

CENTRE FOR TELEMATICS AND INFORMATION  
TECHNOLOGY

**CTIT**

PROGRESS REPORT  
2009 - 2010

UNIVERSITY OF TWENTE.





---

4	LEADERSHIP
5	CHALLENGES
6	RESEARCH PROFILE
10	APPLIED SCIENCE OF SERVICES FOR INFORMATION SOCIETY TECHNOLOGIES (ASSIST)
11	TECHNOLOGY-ASSISTED ELDERCARE
12	DEPENDABLE SYSTEMS AND NETWORKS (DSN)
13	MAKING THE RIGHT CONNECTION FOR DEPENDABLE SYSTEMS
14	WIRELESS AND SENSOR SYSTEMS (WISE)
15	SMART CRUISE CONTROL FIGHTS PHANTOM TRAFFIC JAMS
16	NATURAL INTERACTION IN COMPUTER-MEDIATED ENVIRONMENTS (NICE)
17	CARE ROBOTS AND THE GOOD LIFE
18	INTEGRATED SECURITY AND PRIVACY IN A NETWORKED WORLD (ISTRICE)
19	WHO SHOULD KNOW EVERYTHING ABOUT YOUR KNEE INJURY?
20	INDUSTRIAL ENGINEERING AND ICT (IE&ICT)
21	INCORPORATING RISK CONSTRAINTS INTO PRICING MEASURES
22	SPIN-OFFS SERVE AS A COMMUNICATION TOOL FOR UNIVERSITY'
23	ENTREPRENEURSHIP IS A REWARDING EXPERIENCE IN ITSELF
24	RESEARCH GROUPS
31	SCIENTIFIC OUTPUT 2009
38	ORGANIZATION
39	ADDRESSES

# THE YEAR 2010 LOOKS LIKE A BRIGHT YEAR. EUROPE KNOWS HOW IMPORTANT ICT IS FOR ITS FUTURE AND SHOWS THE WAY FOR THE NETHERLANDS

Prof.dr. Peter M.G. Apers  
Scientific Director

## LEADERSHIP

The year 2009 can be characterized as a period in which a major investment in the future of ICT took place. At the same time it sometimes meant swimming upstream against feelings that new ICT developments can be taken for granted and that no further research investments are necessary. The strength of ICT lies in the enormous positive impact ICT has on our economy and quality of life. At the same time this is its weakness: ICT has become a commodity that in the eyes of many does not require a level of research funding comparable to its impact. For ICT researchers this duality is difficult to comprehend, because ICT research solutions for societal and economic challenges are within reach. Together with domain experts ICT researchers can contribute to improve mobility, to lower the cost of healthcare, reduce the usage of energy and at the same time connect individuals contributing to a more coherent society.

Both in the Netherlands and Europe a roadmap has been made for the future of ICT and its application domains. In the Netherlands the COMMIT project for the FES was submitted with the right balance of cutting edge fundamental research and research focused on societal and economical challenges. The COMMIT project will give the Netherlands, with its high quality ICT researchers, a crucial advantage in the development of new products and services in many different domains. ICT not only makes it possible to produce products more efficiently and cheaper, but at the same time, products can become more intelligent and therefore of more interest for the users. ICT also has its disruptive side. Completely new services based on new business models in which former competitors start to work together. CTIT is proud that many of its researchers share this vision and actively contributed to the COMMIT proposal. CTIT together with TU Delft and UvA will play a leading role in COMMIT.

At the European level EIT (European Institute for Innovation and Technology) was founded in Budapest. Its goal is to speed up innovation. In 2009 there was a call for KICs (Knowledge Innovation Communities) in three areas: ICT, Climate and Energy. Together with four other countries (Sweden, Finland, Germany and France) the Netherlands submitted the ICT KIC called EIT ICT Labs. Its goal is to speed up ICT innovation, by turning ideas into products more quickly and by embracing open innovation.



After a thorough review by experts EIT ICT Labs was invited for the hearings in Budapest in December. In a kind of beauty contest, in which the director of NIRICT represented all universities in the consortium during the hearing, EIT ICT Labs was selected as the ICT KIC. EIT has a vision that ICT can really make a difference in addressing the major challenges society is facing and that EIT ICT Labs can give Europe a leading position in ICT. In the Netherlands the signing core partners are: Philips, Novay and 3TU.NIRICT, in close cooperation with CWI and TNO ICT, with commitment from ESI, Holst Centre, VUA, UvA, UU, combined with VCs and the ecosystems of PointOne and COMMIT. Our goal is to lead and facilitate a cultural change in breeding a new generation ICT entrepreneurs who know how to capitalize on research investments.

The year 2010 looks like a bright year. Europe knows how important ICT is for its future and shows the way for the Netherlands.

Peter M.G. Apers  
March 2010

# CTIT IS PERFECTLY POSITIONED TO SUSTAIN ITS LEADING POSITION AS AN INTERNATIONAL INSTITUTE

Prof.dr. Emile H.L. Aarts  
Chairman of the Supervisory Board

## CHALLENGES

Most of us will remember 2009 as the year in which the global financial system almost fully collapsed turning the world into a crisis almost as deep as that of the 1920's a century ago. The crisis dominated headlines as it spread around the world to become daily reality. For most of us it was the first time we were confronted with the devastating effects of a major economical setback. Many of us closely witnessed the serious problems it caused for our companies and organizations and the effect it had on individual people in terms of jobs and income.

However, 2009 also marks a year of introspection and reflection. Many people started pondering about the state of affairs, questioning the way society had developed over the past decades. Is it desirable to grow economies at all cost? Do we need global expansion to reach higher levels of productivity? Should we put our scarce resources at risk to ever increase luxury standards? For many of us the financial crisis served as a wake-up call: we no longer believe economic growth is the only driving force behind innovation. We are looking for prosperity rather than for profit, wanting to develop a sustainable present without compromising the future of our children.

The Centre for Telematics and Information Technology (CTIT) of the University of Twente has taken up the challenge to contribute to the sustainable development of our society by providing innovative ICT solutions to a variety of societal problems. Many of the 38 PhD studies that were completed this year deal with studies that are relevant in the context of green ICT. Three projects, SecurityMatters, Smart Signs and BloomWise received STW Valorization Grants enabling them to turn their knowledge into business solutions. In addition, several new projects were started using national and European funds with the aim to provide ICT solutions to problems that are relevant to society. CTIT has also taken the lead to revisit the ICT field and to explore new venues for future ICT applications. At the 15th anniversary of CTIT, during its annual symposium in June 2009, a number of renowned experts gave their personal opinions on the future directions for ICT research, thereby provoking lively discussions leading to new insights among the research community. To consolidate CTIT's thoughts on the future, the initiative was launched to compile a booklet entitled "Living the ICT Future" in



which over 40 PhD students presented their views on the role of ICT in a future society. This very exciting project demonstrates the strength of CTIT both in terms of innovative power as well as creative spirit. Building on its young and talented workforce CTIT is ready to live up to the challenges of the future.

Celebrating its fifteenth anniversary is a truly remarkable achievement for which we congratulate the management team and all those who have contributed over the years. The unique combination of research areas ranging from fundamental ICT research up to business engineering and behavioural sciences will continue to provide CTIT with the knowledge basis necessary to face the innovation challenges of the future. CTIT is perfectly positioned to sustain its leading position as an international institute in the dissemination and valorization of valuable ICT results. The major challenge for the years ahead will be to demonstrate the main added value of ICT to a broader audience leading to a wide recognition within society.

On behalf of the CTIT Supervisory Board  
Emile Aarts (chairman)

# ICT ENHANCES THE QUALITY OF LIFE, IMPROVES OUR WELL-BEING, CREATING A FABRIC OF NEW SOCIAL RELATIONSHIPS

Iddo Bante  
Business Director



## RESEARCH PROFILE

CTIT is one of the primary ICT-research institutes in Europe with a research staff of almost 450 employees. For more than 15 years, CTIT plays a leading role exploring communication technologies, multimedia design and embedded systems and applying novel ICT solutions in a diversity of domains including manufacturing and logistics, healthcare and well-being, media and services.

CTIT has contributed significantly to the disclosure of new ICT research fields such as security, sensor systems and interaction technologies. Through its many industrial liaisons and its vast network of related research institutes, CTIT plays a major role in a variety of social and technological innovation processes. This leading role is visible both in the high volume of externally funded research and in CTIT's active role in (inter)national policy discussions on ICT research and innovation. Many of the new insights have led to tangible societal and business results. During the previous eight years, newly developed technologies have formed the basis for more than 60 start-up businesses.

### RESEARCH THEMES

ICT does not just enable us to do new things, ICT shapes how we do them. This constitutive character requires a research approach that combines perspectives from technology, business models and user needs. The 28 research groups cover a broad and multidisciplinary field ranging from primarily technology-oriented towards highly application-oriented, from ICT to business engineering and behavioural sciences. This combination provides CTIT with a unique blend of scientific disciplines that stimulates the exploration of multidisciplinary topics. In the last eight years newly developed technologies have led to the creation of more than 60 start-up businesses.

### APPLIED SCIENCE OF SERVICES FOR INFORMATION SOCIETY TECHNOLOGIES (ASSIST)

Research in service architectures and software infrastructures fostering innovative, open and cost-effective solutions for health and other application areas.

### DEPENDABLE SYSTEMS AND NETWORKS (DSN)

Development and application of methods and techniques to make

dependable ICT systems (commercial consumer-market systems, as well as specialized systems) reality.

### WIRELESS & SENSOR SYSTEMS (WISE)

Design and validation of new techniques for large-scale wireless communication and sensor systems and their applications.

### NATURAL INTERACTION IN COMPUTER-MEDIATED ENVIRONMENTS (NICE)

Research and build natural intelligent interactive systems that people enjoy interacting with, by making interactions between users and technologies as easy, efficient and engaging as possible.

### INTEGRATED SECURITY AND PRIVACY IN A NETWORKED WORLD (ISTRICE)

Contributing to a comprehensive framework for the engineering, the deployment and the maintenance of secure distributed systems, in which existing and new techniques are harmonized and integrated.

### INDUSTRIAL ENGINEERING AND ICT (IE&ICT)

Analysis and design of processes in business and society, as well as their optimization, management and decision support.

Research topics, application domains, participating research groups and a selection of projects and spin-off companies per SRO are presented on the following pages. An overview of all CTIT research groups can be found at the end of this progress report.

**APPLICATION DOMAINS**

The impact of ICT on productivity growth across the economy is undisputable and a wide range of opportunities is emerging from new technology breakthroughs and from new demands for ICT-based innovations in an evolving business and societal context. CTIT research forms the basis for both new business opportunities in web-based services and in new application areas of ICT such as energy efficiency, health and wellbeing, safety and security, the creative industry, mobility and transport or location-based services.

The aging population is challenging us to build a more sustainable health and social care system. Assisting persons in need from a distance and not only monitoring them, but also taking appropriate actions when required, is a task that ICT will have to find solutions for. Products and services for the health and well-being sector require a relentless effort to improve the ease of use both for the professionals and the consumers hiding the inherent complexity of the underlying systems.

Regarding sustainability of the environment, ICT will play a determining lead role in our improved control of energy consumption as well as natural resources. ICT is essential when it gets to manage the smart grids of the future, billing the roaming consumer, providing energy that is produced in a decentralized method or environmental monitoring via sensor networks. Although the potential contribution of ICT is high, we are still in the early phase of exploiting this potential.

Safety and Security are multidisciplinary fields that have technological, legal, regulatory and societal aspects. Security systems melt into the environment with the goal to increase safety in public areas.

ICT is the ideal tool for managing the full life-cycle of products and services in an enterprise. Improved ICT-based enterprise resource planning will, for example, include energy efficiency data on the whole process. CTIT combines the required knowledge on new and innovative communication infrastructures such as ad-hoc wireless and sensor networks, intelligent data processing techniques and the development of models and simulations to understand the behaviour of traffic participants.

**COOPERATION AND INNOVATION**

ICT is at the heart of innovation, it is revolutionizing the way we do business and the way we live. ICT creates new services and products and thus new economic activity. It enhances the quality of life, improves our well-being and creates a fabric of new social relationships. Such innovations require collaboration beyond organizational boundaries, intensive interaction between the various players in the whole innovation chain, each with its own expertise. CTIT is perfectly well positioned to sustain its leading position as an international research and innovation institute in the dissemination and valorization of valuable ICT results. Important instruments to realize this goal are:

**3TU.NIRICT**

CTIT is one of the founding fathers of the 3TU Netherlands Institute for Research on ICT (3TU.NIRICT), which bundles the ICT research and innovation activities of the three Universities of Technology in the Netherlands (Delft, Eindhoven and Twente). Joint acting forms the basis for 3TU.NIRICT which brings together over 70 research groups from the disciplines computer science, electrical engineering, mathematics and several ICT application domains. More than 1200 researchers collaborate, which makes NIRICT the most important academic research partner in the Netherlands. NIRICT's research programme consists of a Strategic Research Agenda (closely linked to the national and international

research agenda's), a Long-Term Research Agenda (3TU.Centre for Dependable ICT Systems CeDICT), and an Innovation Agenda.

**EIT.ICT Labs**



*"Turn Europe into the global leader in ICT innovation"* is the mission for the new Knowledge and Innovation Community selected in tough competition by the European Institute of Innovation and Technology (EIT). ICT Labs builds centres on five co-locations - Berlin, Eindhoven, Helsinki, Paris and Stockholm - to create

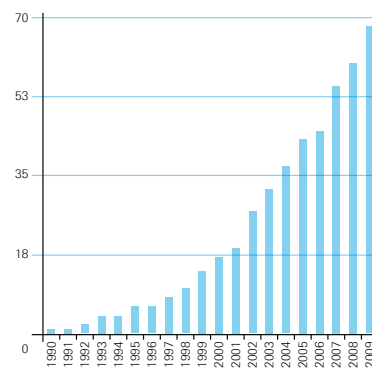
a world-class innovation ecosystem, turning the potential of the "Future Internet" into benefits for the citizens of Europe. Peter Apers (scientific director of CTIT and director of 3TU.NIRICT) is coordinator of the ICT Labs activities in the Netherlands.

Starting in 2010, EIT.ICT Labs will connect world leading companies, globally renowned research institutes and top-ranked universities all dedicated to speeding up innovation to address the grand challenges facing our society. Committed to an efficient open innovation model, ICT Labs will generate faster transformation of ideas and ICT technologies into new products, services and businesses, boosting Europe's future competitiveness in all sectors of society. Dutch core-partners are 3TU.NIRICT, Philips, TNO-ICT, Novay, CWI and the Embedded Systems Institute.

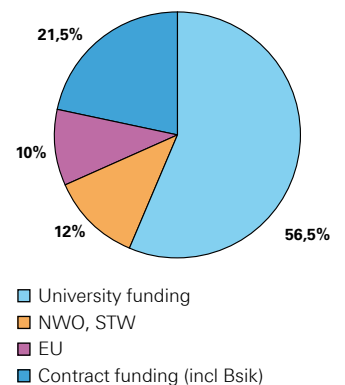
**MANPOWER:**  
450 researchers / 250 fte

**TURNOVER:**  
26.5 M-€

**NUMBER OF SPIN-OFF COMPANIES**



**FUNDING SOURCES**



**PARTICIPATING DEPARTMENTS:**

Electrical Engineering, Mathematics & Computer Science / Management and Governance / Engineering Technology / Behavioural Sciences

**MISSION:**

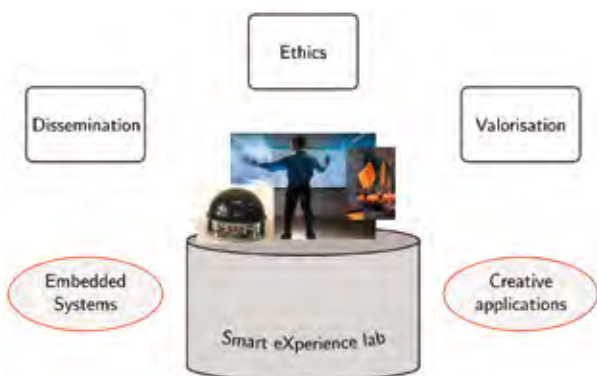
To be an internationally acknowledged scientific research institute in the area of design and application of advanced telematics and information technology systems and their integration into user environments.

**SOME LIAISONS:**

Philips, NXP, Siemens, Ericsson, Shell, British Telecom, Telefonica, IBM, Alcatel-Lucent, Atos Origin, Nokia, SAGEM, France Telecom, CEA, Infineon, GEMPLUS, ING Bank, ABN-AMRO Bank, Thomson, Thales, DaimlerChrysler, Ortec, Microsoft, SAP, Vodafone, Chess-IT, ASML, Silicon Hive, Océ, Nedap, CMG, Essent, Max Planck Institute, Fraunhofer Institute, INRIA, VTT, ETH Zürich, DFKI, Novay, Holst Institute, TNO, Twente Institute for Mobile and Wireless Communications, Embedded Systems Institute, rehabilitation centres, homecare institutes, hospitals, universities, etc.

### Smart eXperience living lab

Many promising research results remain in the laboratory due to difficulty in assessing the value of these technologies in a realistic setting. Therefore, in 2009 CTIT has set up the Smart eXperience living lab (SmartXp). SmartXp connects users with core technology in a way that individuals can experiment with state-of-the-art technology. Their perception will guide the further development and application of new technology. In this sophisticated living lab infrastructure, researchers from a wide range of disciplines work closely together, enabling cross-disciplinary approaches and non-traditional application ideas. The SmartXp lab is part of the 3TU.NIRICT Smart Environments Lab infrastructure.



### Smart Systems Business Accelerator:

CTIT creates about seven high-tech spin-off companies a year. Research activities of the CTIT groups have formed the basis for more than 60 start-up businesses, facilitating a natural flow from knowledge to products and services. The CTIT Smart Systems Business Accelerator (SSBA) is an important instrument to speed up the fast expansion of these young ICT-based ventures. Many of them have received business awards and valorization grants.

In 2009, three CTIT spin-offs (SecurityMatters, Smart Signs and BloomWise) received the STW Valorization Grant phase II (200.000 Euro); in the same year, VC funds have been investing in several older spin-off companies. EIT.ICT Labs will be important to facilitate the further international growth of these new ventures.

### RECENTLY FORMED CTIT-LINKED SPIN-OFF COMPANIES

#### TRADE BASE

Dennis Doubovski, Trade Base facilitates trading between companies via a digital trading platform. Using this platform companies automate their buying and selling processes from searching for a product, ordering it, paying for it and delivering it.

[www.trade-base.nl](http://www.trade-base.nl)

Link to CTIT: Human Media Interaction

#### MOBILE2CONNECT

Roel Schiphorst, Mobile2Connect Technologies has developed a software platform for mobile phones, which combines location based service (LBS) technology with mobile transaction technology. In this platform the mobile phone and its environment are the key starting points.

[www.mobile2connect.eu](http://www.mobile2connect.eu)

Link to CTIT: Signals and Systems

#### ENTROPY

Stanislav Pokraev, Model-driven Semantic Integration of Service-Oriented Applications.

Link to CTIT: Information Systems and SRO ASSIST

#### BIBIX

Sabih Gerez, Bibix is specialized in the design of baseband and RF ICs for cordless telephony (DECT and related technologies).

[www.bibix.nl](http://www.bibix.nl)

Link to CTIT: Computer Architecture for Embedded Systems

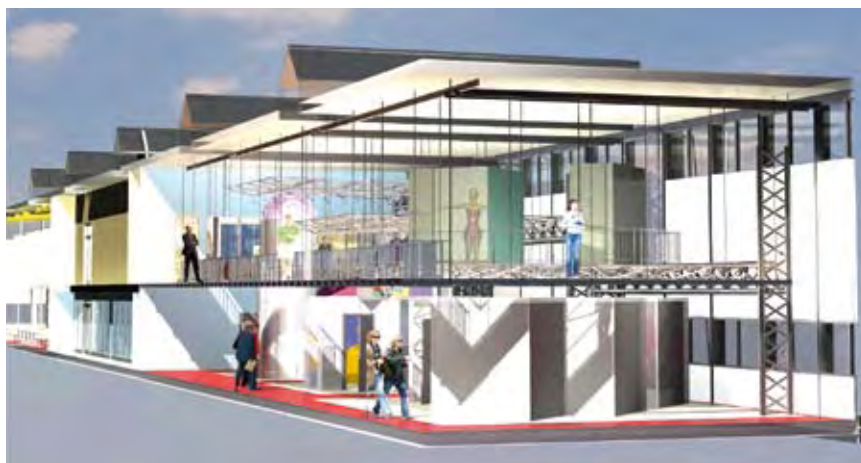
#### DISTIMO

Vincent Hoogsteder, Distimo is an innovative app store analytics company built to solve the challenges created by a widely fragmented app store marketplace filled with equally fragmented information and statistics.

[www.distimo.com](http://www.distimo.com)

Link to CTIT: Databases

Smart eXperience living lab



## SELECTION OF AWARDS 2009

### AWARDS

Raluca Marin-Perianu (Pervasive Systems): Christiaan Huygens Award 2009 for her PhD research.

Nelly Oudshoorn (Science, Technology and Policy Studies): 2009 Diana Forsythe Award of the American Medical Informatics Association (AMIA) for her paper "Diagnosis at a distance. The invisible work of patients and healthcare professionals in cardiac telemonitoring technologies" published in *Sociology of Health and Illness*. 2008 vol. 30, nr 2, 272-295.

Jan Telgen (Operational Methods for Production and Logistics): IFPSM (International Federation of Purchasing and Supply Management) Research Award 2009.

Albert Douma (Operational Methods for Production and Logistics): BETA Research School Best Dissertation Award 2009.

Emile Kelkboom (Signals and Systems and Philips Research): EBF European Biometric Research Award 2009.

Haiyun Xu (Signals and Systems): BF European Biometric Industry Award 2009 for her paper on "Complex Spectral Minutiae Representation For Fingerprint Recognition".

Mark Bentum (Telecommunications Engineering): Veder Price for work on the Dwingeloo Radio telescope.

### GRANTS

Willemijn Heeren (Human Media Interaction): NWO Veni-grant for "Melodieën in fluisterspraak".

Roel Schiphorst (Signals and Systems): STW Valorization Grant – Phase 1, MobiTrans: Mobile Transaction Technology.

Marten van Sinderen and Stanislave Pokraev (Information Systems): STW Valorization Grant - Phase 1, ENTROPY.

Anna Sperotto and Yimeng Yang (Design and Analysis of Communication Systems): Google Anita Borg Memorial scholarship finalists.



### BEST PAPER AWARDS

Mehmet Aksit, Arend Rensink and Tom Staijen (Software Engineering and Formal Methods and Tools): Best Paper Award for "A Graph-Transformation-Based Simulation Approach for Analysing Aspect Interference on Shared Join Points", AOSD 2009.

Roan Boer Rookhuiszen and Mariët Theune (Human Media Interaction) for "Generating instructions in a 3D game environment: efficiency or entertainment?" INTETAIN 2009.

Desi Dimitrova (Design and Analysis of Communication Systems): Best Paper Award for "Performance of relay-enabled uplink in cellular networks - a flow level analysis" by Desislava Dimitrova, Hans van den Berg and Geert Heijenk, at the International Conference on Ultra Modern Telecommunications (ICUMT) 2009, St. Petersburg.

Marcel Groothuis (Control Engineering): Best student paper award for "HW/SW Design Space Exploration on the Production Cell Setup", CPA2009.

Marco Pasch, Nadia Bianchi-Berthouze, Betsy van Dijk and Anton Nijholt (Human Media Interaction) for "Immersion in Movement-Based Interaction", INTETAIN 2009.

Zornitza Racheva (Information Systems) for "Value Creation by Agile Projects: Methodology or Mystery?" by Zornitza Racheva, Maya Daneva and Klaas Sikkell at the 10th International Conference on Product Focused Software Development and Process Improvement (PROFES 2009), Oulu, Finland.

Anna Sperotto (Design and Analysis of Communication Systems): Best Paper Award for "Hidden Markov Model Modelling of SSH Brute-force Attacks" by Anna Sperotto, Ramin Sadre, Pieter-Tjerk de Boer and Aiko Pras, at the "20th IFIP/IEEE International Workshop on Distributed Systems: Operations and Management" (DSOM 2009), Venice.

### BEST DEMO AWARD

Wim Fikkert and Michiel Hakvoort (Human Media Interaction) for "Feelsound", INTETAIN 2009.

Dirk Heylen, Mark ter Maat and Maja Pantic e.a. (Human Media Interaction) for "A Demonstration of Audiovisual Sensitive Artificial Listeners", ACII2009.

Danny Plass-Oude Bos e.a. (Human Media Interaction) for "AlphaWoW", BrainGain 2009.

### BEST POSTER AWARD

Martijn van Eenennaam (Design and Analysis of Communication Systems) at the CeDICT Day on Dependable ICT Systems.

# APPLIED SCIENCE OF SERVICES FOR INFORMATION SOCIETY TECHNOLOGIES (ASSIST)



Applied Science of Services for  
Information Society Technologies (ASSIST)  
Coordinators: Dr. ir. Marten van Sinderen  
Dr. Andreas Wombacher  
I [www.ctit.utwente.nl/research/sro/assist/](http://www.ctit.utwente.nl/research/sro/assist/)  
E [m.j.vansinderen@utwente.nl](mailto:m.j.vansinderen@utwente.nl)  
E [a.wombacher@utwente.nl](mailto:a.wombacher@utwente.nl)  
P +31 (53) 4893677 / 4893772

ASSIST addresses research in *service* architectures and *software* infrastructures fostering innovative, open and cost-effective solutions for *health* and other application areas.

Services have become a strategic capability for industry and society. A service consumer selects services, and possibly creates service compositions, which meet his business needs. Generally, he does not own the services and therefore does not need to be concerned with ownership issues such as provision of a service infrastructure, use of the right technology to implement the services, integration of legacy systems and services maintenance.

This sounds promising and beneficial, however, there are still challenges remaining. Some of them are being addressed in this SRO:

- In order to achieve effective application of service technology to enterprises and business networks, a multidisciplinary approach is necessary which links enterprise engineering with services engineering. This **Service Science** addresses a generic *Service Engineering Process* considering different abstraction levels in an organization – from management to programmer.
- The idea of services is that they are used by many applications in many organizations. The re-use of services and the creation of service compositions is still a challenging task due to many composition constraints of involved parties on data formats, communication and security protocols as well as quality requirements of the service. **Service mediation and evolution** techniques can help a service engineer in dynamically creating service compositions and maintaining these compositions during the life-time of the composite service.

- Services accessible by many organizations form a service ecosystem, i.e., services are a very dynamic market of offerings and requests. Prices and availability of services depend on demand and offers from service provider and requestor, and the competition in service offerings. Modelling the dynamics of these quality parameters as a dynamic system enables to **online optimize the Quality of Service (QoS)** parameters per service within the service ecosystems.

ASSIST has a strong focus on healthcare applications. Recent developments in healthcare have created a demand for reducing cost and at the same time increasing quality of life. A service approach is expected to be able to significantly contribute to the development of solutions for the contemporary problems in the healthcare domain:

- (i) Inter-operability of healthcare systems (i.e., sharing health information and connecting health with non-health applications);
- (ii) easy access to healthcare applications and information (i.e., technology-transparent use of health services);
- (iii) system agility (i.e., situation-driven composition of health services);
- (iv) business process support (i.e., process-centered composition of health services);
- (v) self-/tele-care (i.e., personalized mobile health services exploiting ambient intelligence).

## PARTICIPATING RESEARCH GROUPS

- Biomedical Signals and Systems
- Centre for Studies of Science, Technology and Society
- Databases
- Discrete Mathematics and Mathematical Programming
- Human Media Interaction
- Information Systems
- Information Systems and Change Management
- Operational Methods for Production and Logistics
- Software Engineering
- Stochastic Operations Research

## TECHNOLOGY-ASSISTED ELDERCARE

### JAN-WILLEM VAN 'T KLOOSTER

The ageing of the population calls for smart solutions in healthcare. Remote monitoring can help elderly people continue living in their familiar surroundings for as long as possible. This type of technology needs to be smart, flexible and user-friendly. Researcher Jan-Willem van 't Klooster thinks that it will be possible as soon as 2012.



The development of usable technology starts with good field research with the potential user. For this reason, Jan-Willem van 't Klooster has spent the past year interviewing the residents and personnel of the healthcare centre Hoogstaete in Sittard. From these interviews, he hoped to learn which resources already exist, what needs to be improved and which demands the technology should meet.

The study revealed three important needs: providing support to people with forgetfulness - for example, taking medication on time -, performing remote monitoring of residents' health and achieving improvement in social interaction - *community building* - in order to prevent loneliness. Van 't Klooster elaborates, "There is still not much good technology available in this area. The equipment that does exist is not used very much in the care of the elderly, or it is not efficient. One example is the medicine dispenser that shows when and in what dosage a person should take medications. Although it does exist, it is not yet possible to program it remotely using a digital planner."

Van 't Klooster expects the combination of functions to be beneficial as well. "If you've forgotten your medication and you're sitting in the park, you need to be reminded to take your medication once you come home. If this type of reminder system is used for other purposes as well, it can let you know that it's time for an activity outside the home. It is a matter of configuring the technology for multiple purposes. It should be customized for each user. This would allow everyone to have access to the necessary functions, according to the individual situation."

This last point also holds for telemonitoring. Every healthcare centre, including Hoogstaete, seeks to ensure the health of its residents as much as possible. Measurement

devices can be used to keep an eye on processes as heart rate or blood-oxygen level. Mobile-phone contact can ensure that doctors or other authorized healthcare workers can consult the results of the measurements from any workplace, and take action if necessary. It can go even further: residents can be encouraged to engage in physical activity in order to maintain their condition. "Although this type of device does exist, it is not yet coordinated with other devices in the healthcare centre."

The third function of the technology to be developed involves the stimulation of social contact. One example would be a reminder of the bridge tournament in the recreation room. Another would be a signal, based on sensors in the residence, that the resident did not leave the apartment the entire day.

All of these possibilities depend on the integration of multiple functions and services into a technology that can be easily operated by personnel and elderly residents of healthcare facilities. Van 't Klooster refers to this as a service composition - a customized package. "The technology either does not yet exist, or it is fragmented. We hope to add

cohesion and deliver customization through the flexible combination of functions. This type of package could then be offered on screens at various levels. It could be on the LCD television in the living room, which is connected to the computer. It could also be on a touch screen. The smallest screen would be the display on a mobile telephone."

The PhD-candidate researcher will be spending the coming time developing the medication dispenser and ambulant monitoring: the mobile device that allows remote health monitoring. In 2012, the results will be tested in a pilot project involving approximately ten residents of the healthcare centre Hoogstaete in Sittard. The technology is ultimately intended to benefit all elderly people in the Netherlands, as well as in other countries. Van 't Klooster observes, "In the future of healthcare for the elderly, the ideal will be for people to remain living in their familiar surroundings as long as possible, supported by technology that helps them take their medication on time, keep exercising and avoid wasting away in their homes."

#### U-CARE

The title of the research programme, U-Care, stands for User-tailored Care service platform. In other words, it represents customization in healthcare support. Researchers from the University of Twente are active in four different components:

- The desirable and feasible applications of technology in healthcare
- The development of a business model that can place packages containing the investigated applications successfully on the market
- The integration of new applications into existing systems (for example, patient-tracking systems)
- Tailoring: the customization of systems according to the needs of the user

Within the U-Care research programme, software and technology specialists from the University of Twente are collaborating with Orbis Medical & Healthcare (*Orbis Medisch & Zorgconcern*), IBM Netherlands, the TKH Group, Mobihealth B.V., and IZIT (Healthcare Innovation through IT; in Dutch: *Innovatie van Zorg door ICT*), the association of healthcare organizations in Twente.

# DEPENDABLE SYSTEMS AND NETWORKS (DSN)



Computer systems provide vital services to society. They control our gas and power plants, airplanes, MRI scanners, internet book stores and so on. These systems are extremely complex: operating in unpredictable environments, being bound to scarce resources such as power and memory, and subject to complex deadlines. On the other hand, they must be dependable, i.e. being operational 24 hours a day and recover from failures quickly, otherwise lives or economic assets might be at risk.

Dependable Systems and Networks (DSN)

Coordinators: Dr.ir. Jan Broenink

Dr. Marielle Stoelinga

I <http://www.ctit.utwente.nl/research/sro/dsn/>

E [j.f.broenink@utwente.nl](mailto:j.f.broenink@utwente.nl)

E [m.i.a.stoelinga@utwente.nl](mailto:m.i.a.stoelinga@utwente.nl)

P +31 (53) 4892793 / 4893773

The IFIP 10.4 Working Group defines a computing system to be dependable if reliance can be justifiably placed on the service it delivers. This means that dependability needs rigorous analysis techniques to be able to reason about system reliability: with means to accurately analyze and predict the system dependability at design time, life-threatening or very costly errors during system operation can be prevented. In other words, the system design processes must be founded on rigorous frameworks, in a way that design alternatives can be evaluated against trustworthiness criteria.

This does involve software, hardware and a combination of both. Therefore, research groups from Electrical Engineering, Computer Science and, given the rigor needed in this field, Mathematics are participating in this SRO.

## AIM

The aim of the SRO DSN is to develop and apply methods and techniques to make dependable ICT systems reality. We focus on two application areas. First: permanently available services, like 7x24 online services (e.g. web shops and airline reservation systems) and critical infrastructures (e.g. railways and power and gas grids). Second: software-intensive embedded systems like service robots, automotive and aircrafts. Key goal of the SRO is to bridge the gap between theory and practice by bringing together work on both modelling (what are good models to predict dependability?) and applications (is it possible to build dependable systems?).

## DSN RESEARCH

The research is focusing on three themes

- Large-scale dependability modelling  
This theme investigates rather abstract models of very large systems.

Large systems result in large models. The challenge lies in handling the huge state spaces of these stochastic models.

- Trustworthy communication for mobile applications  
The aim of this theme is designing truly dependable wireless hardware, combining self-test and redundancy in the circuits, at minimal costs.
- Model-driven software design  
This theme combines software models with models of the machines to be governed, using them to generate software to control the machine. Challenge here is the software and hardware models being truly different in nature. Therefore, we need frameworks that overarch these different types of models.

These three research lines are coupled in a joint case study: a set of battery-powered small mobile robots performing a task together. Through this case study, the full spectrum of the design and implementation of hardware for computation and communication, software for computation and communication, as well as modelling and analysis to support design decisions is being explored.

In the (near) future, we expect a spin-off towards daily-life situations: smooth operating public transport information and ticketing systems, really trustworthy smart phones, dependable and autonomous service robots, to name a few. However, before this happens pervasively, a lot of research and design work will need to be done.

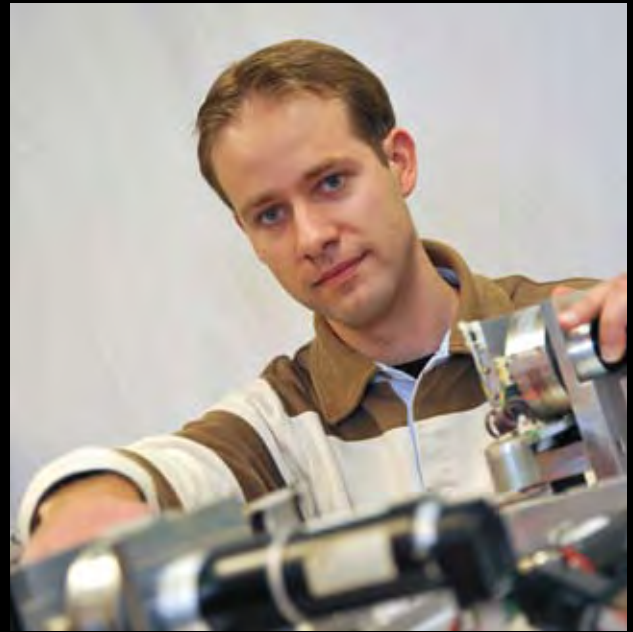
## PARTICIPATING RESEARCH GROUPS

- Computer Architecture for Embedded Systems
- Control Engineering
- Design and Analysis of Communication Systems
- Distributed and Embedded Security
- Formal Methods and Tools
- Integrated Circuit Design
- Software Engineering
- Stochastic Operations Research
- Telecommunication Engineering

## MAKING THE RIGHT CONNECTION FOR DEPENDABLE SYSTEMS

### MARCEL GROOTHUIS

By definition, several disciplines are involved in the design, testing and construction of mechatronic devices and apparatus. In his PhD thesis project, Marcel Groothuis, MSc shows that model-driven design can shorten the time-to-market of new products. Conditions include adequate interconnection between software tools and the intensification of a suitable multidisciplinary approach.



Four disciplines are always involved in mechatronic design and testing processes: electronics, mechanics, software engineering and control engineering. "In most projects, the experts meet one another at the very beginning", Marcel Groothuis observes. "Too often, however, the collaboration stops and the experts go back into their own familiar routines until very late in the project."

#### INTEGRATION TESTS

Groothuis strongly believes that this situation causes many opportunities to be missed, deepens misunderstandings and causes unnecessary time-to-market delays. Especially for complex mechatronics, he advocates early "integration tests", supported by multidisciplinary computer simulation techniques that use a clever combination of existing software tools. "Software developers usually examine the potential success of their products by testing them on simple, standardized test benches",



Groothuis explains. "We are exploring the advantages of using a combination of tools (for example AutoCad or SolidWorks interconnected with specialized dynamics-modelling and simulation tools, like 20-Sim) as a test bench for the software. These tools are used in the process of designing real complex systems, like robot arms." The combination of tools should favour the co-simulation process, in which researchers are challenged to collaborate and show one another manifold simulation tests. Previous research at Océ Venlo showed that the usage of simulation tests and the interconnection of software tools could eliminate an entire step in the design of a new type of printer. This result is the reason that research is continuing within the Dependable Systems and Networks (DSN) research orientation in Twente, together with the renowned Embedded Systems Institute, situated at Eindhoven University of Technology.

#### EDUCATIONAL PROGRAMME

Groothuis continues, "Of course, the interconnection and adaptation of software tools require a considerable investment of time. On the other hand, it is possible to demonstrate the advantages of waiting longer before building prototypes in the process of designing complex products. In our educational programmes, we teach our students to act in this way. The results in the experiments we constructed have already shown very clear results."

#### RECYCLING SOFTWARE MODELS

The use of co-simulation is not limited to the design process of a single product, according to Marcel Groothuis. In many cases, parts of larger units are used – almost identically – in new series or in new variations of the same product. Groothuis elaborates, "Océ hopes to recycle models, experiments and their previous simulation outcomes in the production cycles of types that are yet to come. This would help to create a more manageable process, using only a limited number of prototypes. It also represents a learning curve for the company. At some point, however, it is better to go ahead and build a prototype scanner, for example, and use it to test new paper-handling mechanisms."

#### SAFETY

Collaborating with colleagues from other technical backgrounds pays off, especially when complex safety issues are involved, according to DSN coordinator Dr Jan Broenink. "For example, a robot arm moves very quickly and, under some circumstances, in an abrupt, uncontrolled manner." Even in low-scale experimental set-ups, this can lead to dangerous situations for the people involved, as well as for the costly experimental set-up and its surroundings. The clever combination of software tools with mathematical techniques (derived from a specialized UT group on formal mathematics) can be beneficial in this situation as well. Broenink explains, "Mathematics adds to the development process, sometimes in a decisive manner. The introduction of disturbances into simulations can prevent damage to the actual set-up. In some cases, predicted disturbances are very unlikely to occur, in which case a calculated risk can be taken in building a prototype set-up." According to Broenink, the complexity of control systems in everyday products, like cars, makes design approaches that use co-simulation even more attractive. "Control systems grow not only in numbers, as the systems themselves become interconnected in new ways. They should respond to each other flawlessly, all the time. Otherwise, the manufacturer is in big trouble."

# WIRELESS AND SENSOR SYSTEMS (WISE)

The Strategic Research Orientation Wireless and Sensor Systems (WiSe) covers all aspects of wireless and sensor networks from analogue / digital integrated circuit design via wireless networks and computer architecture to distributed systems. Over the last decades, widespread deployment of wireless communication technologies has had a profound impact on our economy and society.

By further enhancing these technologies and by integrating them with physical systems (e.g. by means of sensors and actuators), a major contribution to problems of our society can be given. For example on reducing and controlling risks, reducing traffic congestion and combating global warming. The research within the SRO WiSe plays an important role in realizing this vision of pervasive wireless communications.

The aim of research in WiSe is to design and validate new techniques for wireless and sensor networks and their applications. The research topics are related to the design and application of large-scale wireless communication and sensor systems. The research is a combination of digital information processing, efficient and flexible wireless communication, protocols for networking, efficient reconfigurable architectures and dependable and distributed applications. Our research is typically validated by means of prototypes and (e.g., stochastic) models.

The WiSe research programme focuses on three interrelated themes and applies its research to a number of different application domains:

- **Architecture:** the focus of this theme is on energy efficiency, which needs to be addressed in a comprehensive way at all system levels.
- **Flexible and efficient wireless communications:** this theme ranges from the radio level to the networking level, addressing for example interference resilient transmission techniques and ad-hoc networking techniques for large scale vehicular and sensor networks.
- **Scalability and adaptivity:** in this theme we plan to design and implement

efficient reconfigurable processing platforms and adaptive protocols and algorithms for large-scale wireless and sensor networks.

Research in wireless and sensor systems is typically multidisciplinary and application-oriented. WiSe provides a forum for multidisciplinary research, maintains good and intensive contacts with industry and acts as a clear and transparent interface between industry and the research activities at the University of Twente.

## APPLICATIONS CURRENTLY ADDRESSED BY WISE:

- **Sustainability / energy reduction:** although much of the worldwide increase in electricity consumption is attributed to ICT, the same ICT technology can also be used to reduce the worldwide energy consumption. Wireless sensor networks can, for example, be used to control consumption, production, transportation and storage of electricity (smart grids).
- **Fitness and medical applications:** intelligent miniaturized sensing systems equipped with wireless communication capabilities can monitor and analyze various aspects related to health and fitness. Such systems can process data locally to extract relevant features, apply distributed inference to assess the physical activity and condition of the users, transmit parameters to body implants, digital spectacles, hearing aids, speech control and eventually provide real-time feedback.
- **Security and safety:** security systems fuse into the environment with the goal to increase the safety in public areas (streets, airports, train stations), automated assessment of situations and alarm generation, personal security,



Wireless and Sensor Systems (WiSe)

Coordinators: Prof.dr.ir. Gerard Smit

Dr.ir. Geert Heijnen

I [www.ctit.utwente.nl/research/sro/wise](http://www.ctit.utwente.nl/research/sro/wise)

E [g.j.m.smit@utwente.nl](mailto:g.j.m.smit@utwente.nl)

E [geert.heijnen@utwente.nl](mailto:geert.heijnen@utwente.nl)

P +31 (53) 4893734

P +31 (53) 4895693

safety-critical services, crisis detection and so forth.

- **Transport and mobility:** companies in distribution, transport and industry are under constant pressure to optimize their process efficiency and to improve service levels for their customers. Bridging the gap between the physical world ("The flow of goods") and the digital world ("The flow of information") provides tremendous value to achieve these objectives. Furthermore, vehicle-to-vehicle and/or vehicle-to-infrastructure communication has the potential to enhance the safety and efficiency of traffic systems, emission reduction from vehicles and to enrich the comfort of travelers. For example the Connect & Drive project (see interview on next page) aims to develop and test a cooperative adaptive cruise control system.

## PARTICIPATING RESEARCH GROUPS

- Computer Architecture for Embedded Systems
- Pervasive Systems
- Signals and Systems
- Design and Analysis of Communication Systems
- Discrete Mathematics and Mathematical Programming
- Integrated Circuit Design
- Short Range Radio
- Stochastic Operations Research

# SMART CRUISE CONTROL FIGHTS PHANTOM TRAFFIC JAMS

## WOUTER KLEIN WOLTERINK & MARTIJN VAN EENENNAAM

In heavy traffic, one unexpected foot on the brake can be enough to cause a serious traffic jam. Such "phantom traffic jams" can be prevented by making automobiles communicate better. Wouter Klein Wolterink and Martijn van Eenennaam are developing the technology for the new Cooperative Adaptive Cruise Control.



An estimated thirty percent of all traffic jams in the Netherlands are not caused by accidents or construction work, but by delayed, forceful braking. One driver suddenly reduces speed, the driver behind reacts by applying the brakes, forcing the third driver to brake even harder to avoid a collision. The first driver can keep going, simply because there is no problem, but a traffic jam forms in the wake. "It is a sort of shockwave against the flow of traffic. It sets off a harmonica effect: the first vehicles can keep moving, while other vehicles are added at the end of the phantom traffic jam," explains CTIT researcher Wouter Klein Wolterink.

Klein Wolterink is not a traffic expert. His Master's degree is in telematics. As a PhD-student, he is involved in research aimed at finding a solution for the problem of phantom traffic jams, in collaboration with fellow telematician Martijn van Eenennaam. The potential solution already has a name: Cooperative Adaptive Cruise Control (CACC). The technology is expected to do something that people are not always capable of doing: anticipating the actions of several vehicles ahead. "Most drivers don't usually look farther ahead than one or two vehicles, particularly in heavier traffic. They don't realize that they should brake until it's too late. A signal indicating that a traffic jam is forming ahead can allow drivers the opportunity to reduce their speed gradually, thereby avoiding being caught in traffic. It's all about anticipation", observes Van Eenennaam.

In this sense, CACC goes beyond the existing Adaptive Cruise Control (ACC) system, with which a limited number of the more expensive vehicles are equipped. As soon as the distance between vehicles becomes too short, the system reduces the acceleration of the second vehicle. "The basic Adaptive Cruise Control is largely a

convenience application, and it doesn't offer a solution for phantom traffic jams", observes Klein Wolterink. "CACC goes further by communicating with more vehicles in the immediate area. It helps traffic flow more efficiently, thereby increasing safety and reducing CO<sub>2</sub> emissions."

The project in which the two CTIT researchers are involved is known as "Connect & Drive". As the name suggests, communication with other vehicles is essential. Van Eenennaam is responsible for ensuring that the units to be installed in vehicles, currently being developed, will be able to communicate as much data as possible. "Each vehicle needs to transmit and receive information about speed, acceleration and position several times per second. This information can be used to regulate the speed of the vehicle. This is no small task. In addition, the ideal system should use the same platform that is used for road pricing and similar systems. Conceivably, it could even be used to communicate information about the technical state of the vehicle directly to the garage." All of this will require considerable airtime, which could become problematic, as messages could start to collide with each other, according to Van Eenennaam. "It's like a crowded living room where everyone is talking at the same time and no one can understand each other. I'm going to orchestrate the flow of information in such a way that all of the messages are transmitted intact and on time within the platform. How? One option would be to make each transmitter wait its turn. Another option would be to limit the number of messages per second."

Klein Wolterink is working with the communications protocol that will bring vehicles in contact with each other. In other words, he is developing a way to steer all of

the information through the network quickly and efficiently. "Take a vehicle trying to merge onto the motorway. To keep traffic moving, the other vehicles on the motorway need to know well ahead of time that they need to allow the space needed to merge. This information can be transmitted by roadside equipment that continuously informs motorway users about the merger's speed and position. The vehicles then decide amongst themselves who is going to yield." In order to solve the problem of phantom traffic jams, it will be necessary for enough vehicles to be equipped with the new generation of cruise control. A built-in CACC is still some time away, but Van Eenennaam is optimistic. "The global scale of the automobile industry and the interests of governments - safety, mobility - are advantageous factors." Klein Wolterink notes that Connective Cruise Control, a forerunner of CACC, can offer an interim solution. "It can be used in any vehicle, just like a TomTom. The system advises the driver when to take such actions as letting up on the accelerator. Even this type of system can improve traffic flow considerably."

### CONNECT & DRIVE

In their research on the new generation of cruise control, Wouter Klein Wolterink and Martijn van Eenennaam are collaborating on the project "Connect & Drive: Vehicle-to-vehicle Communications". They are working within the Design and Analysis of Communication Systems (DACS) research group at the University of Twente.

In addition to the UT, the following parties are involved in the research: TNO, TU Eindhoven, TU Delft, Centric Tsolve, Fourtress and Twente Institute for Wireless Mobile Communications (WMC). TNO is contacting frequent practical tests of the technology, as in February 2010 on the A270 between Helmond and Eindhoven. The completion date for the study on Cooperative Adaptive Cruise Control is in 2011.

# NATURAL INTERACTION IN COMPUTER-MEDIATED ENVIRONMENTS (NICE)



Natural Interaction in Computer-Mediated Environments (NICE)

Coordinator: Dr. Dirk Heylen

I <http://www.ctit.utwente.nl/research/sro/nice>

E [d.k.j.heylen@utwente.nl](mailto:d.k.j.heylen@utwente.nl)

P +31 (53) 4893745

Nintendo's Wii controller, enabling whole-body interaction, made a commercial success of ideas and dreams that until now were only embodied in mock-ups and prototypes in research labs investigating multimodal interaction or realized in one-off futuristic electronic art works. Nintendo implemented and marketed a killer-app. Within the SRO NICE multimodal human-computer interaction is a key research area. What remains to be done?

Trends and challenges for innovative interaction research are manifold. First of all: the search for enabling the extraction of useful information from users in all ways imaginable. The Wii lets people make natural movements to control a virtual paddle or golf club by controlling a real one. The sensors in the controller capture and extract information regarding movements. What would happen if we just have users imagining the movements they would like to make, capture the brain signals that go with this imagination effort and use these to control the game? Within the SRO NICE, the research on Brain Computing Interaction (BCI) is pursuing such possibilities.

Both the Wii controller and the imagined movement type of BCI are still in the "command-and-control" paradigm: the user has to make a conscious effort to command and control the system. The goal of attentive, adaptive interfaces with implicit interaction is to have the system infer what users want from observing their actions. The dream shared with Ambient Intelligence research is to equip the environment with sensors and actuators that respond to the user's actions, unobtrusively and fully automatic, figuring out the user's state-of-mind, emotions, mood and to adapt the environment, the lights and music, to enhance the feeling of well-being.

Virtual humans and humanoid robots offer another form of human-technology interaction as a natural and intuitive kind of interface. In one of the NICE projects a companion robot is tested which talks to people concerned about their lifestyle, a couple of times a day asking how they are doing and whether they achieved the amount of exercise they had planned. Both technology and acceptance are investigated. Another project uses a virtual

## NEW PROJECTS 2009

Kanalen in Balans	(Novay)
Channel Choice	(Belastingdienst)
Gedragbeïnvloeding mediagebruik	(Belastingdienst)
Benchmarking e-overheid	(Alliantie Vitaal bestuur en ICT)
Kanalen Publieksvoorlichting	(AZ,RVD)
Administratieve Lastenverlichting bedrijven ICT	(Alliantie Vitaal bestuur en ICT)
Scenario's intermediaire overheidsdiensten	(Alliantie Vitaal bestuur en ICT)
Doelgroepdenken overheid	(Alliantie Vitaal bestuur en ICT)
Doelgroepsegmentatie bedrijven	(Belastingdienst)
Antwoord voor Bedrijven	(EZ)
Zelftest digitale vaardigheden	(EZ)
Trendrapport Toegang en Vaardigheden ICT 2009	(EZ)
Social Engagement for Robots and Agents	(EU/FP7)
Puppy IR	(EU/FP7)
Metaverse-1	(EU/FP7)
SSPNet Network of Excellence	(EU/FP7)

human in a teaching environment that tries to figure out the motivational state of users from their actions and facial expressions. An assessment of their motivational state together with their performance on the task leads to different forms of empathetic feedback.

Researchers within the SRO NICE take the whole range of innovative interaction options into account that were mentioned above. Making this type of interactions possible involves the integration of diverse technologies, from computer vision, sensor technologies, signal processing to machine learning, knowledge representation, artificial intelligence and further to graphics, animation, virtual reality and so on. They also require an integration of computational technologies and human science research. The goals of the research within NICE is not just to contribute to the technological part but also to gain better understanding of the use of technologies, the acceptance and the ethical issues surrounding them.

## PARTICIPATING RESEARCH GROUPS

- Human Media Interaction
- Databases
- Cognitive Psychology and Ergonomics
- Instruction Technology
- Media Communication and Organization
- Philosophy of Technology

## CARE ROBOTS AND THE GOOD LIFE

### AIMEE VAN WYNSBERGHE

Robots will play an important role in the healthcare services of the future. The technical possibilities seem endless. But how much do we like the idea of being dressed by a robot in the future? And how do we like the idea of being operated on by a surgeon on the other side of the globe? Aimee van Wynsberghe is studying the ethical side of the healthcare robot.



Paro looks just like an ordinary toy seal. With its white fur and soulful eyes, it has proved to be an adorable little creature for elderly people with dementia. It can move, react to voices and even blink his eyes – but it also flawlessly records the presence or absence of its owner. The Japanese robot is not a thing of science fiction, it has already made its appearance in nursing homes in the Netherlands.

The robot has thus already arrived in the healthcare system. In the years to come, it will be appearing more often in many different forms. It is an unavoidable development in light of population ageing and the shortage of healthcare personnel. “In the next years, companies like Honda will be investing eight billion dollars in the development of social robots – robots that have some form of interaction with people. That says a lot. Engineers are working with prototypes here at Twente as well. They are focusing on the technical aspects, and we are providing input on the ethical side of a healthcare robot”, explains researcher Aimee van Wynsberghe.

Her study focuses on the question of how healthcare robots can contribute to a good life. “There is obviously no standard definition for a good life”, asserts Professor Philip Brey of the UT, Van Wynsberghe’s supervisor. “But there are universal elements, such as friendship. Everyone needs friendship.”

The question is whether people are capable of making friends with a robot or entrusting a robot with social tasks. Van Wynsberghe: “Paro shows that it’s possible. There are robots that take care of children. There are robots that can read emotions on our faces. For example, they can register that I am happy and then react by telling a joke. They can talk, dance – just about anything is possible. The question is whether we

want to use technology to fulfil our social-emotional needs. Several factors can affect the answer to this question. In general, older people are less familiar with technology than younger people are. Different generations thus look at it from different angles. In America and Western Europe, we are less enthusiastic about the widespread use of robots, while countries like Japan are much less reserved in this area.”

On a technical level, the rise of the healthcare robot is inevitable. In the Netherlands, more and more hospitals and rehabilitation centres are working with them. At the University of Twente, robots with a variety of characteristics are being developed and studied. One performs invasive medical procedures and another helps patients with rehabilitation. Van Wynsberghe is talking with fellow researchers to discover what is already possible and how far it can go in the future: “A surgeon performs an operation from behind a computer. That is better ergonomically and it is safer for the patient. But there’s also an ethical side to the story.

The patient is no longer Mr Jansen, who has a wife and two children. He is a person on a monitor. In this regard, it looks as if the surgeon is playing a video game. Are we considering this sufficiently? What about the patient who has to put himself in the hands of a physician who could be controlling the operating robot from the other side of the world? Can he do that? Would he want to?”

This study is intended to provide ethical input for the engineers who are working on the technological development of healthcare robots. One issue involves the robot’s appearance. Should it look like a person, with eyes, a nose and a mouth? Brey elaborates, “Some people say that this can raise false expectations. After all, a robot is not a person, and so you wouldn’t think it should look like one.” But it’s not always that simple, adds Van Wynsberghe. “In America, researchers gave a name to the robot vacuum cleaner, which looked nothing like a person. This robot was treated as a pet.”



### CENTRE FOR ETHICS AND TECHNOLOGY

Van Wynsberghe is one of twenty doctoral students in the 3TU Centre for Ethics and Technology of the three universities of technology (Twente, Delft and Eindhoven). Representing the University of Twente in the centre is Prof. dr Philip Brey, Professor of the philosophy of technology in the Faculty of Behavioural Sciences. He is supervising Van Wynsberghe in her study of “Natural Interaction in Computer-mediated Environments”.

# INTEGRATED SECURITY AND PRIVACY IN A NETWORKED WORLD (ISTRICE)



Integrated Security and Privacy in a Networked World (ISTRICE)  
 Coordinator: Prof. dr. Pieter Hartel  
 I [www.ctit.utwente.nl/research/sro/istrice](http://www.ctit.utwente.nl/research/sro/istrice)  
 E [p.h.hartel@utwente.nl](mailto:p.h.hartel@utwente.nl)  
 P +31 (53) 4892411

“Recommendation 1: The EC should stimulate **interdisciplinary** research, technology development and deployment that addresses the trust and security needs in the Information Society. The priority areas are: (1) **Security** in networked service and computing environments, (2) **Trust, Privacy** and Identity management frameworks, (3) Engineering principles and architectures for trust, privacy, transparency and accountability, including enabling technologies (e.g. **cryptography** and **biometrics**) and (4) Data and policy governance and related socio-economic aspects”.

Technologies and ICT in particular, deeply affect our lives, mainly in the way we deal with information and knowledge. As a consequence, the use of ICT raises fundamental questions regarding security and privacy. At the same time, our developing dependency on digital infrastructures and services has increased our exposure to new threats at a disturbing scale. A few examples: personal healthcare records, biometric templates used in travel documents and electronic services for citizens.

Many concerns for data security and unauthorized secondary uses have been raised. Several cases have emerged in the last few years; millions of personal data records were stolen or lost. Critical infrastructures become fully dependent on networked control systems and connections across national borders. Protection of critical infrastructures, including telecommunication, energy and transport has never been more essential. In the last few years we have seen the appearance of social networks evolving into complex platforms, reaching significantly beyond their original concept. The loss of privacy could easily be one of the consequences of this adolescent technology.

Networks and systems are increasingly vulnerable to attacks from various sides. Intensive research in a variety of security topics is needed more than ever. ISTRICE approaches these problems in a multidisciplinary fashion, which is firmly anchored in the underlying disciplines like cryptography and biometrics as well as risk management and protocol engineering.

For example: solutions that the ISTRICE partners have developed so far:

1. SCADA systems monitor and control a large part of the critical infrastructure, for

instance water, gas and electricity supply, as well as the functioning of nuclear and chemical plants. Using advanced network intrusion detection systems we have been able to reconstruct SCADA protocols and detect misuse on SCADA systems based on behavioural information. Our research results are now valorized by the spin-off company SecurityMatters.

2. We have been working on discovering criminogenic flaws in physical and IT security policies as well. On the one hand we have been focusing on the scientific study of the prevention of crime, working on the enhancement of video surveillance with face recognition developing a new face alignment algorithm and a method for illumination compensation. On the other hand we have shown during a penetration test on the physical security of an organization that surveillance cameras and access control play a limited role in the security of the organization and that the level of security awareness of the employees plays the biggest role in stopping crime, such as laptop theft.

3. Nowadays, personal data are being stored at diverse places, i.e. emails handled by free web mail services or medical data (e.g. the Dutch electronic patient record). This development raises concerns regarding the security and privacy of data. We address these concerns by developing methods for storing data in an encrypted format in a way that unauthorized parties cannot read the data, while still allowing efficient queries on the data by authorized parties.

4. As a last example we will mention the security issues associated with all small devices surrounding us, e.g. sensor nodes, smart cards, healthcare

monitoring equipment etc. Ensuring the security and privacy requirements of these systems is a growing problem. The two intrinsic characteristics of such systems – resource limitation and physical accessibility – cause a unique challenge for their security. We have been developing secure lightweight algorithms and protocols suitable to be used in (body) sensor networks.

We are now working towards a broader agenda called “reliable food”, where ICT security technology contributes to increasing the quality of food and to reduce the risk of fraud along the production chain. The first project “Natural Teggs” focuses on fraud prevention in fresh eggs production logistics.

## PARTICIPATING RESEARCH GROUPS

- Distributed and Embedded Security
- Signals and Systems
- Centre for Studies of Science, Technology and Society
- Databases
- Design and Analysis of Communication Systems
- Information Systems
- Philosophy

## WHO SHOULD KNOW EVERYTHING ABOUT YOUR KNEE INJURY?

### LUAN IBRAIMI

Encryption schemes in modern healthcare applications involving privacy-sensitive medical data call for new approaches that can address the complex scenarios that could occur. The search for a data-centric strategy, including a formula for defining access policies for the same data, appears to be very promising.



During the first year of his PhD study at the University of Twente and during his second year at Philips Research, Luan Ibraimi carefully formulated his research objectives within the CTIT programme: Integrated Security and Privacy in a Networked World (Istrice). He is currently studying a new approach that will enable secure storage and controlled sharing of patient health records in different scenarios. A scheme is proposed whereby patients can encrypt their own health records according to specific access policies. Two trusted authorities are distinguishable within this scheme. The first obviously involves healthcare workers in the professional domain. Examples include general practitioners, specialist physicians, personal fitness coaches and even insurance company representatives.

#### UNTRUSTED SERVERS

People in the social domain also have an interest in closely following the health history of particular patients. Examples include family representatives or close friends. "The scheme allows patients to store their personal health records in a protected form, even on untrusted commercial servers", Ibraimi states. "It is suitable for modern healthcare settings, as it helps patients to share their records securely, with users from various domains." Patients specify only the attributes that

recipients need to have in order to access their data. A recipient therefore does not even need to know the exact identity of the user. Prof. Willem Jonker is supervising Ibraimi's project, together with Prof. Pieter Hartel, head of the research group on Distributed and Embedded Security (DIES), which is also involved in the project. Jonker explains, "Only doctors who have credentials that satisfy the policy can gain access to the data. In emergency situations, the system must be able to grant first-aid workers access to the data as well, if necessary."

"I am very much in favour of using the data-centric approach that is at the centre of all this, instead of the current system management strategies. For example, who should know the details of a knee injury you had one year ago? Your general practitioner: yes! Your fitness coach: yes! Your employer: probably not. The same applies to the insurance company; it depends on the actual situation. As an outcome of confidential conversations with their general practitioners, patients are able to specify which individuals can gain access to their data. We refer to this specification as the policy. We attach the policy to the actual data."

#### ATTACK SCENARIOS

Ibraimi's work currently consists of defining, constructing and verifying encryption

schemes emerging from this approach.

Applying known mathematical techniques, he has already filed one patent application. Another is on the way.

Ibraimi explains, "After defining the algorithms, I use attack scenarios in order to prove that they can be resisted in a proven manner. I distinguish between attacks coming from outside and from within the healthcare setting itself. Security against external attacks is easier to prove than is security against internal attacks."

"For example, the technique of computing discrete logarithms is used to show that an attack is not possible. This is done by comparing the attack to a known mathematical problem that is currently unsolvable. If this can be done, the attack can be classified as NP-hard, meaning that no problems can arise in the type of attack mentioned before." Willem Jonker very much hopes that the work of Luan Ibraimi and his colleagues, both at the University Twente and at Philips Research, will contribute to the international standards for personal health records, which are currently under construction.

Jonker observes, "There is still much work to be done. The international standardization process is permanently under construction. We write proposals based on our work to contribute to this process, obviously in the hope that our approach will ultimately prove best suited for the job."



#### "UNDERSTANDING THE APPLICATION IS OF MAJOR IMPORTANCE"

Willem Jonker: "Luan spent the second year of his PhD study at Philips Research in Eindhoven, where I coordinate research for the Lifestyle sector. The topics we address include lifestyle management and preventive health. Working at Philips Research, Luan gained a feeling for the real problems in this kind of medical systems. Understanding the application is of major importance. By regularly meeting researchers who work on the frontlines on a daily basis, he developed a good sense of the scientific questions that are currently at hand." "Although research driven by scientific curiosity is also necessary, I prefer a more applied strategy. Such strategies fit well within the CTIT institute for several reasons: healthcare is a public goal, the research has multidisciplinary elements, like ethics and legal issues, and the accumulation of knowledge can bridge the gap with activities that are attractive to industry. This is obviously very interesting to us here in Twente, given that we are an entrepreneurial university."

# INDUSTRIAL ENGINEERING AND ICT (IE&ICT)



Industrial Engineering and ICT (IE&ICT)  
Coordinator: Prof.dr. Richard Boucherie  
I [www.ctit.utwente.nl/research/sro/ie-ict/](http://www.ctit.utwente.nl/research/sro/ie-ict/)  
E [r.j.boucherie@utwente.nl](mailto:r.j.boucherie@utwente.nl)  
P +31 (53) 4893432

The Strategic Research Orientation Industrial Engineering & ICT (IE&ICT) focuses on the analysis and design of processes in business and society as well as their optimization, management and decision support. Currently, performance in ICT and Industrial Engineering are often optimized separately. The increasing size and complexity of systems and resulting vast growth of the ICT environment for data and control communication requires a joint design of both systems and their ICT environment. An improved system design leads to reduced ICT costs. A better ICT environment will result in better system performance.

The UT is well positioned to be a key player in this area. On the one hand, Industrial Engineering is a well-established field of research that is well positioned in application domains including Civil Engineering, Industrial Design Engineering, Mechanical Engineering and Management Science. On the other hand, all groups are related via the common mathematical modelling language of Operations Research, which is a key research area within Applied Mathematics as well. Furthermore, the UT is by way of CTIT well positioned in the area of ICT. Moreover, via the recently launched Industrial Engineering track in the Twente Graduate School, the UT now has strongly intertwined research and education programmes in the area of Industrial Engineering & ICT.

## RESEARCH CHALLENGES

Industrial Engineering has its roots in classical production processes. It is multidisciplinary by nature and aimed at the enhancement of systems and processes in a wide range of applications including logistics, mobility, the financial sector and healthcare. Traditionally these systems have been studied mostly as centrally controlled systems. The advent of ICT drastically changed the research perspective. Real-time exchange of information and the possibility to apply decentralized optimization algorithms (e.g. using agent technology) on a real-time basis has given rise to completely new research questions. Decentralized control plays an important role in modelling problems in which the decisions of many autonomous parties have to be integrated, such as in healthcare. Design, analysis and optimization of decentrally controlled systems is a major challenge at the edge of performance analysis and ICT. The IE&ICT research challenges are to a large extent embedded in UT based application

oriented centres or laboratories (CHOIR, AIDA, FELab) and are affiliated with the national research schools Beta and TRAIL and 3TU institutes NIRICT, AMI and SCIMM.

- FELab (Financial Engineering Laboratory) develops highly sophisticated analytical techniques for the financial markets. These financial models are currently extended to model and analyze trading at energy markets as well and will in the future be extended to model and analyze environmental issues such as carbon emission trading.
- CHOIR (Centre for Healthcare Operations Improvement & Research) aims at developing the future healthcare environment from a logistics perspective supporting healthcare institutions in their efforts to increase the quality of services while simultaneously decreasing costs. New business process technologies assist healthcare institutions to provide high-quality care, combined with continuous innovation at minimal costs. These business process improvements often result in lower work pressure and higher employee retention.
- The knowledge centre AIDA (Applications of Integrated Driver Assistance) develops safe and efficient driver support systems. The first generation of these systems is now in show rooms: navigation systems using real-time traffic information, adaptive cruise control and lane departure warning. In order to take further steps, the impact of driver support systems on drivers in terms of e.g. driving performance and behavioural adaptation and traffic flows in terms of e.g. traffic safety and traffic throughput is studied in detail.

## PARTICIPATING RESEARCH GROUPS

- Centre for Transportation Studies
- Finance and Accounting
- Information Systems and Change Management
- Information Systems
- Operational Methods for Production and Logistics
- Discrete Mathematics and Mathematical Programming
- Statistics and Probability
- Stochastic Operations Research
- Stochastic System and Signal Theory

## INCORPORATING RISK CONSTRAINTS INTO PRICING MEASURES

### OVE GÖTTSCHE

In his PhD research project, Ove Götttsche is focusing on mathematical models in finance. The goal of the project is to structure and support final pricing and trading decisions in modern finance, not to predict future market prices. This difference is often misunderstood in the media.



How mathematicians deal with risk in modern finance is difficult to grasp, even for analysts. Too often, they change their expectations of the value of businesses according to short-term information, usually in response to extremely good or extremely bad news. Ove Götttsche and Professor Arun Bagchi of the CTIT Financial Engineering Group are investigating useful and secure, long-term models that are crucial for risk management, asset pricing and portfolio management.

"Our main focus is on pricing and risk", notes Bagchi. "High-finance modelling involves actual trading techniques, which is highly mathematical already. Risk creeps into the model at all levels. It is possible to adjust the model accordingly, at least to some extent. However, the risk that the entire market will collapse, for example, when trading stops or liquidity ends, should be avoided at all costs. Mathematical models can deal with that to some extent. Compare it to flood risk in case of a dyke

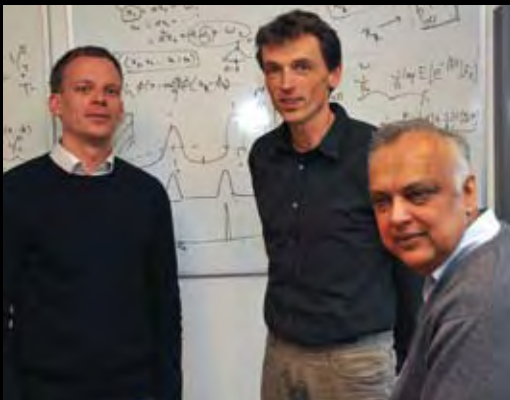
breach in the Netherlands. They are constructed such that a disaster might occur under extreme circumstances once every 1500 years."

#### TECHNOLOGY FOUNDATION STW

Technology Foundation STW supports many of the projects of the Financial Engineering (FE) Group. Bagchi stresses that the Netherlands is heavily dependent upon the financial services industry, which comprises thirty percent of all national income. The FE Group is part of the CTIT Strategic Research Orientation on Industrial Engineering and ICT. The expertise is derived from analytical finance, stochastic mathematics and signal theory. Götttsche explains that long-term global developments have changed financial markets in recent years. "Volatility is an important parameter, both now and in the near future", he states. "It will intensify in response to decreasing diversity of information and increasing complexity in financial markets."

"These trends contain paradoxical elements. Because information is easily accessible, almost all participants in the markets around the world are using the same financial news services. Combined with the globalization of financial networks, this can lead to herding behaviour in the decision-making processes of the analysts."

"Furthermore, the increase of mathematical models in finance makes it difficult to decide whether the departure of theoretical prices from the market prices could increase the possibility of risk-free profits, or whether it simply indicates the need for new models." Nonetheless, Götttsche is convinced that it is possible to control financial markets, even though such control is difficult to achieve. The supervision of stock and even currency markets on an international level is a worthy objective. "With the help of mathematical methods and rational decision-making by national governments, it might be possible to achieve these goals."



#### THE COST OF RISK

The price of certain liabilities (for example, case derivatives) is determined by using methods that take the cost of risk into account. Many regulators require financial institutions to keep a certain level of cash reserves on hand in order to counterbalance their risks. It should therefore be possible to quantify these costs as losses, due to the passive holding of cash.

This type of framework could lead to program for optimizing the ratio of assets to liabilities that can deal with long-term risks. It could also be applied in the context of markets in which it is not always possible to trade assets in the quantities desired, due to restricted liquidity in the underlying markets. "Incorporation will be an integral part of the analysis in our projects", Bagchi states.

# SPIN-OFFS SERVE AS A COMMUNICATION TOOL FOR UNIVERSITY

Professor Paul Havinga, chairman of Pervasive Systems, considers the three spin-off companies that the group has already delivered to be quite a number. He believes that funding and supporting tools for starting companies are now straightforward and easily accessible. Nevertheless, initiating a successful business is never guaranteed and it is in no way straightforward. "I enjoy it tremendously, seeing people grow personally and using new ideas to create economic value. The activity is attracting attention from all over the region."

Who would read one of the nearly two hundred scientific papers that Prof. Paul Havinga has published during his career at the University of Twente, aside from his colleagues? He poses this challenging question himself and he has thought about it many times. He imagines that researchers in a large company in the Netherlands might grasp some concepts regarding his area of expertise: the design and development of architectures, algorithms, protocols and technology for pervasive distributed systems. "Considering Twente alone, the chances are even smaller", Havinga continues. "I am convinced that I have more non-scientific readers in Japan than I do in the Netherlands."

## DIRECT CONTACT

The transfer of knowledge produced within the university into society remains a tough job. Knowledge institutes (for example, TNO) or central offices for scientific research certainly contribute to narrowing the gap. Nothing compares to direct contact, however, as Havinga states convincingly.

"Spin-offs deliver economic value to society immediately. Moreover, they cooperate in national and European projects, gaining contacts with major companies and manifold market representatives, in the most direct way possible. This enriches my work as a professor as well. Many PhD projects are inspired by these contacts. Their work is followed with interest from within the companies and it is even supported personally within projects. Spin-offs serve as a communication tool for university."

In 2004, Havinga established the start-up company Ambient Systems, which currently numbers twenty-five employees. The cool chain monitor is one of its latest



Prof. dr. Paul Havinga  
Chairman of Pervasive Systems

products. It is based on wireless RFID sensors that can communicate locally as a system before transmitting messages about the status of the products with which they travel.

Havinga elaborates, "The idea of locally distributed systems was new at the time, but very promising. It was obvious to anyone with a good sense of the potential of the technology involved and the market trends in transport or other sectors. After the European 'Eyes' project and after marketing several innovative products, the Ambient Systems concept in logistics and transport has become powerful on its own and it will remain so for years to come."

## HUMAN MOTION

In 2008, two other spin-offs emerged: Smart Signs Solutions, which develops electronic signposting systems, and Inertia Technology. The core business of Inertia involves the development of a new set of user-centric services, based on the analysis of human motion and the interaction among users and their surroundings.

Havinga was a co-owner of Ambient Systems from the beginning. His involvement with Inertia is limited to that of a shareholder, although he also stimulates the former doctoral students who are now working there by giving advice, whether as a scientist or as an entrepreneur. Havinga strongly believes in the potential of

measurement and the environmentally conscious local processing of activity sensor systems for various applications in sports, healthcare or even the gaming industry.

#### SUPPORTING TOOLS

Havinga continues: "Ambient Systems is now running on its own means. The people involved are doing a great job and my direct involvement has been systematically reduced to a minimum." Inertia is still a young company. They receive a great deal

of help from the TOP grants of Twente University and a valorization grant from Dutch Technology Foundation STW. They are also able to perform feasibility studies, use voucher grants and cooperate with Silicon Valley companies. In the near future, they will be working more intensively with a business mentor.

"I believe that these supporting tools are now straightforward and easily accessible. Nonetheless, the entrepreneurial and

technical skills of the people involved remain at the core of it all. Starting such a risky adventure at a young age is not for everyone. It calls for a special personality, a free spirit."

## ENTREPRENEURSHIP IS A REWARDING EXPERIENCE IN ITSELF

Inertia Technology is advancing a concept that targets the interactions of users with their surroundings. Using low-cost wireless sensor nodes, Inertia captures and monitors the motion of people and moving objects, recognizes current situations and activities, provides constructive feedback and takes appropriate actions.

The *Inertia system* is a collection of sensor nodes to form a self-organizing wireless mesh network. Using the wireless medium as the communication channel, the system processes data collaboratively and performs distributed monitoring and actuating tasks.

One unique feature of the Inertia system is its ability to analyse the dynamics of the environment using only low-power wireless sensor nodes. The movement analysis and interpretation takes place within the sensor network and it does not depend on any external equipment or infrastructure.

Dr. Raluca Marin-Perianu, Managing Director Inertia Technology, is one of the initiators of Inertia. In 2009, she won the Christian Huygens Prize for her PhD thesis, "Wireless Sensor Networks in Motion."

*When did you decide to start your own company, together with your business partners?*

My husband, Mihai Marin-Perianu, and I decided to start Inertia at the end of our PhD studies.

*Was there a 'decisive moment' in taking this step?*

We took the decision in the last year of our PhD studies, when we discovered the commercial potential of this technology. This was not exactly a 'decisive moment'; perhaps it was more of a gradual process. The decision of the European Commission to initiate the Ambient Assisted Living joint programme, in which Inertia is currently involved, was one important incentive.

*Have you always been an entrepreneur at heart or are you still learning it on a daily basis?*

Entrepreneurship had attracted my attention much earlier, but I have only now begun to take concrete action. I have learned a lot since we started the company, and I consider that a rewarding experience in itself.



Dr. Raluca Marin-Perianu, Managing Director Inertia Technology

# RESEARCH GROUPS



**NAME:** Prof.dr.ir. H.J. Hermens  
**CHAIR:** BSS/Remote Monitoring and Treatment  
**PHONE:** +31 (53) - 4892762  
**EMAIL:** h.j.hermens@utwente.nl  
**WEBSITE:** <http://telemedicine.ewi.utwente.nl/>

The *Telemedicine Group* investigates and develops smart, end-to-end systems for remote monitoring and remotely supervised treatment of patients with chronic conditions.

We investigate the design, prototyping and validation of such systems in close collaboration with the stakeholders, including the underlying architecture, sensing and feedback concepts and technology, the mobile service platforms, autonomic (sub)systems and intelligent clinical decision support.

Present target populations involve subjects with chronic neck / shoulder pain, chronic heart failure and COPD.

This Telemedicine Group has a strong background in both Biomedical Engineering (BSS) and ICT and has a well established cooperation network with engineering, health science and clinical groups. As such, the group is both embedded in the research institute CTIT and in the Biomedical Research Institute Mira.



**NAME:** Prof.dr.ir. E.C. van Berkum  
**CHAIR:** Centre for Transport Studies  
**PHONE:** +31 (53) - 4894886  
**EMAIL:** e.c.vanberkum@utwente.nl  
**WEBSITE:** <http://www.vvr.ctw.utwente.nl/en/index.htm>

The Centre for Transport Studies (CTS) researches the performance of (inter)urban transport networks from a multidisciplinary and integral perspective.

It develops quantitative and qualitative methods for understanding and describing traffic and transport phenomena and patterns, for improving the underpinning of planning and management processes and for assessing impacts of human behaviour and technological innovations.

Research themes are: strategic planning and sustainable development issues for (urban) transport systems, land use transport interactions, mobility monitoring and management and the application of integrated driver support systems and services. CTS hosts the knowledge centre AIDA, a cooperation between TNO and the University of Twente.



**NAME:** Prof.dr. W.B. Verwey B.Sc.  
**CHAIR:** Cognitive Psychology & Ergonomics  
**PHONE:** +31 (53) - 4893611/4764  
**EMAIL:** w.b.verwey@gw.utwente.nl  
**WEBSITE:** <http://www.gw.utwente.nl/cpe/>

The chair for Cognitive Psychology and Ergonomics conducts research and provides courses in design and evaluation of internet and media systems using fundamental knowledge from cognitive psychology and cognitive ergonomics.

The focus of the chair is on the development of criteria for simulators and virtual environments for skill training on basis of knowledge of human cognition.

Current projects involve criteria for medical training (e.g., anatomical knowledge, surgical skills) and multimodal information presentation and transfer of perceptual-motor skills from simulator to real task environments.

Also, results from more fundamental experiments are used for better understanding and solving applied issues.



**NAME:** Prof.dr. J.A.G.M. van Dijk  
**CHAIR:** Communication Science and the Sociology of the Information Society  
**PHONE:** +31 (53) - 4893286/3299  
**EMAIL:** jan.vandijk@utwente.nl  
**WEBSITE:** <http://www.gw.utwente.nl/mco/en/>

Van Dijk and his staff investigate digital media use in the context of the individual, the organization and society. The focus is on the confrontation between technical design and use in actual social and behavioural contexts.

Van Dijk's own teaching chair is preoccupied with the broad social impacts of ICT. He does so from a network perspective.

Currently his chair focuses on two research areas:

1. e-Government innovation, organization and communication and
2. media psychology: drivers of the acceptance and use of new technologies by individual users in social contexts.

Van Dijk is leading the *Center of e-Government Studies* established in 2009 as a sequel to the research programme called ICT and Government Organizations that was launched in a covenant with the Dutch Tax and Customs Service in 2003. The programme and the Centre are linked to the SRO- ASSIST.



**NAME:** Prof.dr.ir. G.J.M. Smit  
**CHAIR:** Computer Architectures for Embedded Systems  
**PHONE:** +31 (53) - 4893734  
**EMAIL:** g.j.m.smit@ewi.utwente.nl  
**WEBSITE:** <http://caes.ewi.utwente.nl>

The research of the CAES group focuses on energy-efficient embedded systems containing a mixture of hardware and software. It may be as simple as a sensor, or as complex as an image processing system, or even an entire phased array antenna system.

The main focus of the CAES group is on:

- 1) energy-efficiency of ICT systems, in particular efficient architectures for adaptive streaming applications,
- 2) using ICT systems for efficiency, in particular optimization algorithms for energy management in buildings,
- 3) testable design of low-power embedded systems, e.g. for car systems.



**NAME:** Prof.dr.ir. S. Stramigioli  
**CHAIR:** Control Engineering  
**PHONE:** +31 (53) – 4892794/2606  
**EMAIL:** S.Stramigioli@utwente.nl  
**WEBSITE:** <http://www.ce.utwente.nl/>

Control Engineering deals with applications of modern systems and control methods to practical situations. Focus is on robotics, as a specific class of mechatronic systems, which are highly dependable. Activities range from theory, methods, tools, towards applications.

Robot application areas are inspection robots (for the gas grid), medical robots (assistant to surgeons), service robots (street cleaning, service to people) and humanoid robots. Next to these robots, we have in our lab quite a variety of robotic / mechatronic setups.

The science and engineering topics we work on are modelling and simulation of physical systems, intelligent control, advanced robotics and embedded control systems. The concept of ports for interconnecting models of the physical system, controllers and software is a common factor, allowing for elegant means of tearing, zooming and linking of these models.



**NAME:** Prof.dr. P.M.G. Apers  
**CHAIR:** Databases  
**PHONE:** +31 (53) - 4893690  
**EMAIL:** p.m.g.apers@ewi.utwente.nl  
**WEBSITE:** <http://db.cs.utwente.nl/>

The Database group's mission is to provide data management to create added value on top of autonomous data sources.

Nowadays huge amounts of data are produced by both humans and devices connected to the Internet. This has led to information overload and a decrease in trust of data, as well as an increase of privacy threats. However, applications need high data quality providing privacy. Our research extends database systems with functionality to filter and compute relevant information, to reduce the unreliability of data and to protect privacy.

- Search on semi-structured data  
Specifically, XML databases and distributed search
- Enriching uncertain data  
Specifically, data integration and streaming data
- Security and Privacy  
Specifically, search in encrypted data, secure handling of medical data and progressive degradation of data

Applications: web search, sensor network, e-Health, ambient intelligence



**NAME:** Dr.ir. A. Pras (ad interim)  
**CHAIR:** Design and Analysis of Communication Systems  
**PHONE:** +31 (53) - 4898041  
**EMAIL:** a.pras@utwente.nl  
**WEBSITE:** <http://dacs.ewi.utwente.nl/>

DACS focuses on dependable networked systems. A (networked) system is called dependable, whenever reliance can justifiably be placed on the services it delivers. Research is performed on three types of networked systems.

Research on wired network systems (primarily internet) focuses on operational aspects, i.e., managing and optimizing configurations, as well as on intrusion detection. Performing and interpreting measurements play an important role in this research. Research on wireless systems focuses on the design, evaluation and prototype implementation of new protocols and algorithms in ad-hoc networks, especially vehicle-to-vehicle and sensor networks.

Research on embedded networked systems focuses on system specification and evaluation (numerical and simulative) techniques to describe such systems and the resource constraints they have to operate under. This includes the development of new stochastic model checking techniques and the application thereof to predict dependability and performance properties.




---

**NAME:** Prof.dr. M.J. Uetz  
**CHAIR:** Discrete Mathematics and  
 Mathematical Programming  
 (DMMP)  
**PHONE:** +31 (53) - 4893420 / 3402  
**EMAIL:** m.uetz@utwente.nl  
**WEBSITE:** <http://dmmp.ewi.utwente.nl>

In the past 60 years, Discrete Mathematics and Mathematical Programming has put forth numerous success stories, starting with mathematical program to support the Berlin Air Lift, towards the innumerable algorithms and protocols that support our contemporary digital society. We work towards the continuation of this success story, thereby contributing to a better functioning of our society – and at the same time hope to enhance the field by unveiling beautiful theorems.

Research & teaching is centered around the areas:

- Combinatorial Optimization
- Mathematical Programming
- (Algorithmic) Game Theory

Our vision is to achieve strong theoretical results on structure and tractability of optimization problems, as well as the implementation of algorithms in the form of prototype computer software. Typical application areas are logistics, internet, telecommunication, energy or healthcare, to name a few.




---

**NAME:** Prof.dr. P.H. Hartel  
**CHAIR:** Distributed and Embedded  
 Security  
**PHONE:** +31 (53) - 4892411  
**EMAIL:** pieter.hartel@utwente.nl  
**WEBSITE:** <http://dies.cs.utwente.nl>

Our research focuses on the analysis and design of distributed and embedded systems. These are complex, heterogeneous, networked systems that operate in often hostile environments and under severe resource constraints. We are primarily interested in security properties.

Our interest in security properties stems from the fact that security is important for applications but very delicate. For example only one leak is sufficient to spoil the security of a system. It is therefore imperative to control the security properties of all components of a system. This is hard because (1) there might be a large number of components and (2) we do not even know all the components of a system that interacts with the outside world. Interaction with the world around occurs, for example when people are required to use passwords that are not easy to guess, or when the network is wireless, and thus shares the airwaves with everybody else.

Our teaching focuses on the security related courses of the computer science curriculum. For example at bachelor level we teach operating systems and at master level we teach the introduction to computer security.




---

**NAME:** Prof.dr. J. van de Pol  
**CHAIR:** Formal Methods and Tools  
**PHONE:** +31 (53) - 4893017  
**EMAIL:** vdpol@cs.utwente.nl  
**WEBSITE:** <http://fmt.cs.utwente.nl/>

The Formal Methods and Tools (FMT) group develops and applies formal theories, techniques and tools to support the development and analysis of reliable software intensive embedded systems. Various system aspects are addressed: safety, correctness, dependability and hybrid aspects.

The focus points of the research are: to address quantitative aspects, such as time and probabilities; to scale the methods by developing parallel and distributed algorithms and tools; and to make verification and testing techniques directly applicable to design models and actual software.




---

**NAME:** Prof.dr.ir. A. Nijholt  
**CHAIR:** Human Media Interaction  
**PHONE:** +31 (53) - 4893740  
**EMAIL:** anijholt@cs.utwente.nl  
**WEBSITE:** <http://hmi.ewi.utwente.nl>

Research activities of the Human Media Interaction group include human-computer interaction, multimedia processing, speech and language technology and virtual and augmented reality.

Important research issues are multimedia retrieval, dialogue modelling, embodied conversational agents (virtual humans) and multi-party and multimodal interaction.

Much of the research efforts are undertaken in the context of the ambient intelligence paradigm. This paradigm concerns the combination of ubiquitous computing and the design of social and intelligent interfaces.

Apart from ambient intelligence other application areas are cultural heritage and game environments. Supporting technologies are machine learning, graphics and animation, brain-computer interfacing and multi-agent systems. Supporting disciplines are cognitive and behavioural sciences, (social) psychology and linguistics.



**NAME:** Prof.dr. R.J. Wieringa  
**CHAIR:** Information Systems  
**PHONE:** +31 (53) - 4894283  
**EMAIL:** roelw@cs.utwente.nl  
**WEBSITE:** <http://is.cs.utwente.nl>

Today's information systems are used in a decentralized context, ranging from social networks without central coordinator, to value webs consisting of profit-and-loss responsible businesses. In all these situations, information systems need to be designed in accordance with the goals of a disparate set of stakeholders, to support or perform processes that may or may not be specified and to avoid harm to security and privacy of the actors involved.

The research mission of the Information Systems group is to develop methods, concepts and tools for the cost-effective design and management of information systems in large decentralized networks. We perform projects in the areas of architectures, requirements and security of decentralized information systems.



**NAME:** Prof.dr. J. van Hillegersberg  
**CHAIR:** Information Systems & Change Management  
**PHONE:** +31 (53) - 4893500  
**EMAIL:** j.vanhillegersberg@utwente.nl  
**WEBSITE:** <http://www.mb.utwente.nl/iscm/>

The department of Information Systems & Change Management (ISCM) conducts research and offers education in design and implementation of information systems and services. We focus on:

- Methodologies for engineering information services, systems and architectures
- Business modelling, adoption and use of information services, systems and architectures
- Change, transformation and leadership in the context of services innovation and excellence

We have a special interest in inter-organizational systems connecting networks of businesses and government. We are studying novel ways of organizing networks like dynamic global sourcing and multi-agent coordination. Our main expertise is in logistics, healthcare, government and software and high-services industries.

Publications of the department members can be found in such reputable international journals as Organization Science; Information Systems; Communications of the ACM, MISQ, Decision Support Systems.



**NAME:** Prof.dr.ir. B. Nauta  
**CHAIR:** Integrated Circuit Design  
**PHONE:** +31 (53) - 4892655  
**EMAIL:** b.nauta@utwente.nl  
**WEBSITE:** <http://icd.ewi.utwente.nl>

In the Integrated Circuit Design group (ICD-group) we do research on integrated transceiver hardware in CMOS technology. This includes transmitters and receivers for wireless and wireline communication systems.

We develop innovative analogue and mixed signal IC design techniques to further digitize these systems, so they can be integrated on a chip at high performance and low cost. Also research is carried out on alternative Radio Systems as well as Microwave Integration.

The ICD group addresses their challenges in close cooperation with the industry, in order to find fundamental solutions for practical problems.



**Name:** Prof.dr. A.J.M. de Jong  
**Chair:** Instructional Technology  
**Phone:** +31 (53) - 4893613  
**Email:** a.j.m.dejong@utwente.nl  
**Website:** <http://www.gw.utwente.nl/list/>

The main goal of the research programme of this chair is to investigate processes that underlie inquiry learning, to identify characteristic difficulties students have in the inquiry process and to design and evaluate technology based instructional arrangements (e.g. computer simulations and cognitive scaffolds) that help to prevent or overcome these problems.

Of specific interest are techniques to optimize computer mediated collaborative inquiry learning, affordances of interfaces (graphical, textual etc.) for learning, the creation of software artefacts (e.g., runnable computer models) by learners and adaptivity of technology enhanced learning environments on the basis of educational data mining techniques.



**NAME:** Prof.dr.ir. M.J.F. Wouters  
**CHAIR:** Finance & Accounting  
**PHONE:** +31 (53) - 4894498  
**EMAIL:** m.j.f.wouters@utwente.nl  
**WEBSITE:** <http://www.mb.utwente.nl/fa/>

The research addresses the use of financial information in industrial engineering and management. For nonfinancial companies, the research focuses on the usage and design of management accounting information and performance measurement systems in areas such as manufacturing, purchasing, supply chain management, new product development and business market management.

For financial companies, such as banks, insurance companies and pension funds, the focus is on risk management. The increasing complexity of financial contracts, the growing overlap between providers of financial products (such as the merging of banks and insurance companies) and the emerging markets for "new" products (such as electricity, milk quota or emission rights) have resulted in a demand for quantitative instruments for risk management. This research focuses on analyzing and managing financial risks. Furthermore, there are connections between these domains, mainly through corporate finance topics such as derivative products, real options and finance decisions.



**NAME:** Prof.dr. A.A. Stoorvogel  
**CHAIR:** Mathematical Systems & Control Theory  
**PHONE:** +31 (53) - 4893449  
**EMAIL:** a.a.stoorvogel@math.utwente.nl  
**WEBSITE:** <http://www.math.utwente.nl/ssb>

Systems and control theory is an area of research which studies, often complex and heterogeneous, processes and their interaction with the environment. This requires models for the dynamical behaviour of the process and a thorough analysis of this behaviour. We also try to improve the behaviour by designing another dynamical system, which interacts with the given system.

Nowadays, many complex systems consist of a large number of embedded subsystems which all interact with each other. It is non-trivial to analyze the overall system and its behaviour. We also want design the coupling of these different components, in such a way that the overall system has desirable behaviour. This requires fundamental insight in the behaviour of interconnected components and how to suitably model this behaviour.



**NAME:** Prof.dr. W.H.M. Zijm  
**CHAIR:** Operational Methods for Production and Logistics  
**PHONE:** +31 (53) - 4893912  
**EMAIL:** w.h.m.zijm@utwente.nl  
**WEBSITE:** <http://www.mb.utwente.nl/ompl/>

The research and education of the department OMPL focuses on the optimization of business processes in industry and service organizations. Special emphasis is on supply chain planning and control, distribution logistics, materials handling, manufacturing and maintenance systems, purchasing and management of healthcare organizations. The design and analysis of quantitative models and techniques dominates both our educational and research approach.

The research constitutes an interface between domain knowledge in manufacturing, logistics and purchasing and the IT structures and systems necessary for implementing these quantitative methods in DSS (decision support systems). The main goal is to improve the productivity and / or service level of the business processes under consideration. As such, the group is working intensively with a variety of industries and public organizations, in the latter focusing in particular on the healthcare sector.



**NAME:** Prof.dr.ing. P.J.M. Havinga  
**CHAIR:** Pervasive Systems  
**PHONE:** +31 (53) - 4894619  
**EMAIL:** P.J.M.Havinga@utwente.nl  
**WEBSITE:** <http://www.ps.ewi.utwente.nl>

The Pervasive Systems (PS) group investigates a new distributed systems paradigm of embedded and flexibly networked systems, based on virtually unbounded sets of hardware artefacts made flexible by software and embedded in everyday objects or new types of devices.

PS research focuses on the following research topics:

- *Transparency*: a vast number of components must cooperate to support an application as unobtrusively as possible;
- *Scalability*: making efficient use of scarce resources independent of growth;
- *Evolvability*: adaptation to a dynamically changing environment;
- *Dependability*: the system should provide reliable services in spite of inherently unreliable nodes and connections due to resource constraints.

The supporting architectures should be open, distributed and scalable, naturally integrating heterogeneous devices ranging from tiny actuators to large computers.



NAME: Prof.dr. P.A.E. Brey  
 CHAIR: Philosophy  
 PHONE: +31 (53) - 4894426  
 EMAIL: p.a.e.brey@utwente.nl  
 WEBSITE: <http://www.gw.utwente.nl/wijsb/>

The chair in General Philosophy is the central chair of the department of Philosophy of the University of Twente. The aim of the department's research programme "Philosophy of Technology and Technological Culture" is to contribute to a better philosophical and ethical understanding of technology and its relation to society. The research strengths of the department include philosophy and ethics of biomedical technology (embedded in the institute BMTI), philosophy and ethics of information and communication technology (CTIT), and philosophy of nanotechnology (MESA+). The department also houses a personal professorship in Human-Technology Relations and an extraordinary professorship in Art and Technology. Regarding teaching, the department participates centrally in the master programme Philosophy of Science, Technology and Society (PSTS) and participates in most engineering and social science programmes at the University of Twente. The department also participates in the 3TU.Centre for Ethics and Technology.



NAME: Prof.dr.ir. C.H. Slump  
 CHAIR: Signals and Systems  
 PHONE: +31 (53) - 4892780  
 EMAIL: c.h.slump@ewi.utwente.nl  
 WEBSITE: <http://www.sas.ewi.utwente.nl>

The purpose of the chair Signals and Systems is in teaching and in research on signal analysis and signal processing. Signals are considered to be carriers of information. Systems are characterized, analyzed and designed aiming at the processing of signals.

The research concentrates on *Sensory Data Analysis and Image Processing*, with focus on pattern recognition and image processing in biometrics and medical imaging.

The research perspective is driven by the application domain in the context of embedded systems. In biometrics the chair works on fingerprints and face recognition.



NAME: Prof.dr.ir. M. Aksit  
 CHAIR: Software Engineering  
 PHONE: +31 (53) - 4892638  
 EMAIL: aksit@ewi.utwente.nl  
 WEBSITE: <http://trese.cs.utwente.nl>

Twente Research and Education on Software Engineering (TRESE), is the popular name of the *Software Engineering Group* at the Department of Computer Science in the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente.

The research activities are organized within the context of the research institute CTIT. Research is carried out in four complementary sub-programmes: programming languages, architecture, services and verification and optimization. The overall research strategy is called quality-oriented software engineering.



NAME: Prof.dr. W. Albers  
 CHAIR: Statistics and Probability  
 PHONE: +31 (53) - 4893434  
 EMAIL: w.albers@utwente.nl  
 WEBSITE: <http://www.math.utwente.nl/sp/>

A major area of our research concerns finance and insurance. The study of effects of dependencies in risk analyses is an important topic here. An example can be found in stop-loss premiums from insurance, in particular their instability due to dependent underlying risks.

Methods required concern estimation of extreme quantiles. This is mathematically challenging and moreover, also of interest for a second area of our research, Statistical Quality Control. In many large scale production processes (e.g. in semiconductor industry), setting adequate test limits and control charts, can offer a very worthwhile saving in yield. In addition, these quality control methods appear very promising for the emerging area of healthcare monitoring.



**NAME:** Prof.dr. R.J. Boucherie  
**CHAIR:** Stochastic Operations Research  
**PHONE:** +31 (53) - 4893432  
**EMAIL:** r.j.boucherie@utwente.nl  
**WEBSITE:** <http://www.math.utwente.nl/sor/>

The Stochastic Operations Research (SOR) group focuses on fundamental mathematical research in the area of applied probability and operations research and its applications in (tele) communications, logistics and healthcare. Fundamental research includes the areas of Markov chains, stochastic processes, queueing theory, fluid queues and game theory. Typical applications include cooperation and profit distribution in supply chains, Google's Page Rank, modelling and analysis of Internet protocols such as TCP/IP, Quality of Service in wireless networks such as Wireless LANs and ad-hoc networks, optimization of end-to-end patient flows in hospitals, and facility location in transportation networks.

SOR participates in the CTIT SRO's IE&ICT, ASSIST, WiSe and DSN and is a member of the 3.TU-TNO-CWI expertise centre E-Quality, in the area of Quality of Service in ICT.



**NAME:** Prof.dr. A. Bagchi  
**CHAIR:** Stochastic System and Signal Theory  
**PHONE:** +31 (53) - 4893406  
**EMAIL:** a.bagchi@utwente.nl  
**WEBSITE:** <http://www.math.utwente.nl/ssb/msc/>

Stochastic system theory deals with (controlled) dynamical systems where the input is random and the output is corrupted by noise. The study of such systems is closely related to problems in statistical signal processing. Application of stochastic system theory has been increasingly concentrated on the expanding field of financial engineering.

Hedging in incomplete markets, infinite-dimensional models of interest rates and energy derivatives are some active areas of research in this field within the chair at present. There is close collaboration in this field with the department of Finance and Accounting in the School of Management and Governance.

Another active area of research is particle filtering with application to the detection of moving objects using distributed sensors. The chair has close collaboration with industry in the Netherlands.



**NAME:** Prof.dr. N.E.J. Oudshoorn  
**CHAIR:** Technology Dynamics and Healthcare  
**PHONE:** +31 (53) - 4893344 / 3353  
**EMAIL:** n.e.j.oudshoorn@utwente.nl  
**WEBSITE:** <http://www.mb.utwente.nl/stehps/>

The research of the chair aims to understand how the future use of information and communication technologies (ICT) is anticipated during the design and implementation of the technology in order to understand the successes and failures of technological innovations.

This research builds on recent insights that successful technological innovation requires a dynamic process of continuous interactions between the design of ICT and the contexts of use. Researchers at the centre have developed a specific methodology (constructive technology assessment, CTA) to facilitate the integration of social criteria in the development of technology.

The research of this chair focuses on the development, testing, implementation and use of new and emerging ICT in various sectors.



**NAME:** Prof.dr.ir. F.B.J. Leferink  
**CHAIR:** Telecommunication Engineering  
**PHONE:** +31 (53) - 4893856  
**EMAIL:** te@ewi.utwente.nl  
**WEBSITE:** <http://www.ewi.utwente.nl/te/>

Telecommunication is any transmission and/or emission and reception of signals representing signs, writing, images and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic system.

The principal research areas of the Telecommunication Engineering Group are short range radio, optical signal processing networks (RF-photonics) and electromagnetic compatibility. This research is specifically aimed at practical applications such as wireless sensor networks and optical beam forming systems for wireless communications and radar systems.

# SCIENTIFIC OUTPUT 2009

## DISSERTATIONS

### J.W. Balkema (27-08-2009)

Design and Realisation of an Efficient Content Based Music Playlist Generation System  
UT Universiteit Twente, ISBN: 978-90-365-2886-3  
Prom.: prof.dr.ir. C.H. Slump & prof.dr.-ing K. Brandenburg

### G.M. Beumer (16-10-2009)

Face recognition, a landmarks tale  
UT Universiteit Twente, ISBN:978-90-365-2891-7  
Prom./coprom.: prof.dr.ir. C.H. Slump & dr.ir. R.N.J. Veldhuis

### D. Bolzoni (25-06-2009)

Revisiting Anomaly-based Network Intrusion Detection Systems  
UT Universiteit Twente, ISBN: 978-90-365-2853-5  
Prom./coprom.: prof.dr. S. Etalle & prof.dr. P.H. Hartel

### M.R. Czenko (26-06-2009)

TuLiP -Reshaping Trust Management  
UT Universiteit Twente, ISBN: 978-90-365-2854-2  
Prom.: prof.dr. S. Etalle & prof. P.H. Hartel

### S. Ciraci (17-12-2009)

Graph Based Verification of Software Evolution Requirements  
UT Universiteit Twente, ISBN: 978-90-365-2956-3  
Prom./coprom.: prof.dr.ir. M. Akşit & dr. P.M. van den Broek

### M.A.C. Dekker (02-12-2009)

Flexible Access Control for Dynamic Collaborative Environments  
UT Universiteit Twente, ISBN: 978-90-365-2950-1  
Prom.: prof.dr. P.H. Hartel & prof.dr. S. Etalle

### O. Durmaz Incel (20-03-2009)

Multi-Channel Wireless Sensor Networks: Protocols, Design and Evaluation  
UT Universiteit Twente, ISBN: 978-90-365-2812-2  
Prom./coprom.: prof.dr. S.J. Mullender & prof.ir. P.G. Jansen

### S. Evers (25-09-2009)

Sensor Data Management with Probabilistic Models  
UT Universiteit Twente, ISBN: 978-90-365-2867-2  
Prom.: prof.dr. P.M.G. Apers & prof.dr. L. Feng

### R. de Haan (04-06-2009)

Queueing Models for Mobile Ad Hoc Networks  
UT Universiteit Twente, ISBN: 978-90-365-2827-6  
Prom./coprom.: prof.dr. R.J. Boucherie & dr. J.C.W. van Ommeren

### T. Han (25-09-2009)

Diagnosis, Synthesis and Analysis of Probabilistic Models  
UT Universiteit Twente, ISBN: 978-90-365-2858-0  
Prom.: prof.dr.ir. J.-P. Katoen

### W.K. Havinga (10-06-2009)

On the Design of Software Composition Mechanisms and the Analysis of Composition Conflicts  
UT Universiteit Twente, ISBN: 978-90-365-2842-9  
Prom./coprom.: Prof.dr.ir. M. Akşit & dr.ir. L.M.J. Bergmans

### A. Jehangir (09-04-2009)

A Security Architecture for Personal Networks  
UT Universiteit Twente, ISBN: 978-90-365-2818-4  
Prom.: prof.dr.ir. B.R.H.M. Haverkort & prof.dr.ir. S. Heemstra de Groot

### M.G. Khatib (11-06-2009)

MEMS-Based Storage Devices. Integration in Energy-Constrained Mobile Systems

UT Universiteit Twente, ISBN: 978-90-365-2847-4  
Prom./coprom.: prof. P.H. Hartel & dr.ir. L. Abelmann

### M. Van Le (12-11-2009)

Towards an Inter-domain Billing System to Support Dynamic Service Provisioning  
UT Universiteit Twente, ISBN: 978-90-365-2924-2  
Prom./coprom.: prof.dr.ir. L.J.M. Nieuwenhuis, prof.dr. G.B. Huitema (University of Groningen) & dr.ir. B.J.F. van Beijnum

### S.M. Louwsma (09-12-2009)

Time-interleaved Analog-to-Digital Converters  
UT Universiteit Twente, ISBN: 978-90-365-2944-0  
Prom./coprom.: prof.ir. A.J.M. van Tuijl & prof.dr.ir. B. Nauta

### D.A.I. Marpaung (27-08-2009)

High dynamic range analog photonic links: design and implementation  
UT Universiteit Twente, ISBN: 978-90-365-2860-3  
Prom./coprom.: prof.dr.ir. W. van Etten & dr.ir. C.G.H. Roeloffzen

### D. Miretskiy (12-11-2009)

Queueing networks: rare events and fast simulations  
UT Universiteit Twente, ISBN: 978-90-365-2909-9  
Prom./coprom.: prof.dr. R. Boucherie, prof.dr. M.R.H. Mandjes & dr.ir. W.R.W. Scheinhardt

### K. Muthukrishnan (04-09-2009)

Multimodal Localisation: Analysis, Algorithms and Experimental Evaluation  
UT Universiteit Twente, ISBN: 978-90-365-2890-0  
Prom.: prof.dr. P.J.M. Havinga

### V. Nunes Leal Franqueira (13-11-2009)

Finding Multi-step Attacks in Computer Networks using Heuristic Search and Mobile Ambients  
UT Universiteit Twente, ISBN: 978-90-365-2923-5  
Prom./coprom.: prof.dr. R.J. Wieringa & dr. P.A.T. van Eck

### J.J. Paulus (22-01-2009)

Online Scheduling & Project Scheduling  
UT Universiteit Twente, ISBN: 978-90-365-2753-8  
Prom./coprom.: prof.dr. M.J. Uetz & dr. J.L. Hurink

### W.J. Pieterse (26-03-2009)

Channel choice: citizens' channel behavior and public service channel strategy  
UT Universiteit Twente, ISBN: 978-90-365-2807-8  
Prom.: prof.dr. J.A.G.M. van Dijk

### S. Pokraev (22-10-2009)

Model-Driven Semantic Integration of Service-Oriented Applications  
UT Universiteit Twente, ISBN: 978-90-75176-49-0  
Prom./coprom.: prof.dr. R.J. Wieringa, prof.dr. M. Reichert & dr.ir. M.W.A. Steen

### R.W. Poppe (02-04-2009)

Discriminative Vision-Based Recovery and Recognition of Human Motion  
UT Universiteit Twente, ISBN: 978-90-365-2810-8  
Prom./coprom.: prof.dr.ir. A. Nijholt & dr. M. Poel

### Z. Ru (12-11-2009)

Frequency Translation Techniques for Interference-Robust Software-Defined radio receivers  
UT Universiteit Twente, ISBN: 978-90-365-2925-9  
Prom./coprom.: prof.dr.ir. B. Nauta & dr.ing. Eric A. M. Klumperink

**S. Saha (08-09-2009)**

Topics in particle filtering and smoothing  
 UT Universiteit Twente, ISBN: 978-90-365-2864-1  
 Prom./coprom.: prof.dr. A. Bagchi & dr. P.K. Mandal

**D. San Segundo (10-09-2009)**

Spectroscopic quantum imaging using pixel-level ADCs in  
 Semiconductor-based Hybrid pixel detectors  
 UT Universiteit Twente, ISBN: 978-90-365-2852-8  
 Prom./coprom.: prof.dr.ir. B. Nauta & dr. J. Visschers

**R.G. Santana Tapia (04-12-2009)**

Assessing business-IT alignment in networked organizations  
 UT Universiteit Twente, ISBN: 978-90-365-2927-3  
 Prom./coprom.: prof.dr. R.J. Wieringa, dr. P.A.T. van Eck &  
 dr. M. Daneva

**P. Serdyukov (24-06-2009)**

Search for Expertise: going beyond direct evidence  
 UT Universiteit Twente, ISBN: 978-90-365-2845-0  
 Prom./coprom.: prof.dr. P.J.M. Apers & dr.ir. D. Hiemstra

**H. Sozer (29-01-2009)**

Architecting Fault-Tolerant Software Systems  
 UT Universiteit Twente, ISBN: 978-90-365-2788-0  
 Prom./coprom.: prof.dr.ir. M. Akşit & dr.ir. B. Tekinerdoğan

**Q. Tao (06-02-2009)**

Face verification for mobile personal device  
 UT Universiteit Twente, ISBN: 978-90-365-2788-0  
 Prom./coprom.: prof.dr.ir. C.H. Slump & dr.ir. R.N.J. Veldhuis

**K.P. Truong (27-08-2009)**

How Does Real Affect Affect Recognition In Speech?  
 UT Universiteit Twente, ISBN: -90-365-2880-1  
 Prom.: prof.dr. F.M.G. de Jong & prof.dr.ir. D.A. van Leeuwen, RU/TNO

**I.I. Tsjernikova (29-10-2009)**

Developing and investigating validity of a knowledge management  
 game simulation model  
 UT Universiteit Twente, ISBN: 978-90-365-2915-0  
 Prom.: prof.dr. R. de Hoog

**Y. Volkovich (24-04-2009)**

Stochastic Analysis of Web Page Ranking  
 UT Universiteit Twente, ISBN: 978-90-365-2823-8  
 Prom./coprom.: prof.dr. R.J. Boucherie & dr. N. Litvak

**J.M. Wesselink (26-11-2009)**

A rapid prototyping system for broadband multichannel active  
 noise and vibration control  
 UT Universiteit Twente, ISBN: 978-90-365-2936-5  
 Prom./coprom.: prof.dr.ir. C.H. Slump & dr.ir. A.P. Berkhoff

**M.H. Wiggers (19-06-2009)**

Aperiodic Multiprocessor Scheduling for Real-Time Stream  
 Processing Applications  
 UT Universiteit Twente, ISBN: 978-90-365-2850-4  
 Prom./coprom.: prof.dr.ir. G.J.M. Smit & dr.ir. M.J.G. Bekooij

**P.T. Wolkotte (15-01-2009)**

Exploration within the Network-on-Chip Paradigm  
 UT Universiteit Twente, ISBN: 978-90-365-2757-6  
 Prom.: prof.dr.ir. G.J.M. Smit

**J.Wu (02-09-2009)**

Removable Edges in 4-Connected Graphs  
 UT Universiteit Twente, ISBN: 978-90-365-2892-4  
 Prom./coprom.: prof.dr.ir. H.J. Broersma & prof.dr. X. Li

**Q. Zhang (26-02-2009)**

Cognitive Radio on a Reconfigurable MPSoC Platform  
 UT Universiteit Twente, ISBN: 978-90-365-2797-2  
 Prom./coprom.: prof.dr.ir. G.J.M. Smit & dr.ir. A.B.J. Kokkeler

**SELECTION OF SCIENTIFIC PUBLICATIONS**

A selection of publications is presented below. An overview of all  
 publications of CTIT participants will be available on the CTIT  
 website: <http://www.ctit.utwente.nl/library> and  
<http://eprints.eemcs.utwente.nl>

**Abdel Kader, R. and Boncz, P., Manegold, S. and Keulen, M. van**  
 ROX: Run-Time Optimization of XQueries. Proceedings of the 35th  
 ACM SIGMOD International Conference on Management of Data  
 (SIGMOD2009), 29 June - 02 July 2009, Providence, Rhode Island,  
 USA. pp. 615-626. ACM. ISBN 978-1-60558-551-2

**Akşit, M., Rensink, A. and Staijen, T.**

A Graph-Transformation-Based Simulation Approach for Analysing  
 Aspect Interference on Shared Join Points. In: AOSD '09:  
 Proceedings of the 8th ACM International Conference on Aspect-  
 Oriented Software Development, 3-6 Mar 2009, Charlottesville,  
 Virginia, USA. pp. 39-50. ACM. ISBN 978-1-60558-442-3

**Albers, W. and Kallenberg, W.C.M.**

CUMIN charts. *Metrika* 70, pp. 111-130.

**Albers, W., Kallenberg, W.C.M. and Lukocius, V.**

A flexible model for actuarial risks under dependence. *Scand.*  
*Actuar. J.* 2009, pp. 152-167.

**Aly, R.B.N. and Hiemstra, D.**

Concept detectors: how good is good enough? Proceeding of the  
 17th ACM International Conference on Multimedia, 19-22 Oct  
 2009, Beijing, P.R. Republic of China. pp. 233-242. ACM.  
 ISBN 978-1-60558-608-3

**Andrey, L., Festor, O., Lahmadi, A., Pras, A. and Schoenwaelder, J.**

Survey of SNMP performance analysis studies. *International*  
*Journal of Network Management*, 19 (6). pp. 527-548.  
 ISSN 1055-7148

**Annema, A.J., Veldhorst, P., Doornbos, G. and Nauta, B.**

A sub-1-V Bandgap Voltage Reference in 32nm FinFET  
 Technology. 2009 IEEE International Solid-State Circuits  
 Conference (ISSCC), San Francisco, February 8-12, 2009. Digest  
 of Technical Papers, pp. 332-333, ISBN 978-1-4244-3457-2.

**Avsar, Z.M., Zijm, W.H.M. and Rodoplu, U.**

An approximate model for base-stock-controlled assembly  
 systems. *IIE transactions*, 41(3), pp. 260-274.

**Bagchi, A. and Suresh Kumar, K.**

Dynamic asset management with risk-sensitive criterion and  
 non-negative factor constraints: a differential game approach.  
*Stochastics: An International Journal of Probability and Stochastic*  
*Processes*, 81 (5). pp. 503-530. ISSN 1744-2508.

**Banerjee, A., Wolkotte, P.T., Mullins, R.D., Moore, S.W. and Smit, G.J.M.**

An Energy and Performance Exploration of Network-on-Chip  
 Architectures. *IEEE Transactions on Very Large Scale Integration*  
 (VLSI) *Systems*, 17 (3). pp. 319-329. ISSN 1063-8210

- Barnat, J., Chaloupka, J. and Pol, J.C. van de**  
Distributed Algorithms for SCC Decomposition. *Journal of Logic and Computation*, Advance Access published February 17, 2009, doi:10.1093/logcom/exp003. ISSN 0955-792X
- Basten, R.J.I., Schutten, J.M.J. and Heijden, M.C. van der**  
An efficient model formulation for level of repair analysis. *Annals of Operations Research*, 172(1), pp. 119-142.
- Bijnum, B.J.F. van, Pawar, P., Dulawan, C.B. and Hermens, H.J.**  
Mobile virtual communities for telemedicine: research challenges and opportunities. *International Journal of Computer Science & Applications*, 6 (2). pp. 19-37. ISSN 0972-9038
- Ben Allouch, S., Dijk, J.A.G.M. van and Peters, O.**  
The Acceptance of Domestic Ambient Intelligence Appliances by Prospective Users. In Tokuda, H., Beigl, M., Friday, A., Bernheim Brush, A.J. & Tobe, Y. (Eds.), *Lecture Notes in Computer Science Vol. 5538. Lecture notes in computer science* (pp. 77-94). Heidelberg Germany: Springer Verlag.
- Bentum, M.J., Verhoeven, C.J.M., Boonstra, A.J., Veen, A.J. van der and Gill, E.K.A.**  
A Novel Astronomical Application for Formation Flying Small Satellites, 60th International Astronautical Congress, Daejeon, Republic of Korea
- Bie, J. and Lo, H. K.**  
Stability and Attraction Domains of Traffic Equilibria in a Day-to-day Dynamical System Formulation, *Transportation Research Part B: Methodological*, Vol. 44(1) pp.90-107
- Blom, H.A.P., Bakker, G.J. and Krystul, J.**  
Rare event estimation for a large-scale stochastic hybrid system with air traffic application. In: *Rare Event Simulation using Monte Carlo Methods*. John Wiley & Sons, pp. 193-214. ISBN 9780470772690.
- Bodenstaff, L., Wombacher, A., Reichert, M.U. and Jaeger, M.C.**  
Analyzing Impact Factors on Composite Services. *Proceedings of the IEEE International Conference on Services Computing (SCC2009)*, Bangalore, India. pp. 218-226. IEEE Computer Society Press. ISBN 978-0-7695-3811-2
- Bolzoni, D., Etalle, S. and Hartel, P.H.**  
Panacea: Automating Attack Classification for Anomaly-based Network Intrusion Detection Systems. *Recent Advances in Intrusion Detection (RAID)*. pp. 1-20. *Lecture Notes in Computer Science* 5758. Springer Verlag. ISBN 978-3-642-04341-3
- Boucherie, R.J. and Dijk, N.M. van**  
Monotonicity and error bounds for networks of Erlang loss queues. *Queueing systems*, 62 (1-2). pp. 159-193. ISSN 0257-0130
- Brey, P.A.E. and Soraker, J.H.**  
Philosophy of Computing and Information Technology. In A. Meijers (Ed.), *Philosophy of Technology and Engineering Sciences (Handbook for Philosophy of Science, IX)*, pp. 1341-1408. Amsterdam: Elsevier
- Briggle, A.R. and Spence, E.H.**  
Cosmopolitan Friendship Online. In G. Watson, B.G. Renzi, E. Viggiani & M. Collins (Eds.), *Friends and Foes Volume II: Friendship and Conflict from Social and Political Perspectives*, pp. 53-64. Cambridge: Cambridge Scholar Publishing
- Broek, E.L. van den and Westerink, J.H.D.M.**  
Considerations for emotion-aware consumer products. *Applied Ergonomics*, 40(6), pp. 1055-1064
- Broenink, J.F. and Groothuis, M.A.**  
HW/SW Design Space Exploration on the Production Cell Setup, *Communication Process Architectures 2009*, Eindhoven, The Netherlands
- Broenink, J.F., Groothuis, M.A. and Bezemer, M.M.**  
Analysing gCSP Models Using Runtime and Model Analysis Algorithms, *Communicating Process Architectures 2009*, Eindhoven
- Buhan, I.R., Boom, B.J., Doumen, J.M., Hartel, P.H. and Veldhuis, R.N.J.**  
Secure pairing with biometrics. *International Journal of Security and Networks*, 4 (1/2). pp. 27-42. ISSN 1747-8405
- Burgwal, M.D. van de, Wolkotte, P.T. and Smit, G.J.M.**  
Non-power-of-Two FFTs: Exploring the Flexibility of the Montium TP. *International Journal on Reconfigurable Computing*, 2009. 678045. ISSN 1687-7195
- Burla, M., Garcia-Garcia, A., Zhuang, L., Meijerink, A., Roeloffzen, C.G.H., Marpaung, D.A.I., Khan, M.R.H. and Etten, W.C. van**  
Optical phase synchronization in coherent optical beamformers for phased array receive antennas, *IEEE Photonic society Annual Meeting 4-8 Oct 2009, Belek-Antalya, Turkey*. pp. 693-694. IEEE Computer Society Press. ISBN 978-1-4244-3681-1
- Chatterjea, S. and Havinga, P.J.M.**  
Improving temporal coverage of an energy-efficient data extraction algorithm for environmental monitoring using wireless sensor networks. *Sensors*, 9 (6). pp. 4941-4954. ISSN 1424-8220
- Chen, C., Veldhuis, R.N.J., Kevenaer, T.A.M. and Akkermans, A.H.M.**  
Biometric Quantization through Detection Rate Optimized Bit Allocation. *EURASIP Journal on Advances in Signal Processing*, 2009. 784834. ISSN 1687-6172
- Coeckelbergh, M.J.K.**  
Personal robots, appearance and the Good: A methodological reflection on roboethics. *International Journal of Social Robotics*.
- Curtain, R., Iftime, O.V. and Zwart, H.J.**  
System theoretic properties of a class of spatially invariant systems. *Automatica*, 45 (7). pp. 1619-1627. ISSN 0005-1098.
- Daniele, L.M., Ferreira Pires, L. and Sinderen, M.J. van**  
An MDA-based approach for behaviour modelling of context-aware mobile applications. In: *Proceedings of the Fifth European Conference on Model-Driven Architecture Foundations and Applications, ECMDA-FA 2009*, Enschede, The Netherlands. pp. 206-220. *Lecture Notes in Computer Science* 5562. Springer Verlag. ISBN 978-3-642-02673-7
- Doorn, E.A. van, Pollett, P.K.**  
Quasi-stationary distributions for reducible absorbing Markov chains in discrete time. *Markov Process. Related Fields* 15, pp. 191-204
- Doorn, E.A. van and Zeifman, A.I.**  
On the speed of convergence to stationarity of the Erlang loss system. *Queueing Syst.* 63, pp. 241-252

- De Alfaro, L., Faella, M. and Stoelinga, M.I.A.**  
Linear and Branching System Metrics. *IEEE Transactions on Software Engineering*, 35 (2). pp. 258-273. ISSN 0098-5589
- Deursen, A.J.A.M. van and Dijk, J.A.G.M. van**  
Using the Internet: Skill Related Problems in Users' Online Behavior. *Interacting with computers*, 21(5-6), 393-402
- Dijk, J. van and Winters-van Beek, A.**  
The Perspective of Network Government. In Albert Meijer, Kees Boersma & Pieter Wagenaar (Eds.), *ICTs, Citizens and Governance: After the Hype! (Innovation and the Public Sector (14))* (pp. 50-65). Amsterdam: IOS Press.
- Douma, A.M., Schutten, J.M.J. and Schuur, P.C.**  
Waiting profiles: An efficient protocol for enabling distributed planning of container barge rotations along terminals in the port of Rotterdam. *Transportation research Part C*, 17, pp. 133-148.
- Driessen, T.S.H. and Hu, C.C.**  
A note on equivalence of consistency and bilateral consistency through converse consistency, *Games and Economic Behavior* 65(2), pp. 644-648
- Drunen, A. van, Broek, E.L. van den, Spink, A.J. and Heffelaar, T.**  
Exploring workload and attention measurements with uLog mouse data. *Behavior Research Methods*, 41(3), pp. 868-875
- Eenennaam, E.M. van, Klein Wolterink, W., Karagiannis, G. and Heijnen, G.J.**  
Exploring the Solution Space of Beaconing in VANETs. In: *First IEEE Vehicular Networking Conference, VNC2009, 28-30 Oct 2009, Tokyo, Japan*. IEEE Communications Society. ISBN 978-1-4244-5687-1
- Etalle, S. and Winsborough, W.H.**  
Maintaining control while delegating trust: Integrity constraints in trust management. *ACM Transactions on Information and System Security*, 13 (1). 5. ISSN 1094-9224
- Eysink, T.H.S., Jong, T. de, Berthold, K., Kollöffel, B.J., Opfermann, M. and Wouters, P.**  
Learner performance in multimedia learning arrangements: An analysis across instructional approaches. *American Educational Research Journal*, 46, pp. 1107-1149.
- Fatemi, H., Sinderen, M.J. van and Wieringa, R.J.**  
From business value model to coordination process model. *Proceedings of the Second IFIP WG5.8 International Workshop on Enterprise Interoperability, IWEI 2009, 13-14 October 2009, Valencia, Spain*. pp. 94-106. *Lecture Notes in Business Information Processing* 38. Springer. ISSN 1865-1348 ISBN 978-3-642-04749-7
- Gao, X., Klumperink, E.A.M., Bohsali, M. and Nauta, B.**  
A Low Noise Sub-Sampling PLL in Which Divider Noise Is Eliminated and PD-CP Noise Is not multiplied by  $N^2$ . *Special issue of the IEEE Journal of Solid-State Circuits on ISSCC 2009*, vol.44, no.12, pp.3253-3263, Dec. 2009
- Gerven, M. van, Farquhar, J., Schaefer, R., Vlek, R., Geuze, J., Nijholt, A., Ramsay, N., Haselager, P., Vuurpijl, L., Gielen, S. and Desain, P.**  
The Brain-Computer Interface Cycle. *Journal of Neural Engineering*, 6 (4). pp. 1-10.
- Geurs, K.T., W. Boon, W. and Wee, B. van**  
Social impacts of transport: literature review and state-of-the-practice transport appraisal in the Netherlands and the United Kingdom. *Transport Reviews* 29(1): 69-90
- Gijlers, A.H. and Jong, T. de**  
Sharing and confronting propositions in collaborative inquiry learning. *Cognition and instruction*, 27, pp. 239-268.
- Gijlers, A.H., Saab, N., Joolingen, W.R. van, Jong, T. de and Hout-Wolters, B.H.A.M. van**  
Interaction between tool and talk: How instruction and tools support consensus building in collaborative inquiry learning environments. *Journal of Computer Assisted Learning*, 25, pp. 252-267.
- Göknil, A., Kurtev, I., Berg, K.G. van den and Veldhuis, J.-W.**  
Semantics of trace relations in requirements models for consistency checking and inferencing. *Software and Systems Modelling, Online*. ISSN 1619-1366
- Gong, Z., Hartel, P.H., Nikova, S.I. and Zhu, B.**  
Towards Secure and Practical MACs for Body Sensor Networks. *10th International Conference on Cryptology in India (INDOCRYPT), 13-16 Dec 2009, New Delhi, India*. pp. 182-198. *Lecture Notes in Computer Science* 5922. Springer Verlag. ISBN 978-3-642-10627-9
- Groothuis, M.A., Frijns, R.M.W., Voeten, J.P.M. and Broenink J.F.**  
Concurrent Design of Embedded Control Software, in: *Proceedings of the 3rd International Workshop on Multi-Paradigm Modelling (MPM2009), EASST, ECEASST*.
- Güleşir, G., Berg, K.G. van den, Bergmans, L.M.J. and Akşit, M.**  
Experimental evaluation of a tool for the verification and transformation of source code in event-driven systems. *Empirical Software Engineering*, 14. pp. 720-777. ISSN 1382-3256
- Gurov, D. and Huisman, M.**  
Reducing Behavioural to Structural Properties of Programmes with Procedures. In: *Verification, Model Checking, and Abstract Interpretation, January 18-20, 2009, Savannah, GA, USA*. pp. 136-150. *Lecture Notes in Computer Science* 5403. Springer Verlag. ISBN 978-3-540-93899-6
- Haan, R. de, Boucherie, R.J. and Ommeren, J.C.W. van**  
A polling model with an autonomous server. *Queueing systems*, 62 (3). pp. 279-308. ISSN 0257-0130
- Han, T., Katoen, J.P. and Damman, B.**  
Counterexample Generation in Probabilistic Model Checking. *IEEE Trans. Software Eng.* 35(2): 241-257 (2009) ISSN 0098-5589
- Heskamp, M., Schiphorst, R. and Slump, C.H.**  
Chapter 16: Public safety and cognitive radio. In: *Cognitive Radio Communications and Networks*. Elsevier, pp. 467-488. ISBN 978-0-12-374715-0
- Heydenreich, B., Müller, R., Uetz, M. and Vohra, R.**  
Characterization of revenue equivalence, *Econometrica*, 77(1), 2009, pp. 307-316
- Hölzenspies, P.K.F., Braak, T.D. ter, Kuper, J., Smit, G.J.M. and Hurink, J.L.**  
Run-time Spatial Mapping of Streaming Applications to Heterogeneous Multi-Processor Systems. *International Journal of Parallel Programming*, 38 (1). pp. 68-83. ISSN 1573-7640

**Iacob, M.E., Jonkers, H., Lankhorst, M. and Proper, E.**  
ArchiMate 1.0 Specification. Zaltbommel: Van Haren Publishing

**Jacob, B. and Zwart, H.J.**  
On the Hautus test for exponentially stable  $C_0$ -groups. SIAM Journal on Control and Optimization, 48 (3). pp. 1275-1288. ISSN 0363-0129

**Jong, T. de, Gog, T. van, Jenks, K., Manlove, S.A., Hell, J.G. van, Jolles, J., Merrienboer, J.J.G. van, Leeuwen, T.H. and Boschloo, A.**  
Explorations in learning and the brain: On the potential of cognitive neuroscience for education. New York: Springer

**Jongerden, M.R. and Haverkort, B.R.H.M.**  
Which battery model to use? IET Software, 3 (6). pp. 445-457. ISSN 1751-8806

**Jonker, P., Still, G. and Twilt, F.**  
On the stratification of a class of specially structured matrices, Optimization 58(6), 2009, pp. 685-712

**Joosten, R.J.**  
Paul Samuelson's critique and equilibrium concepts in evolutionary game theory, Papers on Economics and Evolution #0916, ISSN 1430-4716, Max Planck Institute on Economics

**Joosten, R.J.**  
Strategic Advertisement with Externalities: A New Dynamic Approach, in: Modelling, Computation and Optimization (S.K. Neogy, A.K. Das & R.B. Bapat, eds.), ISBN 978-9-8142-7350-3, pp. 21-43

**Kallenberg, W.C.M.**  
Estimating copula densities, using model selection techniques. Insurance Math. Econom. 45, pp. 209-223.

**Kerkhoff, H.G. and Zhang, Xiao**  
Fault co-simulation for test evaluation of heterogeneous integrated biological systems. Microelectronics Journal, ISSN 0026-2692

**Kern, W. and Paulusma, D.**  
On the core and  $f$ -nucleolus of flow games Mathematics of Operations Research, 34(4), pp. 981-991

**Keulen, M. van and Keijzer, A. de**  
Qualitative Effects of Knowledge Rules and User Feedback in Probabilistic Data Integration. The VLDB Journal, 18 (5). pp. 1191-1217. ISSN 1066-8888

**Kordy, P.T., Langerak, R. and Polderman, J.W.**  
Re-verification of a Lip Synchronization Algorithm using robust reachability. In: Formal Methods for Aerospace, 03 Nov 2009, Eindhoven, The Netherlands. Technische Universiteit Eindhoven

**Laird, J., Geurs, K. and Nash, C.**  
Option and non-use values and rail project appraisal. Transport Policy 16(4): 173-182

**Law, Y.W., Palaniswami, M., Hoesel, L.F.W. van, Doumen, J.M., Hartel, P.H. and Havinga, P.J.M.**  
Energy-Efficient Link-Layer Jamming Attacks against Wireless Sensor Network MAC Protocols. ACM Transactions on Sensor Networks, 5 (1). 6. ISSN 1550-4859

**Lazonder, A.W., Wilhelm, P. and Lieburg, E. van**  
Unraveling the influence of domain knowledge during simulation-based inquiry learning. Instructional science, 37, pp. 437-451

**Leferink F.B.J.**  
Educating electromagnetic effects using printed circuit board demos, International Symposium on Electromagnetic Compatibility, 20-24 Jun 2009, Kyoto, Japan. pp. 165-168. Institute of Electronics, Information and Communication Engineers. ISBN 978-4-88552-239-0

**Litvak, N. and Ejov, V.**  
Markov chains and optimality of the Hamiltonian cycle. Mathematics of operations research, 34 (1). pp. 71-82. ISSN 0364-765X

**Litvak, N., Scheinhardt, W.R.W. and Volkovich, Y.V.**  
In-Degree and PageRank of web pages: why do they follow similar power laws?. Internet mathematics, 4 (2-3). pp. 175-198. ISSN 1542-7951

**Liu, F. and Heijenk, G.J.**  
On the impact of network dynamics on a discovery protocol for ad-hoc networks. International Journal of Business Data Communications and Networking, 5 (2). pp. 16-34. ISSN 1548-0631

**Lombriser, C., Marin-Perianu, R.S., Roggen, D., Havinga, P.J.M. and Tröster, G.**  
Modelling Service-Oriented Context Processing in Dynamic Body Area Networks. IEEE Journal on Selected Areas in Communications, 27 (1). pp. 49-57. ISSN 0733-8716

**Malakuti Khah Olun Abadi, S., Bockisch, C.M. and Akşit, M.**  
Applying the Composition Filter Model for Runtime Verification of Multiple-Language Software. In: The 20th annual International Symposium on Software Reliability Engineering, ISSRE 2009, 16-19 Nov 2009, Mysore, India. pp. 31-40. IEEE Computer Society Press. ISBN 978-0-7695-3878-5

**Manthey, B.**  
k-Means Has Polynomial Smoothed Complexity, Proc. 50th Ann. Symp. on Foundations of Computer Science, IEEE, 2009, pp. 405-414

**Marpaung, D.A.I., Roeloffzen, C.G.H. and Etten, W.C. van**  
Enhanced dynamic range in a directly modulated analog photonic link, IEEE Photonics Technology Letters, 21 (24). pp. 810-812, 2009. ISSN 1041-1135

**Meijer, F., Geudeke, B.L. and Broek, E.L. van den**  
Navigating through Virtual Environments: Visual realism improves spatial cognition. CyberPsychology and Behavior, 12(5), pp. 517-521

**Mes, M.R.K., Heijden, M.C. van der and Schuur, P.C.**  
Dynamic threshold policy for delaying and breaking commitments in transportation auctions. Transportation Research Part C, 17(2), pp. 208-223.

**Molderink, A., Bosman, M.G.C., Bakker, V., Hurink, J.L. and Smit, G.J.M.**  
Simulating the effect on the energy efficiency of smart grid technologies. In: Proc. Winter Simulation Conference, IEEE, 2009, pp. 13-16

**Moody, D.L.**  
The "Physics" of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. IEEE Transactions on Software Engineering, 35(6), pp. 756-779

- Nahuis, R.**  
The rise and fall of self-service in Amsterdam trams: User technology relations in a case of service innovation. *Technology Analysis and Strategic Management*, 21(2), pp.233-247
- Nguyen, V.Y. and Ruys, T.C.**  
Memoised Garbage Collection for Software Model Checking. In: *Proceedings of the 15th International Conference on Tools and Algorithms for the Construction and Analysis of Systems (TACAS 2009)*, 22-29 March 2009, York, UK. pp. 201-214. *Lecture Notes in Computer Science* 5505. Springer Verlag. ISBN 978-3-642-00767-5
- Nijholt, A., Zwiers, J. and Peciva, J.**  
Mixed reality participants in smart meeting rooms and smart home environments. *Journal of Personal and Ubiquitous Computing*, 13 (1). pp. 85-94
- Nooij, R. de, Kallenberg, L.A.C. and Hermens, H.J.**  
Evaluating the effect of electrode location on surface EMG amplitude of the m. erector spinae p. longissimus dorsi. *Journal of Electromyography and Kinesiology*, 19 (4). e257-e266. ISSN 1050-6411
- Nurdin, H.I., Mazumdar, R.R. and Bagchi, A.**  
Reduced-dimension linear transform coding of distributed correlated signals with incomplete observations. *IEEE Transactions on Information Theory*, 55 (6). pp. 2848-2858. ISSN 0018-9448
- Oost, E. van, Verhaegh, S. and Oudshoorn, N.**  
From Innovation Community to Community Innovation: User-initiated Innovation in Wireless Leiden. *Science. Technology & Human Values*. Issue 34, nr.2, pp. 182-205
- Oost, E. van, Verhaegh, S. and Oudshoorn, N.**  
Community based innovation. In: *The genesis of Wi-Fi and the road toward global success*. Oxford University Press
- Oude Alink, M.S., Kokkeler, A.B.J., Klumperink, E.A.M., Rovers, K.C., Smit, G.J.M. and Nauta, B.**  
Spurious-Free Dynamic Range of a Uniform Quantizer. *IEEE transactions on circuits and systems II: Express Briefs*, Volume 56 (6). pp. 434-438. ISSN 1549-7747
- Oudshoorn, N.**  
Zorg op afstand. De politiek van draagbare ECG apparatjes. In F. Bolkestein et al (eds). *De Politiek der Dingen*. Uitgeverij Damon
- Oudshoorn, N.**  
Physical and digital proximity. Emerging ways of healthcare in face-to-face and telemonitoring of heart-failure patients. *Sociology of Health & Illness*, vol 31 (3), pp. 390-405
- Pantic, M. and Vinciarelli, A.**  
Implicit Human-Centered Tagging. *IEEE Signal Processing Magazine*, 26 (6). pp. 173-180
- Pantic, M. and Cohn, J.F.**  
Visual and multimodal analysis of human spontaneous Behaviour: Introduction to the Special Issue. *Image and Vision Computing*, 27 (12). pp. 1741-1742
- Pieters, W. and Cleeff, A. van**  
The Precautionary Principle in a World of Digital Dependencies. *IEEE Computer*, 42 (6). pp. 50-56. ISSN 0018-9162
- Pieterse, W.**  
Channel choice : citizens' channel behavior and public service channel strategy. UT Universiteit Twente (295 pag.) (Enschede: Universiteit Twente).
- Ponisio, M.L., Eck, P.A.T. van and Riemens, L.**  
eCustoms Case Study: Mechanisms behind Co-operation Planning. *Proceedings of the IADIS International Conference e-Commerce 2009*, 19-21 June 2009, Algarve, Portugal. pp. 35-44. IADIS Press. ISBN 978-972-8924-89-8
- Pras, A., Nieuwenhuis, L.J.M. Meent, R. van de and Mandjes, M.R.H.**  
Dimensioning Network Links: A New Look at Equivalent Bandwidth. *IEEE Network*, 23 (2). pp. 5-10. ISSN 0890-8044
- Reilink, R., Visser, L.C., Bennik, J., Carloni, R., Brouwer, D.M. and Stramigioli, S.**  
The Twente humanoid head, *IEEE International Conference on Robotics and Automation, ICRA 2009*, Kobe, Japan, pp. 1593-1594
- Ritsema, C.J., Kuipers, H., Kleiboer, L., Elsen, E. van den, Oostindie, K., Wesseling, J.G., Wolthuis, J.-W. and Havinga, P.J.M.**  
A new wireless underground network system for continuous monitoring of soil water contents. *Water Resources Research*, 45. pp. 1-9. ISSN 0043-1397
- Roc'h, A., Iannarelli, R. and Leferink F.B.J.**  
New materials for Inductors. *EMC Europe 2009*, 11-12 jun 2009, Athens, Greece. pp. 1-4. *IEEE Computer Society Press*. ISBN 978-1-4244-4107-5
- Roorda, B. and Schumacher, J.M.**  
Time Consistency of Nonconvex Risk Measures. *Discussion Paper*. Tilburg, The Netherlands: Netspar, Network for Studies on Pensions, Aging and Retirement
- Ru, Z., Moseley, N. A., Klumperink, E.A.M. and Nauta, B.**  
Digitally-Enhanced Software-Defined Radio Receiver Robust to Out-of-Band Interference. *Special issue of the IEEE Journal of Solid-State Circuits on ISSCC 2009*, vol.44, no.12, pp.3359-3375, Dec. 2009
- Shao, X., Schiphorst, R. and Slump, C.H.**  
An Opportunistic Error Correction Layer for OFDM Systems. *EURASIP Journal on Wireless Communications and Networking*, 2009 (2009). 750735. ISSN 1687-1499
- Schinkel, D., Mensink, E., Klumperink, E.A.M., Tuijl, A.J.M. van and Nauta, B.**  
Low-Power, High-Speed Transceivers for Network-on-Chip Communication. *IEEE transactions on Very Large Scale Integrations (VLSI) Systems*, January 2009, vol 17, nr 1, pp 12-21
- Schmettow, M.**  
Controlling the Usability Evaluation Process under Varying Defect Visibility. In Alan F. Blackwell (Ed.), *Proceedings of the HCI 2009*
- Schotanus, F., Telgen, J. and Boer, L. de**  
Unraveling quantity discounts. *Omega*, 37(3), pp. 510-521
- Schraagen, J.M.C.**  
Designing training for professionals based on subject-matter experts and cognitive task analysis. In K.A. Ericson (Ed.), *Development of professional expertise: Toward measurement of expert performance and design of optimal learning environments*, pp. 157-179. New York: Cambridge University Press

**Serdyukov, P., Murdock, V. and Zwol, R. van**

Placing Flickr Photos on a Map. In: Proceedings of the 32nd international ACM SIGIR conference on Research and development in information retrieval, 19-23 Jul 2009, Boston, USA. pp. 484-491. ACM. ISBN 978-1-60558-483-6 5

**Soer, M.C.M., Klumperink, E.A.M., Ru, Z., Vliet, F.E. van and Nauta, B.**

A 0.2-to-2.0GHz CMOS Receiver without LNA achieving >11dBm IIP3 and <6.5 dB NF. 2009 IEEE International Solid-State Circuits Conference (ISSCC), San Francisco, February 8-12, 2009, Digest of Technical Papers, pp. 222-223, ISBN 978-1-4244-3457-2.

**Spence, E.H.**

A Universal Model for the Normative Evaluation of Internet Information. *Ethics and Information Technology*, 11(4)

**Spil, A.A.M., LeRouge, C., Trimmer, K. and Wiggins, C.**

IT Adoption and evaluation in healthcare: Evolution and Insights in Theory, Methodology and Practice. *International Journal of Healthcare Information Systems and Informatics*, 4(3), pp. 69-96

**Stramigioli, S., Carloni, R. and Visser, L.C.**

Vision based motion control for a humanoid head, Proceedings of the RSJ/IEEE International Conference on Intelligent Robots and Systems, 2009, Saint Louis, Missouri, USA, pp. 5469-5474

**Tao, Q. and Veldhuis, R.N.J.**

Threshold-optimized decision-level fusion and its application to biometrics. *Pattern Recognition*, 42 (5). pp. 823-836. ISSN 0031-3203

**Thomas, T. and Berkum, E.C. van**

Detection of Incidents and Events in Urban Networks, *IET Intelligent Transport Systems*, 2009, Vol. 3, 2, pp. 198-205

**Thomas, T., Weijermars, W.A.M. and Berkum, E.C. van**

Predictions of Urban Volumes in Single Time Series, *IEEE Transactions on Intelligent Transportation Systems*, accepted and forthcoming

**Trieschnigg, R.B., Pezik, P., Lee, V., Jong, F.M.G. de, Kraaij, W. and Rebholz-Schuhmann, D.**

MeSH Up: effective MeSH text classification for improved document retrieval. *Bioinformatics*, 25 (11). pp. 1412-1418

**Voerman, G.E., Fleuren, J.F.M., Kallenberg, L.A.C., Rietman, J.S., Snoek, G.J. and Hermens, H.J.**

Patient ratings of spasticity during daily activities are only marginally associated with long-term surface electromyography. *Journal of Neurology, Neurosurgery, and Psychiatry*, 80 (2). pp. 175-181. ISSN 0022-3050

**Verbeek, P.P.C.C.**

Ambient Intelligence and Persuasive Technology: The Blurring Boundaries Between Human and Technology. *Nanoethics*, 3(3), pp. 231-242

**Weering, M.G.H. van, Vollenbroek-Hutten, M.M.R., Tonis, T.M. and Hermens, H.J.**

Daily physical activities in chronic lower back pain patients assessed with accelerometry. *European Journal of Pain*, 13 (6). pp. 649-654. ISSN 1090-3801

**Widya, I.A., Bults, R.G.A., Beijnum, B.J.F. van, Sandsjö, L., Schaake, L., Huis in 't Veld, M.H.A., Jones, V.M. and Hermens, H.J.**

Requirements Elicitation in a Telemedicine Pain-treatment Trial. In: 17th IEEE International Requirements Engineering Conference, 31 Aug - 4 Sep 2009, Atlanta, GA, USA. pp. 309-314. IEEE Computer Society Press. ISSN 1090-705X ISBN 978-0-7695-3761-0

**Wieringa, R.J.**

Design Science as Nested Problem Solving. Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology, Philadelphia. pp. 1-12. ACM. ISBN 978-1-60558-408-9

**Wijngaert, L. van de and Bouwman, H.**

Would you share? Predicting the potential use of a new technology. *Telematics and Informatics*, 26 (2009), 85-102

**Wijnhoven, A.B.J.M.**

Information Management An informing approach. London: Routledge

**Wombacher, A.**

Alignment of Choreography Changes in BPEL Processes. In: Proceedings IEEE International Conference on Services Computing (SCC2009), 21-25 September 2009, Bangalore, India. pp. 1-8., IEEE Computer Society Press. ISBN 978-0-7695-3811-2

**Wouters, M., Anderson, J., Narus, J. and Wynstra, F.**

Improving sourcing decisions in NPD projects: Monetary quantification of points of difference. *Journal of Operations Management*, 27 (1): pp. 64-77

**Wouters, M.**

A Developmental approach to performance measures—Results from a longitudinal case study. *European Management Journal*, 27 (1): pp. 64-78

**Xu, H., Veldhuis, R.N.J., Bazen, A.M., Kevenaer, T.A.M., Akkermans, A.H.M. and Gokberk, B.**

Fingerprint Verification Using Spectral Minutiae Representations. *IEEE Transaction on Information Forensics and Security*, 4 (3). pp. 397-409. ISSN 1556-6013

**Zarifi Eslami, M. and Sinderen, M.J. van**

Flexible home care automation adapting to the personal and evolving needs and situations of the patient. 3rd International Conference on Pervasive Computing Technologies for Healthcare, 2009. *Pervasive Health 2009*, 31 Mar 2009, London, UK. pp. 1-2. IEEE. ISBN 978-963-9799-42-4

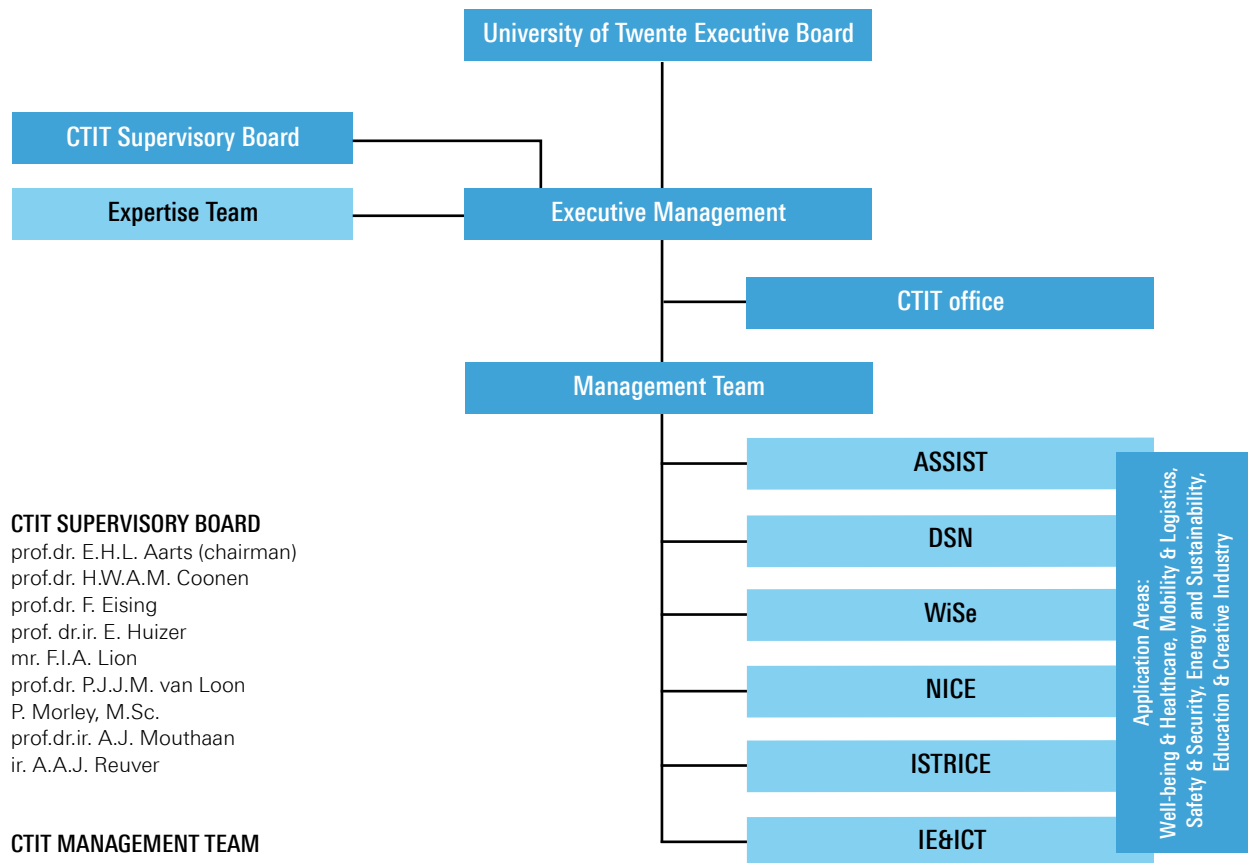
**Zhang, Yang, Meratnia, N. and Havinga, P.J.M.**

Why General Outlier Detection Techniques Do Not Suffice For Wireless Sensor Networks? In: *Intelligent Techniques for Warehousing and Mining Sensor Network Data*. IGI Global. ISBN 978-1-60566-328-9

**Zonderland, M.E., Boer, F., Boucherie, R.J., Roode, A. de and Kleef, J.W. van**

Redesign of a university hospital preanesthesia evaluation clinic using a queuing theory approach. *Anesthesia & Analgesia*, 109 (5). pp. 1612-1621. ISSN 0003-2999

# ORGANIZATION



# ADDRESSES

## CTIT (CENTRE FOR TELEMATICS AND INFORMATION TECHNOLOGY)

Scientific director: prof.dr. P.M.G. Apers  
 Business director: drs. I. Bante  
 Project officer: drs. W.G. Hiddink  
 Secretaries: mrs. A.E. Davidson and mrs. A.G.H. Westhoff  
 Address: University of Twente, CTIT  
 P.O. Box 217  
 7500 AE Enschede  
 the Netherlands  
 Telephone: +31 (53) 4898031 / 4893994  
 Fax: +31 (53) 4891070  
 E-mail: office@ctit.utwente.nl  
 Website: www.ctit.utwente.nl

## VISITING ADDRESS

The CTIT is located on the campus of the University of Twente, building Zilverling, Enschede.

## DIRECTIONS TO CTIT

By car:  
 Take the A35 direction Enschede exit Enschede-West and follow signposts to UNIVERSITEIT.

## BY TRAIN/BY BUS:

You can reach the university from the railway stations at Hengelo, Enschede and Drienerlo. There is a bus in the direction of the university about every half an hour.

For more information on public transport, please call the campus: +31 (53) 4899111.



Secretary:  
Sandra Westhoff



Secretary:  
Miranda Davidson



Project officer:  
Wilma Hiddink



Staff member:  
Jorien van Loon



CTIT's Secretariat:  
Trudie Godwaldt, Ida den Hamer, Ellen ter Brugge,  
Sandra Westhoff and Miranda Davidson

