KoF 2011 Evaluation Document

Department of Information Technology

Håkan Lanshammar, Head of Department
   Professor of Automatic Control and Systems Analysis

Joachim Parrow
   Professor of Computing Science

Bengt Jonsson
   Professor of Computer Systems

Bengt Sandblad
   Professor of Human-Computer Interaction

Torsten Söderström
   Professor of Automatic Control

Gunilla Kreiss
   Professor of Numerical Analysis

Sverker Holmgren
   Professor of Scientific Computing
Reading Instructions

Information Technology at Uppsala University is a large department which since 2011-01-01 comprises six divisions encompassing six research programs, see below. However, during 2007-2010 (the period covered by this evaluation), the structure was slightly different. Thus, this report refers to this old structure where the IT-department consisted of five divisions and six research programs:

- The Division of Computing Science (Research program Computing Science) [1/7]
- The Division of Computer Systems (Research program Computer Systems) [2/7]
- The Division of Human-Computer Interaction (Research program Human-Computer Interaction) [1/7]
- The Division of Systems and Control (Research program Automatic Control) [1/7]
- The Division of Scientific Computing (Research programs Numerical Analysis and Computational Science) [2/7]

The quotient in square brackets corresponds approximately to the relative contribution to the total size of the department.

In the KoF 2011 evaluation, the six research programs will be scrutinized by different panels:

**Panel 12:** This panel evaluates in total seven research programs: Divisions of Systems and Control (one research program) and Scientific Computing (two research programs) at the Department of Information Technology, together with the Department of Mathematics (three research programs) and the Centre for Image Analysis (one research program).

**Panel 18:** This panel evaluates three research programs, all at the Department of Information Technology: Divisions of Computing Science, Computer Systems, and Human-Computer Interaction (one research program each).

To facilitate the evaluation we have chosen to explicitly partition most of the presentation below between the divisions. However, the report also contains several brief general sections covering the whole department. Also, the major multidisciplinary research centres associated with the department are presented at the department level.

All references cited in the text are available at [http://www.it.uu.se/research/references/KoF2011](http://www.it.uu.se/research/references/KoF2011). Selected references are also listed in Sections A4 and A5. The format of the reference identifiers is Xnn, where X is a letter that identifies a division according to:

- D Computing Science
- C Computer Systems
- H Human-Computer Interaction
- S Systems and Control
- N Scientific Computing
- E Computing Education Research

From 2011-01-01, the Centre for Image Analysis is part of the IT department, as the Division of Image Analysis, while the research in computerized image analysis is coordinated with the research in human-computer interaction within the new research program Image Analysis and Human-Computer Interaction.
Executive Summary

- We are scientifically strongest and leading the research in Sweden in critical areas for the future development of society.
- In some areas, our research groups have been deemed to be world-leading in other recent international evaluations.
- During the last years, our research has developed towards a stronger focus on larger, coherent research initiatives, and larger external grants, involving several groups within the department and often also external partners.
- Besides continuing our research in areas where we are already very strong, we are moving into new exciting areas. Parallel software is a key topic for much of our research. We also have an increasing engagement in Biomedical IT and in IT for sustainability.
- The societal impact of our education and research is high and continuously rising. Our alumni are to a large extent active in strategically important companies of all sizes, from start up’s to large size corporations like Ericsson AB and ABB.
- We are proud that we are developing very strongly and now have close to 10% of the faculty resources for research. The target for 2015 is 40 MSEK as a base resource (Basresurs), i.e. 15% of the current total faculty resources.
- We have over 20% of the undergraduate and graduate teaching of the faculty, and 15% on the doctorate level.
- Our research should be defined as a core area for Uppsala University in its strategic planning.
- Our former students and PhD graduates have an excellent labour market.
GLOSSARY

Below, a number of specific “local” acronyms used in the text, mainly referring to major research projects, are explained for easy reference.

CoDeR-MP (Computationally Demanding Real-Time Applications on Multicore Platforms): Funded by the Foundation for Strategic Research (SSF), 20 MSEK for 2009-2014. Focus on software development for and migration to embedded multicore platforms. Involves divisions of Computer Systems and Systems and Control and e.g. ABB, SAAB Systems.

eSSENCE: National strategic research effort in e-Science funded by the Ministry of Education, 102 MSEK for 2010-2014 with anticipated continuation. A cross-disciplinary effort (including also groups at the Universities in Lund and Umeå) on the development of e-Science tools in a span of areas. Involves divisions of Scientific Computing (also hosts the co-director of eSSENCE) and Computing Science.

CIM (Centre for Interdisciplinary Mathematics): Centre funded by Uppsala University (currently 3,8 MSEK/year) facilitating joint research between the mathematical sciences and other disciplines. Involves researchers at the divisions of Scientific Computing (also hosts the Director of CIM) and Systems and Control.


SSPI (Scalable search of product life cycle information): Funded by SSF, 24 MSEK for 2009-2013). Developing software systems for efficient and scalable search of product data and meta-knowledge produced during the entire product life cycle. Involves researchers at the Division of Computing Science and also researchers at Luleå Technical University.

SysTEAM (Systems and Signals Tools for Estimation and Analysis of Mathematical Models in Endocrinology and Neurology): Concentrated around an ERC Advanced Grant, 25 MSEK for 2010-2014. Develops innovative and agile model-based tools for application in biology and medicine. Involves researchers at the Division of Systems and Control and at the Uppsala University Hospital.

UPMARC (Uppsala Programming for Multicore Architectures Research Center): A Linnaeus centre of excellence (the only one in Computer Science) funded by the Swedish Research Council, 62 MSEK for 2009-2018. Focusing on programming for multicore platforms. The project involves researchers at the divisions of Computing Science, Computer Systems and Scientific Computing.

WISENET: A VINN-excellence centre funded by the Swedish Agency for Innovation (VINNOVA), 62 MSEK for 2007-2017 (matched by equal amount of industry funding). Interdisciplinary research on wireless sensor networks. Involves researchers at the Division of Computer Systems, other academic groups and 14 industrial partners.

VA-kluster Mälardalen: A cross-disciplinary research and education consortium within the water and sanitation area. Involves researchers at the Division of Systems and Control, and also Royal Institute of Technology (KTH), Swedish University of Agricultural Sciences (SLU), Mälardalen University (MDH), Lund University, six wastewater utilities in Mälardalen, and the Swedish Environmental Research Institute.
A: Strategic aspects on research

A1: Summary of research activities

The research at the Department of Information Technology (DIT) spans over a complete set of fields, during the period covered by the KoF 2011 evaluation comprising six interacting research programs in Computing Science, Computer Systems, Human-Computer Interaction, Automatic Control, Numerical Analysis and Computational Science. Particularly strong and large groups, performing leading research at the international front-line, are found in areas like

- Specification, verification, and analysis of embedded and parallel programs.
- Signal processing and system identification.
- Construction, analysis and implementation of numerical methods for partial differential equations.

DIT is one of the largest departments in the Faculty, hosting in total 199 employees, including 25 full professors and about 100 PhD students. Since DIT was formed by merging five smaller departments in 1999, 116 PhD and 95 Licentiate degrees have been awarded.

The research at DIT is performed in both pure and applied fields in an overall healthy balance. The department leads or is heavily involved in a number of interdisciplinary centres of excellence, strategic research efforts and other major research projects further described in the Glossary (page 4). Researchers at DIT are active in a large number of collaborative projects with groups at other leading universities all over the world (see Section B3) as well as across various fields of business and the public sector (see Section B4). Many of the professors have industrial experience with continuing ties. The department also hosts several outstanding individual researchers, e.g. a recipient of ERC Advanced Grants, two ISI Highly Cited Researchers, one member of the European Academy of Sciences, and one member of the Royal Society of Sciences (the oldest scientific society in Sweden).

DIT research is effective and productive, see Figure 1.

![Figure 1. Key indicators for the IT department, expressed as % of Faculty of Science and Technology, Uppsala University totals. (FTE=Full Time Equivalents, Source: GLIS)](image)

The research at the department is conducted in vibrant and expanding fields, where an ability to adjust and initiate new research directions is essential. During recent years, several new faculty-funded professorships have been initiated, for example in Computer Architecture, Databases, Computer Communication, Embedded Systems and Computational Science. Even
though resources are limited several researchers at international top level have been recruited, also to junior tenure-track positions.

The department has extensive research activities, which also provides an excellent foundation for both graduate and undergraduate education. The number of Bachelor and Master level student is about 4000 annually, corresponding to 1000 full time students. In 2009 the Department was selected as the Teaching Department of the Year by the University Student Union. This extensive engagement in education is complemented and supported by the UpCERG initiative pursuing research in computing and engineering education\textsuperscript{1,2,3}. This effort involves researchers from the divisions of Computer Systems, Human-Computer Interaction and Scientific Computing. The mission is to contribute to a deeper understanding of student learning processes in computing, and the relationship between student learning, the computing curriculum, and the higher education learning environment. The group conducts research in three major areas; student learning and conceptual development in computer science and engineering, with the aim of improving student learning and teaching methods, E-learning and information and communication technologies in learning, and theoretical research on the manner in which learning takes place in Computer Science. UpCERG is one of the most influential groups in the Nordic region in its field, and has a strong international and national profile. The group directs the CeTUSS center, a Swedish National Centre for Student Centred Learning in Engineering, and is a core node in the Nordic Network for Engineering Education Research (NNEER) funded by NordForsk. Group members currently serve as Chair of the IEEE FIE Conference Steering Committee and are represented on the programme committees and editorial boards of many major international conferences in Education Research operating under the auspices of the IEEE and ACM.

Our vision for the coming 5 years is that our research fields will be recognized in strategies and actions as one of the university’s golden nuggets and a key player when it comes to present and future challenges. Our firm theoretical basis in combination with established collaborative efforts with other fields give us an excellent position in meeting scientific as well as societal challenges.

When it comes to sustainability, our efforts related to multicore, networked and embedded systems, simulation based science and engineering, handling and analysis of data, energy conservation, traffic control, management of water resources, usability and ethics, are highly relevant. Another challenge is related to the ageing population, where we have activities in biomedical and health care systems, systems/molecular biology, image analysis and visualization.

**Actions that would Improve the Quality of the Department’s Research**

We gratefully acknowledge that during the last few years we have obtained a more reasonable share of faculty resources for research than before. However, it is still clear that we have a potential to expand our PhD program considerably. In contrast to many other disciplines, our PhDs are highly appreciated in industry as well as academia, and we clearly see that they get highly qualified positions in strategically important companies for Sweden, established as well as start-ups. We propose that the university takes a more strategic approach to PhD education, focussing resources to programs where PhDs are produced that are highly demanded in industry and society.

Considering also the fact that our department has more than 20% of the Bachelor and Master level students of the faculty, we strongly argue that our basic faculty funding (Basresurs) for research should be at least 15% of the faculty total, in today’s value corresponding to 40 MSEK. This would enable us to increase the volume of our PhD programs and reach 20% of
the faculty total, which would be advantageous for Uppsala University and for the future development of Sweden.

We also point out that it is crucial for us to maintain and further develop our base of excellent teachers, who are also active researchers. We therefore need economic resources to ensure that the teaching staff can also be active researchers. The departments have a strategic resource of faculty funded research that can only be used for temporary employments, primarily PostDocs. In the past, this resource was partially used to fund the research for selected professors, and we consider it to be an obstacle that this is no longer possible. We suggest that this resource, labelled as general time limited resource (Allmän tidsbegränsad resurs) is opened up so that it can be used in a way that strategically suits the department best.

To meet present and future challenges like the strive for a sustainable development, and an ageing population, information technology is a major enabling factor. Here Uppsala University has a golden opportunity to take a leading role by selecting the research in the Department of Information Technology as a core area. A recent governmental enquiry pointed out Uppsala University as the scientifically strongest in Sweden in computer science and mathematics. According to this study, our research together with mathematics is in fact the strongest research area at Uppsala University among all areas where our University has the leading role in Sweden.

![Figure 2. The strength of computer science/mathematics at Swedish universities, according to a recent governmental enquiry (SOU 2007:81, Nov 2007). The numbers are equivalent number of full time researchers performing on world average level. In Uppsala this is accomplished by about half that number of researchers. The analysis is based on bibliometry.](image-url)

Below, the research activities at each division are summarized.

**Division of Computing Science**

We conduct research in the areas of semantics and process calculi, database technology, programming language technology, and combinatorial problem solving. Researchers at the division participate in the major research projects PROFUN, UPMARC and SSPI and also within the strategic research area effort eSSENCE.

In semantics and process calculi the goal is to provide semantic models for a variety of parallel and mobile systems, based on the pi-calculus and its subsequent variants (the fusion
calculus\textsuperscript{D23} and recent psi-calculi\textsuperscript{D4}). We develop formal semantic definitions, proof systems, analysis methods and tools.

In database technology we develop methods and techniques for scalable management of data from distributed and heterogeneous data sources\textsuperscript{D6}. Emphasis is on optimization strategies for search, analyze, and integration of data from data streams\textsuperscript{D7}, databases, data producing equipment\textsuperscript{D8,9}, and other data sources\textsuperscript{D11} utilizing modern distributed computing environments\textsuperscript{D10}.

In combinatorial problem solving, we work on the theory\textsuperscript{D3,15,16,20} of constraint programming, that is the modelling and efficient solving of combinatorial problems, by global or local search, with applications in sensor networks\textsuperscript{D13}, verification, air traffic management\textsuperscript{D14,21}, etc\textsuperscript{D22}.

In language technology we study programming of parallel and concurrent systems, and develop programming language constructs and type-and-effect systems that guarantee safety properties of programs written in imperative\textsuperscript{D28}, object-oriented\textsuperscript{D32,33}, and functional languages\textsuperscript{D29}.

Division of Computer Systems

Research at the Division of Computer Systems (DoCS) covers a wide spectrum of topics addressing the design and development of computer systems, ranging from formal modelling, specification, and analysis, to experimental design, implementation, and evaluation. These research directions are coarsely grouped into the four areas listed below. Having such a wide variety of research within one program facilitates collaboration and flexible management of resources.

**Algorithmic Verification:** Explores methods and tools for automated verification of concurrent and distributed systems. Our primary focus is on the use of model checking techniques, which we extend to cope with infinite state-spaces by incorporating advances from SAT-solving, constraint-solving and abstract interpretation. We also develop techniques for generating behavioural models of software components by analyzing sequences of test executions, and use them for test generation\textsuperscript{C11,22}.

**Computer Architecture:** Develops efficient modelling techniques for estimating and tuning performance and energy consumption of sequential and parallel applications with respect to architectural parameters. The focus is on using runtime measurements taken on real systems to develop new modelling methods for analyzing and improving performance and energy consumption, especially with respect to multicore and manycore architectures.

**Computer Networks:** Investigates wireless mobile networking through real-world experiments\textsuperscript{C32}. We develop and evaluate protocols that support mobility and new applications within wireless sensor and opportunistic networks\textsuperscript{C31}, and how they relate to content forwarding in new Internet architectures\textsuperscript{C23,31}. A significant part of our research studies security and resilience in these networks.

**Embedded Systems:** Develops technology and tools for specification and analysis of real-time systems, to be used for model-based design of real-time embedded systems. Our work on verification of timed systems, analysis of scheduling policies, component specification, and tool development, has resulted in the UPPAAL\textsuperscript{C14,30}, and TIMES toolsets\textsuperscript{C10,21}. Current work includes resource management for predictable embedded applications on multicore platforms\textsuperscript{C24,25,26}.

Our research is increasingly addressing two major challenges for contemporary computer science:
The Multicore Challenge: the multicore revolution has brought the need to enable developers to build correct, scalable, efficient, and predictable software, with modest effort. PIs from DoCS have lead the formation of the Linnaeus center of excellence UPMARC, and the CoDeR-MP project, both focusing on techniques for developing multicore software.

The Challenge of Networked and Embedded Systems (NES): the emergence of ubiquitous embedded processing brings the challenge of developing software for large networks of embedded computers. Addressing this challenge, we have formed WISENET, a VINN-excellence centre for interdisciplinary research on Wireless Sensor Networks, and PROFUN focusing on macroprogramming of wireless sensor networks.

In addition, a larger grant on Software Verification addresses research on algorithmic verification of concurrent software.

PIs from DoCS have lead the formation of all the above major projects, witnessing the role of DoCS for collaboration at the department. The Computer Networks group is active in the national research centers CNDS (Center for Natural Disaster Science) and CNS (Center for Networked Systems). Our broad ranging international collaborations include participation in EU Networks of Excellence: ARTISTDesign, HIPEAC, and in the FP7 projects: CONNECT, CREDO, ERA, HAGGLE, HEAP, and ResumeNet.

The research at DoCS has resulted in a number of successful start-up companies. Acumen was started 2006 based on our research in efficient modelling technology and developed a set of products for productive performance-tuning for multi-core platforms. Acumen was acquired in Sept 2010 by Rogue Wave Software, “the largest independent provider of cross-platform software development tools and embedded components for the next generation of HPC applications.” OptiMobile is based on our research on wireless VoIP over WLAN, and delivers VoIP software for smart phones: iPhone, Android, Symbian and Win7. It received the "Guldmobilen" award for "innovation of the year" in 2006. UP4ALL is a start-up company commercializing and marketing the UPPAAL model checker.

Division of Human-Computer Interaction

Our mission is to improve the world, a least for all skilled professionals who use computers as their main work tool. We are currently working towards this mission in the areas of IT supported work, work environment, new technologies and media in society, ethical aspects of IT and education and training of future computer and systems engineers.

Our research in the area of work environment and IT supported work concerns how to design and develop efficient and useful support systems for human activities. Research activities are performed in immediate cooperation with different organisations. We study how computer systems should be designed, developed, deployed and evaluated, for usability, work efficiency, safety and for a good work environment. Examples of applications are health care systems, patient records, administrative work, human decision making, case handling systems, e-government, control of industrial processes, control of traffic and vehicles e.g. in train traffic. In research on new technologies and media we are focusing on different sectors of society and what the driving forces and effects are. We are interested in ethical aspects of IT, as they are significant in a changing world and for a sustainable society.

Another mission is to make sure that next generation of computer and systems engineers have better understanding for users and usability. In the area of HCI and didactics our research contributes to a deeper understanding of students’ learning processes.
Most research is action oriented. We do not only study the problems, we try to solve them. Our research is truly interdisciplinary where knowledge about human perception, cognition and decision-making are central, and our methods have their background in behavioural sciences, technology and computer science.

Division of Systems and Control

Our mission and goal is to produce world class research within automatic control and signal processing. We strive to have a mix of theory and applications of importance to the society, dealing with energy efficiency, sustainability, healthcare, etc. Researchers at the division participate in the major research projects CoDeR-MP and PROFUN and also within the Centre for Interdisciplinary Mathematics (CIM).

In automatic control, theoretical work concerns nonlinear, discontinuous and optimal control, and interaction analysis. There is also applied work on solar energy plants\(^{39,40}\), processes in the steel industry, and wastewater treatment processes\(^{35,23,24}\), where we now are leading a regional research and education consortium aiming at developing control strategies for improved resource and energy efficiency. Other important works include fault detection\(^{17,6}\) with various applications in industrial diagnosis systems.

Our research in system identification and signal processing is versatile, and deals with a number of important problems. Examples include identification of continuous-time systems, errors-in-variables problems, estimation of material functions, spectral analysis of irregularly sampled data with applications in astronomy, multiinput-multioutput (MIMO) radar, magnetic resonance imaging (MRI), waveform design for active sensing, identification of block-oriented nonlinear Wiener systems, identification of nonlinear systems using state-space models, and parameter estimation under lack of excitation. Our research concerning analysis and extensions of many ‘classical’ identification problems and methods, as summarized in a book\(^{31}\), are still the basis for how we approach many fundamental estimation problems.

The research on biomedical systems is centered around an Advanced Grant from the European Research Council (SysTEAM), which envisages a research program that will lead to innovative and agile model-based tools for applications in biology and medicine. Research is also performed on methods for fast and accurate tracking of human movement with applications in medicine. The developed methods have led to new clinically important applications\(^{13,8}\).

Division of Scientific Computing

The overall goal of the Division of Scientific Computing (DSC) is to produce outstanding research in numerical analysis and computational science and engineering. Research at DSC focuses on analysis and development of numerical methods, algorithms, programming techniques, and implementations on parallel computers.

Since the establishment of the Scientific Computing (SC) program at UU in 1965, the "Uppsala school" has earned substantial international recognition for front-line research on construction and analysis of numerical methods for partial differential equations (PDEs). So far, the SC program at UU has produced 74 PhDs, many of whom are today leading SC researchers at other renowned universities while others have successful careers in industry.

DSC research is firmly rooted in classical numerical analysis for PDEs. However, during the years DSC has also taken an active role in the evolution of the whole field of SC. Today, the research portfolio at DSC includes two research programs, Numerical Analysis and Computational Science, and has a uniquely broad and complete scope ranging from
mathematical modelling and classical numerical analysis over software development and high-performance computing (HPC).

DSC has a strong tradition in design of efficient parallel algorithms and implementation of scientific software for large-scale problems. Recently, this research was further strengthened by the DSC involvement in the Linnaeus Centre of Excellence UPMARC. DSC has also taken a leading role in the development of HPC infrastructure in Sweden, including the build-up of the HPC-centre UPPMAX at UU and the development of the national large-scale computing and data storage infrastructure in SNIC.

Researchers at DSC have been engaged in numerous collaborative cross-disciplinary research projects in a range of different fields including fluid flow, electromagnetics, acoustics, quantum mechanics, systems/molecular biology, financial mathematics, genetics, and geophysics. Thus, collaborative projects including researchers from other institutions and industry have been common. Of the DSC publications presented since 2007, 64% has at least one co-author outside the division. This line of development has recently been further strengthened by DSC's leading role both in the Centre for Interdisciplinary Mathematics (CIM) at UU and in the national e-Science Strategic Research Area consortium eSSENCE.

CIM has a postdoc program and is currently initiating a graduate school in interdisciplinary mathematics. CIM projects and activities are chosen to promote collaboration between the mathematical sciences and other disciplines. The aim is to promote the development of new mathematical and computational tools to understand real world systems. Within eSSENCE, DSC is providing a core of expertise in the development of new e-science methods and tools, enabling collaborative efforts for solving challenging problems in science and technology.

Internationally, Sweden has a strong position in SC research and DSC is, together with the numerical analysis group at KTH, one of the two largest and most prominent SC groups in the country. For many years, these groups have also collaborated closely, e.g. by having joint research projects (examples are the VINNOVA Centre of Excellence PSCI resulting e.g. in the spin-off company Efield and the Linnaeus Centre of Excellence FLOW), graduate courses, workshops, one summer school, seminars, PhD students, and supervision. DSC research is also conducted in an international context, and almost all DSC researchers take active part in collaborative projects involving leading international partners. For example, DSC has joint PhD students with Stanford University and ETH, Zürich.
A2: Current, Particularly Successful Research Activities

Division of Computing Science

We have developed the psi-calculi\textsuperscript{D4,24,25,26,27}; a recent generalisation of parameterised calculi for mobile processes, which can be instantiated to cover many existing calculi and application areas, with a novel and simple semantics. The proofs have been machine checked and constitutes one of the largest such efforts in the world.

We have developed novel technologies for enabling scalable search of relational databases and other knowledge sources in terms of semantic web representations and on integrating heterogeneous engineering data. Another area of expertise is scalable search of scientific data. Recently our parallel data stream manager produced the best published results for the data stream processing benchmark Linear Road\textsuperscript{D5}. Our results are attracting quite considerable interest from both industry and academia, which has resulted in new research projects providing considerable new funding.

We exploit structure inherent in automaton-based descriptions of constraints (as building blocks for problem models) in both global\textsuperscript{D3} and local search\textsuperscript{D12,17}.

We have developed the HiPE native code compiler for Erlang\textsuperscript{D30} and the Dialyzer static analysis tool for finding type errors and concurrency defects in Erlang applications\textsuperscript{D31}.

Research on combinatorial auctions, bidding constraints, and bid analysis has generated a spin-off company (Trade Extensions) dealing with advanced optimization-based negotiations.

Division of Computer Systems

Each of our research directions has a strong tradition of world-leading research. Our division has consistently been one of the most successful recipients of grants from VR, the science council, and of larger grants from VINNOVA, SSF, and VR. A significant part of our research is conducted within larger umbrella project. In this section, we structure the presentation according to research direction.

**Algorithmic verification.** We have been one of the main contributors in the area of program verification and infinite-state model checking during the last two decades\textsuperscript{C1,2,15}. During the last five years, our work has resulted in more than 70 publications and four best-paper awards at top-ranked venues. We have developed several new algorithms for classical problems such as minimization and language inclusion defined on word, tree and Büchi automata\textsuperscript{C5,9}. We have considerably increased the power of the Regular Model Checking framework, making it applicable to a wide class of systems, including several difficult benchmarks that were beyond the reach of existing methods\textsuperscript{C4}. We have developed several comprehensive theories where we have derived fundamental decidability and complexity results for timed and probabilistic systems\textsuperscript{C3}.

**Computer Architecture.** Our unique modelling technology for explaining multicore application behaviour has been expanded in several directions: Our early models of random caches and thread interaction\textsuperscript{C13,16} have been expanded with models of LRU caches, cache sharing effects and automated application optimization\textsuperscript{C17,18,27,35}. New runtime techniques have been developed to efficiently collect runtime information, detect application phases on-line, and measure sensitivity to cache sharing. As far as we know these are the fastest such methods to date.

**Computer Networks.** In the areas of Opportunistic and Sensor Networking, our implementation of the proposed ad hoc routing protocol standard AODV\textsuperscript{C12} has spread to more than 1000 organizations all over the world. In our second-generation wireless sensor network test-bed we introduce robots carrying mobile phones as mobile nodes. A novel feature is that the test-bed is
relocatable to other institutions and to the actual target environment$^{32}$. A pioneering research has been done with content spreading and searching within opportunistic networks$^{31}$. Of interest is how fast content and interest for content is spread in these networks. An important part of the algorithms is shredding of content, which may lead to diversity starvation

**Embedded Systems.** As one of the internationally leading groups in model checking of real-time systems, we have developed UPPAAL$^{14,30}$, a tool for verification of real-time systems, widely used over the world in academia and industry with over 1300 citations and 40,000 downloads since 1995. We have also developed TIMES, a tool for scheduling and system-level timing analysis$^{10,21}$, which received the ETAPS tool award in 2002. Our recent work on multicore embedded systems has lead to several state-of-the-art results, notably, the work on multiprocessor scheduling$^{25}$, which received the best paper award of RTSS 2009 and the work on extending Liu and Layland's classic result on rate-monotonic scheduling for uniprocessor to multiprocessor platforms$^{26}$, which solved a long standing open problem in real-time scheduling and is considered as one of the breakthrough results in the real-time systems community.

Our research environment is definitely on the level of the strongest ones in Europe in comparable areas. This goes both for the division as a whole (possible comparisons, e.g., with VERIMAG in Grenoble) as well as for individual groups, each of which is among the leading ones world-wide. We are consistently invited to work with the best groups in Europe, e.g., to participate in and also coordinate European projects with the leading groups in Europe, we have been invited to organize leading international conferences (e.g. SIGCOMM, MobiSys) and participate as program chairs (e.g. EMSOFT, TACAS).

Our multicore platform efforts are of comparable size and funding to similar efforts in the US (Berkeley PARLAB, Stanford PPL, UIUC). In comparison with these, UPMARC has a longer-term agenda (10 years), a more holistic approach, and is more focused on fundamental research questions. Our sensor network effort Wisenet is also in parity with similar efforts at UCLA and ETH/EPFL. Wisenet is more oriented to integration of hardware and system software compared to these two other efforts.

**Division of Human-Computer Interaction**

We have developed a model for describing, analyzing and designing complex human control situations. Applications concern mainly train traffic control systems$^{3,4}$. The development of Sweden’s next generation of train traffic control systems will be based on our results.

Models for user centred systems design, including modules for usability coaching, active user participation, design of future work processes and interface design have been developed. The research is focused on supporting user centred work in practice$^{27}$. A major focus is on administrative applications. A new method ‘usability coaching’ has been developed$^{33}$, as well as a process for system developers doing field studies$^{6}$. Work environment problems in computer supported work are studied. Methods aimed at reducing e.g. cognitive problems have been included as modules in system development models, e.g. usability-index questionnaires$^{27}$. Our research has been rewarded as pioneering.

Research on IT in health care have been very successful and appreciated$^{30}$. Research in computer ethics has been pioneering in developing practical methods and tools to support the integration of ethical aspects in systems design, such as the ETHXPERT tool$^{12,14,24,26,29}$. Studies of new patterns of usage on the Internet among early adopters have provided enhanced understanding of the social and economic drivers. These findings have achieved
much attention\textsuperscript{H11}. Current action research studies in HCI didactics have resulted in development and establishment of the concept ‘open ended group project’\textsuperscript{H19}.

During 2009 we arranged INTERACT 2009, one of the most important international conferences in HCI\textsuperscript{H32}.

Few HCI departments in Sweden or internationally have the same work life oriented research profile as ours. Other departments we can compare us with are: KTH, Stockholm, the HCI Group. Linköping University, Department of Computer and Information Science. University of Toronto, Cognitive Engineering Laboratory. City University London, Centre for HCI Design. Aarhus University, Human-Computer Interaction. University of Nottingham, Human Factors, Faculty of Engineering.

**Division of Systems and Control**

KOF ’07 evaluated our research in signal processing and system identification to be world leading. This research has recently expanded towards the field of biomedical systems.

Our research results in signal processing were among the first in the world to recognize and leverage the flexibility of MIMO radar\textsuperscript{S3,12,16,22,34,39}. This new type of radar has both military and civilian applications; examples of the latter kind of applications dealt with by our group include breast cancer detection using sensor arrays and hyperthermia based treatment of cancerous tissues. In parallel to this work, an intensive research has been conducted on waveform design for active sensing with applications from wireless communications to pulse compression-based sonar and radar\textsuperscript{S11,21,31,32,33}.

We have produced significant results on modelling continuous-time noisy systems\textsuperscript{S14,15}, stochastic systems\textsuperscript{S26}, and errors-in-variables system identification\textsuperscript{S3,27,38,20}. Estimation of material functions for viscoelastic materials is important in mechanical engineering and design\textsuperscript{S18,30,19,20}.

Other research deals with identification and control of nonlinear systems\textsuperscript{S5,10,2}. Recent work focuses on recursive identification\textsuperscript{S37}. New methods for identification and control in the field of anaesthesia have been developed\textsuperscript{S25}. We have also present work on modelling and control of waste-water treatment plants and repetitive control.

There are several groups with a similar profile (combining signal processing, system identification and control) to ours, but application areas may vary. The more prominent ones on an international scale include the groups at KTH, Linköping, Lund, Delft, Leuven, Lausanne, Cambridge, Stanford, MIT, Imperial College, and Newcastle (Australia). Many of these groups are larger than our division; yet we believe we have similar achievements. We have cooperated extensively and have joint publications with colleagues from many institutions, including several of the above groups.

**Division of Scientific Computing**

The division is renowned worldwide for its leading research on construction and stability analysis of finite difference methods for PDE\textsuperscript{N10,11}. The recent international evaluation of Swedish mathematics states that the research at DSC (together with the SC group at KTH, with which DSC has a long history of close collaboration) is outstanding and that the research is clearly of the highest strategic relevance. Traditionally, a main focus of DSC research is on hyperbolic PDE, with applications in fluid flow and wave propagation\textsuperscript{N12,13}. Since 1965, the chair professors in Numerical Analysis at DSC have led this field internationally.

A major goal of DSCs current research is to enable solution of more complex PDE problems in a wider span of application areas by developing new approximation schemes and increasing
the efficiency of numerical solvers. For flow problems more complex settings, e.g. two-phase flow\textsuperscript{N5a,b}, are considered and challenging problems with multi-physics models\textsuperscript{N14,15} are tackled. Also, stable high order methods are derived and analyzed\textsuperscript{N16,17}. For several application areas, adaptive methods in space and time are developed\textsuperscript{N18,19} for reducing the computational work and for error control\textsuperscript{N20,21}. Accuracy and stability at boundaries are non-trivial issues where DSC is contributing significantly\textsuperscript{N1}. Also, alternative approximation techniques such as radial basis functions are employed and analyzed\textsuperscript{N8,22}. Significant results in PDE-based design optimization\textsuperscript{N23} have been accomplished and several recently initialized research projects involve hybrid models and methods where PDE are combined with ODE\textsuperscript{N24} and/or stochastic schemes\textsuperscript{N25}. Another internationally recognized line of research is the development of fast, reliable and parallelizable iterative solvers and preconditioners for systems of equations arising from PDE problems\textsuperscript{N2,26}. Within collaborative efforts some projects in other fields of computing, e.g. global optimization\textsuperscript{N27}, have also emerged.

Complementing the research on numerical methods, there are also significant research activities in the fields of parallel algorithms\textsuperscript{N28,29}, efficient implementation on parallel computer systems\textsuperscript{N30}, and software architecture\textsuperscript{N31}. Different aspects of parallelization and implementation of numerical algorithms on parallel architectures\textsuperscript{N36} are studied within the framework of the centre of excellence UPMARC. DSC research has produced widely used software, e.g. for two-phase flow (the two-phase flow module in the commercial multi-physics simulation tool COMSOL is based on DSC work), for systems biology (providing the free URDME software), and for genetics (providing components in e.g. the R/QTL code and the GridQTL portal).

An example showing the broad competence of DSC is the numerical quantum dynamics project, involving also researchers in quantum chemistry. Here, modelling techniques and numerical methods for the Schrödinger equation are derived and analyzed, including methods of reduced computational complexity\textsuperscript{N32}, high-order discretizations\textsuperscript{N33} and boundary conditions\textsuperscript{N34}, adaptive methods\textsuperscript{N35}, and schemes for error control\textsuperscript{N36}. The new methods are implemented in optimized parallel codes, e.g. in the Ergo\textsuperscript{N37} and HaPARANDA\textsuperscript{N38} frameworks, and used to solve problems of interest in quantum chemistry\textsuperscript{N39}. Three examples of other cross-disciplinary actions are the project on models and numerical methods for molecular systems biology\textsuperscript{N40}, the research effort in computational financial mathematics\textsuperscript{N41}, and the effort on statistical modelling and computational methods for genetics\textsuperscript{N42}. In many cases, these collaborative efforts result in publications in both mathematical/computational journals and journals in the application fields.

Comparing the DSC research to other similar activities, DSC aims for the excellence of research at e.g. the Seminar for Applied Mathematics (SAM), ETH, Zürich. Within Sweden, the excellence in research at DSC is at the same level as the Numerical Analysis group at KTH. Compared to these two groups, DSC has the advantage of a more complete coverage of the SC field, including all aspects of Numerical Analysis and Computational Science and very well-established collaborative efforts with research groups in applications.
A3: Most Promising Research Directions

The potential to develop new directions of research at the department is very high. The rapid development of the field of Information Technology and the potential impact of IT research on industry and society guarantees that new interesting research areas are constantly emerging. The department hosts leading groups with excellent national and international contacts within their fields and already well-developed cross-disciplinary collaborations. Also, the research environment is fruitful, with good infrastructure and a good recruitment base for graduate students in a variety of fields. One essential condition that is not completely fulfilled today is the possibility to attract leading young researchers in new fields by providing significant resources for research and development of new projects.

Division of Computing Science

We intend to explore new application areas of process calculi such as higher-order languages and more general communication primitives such as broadcasting. The development of the formal proof repositories in Isabelle will continue, and through that we will participate in the development of Isabelle. We shall construct of algorithms and tools to analyse specifications and programs formulated in such calculi, and introduce type systems to ensure correctness properties and measures to represent consumption of resources such as time and power. Strengthened interaction between this research and the programming language and automatic verification efforts within this department is a strategic goal.

We will develop methods for scalable search and analyzes of very high volume streaming data for industrial and scientific applications in terms of semi-structured semantic web based representations. On-line analyzes for decision support involve not only data filtering, but expensive numerical computations, e.g. statistical data stream mining algorithms, must be applied on combinations of streaming and stored data. A challenge is to provide scalable data stream processing both with respect to data flow volume and computational power. Our approach is to develop techniques for scaling out stream processing and real-time computations based on adaptive distributed optimization strategies and algorithms.

We aim at fundamentally changing the way how constraints, seen as reusable software components for combinatorial problem solving, are conceived and developed. We propose a radical departure from today's art of ad-hoc programming toward a scientific process based on the principled derivation of constraint implementations from widely reusable constraint specifications.

We shall facilitate programming of parallel and concurrent systems on multicore machines by means of development of novel programming abstractions, verification techniques and ways to automatically parallelise software in ways that relieve the programmer from the hassle of subtle memory models and concerns for deployment on different (homogeneous or heterogeneous) multicore hardwares.

Division of Computer Systems

Future research will to a significant extent address the challenges of multicore platforms and networked embedded systems. The department has a strong opportunity to lead the research frontier in these areas, by leveraging on existing expertise in key areas, including language technology, computer architecture, networking, resource management, performance profiling, correctness verification, and application programming. Let us describe important challenges.

Resource Management: Multicore processors bring the unique opportunity to execute different types of applications on the same platform, where applications may have different requirements on
performance, predictability and power consumption. In the context of embedded real-time systems, the key challenge is to develop isolation techniques to protect hard real-time applications of high criticality from interference by soft real-time applications of low criticality. We will develop techniques for multiprocessor scheduling and cache partitioning for temporal and spatial isolation. To deal with the shared memory bandwidth, new techniques must be provided to develop applications with predictable memory access behaviors unless hardware support such as TDMA-based arbitration is available on the platform. Techniques for timing analysis will be developed. For performance/energy trade-off, we need to develop techniques for measuring each application’s sensitivity to sharing of caches, predicting the actual sharing of resources, and controlling the scheduling of shared resources. We have started developing techniques for measuring and modeling power usage and automatically tune for optimal energy efficiency, especially in the context of reconfigurable hardware. A companion activity is the development of fine-grain energy-consumption measuring techniques and dynamic feedback algorithms for energy-lean execution.

**Verification:** The advent of ubiquitous parallel programming brings the challenge to develop techniques for analyzing and verifying software on multicore systems at different levels of the software stack: from multithreaded programs using high-level synchronization operations, to low-level lock-free implementations of performance-critical services. We have started targeting several breakthroughs, such as solving verification problems for various relaxed memory models; studying decidability and complexity of correctness problems against new correctness criteria such as linearizability and serializability; developing compositional analysis techniques based on examining thread interfaces and their efficient compositions; developing abstraction techniques for verifying concurrent programs; and performing shape analysis on program with dynamic data structures. To obtain WCETs, we combine abstract interpretation for interference analysis of local cache misses with model checking for system-level timing analysis.

**Networked Systems:** The rapidly emerging areas of “Internet of Things” and sensor networks create new areas for computer systems research. It is predicted that 50 Billion small nodes will be interconnected in the near future. Major research challenges are how to program all these nodes, how to maintain them in a self-managed way, and how to provide security, privacy and resilience against malfunctioning nodes. The department is in a good position to address these challenges both from theoretical as well as experimental research. Privacy and security is carried out in the context of e-Health and Body Area Networks and architectures for authorization, storage of sensitive data with mobility will be explored. Resilient network research is carried out in the ResumeNet project and we intend to extend that work into large sensor networks with intermittent connectivity and sensing coverage. A new full professor in Sensor networks programming is being recruited. The ProFUN effort is addressing macroprogramming of sensor nodes, combining expertise of several groups in the department.

**Division of Human-Computer Interaction**

It will remain our main mission to study work related IT and to contribute to usable systems that support efficient, safe and sustainable work. Research on work environment and health problems in IT-supported work is extremely important. We plan to continue the development of knowledge and systems for human operators in complex control situations. We see a need for more research concerning IT in health care. Yearly investments in hospital information systems are huge, but the potential benefits are not reached. We will start research on interaction design for assistive and supportive technology for people with special needs.
The importance of sustainable systems will be growing. Our ethical tools and methods will be developed further and they will be applied to different areas of systems design. We have started developing tools that can support the construction of autonomous ethical agents\(^1\). Didactic research on HCI knowledge transfer will continue focusing on professional competences, the computing curriculum, and the higher education learning environment\(^2\). We will start a challenging and interesting development during 2012, when the programs for image analysis and human-computer interaction will be merged. The plans are to keep existing research fields and develop visualization as a new one.

During the last years we have greatly increased the volume of our undergraduate teaching. The result has been a heavy work load for teachers and less time for research. The number of PhD students is today too low. We have to find a better balance between teaching and research for the senior researchers and recruit more PhD students. The problem is mainly related to faculty and external funding. Our strategy is also to strengthen different collaborations, nationally and internationally.

**Division of Systems and Control**

We will continue to pursue and expand our pioneering research work on MIMO radar and waveform diversity-based active sensing. This new paradigm of sensing is expected by many to lead to significant advances of active sensing systems similar to the MIMO revolution in wireless communications.

The goal for our research in biomedical systems is to bridge the gap between systems biology, medical signal processing and control engineering. The ERC project aims primarily at devising analysis and design methods for feedback drug dosing in Parkinson disease and anaesthesia and for explication of feedback endocrine systems\(^5\). Uppsala University Hospital, University of Porto, and Abbott Labs provide medical and biological competence.

Researchers from computer science and automatic control at UU have teamed up with industrial partners in an SSF-funded project in order to provide key technological solutions for developing, migrating, and maintaining embedded systems on multicore platforms with high computational demand under real-time and resource constraints.

Research in the environmental area has been extended to include modelling and control of catalytic after-treatment for diesel engines\(^4\). Continued research will focus on monitoring and model based control using the developed models. In the future we also expect new research applications including climate control in buildings using wireless sensor networks.

The vision for future work on recursive nonlinear identification is to develop algorithms, results, and software that can be applied to a very wide class of nonlinear system. Insights in machine learning, statistics and convex optimization can play an important role in this picture.

Other potential new areas where our competence fits include brain-computer interaction, system identification for PDE models\(^3\), applications related to efficient production and use of energy, nonlinear system identification towards related control problems, and cellular navigation for 4G networks\(^6\), using advanced sensor fusion methods\(^3\).

**Division of Scientific Computing**

Internationally, Computational Science and Engineering (CSE) is a field of rapidly increasing importance. Future CSE challenges will concern problems of exceptional complexity. The development of models, algorithms, and software for the solution of emerging problems requires expertise beyond what can be found within departments in application fields. However, a successful effort in this field also involves a range of skills that cannot be found in
a traditional group in Applied Mathematics/Numerical Analysis, and it lies within the DSC strategy to cover this gap. The CSE effort at DSC has recently been further strengthened by the recent establishment and consolidation of the research program in Computational Science.

The combined expertise within the DSC research programs in Numerical Analysis and Computational Science and the already extensive collaborative research frameworks brings DSC to a unique position of being a long-term centre of gravity for CSE in Sweden. The recent international evaluation of mathematics in Sweden stated: "The joint programs of KTH and Uppsala promise to retain in Sweden one of the best centres of numerical analysis/computational science in the world and continue its strong tradition in this field". It is DSCs intention to continue and further develop the collaboration with KTH.

Three method areas which are particularly important for strategic applications and in which there is a particular potential for progress at DSC are multiscale modelling and computation; high-dimensional problems; and uncertainty quantification. A firm basis for future research along these lines is provided by the recent strategic recruitments of four young researchers working in these fields to tenure-track positions, and research at DSC is already evolving in these three directions.

**Multiscale analysis, modelling and computation** concern phenomena where many different time and length scales are important. The approach involves a hierarchy of coupled models valid at different scales where the numerical methods need to be highly efficient for each scale and the coupling between different scales is often nontrivial. Applications are found in e.g. materials science, complex fluid flow and biology. At DSC, development of computational methods and software for multiscale problems in two-phase flow\textsuperscript{N5a,b}, systems biology\textsuperscript{N7}, and porous media\textsuperscript{N43} is performed.

**High-dimensional problems** originate from e.g. quantum mechanics and molecular biology. Deterministic algorithms have advantages over traditional Monte-Carlo methods providing faster convergence and better error control. However, for such methods the computational work in general grows exponentially with the number of dimensions. Modern adaptive PDE methods using high-order schemes or mesh-free methods based on radial-basis functions\textsuperscript{N8,44} can reduce the growth, but often new modelling approaches based on the underlying structure of the problem must also be considered. At DSC, efficient methods for high-dimensional PDE have been developed\textsuperscript{N45} and software has been produced and used for applications\textsuperscript{N46}.

Computational analyses of fixed geometric/parametric configurations often constitute only the first step in a scientific task or a task leading to a decision in industry or society. An important aspect of CSE is design optimization, for e.g. mechanical, electrical, and optical components, and the related field of uncertainty quantification, where a mathematical approach is taken to estimate the sensitivity of the computational results to errors or stochastic variations in models and their parameters. At DSC, advances in design optimization\textsuperscript{N47} have been made and the first results in uncertainty quantification\textsuperscript{N49} have been published.

To optimize the impact on CSE, the research on methods described above will be complemented by a continued, integrated effort on developing and analyzing parallel algorithms and software for scientific computing, e.g. enabled by the involvement in UPMARC and collaboration with researchers at Umeå University on software for high-performance and distributed computing\textsuperscript{N48}. 
A4. Publications representing the research activity

Division of Computing Science

[D1] R. Milner, J. Parrow, and D. Walker. A calculus of mobile processes - Part I and Part II. Information and Computation 100:1-77, 1992. [This is the seminal and much cited work introducing the pi-calculus, containing motivations, examples, formal definitions and proofs about its fundamental properties.]


Division of Computer Systems


[C30] K. G. Larsen, P. Pettersson and W. Yi. UPPAAL in a Nutshell. Springer International Journal: Software Tools for Technology Transfer/ 1(1/2), Springer-Verlag, 1997. pp 134-152. [This paper presents the basic theory, tool architecture and main features of UPPAAL; it has been one of the standard references for model checking of real-time embedded systems]


runtime data required by the model with an overhead of 30%. To our knowledge by far the fastest model at that time. We have since then cut the runtime overhead a factor two.

Division of Human-Computer Interaction  

[H20] M. Daniels, Å Cajander, R McDermott, and B von Konsky. *Assessing professional skills in engineering education.* In Proc. 13th Australasian Computing Education Conference, CRPIT, Australian Computer Society, 2011. [This paper elaborates how professional skills can be assessed through reflections in project based courses]


Division of Systems and Control  
[S1] T. Söderström and P. Stoica. *System Identification.* Prentice-Hall International, Hemel Hempstead, UK, 1989. [This is both a textbook and a research monograph summarizing many results by the authors up to the time of publication. The book has been very well received.]


Division of Scientific Computing  


**Computing and Engineering Education (Cross-Division Effort)**

A5. Publications representing renewal of research activity

Division of Computing Science


[D5] E. Zeitler and T. Risch: Scalable Splitting of Massive Data Streams, Proc. 15th Conf. on Database Systems for Advanced Application, DASFAA 2010. [This paper presents the best published performance of a DSMS engine so far and provides the basis for further research]

Division of Computer Systems


[C24] N. Guan, M. Stigge, W. Yi, and G. Yu. Cache-Aware Scheduling and Analysis for Multicores. In the proc. of the 7th International Conference on Embedded Software, Oct. 12-16, 2009, Grenoble, France [The paper proposes to use cache-coloring/cache partitioning to isolate and minimize interferences due to cache misses among concurrent threads on multicore; it presents also scheduling algorithms and analysis techniques, which take cache-partitioning into account for real-time applications.]

[C28] G. Keramidas, V. Spiliopoulos, and S. Kaxiras. Interval-based models for run-time DVFS orchestration in superscalar processors. Proc. 7th International Conference on Computing Frontiers. New York: ACM Press; 2010. pp. 287-296. [This paper describes the first two simple analytical models that can accurately predict processor performance and power consumption with respect to Dynamic Voltage/Frequency Scaling. Because they are simple and practical they can be used to implement accurate, online (runtime), DVFS policies, targeted to optimize various power-efficiency metrics.]

Division of Human-Computer Interaction


[H13] I. Kavathatzopoulos and M. Laaksoharju. Ethical usability of IT systems: How to consider relevant factors and how to find solutions. In Proceedings of the Fifth Asia-Pacific Computing and Philosophy Conference, Tokyo University, Tokyo, 2009. [This paper presents a new and practical way to use in autonomous systems ethical decision making based on the main philosophical considerations and psychological research findings]
Division of Systems and Control


Division of Scientific Computing


[N8] E. Larsson and B. Fornberg, *Theoretical and computational aspects of multivariate interpolation with increasingly flat radial basis functions*, Computers and Mathematics with Applications, 49 (2005), pp. 103-130. [The paper is a major step in understanding the connection between polynomial and radial basis function interpolation]

**A6. List of publications not included in DiVA**

**Division of Computer Systems**


A. Brillout, D. Kroening, P. Rümmer, T. Wahl. *Beyond Quantifier-Free Interpolation in Extensions of Presburger Arithmetic*. 12th International Conference on Verification, Model
Checking, and Abstract Interpretation (VMCAI), Austin, Texas, January 2011, to appear in LNCS

D. Kroening, J. Leroux, P. Rümmer. Interpolating Quantifier-Free Presburger Arithmetic. 17th International Conference on Logic for Programming, Artificial Intelligence and Reasoning, Yogyakarta, Indonesia, October 2010, Springer-Verlag, LNCS 6397, pages 489-503


P. Rümmer. A Constraint Sequent Calculus for First-Order Logic with Linear Integer Arithmetic. 15th International Conference on Logic for Programming, Artificial Intelligence and Reasoning (LPAR), Doha, Qatar, 2008, Springer-Verlag, LNCS 5330, pages 274-289


**Division of Human-Computer Interaction**

The references below are not in the DiVA database. Some papers are authored after 2007 by Lars Oestreicher prior to his employment as senior researcher in the division. The INTERACT proceedings was edited by researchers from the division of HCI.


**Division of Systems and Control**

The references below are not in the DiVA database. Some of the papers are authored by Torbjörn Wigren, adjunct professor, as part of his industrial work. Other papers are authored by our new team members Kjartan Halvorsen, Kristiaan Pelckmaans and Darine Zambrano, prior to their employment in the division.


**Division of Scientific Computing**

The references below are not in the DiVA database. The papers are authored by our recently recruited researchers Axel Målqvist and Ken Matsson prior to their employment as senior researchers in the division and relevant for their future research at DSC.


A7. The department’s situation and actions in response to KoF07

On the Department level, we are most satisfied with the outcome of KoF07. It was concluded that our research in many cases is in par with the international top level or even world leading.

One recommendation was: “The evaluation team recommends that the level of university support for Information Technology be examined carefully, and that any shortfall relative to the university average be redressed immediately.”

In the last years, the faculty has revised the way research funding is distributed, in order to make it transparent and not based on historic data. This has lead to a positive development for us, and we now have a share of the resources that are more in line with the university average. We have also received added funding from the university as well as faculty level directed to some specific research areas, which are commented below under the division headings.

The KoF07 evaluation pointed out the need for a department-wide research strategy and less fragmented funding. These comments contributed to the formation of larger research constellations, which have been very successful in obtaining more funding, and creating interdisciplinary focuses for research work in the department. The idea to base the research constellation on the multicore revolution came from the computer architecture group, who saw the need to devote more focus to this problem. As a result, we planned and successfully obtained funding for the UPMARC and CoDeR-MP research umbrella projects. Another department wide initiative related to embedded systems is the PROFUN umbrella project.

In 2007 basically all faculty resources was directed to the research programmes, and there were no funds available on the department level. From 2011 this situation has changed to the better, and the department therefore has some economic strength to realize common strategies. We are now allocating about 1 MSEK to support the recruitment and retention of female PhD students and seniors, which is crucial for us, since our gender balance is a major problem. About the same amount is used to give teachers the opportunity to also be active in research. A third area where we are now active on the department level is to co-fund strategic recruitment and external projects of strategic importance for the department. The level of this support is also close to 1 MSEK. We also have department funds, 1.3 MSEK for 2011, devoted to the recruitment of junior researchers to temporary positions, mainly post-docs.

Finally, a reorganisation worth mentioning is the inclusion of the Center of Image Analysis into the department and the formation of a new research programme combining Image Analysis and Human Computer Interaction. Here Visualization is a common theme and we are looking forward to a strengthening of these research areas, the existing research directions as well as new possibilities that arises when the groups are combined.

Division of Computing Science

Programming language research has traditionally been strong in the Division of Computing Science and has been strengthened by the hiring of Prof. Parrow and his group, which is working mainly on semantics and theory. The programming language implementation group has shrunk since the previous KoF evaluation; most of its members have found better paid positions in industry (Klarna, Google, Oracle, Acumem).

Division of Computer Systems

The previous KoF evaluation evaluated research activities very favourably. In particular the activities on verification and on memory modeling were singled out as world class/world leading. The previous evaluation recommended additional competencies in two areas:
**Embedded Systems.** This recommendation prompted the Vice-chancellor of Uppsala University to allocate funding for a chair in Embedded Systems, now filled by Wang Yi, who is building up research and education programs in the area. An M.Sc program in embedded systems was established in 2009, with 30 students accepted out of over 500 applications in 2010. A temporary junior faculty member (Philipp Rümmer) has been recruited in the area, and one more junior faculty position will be filled in 2011.

**Architecture:** This recommendation has prompted the department to recruit one more senior faculty member in the area (Stefanos Kaxiras), who is building up research activities on power efficient computing. Also, a junior faculty member (David Black-Schaffer) has been recruited in the area and adds knowledge about compilers and GPU computing.

In addition to these measures, additional resources have been allocated to provide long-term basic support for the algorithmic verification group. PIs at the division have also devoted significant effort to the formation of and fund raising for larger collaboration projects.

**Division of Human-Computer Interaction**

The KoF report from 2007 focused on two main areas for development. The first concerned the dissemination of our research results to the HCI research community. We have continued our long term studies, but also tried to summarize our results. This has been published and used as a basis for new projects, e.g. in health care, and included in our teaching programs.

The second area concerned the fact that HCI research was spread too broadly at the university. The result was not a merge, but a structural improvement. Our division has increased faculty funding today. The faculty of social sciences has profiled its HCI group more towards social science. We have a fruitful relationship and a joint HCI master program.

**Division of Systems and Control**

There has been an increased funding by the faculty and the university to the group, partly as a result of KOF 2007. Specifically, funding for a research associate started 2009. Faculty resources for a PostDoc and economic support for a promoted professor came 2010. An increased faculty funding, based on previous achievements, appeared in 2011.

It was recently decided to meet the shift of generations in the division by recruiting more junior members as a complement to the existing staff. Kristiaan Pelckmans is a new research associate, Darine Zambrano is postdoc researcher, Kjartan Halvorsen is half-time lecturer. In addition one position as (full-time) lecturer in systems modelling is soon to be filled, and another new lecturer position in automatic control is planned for the near future.

**Division of Scientific Computing**

Since 2007, the research program in Computational Science has been consolidated with base funding from the faculty, complementing the since long established program in Numerical Analysis. Also, DSC has recruited four young lecturers to tenure-track research positions as assistant professors since 2007, and a fifth position is under recruitment, vitalizing and broadening the DSC research. One example is the use of finite element methods for multiscale problems in general geometries pursued by one of the new lecturers. Their research is supported by UPMARC, the Swedish Research Council, the faculty, and eSSENCE. Several PhD and PostDoc positions have been filled recently. Two PostDocs are shared with other departments and the funding for them is from the Center for Interdisciplinary Mathematics (CIM). The head of CIM is one of the new tenure-track researchers at DSC.
**A8. Present a list of significant prizes and awards**

**Division of Computer Systems**


**Per Gunningberg**, 56, Male, 2010, Dogan Yazar's master thesis RESTful Wireless Sensor Networks has been awarded the 2010 Bengt Asker Award for best MSc thesis in the area of realtime and embedded systems. Per Gunningberg examiner and co-supervisor.


**Stefanos Kaxiras**, 40, Male, 2009, 2009 ACM Distinguished Scientist. ACM: “The Distinguished Member Grade recognizes those ACM members with at least 15 years of professional experience […] who have achieved significant accomplishments or have made a significant impact on the computing field".

**Lars-Åke Larsson**, 39, Male, 2010, ACM MobiSys Best Demo Award 2010

**Edith Ngai**, 29, Female, 2010, VINNOVA (The Swedish Governmental Agency for Innovation Systems) VINNMER Fellowship


**Division of Human-Computer Interaction**

**Ása Cajander**, 37, Female, 2009, Best paper award at Australian Computing Education Conference (ACE) 2009 for the paper ”Evolution of an International Collaborative Student Project” by Laxer, C., Daniels, M., Cajander, Å., and Wollowski, M.

**Lars Oestreicher**, 46, Male, 2009, IFIP Silver Core Award.

**Division of Systems and Control**

**Peter Stoica**, 58, Male, 2008, Co-recipient of the Barry Carlton Award of the IEEE Aerospace and Electronic Systems Society, which "acknowledges what is judged the best
paper in IEEE AES Transactions in each calendar year, and which is one of IEEE's oldest and AES highest honor".

**Peter Stoica**, 57, Male, 2007—pres, Fellow of EURASIP elected for "contributions to modern spectral analysis" (EURASIP Fellowship, which is one of the Association's most prestigious honors, was awarded in 2007 for the first time).

**Peter Stoica**, 59, Male, 2009, Co-author of the contribution that has received the Lockheed Martin Best ATR Student Paper Award at the SPIE Defense, Security and Sensing Conference, Orlando, FL, 2009.

**Peter Stoica**, 60, Male, 2010, Recipient of an Advanced Grant Award of the European Research Council

**Peter Stoica**, 60, Male, 2010, Co-author of the contribution that has received the Best Student Paper Award at the 2nd International Workshop on Cognitive Information Processing, CIP 2010, Elba, Italy, 2010.

**Torsten Söderström**, 64, Male, 2010, Rudbeck Medal, Uppsala University

**Torbjörn Wigren**, 45, Male, 2007, Ericsson Inventor of the Year

**Darine Zambrano**, 29, Female, 2007, 1º place in the “HYCON WP2 solar benchmark exercise award” by European Embedded Control Institute (EECI), International Curriculum Option.

**Division of Scientific Computing**

**Elisabeth Larsson**, 35, Female, 2007 The Göran Gustafsson award for young researchers. Award sum 1 200 000 SEK over three years

**Axel Målqvist**, 29, Male, 2008, The Göran Gustafsson award for younger researchers, 300.000 SEK

**A9. Additional sources of information**

All references cited in the text are available at http://www.it.uu.se/research/references/KoF2011. The list found at the web page also includes the references listed in Sections A4 and A5.

General information for the department is found at http://www.it.uu.se/?lang=en

Research information for the department: http://www.it.uu.se/research/?lang=en

This page links to the division’s research information sites:

- Computing Science http://www.it.uu.se/research/csd
- Computer Systems http://www.it.uu.se/research/docs
- Human-Computer Interaction http://www.it.uu.se/research/hci
- Systems and Control http://www.it.uu.se/research/syscon
- Scientific Computing http://www.it.uu.se/research/scicomp

More information about faculty members and PhD students at the department is available on the personal home pages found at http://www.it.uu.se/katalog/ and http://www.it.uu.se/katalog/byjobgroup.
## Part B: Quantitative summary of research activities

### B1. Engagement and involvement in the scientific society (since 2007)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total number (T)</th>
<th>Number of individuals contributing (N)</th>
<th>Computing Science</th>
<th>Computer Systems</th>
<th>Human-Computer Interaction</th>
<th>Systems &amp; Control</th>
<th>Scientific Computing</th>
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<td>Plenary or keynote talks at international conferences</td>
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<td>Invited talks at international conferences</td>
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<td>Assignment in research councils and foundations</td>
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<td>Assignment as expert at evaluations for professor and lecturers positions</td>
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<td>Assignment as editor or member of editorial boards</td>
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<td>Member of international scientific councils</td>
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<td>Member of academies and learned societies</td>
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*IT Dept specific data:*

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<th>Computing Science</th>
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<th>Human-Computer Interaction</th>
<th>Systems &amp; Control</th>
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<td>Hosting/Chair of major conferences</td>
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**B2. Actions for renewal** (since 2007)

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<th>External recruitments (with doctoral exam from another university)</th>
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<td>Number of granted external funds for new projects (excluding minor grants)</td>
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**B3. International collaboration** (since 2007)

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<th>Research visits abroad (of at least 3 months duration)</th>
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<td>Number of collaborating institutions with joint publications</td>
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**B4. Engagement and interaction with society** (since 2007)

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