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UNIVERSITET

Version 2007-02-15

KoF07 Evaluation Document

Department of Information Technology

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Reading instructions

Information Technology at Uppsala University is a large department which comprises five divisions, each corresponding to a research program. In the list below, the quotient in square brackets corresponds approximately to the relative contribution to the total size of the department:

- Computing Science (Program *Datalogi*) [1/7]
- Computer Systems (Program *Datorteknik*) [2/7]
- Human-Computer Interaction (Program *Människa-datorinteraktion*) [1/7]
- Systems and Control (Program *Reglerteknik*) [1/7]
- Scientific Computing (Program *Numerisk analys* och *Tillämpad beräkningsvetenskap*) [2/7]

In the evaluation, different divisions will be scrutinized by different panels. To facilitate this, we have chosen to explicitly partition most of the presentation below between the divisions. However, Section A1 contains a brief general description of the department. Also, the multidisciplinary research centers associated with the department are presented.

All references cited in the text are available at http://www.it.uu.se/research/references/KoF2007. 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

A: Strategic aspects on research

A1: Summary of research activities

The research at the Department of Information Technology spans over several fields, ranging from the gathering and management of data via signal processing, over computational and control engineering and numerical analysis, to communication of results with the aid of database management and human-computer interaction. Particularly strong and large groups, performing leading research at the international front-line, are found in areas like

- Specification, verification, and analysis of real-time and distributed systems.
- Signal processing and system identification.
- Construction, analysis and implementation of numerical methods for partial differential equations.

The department has a strong focus on research, which also provides an excellent foundation for both graduate and undergraduate education. The history of the department goes back to pioneering activities in IT at Uppsala University in the early 1960s. Some brief facts about the department are:

- About 200 employees (including graduate students)
- 80 faculty, including 25 full professors. About 90 graduate students
- 76 PhD and 75 Licentiate degrees awarded between 1999 and 2006
- A number of national research centers, centers of excellence and research or infrastructure coordination bodies are hosted by or associated with the department
- The department hosts one member of the Royal Academy of Science, three members of the Royal Academy of Engineering Science, and two Highly Cited Researchers (as defined by ISI HighlyCited.com)
- In a recent investigation (using Citeseer) of citations of publications by Swedish professors in the fields described above, four of the six most highly cited researchers were employed at the Department of IT, Uppsala University.
- 3,600 students at the undergraduate and masters level take courses at the department annually

The research is performed in both pure and applied fields in an overall healthy balance. The department is 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 research at the department is effective and productive, see Figure 1.

External funding, including grants acquired in tough competition from government funding agencies, currently covers 70% of the total research budget. The Faculty board is aware of the vulnerability implied by this situation, and during the last years an increase of the level of university funding has been initiated. Still, the large educational assignments, combined with limited and short-term research funding, has resulted in that some faculty members today have very limited possibilities for pursuing research projects.

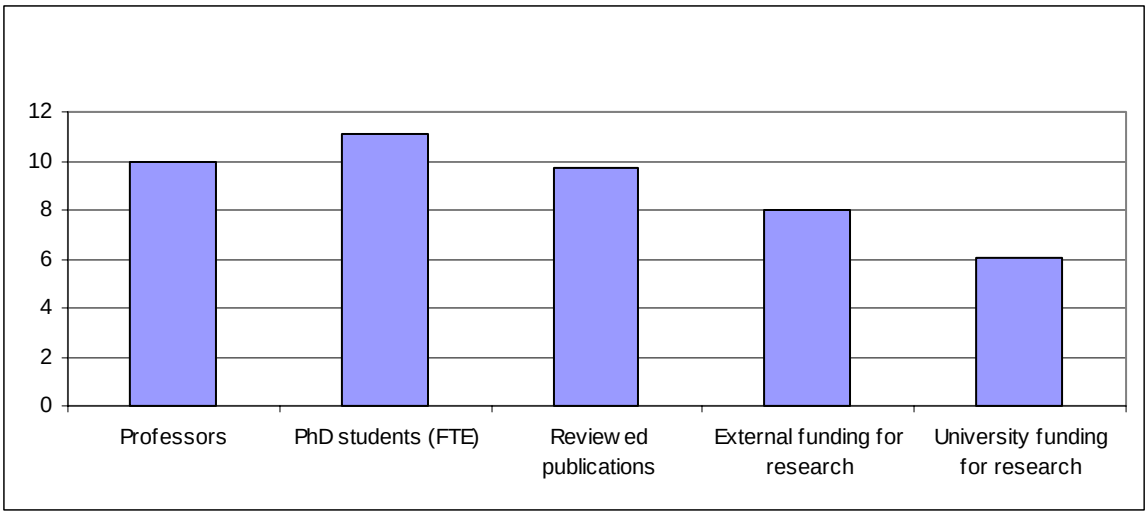

Figure 1. Key indicators for the IT department for 2005, expressed as % of Faculty of Science and Technology, Uppsala University totals. (FTE=Full Time Equivalents, Source: GLIS)

The research at the department is conducted in vibrant and expanding fields, where an ability to adjust and initiate new research directions is essential. Lately, several new programs have been initiated, for example in Computer Architecture, Databases and Computational Science and Engineering. Also, many of the research groups at the department are highly reputed, and even though resources are limited several researchers at international top level have been recruited.

A number of research centers are associated with the department: ASTEC (Advanced Software Technology), ARTES (A network for Real-Time research and Education in Sweden) and PSCI (Parallel and Scientific Computing Institute) are national centers of excellence. A group at the department has also recently been awarded a Vinnova Excellence Center, WISENET. Here a multidisciplinary approach is taken to solve fundamental problems on energy management, cost, security, gateways, antennas, efficient communication, fault tolerance and self-organization.

The department plays a central role in the Uppsala-based national graduate schools FMB (Graduate School in Mathematics and Computing) and NGSSC (National Graduate in Scientific Computing). Also, the IT department hosts the university-wide center UPPMAX (Uppsala Multidisciplinary Center for Advanced Computational Science) as well as the leadership for SNIC (Swedish National Infrastructure for Computing). The Department is co-located and also shares some researcher positions with the Center for Image Analysis. This center is run by Uppsala University in collaboration with the Swedish University of Agricultural Sciences, conducting research in computerized image analysis.

Division of Computing Science

The research at the CS division is organized in research groups, where the common goal is to maintain a fruitful and dynamic academic environment. The main directions are:

Database Technology (UDBL): (Risch) Methods and techniques for managing data from heterogeneous and distributed data sources. Emphasis is on modern query processing techniques for efficient searching and integration of data from heterogeneous databases, storage managers and other data sources in a distributed environment.

Programming Language Implementation: (Sagonas) Design of efficient runtime system architectures for highly concurrent languages, development and experimental evaluation of new memory management algorithms, and detecting software defects using static analysis techniques such as annotation-free type inference.

Algorithms and Data Structures: (Andersson) Fundamental textbook-style problems like sorting and searching, a number of strong results have been produced over the years. Within the algorithm group, there are also ongoing activities in e-commerce.

Constraint Technology (ASTRA): (Flener) Principles and practice of constraint technology, modelling and efficient solving of the ubiquitous and important combinatorial (optimization) problems in commerce, engineering, management, and science, by global or local search.

Division of Computer Systems

Research at DoCS considers computer networks, computer architecture, and embedded systems along two main directions, one being formal specification and analysis, the other being experimental systems, development systems, architecture design and evaluation.

On specification and analysis, several directions are pursued. For *Algorithmic Verification of concurrent and distributed systems*, we primarily use model checking techniques, which are extended to cope with infinite state-spaces by incorporating techniques from SAT-solving, constraint-solving and abstract interpretation. For *Specification and Analysis of Real-Time Systems* our work on verification of timing properties, analysis of scheduling policies, component specification, and tool development, has resulted in the *UPPAAL* and *TIMES* toolsets. The overall goal is to develop technology and tools for model-based design of real-time embedded systems. In *Calculi for Mobile Processes* such as the pi-calculus and its subsequent variants (e.g., the fusion calculus), we develop new proof methods for such calculi, to handle, e.g., data types, and tools for analyzing and manipulating specifications. We develop techniques for *Test Suite Generation* from models of concurrent systems, as well as for generating models by observing test executions. We develop sampling techniques for *estimating and tuning performance* of high-performance software applications with respect to architectural parameters.

In experimental systems research, techniques are developed for improving high-performance *multi-threaded computer system architectures*, such as multicore, SMP and NUMA.Our *Communications research* deals with wireless mobile networking. We develop and evaluate protocols that support mobility and new applications more efficiently than current Internet protocols. A significant part of our research studies spontaneous, ad-hoc, autonomic networks. Such networks must be self-managed, reliable and secure.

Our broad ranging international collaborations include participation in EU Networks of Excellence: ARTIST2, HIPEAC, the recently initiated FET project HAGGLE and recently concluded project PROFUNDIS. We have been coordinating ARTES, the Swedish network for Real-Time research and graduate Education in Sweden, for the last 10 years. We have been a driving force in two ``Competence centers" ASTEC (Advanced Software Technology) and PSCI (Parallel and Scientific Computing), and as mentioned in the introduction we coordinate the new Vinnova excellence center WISENET.

Division of Human-Computer Interaction

Research in Human-Computer Interaction (HCI) is mainly concerned with how humans and technological systems can interact to obtain efficient and useful support for human activities. We study how computer systems and other technological systems should be designed, developed and deployed, for work efficiency, safety and for a good work environment.

Our research is cross-disciplinary. Knowledge about human perception, cognition, decision-making and human errors are central. Our methods have a background in behavioural sciences. Knowledge from technology and computer science is also important. Methods for analysis, design, construction and evaluation of user interfaces are developed. We study organisational aspects and work environment in computer supported work, user centred systems development [H1], design of user interfaces, evaluation methods, human decision making, computer ethics, work environment and health problems [H2].

Our research activities are performed in cooperation with different organisations. Examples of applications are health care systems, telemedicine, medical documentation, home care, mobile technology, administrative work, case handling systems, e-government, control of industrial processes, control of traffic and vehicles systems such as trains and high speed ferries.

Division of Systems and Control

In *automatic control*, theoretical work focuses on nonlinear control. There is also applied work on solar energy plants, fault detection, steel industry applications, active vibration and noise control, and modelling, analysis and control of waste-water treatment plants, and other topics.

Our research in *estimation, system identification and signal processing* is versatile, and deals with many different problems. Examples include identification of continuous-time systems, errors-in-variables problems, estimation of material functions, estimation of diffusion processes, spectral analysis, NMR spectroscopy, echo cancellation, wireless communications, radar signal processing, SAR imaging, spatial diversity in wireless communications, biomedical signal processing, array signal processing, optimal experiment design, identification of block-oriented nonlinear Wiener systems, identification of nonlinear systems using state-space models, periodic signal modelling using nonlinear ODE's, and other topics.

The research on *biomechanics* develops tools for accurate, fast and highly automatic estimation of joint motion and forces during various activities such as standing, walking and running.

We have been publishing extensively (almost 1000 papers). Six out of 8 (soon 7) teachers are professors.

Division of Scientific Computing

The Division of Scientific Computing (DSC) is a leading center for research and education in Scientific Computing (SC). Internationally, Sweden has a strong position in SC research since the area's birth. DSC is one of the two largest and most prominent SC groups in the country. The other is the numerical analysis group at KTH in Stockholm, with which there has been significant cooperation over the years.

The research at DSC has a broad scope, ranging from classical numerical analysis over software development and high-performance computing (HPC) to collaborative projects in Computational Science and Engineering and industrial applications. The research has traditionally been, and still is, focused on the solution of partial differential equations (PDE), but projects in other fields have also emerged, e.g. global optimization[N8]. The "Uppsala school" has earned substantial international recognition for front-line research on construction, analysis and implementation of numerical methods for PDE. By the end of 2006, the SC graduate education program had yielded a total of 70 PhDs, many of who have become leading SC researchers.

Today, DSC hosts a range of competence covering all aspects of SC research: Mathematical analysis, development and analysis of numerical approximations for PDE, development and analysis of numerical linear algebra algorithms, and HPC algorithms, programming techniques and. The research has always been conducted in close relation to important application fields, such as fluid flow, electromagnetics, and acoustics, often within collaborative projects including researchers from other departments/institutions or industry. Recently, problems in e.g. geology, molecular biology, quantum mechanics, financial mathematics and genetics have been added to the DSC project portfolio. The pure PDE problems are in some cases being replaced by more complex problems. For example, several research projects where hybrid numerical methods, combining PDE with ODE or stochastic models, have recently been or are being initialized.

A trademark of DSC is that research projects not only consider mathematical modeling and numerical methods, but also exploit the full potential of using modern HPC resources for large-scale computations. DSC has a strong tradition in design of efficient algorithms and implementation of scientific software for large-scale problems. DSC acquired its first parallel computer system already 1987, and since then has led the development of HPC at Uppsala university, including the recent build-up of the multidisciplinary center UPPMAX.

Important infrastructure, etc.

The department's administrative support organization is lean but characterized by professionalism and back-up for critical functions. Around 15 people are employed for administrative and computer support tasks. The leadership has a strong focus on creating a positive and creative working environment, which is reflected upon e.g. in[S12].

Besides around 500 workstations with servers the department hosts several high performance computers: Ra (cluster, 280 processors), Ngorongoro (SMP, 48 processors), and Hagrid (cluster,100 processors, part of SweGrid). These systems are available to researchers at Uppsala University through the center UPPMAX.

Uppsala STS, Science & Technology Studies Center, is a multi-disciplinary centre hosted by the department for research on the relation between science, technology and society. The department also hosts the Swedish IT-User Centre, *Nita*.

A2. Describe currently active particularly successful research areas **and groups/networks, in a national or international perspective. List actions that would further improve the quality of the department's research in general.**

Division of Computing Science

Although we are a small division, we have managed to host strong research groups covering a wide range, and here we highlight some of the best results.

Database Technology: As our current research vehicle we have developed a mediator engine, Amos II, based on a functional data model. Using this prototype, we have developed and verified a number of results on query optimization and proven the strength of functional data models for these purposes [D10, D11, D12]. The results are summarized as part of a book on state-of-the-art in functional query processing[D2]. We wrote three chapters of the book.

Programming Language Implementation: The research vehicle has been the HiPE (High Performance Erlang) native code compiler [D19], which is part of Erlang/OTP (Open Telecom Platform) used by Ericsson and several companies around the world. Compiler optimizations (e.g. faster register allocation, efficient pattern-matching compilation of bit stream data [D18], novel static analysis for guiding the memory allocator) and real-time memory management techniques have been developed and tailored to the characteristics of such languages and their application domain[D3, D17].

Algorithms and Data Structures: A number of world-leading results have been presented. In particular, new bounds for fundamental problems, such as sorting and searching[D1, D6], have been presented for realistic computational models (that reflect what we can program in standard imperative programming languages such as C). These results have changed some fundamental "facts" about basic algorithmic complexities and are also cited in modern textbooks.

Constraint Technology: By focusing on combinatorial substructures that are frequently used in models of combinatorial (optimization) problems, we developed (some of) the first tractable methods for the detection and breaking of symmetries [D14,D15,D16], thereby making more problem instances solvable by global search.

Division of Computer Systems

The interplay between research on formal specification and verification, and research on systems development in computer networks, computer architecture, and real-time systems, was originally motivated by the need for protocol verification. By now, world-leading contributions in several areas have been generated.

Our work on *algorithmic verification of concurrent and distributed systems* has generated a general framework for symbolic model checking of *infinite-state systems* which combines techniques from model checking and rewriting[C1] .It has led to analysis techniques for many practically significant classes of systems, including protocols communicating over lossy FIFO channels[C13,c14], cache coherence protocols, and timed Petri nets[C15]. Another contribution is *Regular model checking*[C2], which makes symbolic model checking applicable to parameterized systems with an arbitrary number of components, by replacing BDDs with

finite automata. We pioneered techniques to use SAT-solving[C12], as an alternative to BDDs, and in combination with other techniques such as unfolding.

As part of our internationally leading work on *specification and analysis of real-time systems* we have developed *UPPAAL*[C4], a leading tool for specification and analysis of timed systems with over 600 citations and 25,000 downloads since 1995. UPPAAL has been recognized among the prominent contributions to the advances of verification technology. Case-studies with industrial involvement are numerous. Based on UPPAAL, a new theory for scheduling analysis is developed[C5], which significantly generalizes the computation models and analysis techniques in classical real-time scheduling theory. This work is the basis for the *TIMES* tool, which received the ETAPS tool award in 2002[C20].

In the area of *Calculi for mobile processes*, we have been part of the pioneering work on developing the *pi-calculus*[C3], a breakthrough in extending the expressiveness of process algebras, and since then we have been among the leading groups in the world. Subsequent developments include the *fusion calculus*[C25], analysis tools (such as the *Mobility Workbench*[C27,] a successor of The *Concurrency Workbench*), and new analysis algorithms.

Our *Computer architecture research* is built on a history of applied research, such as the introduction of the *Cache-Only Memory Architectures* (COMA) system architecture and the simulation techniques which resulted in the *SIMICS* simulator. It also reflects years of advanced product development in industry, such as the Sun Enterprise servers, the Sun WildFire NUMA/COMA system[C6] and the Sunfire Link interconnect. More recently, we have developed efficient shared-memory implementations in software, which require minimal hardware support, as well as tools for analyzing memory performance, such as *StatCache*[C18] which can monitor an application in its native surrounding while imposing an overhead of only 30% compared with native execution.

In the areas of *Opportunistic and Sensor Networking*, our implementation of the proposed ad hoc routing protocol standard *AODV* (http://core.it.uu.se/core/index.php/AODV-UU) has spread to more than 1000 organizations all over the world and our ad hoc testbed *APE* (http://apetestbed.sourceforge.net/) is used worldwide. A significant result of the testbed work is the discovery of the so called *gray zone* phenomenon, which creates a situation where ad hoc routing protocols become unstable[C7,C24]. Our research on gateways demonstrates how mobile and multiple gateways can be self-configured in an ad hoc network[C26]. Pioneering work has been done on power savings in sensor and ad hoc networks and how to boot-strap security in sensor systems[C26].

Division of Human-Computer Interaction

Research in Human-Computer Interaction (HCI) has a relatively long history. Since 25 years we study usability of IT-systems in computer supported work, based on a multi-disciplinary approach [H6, H7]. Today we do successful research in several areas.

We have developed a model for describing and analysing complex *human control situations* [H8]. Research concerns analysis of complex control and decision systems and design of new control systems and operator interfaces, for high speed ferries [H9], train traffic control[H10] and train drivers [H11].

Models for *user centred systems design*, including modules for active user participation, design of future work processes and interface design have been developed [H3]. The research is focused on supporting user centred work in practice.

A major focus concerns *administrative applications*. We have an extensive cooperation with 5 governmental authorities, aimed at improving their competencies and methods when developing future IT-supported work processes [H12]. We have used "future workshops" as a method to specify new work processes and detailed requirements for new IT-support.

Work environment problems in computer supported work are studied. Methods aimed at reducing e.g. cognitive problems has been developed, tested and included as modules in system development models [H2].

We develop prototypes for new IT-support systems, e.g. in *telemedicine* [H14] and *home care* [H15]. Usability aspects of future mobile work support systems are studied [H4].

Ethical aspects of IT are significant in a changing world, and they affect IT usability. We focus on developing ethical methods and tools adapted to stakeholders' values, interests and principles [H5].

We have an intensive *engagement in the scientific society* through committees, interest groups, networks of excellence etc. We host NITA, the Swedish IT-User Centre. We are active in supporting consumer driven quality assessment of IT systems through Users Award [H16].

Division of Systems and Control

The world-leading research in signal processing and system identification has been and continues to be recognized by several awards.

Stoica´s recent work include radar signal processing[S4], biomedical signal processing applications[S7,S19], and block coding[S1, S13]. His work in all these fields has been very highly recognized internationally. His work in the area of spectral analysis of signals has provided a number of fundamental results and has led to the introduction of several enhanced methods with applications in magnetic resonance spectroscopy for biomedicine, nuclear quadrupole resonance spectroscopy for aviation security and explosive detection, analysis of brain signals, synthetic aperture radar imagery, irregularly sampled data analysis and acoustic imaging.

Söderström and colleagues have produced significant research on modelling continuous-time noisy systems[S2,S14, S15], and stochastic systems[S22].

Our research concerning analysis and extensions of many 'classical' identification problems and methods, as summarized in the book[S3], are still the basis for how we approach many fundamental estimation problems. See also[S10, S23]. Further, many very frequently cited papers on temporal and spatial spectral analysis have been written[S8, S24, S25, S26].

The research by Wigren deals with identification of nonlinear systems. That work has resulted in several well cited papers[S5, S28] that treat the convergence properties of recursive algorithms for nonlinear block-oriented Wiener systems.

During the last 15 years Carlsson and co-workers have been involved in various successful applications in modelling and control of wastewater treatment processes[S27].

Other important work include human gait analysis[S11], where the developed methods have lead to new clinically important applications, and fault detection[S9,S17] with various applications in industrial diagnosis systems.

Division of Scientific Computing

The division is renowned worldwide for leading research on construction and stability analysis of finite difference methods for PDE. A main focus of the work is hyperbolic PDE, with applications in different aspects of fluid flow, acoustics and electromagnetics. The chair professors in numerical analysis at DSC have headed the progress of this field on the international level, making significant contributions by introducing new classes of methods and new analysis tools, and also by synthesising and explaining existing results. Much of the classical work on PDE discretizations is summarized in[N1]. The recruitment of prof. G. Kreiss in 2006 guarantees continued progress in this area[N2].

Over the years the main goal of DSC research is to enable solving larger, more complex PDE problems by increasing the efficiency of numerical solvers. The use of high order schemes[N11,N12] has the advantage that fewer variables and less computer memory are necessary for an accurate representation of the solution. In collaboration with leading research groups in fluid mechanics in academia and government labs, stable high order methods are currently being derived and analyzed[N13,N14,N15]. Also, adaptive methods [N16] in space and time are used for reducing the computational work. Accuracy and stability at boundaries are non-trivial issues, where research at DSC is contributing significantly[N3,N17].

Another line of internationally recognized research is the development of fast and reliable iterative solvers for systems of equations arising from discretizations of PDE. To achieve a short overall execution time, it is crucial to construct parallelizable preconditioners[N4]. At DSC, preconditioners based on fast transforms have been constructed[N18,N19] and successfully applied to PDE discretizations[N20,N5,N21] from applications in fluid mechanics[N22], underwater acoustics[N23,N24], and electromagnetics[N25]. A result of these efforts is a solver of the Helmholtz Equation for Layered Media (HELM), now in operational use at the Swedish Defense Research Agency. Recently, preconditioning based on fundamental solutions[N26] and algebraic multilevel techniques[N27,N28] have been developed and implemented.

Complementing the research on numerical methods for PDE, there are also significant research activities in the fields of software architecture[N29], parallel algorithms and efficient implementation on high-performance computers. Novel load balancing schemes for parallel numerical PDE solvers have been developed[N6], and are incorporated in the oceanographic model at the Swedish Meteorological and Hydrological Institute[N30]. Different aspects of data locality for PDE algorithms[N31] are studied in collaboration with the group in Computer Architecture at the department. Very efficient implementations of basic PDE solver algorithms on emerging chip multiprocessors have received international interest[N32].

An example showing the broad competence of DSC is the development of General ElectroMagnetic Solvers for simulation of high frequency electromagnetic wave propagation in collaboration with KTH. The project was part of the Parallel and

Scientific Computing Institute, in which DSC, the KTH group, and a number of Swedish enterprises were partners. The time domain solver developed in the project is a stable hybrid method. It combines the efficiency of a finite difference method with the accurate boundary treatment of a finite element method on an unstructured mesh near curved surfaces[N33,N34]. For frequency domain computations, the multipole method was implemented for fast evaluation of monostatic and bistatic radar cross section applications[N7,N35]. Today, the codes are used for production calculations on in the analysis and design[N36] of antennas and aircraft configurations at Saab and Ericsson Microwave Systems. A new company, Efield, was founded in 2006 to further develop and market the codes.

Actions that would further improve the quality of the department's research in general.

A main goal of the department is to continuously develop the research environment and keep it competitive at the highest international level. This includes the ability to attract top-class researchers and to give them sufficient resources for pursuing their work. Today, many of the research projects at the department are conducted at the international forefront but the lack of long-term funding may limit future progress. An increase of the basic university funding to a level that corresponds to the production of research results has already been initiated, and it is important that this is continued at an accelerated rate. This will enable the department to be even more competitive in recruitments and to create an academic environment where all faculty members are active researchers.

A3. Describe the most promising future research directions for the department. Comment upon the conditions to develop new directions of research.

Division of Computing Science

Building on our strong areas of expertise, the common directions of our future plans are concentrating on Internet, Telecom, and e-Commerce applications.

Information Management: We will concentrate on developing methods for processing search over data in terms of i) semi-structured semantic web based representations[D5], and ii) high volume parallel data streams for scientific applications[D13]. A challenge in both cases is to provide scalable search as the data volume increases and the queries become complicated. Our approach is to develop novel dynamic query transformation techniques and distributed execution strategies.

Large telecom applications: In order to meet the future needs in the telecom area, we design static analysis techniques for automatically detecting software defects in large telecom applications. The tool employing these techniques, called Dialyzer, is commercially used and is extremely effective[D20]. We are currently extending this work to detect concurrency defects in programs that communicate via message passing [D17].

E-Commerce: We direct our interest towards resource allocation and electronic commerce, with special focus on combinatorial auctions, bidding constraints, and bid analysis. This has generated a number of publications [D7, D8, D9], and a spin-off company dealing with advanced optimization-based negotiations (Trade Extensions www.tradeextensions.com). The group leader (Andersson) now divides his time between industry and academia.

Constraint Technology in Practice: Constraint technology holds a very high potential for practical applications, which often harbour exciting multidisciplinary research challenges. The group has started to orient some of its activities towards the scalable use of constraint technology for real-life problems, in electronic commerce (with the Algorithms/e-Commerce group), biology, finance [D4], and air-traffic management (with EuroControl).

Division of Computer Systems

Two strong current trends in computing are the broad introduction of multicore processors, which are now becoming mainstream, and the rapid development of wireless networks with numerous heterogeneous nodes for a variety of applications. DoCS will address challenges posed by these trends by a joint effort on formal modeling and analysis techniques and on experimental systems research.

The use of multicore processors, implies that increased program performance can be sought only by exploiting parallelism in the application. This poses the challenge of *techniques and tools for developing efficient parallel software* which at the same time is at least as reliable as its simpler sequential counterpart.

We are developing tools to help programmers tune their code for multiprocessor platforms, by extending *StatCache* for analyzing cache performance, to handle multithreaded execution[C10],

and developing techniques for modeling the interaction between independent threads. Successful applications in scientific computing have already yielded significant speed-up of state-of-the-art implementation on SMP/NUMA architectures[C28].

Multiprocessor platforms will favor systems with distributed structure and message-passing communication. We are extending the TIMES and UPPAAL toolsets to analyze timing and resource requirements for such systems[C9]. To make analysis scale to loosely coupled systems, new techniques for component specification, which correlate timing properties with and available processing power are being developed.

Testing must be adapted to parallel applications, e.g., revising appropriate notions of coverage. We are developing a tool infrastructure, based on UPPAAL, for *Model based test generation*, where coverage criteria can be adapted to a priori knowledge about the systems[C19], and are also adapting automata learning techniques to generate component models for use in test generation and systems verification[C21].

The department leads the recently established WISENET national center of excellence in *wireless sensor network research*. Challenges for such networks include system heterogeneity, limited system resources, security aspects, and unpredictable intermittent connectivity, The Internet algorithms cope badly with these challenges. Gunningberg's group are designing new algorithms/protocols for route discovery, naming, data forwarding and security, as well as new opportunistic forwarding techniques[C23]. In the EU-funded FET project HAGGLE on opportunistic networking, we lead the architecture work on the testbed and analysis.

Based on the strong tradition on algorithmic verification of parameterized protocols, we are developing techniques for automated formal analysis for distributed systems with arbitrary, changing, and unpredictable topologies, such as found in, spontaneous wireless networks[C8,C29,]. Developed techniques will also be a contribution to the rapidly developing research field of analyzing programs with dynamic data and object structures. Work has started on techniques for analyzing stochastic performance and dependability properties of infinite-state system models (such as timed automata and Markov chains[C11]), with the aim to produce techniques that can be used to analyze performance of wireless networks.

Properties related to safety and security for distributed systems are being studied in the framework of process calculi for mobile systems (Parrow, Victor). A theorem prover for proving security properties for process calculus descriptions is being developed in an emerging collaboration with Microsoft Research in Cambridge.

The Uppsala Computing Education Research Group (*UpCERG*) is conducts research related to educational environments and specific didactic and pedagogic issues confronting the computing disciplines. The focus is on understanding student learning and the relationship between student learning and the higher education learning environment. The research vision is to stimulate didactic renewal and teaching and learning innovation. The group directs *CeTUSS*, the National Center for Student Centered Learning in Engineering.

Division of Human-Computer Interaction

Tomorrow most work activities will depend on technological support systems and the usability of these become extremely important.

We plan to continue the development of knowledge and prototype systems for *operators in complex control situations*. Our partners, e.g. in train traffic, now base their development of future traffic control systems on our results. We see an increasing interest from the car industry to cooperate in research on driver environments.

Another strategic area concerns *future mobile work*. We already have ongoing research on usability in mobile systems and applications in specific work areas such as home care. We here also participate in international networks (e.g. the Saltsa Mobility Group).

Most of our research and applications are based on a *user centred approach*, and this has been a success factor. We continue our research on user centred methods in practice. Here most research is performed in close cooperation with different organisations, e.g. administrative organisations, where methods can be evaluated in real projects. Here also ethical aspects of new information technology will be investigated.

In some fields the quality of IT systems is extra important, e.g in *health care*. We continue our efforts e.g. concerning patient record systems and in telemedicine.

We see research on *work environment and health problems* in IT-supported work as extremely important. The goal is to contribute to more sustainable work situations. We have earlier studied *cognitive work environment problems*, which are mainly related to the usability of the IT system, and applications of the demand/control/support model from Karasek & Theorell. This has been very successful, and research will continue.

In order to get more attention on usability and work environment issues, we have found that it is necessary to investigate *cost/benefit aspects of usability*. We have initiated research concerning economic aspects of IT systems.

Division of Systems and Control

Stoica and his colleagues have been among the first in the world to recognize and exploit the versatility of MIMO radar. There are also many possible applications of this work, for example to breast cancer detection[S31], hyperthermia-based treatment of cancer, and to several military operations.

Some of Stoica's recent research is in the area of NQR signal processing for explosive and narcotics detection, and also for pharmaceutical applications. Both of these research areas contain a large number of fundamental theoretical aspects that will be further addressed; for example, how to design multivariate signals constrained to have a constant modulus and optimizing a performance metric is an important largely-open fundamental problem.

The community shows an increasing interest for errors-in-variables system identification[S20], and it is a major topic in the division. Söderström gave recently an invited plenary talk, and has also a journal survey paper on the topic[S6]. Several fundamental questions remain in the area.

Estimation of material functions for viscoelastic materials is important in mechanical engineering and design. Our work so far has lead to many interesting results in this area. Besides many journal and conference papers[S16,S18,S21], overviews of this research have been presented at several international meetings.

Research in the division can be expected to grow in biomedical applications and industrial cooperation in general. Potential new areas include brain-computer interaction, system identification for PDE models[S30], modelling and control of smart buildings / materials, applications related to efficient production and use of energy, and nonlinear system identification towards related control problems. Previous work on sensor fusion[S29] is planned to be the starting point for development of new cellular navigation technology.

Division of Scientific Computing

Internationally, Computational Science and Engineering (CSE) is a technological field of rapidly increasing importance. A number of high-impact evaluations and reports[1] have recently identified an urgent need for increased research efforts aimed at the development of *advanced simulation and design tools for engineering and scientific systems.*

Successful CSE will be highly interdisciplinary, involving a range of skills that cannot be found in one department. The complexity in the hard- and software required for the solution of emerging CSE problems requires expertise beyond what normally can be found within departments in application fields. Nationally, DSC is the leading group when it comes to broad expertise and experience of analysis and development of numerical methods, solution algorithms, programming techniques, parallel implementations on modern computer architectures, and collaborative projects in CSE. DCS is therefore in a unique position to be a center of gravity for a long-term CSE initiative in Sweden and to make a significant contribution at the international level. Such an initiative will involve strategic, long-term partnerships with leading application department, built on our existing cooperations.

Fueled by the ever-increasing computing power, storage capacity, and network bandwidth, future CSE challenges will concern problems of exceptional complexity. Three areas in which there is a particular potential for progress, and where the competences within DSC provide a solid framework for further research, are *multiscale analysis, modeling and computation*; *high-dimensional problems*; and *design optimization/inverse problems.*

Multiscale analysis, modeling and computation concern phenomena where many different time and length scales are important. Applications are found in e.g. materials science, complex fluid flow and biology. The approach involves a hierarchy of coupled models, each valid on different time and length scales. The numerical methods need to be highly efficient for each scale. Moreover, the coupling between the models is highly nontrivial to formulate and analyze both on the mathematical and on the numerical side.

[1] E.g. the PITAC Report to the President on Computational Science, June 2005, http://www.nitrd.gov/pitac/reports/index.html, and Nature 440, February 23 2006, Theme on Future of Computing (8 papers).

A related field concerns methods for *high-dimensional* PDE in e.g. financial mathematics, quantum mechanics and molecular biology. Deterministic algorithms have advantages over traditional Monte-Carlo methods such as faster convergence and better error control. However, the “curse of dimensionality” is a problem, i.e. the computational work grows exponentially with the number of dimensions. Modern adaptive PDE methods using high-order schemes or mesh-free methods based on radial-basis functions can reduce the growth, but must be combined with new approaches based on the underlying structure of the problem to eliminate the curse.

Computational analyses of fixed geometric/parametric configurations often constitute only the first step in a scientific task. The ultimate goal is often to improve the geometry or to determine parameters that cannot be directly observed. Therefore, increasingly large portions of future CSE will likely concern *design optimization and inverse problems*, for instance in the form of design optimization of mechanical, electrical, and optical components.

Research at DSC is already evolving in these three directions. Successful subscale modelling of thin slots and wires was carried out within the Gems project[N37,N38]. Developments of computational methods for multiscale problems in combustion[N39], two-phase flow[N40], and systems biology[N9,N41] are in progress. Efficient methods for high-dimensional PDE are being developed[N42,N43] and used in applications[N44,N45,N46]. Also, recent advances in design optimization techniques are being expanded in various directions: towards the design of low-drag wings[N47], acoustic devices[N10,N48], arterial grafts, and new optimization-based tomography approaches.

Conditions to develop new directions of research.

The potential to develop new directions of research at the department is very high. The constant 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. Two essential conditions that are not completely fulfilled today is the possibility to attract leading young researchers in new fields by providing significant resources for research, and the possibility for non-constrained time for basic research and development of new projects.

A4. Select and present a list of publications representing the research activity

Division of Computing Science

D1: A. Andersson and M. Thorup. Dynamic ordered sets with exponential search trees. To appear in *Journal of the Association of Computing Machinery* (JACM).
[This paper present the final tight upper bound on for searching and updating a dynamic ordered set in a natural model of computation.]

D2: T.Risch, V.Josifovski, and T.Katchaounov. Functional data integration in a distributed mediator system. In P.Gray, L.Kerschberg, P.King, and A.Poulovassilis (eds.): Functional Approach to Data Management - Modeling, Analyzing and Integrating Heterogeneous Data, Springer, ISBN 3-540-00375-4, 2003.
[The paper summarizes the results from the Amos II project. It is part of a book on functional query processing where the authors wrote three chapters.]

D3: R. Carlsson, K. Sagonas, and J. Wilhelmsson. Message analysis for concurrent programs using message passing. In *ACM Transactions on Programming Languages and Systems* (TOPLAS), 28(4):715--746, 2006.
[Describes how to optimally structure the runtime system of a concurrent programming language, guided by an efficient global static analysis, and achieve a highly scalable implementation.]

Division of Computer Systems

C1: P. A. Abdulla, K. Cerans, B. Jonsson, and T. Yih-Kuen. Algorithmic analysis of programs with well quasi-ordered domains. *Information and Computation*, 160:109–127, 2000.
[Describes a general methodology for symbolic verification of infinite-state systems. The paper explained uniformly several previously unrelated works on verification of timed automata, Petri nets, lossy channel systems, relational automata, etc. It has also been used to derive new verification algorithms for unbounded networks of real-time processes, broadcast protocols , cache coherence protocols, timed Petri nets, etc.]

C2: A. Bouajjani, B. Jonsson, M. Nilsson, and T. Touili. Regular model checking. In Emerson and Sistla, editors, *Proc. 12th Int. Conf. on Computer Aided Verification*, Volume 1855 of *Lecture Notes in Computer Science*, pp. 403–418. Springer Verlag, 2000.
[Present regular model checking as a paradigm for verification of several parameterized and infinite-state systems. The paper proposes several modeling and verification techniques]

C3: Robin Milner, Joachim Parrow, and David 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.]

C4: K. Larsen, P. Pettersson, and W. Yi. UPPAAL in a nutshell. *Int. J. on Software Tools for Technology Transfer*, 1(1-2):134-152, 1997

C5: E. Fersman, L. Mokrushin, P. Pettersson, and W. Yi. Schedulability analysis of fixed priority systems using timed automata. *Theoretical Computer Science,* 354(2), 2006.
[Develops a new theory for scheduling analysis, which significantly generalizes the computation models and analysis techniques in classical real-time scheduling theory, allowing tasks with much more general arrival rates of tasks and complex behaviour. This papers collects all our results on scheduling, including all detailed proofs.]

C6: E. Hagersten and M. Koster. Wildfire: A scalable path for SMPs. In *High Performance Computer Architecture*, pp.172–181, 1999.
[Wildfire is Hagersten's NUMA/COMA industrial implementation with support for automatic migration and coherent replication of data. This paper evaluates how will these techniques suit important applications such as the TPC-C database workload.]

C7: C. Tschudin, P. Gunningberg, H. Lundgren, and E. Nordström. Lessons from experimental MANET research. *Ad Hoc Networks Journal* 3(2):221-233, 2005.
[This article highlights key lessons learned from real world deployment experiments with our widely distributed ad hoc routing protoccol implementations. We also summarise our work on developing the APE testbed in which reproducible large scale live experiments using standard devices have been performed over the last five years]

Division of Human-Computer Interaction

H1: J. Gulliksen, B.Göransson, I. Boivie, J. Persson, S. Blomkvist, and Å.Cajander. Key principles for user centred systems design. *Behaviour and Information Technology*, Vol. 22, No. 6. pp. 397-409, 2003.
[Describes our approach to how user centred methods can be made functional in practice]

H2: B Sandblad, J Gulliksen, C Åborg, I Boivie, J Persson, B Göransson, I Kavathatzopoulos, S Blomkvist and Å Cajander. Work environment and computer systems development. *Behaviour & Information Technology*, Vol. 22, No. 6, pp. 375–387, 2003.
[Reports on how usability and work environment can be considered in organisational and systems development]

Division of Systems and Control

S1: G. Ganesan and P. Stoica. Space-time block codes: a maximum SNR approach. *IEEE Transactions on Information Theory*, Vol 47, pp.1650-1656, 2001.
[A well cited paper that has presented a new perspective on space-time block coding in wireless communications.]

S2: T. Söderström, H. Fan, B. Carlsson, and S. Bigi. Least squares parameter estimation of continuous-time ARX models from discrete-time data. *IEEE Transactions on Automatic Control*, Vol 42, pp. 659-673, 1997.
[The first in a series of papers, analysing effects of noise on continuous-time modelling using stochastic models.]

S3: 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.]

S4: A. Swindlehurst and P. Stoica. Maximum likelihood methods in radar array signal processing. IEEE Proc., 86(2):421-441, 1998.
[W.R.G. Baker Prize Paper Award which is "presented by the IEEE Board of Directors to the author or authors of the most outstanding paper reporting original work published in the transactions, journals, and magazines of the IEEE Societies, or in the Proceedings of the IEEE."]

S5: T. Wigren. Recursive prediction error identification using the nonlinear Wiener model, *Automatica*, Vol. 29, pp. 1011-1025, 1993.
[A well cited paper that has presented a new perspective on space-time block coding in wireless communications.]

Division of Scientific Computing

N1: B. Gustafsson, H.-O. Kreiss, and J. Oliger. Time Dependent Problems and Difference Methods. John Wiley & Sons, New York, 1995.
[Summarizes much of the classical work on discretization of time dependent PDE]

N2: G. Kreiss and H.-O Kreiss, Stability of systems of viscous conservation laws, *Communications on Pure and Applied Mathematics*, Vol. 51, pp. 1397-1424, 1998.
[Analysis of the effect of viscosity on dynamic properties of solutions to systems of non-linear hyperbolic conservation laws. The first proof of stability for strong shocks.]

N3: J. Nordström and M. H. Carpenter. Boundary and interface conditions for high-order finite-difference methods applied to the Euler and Navier-Stokes equations. *Journal of Computational Physics*, Vol 148, pp. 621-645, 1999.
[A systematic way to construct high order accurate and stable finite difference approximations to initial boundary value problems.]

N4: O. Axelsson and M. Neytcheva. Preconditioning methods for linear systems arising in constrained optimization problems. *Numerical Linear Algebra with Applications*, Vol. 10, pp. 3-31, 2003.
[Surveys preconditioning for matrices on saddle point form, as typically arising in equality constrained optimization problems. It emphasizes some numerical procedures which are optimal in the sense that the computational work is proportional to the number of unknowns and are suitable for HPC implementations]

N5: L. Hemmingsson and K. Otto. Analysis of semi-Toeplitz preconditioners for first-order PDEs. *SIAM Journal on Scientific Computing*, Vol. 17, pp. 47-64, 1996.
[The article contains a thorough analysis of the (asymptotic) convergence properties for a Toeplitz-block preconditioned, minimal residual, iterative method applied to systems of equations, arising in the discretization of first-order PDE. The authors have devised a novel method to determine both the eigenvalues and the eigenvectors to the preconditioned operator.]

N6: J. Rantakokko. Partitioning strategies for structured multiblock grids. *Parallel Computing*, Vol. 26, pp. 1661-1680, 2000.
[Summarizes the work on load balancing and data partitioning techniques for parallel numerical PDE solvers.]

N7: P. Lötstedt and M. Nilsson. A minimal residual interpolation method for linear equations with multiple right-hand sides. SIAM Journal on Scientific Computing, Vol. 25, pp. 2126-2144, 2004.
[The multipole method for Maxwell's equations in electromagnetics is applied to solve scattering problems with many incoming waves. By utilizing the smooth behavior of the waves, a substantial reduction in computational work is achieved.]

A5. Select and present a list of publications representing renewal of research activity

Division of Computing Science

D4: P. Flener, J. Pearson, L.G. Reyna, and O. Sivertsson. Design of financial CDO squared transactions using constraint programming. *Constraints* 12(2), 2007.
[The paper describes the deployment of constraint technology to financial portfolio design, with Merrill Lynch.]

D5: W.Neidl, B.Wolf, C.Qu, S.Decker, M.Sinek, A.Naeve, M.Nilsson, M.Palmér, and T.Risch: EDUTELLA: A P2P networking infrastructure based on RDF. Presented at 11th International World Wide Web Conference, Honolulu, Hawaii, USA, May 2002.
[The paper proposes to use Datalog as query language paradigm for semantic web queries in a P2P system.]

Division of Computer Systems

C8: Parosh Aziz Abdulla, Noomene Ben Henda, Giorgio Delzanno and Ahmed Rezine. Regular Model Checking without Transducers.Proc. TACAS'07 13th Int. Conf. on Tools and Algorithms for the Construction and Analysis of Systems, to appear.
[Presents a simple an efficient procedures with makes it feasible to apply the paradigm of regular model checking to a wide class of protocols. Some of these protocols were earlier beyond the capabilities of existing tools for automatic verification.]

C9: Pavel Krcál, Wang Yi: Communicating Timed Automata: The More Synchronous, the More Difficult to Verify. CAV 2006: 249-262.
[Presents the first decidability results for timed channel systems. The message is that for timed systems containing unbounded FIFO channels, there is almost no interesting properties that are decidable due to synchronization on the global time.]

C10: E. Berg, H. Zeffer, and E. Hagersten. A statistical multiprocessor cache model. In *Proc. IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS-2006)*, 2006.
[This paper extends Hagersten's Statcache technique to also model multithread execution and to classify the different miss categories. It also described how sparse statistical data from one execution can be used to estimate the performance of a wide variety of other topologies.]

Division of Human-Computer Interaction

H3: N. Johansson, T. Lind, and B. Sandblad. Usability in IT Systems for Mobile Work. In Andriessen E och Vartiainen M eds., *Mobile Virtual Work: A New Paradigm?*, Springer Verlag, 2006.
[Describes both how mobile usability can be studied and how this can be considered when developing support systems for home care organizations]

H4: E. Olsson.What Active Users and Designers Contribute in the Design Process. *Interacting with Computers*, 16(2), 377-401, 2004.
[Describes, based on cases from design of operator systems, how an efficient participatory design process can be organised]

Division of Systems and Control

S6: T. Söderström. Errors-in-variables methods in system identification. *Automatica*, to appear as a survey paper, 2007.
[An overview of EIV results currently available, describing contributions to the field by various researchers including the author.]

S7: P. Stoica, Y. Selen, N. Sandgren and S. Van Huffel, Using prior knowledge in SVD-based parameter estimation for magnetic resonance spectroscopy--the ATP example. *IEEE Transactions on Biomedical Engineering*, Vol 51, pp. 1568-1578, 2004.
[This paper presents an advanced signal processing methodology for exploiting a priori information about the spectral peaks that occur in magnetic resonance spectroscopy.]

Division of Scientific Computing

N8: K. Ljungberg, S. Holmgren and Ö. Carlborg. Simultaneous search for multiple QTL using the global optimization algorithm DIRECT. Bioinformatics, Vol. 20, pp. 1887-1895, 2004.
[An efficient algorithm for solving least-squares problems with a specific structure is combined with an extended algorithm for global optimization. The scheme is applied to problems in genetics, where the solution can be computed several orders of magnitude faster than with existing methods]

N9: P. Lötstedt and L. Ferm. Dimensional reduction of the Fokker-Planck equation for stochastic chemical reactions. Multiscale Modeling & Simulation, Vol. 5, pp. 593-614, 2006.

[A stochastic, mesoscopic model is simplified by splitting it into a smaller stochastic part and a deterministic, macroscopic part. The problem is then solved efficiently on a mesoscopic scale coupled to a macroscopic scale.]

N10: E. Wadbro and M. Berggren. Topology optimization of an acoustic horn. Computer Methods in Applied Mechanics and Engineering, Vol. 196, pp. 420-436, 2006.
[Optimization of the material distribution inside an acoustic device. One of only a few works on topology optimization devoted to wave propagation problems.]

A6. List of publications not included in OPUS

Selected publications of Gunilla Kreiss, 2002-2006. Gunilla Kreiss was recruited to the chair in Numerical Analysis in July 2006.

M. Liefvendahl, G. Kreiss, Bounds of the Threshold Amplitude for plane Couette Flow, *Journal of nonlinear Mathematical Physics*, vol 9, no 3, 2002.

M. Liefvendahl, G. Kreiss, Analytical and Numerical Investigation of the resolvent for plane Couette Flow, *SIAM Journal of Applied Mathematics*, vol 63, no3, 2003

M. Siklosi, G. Kreiss, Elimination of first order Errors in time Dependent Shock Calculations, *SIAM Journal of Numerical Analysis*, vol 41, no 6, 2003

D. S. Henningson, G. Kreiss, Threshold amplitudes in subcritical shear flows. Nonlinear stability bounds. In Proceedings of the *IUTAM Symposium on Non-Uniqueness of Solutions to the Navier-Stokes Equations and their Connection with Laminar-Turbulent Transition*, Bristol, August 2004

G Kreiss, H-O Kreiss, J Lorenz, Stability of Viscous shocks on finite intervals, in proceedings of *Tenth international conference on Hyperbolic problems*, Osaka, September 2004,

E. Olsson, G. Kreiss, A Conservative Level Set method for Two Phase Flow, *Journal of Computational Physics*, vol 21, no 1,p225-246, 2005.
[Number 2 on JCPs list of most downloaded papers (last quarter of 2005)]

P-O. Åsen, G. Kreiss, A Rigorous Resolvent Estimate for Plane Couette Flow, *Journal of Mathematica Fluid Mechanics*, published online, 2005,

D. Appelö, G Kreiss, A New Absorbing layer for Elastic Waves, *Journal of Computational. Physics*, vol 215(2), p642-660, 2006.

D. Appelö, T. Hagstrom, G. Kreiss. Perfectly matched layers for hyperbolic systems: General formulation, well-posedness, and stability, *SIAM Journal of Applied Mathematics*, 67 (2006), pp. 1-23.

P-O Åsen, G. Kreiss, Resolvent bounds for pipe Poiseuille flow, *Journal of Fluid Mechanics*, 568, pp. 451-471, 2006.

A7. List of significant prizes and awards

Division of Computer Systems (Program: Datorteknik)

Parosh Abdulla, 45, Male, Lisa Kaati, 31, Female, 2006. Best Paper award at CIAA'2006 -- the 11th International Conference on Implementation and Application of Automata.

Per Gunningberg, 49, Male, 2002. Outstanding paper award: Voigt, T. and Gunningberg, P., Adaptive Resource based Web Server Admission Control, , 7th IEEE Symposium on Computers and Communication, Taormina/Giardini Naxos, Italy, July 2002.

Per Gunningberg, 53, Male, 2006. Golden Mobile Award 2006 - my earlier research through my company optimobile, www.optimobile.se

Joachim Parrow, 49, Male. 2005. Included by ISI (the Institute of Science Information) on the list of the 250 most highly cited researchers in Computer Science in the world. Parrow is one of totally two researchers in Sweden in this field on the list.

Parosh Aziz Abdulla and Luc Boasson and Ahmed Bouajjani. Effective Lossy Queue Languages. Award of EATCS – European Association for Theoretical Computer Science, for Best Paper at *ICALP' 01, 28th Int. Colloquium on Automata, Languages, and Programming*, 2001.

The TIMES tool by T. Amnell, E. Fersman, L. Mokrushin, P. Pettersson and W. Yi received the tool award at ETAPS 2002, Grenoble, France.

Division of Human-Computer Interaction (Program: Människa-datorinteraktion)

Bengt Sandblad, 57, Male, 2005. *The Levi Award for IT support in work environment***.** The Swedish Association of Graduate Engineers has awarded Professor Bengt Sandblad at Uppsala University the Levi Award in 2005 for his pioneering work in Psychosocial Work Enivironments.

Division of Systems and Control (Program: Reglerteknik)

Peter Stoica, 55, Male. 2004. Co-recipient of the Björkenska Prize (Major Research Award of Uppsala University).

Peter Stoica, 56, Male.2005. Recipient of the IEEE Achievement Medal awarded for "outstanding contributions to the field of Statistical Signal Processing".

Peter Stoica, 56, Male. 2005. Co-author of the contribution that has received the Best Student Paper Award at the 39th Asilomar Conference on Systems, Signals and Computers.

Peter Stoica, 56, Male. 2005. Included by ISI (the Institute of Science Information) on the list of the 250 most highly cited researchers in Engineering in the world. Stoica is one of totally two researchers in Sweden in this field on the list.

Torsten Söderström, 61, Male, 2006. IFAC Fellow. Citation: `for scientific contributions to system identification, for pedagogical explanations of identification to wide audiences and for inspiration to the scientific community'.

A8. Additional sources of information

All references cited in the text are available at http://www.it.uu.se/research/references/KoF2007. 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/tdb

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

Clarification: In the tables **total numbers** for the department should be presented (not detailed lists). During the visits the experts might ask for more detailed explanation regarding the numbers presented.

B1. Engagement and involvement in the scientific society (since 2003)

			82%		96%		100%		100%		100%	
			9		22		6		8		28	
			11		23		6		8		28	
			T	N	T	N	T	N	T	N	T	N
	Total number (T)	Number of individuals contributing (N)	Computing Science		Computer Systems		Human-Computer Interaction		Systems & Control		Scientific Computing	
Plenary or keynote talks at international conferences	23	8	0	0	15	4	5	2	2	1	1	1
Invited talks at international conferences	73	30	1	1	23	8	8	4	13	4	28	13
Assignment in research councils and foundations	44	20	2	2	27	7	1	1	6	4	8	6
Assignment as expert at evaluations for professor and lecturers positions	56	21	4	2	23	8	8	2	12	5	9	4
Assignment as editor or member of editorial boards	47	24	7	4	11	7	6	3	13	4	10	6
Member of international scientific councils	15	12	3	3	4	2	3	2	2	2	3	3
Member of academies and learned societies	33	17	6	3	5	4	6	3	9	3	7	4
IT Dept specific data:												
Hosting/Chair of major conferences	29	13	7	2	18	8	2	1	0	0	2	2
Member of Program Committee of major Conferences/Workshops …..	191	29	51	5	113	15	15	3	4	1	8	5

B2. Actions for renewal (since 2003)

External recruitments (with doctoral exam from another university)	5	0	0	0	3	0	0	0	0	0	2	0
Internal recruitments (with doctoral exam from Uppsala University)	10	0	2	0	3	0	2	0	0	0	3	0
Number of granted external funds for new projects (minor grants not included)	81	0	12	0	17	0	20	0	13	0	19	0

B3. International collaboration (since 2003)

Research visits abroad (of at least 3 months duration)	13	10	2	2	5	4	0	0	2	1	4	3
Visiting researchers (of at least 3 months duration)	10	7	1	1	7	4	1	1	0	0	1	1
Number of collaborating institutions with joint publications	155	33	13	4	85	11	10	3	21	4	26	11

B4. Engagement and interaction with society (since 2003)

Adjunct professorships	3	3	0	0	0	0	0	0	1	1	2	2
Popular science papers/books	12	5	0	0	4	2	8	3	0	0	0	0
Textbooks	10	7	3	3	1	1	1	1	5	2	0	0
Spin-off commercial companies	9	9	2	2	4	4	2	2	0	0	1	1
Governmental/societal assignments	14	9	4	4	4	2	2	2	0	0	4	1
IT Dept. specific data:												
Patents	49	4	0	0	25	2	0	0	24	2	0	0
Widespread Computer Programs	21	13	7	3	10	6	0	0	2	2	2	2
3GPP Standardization Contribution	3	1	0	0	0	0	0	0	3	1	0	0

Part C: Data extracted from common databases

See enclosed data regarding:

- **Personnel**
  1. Senior Research Staff, Professor (Chair and promoted)
  2. Docent (Associate Professor)
  3. Postdoctoral staff
  4. Doctoral students
  5. Other staff (all categories except the above)
- **Research examinations**
- **Publications**
- **Economy (research related)**

C1. If motivated, comment upon the extracted data

Clarification: Since the data regarding personnel, exams and economy is submitted according to university-wide (or national) standards and regulations the actual figures are fixed. However, due to the selection of data, you might want to comment upon circumstances with regard to traditions, profiles etc. in your specific research field. Remember that the assessment does not compare different departments within Uppsala University. It should rather reflect the quality and renewal of each department compared to that of other universities and departments (involved in the same research field).

Text (optional, if you have specific comments on data in part C)…

The economic data given in part C must be interpreted with great care. A substantial proportion of the faculty and university funding is transferred to the department by adjustments performed after the books are closed, and thus do not show up in part C. Therefore the figures on revenues and costs do not give the full picture. From these data one might get the impression that the department are loosing several Million SEK every year, which is not correct. The actual figures for 2004 and 2005 where in the red, but not as negative as it may appear in part C. For 2006, the net result was approximately + 1 Million SEK.

Concerning bibliographic data, Uppsala University publication data base OPUS is used. For our department the information in OPUS should be reliable for the time period 2002-2006 as far as refereed publications are concerned. However, for 2001 and earlier, OPUS is not a reliable source.
The same applies also for non-refereed publications for all years, since our main focus has instead been on entering refereed publications. Here an exception is the Division of Scientific Computing, where an effort has been made to enter also non-refereed publications for 2002-2006.