larsen, G. Lin, R. van Stee (2003). Tight bounds on the competitive ratio on accommodating sequences for the seat reservation problem. Journal of Scheduling 6(2), 131–147.
2. D.D.B. van Bragt, J.A. La Poutré (2003). Why Agents for Automated Negotiation Should Be Adaptive, Netnomics (5), 101–118.
3. M. Chrobak, L. Epstein, J. Noga, J. Sgall, R. van Stee, T. Tichy, N. Vakhania (2003). Preemptive scheduling in overloaded systems. Journal of Computer and Systems Sciences 67(1), 183–197.
4. B.G.W. Craenen, A.E. Eiben, J.I. van Hemert (2003). Comparing evolutionary algorithms on binary constraint satisfaction problems. IEEE Transactions on Evolutionary Computation 7(5), 424–444.
5. L. Epstein, R. van Stee (2003). Lower bounds for on-line single-machine scheduling. Theoretical Computer Science 299(1–3), 439–450.
6. L. Epstein, C. Imreh, R. van Stee (2003). More on weighted servers or fifo is better than lru. Theoretical Computer Science, 306(1-3), 305–317.
7. E. Gerding, D. van Bragt, J.A. La Poutré (2003). Multi-Issue Negotiation Processes by Evolutionary Computation: Validation and Social Extensions, Computational Economics 22(1), 39–63.
8. S. Oudshoff, I. Bosloper, T. Klos, B. Spaanenburg (2003). Knowledge Discovery in Virtual Community Texts: Clustering Virtual Communities. Journal of Intelligent and Fuzzy Systems 14(1), 13–24.

9. S.S. Seiden, R. van Stee (2003). New bounds for multi-dimensional packing. Algorithmica 36(3), 261–293.
10. S.S. Seiden, R. van Stee, L. Epstein (2003). New bounds for variable-sized online bin packing. SIAM Journal on Computing 32(2), 455–469.

Publications in other journals and other scientific output

Conference Proceedings

1. S. Albers, R. van Stee (2003). A study of integrated document and connection caching. In Automata, Languages and Programming (ICALP). Springer Lecture Notes in Computer Science (LNCS), number 2719, Springer-Verlag, 653–667.
2. F. Alkemade, J.A. La Poutré, H.M. Amman (2003). Intermediaries in an electronic trade network. Proceedings of the 4th ACM Conference on Electronic Commerce (EC-03). ACM Press.
3. F. Alkemade, J.A. La Poutré, H.M. Amman (2003). Intermediaries in an electronic trade network. T. Heskes, P. Lucas, L. Vuurpijl, W. Wiegerinck (eds). Proceedings of the Fifteenth Belgium Netherlands Conference on Artificial Intelligence (BNAIC), 381–382.
4. E. Gerding, J.A. La Poutré (2003). Bargaining with Posterior Opportunities: An Evolutionary Social Simulation. M. Gallegati, A.P. Kirman, M. Marsili (eds). The Complex Dynamics of Economic Interactions Lecture Notes in Economics and Mathematical Systems (LNEMS) 531, Springer-Verlag, 241–256.
5. J.I. van Hemert (2003). Evolving binary constraint satisfaction problem instances that are difficult to solve. Proceedings of the IEEE 2003 Congress on Evolutionary Computation (CEC), IEEE Press, 1267–1273.
6. P.J. 't Hoen, S.M. Bohte (2003). COllective INtelligence with Sequences of Actions, European Conference of Machine Learning 2003, Springer Lecture Notes in Artificial Intelligence (LNAI), 2837, Springer-Verlag, 181–92.
7. P.J. 't Hoen, D.D.B. van Bragt, J.A. La Poutré (2003). A Decommitment Strategy in a Competitive Multi-Agent Transportation Setting. Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS), Melbourne, Australia, ACM Press, 1010–1011.
8. L. Kesselman, Y. Mansour, R. van Stee (2003). Improved competitive guarantees for qos buffering. Algorithms - ESA 2003. Springer Lecture Notes in Computer Science (LNCS), 2832, Springer-Verlag, 361–373.
9. D.J.A. Somefun, H. La Poutré (2003). Bundling and Pricing for Information Brokerage: Customer Satisfaction as a Means to Profit Optimization. Proceedings of IEEE/WIC International Conference on Web Intelligence (WI2003), IEEE Computer Society Press, 182–189.
10. D.J.A. Somefun, E. Gerding, S Bohte, H. La Poutré (2003). Automated negotiation and bundling of information goods. T. Heskes, P. Lucas, L. Vuurpijl, W. Wiegerinck (eds). Proceedings of the Fifteenth Belgium Netherlands Conference on Artificial Intelligence (BNAIC), 435–436.

CWI reports

SEN-E0315, SEN-E0316, SEN-E0317, SEN-E0318, SEN-E0304, SEN-R0302, SEN-R0301.
See page 180 for complete titles.

Software developed

In the ASTA project (see page 91), a webbased platform for trading information goods was developed, together with TNO and ING. In the platform (prototype), agents can bargain for their owners to obtain desired information goods. Moreover, a central agent bargains on behalf of the seller with the various (buying) agents: Somefun, Gerding, S. Bohte, J.A. La Poutré.

In the DEAL project (see page 92), software was further developed for simulation and visualisation of a market-based model for logistics management in transportation: 't Hoen, Redekar, Robu, La Poutré).

Deliverables for projects

Several deliverables have been produced for the ASTA and DEAL 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' (page 98). Also, a demonstration and closing workshop was held for the ASTA project (pages 94 and 91).

Book chapters

1. F. Alkemade, J.A. La Poutré, H.M. Amman (2003). An agent-based evolutionary trade network simulation. A. Nagurney (ed.), Innovations in Financial and Economic Networks. Edward Elgar Publishing Inc., Massachusets (USA), 237–252.

PhD theses

1. S.M. Bohte (2003). Spiking Neural Networks. UL, March 5, Advisors: J.N. Kok and J.A. La Poutré.

Erratum ORA 2002

Regarding PhD theses (page 91): The thesis advisors ('promotors') of R. van Stee were Prof.dr.ir. J.A. La Poutré and Prof.dr. J.N. Kok.

Professional products

Patents

- Method and System for Automated Marketing of Attention Area Content, joint pattent of CWI and KPN; S.M. Bohte, E.H. Gerding, J.A. La Poutré and KPN-employees; patent US 2003018539 (January 23, 2003, USA) and EP 1274034 (January 8, 2003, EU).

Publications for a broad audience

- E.H. Gerding (2003). Onderhandelen is ook maar een spel, CWI in Bedrijf, October 17.
- Ch. Wentink (ed.), J.A. La Poutré, Handjeklap achter de Browser, Natuur en Techniek Wetenschapsmagazine 71(2), 72–74.
- J.A. La Poutré (2003). Self-organisation: logistics and economics, Executive Forum Meeting 'e-Science als motor van innovatie', WTCW, Amsterdam, July 3.
- M. Vincken (ed.), T. Heskes, and J.A. La Poutré (2003). Met Meer Parameters, Betere Conclusies, PT Industrieel Management, September 28–30.
- J.A. La Poutré (2003). Met intelligent plannen heb je een zorg minder, Open Dag Wetenschapsweek', CWI, October 18.

Other output

Grants

- S.M. Bohte, NWO TALENT grant 'Adaptive software agents for electronic markets', for a one year visit to the Univ. Colorado, Boulder, May 2003–May 2004.
- S.M. Bohte, NWO Veni grant 'Scalable Reinforcement Learning in Asynchronous Spiking Neural Networks', May 2004–May 2007.
- A grant proposal (FACS) for an experimental computer cluster tailored to the needs of CWI groups SEN4, SEN2 and INS1 was awarded by NWO.

MODELLING, ANALYSIS AND SIMULATION

Principal research area and mission

Cluster MAS is a mathematics cluster whose principal research area is *Applied and Numerical Mathematics*. The emphasis lies on partial differential equations with mathematical analysis, scientific computing, computational fluid dynamics and computational electro magnetics as major activities across all three MAS themes. Smaller sized activities include control and system theory (discrete event systems, hybrid systems, realization theory, system identification theory), asymptotics and special functions (with involvement in a major revision of the classical Handbook of Mathematical Functions), computational number theory (factoring large numbers into primes), and discrete tomography.

Applications for MAS research are found everywhere in physics, life-, geo- and environmental sciences, in engineering and in many industrial and technological fields. Ongoing trends in computer hardware with desktop performance in the gigaflop range further increases the demand for advanced modelling, analysis and simulation with applied and computational mathematics at the center of interest. The cluster policy is to hold a strong position in this rapid 'computational science' development. This requires a balance between long lasting discipline oriented and more short term applied research with in particular an enduring attention for new challenges from applications. As a result, a considerable part of our current research is application driven.

Cluster staff

Name	Fte	Function
Prof.dr. J.G. Verwer	0.2	Cluster leader
N. Mitrovic	0.4	Secretary
Drs. J. Kok	0.4	Computer support
Dr. N.M. Temme	0.2	Management support

Research themes

Name	Leader
MAS1 – Nonlinear PDEs: Analysis and Scientific Computing	Dr. M.A. Peletier
MAS2 – Computing and Control	Prof.dr.ir. B. Koren
MAS3 – Nonlinear Dynamics and Complex Systems (pilot)	Prof.dr. U.M. Ebert

As regards applications, theme MAS1 focuses on problems from the earth and life sciences, theme MAS2 on engineering and industrial problems, and the pilot theme MAS3 on problems from physics. See pages 100 (MAS1), 112 (MAS2), 130 (MAS3) for their reports.

Nonlinear PDEs: Analysis and Scientific Computing – MAS1

Mission

The research within this theme focuses on the mathematical and numerical analysis of partial differential equations (PDEs). A minor activity is asymptotics for special functions. The nature of the research ranges from fundamental to practical and is for a considerable part application driven. All application-driven research activities emanate from new challenges from earth sciences and biology and medicine

(life science applications), which are fields where mathematical modelling and scientific computing are rapidly becoming more and more important.

Theme leader

Dr. M.A. Peletier

MSC or CR classification

33, 35, 65, 92

Subthemes

Name	Leader
MAS1.1 – PDEs in the Life Sciences	M.A. Peletier
MAS1.2 – PDEs at CWI	M.A. Peletier
MAS1.3 – Numerical Analysis of PDEs	J.G. Verwer
MAS1.4 – Asymptotics and Special Functions	N.M. Temme

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. J.G. Blom	1.0	researcher	indefinite	MAS1.1
Dr.ir. J.E. Frank	1.0	researcher	indefinite	MAS1.1; MAS1.3
Dr. L'. Fraštia	1.0	post-doc	2002-02-01 till 2003-01-31	MAS1.1
Ir. J.K. Krottje	1.0	PhD student (NWO)	2001-04-01 till 2005-03-31	MAS1.1
Dr. M.A. Peletier	0.8	theme leader, leader MAS1.1,1.2		MAS1.1; MAS1.2
N.N. Pham Thi, MSc	1.0	PhD student (NWO)	2002-09-01 till 2006-08-31	MAS1.1
Drs. R. Planqué	1.0	PhD student	2000-12-01 till 2004-11-30	MAS1.1
Dr. B.P. Sommeijer	1.0	researcher	indefinite	MAS1.1
Dr. N.M. Temme	0.8	leader MAS1.4	indefinite	MAS1.4
Prof.dr. J.G. Verwer	0.6	cluster leader, leader MAS1.3	indefinite	MAS1.1; MAS1.3
Dr. J.F. Williams	1.0	researcher (RTN)	2003-10-01 till 2004-10-01	MAS1.1

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. O. Diekmann (UU)	p.m.	advisor	2001-01-01 till 2003-12-31	MAS1.1
Prof.dr. A. Doelman (UvA)	0.2	researcher	2002-09-01 till 2007-09-01	MAS1.2
Prof.dr.ir. C.J. van Duijn (TUE)	0.2	researcher	2002-09-01 till 2007-09-01	MAS1.2
Prof.dr. J. Hulshof (VU)	0.2	researcher	2002-09-01 till 2007-09-01	MAS1.2

Prof.dr.ir. L.A. Peletier (UL)	0.2	researcher	2002-09-01 till 2007-09-01	MAS1.2
Prof.dr. H.V. Westerhoff (VU)	p.m.	advisor	2001-01-01 till 2003-12-31	MAS1.1

Scientific report

Highlights

The complete characterization of solutions in the rod-on-cylinder problem (see below) was a breakthrough. It was surprising to see that with relatively few assumptions the solutions could be characterized in great detail. The understanding gained in this problem opens the door to related problems on free rods.

An important moment is always the awarding of a PhD diploma. Ignacio Guerra Benavente succesfully defended his PhD thesis on January 15, at the TUE.

On the funding side, 2003 was a fruitful year. Theme leader Peletier obtained a Vernieuwingsimpuls (Vidi) grant, one PhD project was funded by NWO/STW-Wiskunde Toegepast, and three PhD projects were funded in the programme Computational Life Sciences. MAS1 also has 2 projects within CWI's BRICKS programme (ICES-KIS3). In the Open Competition NWO funded the research proposal 'Stability of patterns in free-boundary combustion problems' by Hulshof and Doelman. Two PhD students are now working on this project, Vincent Guyonne and Hala Elrofai. This includes work related to experiments with flame balls carried out during the Space Shuttle missions.

J.F. Williams was appointed as post-doc. He is financed by Hulshof's RTN project 'Nonlinear Partial Differential Equations describing Front Propagation and other Singular Phenomena', HPRN-CT-2002-00274.

N.M. Temme presented a plenary lecture at the SIAM Annual Meeting in Montreal in June.

J.G. Verwer and W.H. Hundsdorfer (MAS3) finished their book 'Numerical Solution of Time-Dependent Advection-Diffusion-Reaction in Equations'. It has been published in the Springer Series in Computational Mathematics, Vol. 33, 2003.

PhD students

I.A. Guerra Benavente
J.K. Krottje
R. Planqué
N.N. Pham Thi

MAS1.1 – PDEs 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. In 2003 the subtheme comprised five 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, M.A. Peletier
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. In 2003 research was done on a number of subjects.

• Study of the influence of spatial effects on biochemical pathways with a reaction-diffusion type model (funded by the ICES-KIS2 programme 1999–2002). This project was terminated this year with the transfer of a software program and the appearance of two publications.

• Study of mesoscale simulation paradigms for reaction-diffusion phenomena in the cell. 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) and BMT (TUE) we want to compare and couple different mesoscale simulation paradigms for advection, reaction and diffusion: PDEs (MAS1.1), Lattice-Boltzmann/Lattice

Gas (SCS), and molecular dynamics (BMT). A project proposal for the comparison of the PDE vs. the LBE/LGA approach on biologically relevant problems has been granted by NWO via the Wiskunde Toegepast programme.

• Investigation of a class of continuum models for lipid bilayers. These models are based on ideas common in polymer chemistry and have a mesoscopic character. At a macroscopic scale the state is given by the density of specific parts of the lipids and the solvent and the evolution of the density is driven by the gradient of a potential field for which the miscroscopic description of the system is used. The model takes the form of a computationally expensive, implicit system of PDEs with a strong non-local character. The research resulted in one publication. Proposals have been submitted to develop efficient 3D computer models.

• Modelling and simulation of developmental regulatory networks with a generalization of the standard connectionist model used for modelling genetic interactions. The model will be coupled with a biomechanical model of cell aggregates and used to study the formation of spatial and temporal expression patterns of gene products during development in cellular systems. Mathematically speaking this amounts to continuum-discrete hybrid models where discrete, moving and deformable objects in which biochemical reactions take place exchange species with the surrounding environment modelled as a continuum in which species diffuse and decay. This project is a collaboration with J.A. Kaandorp (SCS/UvA). A pilot implementation by T. Krul (SCS/UvA) of a simplified model − without cell motion − showed promising simulations of the formation of stripes of expression of the Eve gene in the *Drosophila* embryo. The research resulted in one publication and a granted proposal for a continuation project.

A large-scale proposal, headed by Peletier, has been granted by NWO-Computational Life Sciences. In collaboration with IMBW (VU), SCS (UvA), and MAS2.3 mathematical and computational techniques for the systems biology of the cell will be developed, implemented and validated. The research focus in the PhD project within MAS1.1 will be multi-adaptive numerical methods for the efficient solving of reaction-diffusion PDEs 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, 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, Planqu (PhD research) and Peletier are concentrating on a model problem of lower dimension: A twisted rod that is forced to lie on a cylinder.

In 2003 two important results were obtained. First, a general investigation was concluded into the correct description of *writhe for open rods*, a generalization of this fundamental concept that is well-known in the theory of closed rods. A manuscript was submitted to Archive for Rational Mechanics and Analysis (report MAS-E0316). Secondly, a complete characterization of the behaviour of rods twisted around a cylinder (see above) was proved, with a remarkable level of detail; a manuscript is in preparation.

Title	Aqueous biology, biofilm project
Period	2000–2003
Leader	B.P. Sommeijer
Staff	M.A. Peletier, B.P. Sommeijer
Funding	EU
Partner	W. Admiraal, Aquatic Ecology and Ecotoxicology-group, UvA

Progress report. Several European partners joined forces in a project called BIOFILMS, running from 2000 until 2003 and funded by the EU. A biofilm is a thin layer composed of microalgae, bacteria and their mucus and occurs in all natural rivers and lakes. Since natural biofilms act as high-tech conditioners for drinking-water, they are frequently exploited by drinking-water

companies to regulate organic matter content in the water. The role of CWI (Peletier and Sommeijer) in this project is to model a biofilm mathematically and to give advice on how to simulate various scenarios. For that purpose, an existing software package (AQUASIM) has been used. The biofilm schematized in the model is composed of two characteristic algal groups with different growth strategy and a bacterial compartment. Moreover, EPS (extracellular polymeric substances) and POC (particulate organic matter) have been added to the model. Finally, external forces, like grazing, have been included in the model. The BIOFILM project ended April 2003, and a final report has been written (see: `www.science.uva.nl/research/aee/eu/biofilms/`). Jointly with the Aquatic Ecology and Ecotoxicology-group of the UvA, a paper on specific modelling aspects is in progress.

Title	Microbial ecology, phytoplankton models
Period	2001–2005
Leader	B.P. Sommeijer
Staff	N.N. Pham Thi, B.P. Sommeijer, J.G. Verwer
Funding	NWO (Computational Science Programme)
Partner	J. Huisman, Inst. of Biodiversity and Ecosystems Dynamics, UvA

Progress report. Models that simulate phytoplankton dynamics in relation to mixing processes and species-specific vertical velocities (sinking or buoyancy) generally have the form of an integro-partial differential equation (integro-PDE). The 'integro part' enters the model through the light intensity which is needed for photosynthesis and which depends on the concentrations (because of absorption). Of special interest are competition models in which many species 'struggle for light'. Such models, leading to systems of integro-PDEs, are computationally very demanding, especially in more spatial dimensions. In previous years, efficient numerical algorithms were developed for the one-dimensional problem (i.e., the vertical). In close cooperation with J. Huisman (UvA), several studies have been carried out with this model. Based on this work, Pham Thi extended this competition model to three spatial dimensions by including horizontal mixing and water flow. To keep the computational work at a manageable level, special attention was paid to efficiently solving the systems arising in the implicit time integration method. Results have been described in CWI report MAS-R0314 (submitted).

A next topic is the development of efficient solution techniques for competition models in combination with a model for nutrients. In the aforementioned competition studies, light has been considered as the only limiting factor and nutrients were assumed to be amply available. In some part of the oceans this assumption is not valid and nutrients (like phosporus, nitrogen,...) form a restrictive resource as well. Moreover, light and nutrients cause contrasting gradients since light supply is from above, whereas nutrients are often supplied from the bottom. First results on this extended model will appear in 2004.

Finally, a contract study for Nuon has been performed. Here the question was whether the deeper part of Lake Nieuwe Meer could be utilized as a resource of cooling water for the buildings along the 'South-Axis of Amsterdam'. For that purpose the lake has to be artificially stratified to have a sufficiently cool deeper part but retaining artificial mixing of the upper water layer to prevent blooms of the toxic, buoyant species Microcystis. Several scenarios have been considered and the conclusion was that the goals could be achieved as long as the artificial mixing (of the upper layer) by means of air tubes is sufficiently deep (10 to 15 m).

Title	Neurobiology, modelling of axon growth
Period	2001–2005
Leader	J.G. Verwer
Staff	J.K. Krottje, J.E. Frank, J.G. Verwer
Funding	NWO (Wiskunde Toegepast)
Partners	A. van Ooyen, J. van Pelt (Netherlands Institute for Brain Research, NIH/KNAW)

Progress report. The PhD project of Krottje concerns the development and analysis of numerical methods for a mathematical model for the outgrowth of axons from neurons in the nervous system. The model in use at this moment has been suggested by a cooperating group at the NIH (Netherlands Institute for Brain Research) and comprises a set of parabolic PDEs for attracting and repelling biochemical species coupled to gradient equations for the axon

paths. Analytical results on the model were published by Krottje in his article 'On the dynamics of a mixed parabolic-gradient system', Communications on Pure and Applied Analysis, 2(4), 521–537, 2003. This year he investigated a class of mesh-free numerical methods. Results were published in 'A variational mesh-free method for solving time-discrete diffusion equations', CWI report MAS-E0319. These mesh-free methods will provide a flexible set-up for a future numerical software-package for the NIH. To prepare this step towards software, Krottje is preparing a test paper in cooperation with Dr. A. van Ooyen, NIH.

MAS1.2 – PDEs at CWI

In its present form, this subtheme started September 1, 2002, with one-day per week secondments at CWI of the professors A. Doelman (UvA), C.J. van Duijn (TUE), J. Hulshof (VU) and L.A. Peletier (UL). The main goal is to generate more research activity in the analysis of PDEs at CWI and in the Netherlands by creating a 'hot spot' of PDE analysis at CWI. This will be achieved by strengthening cooperations in the field between the four universities and CWI. Activities in this subtheme will focus on joint seminars and joint research projects.

Title	Textbook ODEs in PDEs
Period	2002–2004
Staff	C.J. van Duijn, L.A. Peletier
Funding	CWI

Progress report. Work on this project has been put on the back burner in favour of a new joint project on travelling waves and entropy solutions of the Buckley-Leverett equation.

Title	Patterns in gravity-driven groundwater flow
Period	2002–2004
Leader	C.J. van Duijn
Staff	C.J. van Duijn
Funding	CWI
Partners	G.J. Pieters (TUE), P. Knabner (Univ. Erlangen), K. Johannsen (Univ. Heidelberg)

Progress report. A central issue in modelling gravity-driven groundwater flow is the derivation and mathematical analysis of the amplitude equations near the minimum of the stability boundary. This project aims at enhancing insight by studying specific patterns.

Title	Linearization in free boundary problems
Period	2002–2004
Leader	J. Hulshof
Staff	J. Hulshof
Funding	CWI
Partners	C.M. Brauner (Univ. Bordeaux), A. Lunardi (Univ. Parma), J.F. Ripoll (Stanford Univ.)

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.

Title	Spike hierarchy in the Gray-Scott Model
Period	2002–2004
Leader	A. Doelman
Staff	A. Doelman, L.A. Peletier
Funding	CWI
Partner	T.J. Kaper (Boston Univ.)

Progress report. In 1983 Gray and Scott proposed a system of two reaction-diffusion equations as a model system for understanding complex dynamics in chemical reactions, and the understanding of the formation of patterns such as the birth of multi-bump spikes and travelling fronts. In a joint project Doelman, Peletier, and T.J. Kaper from Boston Univ. are studying a sequence of saddle-node bifurcations leading to a hierarchy of spikes with increasing complexity.

Considerable progress has been made on this project. In a marriage of analytical and geometrical results a very clear picture is emerging of a family of multibump homoclinic orbits of a reduced system, which is central to the description of the 'inner' solution of homoclinic orbits of the full Gray-Scott system of equations.

MAS1.3 – Numerical Analysis of PDEs

This subtheme is particularly concerned with numerical PDE analysis with a focus on theoretical aspects. An outstanding activity is the Veni project Geometric numerical methods for continuum mechanics granted in 2002 by NWO to J.E. Frank.

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. The mathematical equations modelling atmospheric fluids 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 relevant solutions in the absence of traditional numerical accuracy. Work has continued to extend the Hamiltonian Particle-Mesh method to two-layer models and most recently to spherical geometry. The method was also applied to standard shallow water test problems on the sphere. Joint work with S. Reich of Imperial College London.

A second topic of this project is the numerical discretization of nonlinear wave equations. The Landau-Lifshitz equation models the evolution of magnetic spin in a ferromagnetic material. The so-called 'multisymplectic structure' of this equation (it is a Hamiltonian PDE both in space and time) was investigated, yielding a first example of a 'multisymplectic Poisson structure'. A multisymplectic discretization was not discovered, but application of the box scheme yields a method that has an exact discrete analogue of the associated energy flow equation. This has immediate ramifications for energy conserving simulations on nonuniform grids. We also observe that the box scheme is reflection-free on nonuniform grids. This result can be generalized to a larger class of methods, and is the subject of ongoing investigations.

Title	Textbook
Period	2000–2003
Leader	J.G. Verwer
Staff	J.G. Verwer
Funding	CWI
Partner	W.H. Hundsdorfer (MAS3)

Progress report. This project has ended successfully; the book has been published (W.H. Hundsdorfer and J.G. Verwer (2003), Numerical Solution of Time-Dependent Advection-Diffusion-Reaction Equations, Springer Series in Computational Mathematics, Vol. 33, Springer-Verlag).

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 (Univ. Pamplona), A. Gil and J. Segura (Univ. Madrid)

Progress report. The research on asymptotic analysis (with J.L. López) concentrated on the construction of convergent expansions with asymptotic properties for a certain class of special functions. The method is based on multipoint Taylor expansions of analytic functions. Two papers have been accepted for publication.

With J.B. Sanders a random walk problem on discrete infinite grids has been studied, in particular the asymptotic analysis of the problem.

Research on the numerical aspects of special functions has been continued (with A. Gil and J. Segura). A paper on parabolic cylinder functions, in which contours of integration for these functions are studied, is accepted for publication. Two papers on the computation of modified Bessel functions of pure imaginary orders are accepted for publication. SIAM invited to submit a book proposal, which has been accepted with a contract.

Temme participated in the DLMF project, complete revision of the Handbook of Mathematical Functions, Abramowitz and Stegun (revision of earlier written chapters and editorial work).

Societal aspects and knowledge transfer

External contacts

MAS1.1

National: UvA (SILS, IvI), VU (IMBW), TUE (Wiskunde, BMT), RUG (Biophysical Chemistry).
International: the groups of Otto (Bonn), Thompson/Van der Heijden (London), Budd/Hunt/Britton (Bath), Franks (Bristol),

Manasevich (Santiago), Brezis/Hilhorst (Orsay/Paris).
MAS1.2
National: NIOZ (Maas), UT (wiskunde, Van Gils).
International: Derks (Surrey), Kaper (Boston), Nishiura (Hokkaido), Sandstede (Ohio), Scheel (Minneapolis), Schneider (Karlsruhe), Sivashinsky (Tel Aviv), Brauner (Bordeaux), Roquejoffre (Toulouse), King (Nottingham), Lunardi (Parma), Bertsch (IAC-Rome), Aronson (Minnesota), Frankel (Indianapolis), Catherine Bandle (Basel), Haim Brezis (Paris 6/Rutgers), Rachel Kuske (Vancouver), Stepan Tersian (Rousse, Bulgaria), Johan Gabrielsson and Sandra Visser (AstraZeneca, Södertalje, Sweden).
MAS1.3
International: the groups of Reich (Imperial College London) and Leimkuhler (Leicester).
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).

Contract research

- DLMF project (NIST), see MAS1.4.

Teaching at university

- Multivariabele Analyse (Werktuigbouwkunde), TUE: M.A. Peletier.
- Mathematische Modellen in de Fysiologie (Biomedische Technologie), TUE: M.A. Peletier.
- Instapcursus Rekenvaardigheden (Industrial Design), TUE: M.A. Peletier.

Courses, tutorials

- Capita selecta course 'Numerical solution of partial differential equations', UvA, Second semester 2002–2003: J.G. Verwer.
- Parallel Scientific Computing & Simulation, UvA: B.P. Sommeijer.

Organization of conferences, workshops, courses, meetings

- Bi-monthly Colloquium series PDE@CWI; speakers in 2003 were Tersian (Rousse), Williams (Bath), Van der Heijden (UCL), Meulenbroek (CWI), Bremer (Jülich), Egorov (Delft), De Graaf (Eindhoven), Röger (Nottingham), Baer (Dresden).
- Mathematical understanding of complex patterns in the life sciences, a workshop in the Lorentz Center in Leiden, March 18–27, organized by Danielle Hilhorst, Hiroshi Matano, Masayasu Mimura, and Mark Peletier.
- 10th conference NUMDIFF – Numerical Solution of Differential and Differential Algebraic Equations, Halle, Germany, September 8–11, organized by K. Strehmel, R. Weiner, B.P. Sommeijer and J.G. Verwer. Minisymposium 'Geometric Methods for PDEs' organized by J.E. Frank and S. Reich.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Third International Workshop on Scientific Computing and Applications, Hong Kong, January 6–9: B.P. Sommeijer (Lecture: Splitting methods for partial Volterra integro-differential equations).
- Workshop EU-BIOFILM project, Girona, Spain, January 29–February 2: B.P. Sommeijer (Lecture: Modeling phototrophic biofilms with AQUASIM).
- Lorentz Center Workshop 'Mathematical Understanding of Complex Patterns in the Life Sciences', Leiden, March 18–27: R. Planqué (Poster: A Contact Problem for Rods on Cylinders).
- Nederlands Mathematisch Congres, Nijmegen, May 1–2: J.K. Krottje (Talk: Numerical integration of mixed parabolic-gradient systems); R. Planqué (Talk: A Contact Problem for Rods on Cylinders); B.P. Sommeijer.
- Geometric and Structure Preserving Algorithms for PDEs, Oslo, May 12–15: J.E. Frank (Invited talk: TBA – The Box scheme Applied to micromagnetics).
- SIAM conference on Applications of Dynamical Systems, Snowbird, May 27–31: R. Planqué (Poster: A Contact Problem for Rods on Cylinders); Minisymposium on Discrete Geometry and Geometric Integration: J.E. Frank (Invited talk: Geometric Particle-mesh Methods for Geophysical Fluid Dynamics).

- SIAM Annual Meeting in Montreal, June 19: N.M. Temme (Plenary lecture: Special Functions: Computational Methods and Applications).
- SciCADE 2003 International Conference on Scientific Computation and Differential Equations, Trondheim, June 30–July 4: Minisymposium on Geometric Integration of PDEs: J.E. Frank (Invited talk: Further developments in the Hamiltonian Particle-Mesh method).
- Workshop on Modelling and Simulation in Chemical Engineering, Coimbra, Portugal, June 30–July 4: J.G. Verwer (Invited lecture: An implicit-explicit Runge-Kutta-Chebyshev scheme for diffusion-reaction equations).
- Equadiff, Hasselt, July 2003: M.A. Peletier (Lecture: Modelling lipid bilayers).
- Workshop 2003 AFOSR: 'Advances and Challenges in Time-Integration of PDEs', Brown Univ., Providence, USA, August 18–20: J.G. Verwer (Invited lecture: On solving highly stiff diffusion-reaction systems).
- 10th Seminar NUMDIFF, Halle, Germany, September 8–11: B.P. Sommeijer (Lecture: An explicit-implicit Runge-Kutta-Chebyshev scheme for diffusion-reaction equations).
- 10th conference NUMDIFF Numerical Solution of Differential and Differential-Algebraic Equations, Halle, Germany, September 8–11: Coorganizer minisymposium on Geometric methods for PDEs: J.E. Frank (Lecture: Discretization of wave equations and grid-induced reflections).
- Woudschoten Numerical Analysis Conference, Zeist, October 1–3: B.P. Sommeijer.
- Workshop ADAPT '03: 'Adaptive Methods for Partial Differential Equations and Large-Scale Computation', Rensselaer Polytechnic Institute Troy, New York, October 11–12: J.G. Verwer (Invited lecture: On solving highly stiff diffusion-reaction systems).
- Wageningen Winterschool, December 15–17: M.A. Peletier (Lecture: Diffusion in MCA: adding space to cells).

Working visits

- B. Leimkuhler, Leicester, March 18–21: J.E. Frank (Lecture: Proposal preparation for E.U. Research Training Network).
- Univ. Cantabria, Santander, Spain, September 22–26: N.M. Temme (Lecture: Numerics of Special Functions).
- F. Otto, Bonn, October 21–25: M.A. Peletier (Lecture: Twisting rods around cylinders; a contact problem).
- N. Britton, Bath, December 2003: R. Planqué.

Project meetings

- Meeting for the preparations of the European project 'Validated Library of Special Functions', Univ. Karlsruhe, Germany, February 17: N.M. Temme.
- Annual meeting Computational Science programme (NWO/EW), Eindhoven, November 29: N.N. Pham Thi (Poster: Phytoplankton Dynamics, the Struggle for Light); B.P. Sommeijer.

Other lectures

- UvA Numerica Seminar, January 13: J.E. Frank (Lecture: Multisymplectic numerical treatment of ferromagnetic materials).
- UvA/KdV, February 26: M.A. Peletier (Lecture: Continuum modelling of Lipid Bilayers).
- CWI in Bedrijf, Amsterdam, October 17: B.P. Sommeijer (Lecture: Over het nut en de overlast van fytoplankton).
- CWI Scientific Meeting, October 31: J.E. Frank (Lecture: Geometric Integration of Geophysical Fluids).
- AIO dag, Eindhoven, December 12: R. Planqué.
- MAS seminar, CWI, December 17: N.N. Pham Thi (Lecture: Phytoplankton Dynamics).

Courses

PhD course on 'Conservation Laws', Eindhoven, January 20–24: N.N. Pham Thi.

Visitors

- Gert van der Heijden (UCL), January and February. Host: M.A. Peletier.
- J.F. Williams (Bath), January. Host: M.A. Peletier.
- S. Terzian (Rousse), January. Host: L.A. Peletier.
- A. Logg (Göteborg), May 11–14. (Lecture: Explicit time-stepping for stiff ODEs). Host: J.G. Verwer.

- J. Horak (Basel), May and October. Host: M.A. Peletier.
- G. Lord (Heriot-Watt), July and October. Host: M.A. Peletier.
- J.L. López (Univ. Navarra, Pamplona, Spain), July 21–26. Host: N.M. Temme.
- Weizhang Huang (Kansas), July 23–27. (Lecture: Variational Mesh Adaptation and Mesh Quality Measures). Host: J.E. Frank.
- T. Myers (Cape Town), September. Host: M.A. Peletier.
- M. Röger (Nottingham), December. Host: M.A. Peletier.
- Y. Kevrekidis (Princeton Univ.), December 15–17. (Lecture: Equation-free modeling of complex systems through timesteppers: enabling microscopic simulators to perform system level tasks). Host: J.G. Verwer.

Memberships of committees and other professional activities

L.A. Peletier

- Member of the following Editorial Boards: Advances in Differential Equations, Applied Mathematics Letters, Asymptotic Analysis, Communications in Applied Analysis, Differential and Integral Equations, Journal of the European Mathematical Society, Progress in Nonlinear Differential Equations and their Applications (Series of monographs, Birkhäuser, Boston).
- Elected memberships: Royal Netherlands Academy of Sciences, European Academy of Sciences.
- Member Academie Raad Wiskunde (ARW), steering committee of the Lorentz Center, UL.

M.A. Peletier

- Member Nederlands Platform Systeembiologie.
- Co-advisor for I. Guerra Benavente, TUE, January 15, 2003.
- Associate editor IMA Journal of Applied Mathematics.
- Secretary Koninklijk Wiskundig Genootschap, until April 2003.

B.P. Sommeijer

- Managing editor Letter Section Journal of Computational and Applied Mathematics (JCAM).
- Member organizing committee 10th Seminar NUMDIFF – Numerical Solution of Differential and Differential-Algebraic Equations. (Halle, Germany, September 8–11).
- Editor Proceedings of the Workshop 'Innovative Time Integrators for PDEs', Special Issue APNUM (with J.G. Verwer).

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 Mathematics, for grants of the Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen (IWT), Fall meeting 2003.
- 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.
- Referee work for Acta Applicandae Mathematicae, ACM Transactions on Mathematical Software, Analysis and Application, Constructive Approximation, Journal of Physics A: Mathematical and General, Mathematics of Computation, Proceedings A of the Royal Society of Edinburgh, Studies in Applied Mathematics, Zeitschrift für Mathematik und Physik.

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).
- Member organizing committee 10th Seminar NUMDIFF – Numerical Solution of Differential and Differential-Algebraic Equations. (Halle, Germany, September 8–11).
- Editor Proceedings Workshop 'Innovative Time Integrators for PDEs'. (CWI, November 25–27, 2003.) Special Issue APNUM (with B.P. Sommeijer).
- CWI contact for the Flemish Research Network on Advanced Numerical Methods for Mathematical Modelling (WOG).
- Committee member PhD thesis M. Hochstenbach, May 29, UU (Subspace methods for eigenvalue problems).
- Committee member PhD thesis G. Piella Fenoy, October 30, UvA (Adaptive wavelets and their applications to image fusion and compression).

Academic publications

Publications in refereed journals

1. D.G. Aronson, J.B. van den Berg, J. Hulshof (2003). Parametric dependence of exponents and eigenvalues in focusing porous media flows. European J. Appl. Math. 14 (4), 485–512.
2. J.B. van den Berg, J. Hulshof, J.R. King (2003). Formal Asymptotics of bubbling in the harmonic map heat flow. SIAM J. Appl. Math. 63(5), 1682–1717 (electronic).
3. M. Bertsch, R. Dal Passo, C.J. van Duijn (2003). Analysis of oil trapping in porous media flow. SIAM J. Math. Anal. 35(1), 245–267 (electronic).
4. M.A. Botchev, J.G. Verwer (2003). Improving approximate matrix factorizations for implicit time integration in air pollution modelling, J. Comput. Applied Math. 157, 309–327.
5. C. Cuesta, J. Hulshof (2003). A model problem for groundwater flow with dynamic capillary pressure: stability of travelling waves. Nonlinear Anal. 52(4), 1199–1218.
6. G. Derks, A. Doelman, S.A. van Gils, T.P.P. Visser (2003). Travelling waves in a singularly perturbed sine-Gordon equation. Physica D 180(1–2), 40–70.
7. A. Doelman, T.J. Kaper (2003). Semistrong pulse interactions in a class of coupled reaction-diffusion equations. SIAM J. Appl. Dyn. Syst. 2(1), 53–96.
8. A. Doelman, B. Sandstede, A. Scheel, G. Schneider (2003). Propagation of hexagonal patterns near onset. Eur. J. Appl. Math. 14, 85–110.
9. Ch. Francke, P.W. Postma, H.V. Westerhoff, J.G. Blom, M.A. Peletier (2003). Why the Phosphotransferase System of Escherichia Coli Escapes the Diffusion Limitation of Signal Transduction, Transport and Metabolism that Confronts Mammalian Cells. Biophys. J. 85, 612–622.
10. J. Frank, S. Reich (2003). Conservation properties of smoothed particle hydrodynamics applied to the shallow water equations. BIT 43, 40–54.
11. W. Gautschi, F.E. Harris, N.M. Temme (2003). Expansions of the exponential integral in incomplete gamma functions. Appl. Math. Lett. 16, 1095–1099.
12. A. Gil, J. Segura, N.M. Temme (2003). Computing special functions by using quadrature rules. Numerical Algorithms 33, 265–275.
13. A. Gil, J. Segura, N.M. Temme (2003). Computation of the modified Bessel function of the third kind of imaginary orders: Uniform Airy-type asymptotic expansion. J. Comp. Appl. Math. 153, 225–234.
14. A. Gil, J. Segura, N.M. Temme (2003). On the zeros of the Scorer functions. J. Approx. Theory 120, 253–266.
15. G.W. Hunt, G.J. Lord, M.A. Peletier (2003). Cylindrical Shell Buckling: A Characterization of Localization and Periodicity (262 kB, pdf). Discrete and Continuous Dynamical Systems - Series B (3), 505–518.
16. J.K. Krottje (2003). On the dynamics of a mixed parabolic-gradient system. Communications on Pure and Applied Analysis 2(4), 521–537.
17. L.A. Peletier, S.A.G. Visser, D.R.H. Huntjes, P.H. van der Graaf, M. Danhof (2003). Mechanism-Based Modeling of the Pharmacodynamic Interaction of Alphaxalone and Midazolam in Rats. The Journal of Pharmacology and Experimental Therapeutics (JPET) 307, 765–775.
18. L.A. Peletier, Vivi Rottschäfer (2003). Large time behaviour of solutions of the

Swift-Hohenberg equation. Comptes Rendu Mathématique 336, 225–230.
19. L.A. Peletier, Julia V. Chaparova, Stepan Tersian (2003). Existence and nonexistence of nontrivial solutions of fourth and sixth order ordinary differential equations. Advanced in Differentia Equations 8, 1237–1258.
20. L.A. Peletier, Filippo Gazzola, Patrizia Pucci, James Serrin (2003). Asymptotic behavior of ground states of quasi-linear elliptic problems with two vanishing parameters, Part II. Ann. Institut Henri Poincaré – Analyse Nonlinéaire 20, 947–974.
21. L.A. Peletier, S.A.G Visser, F.L.C. Wolters, J.M. Gubbens-Stibbe, E. Tukker, P.H. van der Graaf, M. Danhof (2003). Mechanism-based Pharmacokinetic/Pharmacodynamic modeling of the electroencephalogram effects of $GABA_A$ receptor modulators: in vitro-in vivi modulators. The Journal of Pharmacology and Experimental Therapeutics (JPET) 304, 88–101.
22. M.A. Peletier, H.V. Westerhoff, B.N. Kholodenko (2003). Control of Spatially Heterogeneous and Time-varying Cellular Reaction Networks: A New Summation Law (math.AP/0211111). Journal of Theoretical Biology 225, 477–487.
23. N.M. Temme (2003). Large parameter cases of the Gauss hypergeometric function. J. Comp. Appl. Math. 153, 441–462.
24. N.M. Temme, R. Vidunas (2003). Parabolic cylinder functions: Examples of error bounds for asymptotic expansions. Analysis and Applications 1, 265–288.

Publications in other journals and other scientific output

Conference proceedings

1. T. Krul, J.A. Kaandorp, J.G. Blom (2003). Modelling Developmental Regulatory Networks, Computational Science – ICCS 2003, Pt IV, Proceedings. Lect. Notes. Comput. Sc. 2660, Springer, Berlin, 688–697.

CWI reports

MAS-E0301, MAS-R0305, MAS-E0316, MAS-E0317, MAS-E0319, MAS-E0320.
See page 181 for complete titles.

Technical reports published elsewhere

1. J. Huisman, K. Joehnk, B.P. Sommeijer (2003). Simulation of the population development of the toxic cyanobacterium Microcustis in Lake Nieuwe Meer under proposed heated inflow scenarios. Technical Report UvA, contract research Nuon.
2. J. Huisman, J. Sharples, J. Stroom, P.M. Visser, W.E.A. Kardinaal, J.M.H. Verspagen, B.P. Sommeijer (2003). Changes in turbulent mixing shift competition for light between phytoplankton species. Technical Report UvA.
3. J. Huisman, B.P. Sommeijer (2003). Dimensionless numbers, turbulent mixing and sinking plankton: a comment on O'Brien et al. Technical Report UvA.

Monograph

W.H. Hundsdorfer, J.G. Verwer (2003). Numerical Solution of Time-Dependent Advection-Diffusion-Reaction Equations, Springer Series in Computational Mathematics 33, Springer-Verlag.

PhD theses

1. Ignacio Guerra Benavente, TUE, January 15, 2003: Stabilization and Blow-up for Some Multidimensional Nonlinear PDEs.
2. J.F. Williams, Bath: Scaling and singularities in higher-order nonlinear differential equations.

Professional products

Contributions to documentaries or radio or TV broadcasting

M.A. Peletier: VARA Laat, November 5 (on De Grote GriepMeting).

Other output

Grants

- J.G. Blom: NWO Wiskunde toegepast, Mesoscale simulation paradigms in the Silicon Cell. Jointly with Kaandorp (UvA).
- J.G. Blom: NWO Computational Life Sciences, Simulation of developmental regulatory networks. Jointly with Kaandorp (UvA).
- M.A. Peletier: Vernieuwingsimpuls (Vidi), Mathematical Analysis of Partially Localized Structures.

- J.G. Blom, M.A. Peletier, J.H. van Schuppen (MAS2): NWO Computational Life Sciences, Mathematics and Computation for the System Biology of Cells.
- B.P. Sommeijer, NWO Computational Life Sciences, Understanding the 'organic carbon pump' in meso-scale ocean flows (jointly with Principal Investigator Kooijman (VU, Earth and Life Sciences) and Dijkstra (IMAU/Atmospheric Science, Colorado, USA)).

Computing and Control – MAS2

Mission

The theme Computing and Control is concerned with the numerical and system-theoretical 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, number theory, and control and system theory. Advanced numerical techniques for complex fluid-flow problems are developed for ship hydrodynamics, and for aircraft and spacecraft aerodynamics. In April, new numerical research started: For the Maxwell equations; computational electromagnetics. A long-standing and successful research activity in the theme is computational number theory and data security. In 2002, this activity was extended with a PhD project on discrete tomography, which has connections with number theory and parallel processing and which has various applications, e.g., in medical imaging and electron microscopy. Control and system theory is currently primarily motivated by network problems from engineering and biology (traffic networks, wireless communication networks, and biochemical reaction networks).

Theme leader

Prof.dr.ir. B. Koren

MSC or CR classification

11-xx, 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 – Computational Number Theory and Data Security	H.J.J. te Riele
MAS2.3 – 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 (often industrial) applications. In 2003, emphasis was placed on the development of:

- numerical methods for the computation of free-surface flows,

- computational techniques for optimization problems in electromagnetics,
- discontinuous Galerkin methods for convection-diffusion problems,
- discretizations of the equations of gasdynamics in special relativity,
- the parallelization of software for the incompressible Navier-Stokes equations.

In MAS2.2 number-theoretical algorithms are studied which have applications in cryptography and image reconstruction and require the help of fast computers, particularly parallel systems. In 2003 emphasis was on the study of algorithms and software for factoring large numbers as a continuous validation of the RSA cryptosystem, and on algorithms and software for the solution of discrete tomography problems.

MAS2.3 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 2003 the research focus included:

- control and realization of piecewise-affine hybrid systems on polytopes,
- control of discrete-event systems with coalgebra, including decentralized control, modular control, and complexity problems for the sensor selection problem,
- algebraic methods for optimization with applications in system identification and control theory, and
- realization of rational positive systems.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. K.J. Batenburg	1.0	PhD student	2002-09-01 till 2006-09-01	MAS2.2: NWO5
Drs. D.P.L.D. Benden	1.0	PhD student	2002-02-01 till 2003-02-01	MAS2.1: NWO2
Dr. P.J. Collins	1.0	post-doc	2003-04-01 till 2005-01-01	MAS2.3: CC
Drs.ir. D. Echeverria	1.0	PhD student	2003-04-01 till 2007-04-01	MAS2.1: IOP
Prof.dr. P.W. Hemker	0.8	CWI Fellow	indefinite	MAS2.1: UvA, NWO1, NWO2, NWO3, STW, IOP, ERCIM
D. Jibetean, MSc	1.0	PhD student	1999-04-15 till 2003-06-15	MAS2.3: SICA
Dr. J. Komenda	1.0	post-doc	2001-05-01 till 2003-09-01	MAS2.3: COCON, CC
Prof.dr.ir. B. Koren	0.8	theme leader, leader MAS2.1	indefinite	MAS2.1: NWO1, STW, BRICKS, NCF, IOP
Drs. A. Kuut	1.0	PhD student	2003-03-01 till 2006-03-01	MAS2.1: NWO2
Dr. D. Lahaye	1.0	post-doc	2003-09-01 till 2005-09-01	MAS2.1: IOP
Ir. M.R. Lewis	1.0	PhD student	1999-10-01 till 2003-12-01	MAS2.1: STW
Drs. M. Nool	0.6	programmer	indefinite	MAS2.1: NCF, IOP, BRICKS
Dr. D.E.A. van Odyck	1.0	post-doc	2001-10-01 till 2003-10-01	MAS2.1: NWO1
Drs. M. Petreczky	1.0	PhD student	2002-08-01 till 2006-08-01	MAS2.3: CONTROL
Dr.ir. H.J.J. te Riele	1.0	leader MAS2.2	indefinite	MAS2.2: NWO4, NWO5

K. Rohloff, MSc	0.3	PhD student	2003-05-01 till 2003-08-01	MAS2.3: CC
Prof.dr.ir. J.H. van Schuppen	0.8	leader MAS2.3	indefinite	MAS2.3: CONTROL, CO-CON, CC, TRAFFIC, RESI, LIFESYSTEMS, SICA
Dr. D. Vasileva	1.0	ERCIM Fellow	2003-09-01 till 2004-06-01	MAS2.1: ERCIM
Ir. J. Wackers	1.0	PhD student	2003-07-01 till 2007-07-01	MAS2.1: BRICKS

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	MAS2.3: CONTROL, CC, RESI
Dr. B. Hanzon	0.2	advisor	1999-05-15 till 2003-06-15	MAS2.3: SICA
Prof.dr. B. van Leer (Univ. Michigan)	p.m.	advisor	indefinite	MAS2.1: STW, BRICKS, NWO1
Dr. P.L. Montgomery (Microsoft Research)	p.m.	advisor	indefinite	MAS2.2: NWO4
N. Paliwal	0.2	trainee of Van Schuppen	2003-05-01 till 2003-07-20	MAS2.3: CONTROL
Dr. L.C. Quispe Yagua	1.0	trainee of Koren	2003-09-01 till 2004-01-01	MAS2.1
Ir. M.H. van Raalte (UvA)	1.0	PhD student	2000-12-01 till 2004-12-01	MAS2.1: UvA
Prof.dr.ir. P. Wesseling (TUD)	p.m.	advisor	till 2004-01-01	MAS2.1
L.C.I. van der Zalm (Noordelijke Hogeschool Leeuwarden)	1.0	trainee of Te Riele	2003-11-01 till 2004-02-01	MAS2.2: NWO4

Scientific report

Highlights

- A new line of research, computational electromagnetics, was started with the appointment of Echeverria (PhD student) and Lahaye (post-doc).
- Several research proposals, in which MAS2 participates, were approved (an NWO open competition proposal of Te Riele, a proposal of Van Schuppen in NWO's Computational Life Sciences Programme, and proposals of Koren and Te Riele in BRICKS).
- On May 17, Hemker was appointed member of the Koninklijke Hollandsche Maatschappij der Wetenschappen.
- On May 23, Koren gave his inaugural lecture at the TUD.
- On June 11, Jibetean successfully defended her PhD thesis Algebraic Optimization with Applications to System Theory, at the VU. Her advisor was Van Schuppen and the co-advisor was Hanzon.
- Wackers was awarded the prize of this year's best graduate at the Faculty of Aerospace Engineering, TUD. The prize was handed to Wackers on November 13 in the old town hall of Delft.

PhD students

K.J. Batenburg
D. Echeverria
D. Jibetean
A. Kuut
M.R. Lewis
M. Petreczky
M.H. van Raalte
J. Wackers

MAS2.1 – Computational Fluid Dynamics and Computational Electromagnetics

Computational Fluid Dynamics Computational Electromagnetics (CFD) is of crucial importance to many processes in science and engineering.

Still one of the most fruitful application areas of CFD is aircraft aerodynamics. To enable aircraft filled with tons of fuel and hundreds of passengers, to safely fly over our heads, a detailed knowledge, understanding and control of aerodynamics is of vital importance. Besides safe, aircraft must also be economical, quiet, etc.

CFD is well-established now in industrial research and development. Evidence for this is found in the Journal of Computational Physics and other, related top journals. The majority of papers in these journals are still CFD papers. At present, CFD starts to cooperate with other disciplines such as solid mechanics (computational fluid-structure interactions) and electromagnetism (computational magnetohydrodynamics). Much fundamental research is still required for these new, challenging cooperations.

Title	NWO1 – Computational magnetohydrodynamics in special relativity
Period	October 2001–September 2003
Leader	B. Koren
Staff	D.E.A. van Odyck
Funding	NWO
Partners	UU, Univ. Michigan, FOM Rijnhuizen

Progress report. Van Odyck numerically solved the quasi-1D equations of special relativistic gas dynamics. It was found that when there is a jump in the tangential velocity component at the contact discontinuity, an $\mathcal{O}(1)$ error occurs in the solution. Koren proposed a way of analyzing this error and, after analysis, Van Odyck proposed and tested possible remedies against it. In the fixes, strict conservation is abandoned.

Van Odyck also revised a paper on earlier work, which he had submitted for publication in the International Journal for Numerical Methods in Fluids. The revised paper, which gives an overview of numerical methods used for the equations of special relativistic hydrodynamics, was accepted for publication.

Title	NWO2 – *hp*-Adaptive methods for 3D convection dominated flows
Period	February 2002–February 2003
Leader	P.W. Hemker
Staff	A. Kuut, P.W. Hemker
Funding	NWO
Partner	UvA

Progress report. March 1, a new PhD student, Kuut, took over the work of Benden, who became member of the CST department. Kuut, who in 2002 wrote an MSc thesis on discontinuous Galerkin (DG) methods, started the work by studying Fourier analysis tools and their application to a-posteriori error estimates for DG-discretization. The convection-diffusion problem was studied and an orientation was made into the study of wavelets and non-linear approximation. All these techniques are needed to lay a firm theoretical base for *hp*-adaptive methods.

Title	NWO3 – Numerical singular perturbation problems
Period	January 2001–December 2003
Leaders	P.W. Hemker, G.I. Shishkin
Staff	G.I. Shishkin, L.P. Shishkina, P.W. Hemker
Funding	NWO
Partners	KUN, Moscow State Univ., Russian Academy of Sciences, Steklov Institute of Mathematics

Progress report. In this project the cooperation between the Institute of Mathematics and Mechanics (IMM, Ural Branch RAS, Ekaterinburg, Russia) and CWI, on research concerning singularly perturbed boundary-value problems, was continued. New ε-uniform numerical methods have been studied for parabolic and elliptic singularly perturbed equations. High-order accurate ε-uniform methods for parabolic convection-diffusion problems were developed on the basis of a defect-correction technique, which allows us to improve the ε-uniform accuracy with respect to the space and/or time variables. The conditions were found for which we can ensure the ε-uniform convergence of defect-correction schemes at a rate of order almost one or two in space, and rates of order up to three in time.

Title	STW – Development of a state-of-the-art Navier-Stokes solver for water flows around moving ships
Period	October 1999–September 2003
Leader	B. Koren
Staff	M.R. Lewis, B. Koren, B. van Leer
Funding	STW
Partner	MARIN

Progress report. Lewis and Koren investigated the suitability of piecewise-uniform meshes for

Navier-Stokes computations with free-surface water waves. For 3D Navier-Stokes flow, a comparison was made between a piecewise-uniform mesh (a simplified Shishkin mesh) and the standard exponentially-stretched mesh. On the piecewise-uniform mesh, an erroneous behaviour of the pressure and normal velocity component was found at the interface between fine and coarse submesh.

Lewis and Koren also made a Fourier analysis of the continuous and semi-discrete water-wave problem. It was found that when imposing the so-called quasi free-surface boundary condition, steady free-surface waves can exist for the full Navier-Stokes equations and their inviscid limit (the Euler equations), but *not* for the in-between equations which the reduced Navier-Stokes equations are. However, for the $\mathcal{O}(h^2)$ discretized reduced Navier-Stokes equations in combination with the $\mathcal{O}(h)$ upwind discretization of the quasi free-surface condition, steady waves *can* exist if the mesh Reynolds number is larger than 2. This analytical result explains numerical results that were found earlier in the project.

Lewis spent most of his time on writing his PhD thesis.

Title	BRICKS – 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, M. Nool, J. Wackers
Funding	ICES-KIS 3
Partners	MARIN; Faculty of Aerospace Engineering, TUD; Platform for Computational Science and Engineering, TUD; Department of Aerospace Engineering, Univ. Michigan, Ann Arbor

Progress report. Given the availability of a perfectly qualified PhD student and anticipating a positive outcome of the research proposal submitted in the large BRICKS-proposal, this project was already started on July 1. (BRICKS was indeed approved, in December).

Wackers and Koren worked on the development of a non-isentropic, conservative and pressure-invariant computational method for two-fluid flows. Wackers succeeded in deriving a novel mathematical-physical model for these flows.

From February 20–28 and from August 1–14 Van Leer visited CWI to advise Wackers and also Lewis (aforementioned STW-project) in their research. Van Leer advised Wackers on the construction of an approximate Riemann solver of HLL-type for the proposed new equations. The first computational results obtained by Wackers (e.g., for a shock wave hitting a helium bubble) already fulfilled our expectations.

Title	UvA – Discontinuous Galerkin methods and singularly perturbed problems
Period	December 2000–November 2004
Leader	P.W. Hemker
Staff	M.H. van Raalte, P.W. Hemker
Funding	UvA
Partner	UvA

Progress report. In this joint project with the UvA, the efficient solution of elliptic problems by means of discontinuous Galerkin methods is studied. In 2003 the emphasis of the research was on the treatment of non-aligned boundary conditions and on the use of multigrid iteration for discretizations of the convection-diffusion equation. The purpose of the research in boundary-condition treatment was to introduce discretization methods of discontinuous Galerkin type for solving second-order elliptic PDEs on a structured, regular rectangular grid, while the problem is defined on a curved boundary. We achieved this goal and developed a method that is high-order accurate, both in the domain and at the curved boundary. With respect to multigrid iteration it was shown that also for the convection-diffusion equation a straightforward multigrid strategy can be optimally efficient, provided that the discrete operator is decomposed into point-wise blocks. The problem was thoroughly analyzed for the case with cubic approximations. This special case represents the canonical form to which all higher-order problems can be reduced. The newly developed ideas were presented at the 10th NUMDIFF Conference on Numerical Solution of Differential and Differential-Algebraic Equations, held in Halle in September.

Title	NCF – Parallel implementation of a state-of-the art, incompressible Navier-Stokes method
Period	December 2000–May 2003
Leader	B. Koren
Staff	M. Nool, B. Koren
Funding	NCF (until May 2002), CWI
Partner	TUD

Progress report. The topic of the research was the parallelization of the least-squares spectral element formulation of the Stokes problem for incompressible flow problems on both structured and unstructured grids. The results revealed that the Additive Schwarz preconditioner is very suitable for the p-refinement version of the least-squares spectral element method.

Nool finished this project and sent a final report to NCF. An adapted version of this report was submitted to the Journal of Parallel Computing.

Title	IOP – 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. Echeverria, P.W. Hemker, B. Koren, D. Lahaye, M. Nool
Funding	IOP-EMVT
Partner	Group Electromechanics and Power Electronics TUE

Progress report. This project, dealing with design optimization in computational electromagnetism, started with the appointment of Echeverria as PhD student in April, and with the appointment of Lahaye as post-doc in September. Together with Hemker they studied a new optimization technique called *space-mapping*.

Since the start of the project, the space-mapping technique was evaluated using two model problems: The first is a C-shaped core with permanent magnet and the second is an actuator without core consisting of a permanent magnet and two coils. The performance of the space-mapping technique was compared with some classical optimization techniques and promising results were obtained. A link between the space-mapping technique and the classical theory of defect correction was also established.

Title	ERCIM – Multigrid for hp-adaptive discontinuous Galerkin discretizations of convection-diffusion equations
Period	September 2003–May 2004
Leader	P.W. Hemker
Staff	P.W. Hemker, D. Vasileva
Funding	ERCIM

Progress report. In this project Vasileva started to get acquainted with the software developed at CWI for multigrid discontinuous Galerkin methods in previous years. The work continued with the implementation of variable convection-coefficients discretization in 3D. After that, a multigrid algorithm with local refinement was developed and implemented. The work was continued with the implementation of an adaptation criterion, developed by Kuut and Hemker, as well as with studying possible ways for semi-refinement.

MAS2.2 – Computational Number Theory and Data Security

Many problems in number theory, e.g., the problem of finding the prime factors of a given large positive integer and the problem of finding the positive integer x for which $a^x \equiv b \bmod p$ where p is a given (large) prime and a and b are given positive integers, are at the basis of modern cryptosystems (RSA, respectively Diffie-Hellman key exchange). This is the main motivation for the study of such problems in this subtheme. In addition, a PhD study was started, in September 2002, in discrete tomography because some algorithms used here (developed by Tijdeman and Hajdu) originate from number theory, and because large sparse matrices are involved which also occur in algorithms for factoring large numbers. So parallel processing techniques used in factoring algorithms are expected to be useful for handling the large matrices which arise in discrete tomography.

Title	NWO4–Factoring large numbers as validation of RSA
Period	January 1997–December 2006
Leader	H.J.J. te Riele
Staff	P.L. Montgomery, H.J.J. te Riele, L.C.I. van der Zalm
Funding	NWO (basic & project funding)
Partners	UL, Univ. Bonn, Microsoft Research

Progress report. Montgomery and Te Riele contributed to the sieving part of the new world record factorization of RSA576 (174 decimal digits) by the General Number Field Sieve (GNFS) factoring method, established on December 3. Later in December, line sieving computations were started on SARA's TERAS parallel computer for the new record factorization of RSA200 (200 decimal digits) by GNFS. Montgomery and Te Riele contributed to the sieving part and the linear algebra part (on SARA's TERAS parallel computer) of the new record factorization (244 decimal digits) by the Special Number Field Sieve (SNFS) factoring method, established on January 3. These three record projects were coordinated by Jens Franke and Thorsten Kleinjung of the Univ. Bonn.

Montgomery and Te Riele factored various numbers from the Cunningham table with help of Montgomery's implementation of SNFS.

In addition, $2^{383} - 3(95)$ and $2, 1786 + (104)$ were factored with GNFS.

Montgomery finished the factorization of all Fibonacci numbers F_n and Lucas numbers L_n with $n \leq 1000$.

In June, Montgomery produced an update of the Number Field Sieve source code. The executables were shipped to several persons who had signed a license agreement for the NFS code.

The linear algebra code (block Lanczos algorithm) was ported to new architectures by Montgomery. The communications overhead (within a multiprocessor MPI run) dropped another 30%.

Medusa, a 32-host SGI Origin at CWI with 64 Gigabytes of memory, is being phased out. High-memory algorithms, especially during the filtering phase of NFS, are being re-examined. At the same time, we must enhance the software to allow 64-bit primes on relations, as we aim for future records.

In a third year trainee project for the bachelor's degree 'Bedrijfswiskunde en Informatica' at the Noordelijke Hogeschool Leeuwarden, Van der Zalm studied the RSA crypto system and the Diffie-Hellman key exchange system, and the main algorithms which are known for attacking the mathematical problems (factoring and discrete log, respectively) on which the safety of these systems is based. A report is available upon request (from the project leader).

Te Riele finished the survey paper on amicable numbers (mentioned in the previous report), written jointly with Jan Munch Pedersen and Mariano García, which will appear, in 2004, in the Proceedings of a Conference in Number Theory in Honour of Professor H.C. Williams, held in Banff, Canada, May 24–30 (to be issued as an AMS publication). This paper has also been issued as CWI report MAS-R0307.

Title	NWO5 – 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, Univ. Debrecen

Progress report. Discrete tomography is concerned with the reconstruction of binary images from a small number of projections. It has various practical applications, ranging from medical imaging to electron microscopy.

Batenburg has extended his work on the optimization of an algorithm of Hajdu and Tijdeman for the reconstruction of binary images from their projections. Early in 2003, he also developed a different class of algorithms for solving such problems. The algorithms work very well on large experimental problem instances. Research in 2003 was mainly focused on exploring and extending these algorithms. Experimental software was developed for reconstructing very large images with various source-detector configurations. The new results have a strong potential to be used in practical applications. Contacts within several potential application areas were established.

MAS2.3 – 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. The international research community is to a large extent focused on the following classes of dynamic systems: Hybrid systems (motivated by the control of engineering sys-

tems by computers); discrete-event systems (motivated by the use of computers for networks); positive systems (motivated by research in biology and medicine). In 2003 the CWI research was directed at:

- Control of hybrid systems with applications to control of car engines.
- Dynamic system properties of hybrid systems.
- Supervisory control of decentralized and modular discrete-event systems.
- Realization of rational positive systems with applications to biological models.

Title	CONTROL – Control of hybrid systems and of discrete-event systems
Period	December 1998–February 2007
Leader	J.H. van Schuppen
Staff	L.C.G.J.M. Habets, N. Paliwal, M. Petreczky, J.H. van Schuppen
Funding	CWI
Partners	UCB, UIUC, Univ. Gent

Progress report. Realization of a specific class of hybrid systems, switched systems, was investigated by M. Petreczky. He obtained a characterization of realizability of such systems and formulated a new proof for the characterization of the reachable subset and of the observability kernel. A paper will be submitted in 2004.

Habets and Van Schuppen determined the co-reachable set of affine systems on polytopes in the plane, or the domain of attraction of the exit sets. The complexity of the geometric properties of the co-reachable sets is a major bottleneck for control of hybrid systems. A paper will be submitted in 2004.

The paper on the control-to-facet problem was revised by further investigating triangulation of polytopes and the complexity issues of the problem.

Paliwal and Van Schuppen have investigated a model for the IEEE 802.11 protocol in particular for the interaction of stations in a wireless local area network. The model was specified in terms of discrete-event systems, and verified by the program UMDES. A paper remains to be completed.

Not directly fitting in this project and neither in other projects, was an investigation of the control problems for pension funds. The investigation was carried out by Van Schuppen in cooperation with Prof. M.A. Petersen (Potchefstroom Univ.) and his PhD student H. Raubenheimer during a visit of Van Schuppen to Potchefstroom Univ. A model was specified for the operation of a pension fund in terms of stochastic differential equations. The optimal control law for the extra financial contributions and the optimal portfolio selection was obtained by the method of optimal stochastic control theory. For the particular case of a quadratic cost function, an explicit form of the control law was obtained. A paper is in preparation and the research will be continued.

Title	COCON – Coalgebra and control
Period	May 2001–May 2003
Leader	J.H. van Schuppen
Staff	J. Komenda, J.H. van Schuppen
Funding	NWO
Partner	SEN3

Progress report. Komenda and Van Schuppen have obtained a characterization for the existence of supervisory controllers for control of decentralized discrete-event systems. Concepts of co-observability relation and a proof of the existence of controllers using co-algebra were obtained. Stronger conditions than co-observability with better algebraic properties were formulated and the relations between them proven. A manuscript has been submitted for publication.

Title	CC – Computation and Control
Period	January 2002–January 2005
Leader	J.H. van Schuppen
Staff	P.J. Collins, L.C.G.J.M. Habets, J. Komenda, K. Rohloff, J.H. van Schuppen
Funding	European Commission (EU.IST.CC)
Partners	Verimag, Parades, ETH Zürich, Lund Univ. Technology, EDF, ABB

Progress report. Collins and Van Schuppen have derived a characterization of observability of piece-wise affine hybrid systems. The approach goes beyond what had been considered in the literature. Special cases of these conditions which are checkable by linear algebra have been formulated. A paper has been accepted for publication at a workshop scheduled for 2004.

Topological properties of hybrid systems were studied in the setting of the trajectory space. A dichotomy was obtained of a hy-

brid system being either non-Zeno or instantaneously Zeno. A paper is scheduled to be submitted to a workshop.

In cooperation with Dr. Andrea Balluchi of the company Parades, Van Schuppen investigated the problem of idle speed control for a car engine. The research is motivated by problems of the company Magneti-Marelli, a subsidiary of Fiat. The problem is difficult because it is a control problem with variable delays, the duration of the delay is subject of control. A hybrid controller was derived which keeps the speed in a specified interval. A preliminary publication was accepted for a workshop scheduled for 2004.

Komenda and Van Schuppen obtained sufficient conditions for a modularly designed supervisor to be globally satisfying the control objective and to be optimal (least restrictive) with respect to this property. For complete observations the condition involves mutual controllability while for partial observations the condition involves mutual controllability and mutual normality. The proofs are based on coalgebra and require establishing that a relation is a bisimulation. A paper has been submitted to a workshop in 2004.

Rohloff and Van Schuppen have investigated a sensor selection problem for control of discrete-event systems. The problem is motivated by the exchange of communications between controllers for discrete-event systems. The sensor selection problem was related to a combinatorial optimization problem, a coloured cut-set problem for a graph. In addition, several heuristic algorithms were formulated and analyzed in regard to their complexity. A paper is in preparation. A second paper is planned to be submitted to a workshop.

Title	TRAFFIC – Control and modelling of motorway traffic
Period	indefinite
Leader	J.H. van Schuppen
Staff	J.H. van Schuppen
Funding	CWI

No research was carried out on this project in 2003.

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.FEW.WISK

Progress report. Van Schuppen has investigated the realization problem for rational positive systems. This class of systems arises as mathematical models for biochemical reaction networks. Dynamic system properties were first studied such as existence and calculation of equilibrium states, symbolic calculation of such equilibrium states, and dissipation properties. The class of systems is closed with respect to series and a specific feedback connection. A characterization of the realization of these systems leads to a factorization problem for polynomials with positive coefficients. Further progress was temporarily halted because the set of polynomials with positive coefficients is not a unique factorization domain. Control problems for rational positive systems were also formulated, they are motivated by rational drug design. An invited lecture was presented at a symposium and a paper is scheduled to be submitted to a conference.

Title	LIFESYSTEMS – Control and system theory for biology
Period	2001–2009
Leader	J.H. van Schuppen
Staff	J.H. van Schuppen
Funding	CWI
Partner	VU

Progress report. A mathematical model for the glycolysis in Trypanosoma brucei formulated by Dr. B.M. Bakker (VU) was transformed partly to the form of a rational positive system. The model can then be used as an example for realization and control of rational positive systems. A report is in preparation.

A research proposal based on cooperation with Prof. H. Westerhoff (VU) was selected for financial support and a new PhD student is expected to start his/her research in 2004.

Title	SICA – System Identification with Computer Algebra
Period	1999–2003
Leaders	B. Hanzon, J.H. van Schuppen
Staff	D. Jibetean, B. Hanzon, J.H. van Schuppen
Funding	NWO
Partner	UM

Progress report. Jibetean completed her PhD thesis which was successfully defended at the VU on June 11.

R.L.M. Peeters (UM), Hanzon, Jibetean have worked on model reduction with respect to the H_2 criterion. A lecture was presented at the European Control Conference 2003.

Jibetean and E. de Klerk (UM) have worked on constrained global optimization of rational functions. A lecture was presented at the workshop on High Performance Methods for Mathematical Optimization 2003. Jibetean and Van Schuppen obtained an algebraic method for system reduction of Gaussian systems. A lecture was presented at the IFAC Symposium System Identification and a paper will be submitted in 2004.

Externally financed networks

Title	SI – System Identification
Period	1998–March 1, 2003
Leader	J.H. van Schuppen (Coordinator)
Staff	L.C.G.J.M. Habets, J.H. van Schuppen
Funding	EU (Training and Mobility of Researchers (TMR))
Partners	Tech. Univ. Vienna (M. Deistler); Cath. Univ. Louvain-la-Neuve, Belgium (M. Gevers); INRIA Sophia Antipolis, France (L. Baratchart); IRISA, Univ. Rennes, France (J.-J. Fuchs); Univ. Cambridge, UK (J.M. Maciejowski); Istituto di Bioingegneria e Control, CNR, Padova (G. Picci); Royal Institute of Technology (KTH), Stockholm (A. Lindquist); Univ. Linköping, Sweden (L. Ljung).

Progress report. The project was completed on February 28. Van Schuppen as coordinator produced the final report. The European Commission has approved the final report and the final payment was received and distributed to the partners before the end of 2003. A new research proposal for the ERNSI network was submitted to the European Commission. CWI participates in this new proposal via a node at the TUD. The coordinator of the new proposal is established at the KTH (Stockholm).

Societal aspects and knowledge transfer

External contacts

- UU, Faculty of Physics and Astronomy, Astroplasmaphysics group (page 115).
- FOM Institute for Plasmaphysics, Rijnhuizen, Numerical plasma dynamics group (page 115).
- Univ. Michigan, Department of Aerospace Engineering, W.M. Keck Foundation Laboratory for Computational Fluid Dynamics (page 115).
- UvA, Korteweg-de Vries Institute for Mathematics, Dynamical Systems and Numerical Analysis group (page 115 and 116).
- KUN, Subfaculty of Mathematics, Department of Numerical Analysis (page 115).
- Moscow State Univ., Chair of Computational Mathematics (page 115).
- Russian Academy of Sciences, Ural Branch, Institute of Mathematics and Mechanics, Ekaterinburg (page 115).
- Maritime Research Institute Netherlands, Ship Powering group (page 115).
- TUD, Faculty of Aerospace Engineering, Chair of Aerodynamics (page 117).
- TUE, Faculty of Electrical Engineering, Electromechanics and Power Electronics Group (page 117).
- Philips Medical Systems, Best, Dept. MR Development (page 117).
- LG. Philips Displays Netherlands B.V., Eindhoven, Electron-optical Design Group (page 117).
- Univ. California at Berkeley, CA, USA (page 119).
- Univ. Illinois at Urbana-Champaign, IL, USA (page 119).
- Univ. Gent, Belgium (page 119).
- Parades, Rome, Italy, Control Department (page 119).
- Verimag, Grenoble, France, Theoretical Computer Science (page 119).

- VU, Department of Mathematics (page 120).
- VU, Department of Cell Biology (page 120).
- UM (page 121).
- NWO Programmacommissie Computational Science.

B. Koren
- Delft Hydraulics.
- DAF Trucks NV, Eindhoven.
- Well Design, Utrecht.
- Shell Global Solutions - Fluid Flow and Thermodynamics.
- Netherlands Organization for Applied Scientific Research, Technical-Physical Department (TNO-TPD), Models and Processes Division.
- TUD, Faculty of Design, Engineering and Production, Thermal Power Engineering Section.
- TUD, Faculty of Civil Engineering and Geosciences, Section Structural Engineering.
- TUD, Faculty of Aerospace Engineering, Chair of Aircraft System Integration.

H.J.J. te Riele
- MAS2.2 has several source code license agreements with companies in The Netherlands, USA, Germany and France which allows them to use the Number Field Sieve factorization code as this was and is being developed by P.L. Montgomery, A.K. Lenstra, M. Elkenbracht-Huizing, S.H. Cavallar and B. Dodson. During 2003, the NFS source code has been made available, on a non-commercial basis, to five other cooperating groups in the USA, Germany, Denmark, Hungary and England.

Projects with partners in public and private sector
- NWO1 (page 115).
- STW (page 115).
- BRICKS (page 116).
- IOP (page 117).
- NWO4 (page 117).
- CC (page 119).

Courses, tutorials
- Numerical Aircraft Aerodynamics II, TUD, January–May: B. Koren.
- Numerical Hydrodynamics, UvA, March–July: P. Hemker
- Compressible Flows, Centre for Fluid Dynamics, June 4: B. Koren. (Lecture: Computational Techniques for Compressible Two-Fluid Flows), J.M. Burgers .
- Control and System Theory - Positive Systems, Departments of Mathematics, VU, February–May: J.H. van Schuppen.
- Mathematical Control and System Theory, Department of Mathematics, VU, September–December: J.H. van Schuppen (jointly with Prof. A.C.M. Ran).
- Stochastic Control with Applications to Mathematical finance, Department of Business Mathematics and Informatics, Potchefstroom Univ., Potchefstroom, South Africa, November: J.H. van Schuppen.

Organization of conferences, workshops, courses, meetings
- Meeting CC project, CWI, Amsterdam, June 16–17: J.H. van Schuppen.
- CWI Seminar Control and System Theory, biweekly both in the Spring and in the Fall: J.H. van Schuppen and P. Collins (Fall 2003).
- CWI Colloquium Control and System Theory, irregularly: J.H. van Schuppen.
- Minisymposium: 'Discontinuous Galerkin Methods' in the 10th Seminar NUMDIFF on Numerical Solution of Differential and Differential-Algebraic Equations, Halle, September 11: P.W. Hemker.
- CFD-meetings at CWI (tri-weekly): B. Koren.
- Meetings STW-project, CWI, March 4 and September 29: B. Koren.
- ERNSI Workshop System Identification, Noordwijkerhout, October 6–8: J.H. van Schuppen.
- EIDMA-CWI Workshop on Factoring Large Numbers, December 12, Utrecht: H.J.J. te Riele. Speakers: Arjen Lenstra (Citibank, NJ, USA and TUE, Lecture: SNFS versus GNFS, and the feasibility of factoring a 1024-bit number with SNFS), Willi Geiselmann and Rainer Steinwandt (Arbeitsgruppe Systemsicherheit, Fakultät für Informatik, Univ. Karlsruhe, Germany, Lecture: A special purpose mesh architecture for sieving in the number field sieve), Paul Leyland (Microsoft Research, Cambridge UK, Lecture: NFSNET—the first year and the next year), Peter Montgomery (Microsoft Research USA, and CWI, Lecture: Filtering large data sets in the NFS), Bruce Dodson

(Lehigh Univ., Bethlehem, PA, USA, Lecture: Filtering NFS relations: weeding, cycles and clique-deletes), Jens Franke (Univ. Bonn, Germany, RSA-576 (174D) factored), Scott Contini (Univ. of Sydney, Australia, Lecture: Two implementation ideas for fast line sieving), and Paul Zimmermann (LORIA/INRIA Lorraine, Nancy, France, Lecture: Towards 60 digits with ECM, presented by Herman te Riele).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Symposium Jaap Korevaar 80 jaar, UvA, January 11: P.W. Hemker, H.J.J. te Riele.
- EIDMA Cryptography Working Group, Utrecht, February 7, April 11, October 10, December 12: H.J.J. te Riele.
- Participation in the Dutch Workshop on Systems Biology, Egmond aan Zee, March 6–7: J.H. van Schuppen.
- IOP Meeting on Non-technical Aspects of Innovation, UvA, March 12: P.W. Hemker.
- Meeting of Full Professors of Department of Exact Sciences, VU, March 18: J.H. van Schuppen.
- Benelux Meeting on Systems and Control 2003, Lommel, Belgium: L.C.G.J.M. Habets, D. Jibetean, J. Komenda, M. Petreczky, J.H. van Schuppen. (Lecture by J. Komenda, March 19: Coalgebra and Coinduction in Discrete-Event Control, Lecture by L.C.G.J.M. Habets: Control of multi-affine systems on rectangles with applications to hybrid biomolecular networks (joint work with C. Belta and V. Kumar, Univ. Pennsylvania)).
- Workshop on Hybrid Systems – Computation and Control (HSCC.2003), Prague, Czech Republic, April 3–5: L.C.G.J.M. Habets, J.H. van Schuppen.
- Participation of J. Komenda in the meeting Coalgebraic Methods in Computer Science (CMCS'2003), Satellite workshop of ETAPS 2003 Conference, Warsaw, Poland, April 5–6: J. Komenda (Lecture on April 6: Coinduction in Control of Partially Observed Discrete-Event Systems).
- Euro-conference on Multiscale Modelling, Multiresolution and Adaptivity, Cambridge, April 7–11: P.W. Hemker.
- Participation in NVBTB Symposium in biology, VU, April 16: J.H. van Schuppen.
- 39e Nederlands Mathematisch Congres, KUN, May 1–2: H.J.J. te Riele.
- International Workshop on Combinatorial Image Analysis, Palermo, Italy, May 14–16: K.J. Batenburg (Lecture: Analysis and optimization of an algorithm for discrete tomography).
- Oberwolfach Workshop 'Schnelle Löser für Partielle Differentialgleichungen', June 1–7: P.W. Hemker.
- IFIP WG 2.5 Meeting and Workshop, St. Wolfgang, Salzburg, Austria, June 15–21: P.W. Hemker.
- 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, June 23–26: B. Koren (Lecture June 24: A Simple and Efficient Space-Time Adaptive Grid Technique for Unsteady Compressible Flows, Lecture June 25: A Pressure-Invariant and Conservative Method for Two-Fluid Flows), M.R. Lewis (Lecture June 26: Efficient Computation of Steady, 3D Water-Wave Patterns), M. Nool (Lecture June 26: An Unstructured Parallel Least-Squares Spectral Element Solver for Incompressible Flow Problems).
- Participation in DISC Summer School Hybrid Systems, Veldhoven, The Netherlands, June 23–26: P.J. Collins, L.C.J.G.M. Habets, N. Paliwal, M. Petreczky, K. Rohloff, J.H. van Schuppen. (J.H. van Schuppen was chairman on June 25).
- Participation in Workshop on Discrete Event Systems Control, a satellite meeting of the Conference on Theory and Applications of Petri Nets, Eindhoven, The Netherlands, June 24: J. Komenda, N. Paliwal, and K. Rohloff.
- Equadiff 2003, Hasselt, Belgium, July 22–26: P.J. Collins (Lecture July 24: Chaotic Lasers: manifolds, bifurcations and symbolic dynamics).
- Workshop Diophantine Approximation, Leiden, July 28–August 2: K.J. Batenburg, H.J.J. te Riele.
- 3rd TEAM (Transmission Electron Aberration-Corrected Microscopy) Workshop, San Antonio, Texas, USA, August 8: K.J. Batenburg (Invited lecture: Mathematical Aspects of Discrete Tomography).
- Participation in NATO Summer School on Chaotic Dynamics and Transport, Cargese, France, August 18–30: P.J. Collins.

- Participation in IFAC Symposium System Identification Rotterdam, August 27–28: J.H. van Schuppen (Lecture August 27: An algebraic method for system reduction of Gaussian systems).
- Participation in 1st International Symposium on Positive Systems, Rome, Italy, August 29–30: J.H. van Schuppen (Invited plenary lecture August 29: Rational positive systems for cell reaction networks).
- Industrial Challenges in the Simulation of Evolving Interfaces, Brussels, September 1–2: B. Koren (Invited lecture: Conservative, Oscillation-Free Computation of Two-Fluid Flows is Possible!), J. Wackers.
- Participation in the European Control Conference, Cambridge, UK, September 1–4: J.H. van Schuppen (Lecture September 2: Decentralized supervisory control with coalgebra).
- 10th Seminar NUMDIFF on Numerical Solution of Differential and Differential-Algebraic Equations, Halle, September 8–11: P.W. Hemker (Lectures September 11: Multigrid Iteration for the Solution of Discontinuous Galerkin Discretizations of Elliptic PDEs), A. Kuut, M. van Raalte (Lectures September 11: Discontinuous Galerkin Discretization with Interior Boundary Conditions).
- Participation in Kick-off Meeting of NWO programme Computational Life Sciences, VU, September 26: P.J. Collins, J.H. van Schuppen.
- Workshop Mathematics of Cryptology, Leiden, September 26–October 2: H.J.J. te Riele.
- Participation in Workshop on Econometric Time Series Analysis, Univ. Linz, Austria, September 29–October 1: J.H. van Schuppen.
- Optimization and Coupled Problems in Electromagnetism, Naples, Italy, September 22–23: D. Echeverria (Lecture September 23: Electromagnetic Shape Optimization with the Space-Mapping Technique).
- Woudschoten Conference on Numerical Mathematics, Woudschoten, October 1–3: D. Echeverria, P.W. Hemker, B. Koren, A. Kuut, D. Lahaye, M.R. Lewis, L.C. Quispe Yagua, M.R. van Raalte, D. Vasileva, J. Wackers.
- Participation in ERNSI Workshop System Identification, Noordwijkerhout, The Netherlands, October 6–8: P.J. Collins, M. Petreczky, J.H. van Schuppen, P.J.C. Spreij. (Lectures by J.H. van Schuppen on October 7: Introduction to research topic of hybrid systems. CWI Research in hybrid systems – Past and current effort).
- NWO-OTKA Workshop on Computational Number Theory, Debrecen, Hungary, October 20–24: H.J.J. te Riele (Lecture: Sieving for primes of the form $x^2 + (x + 1)^2$).
- CWI in Bedrijf, October 17: K.J. Batenburg (Lecture: Discrete Tomografie), J. Wackers (Lecture: Efficiënte Simulatie van Instationaire Stromingen door Roosteraanpassing).
- Oberwolfach Mini-Workshop: Finite Elements and Layer Adapted Meshes, Oberwolfach, November 2–8: P.W. Hemker (Lecture November 4: On a Two-Dimensional Discontinuous Galerkin Discretization with Embedded Dirichlet Boundary Condition. Lecture November 5: Multigrid Iteration for the Solution of the Discontinuous Galerkin Discretization of Elliptic PDEs).
- Participation in SYNCHRON.2003, Marseille, France, November 30–December 4: J.H. van Schuppen (Lecture December 2: Protocol IEEE 802.11: Modeling and control using DES).
- The 20th SARA Superdag, December 4, Amsterdam: M. Nool, H.J.J. te Riele.

Working visits

- Meeting with staff and students from Chair of Aerodynamics, Faculty of Aerospace Engineering, TUD, January 13: B. Koren.
- Parades, Rome, Italy, January 27–31; March 24–28; October 19–25: J.H. van Schuppen.
- RUG, January 30: Dorina Jibetean (Lecture: The H_2 optimal model reduction problem).
- TUE, February 5: D. Jibetean (Lecture: Global minimization of a polynomial function using algebraic matrix methods).
- TUD, February 18: D. Jibetean (Lecture: H_2 model reduction problem).
- Univ. l'Aquila, Italy, March 25: J.H. van Schuppen (Lecture: Realization and control of piecewise-affine hybrid systems).
- Meetings with staff of the group Electromechanics and Power Electronics, TUE, April 25 and September 15: P.W. Hemker.
- Meetings Executive Board Platform for Computational Science and Engineering, TUD, May 28 and October 16: B. Koren.

- Univ. Gent, Belgium, July 3: P. Collins, J. Komenda (Lecture: Decentralized control with coalgebra), N. Paliwal, M. Petreczky, K. Rohloff (Lecture: Sensor selection in discrete-event systems), J.H. van Schuppen.
- Meetings with professor and MSc-student from Section Structural Engineering, Faculty of Civil Engineering and Geosciences, TUD, August 8, October 24, December 11: B. Koren.
- Meeting with project-proposal partners at PNO Consultants, Hoofddorp, August 28: B. Koren.
- Meeting with professor and MSc-student from Thermal Power Engineering Section, Faculty of Design, Engineering and Production, TUD, September 26: B. Koren.
- Meeting with professor and MSc-student from Aircraft Group, Chair of System Integration, Faculty of Aerospace Engineering, TUD, October 31: B. Koren.
- Univ. Potchefstroom, South Africa, November 8–23: J.H. van Schuppen (Short course November 12–14: Stochastic control theory with applications to mathematical finance).
- Meeting with staff of Well Design and DAF Trucks NV, Faculty of Aerospace Engineering, TUD, November 21: B. Koren.
- Meetings with dean Faculty of Aerospace Engineering, TUD, November 28 and December 19: B. Koren.
- Univ. Mannheim, Germany, December 5: K.J. Batenburg (Lecture: An Evolutionary Algorithm for Discrete Tomography).
- Meeting with staff of Models and Processes Division, Netherlands Organization for Applied Scientific Research, Technical-Physical Department (TNO-TPD), December 12: B. Koren.

Project meetings

- Meetings NWO-project Rapid Changes in Complex Flows, UU, January 9 and March 20: P.W. Hemker, B. Koren; August 27: P.W. Hemker, D.E.A. van Odyck.
- Review Meeting of Project EU.IST.CC, LIAFA, Univ. Paris, January 17: J.H. van Schuppen.
- Meetings STW-project Development of a State-of-the-Art Navier-Stokes Solver for Water Flows Around Moving Ships, CWI, March 4 and September 29: P.W. Hemker, B. Koren, M.R. Lewis.
- Meeting of STW Project Mobile Communication Systems, STW, Utrecht, March 18: J.H. van Schuppen.
- Meetings MAS2-EPE related to the project Space-mapping and related techniques for inverse problems in magnetic shape design, with application to on electric actuator, TUE, April 25, July 21 and September 15: D. Echeverria, P.W. Hemker, D. Lahaye; CWI, October 7 and December 1: D. Echeverria, P.W. Hemker, D. Lahaye.
- Meeting of project EU.IST.CC, CWI, June 16–17: P.J. Collins (Lecture: Chaotic Dynamics in Hybrid Systems), C.J.G.M. Habets (Lecture: Reachability of affine systems on polytopes in the plane), J. Komenda (Lecture June 16: Modular control of hybrid systems at the discrete-event level), N. Paliwal, M. Petreczky, K. Rohloff J.H. van Schuppen (Lecture: Control of a Car Engine; Observability of piecewise-affine hybrid systems).
- Meeting IOP-EMVT-project, TUE, July 1: D. Echeverria (Lecture: The Principle of Space-Mapping), P.W. Hemker.
- Participation in EU.IST.CC Meeting, Univ. Siena, Italy, September 22–24: P.J. Collins, L.C.G.J.M. Habets (Lecture: Control of multi-affine systems on rectangles with applications to hybrid biomolecular networks (joint work with C. Belta and V. Kumar, Univ. Pennsylvania)), J.H. van Schuppen (Lecture September 22: Control of a car engine).
- Meeting IOP-EMVT-project, NIMAC, Ede, October 14: D. Echeverria, B. Koren, D. Lahaye.
- Meeting IOP-EMVT-project, TUD, October 29: D. Echeverria, P.W. Hemker, D. Lahaye.
- JMBC Strategy Meeting, TUD, November 5: B. Koren.
- 'Beste Afstudeerder'-award meeting, old town hall of Delft, November 13: B. Koren, J. Wackers.
- NWO Programme Meeting Scientific Computing, TUE, November 28: P.W. Hemker.

Other lectures

- Lecture for UvA Numerica, February 24: M. van Raalte (Discontinuous Galerkin Discretization with Embedded Boundary Conditions).

- Lecture for MPCM Seminar, UT, May 5: J. Wackers (An Adaptive-Gridding Solution Method for the 2D Unsteady Euler Equations).
- Inaugural lecture TUD, May 23: B. Koren (Computational Fluid Dynamics: Wetenschap en Gereedschap).

Courses

- DISC course Design Methods for Control Systems, December 2, 2002–January 27: M. Petreczky.
- Dutch language course, level 2, CWI, January 6–April 1: M. Petreczky.
- Course Control and System Theory – Positive Systems, UvA, February 7–March 21, April 4–25 and May 9–23: M. Petreczky.
- Course of Belgian Graduate School on Systems and Control Hybrid Systems: March 10–14 and March 24–28: M. Petreczky.
- DISC course Modeling and Control of Hybrid Systems: March 17–April 7: M. Petreczky.
- DISC course Systems and Control Theory for Nonlinear Systems, March 17–May 12: M. Petreczky.
- Course Effective Presentations in English by the Language Academy B.V., October 1–December 10: (3 hours a week, total 8 mornings): M. Nool.
- SGI Altix 3700 Optimization and Parallelization Course, Utrecht, November 4: M. Nool.

Visitors

- T. Herendi, Univ. Debrecen, Hungary, January 20–31. Host: H.J.J. te Riele.
- J.M.A. Hofman (NLR), January 20 and February 4 (Lecture: Control-Fluid Interaction in Air-Conditioned Aircraft Cabins). Host: B. Koren.
- D. Echeverria, Univ. Zaragoza, February 24–27 (Lectures: A Multigrid Toolbox for Matlab and Wavelet Packets Applied to ECG Compression). Host: P.W. Hemker.
- D. Lahaye, CRS4, Italy, February 25 (Lecture: Algebraic Multigrid for Two-Dimensional Time-Harmonic Magnetic Field Computations). Host: P.W. Hemker.
- Dr. P.J. Collins, February 25 (Lecture: Chaotic dynamics). Host: J.H. van Schuppen.
- K.C. Patidar, Univ. Tübingen, March 18 (Lecture: A Numerical Study of Pollution Effect via Least-Squares Discretizations). Host: P.W. Hemker.
- B. de Maerschalck, TUD, March 18 (Lecture: Space-Time Least-Squares Spectral-Element Method for Unsteady Flows). Host: B. Koren.
- D. Echeverria, Univ. Zaragoza, April 7–13. Host: P.W. Hemker.
- I. Shparlinski, Macquarie Univ., Sydney, Australia, May 8–9. Host: H.J.J. te Riele.
- A.M. Artoli, UvA, May 27 (Lecture: Mesoscopic Computational Hemodynamics). Host: P.W. Hemker.
- Dr. A. Balluchi, Parades, Rome, June 18–19. Host: J.H. van Schuppen.
- Eiko Kin, Kyoto Univ., July 7–August 15. Host: P.J. Collins.
- J.L. López, Univ. Pamplona, July 24. Host: P.W. Hemker.
- L.C. Quispe Yagua, July 29. Host: B. Koren.
- G.I. Shishkin, November 1–30 (Lecture November 11: On Robust Numerical Methods for Parabolic Boundary/Interior Layers in Flow Problems with Large Reynolds Number. Lecture November 24: On Conditioning of ε-uniformly Convergent Schemes on Special Meshes for Singularly Perturbed Convection-Diffusion Problems). Host: P.W. Hemker.
- L.P. Shishkina, November 1–30. Host: P.W. Hemker.
- B. Walden, Comsol, Stockholm, November 14. Host: P.W. Hemker.
- P.L. Montgomery, Microsoft Research, Redmond, USA, December 8–13. Host: H.J.J. te Riele.

Memberships of committees and other professional activities

K.J. Batenburg

- Referee of papers for scientific journals.

P.W. Hemker

- Full professor Scientific Computing, UvA.
- Member Koninklijke Hollandsche Maatschappij der Wetenschappen.
- Vice-chair Working Group 2.5 on Numerical Software, IFIP.
- Member science committee, Thomas Stieltjes Institute for Mathematics.

- Member steering group Amsterdam Centre for Computational Science, ACCS.
- Member Numerical Algorithms Group, NAG Inc.
- Associate editor Computational Methods in Applied Mathematics.
- Member users committee STW-project 'Development of a state-of-the-art Navier-Stokes solver for water flows around moving ships'.
- Member of PhD committee A.M. Artoli, UvA, October 14.
- Advisor PhD committee G. Piella Fenoy, UvA, October 30.
- Member of PhD committee G. Peeren, TUE, December 9.

B. Koren

- Full professor Computational Fluid Dynamics, TUD, Faculty of Aerospace Engineering, since 2002.
- Member executive committee Platform Computational Science and Engineering, TUD.
- Member MSc committee J. Wackers, TUD, Faculty of Aerospace Engineering, January 7.
- Member PhD committee N. Waterson, TUD, January 13.
- Member PhD committee M.M.J. Proot, TUD, February 18.
- Member MSc committee B. de Maerschalck, TUD, Faculty of Aerospace Engineering, March 12.
- Member MSc committee N. Beishuizen, TUD, Faculty of Aerospace Engineering, May 1.
- Member PhD committee H.J.M. Geijselaers, UT, October 17.
- Member scientific committee ECCOMAS CFD Conference, Rotterdam, 2006.
- Referee of several scientific journal papers.

M. Nool

- Chairman of the Works Council committee VGWM (Veiligheid, Gezondheid, Welzijn en Milieu), until May 1.
- Referee of paper for scientific journal.

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 organizing committee of 5ECM (the fifth European Congress of Mathematicians, to be held in Amsterdam, 2008) (with Prof.dr. A.C.M. Ran, VU, and Dr. J.J.O.O. Wiegerinck, UvA).
- Member of the Board of the Mathematisch Research Instituut onderzoekschool, on behalf of CWI.
- Referee for the Australian Research Council for the selection of Federation Fellows.
- Reviewer for Mathematical Reviews and the Zentralblatt für Mathematik, and referee of papers for various scientific journals.
- Chairman of the CWI-Bibliotheekcommissie.
- Treasurer of the CWI Staff Club.

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.
- Coordinator of the project System Identification which is financially supported by the European Commission through the Training and Mobility of Researchers Program.
- Chairman of the Curatorium of the special chair in mathematical system theory and linear analysis at the VU.
- Member of the PhD committee of M. Reurings, April 29.
- Member of the PhD committee of T. Bellemans, Katholieke Univ. Leuven, Belgium, May 19.
- Advisor of the PhD student D. Jibetean, VU, June 11.
- Member of program committee of IFAC Conference on the Analysis and Design of Hybrid Systems, ADHS03, Saint Malo, France, June 16–18.

- Member of program committee of 13th IFAC Symposium on System Identification (SYSID2003), Rotterdam, The Netherlands, August 27–29.
- Chairman of the steering committee of the ERCIM Working Group Control and System Theory.
- Member of steering committee of the International Symposia on the Mathematical Theory of Networks and Systems (MTNS).
- Member of the program committee of Workshop on Discrete Event Dynamic Systems (WODES.2004), scheduled for September 22–24, 2004.
- Advisor of the organizing committee of SYNCHRO.2004, Dagstuhl, Germany, scheduled for November 28–December 3, 2004.

Academic publications

Publications in refereed journals

1. A.A. Al-Falou, Jan H. van Schuppen (2003). Aggregation in hierarchical discrete-event systems. Discrete Event Dynamic Systems 13, 321–340.
2. E.H. van Brummelen, B. Koren (2003). A pressure-invariant conservative Godunov-type method for barotropic two-fluid flows. Journal of Computational Physics 185, 289–308.
3. Bernard Hanzon, Dorina Jibetean (2003). Global minimization of a multivariate polynomial using matrix methods. J. Global Optimization 27, 1–23.
4. P.W. Hemker, W. Hoffmann, M.H. van Raalte (2003). Discontinuous Galerkin discretisation with embedded boundary conditions. Computational Methods in Applied Mathematics 3, 35–158.
5. Jan Komenda (2003). Coinduction in Control of Partially Observed Discrete-Event Systems. Electronic Notes in Theoretical Computer Science (ENTCS) 82, p. 1.
6. B. Koren (2003). Stromende getallen. Nieuw Archief voor Wiskunde 5, 286–293.
7. A.J. van der Poorten, H.J.J. te Riele, H.C. Williams (2003). Corrigenda and addition to Computer verification of the Ankeny-Artin-Chowla conjecture for all primes less than 10^{11}. Math. Comp 72, 521–523.
8. Herman te Riele, Hugh Williams (2003). New Computations Concerning the Cohen-Lenstra Heuristics. Experimental Mathematics 12, 99–113.
9. G.I. Shishkin, P.W. Hemker, L.P. Shishkina (2003). Novel Defect-Correction High-Order, in Space and Time, Accurate Schemes for Parabolic Singularly Perturbed Convection-Diffusion Problems. Computational Methods in Applied Mathematics 3, 387–404.

Publications in other journals and other scientific output

Unrefereed journals

1. K.J. Batenburg (2003). Optimization of an algorithm for discrete tomography. Electronic Notes in Discrete Mathematics 12, Elsevier.

Conference proceedings

1. H. van Brummelen, B. Koren (2003). A pressure-invariant and conservative method for two-fluid flows. Proceedings of the 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, AIAA-paper 2003-4112, American Institute of Aeronautics and Astronautics, Reston, VA.
2. J. Cnossen, H. Bijl, B. Koren, E.H. van Brummelen (2003). Model error estimation in global functionals based on adjoint formulation. N.-E. Wiberg, P. Diez, (eds). Proceedings of the International Conference on Adaptive Modeling and Simulation, Göteborg, on CD-ROM. International Center for Numerical Methods in Engineering, Barcelona.
3. G. Duivesteijn, H. Bijl, B. Koren, E.H. van Brummelen (2003). Comparison of two adjoint equation approaches with respect to boundary-condition treatments for the quasi-1D Euler equations. N.-E. Wiberg, P. Diez, (eds). Proceedings of the International Conference on Adaptive Modeling and Simulation, Göteborg, on CD-ROM. International Center for Numerical Methods in Engineering, Barcelona.
4. Dorina Jibetean, Ralf Peeters, Bernard Hanzon (2003). Optimal H_2 reduction in state space: A case study. Proceedings European Control Conference 2003, Cambridge, UK, September 1–4, European Control Association (EUCA), on CD-ROM.

5. Dorina Jibetean, Jan H. van Schuppen (2003). An algebraic method for system reduction of stationary Gaussian systems. Proceedings IFAC Symposium System Identification (SYSID2003), IFAC, on CD-ROM.
6. Jan Komenda (2003). Coinduction in Control of Partially Observed Discrete-Event Systems. Proceedings Coalgebraic Methods in Computer Science (CMCS'2003), Warsaw, Poland, April 5–6.
7. Jan Komenda (2003). Coalgebra and coinduction in decentralized supervisory control. Proceedings IFAC Control System Design, Bratislava, September 7–10, only CD-ROM.
8. Jan Komenda, Jan H. van Schuppen (2003). Decentralized supervisory control with coalgebra. Proceedings European Control Conference 2003, Cambridge, UK, September 1–4, European Control Association (EUCA), on CD-ROM.
9. B. Koren (2003). Review of book: Computational Aerodynamics and Fluid Dynamics: an Introduction, by J.-J. Chattot. European Journal of Mechanics / B Fluids 22, 99–100.
10. B. Koren, E.H. van Brummelen, P.W. Hemker, B. van Leer, M.R. Lewis (2003). Fix for solution errors near interfaces in two-fluid flow computations. S. Armfield, P. Morgan, K. Srinivas (eds). Proceedings of the Second International Conference on Computational Fluid Dynamics, Sydney, 2002. Springer, Berlin, 523–528.
11. M. Lewis, B. Koren, H. Raven (2003). Efficient computation of steady, 3D water-wave patterns. Proceedings of the 16th AIAA Computational Fluid Dynamics Conference. Orlando, Florida, AIAA-paper 2003-3973, American Institute of Aeronautics and Astronautics, Reston, VA.
12. M.R. Lewis, B. Koren, H.C. Raven (2003). Computation of 3D steady Navier-Stokes flow with free-surface gravity waves. S. Armfield, P. Morgan, K. Srinivas (eds). Proceedings of the Second International Conference on Computational Fluid Dynamics, Sydney, 2002, Springer, Berlin, 100–105.
13. Margreet Nool, Michael M.J. Proot (2003). A Parallel, State-of-the-Art, Least-Squares Spectral Element Solver for Incompressible Flow Problems. José M.L.M. Palma, Jack Dongarra, Vicente Hernández, A.Augusto Sousa (eds). High Performance Computing for Computational Science – VECPAR 2002, Selected Papers and Invited Talks, Lecture Notes in Computer Science 2565, Springer, Berlin, 39–52.
14. M. Nool, M.M.J. Proot (2003). An unstructured parallel least-squares spectral element solver for incompressible flow problems. Proceedings of the 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, AIAA-paper 2003-4233, American Institute of Aeronautics and Astronautics, Reston, VA.
15. M.M.J. Proot, M.I. Gerritsma, M. Nool (2003). Application of least-squares spectral element solver methods to incompressible flow problems. Proceedings of the 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, AIAA-paper 2003-3685, American Institute of Aeronautics and Astronautics, Reston, VA.
16. Jan H. van Schuppen (2003). Rational positive systems for reaction networks. Luca Benvenutti, Alberto De Santis, Lorenzo Farina (eds). Positive systems. Lecture Notes in Control and Information Sciences 294, Springer, Berlin, 3–5.
17. J. Wackers, B. Koren (2003). A simple and efficient space-time adaptive grid technique for unsteady compressible flows. Proceedings of the 16th AIAA Computational Fluid Dynamics Conference, Orlando, Florida, AIAA-paper 2003–3825, American Institute of Aeronautics and Astronautics, Reston, VA.

CWI reports

MAS-R0301, MAS-R0302, MAS-R0303, MAS-R0304, MAS-R0306, MAS-R0307, MAS-R0308, MAS-R0312, MAS-E0304, MAS-E0308, MAS-E0309, MAS-E0312, MAS-E0321, MAS-E0322, MAS-E0323, MAS-E0324, MAS-E0325, MAS-E0326, MAS-E0327, MAS-N0301.
See page 181 for complete titles.

PhD theses

1. D. Jibetean (2003). Algebraic optimization with applications to system theory, VU, June 11.

Professional products

Publications for a broad audience

1. B. Koren (2003). Computational fluid dynamics: wetenschap en gereedschap. Inaugural lecture, TUD.

Other output

Grants

- B. Koren, BRICKS, 1 PhD student, project: 'Development of a state-of-the-art surface-capturing method for two-fluid flow' (MSV1-6), December 2003.
- H.J.J. te Riele, NWO Open Competitie 2003, 1 PhD student, project: 'Algorithmic validation of widely used cryptosystems', July 7, 2003.
- H.J.J. te Riele, BRICKS, 1 post-doc, project: 'Cryptographic methods' (PDC1-2), December 2003.
- J.H. van Schuppen, NWO Computation Life Sciences Program, 1 PhD student to be stationed at VU.ALW.BIO, 'Towards functional models and control analysis of interconnected metabolic and regulatory networks', jointly with Prof. H.V. Westerhoff, part of proposal: 'Mathematics and computation for the system biology of cells', Dr. M.A. Peletier (coordinator), December 2003.

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. MAS3 investigates fundamental questions (pulled fronts, reaction-advection-diffusion problems) and focuses more and more on electric discharges. On sufficiently large time and length scales, they can be described by reaction-advection-diffusion models for charged species that are coupled in an interesting threefold way to the Poisson-equation of electrostatics. In a way, this model is the 'Navier-Stokes-equation' of electric discharges. Discharges are characterized both by a great need of basic mathematical and physical research and by a wide range of technical applications. Research concerns analytical and numerical studies of the PDE system as well as the systematic derivation of effective models (moving interface, Ginzburg-Landau) on a larger length scale and solution of these models, comparison with systematic 'curiosity driven' experiments and with phenomena in lightning below, in and above thunderclouds as well as thought exchange with industry. Additional research concerns numerical methods for convection-diffusion equations, with emphasis on monotone numerical schemes and grid refinements in space and time.

Theme leader

Prof.dr. U.M. Ebert

MSC or CR classification

65, 35, 41, 58, 82, 92

Subthemes

W.H. Hundsdorfer supervises the projects and project aspects concerned with numerical analysis, while U.M. Ebert accounts for the aspects of modelling and nonlinear analysis. We haven't introduced a subtheme structure.

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. U.M. Ebert	0.8	theme leader	indefinite	MAS3
Dr. W.H. Hundsdorfer	1.0	project leader	indefinite	MAS3
Drs. B.J. Meulenbroek	1.0	PhD student	2001-11-01 till 2005-11-01	MAS3
Ir. C.S. Montijn	1.0	PhD student	2001-10-01 till 2005-10-01	MAS3
Ir. J. Wackers	1.0	temp. PhD student	2003-03-01 till 2003-07-01	MAS3

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Ir. T. Briels (TUE)	0.2	PhD student	2003-05-01 till 2007-05-01	MAS3
Dr. I.R. Rafatov (ERCIM/FOM)	1.0	post-doc	2003-02-01 till 2004-03-01	MAS3
R. Reimer (TUE)	p.m.	trainee		
Dr. A. Rocco (FOM)	1.0	post-doc	2001-09-01 till 2003-03-01	MAS3
Drs. D. Sijacic (FOM)	1.0	PhD student	2000-05-01 till 2004-11-01	MAS3

Scientific report

Highlights

- Book: W.H. Hundsdorfer, J.G. Verwer, Numerical Solution of Time-Dependent Advection-Diffusion-Reaction Equations, Springer Series in Computational Mathematics **33**, Springer-Verlag, 2003 (471 pages).
- Peter Paul Peterich Prize 2003 for W.H. Hundsdorfer for the best proposal in the Open Competition in Mathematics 2003 of NWO.
- Start of experimental PhD project of ir. Tanja Briels on streamer discharges at TUE as an essential counterpart of the analytical and numerical streamer investigations at CWI.
- Inaugural speech U.M. Ebert at TUE on May 9.

PhD students

T. Briels (mainly at TUE), STREAMERS.
B.J. Meulenbroek, see STREAMERS.
C.S. Montijn, see NUMLED.
D. Sijacic, see BARRIER.
J. Wackers contributed 4 months to NUMLED, while waiting for a PhD contract in MAS2.

Project reports

Title	STREAMERS
Period	1998–2007
Leader	U.M. Ebert
Staff	T. Briels, B.J. Meulenbroek, C.S. Montijn, A. Rocco, J. Wackers, W.H. Hundsdorfer
Funding	FOM, CPS, CWI, NWO/FOM (Computational Science)
Partners	E. van Veldhuizen and G.M.W. Kroesen (TUE)

Progress report. Experiment: Since May 2003, the investigation of streamer discharges has gained a third leg: the experimental investigations of PhD student Briels who will work mainly at TUE under the supervision of Dr. E. van Veldhuizen, but will also use the numerical code developed within the project NUMLED.

Simulation: The numerical work on streamers is summarized in the project NUMLED.

Analysis: The analytical investigation is now mainly in hands of PhD student Meulenbroek. (i) In 2003, we submitted a manuscript on a set of exact analytical solutions of the simplest moving boundary reduction of the streamer problem, together with the previous

post-doc Rocco. The solutions confirm the tip splitting instability found numerically. (ii) Meulenbroek has identified the relation between the structure of our exact solutions and an infinite set of conserved quantities of the dynamics, the so-called Richardson moments. (iii) Together with the previous post-doc M. Arrayás (now at Univ. Juan Carlos II, Madrid), Ebert has submitted the combined analytical and numerical derivation of the dispersion relation of transversal linear perturbations of a planar ionization front. (iv) Meulenbroek has incorporated this dispersion relation as a correction into the moving boundary approximation. This leads to a dynamic coupling of the previously independent Richardson moments. The solutions now have to be evaluated numerically which has been implemented. We presently study the results. (v) Meulenbroek also supervises a numerical study of trainee R. Reimer of nonlinear corrections to the dispersion relation from (iii). This will guide future extensions of the moving boundary approximation.

Title	BARRIER
Period	2000–2004
Leader	U.M. Ebert
Staff	D. Sijacic, I.R. Rafatov, W.H. Hundsdorfer
Funding	FOM/ERCIM
Partner	Group H.G. Purwins (Univ. Münster, Germany)

Progress report. In 2003, Rafatov joined the project of PhD student Sijacic for 13 months. Based on the previous analytical and numerical studies of the stationary states of the system and the numerical study of its temporal oscillations, the year brought substantial progress on the following points: (i) Stability analysis of the 1D system characterizing whether oscillations will set in or not, comparison with numerical solutions. (ii) Studies of the systematic adiabatic elimination of the electrons which can be rephrased as a singular perturbation theory. (iii) Calculation of the bifurcation diagram based on the stability analysis. (iv) Writing a simulation program for the 2D system, comparison with the previous 1D results. (v) Stability analysis of the 2D system characterizing the onset of spatio-temporal patterns.

Remaining open problems at this moment: A probably missing branch of the 2D dispersion relation – this needs to be checked with a different algorithm –, a detailed comparison between the 2D simulations and the 2D stability results and the calculation of the 2D bifurcation diagram.

Rafatov has submitted two papers on his previous work, and we have submitted a first paper on oscillations and period doubling in the 1D system, more submissions are in progress.

Title	NUMLED
Period	2002–2006
Leader	W.H. Hundsdorfer
Staff	C.S. Montijn, U.M. Ebert
Funding	NWO/FOM (Computational Science)

Progress report. The research in this project is focused on the numerical solution of pulled fronts and streamer discharges (see also project STREAMERS). In a streamer there are small spatial regions with steep ionization fronts. The natural choice for a numerical code hence seems to be one with adaptive grids or other types of local grid refinement. However, it turns out that such methods fail when applied to negative streamer fronts. This is because such fronts are so-called pulled fronts (see project PULLED), rather than the more familiar pushed or bistable fronts. The failure of adaptive grid methods is generic for such fronts.

In this project we develop appropriate numerical strategies for numerical streamer simulations. A nested multiple-grid approach has been developed by Montijn and Wackers and partially documented in two submitted papers. For the drift-diffusion equations, describing the evolution of the spatial density of ions and electrons, the strategy is based on a curvature monitor together with physical/analytical knowledge (see PULLED), according to which refined regions should include a large part of the leading edge ahead of the streamer front, but they can exclude those regions where densities are below certain thresholds where continuum hypotheses are no longer valid. For the electrostatic equations, describing electric potential and fields, a separate nested grid approach has been developed where an existing fast Poisson solver is used recursively. Here the refinements are based on asymptotic error expansions and maximum principles.

Title	NSADR
Period	indefinite
Staff	W.H. Hundsdorfer, J.G. Verwer (MAS1)
Funding	CWI
Partner	S.J. Ruuth (Simon Fraser Univ., Canada)

Progress report. A book by Hundsdorfer and Verwer entitled 'Numerical Solution of Time-Dependent Advection-Diffusion-Reaction Equations', was published in 2003 by Springer-Verlag. The book describes numerical methods for partial differential equations (PDEs) coupling advection, diffusion and reaction terms. It includes methods for hyperbolic, parabolic PDEs and stiff and nonstiff ordinary differential equations. The emphasizes lies with time-dependent transport-chemistry problems, describing e.g. the evolution of concentrations in environmental and biological applications.

Research cooperation with S.J. Ruuth has continued on the analysis and construction of monotone numerical time integration methods. By such methods unphysical under- and over-shoots are avoided. For hyperbolic conservation laws this can also be formulated by the TVD (total variation diminishing) and TVB (total variation boundedness) properties, which guarantee convergence to the relevant entropy solutions.

Title	REPT
Period	indefinite
Staff	U.M. Ebert
Partners	L. Schäfer (Univ. Essen, Germany), A. Baumgärtner (Forschungszentrum Jülich, Germany)

Progress report. We have continued our study of the so-called reptation model for the Brownian motion of long flexible polymer chains in polymer melts. Previously we were able to reformulate the model such that more steps were analytical solvable. This allows a more systematic study of the chain length dependence. In 2003, we compared our analytical results on the experimentally accessible coherent scattering function with extensive Monte Carlo simulations for the same quantity. The results can be found in a paper that was submitted and published in 2003.

Title	PULLED
Period	indefinite
Staff	U.M. Ebert
Partner	W. van Saarloos (UL)

Progress report. Pulled fronts are characterized by a leading edge that determines the dynamics. This has consequences for the rate of convergence which is universal and algebraic as well as for analytical schemes of perturbation analysis or for numerical schemes, see project NUMLED. A paper submitted in 2003 treats two aspects of pulled fronts that are not monotonic, but form patterns: (i) the algebraic convergence of the generated wave length and (ii) strict bounds that prove that the dynamics of such fronts indeed is pulled even though no maximum principles or gradient dynamics applies.

Societal aspects and knowledge transfer

External contacts

See projects, visits and visitors.

Courses, tutorials

- Tutorial 'Splitting Techniques for Advection-Diffusion-Reaction Equations', at the Workshop on Modeling and Simulation in Chemical Engineering, CIM (Mathematical International Centre), Univ. Coimbra, Portugal, June 30–July 4: W.H. Hundsdorfer.

Organization of conferences, workshops, courses, meetings

- Day seminar CWI/TUE on grid refinement and Poisson solvers for plasma simulations, April 17: talks by C.S. Montijn and J. Wackers (MAS3), S.B. van der Geer and J. Luiten (TUE).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- German-Dutch-Belgian-English Spring Conference on Plasma Physics and Short Time Pe-

riod Physics, Aachen, Germany, March 24–28: U.M. Ebert (Plenary talk: Spontaneous Branching of Discharge Streamers), D. Sijacic (Contributed talk: Stationary and spontaneously oscillating states in DC glow discharges), C.S. Montijn (Poster: A numerical investigation of growing and branching discharge streamers), B.J. Meulenbroek (Poster: Spontaneous branching of discharge streamers: conformal mapping approach), I.R. Rafatov.

- 20th Biennial Conference on Numerical Analysis, Univ. Dundee, June 24–27, W.H. Hundsdorfer (Invited talk: Monotonicity for Time Discretizations).
- Workshop on Modeling and Simulation in Chemical Engineering, CIM - Mathematical International Centre, Coimbra, Portugal, June 30–July 4: W.H. Hundsdorfer (Short course: Numerical Simulations with Advection-Diffusion-Reaction Systems).
- Workshop on Pattern Formation, Institut Henri Poincaré, Paris, July 7–12: B.J. Meulenbroek (Talk: Streamer branching rationalized by conformal mapping techniques).
- V$^{\text{th}}$ Int. Workshop on Microwave Discharges: Fundamentals and Applications, Greifswald, July 8–12: I.R. Rafatov (Talk: Modelling of non-equilibrium spherical microwave discharge).
- ICPIG Greifswald, July 15–19: U.M. Ebert (Proceedings and poster: Spontaneous branching of discharge streamers: conformal analysis and numerical results), I.R. Rafatov (Proceedings and poster: Modelling of non-equilibrium spherical microwave discharge).
- NUMDIFF-10, Halle, Germany, September 8–11: W.H. Hundsdorfer (Talk: Flux Limiting for Diffusion Equations).
- 2nd Int. Workshop 'Trends in Pattern Formation', Dresden, September 15–19: U.M. Ebert (Invited talk: Branching sparks – the dynamics of electric breakdown), T. Briels (Poster: Experimental investigation of growing and branching streamer channels), B.J. Meulenbroek (Poster: Streamer branching rationalized by conformal mapping techniques), D. Sijacic (Poster: Glow discharges: stationary and spontaneously oscillating states).
- Conference of the Dutch-Flemish Numerical Analysis Communities, Woudschoten, October 1–3: C.S. Montijn.
- Workshop of the EU-TMR-network 'Coupling of Atmospheric Layers', Copenhagen, November 18–21: U.M. Ebert (Tutorial: Streamer discharges).
- Comp. Science meeting, TUE, November 28: W.H. Hundsdorfer (Invited talk: Numerical Simulation of growing and Branching Spark Channels), C.S. Montijn (Poster: A numerical investigation of growing and branching discharge streamers), U.M. Ebert.

Other lectures

- Physikalisches Kolloquium, Univ. Greifswald Germany: Branching discharge channels – the dynamics of electric breakdown, October 16: U.M. Ebert.

Courses

- Pattern formation and dynamics in nonequilibrium systems, UL, weekly January 27–April 28: D. Sijacic, B.J. Meulenbroek.
- Stieltjesonderwijsweek: Stabiliteitsanalyse in PDV's. Lorentz Center, Leiden, March 3–7: B.J. Meulenbroek, C.S. Montijn, D. Sijacic.
- Summer school on Low Temperature Plasma Physics: Basics and Applications, Bad Honnef, Germany, September 21–26: C.S. Montijn.
- Aspects of Management, Nijenrode, November 2–7: D. Sijacic.

Visitors

- J.J.A.M. van der Mullen (TUE), February 7 (Talk: On the plasma simulation program PLASIMO). Host: U.M. Ebert.
- E. Brener (Forschungszentrum Jülich, Germany), March 11–13 (Talk: Pattern formation in diffusional growth). Host: U.M. Ebert.
- M. Bär (MPI Physik komplexer Systeme), December 3–5 (Talk on December 3: Complex Patterns in Reaction-Diffusion Systems), (Talk on December 5: Biological Pattern Formation - From Lipid Domains in Membranes to Bacterial Dances). Host: U.M. Ebert.

Memberships of committees and other professional activities

U.M. Ebert

- Part-time professor of physics at TUE, since March 2002.

- Leader of FOM-workgroup FOM-C01 with FOM-employees Sijacic, Rocco and Rafatov since 1999.
- Member of steering committee of research school 'Centrum voor Plasmafysica en Stralingstechnologie' (CPS) and leader of CWI-group of the research school, since 1999.
- Member NWO-EW-Veni-Committee in the winter 02/03.
- Member Dutch organizing committee for the World Year of Physics 2005.
- Member local organizing committee for the XXVII'th International Conference for Phenomena in Ionized Gases (ICPIG XXVII), Veldhoven, July 2005.
- Member PhD committee Carole Maurice, TUE, March 17.
- Member reading and PhD committee Eric Arends, TUE, April 10.
- Member PhD committee Bert Hartgers, TUE, May 14.
- Member MSc committee Daniel Snouck, TUE June 11.
- Member PhD committee Gianluca Geloni, TUE, September 5.
- Member PhD committee Nazar Sushko, TUE, September 23.
- Chairperson PhD committee F. Manders, KUN '04, reading thesis in November 3.
- Member MSc committee Ron Bessems, TUE, November 25.

W.H. Hundsdorfer

- Member reading and PhD committee Bart van de Rotte, UL, December 9.

Academic publications

Publications in refereed journals

1. A. Baumgärtner, U.M. Ebert, L.Schäfer (2003). The coherent scattering function in the reptation model: simulations compared to theory. Eur. Phys. J. E 12, 303–319.
2. V. Bertola, B.J. Meulenbroek, C. Wagner, C. Storm, A. Morozov, W. van Saarloos, D. Bonn (2003). Experimental evidence for an intrinsic route to polymer melt fracture phenomena: A nonlinear instability of viscoelastic Poiseuille flow. Phys. Rev. Lett. 90, 114502, 4 pages.
3. B. Coluzzi, A. Crisanti, E. Marinari, F. Ritort, A. Rocco (2003). A new method to compute the configurational entropy in glassy systems. Eur. Phys. J. B. 32, 495–502.
4. W.H. Hundsdorfer, J. Jaffré (2003). Implicit-Explicit Time Stepping with Spatial Discontinuous Finite Elements. Appl. Num. Math. 45, 231–254.
5. W.H. Hundsdorfer, S.J. Ruuth, R.S. Spiteri (2003). Monotonicity-preserving linear multistep methods. SIAM J. Num. Anal. 41, 605–623.
6. B.J. Meulenbroek, C. Storm, V. Bertola, C. Wagner, D. Bonn, W. van Saarloos (2003). Intrinsic route to melt fracture in polymer extrusion: a weakly nonlinear subcritical instability of viscoelastic Poiseuille flow. Phys. Rev. Lett. 90, 024502, 4 pages.
7. S.N. Sklyar, I.R. Rafatov (2003). Difference Schemes for the class of singularly perturbed boundary value problems. Appl. Num. Anal. and Comp. Math., 8 pages.

Publications in other journals and other scientific output

Conference proceedings

1. U.M. Ebert, B.J. Meulenbroek, C.S. Montijn, A. Rocco, W.H. Hundsdorfer (2003). Spontaneous Branching of Anode-Directed Discharge Streamers: Conformal Analysis and Numerical Results. Proceedings XXVI International Conference on Phenomena in Ionized Gases (ICPIG), Greifswald, Germany, 4, 25–26.
2. W.H. Hundsdorfer (2003). Splitting Techniques for Advection-Diffusion-Reaction Equations. Proceedings Workshop on Modeling and Simulation in Chemical Engineering, CIM - Mathematical International Centre, Coimbra, Portugal, 1–24.
3. W.H. Hundsdorfer, S.J. Ruuth (2003). Monotonicity for Time Discretizations. D.F. Griffiths, G.A. Watson (eds). Proceedings 20th Biennial Conference on Numerical Analysis, Univ. Dundee, Numerical Analysis Report NA/217, 85–94.
4. V.M. Lelevkin, I.R. Rafatov (2003). Modelling of non-equilibrium spherical microwave discharge. Proceedings Vth International Workshop on Microwave Discharges: Fundamentals and Applications, Zinowitz, Germany, 5 pages.

5. V.M. Lelevkin, I.R. Rafatov (2003). On the modelling of non-equilibrium spherical microwave discharge, Proceedings XXVI International Conference On Phenomena in Ionized Gases (ICPIG), Greifswald, Germany, 3, 105–106.
6. S.N. Sklyar, I.R. Rafatov (2003). Difference Schemes for the class of singularly perturbed boundary value problems. Proceedings International Conference on Numerical Analysis and Comp. Math., Cambridge, UK, 145–149.

CWI reports
MAS-E0305, MAS-E0306, MAS-E0309, MAS-E0310, MAS-E0311, MAS-E0312, MAS-E0313, MAS-E0314, MAS-E0315, MAS-E0318.
See page 181 for complete titles.

Monographs

1. W.H. Hundsdorfer, J.G. Verwer (2003). Numerical Solution of Time-Dependent Advection-Diffusion-Reaction Equations. Springer Series in Computational Mathematics, 33, Springer-Verlag, 471 pages.

Professional products

Publications for a broad audience

1. U.M. Ebert (2003). De natuur tegenmoet met pen en PC, inaugural speech, TUE, May 9.
2. U.M. Ebert (2003). Vertakkende vonken – de dynamica van de elektrische doorslag, FOM-jaarboek 2002, 80.
3. U.M. Ebert (2003). Vertakking bliksem wiskundig verklaard, NWO-jaarboek 2002, 55.

Contributions to documentaries or radio or TV broadcastings

U.M. Ebert (2003). Warum Funken und Blitze sich spalten, Deutschlandfunk-radio, March 31.

Other output

Grants

- W.H. Hundsdorfer. Peter Paul Peterich Prize 2003 for the best proposal in the Open Competition in Mathematics 2003 of NWO.

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 or find their way through partners in (inter)national consortia. The policy regarding their construction is to develop them up to the point that real applications can be built and exercised. Exploitation of research prototypes, if warranted, is primarily done outside the institute.

Therefore, the themes foster transfer of research to its business liaisons. The close affiliation with Data Distilleries secures knowledge transfer and feedback on problems in the area of databases and data mining. Likewise, the activities in INS2 on human-computer interaction is closely aligned with the CWI spin-off Epictoid. 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).

INS participates in several large national projects (Bsik MultimediaN, Bsik BRICKS, ToKeN2000) Telematics Top Institute (Topia), international projects (QAIP, NeuroColt) and projects aimed at knowledge transfer. Such participations are considered a valuable asset in driving frontier and innovative research. We expect to continue this line, balancing the challenges of today's ICT with long-term high-risk undertakings.

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 – Data Mining and Knowledge Discovery	Prof.dr. M.L. Kersten
INS2 – Multimedia and Human-Computer Interaction	Prof.dr. H.L. Hardman
INS3 – Visualization and 3D Interfaces	Dr.ir. R. van Liere
INS4 – Quantum Computing and Advanced Systems Research	Prof.dr. H.M. Buhrman

In 2004 the activities centered around digital libraries of Van Eijck and Hazewinkel will be moved to other themes. The activities of Bulterman will be moved into a pilot, SEN5.

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. Furthermore, small-scale individual projects in the area of digital libraries are supported pending a better embedding in or outside the institute.

Theme leader

Prof.dr. M.L. Kersten

MSC or CR classification

16W30, 05E, 68P20, 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. D.C.A. Bulterman	1.0	researcher	indefinite	Medical Mulitmedia, Ambulant Infrastructure
Prof.dr. D.J.E. van Eijck	1.0	researcher	indefinite	Applied Logic
Dr. M. Hazewinkel	1.0	researcher	indefinite	TRIAL, MKMnet
Dr. I. Herman	1.0	researcher	indefinite	W3C activities
A.J. Jansen	1.0	programmer	indefinite	Ambulant Infrastructure
Prof.dr. M.L. Kersten	p.m	theme leader	indefinite	INS0
S. Pemberton	1.0	researcher	indefinite	W3C activities

Scientific report

Activities by M. Hazewinkel

Title	MKMnet (Mathematical Knowledge Management)
Period	September 2002–November 2003
Leader	M. Hazewinkel
Staff	C.L. Blom (SEN3)
Funding	EU network
Partners	many

Progress report. The first deliverables were due February 2003. The CWI group contributed 'Outline current state of formula recognition (informal preliminary report, 5 March)' and 'Dynamic stochastic models for indexes and thesauri, identification clouds, and information retrieval and storage'. The latter is a survey paper to appear in Proceedings IWAP 2002 (KAP, 2003), and serves as the deliverable towards the 'Stochastic models sub WP of the network. Hazewinkel serves as the chairman of the network. In Bertinoro/Bologna, February 15–20, the second international MKM meeting took place integrated with the second meeting of MKMnet. One of the main functions of MKMnet is the preparation of a proposal for FP6. This was mailed on April 23. Title: MKM-NoE (Network of Excellence).

Title	TRIAL SOLUTION[2]
Period	February 2000–May 2003
Leader	M. Hazewinkel
Staff	C.L. Blom (SEN3)
Funding	EU (project)
Partners	many

Progress report. The (pre)final evaluation meeting took place January 28 in Luxembourg. Result: very positive. The project received a three month extension because the group from Nice could not handle its obligations. These have

[2]TRIAL SOLUTION: Tools for Reusable, Integrated, Adaptable Learning Systems/standards for Open Learning Using Tested Interoperable Objects and Networking

been reallocated (to STI, Berlin). On April 23, the CWI sent its final public domain version of its deliverable to the project leader (Ingo Dahn).

Title	Hopf algebras
Period	indefinite
Leader	M. Hazewinkel
Funding	CWI

Title	Noncommutative geometry
Period	indefinite
Leader	M. Hazewinkel
Funding	ESF, network
Partners	many

Multimedia Delivery Infrastructures

The intellectual knowledge on multimedia authoring systems and their delivery over diverse channels forms the basis for embarking on the preparation of a new pilot theme in the near future. The focal point in 2003 is on capitalization of the Oratrix network by acquisition of a demonstrator project. For the initial year, the experiences gained during the Oratrix period are cast into a survey-paper on the scientific challenges as a stepping stone for a larger undertaking.

Title	P4015: Medical Multimedia
Period	January 2003–December 2003
Leader	D.C.A. Bulterman
Funding	Telematics Institute (Topia-II)
Partners	Telematics Institute, Erasmus MC, Dierenkl. NoordNederland

Progress report. This is a new project was begun in 2003 with the Telematics Institute to understand the impact of a new generation of user interface devices on the wireless/tethered distribution and (on-demand) generation of multimedia information. The application area selected for the project was medical multimedia: this domain provides an interesting framework for addressing complex applications with sensitive information that needs to be managed in a location-, context- and user-aware manner. Our work on this project resulted in the publication of two papers (plus one additional paper submitted in late 2003) and several project demonstrators. It was also an investment in understanding an interesting application domain that can be useful in future research.

Title	P4014: Ambulant Infrastructure
Period	January 2003–April 2004
Leader	D.C.A. Bulterman
Funding	NLnet
Partners	INRIA (Fr), PUC-Rio (Brazil)

Progress report. Another new project begun in 2003, the Ambulant project studies the distribution of complex multimedia documents over a hybrid presentation environment (including multiple types of networks, multiple types of devices and multiple classes of users). The first year of this project was dedicated to creating a common research infrastructure that provides an open and instrumentable SMIL 2.0 player that is designed to run on a range of delivery platforms (handheld/PDA through desktop) and across multiple types of network infrastructures (wireless, low-bandwidth through tethered broadband). This project addresses a critical need often cited in the research community: that of provided a common platform that enables common sharing of research results and independent verification of proposed protocols and interfaces.

Societal aspects and knowledge transfer

Teaching at university

M. Hazewinkel

- Course (given), Hopf algebras in combinatorics and physics, Vilnius Univ., Lithuania, June 30–July 4 (5 two-hour lectures).

I. Herman

He made a number of public presentations on W3C technologies:

- 2D Web Graphics: SVG, tutorial at CNR, Pisa, January 10.
- Introduction to the Semantic Web, Semantic Web day, Helsinki, May 6.
- Introduction to the Semantic Web, Technical Univ. Budapest, May 13.
- High Level Overview of W3C Technologies, WWW2003 Conference, Budapest, May 21.
- Overview of W3C, W3C Semantic Tour, London, June 12.
- Introduction to the Semantic Web, W3C Semantic Tour, Munich, June 17.
- High Level Overview of W3C Technologies, W3C Semantic Tour, Brussels, June 24.

- Introduction to the Semantic Web, W3C Semantic Tour, Brussels, June 24.
- Overview of W3C, Evolve Conference, Sydney, August 18. repeated at Monash Univ., Melbourne, August 22.
- 2D Web Graphics: SVG, Evolve Conference, Sydney, 18 August, repeated at Monash Univ. in Melbourne, August 22.
- Introduction to the Semantic Web, Workshop at ITSC, Singapore, October 3.
- Introduction to the Semantic Web, Next Generation Internet Workshop, UPC Madrid, October 22.
- General Overview of W3C, China International Forum for WWW, Beijing, November 12.
- Introduction to the Semantic Web, China International Forum for WWW, Beijing, November 12.
- 2D Web Graphics: SVG, China International Forum for WWW, Beijing, November 13.
- High Level Overview of W3C Technologies, CoPSTICK'03 Conference, Rabat, December 12.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- SMIL Europe 2003, Paris, February: D.C.A. Bulterman.
- Workshop on Network Engineering and Broadband Services, March, Rio de Janeiro, Brazil, March: D.C.A. Bulterman.
- EuroPython 2003, Charleroi, Belgium, June: A.J. Jansen.
- ACM SIG-MM Senior Strategic Retreat, Univ. California, Berkeley, USA, November: D.C.A. Bulterman.
- ACM Multimedia 2003, Berkeley, November: D.C.A. Bulterman.
- E-Learn 2003, Phoenix, AZ, November: D.C.A. Bulterman.
- ACM DocEng 2003, Grenoble, November: D.C.A. Bulterman.
- Control theory meeting, Lubbock, Texas, November 11–16: M. Hazewinkel (Invited Lecture: Hopf algebras and control theory).

Working visits

- Brown Univ., January 18: D.C.A. Bulterman. (Discussions of annotation support on TabletPC computers.)
- Trial meeting, Luxembourg, January 28: M. Hazewinkel.
- MKMnet meeting, Bertinoro/Bologna, February 15–20: M. Hazewinkel.
- Mittag-Leffler Institute, Stockholm, Sweden, March 9–April 6, March 27: M. Hazewinkel (Lecture: Multivariable recursiveness and cofree coalgebras).
- PUC-Rio, March 26–28; D.C.A. Bulterman. (Invited presentation on Annotation of Multimedia).
- Columbia University, September 5: D.C.A. Bulterman. (Discussions on options for supporting medical multimedia).
- Brown Univ., September 6: D.C.A. Bulterman. (Invited lecture on Peer-Level Annotation of Video Objects).
- Oregon Graduate Institute/OSHU, 5 November: D.C.A. Bulterman. (Invited lecture on Annotation of Electronic Patient Records).
- INRIA Alpes, Grenoble, 21 November: D.C.A. Bulterman. (Invited presentation on Multimedia Authoring System Models).
- Univ. Bologna, Italy, December: D.C.A. Bulterman. (Invited presentation on Foundations of SMIL 2.0).

Project meetings

- Topia-II Kickoff Meeting, Beekbergen, January 27: D.C.A. Bulterman.
- Trial meeting, Luxembourg, January 28: M. Hazewinkel.
- MKMnet meeting, Bertinoro/Bologna, February 15–20: M. Hazewinkel.
- Topia-II Meeting, Amsterdam, February 20: D.C.A. Bulterman.
- Topia-II Meeting, EMC, Rotterdam, March 6: D.C.A. Bulterman.
- Topia-II Meeting, EMC, Rotterdam, March 20: D.C.A. Bulterman.
- Topia-II Meeting, EMC, Rotterdam, April 8: D.C.A. Bulterman.
- AMBULANT Meeting, Amsterdam, April 9: D.C.A. Bulterman, A.J. Jansen, K. Kleanthous.
- Topia-II Meeting, Amsterdam, June 2: D.C.A. Bulterman.
- Topia-II Meeting, Enschede, August 18: D.C.A. Bulterman.
- Topia-II Meetings, Emmeloord, August: D.C.A. Bulterman.

- AMBULANT Meeting, Amsterdam, September 3:
  D.C.A. Bulterman, A.J. Jansen, C.L. Blom, K. Kleanthous.
- AMBULANT Meeting, Amsterdam, October 21: D.C.A. Bulterman, A.J. Jansen, C.L. Blom, K. Kleanthous.
- Topia-II Meeting, Enschede, October 27:
  D.C.A. Bulterman.
- MKM meeting, Edinburgh, Scotland, November 24–30: M. Hazewinkel (Opening plenary lecture 'Mathematical knowledge management: what is it and what can be done').
- AMBULANT Meeting, Amsterdam, December 9: D.C.A. Bulterman, A.J. Jansen, C.L. Blom, K. Kleanthous.

Memberships of committees and other professional activities

D.C.A. Bulterman

- Member of the W3C SMIL Interest Group.
- External advisor, Oratrix Development.
- Associate editor, ACM/Springer Multimedia Systems Journal.
- Member of editorial board, Multimedia Tools and Applications, Kluwer.
- Member editor board steering Committee, ACM Transaction on Multimedia Computing, Communications, and Applications (this journal is being launched in 2004).
- Member of the W3C SMIL Interest Group.
- Revewier for numerous conferences and journals.
- Member of the PhD examination board of Débora C. Muchaluat Saade, PUC-Rio (March 26, 2003).
- Programme chair, SMIL Europe 2003, Paris, February 2003.
- Member programme committee, LA-Web, Santiago, Chile, November 2003.
- Brave New Topics co-chair, ACM Multimedia 2004, New York.

D.J.N. van Eijck

- Professor of Logical Aspects of Computational Linguistics, UU, since December 1990.
- Member of the European Network in Computational Logic (initiated by the ESPRIT Basic Research Action 'Compulog'), since March 1997.
- Secretary of the Dutch Society for Logic (VvL).
- Member of the International User and Consultation Group for TRINDI.
- Member of the PhD examination board of Joost Visser, UvA, February 14.
- Member of the PhD examination board of Christophe Costa Florencio, UU, November 14.
- Advisor PhD thesis of Rick Nouwen (together with Henriette de Swart), Uil-OTS, UU, November 21.
- Advisor PhD thesis of Juan Heguiabehere (with Maarten de Rijke as co-advisor), ILLC, UvA, December 4.
- Organizer of the VvL Event on 'Rational and Social Choice', October 31 (special guest: professor Rohit Parikh).

M. Hazewinkel

- Editor Mathematical knowledge management, special (38) Annals of Mathematics and Artificial intellligence, KAP, 228.
- Editor Mondromy and differential equations, Special issue (75) Acta Appl. Math., 2003.
- Member steering committee International conference on algebra and applications, Tula, Russia, April 17–21.
- Chair MKMnet (EC FP5 network).
- Member steering group Noncommutative geometry (ESF project).

I. Herman

- International World Wide Web Conference Committee (IW3C2).
- Member of the editorial board of the journal Computer Graphics Forum.
- Member of the programme committee of the Eurographics'2004 Conference.

A.J. Jansen

- Member of NLUUG executive board.
- Member of the W3C SMIL Interest Group.

S. Pemberton

- Editor-in-chief, ACM/interactions.
- Chair, W3C HTML Working Group. and W3C Forms Working Group.
- Member of ACM SIGCHI executive committee.
- Member of technical programme committee AVI 2004 (Advanced Visual Interfaces).
- Member of panels programme committee WWW 2004 (World Wide Web Conference).
- Member of technical programme committee XML Europe 2004.
- Member of W3C Technical Plenary 2003 program committee.

Academic publications

Publications in refereed journals

1. D.C.A. Bulterman (2003). Position Paper, ACM SIG Multimedia Strategic Retreat. L. Rowe, R. Jain (eds), Berkeley, CA, October 31–November 1.
2. M. Hazewinkel (2003). Symmetric functions, noncommutative symmetric functions, and quasisymmetric functions. Acta Appl. Math. 75, 55–83; also in Proceedings Third International Algebraic Conference in Ukraine: algebraic structures and their applications. Inst. Math. Ukrainian Acad. Sci., 2002, 259–282.
3. M. Hazewinkel, Hugo H. Torriani (2003). Coherence and uniqueness theorems for averaging processes in statistical mechanics. Acta. Appl. Math. 77(2), 105–123.
4. M. Hazewinkel (2003). Cofree coalgebras and multivariable recursiveness. J. Pure and Applied Algebra 183, 61–103.

Publications in other journals and other scientific output

Unrefereed (electronic) journals

1. D.J.N. van Eijck (2003). Het formaliseren van theta theorie. Link – Tijdschrift voor Linguïstiek te Utrecht, 14(1), 36–41.
2. S. Pemberton (2003). The Kiss of the Spiderbot. Interactions, X(1).
3. S. Pemberton (2003). Letter writing, Telephones and Television Interactions, X(3).
4. S. Pemberton (2003). Restrictive Practices, X(4).
5. S. Pemberton (2003). Hotel Heartbreak. Interactions, X(5).
6. S. Pemberton (2003). So Big, So Bad, So Often. Interactions, X(6).
7. S. Pemberton (2003). The Second Most Important Property of the Web. MIT Technical Review.

Conference proceedings

1. D.C.A. Bulterman, SMIL Authoring Systems: The State of the Art. Proceedings of SMIL Europe 2003, Paris, February 2003, 47–53.
2. D.C.A. Bulterman, Annotation of Time-Sensitive Multimedia Information: Doing Something Worthwhile with Streaming Media. Proceedings of the Workshop on Network Engineering and Broadband Services, PUC-Rio, Rio de Janeiro, Brazil, March, 2003.
3. D.C.A. Bulterman, Using SMIL to Encode Interactive, Peer-Level Multimedia Annotations. Proceedings of ACM DocumentEngineering 2003, Grenoble, France, November 2003, 32–41.
4. D.C.A. Bulterman, The Ambulant Annotator: Medical Multimedia Annotations on TabletPC's. Proceedings E-Learn 2003, Phoenix, AZ, November 2003.
5. D.J.N. van Eijck (2003). Parser combinators for extraction. Paul Dekker and Robert van Rooy (eds). Proceedings of the Fourteenth Amsterdam Colloquium, ILLC, UvA, 99–104.
6. M. Hazewinkel (ed.) (2003). Handbook of algebra, Volume 3, Elsevier, 2003, 1161.
7. A.J. Jansen (2003). MacPython Present and Future: The Road to World Domination, in Electronic Proceedings, European Python and Zope Conference 2003, Charleroi, Belgium, June 25–27, 2003. Available at: `http://www.europython.org/sessions/talks/slidespapers`

Software developed

1. Ambulant/G – SMIL 2.0 Windows Player for Win32, D.C.A. Bulterman and A.J. Jansen. Available from `http://www.ambulantPlayer.org/`
2. Ambulant/M – mini-SMIL Player for Linux, Mac-OS/X, and Win32, D.C.A. Bulterman, A.J. Jansen, K. Kleanthous,

D. Benden, C.L. Blom. Available from http://www.ambulantPlayer.org
3. MacPython Software Release, A.J. Jansen. Available from http://www.python.org
4. Ambulant Annotator: A Medical Multimedia Demonstrator, D.C.A. Bulterman. December 2003. Available from: http://www.cwi.nl/projects/Ambulant/Annotator/Demos

Professional products

Publications for a broad audience

I. Herman

He made a number of public presentations on W3C technologies (see page 139), all the presentations are available on-line from the World Wide Web Consortium Web page. The presentations (on http://www.w3.org) were:

1. 2D Web Graphics: SVG (/2003/Talks/1113-BeijingSVG-IH, 2003 /Talks/0818-SydneySVG-IH).
2. Introduction to the Semantic Web (e.g. 2003/Talks/1112-BeijingSW-IH, 2003/Talks/1003-Singapore-IH/).
3. High Level Overview of W3C Technologies (e.g. 2003/Talks/1211-Rabat-IH/).
4. Overview of W3C (e.g. 2003/Talks/1112-BeijingOverview-IH, 2003/Talks/0818-SydneyOverview-IH/).

S. Pemberton

1. S. Pemberton (2003). XForms for HTML Authors, W3C, October 2003, http://www.w3.org/MarkUp/Forms/2003/xforms-for-html-authors.html
2. R. Dyer (2003). The XML.com Interview: Steven Pemberton, May 21, 2003. http://www.xml.com/pub/a/2003/05/21/pemberton.html
3. S. Pemberton (2003). Metamorfose: HTML wordt XHTML, PC Active Magazine.

Contributions to documentaries or radio or TV broadcasting

1. S. Pemberton (2003). The Plugin Patent, Telescoop, Radio 737, September 3.
2. S. Pemberton (2003). So big, So Bad, Telescoop, Radio 737, October 1.
3. S. Pemberton (2003). XForms, Telescoop, Radio 737, October 18.
4. S. Pemberton (2003). Interview, Telescoop, Radio 737, December 27.

Data Mining and Knowledge Discovery – INS1

Mission

The mission of the group is to simplify and improve data management and information analysis in high-demanding application areas, such as multimedia and knowledge discovery. This is realized through the combined expertise in the area of database architectures, multimedia information retrieval, and data mining algorithms. The approach is based on concurrent progress in the development of models, algorithms, techniques, and experimental software platforms. Knowledge transfer is focused on dissemination of the leading platform, MonetDB, which is used in a CWI spin-off company since 1996 and is prepared for the open source community.

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 – Data Mining	A.P.J.M. Siebes
INS1.2 – Multimedia Databases	A.P. de Vries
INS1.3 – Database Architectures	P.A. Boncz

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Drs. A.R. van Ballegooij	1.0	PhD student	1999-10-01 till 2003-09-30	INS1.2: MIA
Dr. P.A. Boncz	1.0	researcher, leader INS1.3	indefinite	INS1.2: MIA AmbientDB
R. Cornacchia MSc	1.0	PhD student	2003-10-01 till 2007-09-30	INS1.2: MultimediaN
Prof.dr. M.L. Kersten	0.6	theme leader	indefinite	INS1.2, INS1.3
Drs. J.A. List	1.0	PhD student	2000-11-01 till 2004-10-31	INS1.2
Dr. S. Manegold	1.0	researcher	indefinite	INS1.3
Drs. K.S. Mullender	1.0	programmer	indefinite	INS1.3
Dr. N.J. Nes	1.0	researcher	indefinite	INS1.3
G. Ramirez Camps MSc	1.0	PhD student	2003-01-01 till 2007-02-28	INS1.2
Dr. Z.R. Struzik	1.0	researcher	1999-02-01 till 2003-07-31	INS1.1
Ir. C. Treijtel	1.0	PhD student	2002-02-01 till 2004-01-31	INS1.3 AmbientDB
Dr.ir. A.P. de Vries	1.0	researcher, leader INS1.2	1999-12-16 till 2003-12-31	INS1.2
Ir. T.H.W. Westerveld	0.4	PhD student	2002-09-01 till 2004-08-31	INS1.2
Drs. M.A. Windhouwer	1.0	PhD student	1998 till 2004-03-31	INS1.2
M. Zukowski (VU)	1.0	PhD student	2003-11-01 till 2007-10-31	INS1.3

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
A. Jančařiková (VU, Karel Univ.)	0.3	MSc student	2002-12-01 till 2003-05-31	INS1.3
B. Sapkota	0.5	MSc student	2003-01-01 till 2003-06-30	INS1.1
V. Shrivastava	0.3	MSc student	2003-05-07 till 2003-07-25	INS1.1
Prof.dr. A.P.J.M. Siebes (UU)	1.0	advisor, leader INS1.1	indefinite	INS1.1
F. Wu	0.3	MSc student	2003-11-01 till 2004-06-30	INS1.1

Scientific report

Highlights

The MultimediaN project proposal was submitted and accepted. Menzo Windhouwer finished his PhD thesis. The vision on Organic Database, a long term grand challenge in database research, was presented by invitational lectures at VLDB, ICDE, and the meeting on the database research self-assessment in Lowell (USA).

PhD students

A.R. van Ballegooij
R. Cornacchia
J.A. List
G. Ramirez Camps
C. Treijtel
T.H.W. Westerveld
M.A. Windhouwer
M. Zukowski

INS1.1 – Data Mining

Title	Knowledge discovery
Period	June 1998–August 2003
Leader	A.P.J.M. Siebes
Staff	A.P.J.M. Siebes, Z.R. Struzik
Funding	CWI
Partner	UU

Progress report. After eight years, this project line was terminated in 2003. The last post-doc (Struzik) took up a job at Tokyo Univ. to continue his research on wavelet theory in economics. Future activities on database support for data mining will be undertaken as part of the database architecture line of research and in cooperation with external parties.

INS1.2 – Multimedia Databases

Title	MASE: Multimedia Access by Sense and Expression
Period	1999–2003
Leader	A.P. de Vries
Staff	A.P. de Vries, N.J. Nes, S. Manegold, M.L. Kersten, A.R. van Ballegooij, J.A. List, G. Ramirez Camps, R. Cornacchia, T. Ianeva, F. Wu
Funding	ICES-KIS MIA
Partners	UvA, UT, Philips Research, Data Distilleries

Progress report. A significant part of the Multimedia Information Retrieval research has been carried out in the context of the Waterland and CIRQUID projects. Apart from those activities, we have improved our probabilistic video retrieval system by taking the full spatio-temporal information into account. The expected gains in effectiveness have been confirmed on the TRECVID 2003 search task. The RAM language has been further developed, aiming to simplify multimedia query processing on large datasets. After the summer, activities have been started to move the software from the Matlab prototyping environment back to MonetDB, with the primary aim to exploit parallellism for the TRECVID 2004 participation. The collaboration with Philips Research has resulted in an internal Philips report on mass customization for ambient intelligence.

Title	Waterland
Period	June 1998–August 2004
Leader	A.P. de Vries
Staff	A.P. de Vries, M.A. Windhouwer, T.H.W. Westerveld
Funding	SENTER
Partners	Telematics Institute, CTIT, TNO-TPD, NOB, NOS

Progress report. Windhouwer completed and defended his PhD thesis titled 'Feature Grammar Systems: Incremental Maintenance of Indexes to Digital Media Warehouses'. In this thesis the formal theory of Feature Grammar Systems is described and related to its actual use in the Acoi system. This system has been extended to reflect lessons learned from the formal theory and several advanced features have been prototyped seperately. Within the Waterland project a feature grammar is realized to handle daily updates of a newspaper collection, which will leed to gradually incorporating these prototypes into the Acoi core system.

Westerveld developed probabilistic models for IR and evaluated these on the Corel dataset. It uncovered the weakness of this set for evaluation purposes, as the intra topic set discriminating factors were too large compared to inter dependency discriminating factors. Analysis on the more realistic TRECVID datasets pointed into the direction of the speech channel and colour palettes as more influential on the effectiveness of the IR methods. Subsequent research aimed at scaling the techniques towards video retrieval with positive results in the area of close-up query evaluations.

Title	CIRQUID
Period	June 2003–December 2007
Leader	A.P. de Vries
Staff	A.P. de Vries, G. Ramirez Camps
Funding	NWO
Partner	CTIT

Progress report. The first two months of 2003, Ramirez Camps finished her master's project as

a student of the FIB at the UPC (Faculty of Informatics at the Techn. Univ. Catalonia). The project was funded by CWI and the Erasmus programme. In the course of the project she finished the MIL implementation of BOND and BOND-H algorithms; undertook a performance comparison between the C and MIL implementations and a small study of the ways you can gain some performance working in MIL.

From March onward she started her PhD within the CIRQUID project (Complex Information Retrieval Queries in a Database), funded by NWO. A first XML-IR prototype system was developed, based upon the previous year's approach, but extended to handle structured queries. The system has been evaluated in context of the Initiative for XML Retrieval (INEX). The system and its results are described in 'The TIJAH XML-IR system at INEX 2003'.

INS1.3 – Database Architectures

Title	AmbientDB & X100
Period	February 2002–2007
Leader	P.A. Boncz
Staff	P.A. Boncz, M.L. Kersten, C. Treijtel, A. Jančařiková, M. Zukowski, N.J. Nes, S. Manegold
Funding	CWI
Partners	Philips NatLab, CTIT (UT)

Progress report. In 2003 we started development of a new database kernel, called X100, which is an evolution of the MonetDB system to better support intensive analysis applications (such as video retrieval) on massive data volumes. This query processing kernel will also be used in AmbientDB & X100 continues our research into the interaction between modern hardware requirements (e.g., exploiting CPU caches, generating high IPC code for deeply pipelined superscalar CPUs) and database archtirecture.

The AmbientDB architectural roadmap was defined in a joint effort with Philips Research and implementation of key components has been started. This cooperation also led to the first AmbientDB publications. However, during the year it became clear that the PhD student hired for this project would quit, thus jeopardizing progress.

Title	MonetDB
Period	1993–indefinite
Leader	P.A. Boncz
Staff	P.A. Boncz, S. Manegold, N.J. Nes, M.L. Kersten, M. Zukowski, K.S. Mullender
Funding	ICES-KIS MIA
Partners	UvA, UT, Data Distilleries

Progress report. In 2003 a lot of energy was devoted to preparing MonetDB for the open-source community. This involved development of user-interfaces, stability improvement, and connectivity software (see below). Collaboration with two new groups was intensified, both challenging the MonetDB technology in various aspects and candidates for good exposure of the results.

With the Database Group at the Univ. Konstanz, Germany, we collaborated on the 'Pathfinder' project. Pathfinder is an XQuery compiler on top of MonetDB. Manegold provided advice and support concerning the efficient use of MonetDB as high-performance database back-end as well as concerning the development and analysis of efficient, cache-aware main-memory algorithms.

With the Knowledge Discovery Laboratory at the Univ. Massachusetts, Amherst, we collaborated on the 'PROXIMITY' project: Proximity is a system for relational knowledge discovery designed and implemented by the Knowledge Discovery Laboratory in the Department of Computer Science at the Univ. Massachusetts, Amherst. Proximity uses MonetDB as its database back-end. Manegold provides remote advice and support concerning the efficient use of MonetDB. In particular, we now maintain the MacOS/X port of MonetDB.

Societal aspects and knowledge transfer

- A. de Vries, P. Boncz organized the weekly scientific meetings of the group.

External contacts

- Special Interest Group on Organic Databases, Philips NatLab, Eindhoven, April–December: P.A. Boncz, M.L. Kersten, C. Treijtel, K.S. Mullender.
- A.P. de Vries, research advisor M. van Doorn, Philips Natlab.
- A.P. de Vries, research advisor T. Ianeva, Univ. Valencia.

- P.A. Boncz, research advisor A. Sinitsyn, Philips Natlab.

Projects with partners in public and private sector

- AmbientDB; see page 146.
- Waterland; see page 145.
- CIRQUID; see page 145.

Teaching at university

- Course Advanced Database Techniques, UvA: M.L. Kersten.

Courses, tutorials

- SIKS cource on Implementing Intelligent search in XML data, Zeist, May 15–16: A.P. de Vries (with M. van Keulen) System architectures and query processing and Access structures.

Spin-offs

The research is conducted in close cooperation with Data Distilleries, the CWI spin-off using the MonetDB code base for its CRM product solutions.

Organization of conferences, workshops, courses, meetings

- Pre-MultimediaN Workshop on Ambient Multimedia Databases, CWI, November 3: P.A. Boncz.
- Dutch Information Retrieval (DIR) workshop, CWI, December 8–9: A.P. de Vries.
- ACM SIGIR 2007, Amsterdam: A.P. de Vries (co-chair).

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- CIDR conference, Asilomar (USA), January 6–7: P.A. Boncz.
- EURANDOM workshop, Eindhoven, January 15–17: A.P. de Vries.
- MediaMill workshop, UvA, January 30: A.P. de Vries.
- ICDE 2003, Bangalore, India, March 8: M.L. Kersten (Invited talk: Organic Database Systems to support an Ambient World; accepted for proceedings).
- Querying Streaming Data Database Conference 2003, RAI, Amsterdam, March 26: M.L. Kersten.
- ECIR, Pisa, Italy, April 14–17: A.P. de Vries.
- The Lowell Database Research Self-Assessment Workshop, Lowell, USA, May 4–6: M.L. Kersten (Invited talk: Managing your personal data and informative query answers; Talk: Organic Database Systems to support an Ambient World).
- ACM SIGMOD Conference 2004, San Diego, USA, June 9–12: M.L. Kersten, S. Manegold.
- Seminar co-hosted by the London Knowledge Management Network, London, UK, June 11: A.P. de Vries (Invited talk: Issues in extending DB technology for (Multimedia) Information Retrieval).
- BNCOD Conference, Coventry, UK, July 15–17: C. Treijtel.
- ACM SIGIR, Toronto, Canada, July 28–August 1: A.P. de Vries.
- ACM SIGIR Conference on Research and Development in Information Retrieval, Toronto, Canada, July 30: T.H.W. Westerveld (Lecture: Experimental Result Analysis for a Generative Probabilistic Image Retrieval Model).
- Multimedia Information Retrieval Workshop, in conjunction with ACM SIGIR, Toronto, Canada, Augustus 1: T.H.W. Westerveld (Lecture: Experimental Evaluation of a Generative Probabilistic Image Retrieval Model on 'Easy' Data).
- E-BioSci/Oriel Workshop, Varenna, Italy, September 2–4: A.P. de Vries (Invited talk: Using Probabilistic Models for Multimedia Retrieval).
- International Workshop On Databases, Information Systems and Peer-to-Peer Computing (DBISP2P), Berlin, co-located at VLDB 2003, September 7–8: P.A. Boncz, (Lecture: AmbientDB: Relational Query Processing in a P2P Network), C. Treijtel.
- VLDB Conference, Berlin, Germany, September 9–12: M.L. Kersten (Invited talk: A database striptease; or how to many your personal data; accepted for proceedings), P.A. Boncz, S. Manegold, N.J. Nes.

- VLDB PhD Workshop, September 11–12: C. Treijtel (Lecture: Complex Query Processing in P2P Network).
- Pre-Multimedian Workshop on Ambient Multimedia Databases, Amsterdam, November: C. Treijtel (Lecture: Relational Query Processing in a P2P Network).
- TRECVID, Gaithersburg, USA, November 17–18: A.P. de Vries, T.H.W. Westerveld (Lecture: Combining Information Sources for Video Retrieval).
- Negende Interdisciplinaire Conferentie Informatiewetenschap, Eindhoven, November 21: A.P. de Vries.
- Dutch Information Retrieval workshop, CWI, December 8–9: G. Ramirez Camps.
- Dutch Information Retrieval (DIR) Workshop, Amsterdam, December 9: T.H.W. Westerveld (Lecture: Combining Information Sources for Video Retrieval).
- INEX workshop Dagstuhl, Germany, December 15–17: G. Ramirez Camps.
- INEX workshop Dagstuhl, Germany, December 15–17: A.P. de Vries.

Working visits

- Microsoft Research + SQLServer Group, Redmond, USA, January 8–9: P.A. Boncz (Invited talk: 10+ fold Query Acceleration by Meeting the Smallprint Conditions for Gigahertz CPU efficiency).
- Visit to Prof.dr. Alon Halevy's group, Univ. Washington, Washington, USA, January 12–14: P.A. Boncz (Invited talk: The AmbientDB P2P DBMS: architecture and roadmap).
- Aalborg Univ., Department of Computer Science, Aalborg, Denmark, July: S. Manegold (Invited talk: The Impact of Modern Hardware Developments on Database Performance – or – The (Fairy) Tale of 'Random Access' Memory).
- Univ. Konstanz, Department of Computer & Information Science, Konstanz, Germany, August: S. Manegold (Invited talk: The Impact of Modern Hardware Developments on Database Performance – or – The (Fairy) Tale of 'Random Access' Memory).

Project meetings

- IRiX meeting, Glasgow, UK, February 13–14 and February 24–26: A.P. de Vries.
- Cirquid project meeting, Zuidlaren, May 18–21: G. Ramirez Camps, A.P. de Vries.
- MultimediaN project preparation meetings: M.L. Kersten.
- Pathfinder working meetings in Konstanz, August: S. Manegold.
- VLDB 2003, Berlin, September: S. Manegold.

Other lectures

- TUD, January 21: A.P. de Vries (Invited talk: Database Techniques and Multimedia Data Management).
- UT, February 14: T.H.W. Westerveld (Guest lecture: A Probabilistic Multimedia Retrieval Model and its Evaluation).
- ACM Symposium on Applied Computing (SAC), Melbourne, FL, USA, March: S. Manegold (Invited talk: Integrated Querying of XML Data in RDBMSs; accepted for proceedings).
- TUE, March 18: A.P. de Vries (Guest lecture: Multimedia Information Retrieval).
- Mini-symposium for G. van Oortmerssen, CWI, May 16: M.L. Kersten (Talk: Een wetenschappelijke duiventil).
- BNCOD PhD Forum, Coventry, UK, July 14–15: C. Treijtel (Lecture: Complex Query Processing in a P2P Network).
- Int. Workshop on Databases, Information Systems and P2P Computing (DBISP2P), Berlin, (co-located with VLDB 2003), September 7–8: P.A. Boncz (Lecture: AmbientDB: Relational Query Processing in a P2P Network).
- VLDB PhD Workshop, Berlin, Germany, September 11–12: C. Treijtel (Lecture: Complex Query Processing in a P2P Network).
- Philips Natlab Colloquium, Eindhoven, October 1: P.A. Boncz (Invited talk: AmbientDB: P2P data management support for ambient intelligent applications).
- Univ. Osnabrück, October 10: A.P. de Vries (Guest lecture: IR Implementation Techniques).
- UT, November 14: A.P. de Vries, (Guest lecture: Multimedia Information Retrieval).

Courses

- Advanced SIKS course on Implementing Intelligent Search in XML Data, Zeist, May 15: M.A. Windhouwer (Lecture: Usage of XML in Digital Libraries).

- SIKS course on Implementing Intelligent Search in XML Data, Zeist, May 15–16: G. Ramirez Camps.
- ESSIR 2003 (summer school) Aussois, France, August 31–September 5: G. Ramirez Camps.

Visitors

- Tzveta Ianeva, Univ. Valencia, April 1. Host: A.P. de Vries.
- L. Boldareva, UT, April 3. Host: A.P. de Vries.
- Christophe Reboud, Nantes, Frankrijk, April 15–May 31. Host: Z.R. Struzik.
- R. Cornacchia, Univ. Bologna, July 1. Host: A.P. de Vries.
- Dr. Alberto Lerner, New York Univ., July 28. Host: P. Boncz.
- Dr. Jonas Karlsson, IBM, Santa Clara Lab (USA), Augustus 6. Host: M.L. Kersten.

Memberships of committees and other professional activities

A.R. van Ballegooij

- Member programme committee RIAO 2004, France.
- Reviewer conferences: SIGMOD 2004, ICDE.

P.A. Boncz

- Organizer AmbientDB workshop, Amsterdam.
- Member programme committee SIGMOD 2004, Paris, France.
- Reviewer VLDB Journal.
- Reviewer conferences: SIGMOD 2003, ICDE, CIDR.

R. Cornacchia

- Reviewer conference SIGMOD 2004.

M.L. Kersten

- Professor of computer science at UvA, since 1993.
- Organizer invitational panel on 'Organic Databases', ICDE Bangalore, India.
- Organizer invitational panel on 'A Database Striptease; or how to manage your personal data', VLDB Berlin, Germany.
- Member programme committee ICDE PhD/WS 2004, Boston, USA.
- Member programme committee SSDBM, Santorini, Greece.
- Member programme committee WISE 2003, Rome, Italy.
- Member programme committee IDEAS 2003, Hong Kong.
- Member programme committee ACM SIGMOD 2003, San Diego,USA.
- Member programme committee ICDE 2003, Bangalore, India.
- Member programme committee CIDR 2003, Asilomar, USA.
- Member ToKeN2000 research programme committee, NWO.
- Member editorial board VLDB Journal, Springer-Verlag.
- 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.
- Member VLDB Endowment, board of trustees.
- European coordinator VLDB 2003, Berlin, Germany.
- Co-founder and member executive board Data Distilleries B.V., Amsterdam.
- Board member of ANMA, Amsterdam New-Media Association.
- Member PhD committee M. Petkovic, UT.
- Member PhD committee F. Steinstra, UvA.
- Reviewer VLDB journal, ACM Transactions on Office Information Systems, Journal Data and Knowledge Engineering.
- Reviewer conferences.

J.A. List

- Reviewer conference SIGMOD 2004.

S. Manegold

- Member programme committee of ACM Symposium on Applied Computing (SAC) 2004.
- Reviewer for VLDB Journal and IEEE TKDE.
- Reviewer conferences: SIGMOD 2004, SIGMOD 2003, ICDE, CIDR.

A.P. de Vries

- Co-chair ACM SIGIR 2007.
- Member IMIX research programme committee, NWO.
- Member programme committee ECIR 2003.
- Member programme committee SIGIR 2003.
- Member programme committee MMIR 2003.
- Member programme committee CBMI 2003.
- Member programme committee ICW 2003.
- Member programme committee DIR 2003.
- Reviewer ACM TODS (Transactions on Database Systems), IEEE TOMM (Transactions on Multi-Media systems), IP&M (Information Processing and Management), JIR (Journal for Information Retrieval).
- Reviewer conferences: ICASSP 2004, SIGMOD 2004.
- Reviewer EU project: InDiCo.
- Senior lecturer, TUD.

G. Ramirez Camps

- Reviewer conference SIGMOD 2004.

C. Treijtel

- Reviewer conferences: SIGMOD 2004, ICDE.

T.H.W. Westerveld

- Reviewer conferences: IP&M, ECIR, CBMI.

M.A. Windhouwer

- Reviewer conference SIGMOD 2004.

Academic publications

Publications in refereed journals

1. T. Westerveld, A.P. de Vries, A. van Ballegooij, F.M.G. de Jong, D. Hiemstra (2003). A Probabilistic Multimedia Retrieval Model and its Evaluation. EURASIP Journal on Applied Signal Processing 2, 186–198. Special issue on Unstructured Information Management from Multimedia Data Sources.

Publications in other journals and other scientific output

1. Z.R. Struzik (2003). Econonatology: The Physics of the Economy in Labour. Physica A: Statistical Mechanics and its Applications 324(1–2), 344–351. The original publication is available from Science Direct, (c) Elsevier Science B.V.

Unrefereed (electronic) journals

1. Z.R. Struzik (2003). Taking the Pulse of the Economy. Quantitative Finance, 3(4). The original publication will be available from Electronic Journals, (c) Institute of Physics and IOP Publishing Ltd.

Conference proceedings

1. P.A. Boncz, C. Treijtel (2003). AmbientDB: Relational query processing in a P2P network. International Workshop on Databases, Information Systems, and P2P Computing (DBISP2P) (co-located with VLDB 2003). Lecture Notes in Computer Science 2788/Lecture Notes in Artificial Intelligence (LNCS/LNAI), (c) Springer-Verlag, Berlin, Germany.
2. T. Ianeva, A.P. de Vries, H. Röhrig (2003). Detecting Cartoons: A Case Study in Automatic Video-genre Classification. Proceedings of the IEEE International Conference on Multimedia and Expo (ICME), I 449-I 452, Baltimore, MD, USA.
3. A.R. Schmidt, S. Manegold, M.L. Kersten (2003). Integrated Querying of XML Data in RDBMSs. Proceedings of the ACM Symposium on Applied Computing (SAC), 509–514, Melbourne, FL, USA.
4. Z.R. Struzik (2003). Econophysics vs Cardiophysics: the Dual Face of Multifractality. H. Takayasu (ed.). Applications of Econophysics, Berlin, New York, Springer-Verlag, etc.
5. Z.R. Struzik (2003). Time Series Rule Discovery: Tough, not Meaningless. Proceedings of the International Symposium on Methologies for Intelligent Systems (ISMIS). Lecture Notes in Computer Science/Lecture Notes in Artificial Intelligence (LNCS/LNAI), (c) Springer-Verlag, Maebashi City, Japan.
6. Z.R. Struzik (2003). Taming Surprises. Intelligent Information Systems: New Trends in Intelligent Information Processing and Web Mining. Advances in Soft Computing (ASC), (c) Springer-Verlag, Zakopane, Poland.

7. T. Westerveld, Arjen P. de Vries (2003). Experimental Evaluation of a Generative Probabilistic Image Retrieval Model on 'Easy' Data. Proceedings of the Multimedia Information Retrieval Workshop, Toronto, Canada. In conjunction with the ACM SIGIR conference on Research and Development in Information Retrieval (SIGIR).
8. T. Westerveld, A.P. de Vries (2003). Experimental Result Analysis for a Generative Probabilistic Image Retrieval Model. Proceedings of the ACM SIGIR Conference on Research and Development in Information Retrieval (SIGIR), Toronto, Canada.
9. M.A. Windhouwer, A.R. Schmidt, R. van Zwol, M. Petkovic, H.E. Blok (2003). Flexible Digital Library Search. A. Dahanayake and W. Gerhardt (eds). Web-enabled Systems Integration: Challenges and Practices, Idea Group Publishing, 200–224.

CWI reports

INS-R0301, INS-R0302, INS-R0304, INS-R0306.
See page 182 for complete titles.

Software developed

The MonetDB database management system (`http://monetdb.cwi.nl`).
INS1 continues the development of its experimentation platforms, i.e. MonetDB database system. Mullender (scientific programmer) has been developing the ODBC interface; Nes continued the development of the SQL-99 query language processor; Manegold has integrated a prototype query optimizer; Kersten developed a graphical user-interface; Boncz rolled-forward kernel enhancements prepared by Data Distilleries; Boncz, Nes, and Kersten prepared the MonetDB website. Manegold devoted most of his time to stabilizing, cleaning and partly extending the code base of MonetDB as well as maintaining and extending its portability (MacOS/X for Univ. Massachusetts, Amherst; AIX for Data Distilleries).

Boncz and Nes developed the low-level code for X100, an evolutionary step towards better performance over very large multimedia databases. Kersten continued the development of Monet-5, geared at the construction of a virtual machine for database processing.

Westerveld, Ianeva and De Vries developed a new version of the video retrieval system, using the spatio-temporal information of the video shots. Van Ballegooij developed a compiler/optimizer for the RAM language. List and Ramirez Camps (co-)developed the TIJAH XML-IR system for INEX.

Book chapters

1. A.R. Schmidt, F. Waas, S. Manegold, M.L. Kersten (2003). A Look Back on the XML Benchmark Project. H.M. Blanken, T. Grabs, H.-J. Schek, R. Schenkel, G. Weikum (eds). Intelligent Search on XML, Lecture Notes in Computer Science/Lecture Notes in Artificial Intelligence (LNCS/LNAI), (c) Springer-Verlag, 263–278, Berlin, New York, etc., Springer-Verlag.
2. A.P. de Vries, J.A. List, H.E. Blok (2003). The Multi-Model DBMS Architecture and XML Information Retrieval. H.M. Blanken, T. Grabs, H.-J. Schek, R. Schenkel, G. Weikum (eds). Intelligent Search on XML. Lecture Notes in Computer Science 2818/Lecture Notes in Artificial Intelligence (LNCS/LNAI), Springer-Verlag, Berlin, New York, etc., 179–192.
3. M.A. Windhouwer, R. van Zwol (2003). Combining Concept- with Content-based Multimedia Retrieval. H.M. Blanken, T. Grabs, H.-J. Schek, R. Schenkel, G. Weikum (eds). Intelligent Search on XML. Lecture Notes in Computer Science 2818/Lecture Notes in Artificial Intelligence (LNCS/LNAI), Springer-Verlag, Berlin, New York, etc., 217–230.

MSc theses

- A. Jančařiková (2003). Distributed query processing over a Peer-to-Peer network supervisor. VU, Thesis advisor: Prof.dr. M. van Steen.
- Brahmananda Sapkota (2003). Design of Peer-to-Peer Protocol for AmbientDB supervisor at CTIT. Thesis advisor: Dr. D. Quartel.
- Master Thesis defense, TTT meeting, CWI, March 6: G. Ramirez Camps. Bond in MIL: An exercise on physical DB design.

Professional products

Publications for a broad audience

1. P.A. Boncz (2003). AmbientDB: P2P Database Technology for Ambient Intelligent Multimedia Applications. ERCIM News 55, 231–246.
2. M.L. Kersten. TCO en de wet van behoud van ellende. Database Magazine, 14(4), 12–13. In Dutch.

Multimedia and Human-Computer Interaction – INS2

Mission

INS2's long expertise in hypermedia and Web technology has over the recent years extended to the Semantic Web. Our long-time interest in authoring has likewise extended into the human-guided, semi-automatic generation of Web-based hypermedia from media repositories encoded with Semantic Web technology. Explorations into hypermedia discourse have guided our development of this process.

The general architecture we assume starts with repositories using Semantic Web technology, for which we explore best practices for application to hypermedia generation. This leads to our investigations in how discourse applies to, and emerges from, semantics, both across all domains and within specific domains and presentation genres. Finally, we develop means of presenting these semantics and the discourse structure around them to the final user. This includes investigating media types, graphic design and user models.

Defining of animated humanized expressive facial interfaces extends our exploration of interaction using multimedia.

Theme leader

Prof.dr. H.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

Name	Leader
INS2.1 – Semantics and Hypermedia Processing	H.L. Hardman
INS2.2 – Social User Interfaces	Zs.M. Ruttkay

Staff

CWI employees

Name	Fte	Function(s)	Period	Subthemes + projects
Y. Bachvarova	1.0	PhD student	2003-01-01 till 2006-12-31	INS2.1: I^2RP
Ir. S. Bocconi	1.0	PhD student	2000-01-01 till 2005-12-31	INS2.1: I^2RP
K.I. Falkovych, MSc	1.0	PhD student	2002-11-01 till 2006-10-31	INS2.1: CHIME
Drs.ing. J.P.T.M. Geurts	1.0	PhD student	2002-06-01 till 2006-05-31	INS2.1: NASH

Prof.dr. H.L. Hardman (0.2 TUE)	0.8	theme leader, leader INS2.1	indefinite	INS2.1: NASH, I^{2}RP, CHIME, QuestionHow, Topia
Dr. F.-M. Nack	1.0	researcher	2000-02-01 till 2006-01-31	INS2.1: CHIME, QuestionHow
Drs. H. Noot	1.0	programmer	indefinite	INS2.2: FASE
Dr. J.R. van Ossenbruggen	1.0	researcher	indefinite	INS2.1: NASH, QuestionHow
Dr. L.W. Rutledge	1.0	researcher	indefinite	INS2.1: Topia, W3C AC
Dr. Zs.M. Ruttkay	1.0	programmer, leader INS2.2	1997-03-16 till 2004-03-15	INS2.2: FASE
K. Schwarz	0.2	researcher	starting September 1	INS2.1

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
Prof.dr. P.M. de Bra	0.2	researcher	1996-10-01 till 2003-10-01	INS2.1: NASH, CHIME
Dr.ir. G.-J. Houben	0.2	researcher	2003-10-01 till 2004-07-31	INS2.1: NASH, CHIME

Scientific report

PhD students

Y. Bachvarova
S. Bocconi
K.I. Falkovych
J.P.T.M. Geurts

INS2.1 – Semantics and Hypermedia Processing

Title	NASH – Networked Adaptive Structured Hypermedia
Period	June 2002–May 2004
Leader	J.R. van Ossenbruggen
Staff	P.M. de Bra, J.P.T.M. Geurts, H.L. Hardman, J.R. van Ossenbruggen
Funding	NWO
Partner	TUE

Progress report. The NASH project is a result of the identification (and partitioning) of research problems by the joint research teams of TUE and CWI who are collaborating in NWO, ITEA and W3C projects related to the generation of hypermedia interfaces for semi-structured multimedia information. While visiting the Garage Cinema Research Group at the Univ. California in Berkeley, Geurts developed a framework to make their ontology-based video annotation toolkit interoperable with the Semantic Web. He also started the development of a prototype that shows how these annotations can be used to automate part of the video montage process, and how such a tool can be based on generic, off-the-shelf Semantic Web software components. Van Ossenbruggen further explored the use of Semantic Web technology to support knowledge intensive XML document transformations. This work is based on a new, conceptual integration of tools from both the XML/XSLT and RDF/OWL world. Results include an RDF-based XSLT extension module and contributions to the open source Semantic Web toolkit Sesame.

Geurts and Van Ossenbruggen worked jointly on an abstract output vocabulary for representing time-based multimedia presentations. This work forms the theoretical bases for the current Cuypers layout module and was presented at the International World Wide Web conference in Budapest. With Bocconi, Geurts worked on Semantic Web-based improvements of the Cuypers engine, and the results of this joint work was presented at the International Semantic Web Conference in Florida.

Title	CHIME – Cultural Heritage in an Interactive Multimedia Environment
Period	November 2002–October 2004
Leader	H.L. Hardman
Staff	K.I. Falkovych, F.-M. Nack
Funding	NWO
Partner	ToKeN2000

Progress report. The goal of the CHIME project is to investigate the use of semantic models for tailoring the presentation of cultural information extracted from existing repositories to differ-

ent types of users. In 2003 we developed the general architecture for the project in which the components from each partner fits. Falkovych developed the implementation design SampLe for the authoring interface. SampLe accounts for multiple aspects of the media repository to presentation authoring processing, including media retrieval and discourse genre selection. Werner designed the graph and interactive interface for SampLe.

Title	I^2RP – Intelligent Information Retrieval and Presentation in public historical multimedia databases
Period	2002–2005
Leader	H.L. Hardman
Staff	H.L. Hardman, Y. Bachvarova, S. Bocconi, K. Schwarz
Funding	NWO
Partners	ToKeN2000, Rijksmuseum Amsterdam, KI/RUG, IKAT/UM, UL

Progress report. The I^2RP project aims at researching and implementing effective information retrieval methods in public historical multimedia databases. In 2003, we defined how to integrate each partner's stand-alone system in a common architecture. We developed a presentation engine for this architecture, and integrated it with other components from the various partners. In particular, this involved cooperation with UL to integrate their natural language component and with IKAT/UM to integrate their ontology processing. Our contribution also includes a mapping of underlying concepts to modalities of media to balance the attention load given by the final presentation to the user.

Title	Topia – Topic-based Interaction with Archives
Period	January 2003–October 2003
Leader	M. Veenstra (Telematics Institute)
Staff	H.L. Hardman, L.W. Rutledge
Funding	Telematics Institute
Partner	Telematics Institute

Progress report. The Topia project explores the discourse-driven generation of hypermedia presentation from semantically annotated media archives. We extended the prototype demonstrator with a direct connection between style processing and the underlying semantics, extending the notion of hypermedia style in a generating environment. We also explored different aspects of discourse and its presentation, including sequence, recurrence, and presentation of branch nodes in hierarchical structure.

Title	QuestionHow
Period	September 2001–August 2003
Leader	H.L. Hardman
Staff	S. Bocconi, J.P.T.M. Geurts, F.-M. Nack, J.R. van Ossenbruggen
Funding	W3C EU/IST
Partners	INRIA, ERCIM, CWI, CNR CNUCE, FhG ImK, Forth, HUJI, CLRC, SICS

Progress report. In the context of W3C's EU/IST funded QuestionHow project, Bocconi, Geurts and Van Ossenbruggen developed an annotation module for the Cuypers generation engine. This module demonstrates the added value of automatic annotation in generated multimedia presentations. At the same time, it also shows how current W3C Recommended languages and protocols (such as SMIL 2.0 and RDF Schema) can be used to realize this in a platform-neutral and interoperable way. The work was presented and well received during the EU project review in Brussels.

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.

INS2.2 – Social User Interfaces

Title	FASE
Period	2003
Leader	Zs.M. Ruttkay
Staff	Zs.M. Ruttkay, H. Noot
Funding	FASE
Partner	FASE

Progress report. The current practice of evaluating the use and effect of embodied conversational agents (ECAs) was extensively studied, resulting in an overview chapter with recommendations for further work, for a book to appear. The GESTYLE markup language for the annotation of text with non-verbal communication acts was further developed and implemented. Extensive study was made on 3D gestures, using the STEP package, developed at the VU, Amsterdam.

Societal aspects and knowledge transfer

Projects with partners in public and private sector

- CHIME , I^{2}RP, Topia , QuestionHow

Teaching at university

- Invited class 'Structured Documents on the Web', TUE, January 7: J.R. van Ossenbruggen.
- Invited class 'Standardization through MPEG-7', UvA, February 22: F.-M. Nack.
- Invited class 'Structured Documents on the Web', VU, March 18: J.R. van Ossenbruggen.
- Invited class 'Syntactic Towards Semantic-driven Document Transformations', UU, October 16: J.R. van Ossenbruggen.

Courses, tutorials

- Full day tutorial on 'SMIL 2.0 – Interactive Multimedia on the Web' at the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20: L.W. Rutledge.
- Full day tutorial on 'Computational Semiotics for New Media and Games' at the Third Computational Semiotics in Games and New Media Conference (COSIGN 2003), Middlesbrough, UK, September 7: F.-M. Nack.
- Full day tutorial on 'Understanding Media Semantics' at ACM Multimedia 2003, Berkeley, CA, USA, November 3: F.-M. Nack (with M. Davis and C. Dorai).
- Full day tutorial on 'SMIL 2.0 – Interactive Multimedia on the Web' ACM Multimedia 2003, Berkeley, CA, USA, November 3: L.W. Rutledge.

Lectures, conferences, courses, working visits

Visits to conferences, workshops, symposia

- TokeN2000 Symposium, TUD, February 21: Y. Bachvarova, S. Bocconi, K.I. Falkovych, F.-M. Nack, H.L. Hardman, J.R. van Ossenbruggen (Posters: CUYPERS - Discourse-Driven Hypermedia Presentations, CHIME – Cultural Heritage in an Interactive Multimedia Environment, winner Best Poster).
- Media Knitting Workshop, V2_, Rotterdam, February 26–28: S. Bocconi, J.P.T.M. Geurts.
- The Future of the Web Workshop, March 26–27, UvT: Y. Bachvarova.
- IBM Academic Workshop on 'Life Science', IBM Böblingen, Germany, March 31–April 1: F.-M. Nack (Presentation: S.M. Eisenstein - or the art of movie viewing).
- The Fifth International Gesture Workshop (GW 2003), Genova, Italy, April 15–17: H. Noot, Zs.M. Ruttkay.
- The 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–23: J.P.T.M. Geurts, H.L. Hardman, J.R. van Ossenbruggen, L.W. Rutledge (Accepted paper: Towards a Formatting Vocabulary for Time-based Hypermedia).
- Fifth DELOS Workshop on Multimedia Contents in Digital Libraries, Chania, Crete, Greece, June 3–4: F.-M. Nack. (Accepted paper: Semantic enabled presentation of information).
- Fachhochschule Darmstadt – Multimedia System Design, Dieburg, Germany, June 23: F.-M. Nack (Lecture: AV Recording and Post-production).
- ERCIM Constraints/CoLogNet Workshop, June 30–July 12, Budapest: Zs.M. Ruttkay.
- The Embodied Conversational Characters as Individuals Workshop at the Second International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS03), Melbourne, Australia, July 15: Zs.M. Ruttkay.

- The Second Hungarian Computer Graphics and Geometry Conference, Budapest, Hungary, June 31–July 1: Zs.M. Ruttkay.
- The 14th Conference on Hypertext and Hypermedia (Hypertext 2003), Nottingham, UK, August 26–30: S. Bocconi, K.I. Falkovych, H.L. Hardman, L.W. Rutledge (Accepted paper: Finding the Story – Broader Applicability of Semantics and Discourse for Hypermedia Generation).
- 1st International Workshop on Scholarly Hypertext at the 14th conference on Hypertext and Hypermedia (HyperText 2003), Nottingham, UK, August 30: S. Bocconi (Accepted paper: Automatic Presentation Generation for Scholarly Hypermedia).
- 1st International Workshop on Hypertext and the Semantic Web at the 14th conference on Hypertext and Hypermedia (HyperText 2003), Nottingham, UK, August 30: K.I. Falkovych, L.W. Rutledge (Accepted paper: Semantics in Multi-facet Hypermedia Authoring).
- The Third Computational Semiotics in Games and New Media Conference (COSIGN 2003), Middlesbrough, UK, September 9–12: F.-M. Nack.
- The Fourth International Working Conference on Intelligent Virtual Agents (IVA 2003), Irsee, Germany, September 15–17: Zs.M. Ruttkay.
- Belgisch Nederlands AI Symposium voor studenten, CWI, October 9: S. Bocconi.
- The 2nd International Semantic Web Conference (ISWC2003), Sanibel Island, Florida, USA, October 20–23: S. Bocconi, J.P.T.M. Geurts, J.R. van Ossenbruggen (Accepted paper: Towards Ontology-driven Discourse: From Semantic Graphs to Multimedia Presentations. (Poster: Implementing DISCourse-driven hypermedia Presentations).
- ACM Multimedia 2003, Berkeley, CA, USA, November 2–8: J.P.T.M. Geurts, F.-M. Nack, L.W. Rutledge (Poster: Colour picking – the pecking order of form and function).
- The First ACM Multimedia workshop on Experiential Telepresence (ETP 03), Berkeley, CA, USA, November 7: F.-M. Nack (Accepted paper: Capturing experience – a matter of contextualising events).
- Conferentie Informatiewetenschap, TUE, November 20: S. Bocconi, L.W. Rutledge, H.L. Hardman (Accepted paper: Intelligent Information Retrieval and Presentation with Multimedia Databases).
- 4th Dutch-Belgian Information Retrieval Workshop, CWI, December 8–9: S. Bocconi, L.W. Rutledge.

Working visits

- School of Computerint, National Univ. Singapore, May 30–August 1: Zs.M. Ruttkay.
- L. Simon at Semmelweis Univ., Budapest, Hungary, July 3: Zs.M. Ruttkay.
- Garage Cinema Research, Univ. California, Berkeley, August 21–December 22: J.P.T.M. Geurts.
- UT, October 5: Zs.M. Ruttkay.
- Univ. Birmingham, Department of Electronic, Electrical and Computing Engineering, UK, October 9: Zs.M. Ruttkay.
- Garage Cinema Research, Univ. California, Berkeley, October 27–November 1: F.-M. Nack.
- Univ. Paris VIII, France, November 18: Zs.M. Ruttkay.

Project meetings

- CHIME project meeting, TUE, January 7: F.-M. Nack.
- ToKeN2000/I^{2}RP project meeting, CWI, February 7: Y. Bachvarova, S. Bocconi.
- ToKeN2000/I^{2}RP project meeting, VU, February 13: Y. Bachvarova, S. Bocconi.
- CHIME project meeting, CWI, March 17: K.I. Falkovych, F.-M. Nack.
- Programme committee meeting for ACM Hypertext 2003, Univ. Nottingham, Nottingham, UK, March 27–28: H.L. Hardman, J.R. van Ossenbruggen.
- Programme Committee meeting for COSIGN 2003, Middlesbrough, UK, April 28–29: F.-M. Nack.
- CHIME project meeting, TUE, May 6: F.-M. Nack.
- CHIME project meeting, VU, June 10: F.-M. Nack.
- Programme committee meeting for ACM Multimedia 2003, IBM T.J. Watson, New York, USA, June 21: L.W. Rutledge.
- ToKeN2000/I^{2}RP project meeting, UL, June 30: Y. Bachvarova, S. Bocconi.
- IEEE Multimedia board meeting, Baltimore, USA, July 7–8: F.-M. Nack.
- CHIME project meeting, TUE, August 18: F.-M. Nack.

- W3C/IST QuestionHow final project review, Brussels, September 16: S. Bocconi, J.R. van Ossenbruggen.
- ToKeN2000/I^{2}RP project meeting, UL, October 15: Y. Bachvarova, S. Bocconi.
- CHIME project meeting, CWI, December 18: F.-M. Nack.

Courses

- SIKS Advanced course: Implementing intelligent search in XML data, Zeist, May 15–16: Y. Bachvarova, S. Bocconi, J.P.T.M. Geurts.
- SIKS Basic Course: Learning and Reasoning and Combinatory Methods, Zeist, June 2–6: Y. Bachvarova, S. Bocconi.
- The First European Summer School on Ontological Engineering and the Semantic Web (SSSW), Cercedilla, Spain, July 26–31: Y. Bachvarova, K.I. Falkovych.
- INFOSYS 246 'Multimedia Information', Univ. California, Berkeley, USA, Fall: J.P.T.M. Geurts.
- Presenting data and information, by Edward Tufte, San Francisco, USA, December 9: J.P.T.M. Geurts.

Visitors

- A.S.K. Manniesing, TUD, start of year to September 1. Host: H.L. Hardman.
- K. Schwarz, Univ. Applied Sciences Darmstadt, start of year to September 1st. Host: H.L. Hardman.
- K. Arora, IIT New Delhi, May 7–July 25. Host: H.L. Hardman.
- G. Gupta, IIT New Delhi, May 15 – July 25. Host: Zs.M. Ruttkay.
- M.W. Kauw A Tjoe, VU, June 1 to end of year. Host: H.L. Hardman.
- R.C.E. van Velthoven, TUE, June 1 to end of year. Host: H.L. Hardman.
- J. Werner, Univ. Applied Sciences Darmstadt, 1 september to end of year. Host: H.L. Hardman.

Memberships of committees and other professional activities

K.I. Falkovych

- Reviewer for the Semantic Web track of the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24.

J.P.T.M. Geurts

- Reviewer for the Semantic Web track of the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24.

H.L. Hardman

- Professor in computer science at TUE, since 2001.
- Supervision of M. Alberink (PhD student since January 2002) as part of cooperation with Telematics Institute.
- Supervision of Susanne Loeber (PhD student since March 2000) as part of cooperation with TUE.
- Supervision of MSc thesis at UvA for J.P.T.M. Geurts, 'Constraints for Multimedia Presentation Generation', February 6: J.R. van Ossenbruggen, H.L. Hardman.
- Supervision of Y. Bachvarova (PhD student since February 2003).
- 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 A. Nigten (PhD student at Central St. Martin's Institute, London since 2002) in collaboration with V2_ (institute for the Instable Media, Rotterdam).
- Co-chair programme committee for the 14th ACM conference on Hypertext and Hypermedia (HT03), Nottingham, UK, August 23–27.
- Member editorial board for the New Review of Hypermedia and Multimedia (NRHM).
- Reviewer for the Journal of Digital Information (JoDI) and Multimedia Tools and Applications (MTAP).
- Member programme committee for the Hypermedia track of the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24.
- Reviewer for the Semantic Web track of the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24.

- Member programme committee of Conferentie Informatiewetenschap 2003, TUE, November 20.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb) and Multimedia (SIGMM).
- Member of the British Computing Society (BCS).
- Supervision of undergraduate students from TUE and VU.

F.-M. Nack

- Supervision of Masters student from TUD.
- Supervision of Diploma students from Univ. Applied Sciences Darmstadt.
- Supervision of trainees from IIT New Delhi.
- Advisor for Diploma Thesis Univ. of Applied Sciences Darmstadt for K. Schwarz, An investigation on the relationship between the user model and graphic representations for the automated generation of multimedia presentations, March 21.
- Advisor for Diploma student J. Werner.
- Editor-in-chief of the IEEE Multimedia journal.
- Editor of the Media Impact Column of IEEE Multimedia journal.
- Reviewer for IEEE Multimedia, IEEE Intelligent Systems, ACM Multimedia Systems, International Journal of Continuing Engineering Education and Life Long Learning.
- Member organizing committee and reviewer for the 3rd Computational Semiotics in Games and New Media Conference (COSIGN 2003), Middlesborough, UK, September 9–12.
- Reviewer for the 11th ACM International Conference on Multimedia (MM03), Berkeley, USA, November 2–8.
- Reviewer for the 29th EUROMICRO Conference, Belek, Turkey, September 1–6.
- Reviewer for the EEE International Conference on Multimedia and Expo (ICME) 2003, Baltimore, Maryland, June 6–9.
- Peer reviewer for the EU project VIZARD.
- Member of the ISO/IEC JTC1/SC29/WG11 group developing the Moving Picture Experts Group Multimedia Content Description Interface (MPEG-7) Description Definition Language (DDL).
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Multimedia (SIGMM), Hypertext, Hypermedia and the Web (SIGWeb) and Computer-Human Interfaces (SIGCHI).

H. Noot

- Member of the Association for Computing Machinery (ACM) and its Special Interest Group on Graphics (SIGgraph).

J.R. van Ossenbruggen

- Member programme committee for the 14th ACM conference on Hypertext and Hypermedia (HT03), Nottingham, UK, August 23–27.
- Member programme committee for the Semantic Web track of the 12th International World Wide Web Conference (WWW 2003), USA, May 7–11; Budapest, Hungary, May 20–24.
- Reviewer for Journal of Systems and Software and Web Semantics: Science, Services and Agents on the World Wide Web.
- 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 Group on Hypertext, Hypermedia and the Web (SIGWeb).
- Supervision of undergraduate students from TUE and VU.

L.W. Rutledge

- Pre-examiner of PhD thesis at Helsinki Univ. Technology for K. Pihkala, Extensions to the SMIL Multimedia Language, November 28.
- Member programme committee for the Multimedia track of the 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24.
- Member programme committee for the 11th ACM International Conference on Multimedia (MM03), Berkeley, USA, November 2–8.
- Reviewer for the 14th ACM conference on Hypertext and Hypermedia (HT03), Nottingham, UK, August 23–27. (awarded Best Reviewer)
- Member programme committee for the ACM Symposium on Document Engineering (DocEng 2003), Grenoble, November 20–22.

- Member programme committee for the 10th International Conference on Multi-Media Modeling (MMM04), Brisbane, Australia, January 5–7, 2004.
- Reviewer for the Journal of Digital Information (JoDI).
- Reviewer for New Review of Hypermedia and Multimedia (NRHM), ACM/Springer Multimedia Systems, Journal of Systems and Software, Software: Practice and Experience.
- Reviewer for the Time for the Web Workshop at the Fifteenth International Conference on Software Engineering and Knowledge Engineering (SEKE 2003), San Francisco, USA, June 30.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Groups on Hypertext, Hypermedia and the Web (SIGWeb) and Multimedia (SIGMM).

Zs.M. Ruttkay

- Member of PhD committee S. Kiss, UT.
- Member of Master thesis committee A. de Smet, UvT, 4 computerpersonages, 4 persoonlijkheden: Experimenteel onderzoek naar de invloed van het uiterlijk van computerpersonages op hun waargenomen persoonlijkheid, October.
- Organizer of the Embodied Conversational Characters as Individuals Workshop at the 2nd International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS03), Melbourne, Australia, July 15.
- Reviewer for the 2nd Hungarian Computer Graphics Conference, Budapest, Hungary, June 31–July 1.
- Reviewer for the 5th International Gesture Workshop (GW 2003), Genova, Italy, April 15–17.
- Reviewer for ERCIM Constraints/CoLogNet Workshop.
- Member of the Association for Computing Machinery (ACM) and its Special Interest Group on Graphics (SIGgraph).
- Member of the John von Neumann Computer Society (NJSZT).
- Supervision of trainees from IIT New Delhi.

Academic publications

Publications in refereed journals

1. Zs. Ruttkay, H. Noot, P. ten Hagen (2003). Emotion Disc and Emotion Squares: tools to explore the facial expression space. Computer Graphics Forum, 22(1), 49–53.

Publications in other journals and other scientific output

Conference proceedings

1. M. Alberink, L. Rutledge, M. Veenstra (2003). Clustering Semantics for Discourse Generation. Workshop Hypermedia and the Semantic Web at the 14th conference on Hypertext and Hypermedia (HyperText 2003), Nottingham, UK, August 30.
2. M. Alberink, L. Rutledge, M. Veenstra (2003). Sequence and Emphasis in Automated Domain-Independent Discourse Generation. Proceedings of Conferentie Informatiewetenschap, Eindhoven, November 20, 3–18.
3. S. Bocconi (2003). Automatic Presentation Generation for Scholarly Hypermedia. 1st International Workshop on Scholarly Hypertext at the fourteenth conference on Hypertext and Hypermedia at the 14th conference on Hypertext and Hypermedia (HyperText 2003), Nottingham, UK, August 30.
4. K.I. Falkovych, F.-M. Nack, J.R. van Ossenbruggen, L. Rutledge (2003). Semantics in Multi-facet Hypermedia Authoring. Hypermedia and the Semantic Web Workshop at the 14th Conference on Hypertext and Hypermedia (HyperText 2003), Nottingham, UK, August 30.
5. J.P.T.M. Geurts, S. Bocconi, J.R. van Ossenbruggen, and L. Hardman (2003). Towards Ontology-driven Discourse: From Semantic Graphs to Multimedia Presentations, Second International Semantic Web Conference (ISWC2003), Sanibel Island, Florida, USA, October 20–23, 597–612.
6. E. Krahmer, S. van Buuren, Zs. Ruttkay, W. Wesselink (2003). Audio-visual Personality Cues for Embodied Agents: An experimental evaluation. Proceedings of the Embodied Conversational Characters as Individuals Workshop at the 2nd International Joint Conference on Autonomous

Agents and Multiagent Systems (AAMAS03), Melbourne, Australia, July 15.

7. F.-M. Nack (2003). Migrating from mobile telephony to multipurpose gadgets, IEEE Multimedia, January–March, 8–11.
8. F.-M. Nack (2003). Aesthetics of contradiction, IEEE Multimedia, January–March, 14–17.
9. F.-M. Nack, A.S.K. Manniesing, L. Hardman (2003). Colour Picking — the Pecking Order of Form and Function. Proceedings of the eleventh ACM International Conference on Multimedia (MM03), Berkeley, USA, November 2–8, 279–282.
10. J.R. van Ossenbruggen, J.P.T.M. Geurts, L. Hardman, L. Rutledge (2003). Towards a Formatting Vocabulary for Time-based Hypermedia. The 12th International World Wide Web Conference (WWW 2003), Budapest, Hungary, May 20–24, 384–393.
11. L. Rutledge, M. Alberink, R. Brussee, S. Pokraev, W. van Dieten, M. Veenstra (2003). Finding the Story – Broader Applicability of Semantics and Discourse for Hypermedia Generation. Proceedings of the 14th ACM conference on Hypertext and Hypermedia (HT03), Nottingham, UK, August 23–27, 67–76.
12. Zs. Ruttkay, Z. Huang, A. Eliëns (2003). The Conductor: Gestures for embodied agents with logic programming. Proceedings of the 2nd Hungarian Computer Graphics Conference, Budapest, Hungary, June 30–July 1, 9–16.
13. Zs. Ruttkay, V. van Moppes, H. Noot (2003). The jovial, the reserved and the robot. Proceedings of the Embodied Conversational Characters as Individuals Workshop at the 2nd International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS03), Melbourne, Australia, July 15.
14. Zs. Ruttkay, Z. Huang, A. Eliëns (2003). Reusable Gestures for Interactive Web Agents. Proceedings of the 4th International Working Conference on Intelligent Virtual Agents (IVA 2003), Irsee, Germany, September 15–17, 80–87.
15. F. Wiesman, S. Bocconi, B. Arsenijevic, Y. Bachvarova, N. Roos, L. Schomaker (2003). Intelligent Information Retrieval and Presentation with Multimedia Databases. Proceeding of the Fourth Dutch-Belgian Information Retrieval Workshop, Institute for Logic, Language and Computation, UvA, December 8–9, 52–56.

CWI reports

INS-E0301, INS-E0302, INS-E0303, INS-E0305, INS-E0306, INS-E0307, INS-E0308, INS-E0309, INS-R0303, INS-R0305, INS-R0307.
See page 182 for complete titles.

Book chapters

1. K.I. Falkovych, M. Sabou, H. Stuckenschmidt (2003). B. Omelayenko, M. Klein (eds). UML for the Semantic Web: Transformation-Based Approaches. Knowledge Transformation for the Semantic Web, IOS Press, 92–106.

MSc theses

1. Katharina Schwarz (2003). An investigation on the relationship between the user model and graphic representations for the automated generation of multimedia presentations. Diploma Media System Design, Univ. Applied Sciences Darmstadt. March 21. Thesis advisor: F.-M. Nack.

Professional products

Publications for a broad audience

1. H.L. Hardman (2003). Smart Style for Conveying Information. Inaugural address given at the TUE, May 2.

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 computer 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

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	J.D. Mulder

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
Drs. B.R. Boschker	1.0	PhD student	2002-11-01 till 2006-11-01	INS3.2
A.J. Jansen	0.6	programmer	2002-5-01 till 2003-5-01	INS3.2
Dr.ir. W.C. de Leeuw	1.0	researcher	indefinite	INS3.1
Dr.ir. R. van Liere	0.8	theme leader, leader INS3.1	indefinite	INS3.1, INS3.2
Dr. J.D. Mulder	1.0	researcher, leader INS3.2	2001-05-01 till 2005-05-01	INS3.2
Ir. A.J. van Rhijn	1.0	PhD student	2002-03-01 till 2006-03-01	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

- The BSIK VL-e project was submitted and accepted.
- Installation of PSS systems at six universities.
- Joint publication in the journal of Chromosome Research.

PhD students

B.R. Boschker
A.J. van Rhijn

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	Motion estimation in time dependent volume data
Period	April 2001–April 2003
Leader	R. van Liere
Staff	R. van Liere, W.C. de Leeuw
Funding	ICES-KIS II
Partner	SILS

Progress report. De Leeuw and Van Liere worked on tracking position and orientation of VR input devices by matching camera images to a device model using minimization algorithms.

De Leeuw continued research on the analysis and visualization of 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.

The research in the project is coordinated by Van Liere, in collaboration with Prof. R. van Driel at the Swammerdam Institute for Life Sciences, 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 and Joint Space Station environments. These environments use multiple mirrors allowing for collaboration in one physical 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 these environments and the developed software will be disseminated into several affiliated national research groups.

Title	PSS – Personal Space Station
Period	April 2001–April 2005
Leader	J.D. Mulder
Staff	J.D. Mulder, 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. These include the study of techniques that deal with noise reduction, and predication in optical tracking.

Van Rhijn, Van Liere and Mulder conducted a comparison study of filtering and prediction methods for tracking devices in virtual environments.

Van Liere and Van Rhijn conducted a comparison study of optical tracking algorithms in virtual environments.

Mulder conducted a user evaluation of various menu selection methods in a virtual environments.

Van Liere and A. Kok (TUE) investigated the effect of co-location and tactile feedback on 2D widget manipulation tasks in virtual environments.

Van Rhijn started research in using projection invariant methods for device tracking using one or more cameras. The underlying algorithms are less sensitive to occlusion and do not pose restrictions on the placement of cameras.

Title	JSS – Joint Space Station
Period	January 2001–November 2006
Leader	J.D. Mulder
Staff	J.D. Mulder, B.R. Boschker

Progress report. The research of Boschker is focused on the study of 3D interactive techniques in a shared virtual environment. Current research is aimed at the registration of multiple workspaces and the synchronization of virtual worlds on distributed workstations.

Boschker and Mulder worked on the development of the Joint Space Station, a concept for collaborative Virtual and Augmented Reality with a shared physical workspace.

Boschker developed a practical tool for easy registration of multiple coordinate systems in a PSS and JSS environment.

Boschker completed the development of a transparent communication layer, based on PVR software architecture. The implementation uses the SOAP standard for the data transport.

Boschker started the design of a general interaction model for collaborative VR systems. The model is based on the 'collaboration cube', with axes 'human-human', 'human-computer' and 'computer-computer' interaction.

Societal aspects and knowledge transfer

External contacts

- TUE
- TUD
- VU

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- IEEE VR 2003, Los Angeles, California, USA, April 13–17: R. van Liere.
- Joint Eurographics - IEEE TCVG Symposium on Visualization, Grenoble, France, May 26–28: W.C. de Leeuw.
- IPT/EGVE '03 Workshop, Zürich, Switzerland, May 22–23: J.D. Mulder, A.J. van Rhijn.
- Dagstuhl Seminar 03231 Scientific Visualization: Extracting Information and Knowledge from Scientific Data Sets, Dagstuhl, Germany, June 1–6: W.C. de Leeuw.
- IEEE Visualization 2003, Seattle, Washington, USA, October 24–28: R. van Liere.

Memberships of committees and other professional activities

R. van Liere

- Member programme committee 'Van Molecuul tot Cel'.
- Member executive committee, Eurographics Association Benelux region.
- IPC Eurographics/IEEE Visualization Symposium.
- IPC Eurographics IPT/EGVE 2003.
- IPC IEEE Visualization 2003.

Academic publications

Publications in refereed journals

1. R. van Liere, W.C. de Leeuw (2003). GraphSplatting: Visualizing Graphs as Continuous Field. IEEE Transactions on Visualization and Computer Graphics 9 (2).
2. E.M.M. Manders, A.E. Visser, A. Koppen, W.C. de Leeuw, R. van Liere, G.J. Brakenhoff, R. van Driel (2003). Four-dimensional imaging of chromatin dynamics the assembly of the interphase nucleus. Chromosome Research 11(5).

Publications in other journals and other scientific output

Conference proceedings

1. W.C. de Leeuw, R. van Liere (2003). MCMR: A Fluid View on Time Dependent Volume Dat. G.-P. Bonneau, S. Hahmann, C. Hansen (eds). Proceedings of EG/IEEE Vissym'03, May, 149–156.
2. W.C. de Leeuw, R. van Liere (2003). Comparing Two Methods for Filtering External Motion in 4D Confocal Microscopy Data. G.-P. Bonneau, S. Hahmann, C. Hansen (eds). Proceedings of EG/IEEE Vissym '03, May, 129–134. R. van Liere IEEE Visualization: Cumulative Index 1900-2002 Proceedings IEEE Visualization 2003, October.
3. R. van Liere, A.J. van Rhijn (2003). Search Space Reduction in Optical Tracking. J. Deisinger, A. Kun (eds). Proceedings of the Immersive Projection Technology and Virtual Environments Workshop 2003 (IPT/EGVE 2003), May, 207–214,
4. R. van Liere, J.D. Mulder (2003). Optical Tracking Using Projective Invariant Marker Pattern Properties. Proceedings of IEEE VR2003, March, 191–198.
5. J.D. Mulder, A.J. Jansen, A. van Rhijn (2003). An Affordable Optical Head Tracking System for Desktop VR/AR Systems. J. Deisinger and A. Kun (eds). Proceedings of the Immersive Projection Technology and Virtual Environments Workshop 2003 (IPT/EGVE 2003), 215–223.

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.
- otracker: a portable optical tracker for one or more cameras. The otracker software includes a module for feature detection, a module for 3D object recognition and a module for object pose determination.

Professional products

Publications for a broad audience

1. J.D. Mulder (2003). 'Personal Space Station handles Virtual 3D Objects'. ERCIM News 5, January, 48–49.

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` (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, INS4.3
R.L.C. Cilibrasi, BSc (Caltech)	1.0	PhD student	2002-09-01 till 2006-09-01	INS4.2; INS4.3: ACAA
Drs. M.G. de Graaf	1.0	PhD student	2001-08-01 till 2003-07-01	INS4.1: RESQ
Dr. P.D. Grünwald	1.0	co-leader INS4.2	2001-07-01 till till 2005-07-01	INS4.2: UL, NEUROCOLT II
Drs. H.P. Röhrig	1.0	PhD student	1998-11-01 till 2003-10-31	INS4.1: QC, QIP, RESQ
Drs. S. de Rooij	1.0	PhD student	2003-10-01 till 2007-10-01	INS4.2; INS4.3: NWO

Drs. R.S. Špalek	1.0	PhD student	2002-09-01 till 2006-09-01	INS4.1; QAIP, REQ
Dr. J.T. Tromp	1.0	researcher	indefinite	INS4.2: NEUROCOLT II; INS4.3: BSI
Prof.dr.ir. P.M.B. Vitányi	0.8	co-leader INS4.2, co-leader INS4.3	indefinite	INS4.1: INS4.2: NEUROCOLT II; INS4.3; collaboration with several people
S. Wehner	1.0	trainee	2003-09-01 till 2004-06-01	INS4.1: RESQ
Dr. R.M. de Wolf	1.0	researcher	2002-09-01 till 2006-09-01	INS4.1: RESQ

Seconded

Name	Fte	Function(s)	Period	Subthemes + projects
T.J. Lee, BSc (UvA)	1.0	PhD student	2002-01-01 till 2006-01-01	INS4.1; INS4.3: QAIP

Scientific report

Highlights

- Start of European project RESQ.
- Vitányi is appointed CWI Fellow.
- Vitányi receives the Medal of the Univ. Helsinki.
- Vitányi receives the Kolmogorov Medal (given to invited plenary speakers at the Kolmogorov Centennial Conference in Moscow).
- Completion of PhD thesis Röhrig.
- Award of Vici grant to Buhrman.
- Cor Baayen Award to De Wolf.

Press coverage:

- La complexité mésurée, Pour La Science (French 'Scientific American'), November 28, by Jean-Paul Delahaye.
- Software to unzip identity of unknown composers, New Scientist, April 12, by Hazel Muir.
- Software sorts tunes, Technology Research News, April 23–30, by Kimberly Patch. Also in Unzipping composers and musical style, by Fred 'zAmboni' Locklear, Ars Technica 4/10/2003.
- De afstand tussen Händel en Hendrix, by Rob van den Berg, NRC-Handelsblad, O&W Bijlage, April 26.
- Zip-programme unmasks composer, Intermediair, April 24 (in Dutch).
- Izvestia newspaper (Russia), Neural: revista di cultura dei nuova media .hactivism .emusic .new media art no 20, glu 2003 (Italy) , Europe Research Consortium News by ERCIM News No. 54, July 2003, Cerebral Dynamics Bulletin (Mexico), ABC Radio (Australia) in Newcastle, Germany by Deutschland Funk, April 28, 2003, Kurier Zeitung, May 6.
- Article about De Wolf and quantum research in NRC Handelsblad.
- Article in de Volkskrant about Buhrman and his Quantum research.

PhD students

R.L.C. Cilibrasi
M.G. de Graaf
T.J. Lee
H.P. Röhrig
S. de Rooij
R.S. Špalek

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	RESQ – Resources for Quantum Computing
Period	2003–2005
Leader	H.M. Buhrman

Staff	M.G. de Graaf, R.S. Špalek, R.M. de Wolf
Funding	EU (Project IST-001-37559)

Progress report. See RESQ progress report and progress report QIP (this document). `http://www.ulb.ac.be/project/RESQ/`

Title	QC – Quantum Computing
Period	1998–2005
Leader	P.M.B. Vitányi
Staff	H.P. Röhrig, post-doc vacancy
Funding	NWO (Grant 612.015.001)

Progress report. Throughout the project Röhrig has primarily been advised by Buhrman. For progress report see QIP project. Röhrig defended his thesis successfully on January 27, 2004.

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

Title	NoE QUIPROCONE IST-1999-29064 and ESF QiT Programme
Period	1999–2005
Leader	H.M. Buhrman
Staff	R.S. Špalek, R.M. de Wolf
Funding	EU and ESF
Partners	QAIP partners

Progress report. Špalek together with P. Høyer (Calgary) showed that bounded depth circuits with a fan-out gate are very powerful. In particular it was shown that the Fourier transform can be implemented as well as the quantum part of Shor's factoring algorithms. This paper has been presented at Symposium for Theoretical Aspects of Computer Science (STACS'03).

A. Ambainis (Latvia and Berkeley), Buhrman, Y. Dodis (NYU), Röhrig considered multiparty quantum protocols for the distributed-computing task of coin flipping. A paper has been accepted for the IEEE conference on Computational Complexity 2004.

Buhrman, P. Høyer (Calgary), S. Massar (Brussels), and Röhrig investigated how to improve experiments that test the nonlocality predictions of quantum mechanics. Using combinatorial techniques developed for quantum communication complexity, they found a family of experiments which is resistant to very inefficient detectors. An extended version showing how the same correlations are robust to both inefficient detectors and a certain level of general noise is in preparation.

Buhrman, L. Fortnow (Chicago), I. Newman (Haifa), and Röhrig extended the notion of property testing to the quantum domain. The field of property testing has attracted much attention in recent years in connection with the PCP theorem and in real-world applications on very large databases.

Buhrman and Röhrig contributed a survey on distributed quantum computing as an invited talk at MFCS 2003.

I. Kerenidis (Univ. Berkeley) and De Wolf addressed the related questions of short 'locally decodable error-correcting' codes (LDC) and communication-efficient 'private information retrieval schemes (PIR). By showing a reduction from 2-query LDC to 1-query quantum-LDC, and 2-server PIR to 1-server quantum-PIR, they could use quantum information theory results to establish exponential lower bounds on 2-query LDCs and linear lower bounds on 2-server PIRs with short answers. In a second paper on quantum PIR, they constructed information-theoretically secure PIR schemes that protect data privacy as well as user privacy, without assuming shared randomness between the database servers. This is impossible in the classical world.

'Robust quantum computation' aims to make quantum algorithms resilient against coherent noise in the input bits. P. Høyer, M. Mosca, and De Wolf showed that the general amplitude amplification technique can be made robust at a constant factor overhead. This paper has been accepted for ICALP 2003. Using this robust search algorithm as a subroutine, Buhrman, I. Newman, Röhrig, and De Wolf showed how a noisy n-bit input can be recovered in $O(n)$ steps. This implies for instance that PARITY can be robustly quantum computed in $O(n)$ steps; this takes $n^* \log(n)$ steps classically–a rare example where quantum computers are more robust against noise than classical computers.

D. Gavinsky (Calgary) and De Wolf studied quantum communication complexity in the

simultaneous message passing model, where Alice (who holds input x) and Bob (who holds y) each send a message to a referee, who should output $f(x, y)$. They improved a quantum fingerprinting construction from Yao (STOC03) but also showed strong limitations on the power of quantum fingerprinting, using a novel connection to geometrical notions that are well studied in machine learning.

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 in 'algorithmic' sufficient statistic, individual statistic that summarize all relevant information in the individual data. We also apply our methods to resolve, and elucidate, problems in in cognitive psychology.

Title	NEUROCOLT II – Neural networks and computational learning theory
Period	April 1999– April 2003
Leaders	P.D. Grünwald, P.M.B. Vitányi
Staff	R.L.C. Cilibrasi, J.T. Tromp
Funding	EU (Working Group Nr. 8556)
Partners	Royal Holloway College Univ. London, and 10 more sites

Progress report. Grünwald continued his collaboration with J.Y. Halpern from Cornell Univ., Ithaca, NY, USA. It was studied how probability distributions should be updated given new information. We show that in many situations, ignoring the information leads to the minimax optimal decision, even though this may seem counterintuitive. The result is connected to phenomena of 'dilation' as studied in the 'imprecise probabilities' community. We also compare it to Bayesian learning.

Grünwald worked with R. Gill (UU) and W. van Dam (MIT) on the statistical strength of nonlocality proofs. Preliminary results are reported in a preprint in the quantphys-archive.

Grünwald and Vitányi wrote a gentle introduction to (Shannon) information theory and Kolmogorov complexity, focusing on the precise relationship between the two theories. This introduction appeared in the Journal of Logic, Language and Information. A follow-up with a detailed comparison of Shannon's rate-distortion and Kolmogorov's minimum sufficient statistic is now in preparation. This follow-up will also contain some new results.

Grünwald worked on an extensive introduction to the MDL Principle. This will appear as the first chapter of a book that Grünwald is editing jointly with I.J. Myung and M.A. Pitt. This book, called Advances in Minimum Description Length: Theory and applications is scheduled to appear towards the end of 2004.

Grünwald continued work on his book about MDL (Minimum Description Length) induction. The book is planned to appear with MIT Press.

Grünwald also continued his work with Professor Henry Tirri's CoSCo-group at the Helsinki Institute of Technology. We give sufficient conditions for the concavity of the conditional likelihood surface of Bayesian network probability models in classification tasks to be concave. The results were published at the 2003 International Joint Conference on Artificial Intelligence.

De Rooij continued work on a datastructure for suffix trees. This enabled him to count frequencies of items. This research can be applied to new statistical compression methods. His research will be presented (as a poster) in IEEEE Data Compression Conference in Snowbird, Utah, in 2004.

Vitányi and H. Diederik (RIVM), P.P.H. Le Brun (Central Hospital Pharmacy The Hague), H.W. Frijlink (Department of Pharmaceutical Technology and Biopharmacy, RUG), D.M. Barends (RIVM), investigated time-dependent nonlinearity of nebulizer drug output. This work was published in the International Journal of Pharmaceutics.

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	RHBNC-Univ. London, and 50 more sites

Progress report. As in NEUROCOLT II.

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 Univ. London, Royal Holloway College Univ. London

Progress report. The research of De Rooij is focused on the design and analysis of algorithms for compression and machine learning.

INS4.3 – 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 studied algorithms for tasks that are too difficult to solve in the worst-case but often can be solved in the average-case. In this interdisciplinary work we cooperated with L. Afanasiev (Graduate School of Logic, UvA), T. Boekhout, E. Kuramae, V. Robert (Fungal Biodiversity Center, Royal Netherlands Academy of Sciences), M. Klein Wolt, Th. Maccarone (Astronomical Institute 'Anton Pannekoek', UvA), E. Verbitskiy (Philips Research).

Cilibrasi, Vitányi and De Wolf present a fully automatic method for music classification, based only on compression of strings that represent the music pieces. The method uses no background knowledge about music whatsoever: it is completely general and can, without change, be used in different areas like linguistic classification and genomics. The resulting unpublished report on the CoR lanl.arXiv.org Los Alamos web archives created a lot of media attention.

Cilibrasi created the CompLearn Toolkit: a suite of simple-to-use utilities that can be used to apply compression techniques to the process of discovering and learning patterns. It is available on the web at `http://complearn.sourceforge.net/`

Title	Distributed algorithmics
Period	2000–2004
Leader	H.M. Buhrman, P.M.B. Vitányi
Staff	H.M. Buhrman, J.T. Tromp, P.M.B. Vitányi
Funding	CWI (basic funding)
Partner	Lucent (Bell Labs)

Progress report. A. Ambainis (IAS), Buhrman, Y. Dodis (NYU), Röhrig, started research in distributed quantum computing. They established protocols that are better than classical protocols, see the QIP progress report.

Tromp, Vitányi presented the first explicit, and currently simplest, randomized algorithm for two-process wait-free test-and-set. It is implemented with two 4-valued single writer single reader atomic variables. A test-and-set takes at most 11 expected elementary steps, while a reset takes exactly 1 elementary step. Based on a finite-state analysis, the proofs of correctness and expected length are compressed into one table.

Vitányi together with Haldar Lucent (Bell Labs) resolved an intricate question in interprocess communication: Shared registers are basic objects used as communication mediums in asynchronous concurrent computation. We propose a very efficient wait-free construction of bounded concurrent timestamp systems from 1-writer multireader registers.

Vitányi resolved another intricate question in interprocess communication: Multireader shared registers are basic objects used as communication medium in asynchronous concurrent computation. A surprisingly simple and natural scheme to obtain several wait-free constructions of bounded 1-writer multireader registers from atomic 1-writer 1-reader registers, that is easier to prove correct than any previous construction.

Title	Kolmogorov complexity and its applications
Period	1999–2003
Leader	P.M.B. Vitányi
Staff	H.M. Buhrman, T.J. Lee, J.T. Tromp, P.M.B. Vitányi
Funding	CWI (basic funding)
Partners	M. Li (Univ. Waterloo, Canada), T. Jiang (UC Riverside, USA)

Progress report. Buhrman, with L. Fortnow (NEC), and A. Pavan (Iowastate) studied average case complexity. They studied the question whether all NP complete sets are easy on average. They show that if this is the case then every randomized polynomial time algorithm can be derandomized (BPP=P). The paper 'Some results on derandomization' is accepted at STACS'03.

Buhrman, together with L. Fortnow (NEC) and R. Chang (Univ. Maryland) studied NP computation in a non-uniform setting. They showed that co-NP is NP computable with 1 bit of advice per length is equivalent to PH collapsing to $D\hat{P}$. The paper 'One bit of advice' was accepted for STACS'03.

Buhrman and Vitányi together with H. Klauck (IAS, Princeton, USA) and N.K. Vereshchagin (Moscow State Univ.) initiated and investigated the theory of communication complexity of individual inputs held by the agents, rather than worst-case or average-case as classically being considered in communication complexity theory. We consider individual communication complexity of total, partial, and partially correct protocols, one-way versus two-way, with (not in this version) and without help bits.

Vitányi investigated the notion of unpredictability in chaos theory through the idea of individual randomness supplied by Kolmogorov complexity.

Vitányi together with N.K. Vereshchagin continued work at showing that Kolmogorov's last scientific proposal, which can be interpreted as a proposal to formulate a new non-probabilistic statistics capable of expressing relations between individual data and models, is in fact a method to choose the best fitting model for the data in a rigorous mathematical sense. This work was reported at IEEE Intn'l Symp. Information Theory in Yokohama (Japan).

Vitányi continued his work on Kolmogorov's structure function. It turns out that this structure function is closely related to Claude Shannon's Rate-Distortion Theory. This work will be included in a joint paper with Grünwald. Together with N.K Vereshchagin (Moscow Univ.) the structure function is studied for various other distortion measures, including 'Euclidean distortion' and 'Hamming distortion', and a general individual data distortion theory is being developed.

Vitányi together with Ming Li, Xin Chen, Xin Li, Bin Ma proposed a new class of metrics appropriate for measuring effective similarity relations between sequences, say one type of similarity per metric. This resulted in a paper being presented at the SIAM-ACM Symposium on Discrete Algorithms in Baltimore, USA. The work was also reported at the IEEE Intn'l Symp. Information Theory in Yokohama (Japan).

Tromp, Vitányi together with M. Li (Univ. Waterloo) continued work on a new representation-independent formulation of Occam's Razor theorem in Computational Machine Learning (saying basically, if you can significantly compress the data into a much shorter theory, then this has good generalization and prediction properties), based on Kolmogorov complexity. This new formulation allows us to: (i) Obtain better sample complexity than both length-based and VC-based versions of Occam's Razor theorem, in many applications; and (ii) Achieve a sharper reverse of Occam's Razor theorem than before. Specifically, we weaken the assumptions made before by Board et al and extend the reverse to superpolynomial running times. The paper was published in Information Processing Letters.

Vitányi together with N. Chater (Warwick Univ.) continued working in cognitive psychology based on algorithmic information theory. One item is the so-called Universal Law of Generalization formulated by Shepard as a robust psychological law that relates the distance between a pair of items in psychological space and the probability that they will be confused with each other, of comparable scope and generality as Newton's general law of gravitation in physics. We generalized Shepard's approach and provided this initially ad-hoc law with a mathematical derivation from first principles. The results appeared in the J. Math. Psychology. Other work in cognitive sciences exploiting the Simplicity Principle interpreted as Kolmogorov

complexity appeared in Trends in Cognitive Sciences.

Title	Computational complexity
Period	2000–2004
Leader	H.M. Buhrman
Staff	H.M. Buhrman, P.M.B. Vitányi, R.M. de Wolf
Funding	CWI (basic funding)
Partner	NEC Research (Rutgers Univ., UC Berkeley)

Progress report. Lee, Buhrman, and D. van Melkebeek worked on the the language compression problem – to find a generic procedure to encode all the strings of a set with a description of close to optimal length, and such that the strings can be decoded efficiently. It is known that no such procedure exists if we desire the strings to be decoded in deterministic polynomial time. The main open question is if such a procedure exists when we desire the strings to be decoded in nondeterministic polynomial time. In 2003 we resolved this problem, showing that such a procedure indeed exists. Our findings appear in the paper 'Language compression and pseudorandom generators', which was accepted to the Conference on Computational Complexity 2004.

Buhrman and L. Torenvliet revived an earlier program to seperate complexity classes using structural properties. The main idea of the program is to separate well-known complexity classes by showing that the complete sets have different structural properties. It is shown that a robustness property, earlier studied by us and other people, can be used to separate complexity classes. In partical settling the robustness of complete sets for EXSPACE will seperate well-known complexity classes. The paper 'Separating complexity classes using structural properties' was accepted for CCC 2004.

Title	Computational genomics
Period	1999–2003
Leader	P.M.B. Vitányi
Staff	R.L.C. Cilibrasi, J.T. Tromp, P.M.B. Vitányi
Funding	CWI (basic funding)
Partners	M. Li (Univ. Waterloo, Canada), T. Jiang (UC Riverside, USA)

Progress report. The last decade has witnessed an explosion in the amount and complexity of genomic data. Much of this data is publicly available for academic and commercial use by biological, medical and pharmaceutical researchers. In order for novel biological discovery to occur, computational tools must be developed to store, manipulate, visualize and analyze the genomic data. The Bioinformatics Research Group designs, develops and assesses computational tools for the exploration of genomic data. Topics include:

- Genome analysis including statistical methods for gene prediction and the detection of horizontally transferred genes.
- Genome compression.
- Sequence alignment, sequence consensus, and motif discovery.
- Algorithms for inferring evolutionary trees.
- Tools for modelling sequence evolution and for conducting simulation studies.

Our research plan includes both the theoretical analysis of algorithms and development of and experimentation with practical computational tools. We have have successfully cooperated (Tromp) in designing a software package (PatternHunter) that gives faster and more sensitive homology search, and improves on popular packages like MegaBlast and BL2SEQ (`http://www.bioinformaticssolutions.com/products/ph.php`), and in designing (Vitányi) a general theory of 'Similarity Metric' leading to a computational method to obtain a first completely automatic computed whole mitochondrial phylogeny tree, and, in a completely different area, automatic derivation of the language tree of 52 Euro-Asian languages based solely on text corpora and no other knowledge.

Societal aspects and knowledge transfer

External contacts

- PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning). Network of Excellence, Sixth Framework Programme, start date of contract December 15. Member of the steering committee; workshop coordinator; conference coordinator; coordinator of the programme 'linking computational learning with statistics' (with G. Lugosi): P.D. Grünwald.

- Work-area manager of EU-Working Group NeuroCOLT II: P.M.B. Vitányi.

Projects with partners in public and private sector

- RESQ; see page 166.
- QC; see page 167.
- QIP; see page 167.
- NoE QUIPROCONE IST–1999–29064 and ESF QiT Programmme; see page 167.
- NEUROCOLT II; see page 168.
- Universal Learning; see page 169.
- PASCAL; see page 168.
- ACAA; see page 169.
- Distributed Algorithmics.
- Kolmogorov complexity and its applications.
- Computational complexity.
- Computational complexity genomics.

Teaching at university

- Course Quantum Computing, UvA, January–April: H.M. Buhrman, H.P. Röhrig, R.M. de Wolf (trading assistant).
- Course Kolmogorov Complexity, Compression, and Learning, UvA, January–April: P.M.B. Vitányi, T.J. Lee.
- Machine Learning Summer School, Tübingen, Germany, August 1–16: P.D. Grünwald (Invited lecturer – four hour tutorial on MDL (Minimum Description Length)). R.L.C. Cilibrasi, S. de Rooij, participants.
- The Second Winterschool Mathematics and Biology, Wageningen, December 15–17: R.L.C. Cilibrasi.

Courses, tutorials

- EURANDOM, Eindhoven, September 23: P.D. Grünwald, 3-hour tutorial on Minimum Description Length.

Organization of conferences, workshops, courses, meetings

- Kickoff meeting RESQ project, CWI, Amsterdam, January 9–11, The Netherlands. Organizer: H.M. Buhrman, H.P. Röhrig, R.M. de Wolf.
- Statistical Learning in Classification and Model Selection, EURANDOM, Eindhoven, January 15–18. Coorganizer: P.D. Grünwald.
- Theory Day, CWI, Amsterdam, February 21. Organization: H.M. Buhrman.
- Centennial Seminar on Kolmogorov Complexity and Applications, Dagstuhl Seminar 03181, Dagstuhl Castle, Germany, April 27–May 2. Coorganizer: P.M.B. Vitányi.
- DIMACS Workshop on Complexity and Inference, DIMACS Center, Rutgers Univ., Piscataway, NJ, USA, June 2–5. Coorganizer: P.M.B. Vitányi.
- Quantum Computing workshop, Eindhoven, June 29. Organization: H.M. Buhrman, H.P. Röhrig, R.M. de Wolf.

Lectures, conferences, courses, project meetings, working visits

Visits to conferences, workshops, symposia

- Symposium on Discrete Algorithms SODA'03, Baltimore, January: H.P. Röhrig (Invited lecture: Quantum Property Testing).
- RESQ kickoff meeting, CWI, January 9: (Lecture: Introduction to quantum computer science).
- Statistical Learning in Classification and Model Selection, EURANDOM, Eindhoven, January 15–18: P.D. Grünwald (Lecture: Universal Modeling: introduction to modern MDL), P.M.B. Vitányi (Lecture: Kolmogorov's structure functions and model selection).
- CS Colloquium, UU, January 24: P.M.B. Vitányi (Lecture: The similarity metric).
- 8 Graduate School SIKS Lectures, Zeist, February 2: P.M.B. Vitányi (Lecture: The similarity metric).
- ULB Brussels, habilitation thesis defense, February 10–11: S. Massar, H.M. Buhrman.
- Complexity Theory Day, CWI, Amsterdam, February, 20: P.M.B. Vitányi (Lecture: Kolmogorov's structure functions and model selection).
- VU, May: H.P. Röhrig (Lecture: Introduction to Quantum Computing).
- 3rd ESF Conference on Advances in Quantum Information Processing, Erice, Italy, March 17: (Lecture: Quantum private information retrieval).
- Centennial Seminar on Kolmogorov Complexity and Applications, Dagstuhl Seminar 03181, Dagstuhl Castle, Germany, April 27–May 2: H.M. Buhrman (Lecture: Increasing

Complexity), T. Lee (Lecture: Approximate Counting and Compression), P.M.B. Vitányi, R. Cilibrasi (Lecture: Universal Clustering).
- 2nd RESQ meeting, Max Planck Institute, Garching, Germany, May 12: R.M. de Wolf, (Lecture: Quantum computing, locally decodable, codes, and private informaton retrieval), H.P. Röhrig, (Lecture: Quantum Property Testing), H.M. Buhrman (Lecture: Quantum Communication Complexity.
- IEEE Conference on Computational Complexity, Aarhus, Denmark, July 7–10: T.J. Lee (Lecture: Nearly Optimal Language Compressin in NP, Rump Session), H.M. Buhrman (Lecture: Kolmogorov Complexity & Computational Complexity) (Kolmogorov day on July 6th).
- Spatial Stochastics Seminar, CWI: H.M. Buhrman (Lecture: Distributed Quantum Computing).
- Vici practise talk, Informatica Platform Nederland, Utrecht, November 4: H.M. Buhrman (Lecture: Vici presentation, QIP).
- Vici presentation NWO, Den Haag, November 12: H.M. Buhrman (Lecture: Vici presentation, QIP).
- LRI, Paris: H.P. Röhrig (Lecture: Quantum Nonlocality with Imperfections).
- Fall school of logic, Pec p. Snezkou, Czech Republic, August: R.S. Špalek (Lecture: Quantum Computation and Quantum Circuits).
- DIMACS Workshop on Complexity and Inference, DIMACS Center, Rutgers Univ., Piscataway, NJ, USA, June 2–5: P.D. Grünwald (Invited lecture: MDL and classification, revisited), P.M.B. Vitányi (Invited lecture: Similarity metric and algorithmic music clustering). P. Vitányi: Discussant.
- INS4 Seminar CWI, June 5: T.J. Lee (Lecture: Approximate Counting and Compression).
- Quantum Computing, Banff center, Banff, Canada, June 15–21:
- Summer school on Quantum Information Science, Calgary, Canada, June 25: R.M. de Wolf (2 lectures: Quantum lower bounds).
- ICALP workshop on quantum computing, Eindhoven, June 29: R.M. de Wolf (Lecture: Quantum computing, locally decodable codes, and private informaton retrieval), H.M. Buhrman (Lecture: Introduction to Quantum Computing).
- ICALP, Eindhoven, June 30: R.M. de Wolf (Lecture: Quantum search on bounded-error inputs).
- International Conference Kolmogorov and Contemporary Mathematics, Russian Academy of Sciences (RAS) and Moscow State Univ. (MSU), Moscow, Russia, June 16–21: P.M.B. Vitányi (Invited plenary lecture: Kolmogorov's structure functions with an application to the foundations of model selection).
- TLO Meeting, CWI, Amsterdam, June 27: P.M.B. Vitányi (Lecture: Music Clustering).
- IEEE International Symposium on Information Theory, Pacifico Yokohama, Yokohama, Japan, June 29–July 4: P.M.B. Vitányi (Lectures: Clustering by Compression; Kolmogorov's Structure Functions, Nonprobabilistic Statistics, and the Foundations of Model Selection).
- Computer Science Dept, Tokyo Institute of Technology, Tokyo, Japan, July 4–31: P.M.B. Vitányi (Lectures: Clustering by Compression; Kolmogorov's Structure Functions, Nonprobabilistic Statistics, and the Foundations of Model Selection).
- Computer Science Dept, Kyoto Univ., Kyoto, Japan, July 9–11: P.M.B. Vitányi (Lecture: Music Clustering by Compression).
- Mathematics Colloquium, Philips Research Center, Philips Campus, Eindhoven, August 27: P.M.B. Vitányi (Lecture: Clustering by compression).
- Mathematical Foundations of Computer Science (MFCS'04), August 27–30: H.M. Buhrman (Invited lecture: Distributed Quantum Computing).
- CWI seminar, Amsterdam, September 18: R.M. de Wolf (Lecture: Quantum computing and AND-OR trees).
- CWI in Bedrijf, CWI, Amsterdam, October 17: R.L.C. Cilibrasi (Lecture: Normalized Compression Distance and Music Clustering).
- Belgium-Netherlands Artificial Intelligence Conference (BNAIC) 2003, Nijmegen, October 23–24: P.D. Grünwald (Contributed lecture: Updating Probabilities).
- Connecting the different faces of information, workshop at UvA, October 30: P.D. Grünwald (Invited lecture: Shannon Information and Kolmogorov Complexity).
- INS 4-quantum seminar, CWI, Amsterdam, November 6: P.D. Grünwald (Lecture: Updating Probabilities).

- EURANDOM, Eindhoven, November 7: P.D. Grünwald (Lecture: in the statistics seminar: Updating Probabilities).
- Workshop Paradigms of Model Building, Univ. Essen/Univ. Dortmund, Statistics Dept., Dortmund, Germany, November 12–14: P.D. Grünwald (Invited lecture: Universal Modeling: introduction to modern MDL), P.M.B. Vitányi (Invited lecture: Kolmogorov's Structure functions and model selection).
- INS4 Seminar, November 20: T.J. Lee: (Lecture: Unexpected Applications of Pseudorandom Generators).
- Computer Science Colloquium, Philips Research Center, Philips Campus, Eindhoven, November 26: P.M.B. Vitányi (Lecture: Algorithmic Statistics).
- INS4 Colloquium, CWI, December 18: S. de Rooij (Lecture: Online Suffix Trees with Counts).

Working visits

- Univ. Paris Sud, Orsay, France, May 14–15: Hosted by Professors E. Gassiat and S. Boucheron. P.D. Grünwald (Invited lectures: Universal Modeling: introduction to modern MDL).
- IBM T.J. Watson Research Center, Yorktown, New York, June 6: Hosted by Dr. J. Langford: P.D. Grünwald.
- Cornell Univ., Ithaca, New York, USA, June 7–10: Hosted by Professor J. Halpern. P.D. Grünwald (Lecture: Universal Modeling: introduction to modern MDL).
- Carnegie-Mellon Univ., Pittsburgh, Pennsylvania, USA, June 11: Hosted by Prof. J. Lafferty. P.D. Grünwald (Lecture: Universal Modeling: introduction to modern MDL).
- Ohio State Univ., Columbus, Ohio, USA, June 12–20: Hosted by Professors I.J. Myung and M.A. Pitt. P.D. Grünwald (Tutorial lecture: Universal Modeling: introduction to modern MDL).
- ESF Forward Look: Nano Sciences and the long term evolution of Information Technology (NSIT) working meeting, in combination with visit LRI quantum Computing group in Paris, September 23–26: H.M. Buhrman.
- Aachen Univ., J. Hromkovic, November 27–28: H.M. Buhrman (Lecture: Quantum Fingerprinting).

Courses

- EURANDOM Eindhoven, 3-hour tutorial on Minimum Description Length. September 23: R.L.C. Cilibrasi.

Visitors

- N.K. Vereshchagin, Moscow State Univ., January 6–February 6. Host: P.M.B. Vitányi.
- Y. Dodis, NYU, January 14–21. Hosts: P.M.B. Vitányi, H.M. Buhrman.
- M. Koucky, Rutgers Univ., January 15–25. Hosts: P.M.B. Vitányi, H.M. Buhrman.
- S. Homer, Boston Univ., February 20–23. Host: H.M. Buhrman.
- D. Barrington, Univ. Massachusetts, Amherst, February 20–23. Host: H.M. Buhrman.
- J. Hastad, Royal Institute of Stockholm, February 20–23. Host: H.M. Buhrman.
- M. Bonet, Univ. Politècnica de Catalunya, February 20–23. Host: H.M. Buhrman.
- I. Newman, Haifa Univ., February 20–23. Host: H.M. Buhrman.
- O. Goldreich, The Weizmann Institute of Science, February 20–23. Host: H.M. Buhrman.
- L. Fortnow, NEC research, Princeton, March 2–9. Host: H.M. Buhrman.
- P. Høyer, Univ. Calgary, April 17–29. Hosts: P.M.B. Vitányi, H.M. Buhrman.
- A. Ambainis, Institute for Advanced Study (IAS), May 4–11. Hosts: P.M.B. Vitányi, H.M. Buhrman.
- O. Regev, UC Berkeley, June 28–July 4. Host: H.M. Buhrman.
- M. Mosca, Univ. Waterloo, June 28–July 4. Host: H.M. Buhrman.
- R. Jain, Tata Institute of Fundamental Research, Mumbai, June 28–July 4. Host: H.M. Buhrman.
- Y. Dodis, NYU, August 13–15. Host: H.M. Buhrman.
- M. Furer, September 21. Host: P.M.B. Vitányi.
- S. Massar, Free Univ. Brussels. Host: H.M. Buhrman.
- P. Clote, December 17. Host: P.M.B. Vitányi.

Memberships of committees and other professional activities

H.M. Buhrman

- Chair programme committee IEEE Conference on Computational Complexity, Aarhus, Denmark.
- Member programme committee of Thirtieth International Colloquium on Automata, Languages and Programming Eindhoven (ICALP'03), The Netherlands.
- Member steering committee Conference on Computation Complexity (CCC).
- Member steering committee Quantum Information Processing (QIP).
- Member programme committee Quantum Information Processing 2003 (QIP'03).
- Member editorial board Theory of Computing Systems TOCS, Journal Computation 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).
- Member of programme board for Computer Sciences, Lorentz Center.
- Member library committee CWI.
- Member Veni evaluation committee (NWO).
- Member PhD committee S. Massar.
- PhD advisor of H.P. Röhrig, R.S. Špalek, T.J. Lee, M.G. de Graaf.
- Master's advisor of J. Cirasella, T. Tusarova, and S. Wehner.
- Member steering committee RESQ.
- Professor at UvA.
- 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

- Member ESPRIT BRA VI NeuroCOLT II Working Group EP 27150: on Fundamental Understanding of Learning and Algorithmic Implementations.
- Member FoLLI (The European Association for Logic, Language and Information).
- Coorganizer with R.D. Gill (UU/EURANDOM) and A.W. van der Vaart (UvA/EURANDOM) J. Lember (EURANDOM) of EURANDOM workshop on Statistical Learning in Classification and Model Selection, EURANDOM, Eindhoven.
- PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning). Network of Excellence, Sixth Framework Programme, start date of contract December 15.
- Member of the steering committee; workshop coordinator; conference coordinator; coordinator of the programme 'linking computational learning with statistics' (with G. Lugosi).

P.M.B. Vitányi

- Professor of Computer Science, UvA.
- CWI Fellow.
- Guest editor J. Computer and System Sciences, special issue on Computational Learning Theory, 1994–1998.
- Editor International Journal of Foundations of Computer Science, World Scientific, since 2001.
- Editor Distributed Computing, Springer-Verlag, since 1987.
- Editor Theory of Computing Systems (formerly: Mathematical Systems Theory), Springer Verlags, since 1991.
- Editor Information Processing Letters North-Holland/Elsevier, since 1993/94.
- Editor Parallel Processing Letters, World Scientific Publishers, Singapore, since 1991.
- Editor Journal of New Generation Computer Systems, Akademie-Verlag, Berlin, since 1989.
- Editor Frontiers in Computing Systems Research, Plenum Annual Review Book Series, Plenum Press, since 1988.
- Member of the Scientific Board, Encyclopaedia of Mathematics, Reidel (updated and annotated translation of the Soviet Mathematical Encyclopaedia) since 1987.
- Member programme committee, 14th European Conference on Machine Learning (ECML-2003), Dubrovnik, Croatia, September 22–26.
- Member programme committee, 14th Annual International Symposium on Algorithms and Computation (ISAAC'03), Kyoto, December 15–17.

- Member organizing programme committee Workshop on Complexity and Inference for the Computational Information Theory and Coding Year (2003) at DIMACS at Rutgers Univ. (with Bin Yu (UC Berkeley) and Mark Hansen (Lucent)).
- Coorganizer (with L. Levin (Boston Univ.), D. Durand (Marseille Univ.), A. Shen (Moscow State Univ.), W. Merkle (Heidelberg Univ.)) of the Centennial Seminar on Kolmogorov Complexity and Applications, Dagstuhl Seminar 03181, Dagstuhl Castle, Germany.
- Member programme committee 15th European Conference on Machine Learning (ECML), Pisa, Italy, September 20–24, 2004.
- Member programme committee Distributed Computing Conference (DISC) 2004, Amsterdam, Holland, October 4–8, 2004.
- Co-chair Organization Distributed Computing Conference (DISC) 2004, Amsterdam, Holland, October 4–8, 2004.
- Member programme committee 29th International Symposium on Mathematical Foundations of Computer Science (MFCS), Prague, Czech Republic, August 22–27, 2004.
- Member of EU Project RESQ IST-2001-37559 (Quantum Computing), 2002–2005.
- Coordinator Project Universal Learning, NWO (project 612.052.004), 2002–2006.
- Coordinator Project Quantum Computing, NWO (Grant 612.015.001), 1998–2007.
- Coordinator Project Average-Case Analysis of Algorithms, NWO (project 612-55-002), 2000–2006.
- Member of the NoE QUIPROCONE IST–1999–29064.
- Member of the ESF QiT Programme.
- Member PASCAL EU Network of Excellence.
- Member IFIP WG 1.2 on Descriptive Complexity and Applications, since 1991. Co-chair of IFIP WG 1.4 on Computational Machine Learning, since 1992.
- Publiciteitscommissie van het Koninklijke Wiskundig Genootschap (Publicity Committee Royal Dutch Mathematical Society), since 1989.
- Advisor Monash Key Centre for Computational Data Analysis, Monash Univ., Clayton Campus, Melbourne, Australia.
- Advisor and evaluator for/of the Japanese Discovery Science Project. The Discovery Science is a three year project from 1998 through 2000 that targets to (1) develop new methods for knowledge discovery, (2) install network environments for knowledge discovery, and (3) establish the Discovery Science as a new area of Computer Science. A systematic research is planned that ranges over philosophy, logic, reasoning, computational learning and system developments.
- Member of the Dutch Robosoccer committee 'Autonomous Interacting Multiagent Soccer'.
- Member committee of the Society for Theoretical Computer Science in the Netherlands (Nederlandse Vereniging voor Theoretische Informatica (NVTI)).
- Member of the board Dutch Institute for Logic, Language, and Computation (ILLC).
- Member Dutch Institute for Programming and Algorithmics (IPA).
- Member Onderzoeksschool Logica (OzL).
- Project leader various SION projects in Machine Learning, Multiple Computing Agents, Cryptography and Randomness, Quantum Computing.
- PhD supervisor in 2003 of H.P. Röhrig, R.L.C. Cilibrasi, S. de Rooij, UvA.

Academic publications

Papers in refereed journals

1. H.M. Buhrman, R.M. de Wolf (2003). Quantum zero-error algorithms cannot be composed. Inf. Process. Lett. 87(2), 79–84.
2. H.M. Buhrman. P. Høyer, S. Massar, H.P. Röhrig (2003). Combinatorics and Quantum Nonlocality PRL, (91), 4, 047903, also quant-ph/0209052, and 10.1103/PhysRevLett. 91.047903.
3. N. Chater, P.M.B. Vitányi (2003). Simplicity: A unifying principle in cognitive science? Trends in Cognitive Sciences (7), 1, 19–22.
4. N. Chater, P.M.B. Vitányi (2003). The generalized universal law of generalization. Journal of Mathematical Psychology 47 (3), 346–369.
5. H. Diederik, P.P.H. Le Brun, H.W. Frijlink, P.M.B. Vitányi, M. Weda, D.M. Barends (2003). Drug output of unvented jet nebulizers as a function of time. International Journal of Pharmaceutics (257) 1–2, 33–39.

6. P.D. Grünwald, P.M.B. Vitányi (2003). Kolmogorov Complexity and Information Theory with an interpretation in terms of questions and answers. Journal of Logic, Language and Information 12, 497–529, October.
7. P.D. Grünwald, J.Y. Halpern (2003). Updating Probabilities. Journal of Artificial Intelligence Research (JAIR) 19, 243–278, October.
8. U. Keich, M. Li, B. Ma, J. Tromp (2003). Computing optimally spaced seeds. Discrete Applied Mathematics, June.
9. I. Kerenidis, R. de Wolf (2003). Exponential Lower Bound for 2-Query Locally Decodable Codes via a Quantum Argument. Proceedings of 35th ACM STOC, 106–115, also quant-ph/0208062.
10. T.J. Lee (2003). Arithmetical definability over finite structures, Mathematical Logic Quarterly, 49(4).
11. M. Li, B. Ma, D. Kisman, J. Tromp (2003). Patternhunter ii: Highly sensitive and fast homology search. Journal of Bioinformatics and Computational Biology.
12. M. Li, J. Tromp, P.M.B. Vitányi (2003). Sharpening Occam's Razor. Inform. Process. Lett. 85(5), 267–274.
13. R.M. de Wolf (2003). Nondeterministicc Quantum Query and Quantum Communication Complexity. SIAM Journal on Computing 32(3), 681–699.

Papers in other journals and other scientific output

Conference proceedings

1. H.M. Buhrman, R. Chang, L. Fortnow (2003). One bit of advice. Proceedings of the 20th Symposium on Theoretical Aspects of Computer Science. Springer, Berlin.
2. H.M. Buhrman, L. Fortnow, I. Newman, H.P. Röhrig (2003). Quantum Property Testing. Proceedings of Symposium on Discrete Algorithms (SODA03), 480–488, also quant-ph/0201117.
3. H.M. Buhrman, L. Fortnow, A. Pavan (2003). Some results on derandomization. Proceedings of the 20th Symposium on Theoretical Aspects of Computer Science, Springer, Berlin.
4. H.M. Buhrman, H. Röhrig (2003). Distributed Quantum Computing. Proceedings of Mathematical Foundations of Computer Science 2003 (MFCS2003) (2747), 1–20 (Invited Contribution).
5. P.D. Grünwald, J.Y. Halpern (2003). Updating Probabilities. Proceedings BNAIC 2003, 2-page abstract, November.
6. P. Høyer, R.S. Špalek (2003). Quantum circuits with unbounded fan-out. Proceedings of Symposium on Theoretical Aspects of Computer Science (STACS03).
7. P. Høyer, M. Mosca, R.M. de Wolf (2003). Quantum Search on Bounded-Error Inputs. Proceedings of 30th International Colloquium on Automata, Languages and Programming (ICALP'03) 291–299, also quant-ph/0304052.
8. M. Li, Xin Chen, Xin Li, Bin Ma, Paul Vitányi (2003). The similarity metric. Proceedings 14th ACM-SIAM Symp. Discrete Algorithms.
9. M. Li, X. Chen, X. Li, B. Ma, P.M.B. Vitányi (2003). Clustering by compression. Proceedings IEEE Intn'l Symp. Information Theory, 261.
10. A. López-Ortiz, C. Quimper, J. Tromp, P. van Beek (2003). A fast and simple algorithm for bounds consistency of the all different constraint. Proceedings IJCAI-2003, 245–250, August.
11. N. Vereshchagin, P.M.B. Vitányi (2003). Kolmogorov's structure functions, nonprobabilistic statistics, and the foundations of model selection. Proceedings IEEE International Symp. Information Theory, 286.
12. H. Wettig, P.D. Grünwald, T. Roos, P. Myllymäki, H. Tirri (2003). When Discriminative Learning of Bayesian Network Parameters is Easy. Proceedings of the Eighteenth International Joint Conference on Artificial Intelligence (IJCAI 2003), Acapulco, Mexico, August.

Technical reports published elsewhere

1. A. Ambainis, H.M. Buhrman, Y. Dodis, H. Röhrig (2003). Multiparty Quantum Coin Flipping quant-ph/0304112.
2. H.M Buhrman, I. Newman, H. Röhrig, R.M. de Wolf (2003). Robust Quantum Algorithms and Polynomials, quant-ph/0309220.

3. H.M. Buhrman, H. Klauck, N.K. Vereshchagin, P.M.B. Vitányi, Individual communication complexity, http://xxx.lanl.gov/abs/cs.CC/0304012
4. R.L.C. Cilibrasi, P.M.B. Vitányi, R. de Wolf (2003). Algorithmic clustering of music, ERCIM News 54, July, 53.
5. R.L.C. Cilibrasi, P.M.B. Vitányi (2003). Clustering by compression, http://xxx.lanl.gov/abs/cs.CV/0312044
6. W. van Dam, R.D. Gill, P.D. Grünwald (2003). The statistical strength of nonlocality proofs. July. Appeared on the arXiv preprint server in the quantum physics archive as quant-ph/0307125.
7. I. Kerenidis, R.M. de Wolf(2003). Quantum Symmetrically-Private Information Retrieval, quant-ph/0307076.
8. P.M.B. Vitányi (2003). Algorithmic chaos http://xxx.lanl.gov/abs/nlin.CD/0303016

Software developed

- CompLearn Toolkit: Machine Learning Via Compression. Available at http://complearn.sourceforge.net/ CompLearn was written by Rudi 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.

APPENDICES

A Statistics of CWI publications

1. Academic publications	2000	2001	2002	2003
In refereed journals	142	139	103	123
In other journals or proceedings	155	139	180	221
Book chapters	15	14	12	23
Total	312	292	295	367
2. Monographs	12	6	9	12
3. PhD theses	11	12	17	9
4. Technical reports published elsewhere	46	27	14	51
5. CWI reports	117	90	71	114
6. Other scientific output	69	88	101	64

Publications and other scientific output 2000–2003

B CWI reports

CWI reports can be downloaded from
`http://db.cwi.nl/rapporten/index.php`

B.1 Downloads of CWI reports 1998–2003

Year	# of reports downloaded	Total # of hits
2003	1164	832112
2002	1065	486002
2001	967	279008
2000	853	149416
1999	740	64607
1998	623	38623

B.2 PNA reports

E series (electronic only)

1. PNA-E0301. Y. Zhan, H.J.A.M. Heijmans. Non-separable 2D wavelets with two-row filters.
2. PNA-E0302. Thomas Bonald, S.C. Borst, Nidhi Hegde, Alexandre Proutière. Wireless Data Performance in Multi-Cell Scenarios.
3. PNA-E0303. Astrid Albrecht, Michael Behrens, Tony Mansfield, Will McMeechan, Marek Reijman-Greene, Mario Savastano, Philip Statham, Christiane Schmidt, Ben Schouten, Martin Walsh. BioVision: Roadmap for Biometrics in Europe to 2010.
4. PNA-E0304. S.R. Athreya, A.A. Járai. Infinite volume limit for the stationary distribution of Abelian sandpile models.
5. PNA-E0305. Number unused.
6. PNA-E0306. A.B. Dieker. Conditional limit theorems for queues with Gaussian input, a weak convergence approach.

R series

1. PNA-R0301. R. Helmers, B. Tarigan. Compound sums and their applications in finance.
2. PNA-R0302. R.M. Brouwer. A bicategorical approach to Morita equivalence for von Neumann algebras.
3. PNA-R0303. J. van den Berg, R.M. Brouwer. Self-destructive percolation.
4. PNA-R0304. S. Caires, J.A. Ferreira. On the nonparametric prediction of conditionally stationary sequences.
5. PNA-R0305. A.B. Dieker, M.R.H. Mandjes. On spectral simulation of fractional Brownian motion.
6. PNA-R0306. M.N.M. van Lieshout, R.S. Stoica. Perfect simulation for marked point processes.
7. PNA-R0307. H.J.A.M. Heijmans, C. Bernard, M. Domanski, B. Pesquet-Popescu, A. Smolic, P. Schelkens, L. Torres. MASCOT: metadata for advanced scalable video coding tools (Final report).
8. PNA-R0308. M.R.H. Mandjes, M.J.G. van Uitert. Sample-path large deviations for generalized processor sharing queues with Gaussian inputs.
9. PNA-R0309. J.A. Ferreira. A goodness of fit statistic for the geometric distribution.
10. PNA-R0310. P. Gregori, M.N.M. van Lieshout, J. Mateu. Mixture formulae for shot noise weighted point processes.
11. PNA-R0311. A.B. Dieker, M.R.H. Mandjes. On Asymptotically Efficient Simulation Of Large Deviation Probabilities.
12. PNA-R0312. S.C. Borst, R. Núñez-Queija, A.P. Zwart. Bandwidth Sharing with Heterogeneous Service Requirements.

13. PNA-R0313. J. van den Berg, A.A. Járai. On the asymptotic density in a one-dimensional self-organized critical forest-fire model.

B.3 SEN reports

E series (electronic only)

1. SEN-E0301. Number unused.
2. SEN-E0302. Number unused.
3. SEN-E0303. C.A. Kupke, A. Kurz, Y. Venema. Stone coalgebras.
4. SEN-E0304. J.I. van Hemert. Evolving Binary Constraint Satisfaction Problem Instances That are Difficult to Solve.
5. SEN-E0305. J.J.M.M. Rutten. An application of coinductive stream calculus to signal flow graphs.
6. SEN-E0306. M.G.J. van den Brand, P.E. Moreau, J.J. Vinju. A generator of efficient strongly typed abstract syntax trees in Java.
7. SEN-E0307. J. Stuber, M.G.J. van den Brand. Extracting Mathematical Semantics from LaTeX Documents.
8. SEN-E0308. M.G.J. van den Brand, P.E. Moreau, J.J. Vinju. Environments for Term Rewriting Engines for Free!
9. SEN-E0309. M. Mernik, J. Heering, A.M. Sloane. When and how to develop domain-specific languages.
10. SEN-E0310. J. Heering, P. Klint. Rewriting-based languages and systems.
11. SEN-E0311. J. Heering. Quantification of structural information: On a question raised by Brooks.
12. SEN-E0312. S.C.C. Blom, N. Ioustinova, N. Sidorova. Timed verification with μCRL.
13. SEN-E0313. Dragan Bosnacki, N. Ioustinova, N. Sidorova. Using Fairness To Make Abstractions Work.
14. SEN-E0314. P. Zoeteweij, F. Arbab. A Component-Based Parallel Constraint Solver.
15. SEN-E0315. P.J. 't Hoen, S.M. Bohte. COllective INtelligence with Task Assignment.
16. SEN-E0316. Susanne Albers, R. van Stee. A Study of Integrated Document and Connection Caching in the WWW.
17. SEN-E0317. Alex Kesselman, Yishay Mansour, R. van Stee. Improved Competitive Guarantees for QoS Buffering.
18. SEN-E0318. E.H. Gerding, J.A. La Poutré. Bargaining with Posterior Opportunities: An Evolutionary Social Simulation.
19. SEN-E0319. A.S. Klusener, R. Lämmel. Deriving tolerant grammars from a baseline grammar.
20. SEN-E0320. Jan Kort, R. Lämmel. A Framework for Datatype Transformation.
21. SEN-E0321. R. Lämmel. Adding Superimposition to a Language Semantics.
22. SEN-E0322. R. Hirschfeld, R. Lämmel, Matthias Wagner. Design Patterns and Aspects – Modular Designs with Seamless Run-Time Integration.
23. SEN-E0323. R. Lämmel, Simon Peyton Jones. Scrap your boilerplate: a practical design pattern for generic programming.
24. SEN-E0324. R. Lämmel, J.M.W. Visser. Strategic polymorphism requires just two combinators!
25. SEN-E0325. R. Lämmel, J.M.W. Visser. A Strafunski Application Letter.
26. SEN-E0326. R. Lämmel, E. Visser, J.M.W. Visser. Strategic Programming Meets Adaptive Programming.
27. SEN-E0327. Jan Kort, R. Lämmel. Parse-Tree Annotations Meet Re-Engineering Concerns.
28. SEN-E0328. R. Lämmel, Christian Stenzel. Semantics-Directed Implementation of Method-Call Interception.
29. SEN-E0329. D.J.A. Somefun, J.A. La Poutré. Bundling and Pricing for Information Brokerage: Customer Satisfaction as a Means to Profit Optimization.

R series

1. SEN-R0301. L. Epstein, R. van Stee. Optimal online bounded space multidimensional packing.
2. SEN-R0302. P.J. 't Hoen, S.M. Bohte. COllective INtelligence with sequences of actions.
3. SEN-R0303. I.A. van Langevelde. Symmetry in labeled transition systems.
4. SEN-R0304. F. Arbab, C. Baier, J.J.M.M. Rutten, M. Sirjani. Modeling component connectors in Reo by constraint automata.

5. SEN-R0305. F. Arbab. Abstract Behavior types: a foundation model for components and their composition.
6. SEN-R0306. C.T.H. Everaars, F. Arbab, B. Koren. Parallel, Distributed-Memory Implementation of a Sparse-Grid Method for Time-Dependent Advection-Diffusion Problems.
7. SEN-R0307. M.G.J. van den Brand, H.A. de Jong, P. Klint, A.T. Kooiker. A Language Development Environment for Eclipse.
8. SEN-R0308. W.J. Fokkink, J.F. Groote, J. Pang, B. Badban, J.C. van de Pol. Verifying a Sliding Window Protocol in μCRL.
9. SEN-R0309. N.R. Mehta, M. Sirjani, F. Arbab. Effective Modeling of Software Architectural Assemblies Using Constraint Automata.
10. SEN-R0310. J.F. Groote, M.K. Keinnen. Solving disjunctive/conjunctive boolean equation systems with alternating fixed points.

N series

1. SEN-N0301. F.E.J. Kruseman Aretz. The Dijkstra-Zonneveld ALGOL 60 compiler for the Electrologica X1 (historical note SEN, 2).

B.4 MAS reports

E series (electronic only)

1. MAS-E0301. J.E. Frank. Geometric space-time integration of ferromagnetic materials.
2. MAS-E0302. R. Carter, C.J. Stanford, A. Weber (eds). CAFE Project – Final report volume I: Trials and surveys.
3. MAS-E0303. A. Bosselaers, R. Carter, R. Hirschfeld, R. Michelsen, S. Mjølsnes. CAFE Project – Final Report volume II: Secure Protocols and Architecture.
4. MAS-E0304. J.H. van Schuppen. Rational positive systems for reaction networks.
5. MAS-E0305. W.H. Hundsdorfer, C. Montijn. A Note on Flux Limiting for Diffusion Discretizations.
6. MAS-E0306. W.H. Hundsdorfer, S.J. Ruuth. Monotonicity for Time Discretizations.
7. MAS-E0307. M.A. Wadee, G.W. Hunt, M.A. Peletier. Kink Band Instability and Propagation in Layered Structures.
8. MAS-E0308. J. Komenda. Coinduction in Control of Partially Observed Discrete-Event Systems.
9. MAS-E0309. J. Komenda. Coalgebra and coinduction in decentralized supervisory control.
10. MAS-E0310. J. Komenda, J.H. van Schuppen. Decentralized supervisory control with coalgebra.
11. MAS-E0311. B.J. Meulenbroek, A. Rocco, U.M. Ebert. Streamer branching rationalized by conformal mapping techniques.
12. MAS-E0312. J. Wackers. A nested-grid finite-difference Poisson solver for concentrated source terms.
13. MAS-E0313. M. Arrayás, U.M. Ebert. Stability of negative ionization fronts: regularization by electric screening?
14. MAS-E0314. A. Baumgärtner, U.M. Ebert, L. Schäfer. The coherent scattering function of the reptation model: simulations compared to theory.
15. MAS-E0315. D. Sijacic, U.M. Ebert, I. Rafatov. Period doubling in glow discharges: local versus global differential conductivity.
16. MAS-E0316. G.H.M. van der Heijden, M.A. Peletier, R. Planqué. A consistent treatment of link and writhe for open rods, and their relation to end rotation.
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19. MAS-E0319. J.K. Krottje. A variational meshfree method for solving time-discrete diffusion equations.
20. MAS-E0320. J.L. López, N.M. Temme. Convergent asymptotic expansions of Charlier, Laguerre and Jacobi polynomials.
21. MAS-E0321. J. Wackers, B. Koren. A Simple and Efficient Space-Time Adaptive Grid Technique for Unsteady Compressible Flows.

22. MAS-E0322. B. Koren, M.R. Lewis. Efficient Computation of Steady, 3D Water-Wave Patterns.
23. MAS-E0323. E.H. van Brummelen, B. Koren. A Pressure-Invariant and Conservative Method for Two-Fluid Flows.
24. MAS-E0324. M.R. Lewis, B. Koren, H.C. Raven. Computation of 3D Steady Navier-Stokes flow with Free-Surface Gravity Waves.
25. MAS-E0325. B. Koren, E.H. van Brummelen, P.W. Hemker, B. van Leer, M.R. Lewis. Fix for Solution Errors Near Interfaces in Two-Fluid Flow Computations.
26. MAS-E0326. G.I. Shishkin, L.P. Shishkina, P.W. Hemker. An A Posteriori Adaptive Mesh Technique for Singularly Perturbed Convection-Diffusion Problems With a Moving Interior Layer.
27. MAS-E0327. K.J. Batenburg. Analysis and optimization of an algorithm for discrete tomography.

R series

1. MAS-R0301. P.W. Hemker, W. Hoffmann, M.H. van Raalte. Discontinuous Galerkin discretisation with embedded boundary conditions.
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8. MAS-R0308. D.E.A. van Odyck. Error reduction at the contact discontinuity in numerical special relativistic hydrodynamics.
9. MAS-R0309. V.M. Lelevkin, I. Rafatov. Modeling of non-equilibrium spherical microwave discharge.
10. MAS-R0310. I. Rafatov, S.N. Sklyar. Difference schemes for the class of singularly perturbed boundary value problems.
11. MAS-R0311. P.J. Collins. Dynamics of surface diffeomorphisms relative to homoclinic and heteroclinic orbits.
12. MAS-R0312. M. Nool, Michael M.J. Proot. An Unstructured Parallel Least-Squares Spectral Element Solver for Incompressible Flow Problems.
13. MAS-R0313. Tadej Kotnik, J. van de Lune. Further systematic computations on the summatory function of the Möbius function.
14. MAS-R0314. N.N. Pham Thi, J. Huisman, B.P. Sommeijer. Simulation of 3D Phytoplankton Dynamics: Competition in Light-Limited Environments.

N series

1. MAS-N0301. J. Wackers. An adaptive-gridding solution method for the 2D unsteady Euler equations.

B.5 INS reports

E series (electronic only)

1. INS-E0301. J.R. van Ossenbruggen, H.L. Hardman, J.P.T.M. Geurts, L.W. Rutledge. Towards a multimedia formatting vocabulary.
2. INS-E0302. K.I. Falkovych, F.-M. Nack, J.R. van Ossenbruggen, L.W. Rutledge. SampLe: Towards a Framework for System-Supported Multimedia Authoring.
3. INS-E0303. J.R. van Ossenbruggen, H.L. Hardman, L.W. Rutledge. Towards Smart Style: Combining RDF Semantics with XML Document Transformations.
4. INS-E0304. A.S.K. Manniesing. Creating harmonious and legible colour schemes in the automated generation of multimedia presentations.
5. INS-E0305. S. Bocconi. Automatic Presentation Generation for Scholarly Hypermedia.
6. INS-E0306. Suzanne Little, H.L. Hardman. Cuypers Meets Users: Implement-

ing a User Model Architecture for Multimedia Presentation Generation.
7. INS-E0307. K.I. Falkovych, F.-M. Nack, J.R. van Ossenbruggen, L.W. Rutledge. Semantics in Multi-Facet Hypermedia Authoring.
8. INS-E0308. J.R. van Ossenbruggen, F.-M. Nack, H.L. Hardman. That Obscure Object of Desire: Multimedia Metadata on the Web (Part I).
9. INS-E0309. J.R. van Ossenbruggen, F.-M. Nack, H.L. Hardman. That Obscure Object of Desire: Multimedia Metadata on the Web (Part II).

R series

1. INS-R0301. A.R. van Ballegooij, A.P. de Vries, M.L. Kersten. RAM: Array processing over a relational DBMS.
2. INS-R0302. Z.R. Struzik. Taking the pulse of the economy.
3. INS-R0303. F.-M. Nack, A.S.K. Manniesing, H.L. Hardman. Colour picking – the pecking order of form and function.
4. INS-R0304. Z.R. Struzik. Rule discovery: Tough, not meaningless.
5. INS-R0305. J.P.T.M. Geurts, S. Bocconi, J.R. van Ossenbruggen, H.L. Hardman. Towards ontology-driven discourse: from semantic graphs to multimedia presentations.
6. INS-R0306. P.A. Boncz, C. Treijtel. AmbientDB: relational query processing in a P2P network.
7. INS-R0307. M.J. Alberink, L.W. Rutledge, M.J.A. Veenstra. Sequence and Emphasis in Automated Domain-Independent Discourse Generation.

C Publications outside the research clusters

W. Mettrop, A. Ong (2003). Wiskunde-informatie in een handomdraai. Nieuw Archief voor Wiskunde, 5e serie, deel 4(2), 118–121.

D ERCIM Fellows and Indian Institute of Technology Summer Internships

D.1 ERCIM Fellows

Name	Research theme	Period
Dr. G.C.K. Abhayaratne	PNA4	2002-06-01–2003-03-01
Dr. R. Gennari	PNA1	2002-07-16–2003-04-01
Dr. B. Li	SEN1	2003-04-01–2003-12-31
Dr. I.R. Rafatov	MAS3	2001-04-01–2002-10-01
Dr. D. Vasileva	MAS2	2003-09-01–2004-06-01

D.2 Indian Institute of Technology Summer Internships

From May 1 till August 1, the following people from IIT were seconded to CWI as summer intern:

Name	Research theme
K. Arora	INS2
G. Gupta	INS2
P. Hegde	SEN2
A. Kumar	PNA4
N. Paliwal	MAS2
G. Redekar	SEN4
V. Shrivastava	INS1
K. Taneja	SEN1

E PhD theses

Author
Date, University
Title
Thesis advisor(s)

I.A. Guerra Benavente
January 15, TUE
Stabilization and Blow-up for Some Multidimensional Nonlinear PDEs
C.J. van Duijn, J. Hulshof (VU)

J.M.W. Visser
February 14, UvA
Generic Traversal over Typed Source Code Representations
P. Klint

S.M. Bohte
March 5, UL
Spiking Neural Networks
J.N. Kok, J.A. La Poutré (TUE)

M. de Jonge
March 6, UvA
To Reuse or to be Reused: Techniques for Component Composition and Construction
P. Klint

C.M. Cuesta
March 6, VU
Pseudo-parabolic Equations with Driving Convection Term
J. Hulshof

D. Jibetean
June 11, VU
Algebraic Optimization with Applications to System Theory
J.H. van Schuppen

G. Piella Fenoy
October 30, UvA
Adaptive Wavelets and their Application to Image Fusion and Compression
P.W. Hemker

M.A. Windhouwer
November 6, UvA
Feature Grammar Systems – Incremental Maintenance of Indexes to Digital Media Warehouses
M.L. Kersten

M.J.G. van Uitert
November 24, TUE
Generalized Processor Sharing Queues
S.C. Borst, O.J. Boxma

F Acronyms of universities in the Netherlands

Acronym	Name of university	Acronym	Name of university
EUR	Erasmus University Rotterdam	UT	University Twente
KUN	Catholic University Nijmegen	UU	University Utrecht
RUG	University Groningen	UvA	University of Amsterdam
TUD	Delft University of Technology	UvT	University of Tilburg
TUE	Eindhoven University of Technology	VU	Free University Amsterdam
UL	University Leiden	WUR	Wageningen University and Research Centre
UM	University Maastricht		