Department of Computer Science, University of Aarhus

Strategic Plan 2008-2012

December 2007 --- Final Draft, version 1.4

This document describes the department's strategic plans for future scientific development and, as a consequence, a plan for employment of new permanent academic staff. The plan is made by the head of department with input from the research committee. It cannot be expected to be implemented exactly as described. It will have to be negotiated with the Dean of the Faculty of Science and furthermore, it is our experience from the previous plans that some of the positions will be postponed/cancelled for different reasons and there may also be situations in which it becomes suitable to add a new position to the plan.

In 2003 the Department of Computer Science developed a 5 year hiring plan. A central goal of the plan was to make a significant increase of the number of permanent academic staff. With some delay, the first two years of the plan were followed. However, the net growth of the permanent academic staff was quite limited. Since the development of the 2003 hiring plan, many internal and external constraints have changed: political priorities (on the national, regional, local and university level), research opportunities/trends, loss of academic staff (and thus expertise in certain areas), and so on. There is still a need for a significant increase of the permanent academic staff. We strongly believe that the growth should be based on strategic considerations and on building existing as well as new areas of research strength.

This document consists of four parts. In the first part we describe the strategic importance and relevance of the field. It is argued that computer science has a vast impact on society, and also on other sciences, and hence receives considerable interest from politicians at all levels. The second part describes the Department of Computer Science, in particular how we contribute to education, research and dissemination activities. Statistics are provided comparing our performance with other departments in our faculty and with other Danish computer science departments. We also briefly present our existing research groups. The third part presents our detailed strategic considerations, while the fourth part presents the resulting development plan for new permanent academic staff towards 2012.

1. Strategic Importance and Relevance

Computers pervade all parts of human activities and they are indispensable in our modern society. They perform financial transactions, are used in the design of almost all products we use (from simple ashtrays to cars, airplanes and infrastructures). They control the operation of numerous everyday devices, are used to plan and perform medical procedures and to control and analyse scientific experiments.

The pervasive use of computers has not only brought computer science in focus as a strategic important research field in general, but it has also been shaping – and continues to shape – the research directions within the field. For example, we are increasingly using networked computing devices such as phones, handhelds and GPS. Advanced networked sensors are increasingly being incorporated in buildings, cars, phones, goods and even humans. This way we are increasingly expecting to be able to access and process very diverse data anywhere at any time. This development has shaped (and also been shaped by) the pervasive computing research area, which e.g. encompasses research in the augmentation of everyday devices with information and communication technology, sensor and actuator based physical/digital integration, and interaction paradigms beyond the desktop metaphor. And as a basis for such work new developments within networks, especially ad hoc networks and wireless sensor networks, as well as security and efficiency play an important role.

The pervasive use of computers and the increased ability to acquire data has also resulted in a spectacular increase in the amount of data we collect. This has in turn led to an increasing number of commercial and scientific applications processing truly massive amounts of data. Articles in the February 2006 focus issue of Nature: *"2020 – Future of computing"* highlights these trends by describing the exponential growth of scientific data. This has shaped the need for research in the area of efficient handling, processing and mining of massive datasets in e.g. the algorithms and database areas.

Another important research trend is the importance of working in interdisciplinary and multidisciplinary teams. Multidisciplinary research in particular has recently been highlighted as a key to future research progress, for example in several articles in the Nature February 2006 focus issue. It is argued that a paradigm shift is currently taking place in the sciences implying that computer science (data collection, organisation and transformation) will become paramount in all sciences. Rather than painstakingly performing experiments and collecting their own data, many scientists will soon spend most of their time "mining" massive up-to-the-minute databases.

The broad trends identified above are not only visible in the computer science research community, but also more generally in the political research priorities on the national, regional, local and university level. However, additional political priorities and factors on each of these levels are also important for the choice of the research directions within our department.

On the national level, research (especially in science and technology) and higher education are targeted as key areas in the development of international competitiveness. Specific initiatives like the "Danish National Advanced Technology Foundation" (Højteknologifonden), the program for "Nano Science/Technology, Bio Technology and IT" (NABIIT), and the program for "User Driven Innovation" (Erhvervs- og Byggestyrelsen) have been set up to promote commercial innovation and growth based on cooperation between public research and industry.

At the regional level the newly established Region Midtjylland (covering the middle part of Jutland) is supplementing its healthcare services (centred around the hospitals of the region) with a focus on business development in three areas: food, energy/environment, and healthcare. In the food-initiative computer science is used for production planning and control; for modelling; for logistics/tracking (e.g. to support the concept "from-earth-to-table" (fra-jord-til-bord)). In the energy/environment-initiative computer science is used for modelling and control (e.g. models of energy supply and use); for new ways of using such information to control and adjust energy production and consumption. The healthcare-initiative is targeting ICT related healthcare products and services.

On a more local level the University of Aarhus has cooperated with the local authorities and industry in creating the IT-City of Katrinebjerg and the Alexandra Institute. Both the municipality and the region continue to give high priority to the development of the IT-City. Katrinebjerg and Alexandra have become national icons for ICT-based cooperation between public research and industry and are already generating a huge demand for ICT research supporting a broad spectrum of industrial and societal innovation initiatives. Some of these have been mentioned above, but in addition to these there is a strong demand for research and people skilled in the relations between ICT infrastructure, systems and applications, on the one hand, and organisational structures and networks, on the other.

Finally, a number of priorities expressed through the 2006-2008 development contract between our university and the Ministry of Science, Technology and Innovation are important for the development of our department. Theoretical natural sciences are among the six focus research areas identified in the contract and our department (as the natural sciences as a whole) has always had a number of strong theoretical groups. Some of the other focus areas (probably most noticeably nanoscience/nanotechnology and molecular medicine) highlight the importance of multidisciplinary research. The multidisciplinary aspects have been further highlighted by the recent fusions with e.g. the Aarhus School of Business (Handelshøjskolen), the Danish National Environmental Research Institute (Danmarks Miljøundersøgelser), and the Danish Institute of Agricultural Sciences (Danmarks JordbrugsForskning). The University is also trying to strengthen the engineering area. Supported by Region Midtjylland ten new full professorships have been announced within the engineering disciplines, including one in computer engineering and another in communication technology.

On the educational side, the university is working on a significant expansion of the new Aarhus Graduate School of Engineering (AGSE), which is part of the university's collaboration with the Engineering College of Aarhus (Ingeniørhøjskolen). The university also has the ambitious goal to double the number of PhD students, and this is likely to imply that the number of PhD students in science (and also in computer science) will have to be more than doubled. A significant expansion (from 350+ admissions in 2005 to 450+ admissions in 2008) of the IT-education on the bachelor and master level is also one of the university's main educational priorities (in fact IT is the only prioritised area within education). It is expected that a good deal of these admissions will have to be in the Department of Computer Science.

Finally, broader use of university research, e.g. through patents, licensing agreements and spin-off companies, as well as collaboration with industry and local government, also takes a prominent place in the university development contract. The IT-City Katrinebjerg and the Alexandra Institute are specifically mentioned as a unique environment for establishing close collaboration between researchers, the private industry and other organisations.

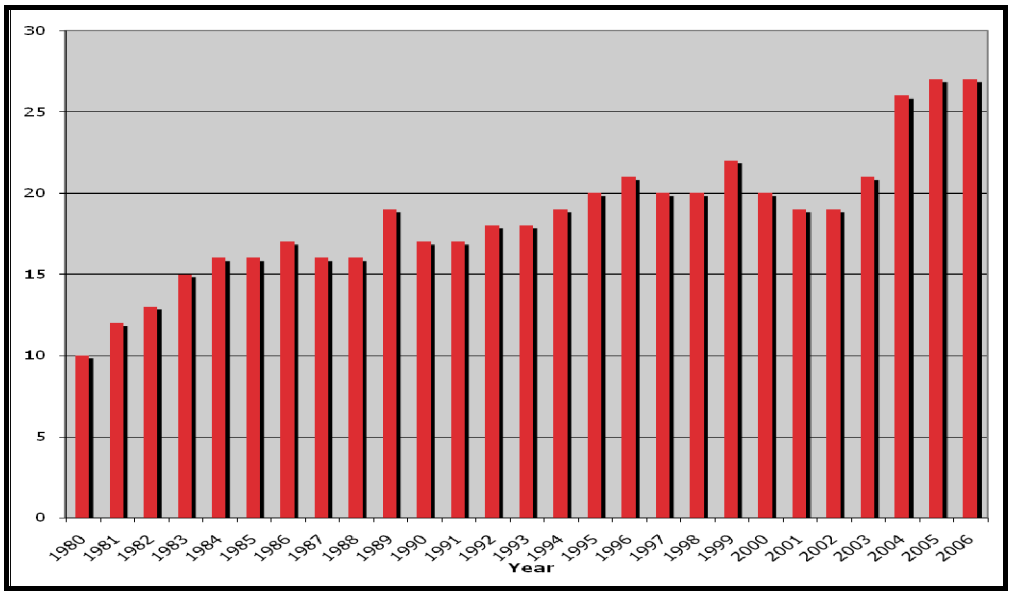
2. The Department of Computer Science

Computer science started at the University of Aarhus in 1971 as a part of the Department of Mathematical Sciences. In the period 1993-1998, computer science went through a very rapid growth increasing the total staff from 80 to 160 people – primarily due to a dramatic increase in the amount of external funding. An independent Department of Computer Science was created in January 1998. Over the next 5-6 years, the department gradually moved to new buildings as a part of the university's plan to concentrate the ITC activities in the IT-City Katrinebjerg. There is a close collaboration with other organisations in Katrinebjerg, in particular with the Department of Information and Media Sciences and the Alexandra Institute.

The department is strong in both theoretical and experimental computer science. While this has been the case for a long time, we have in recent years seen much closer collaboration between the different research groups – even those which have traditionally been perceived as being far from each other (with respect to scientific goals/methods). Partly as a result of this, recent projects at the department have targeted research themes and application areas that are interdisciplinary and multidisciplinary in nature.

As it can be seen from the graph below, the permanent academic staff has been rather stable over the last 20 years and has not increased proportional to the growth in total staff. From 1989 to 2003 there were around 20 members of the permanent academic staff. Then the number was increased to 27.

Development in permanent academic staff (number of persons)



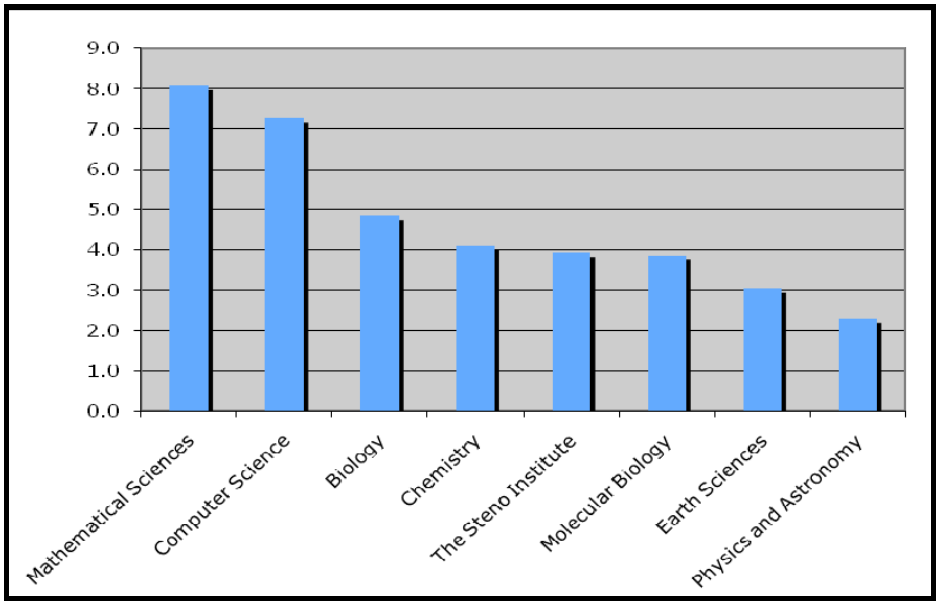
Contributions to Education, Research and Dissemination

Within the University of Aarhus, the department contributes substantially to all of the three basic obligations of Danish universities: education, research and dissemination. Below, we give an overview of the department's contribution in these areas, illustrated by various statistics. The numbers are taken from the university's own statistics (including PURE and "Rektorkollegiets nøgletal") and from a common benchmarking project together with some of the other Danish computer science departments.

Education

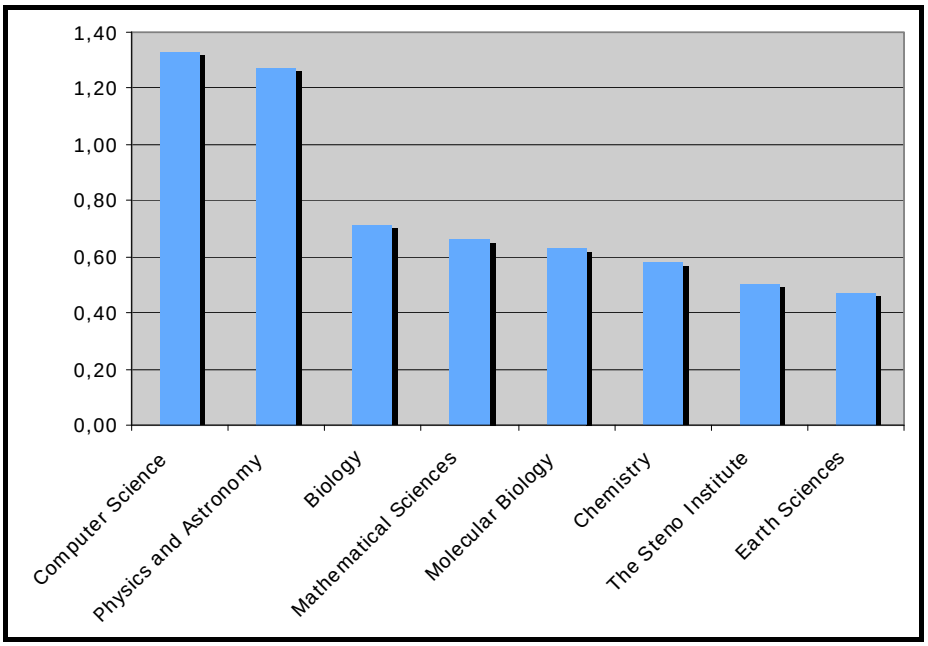
As shown in the statistics below, the department contributes significantly to the education at the Faculty of Science. Compared to the other departments in the faculty, our department ranks second in production of student-years (STÅ) per member of the total academic staff (including temporary staff in externally funded projects). In addition to the "ordinary" student-years reported in the figure below, the department is very active within open-university education (efter- og videreuddannelse). In this area, we produce more than half of the STÅ production at the entire faculty. The total STÅ production at the department has been steadily increasing over the last years, due to new lines of studies and the open-university activities.

STÅ production relative to total academic staff (2006)

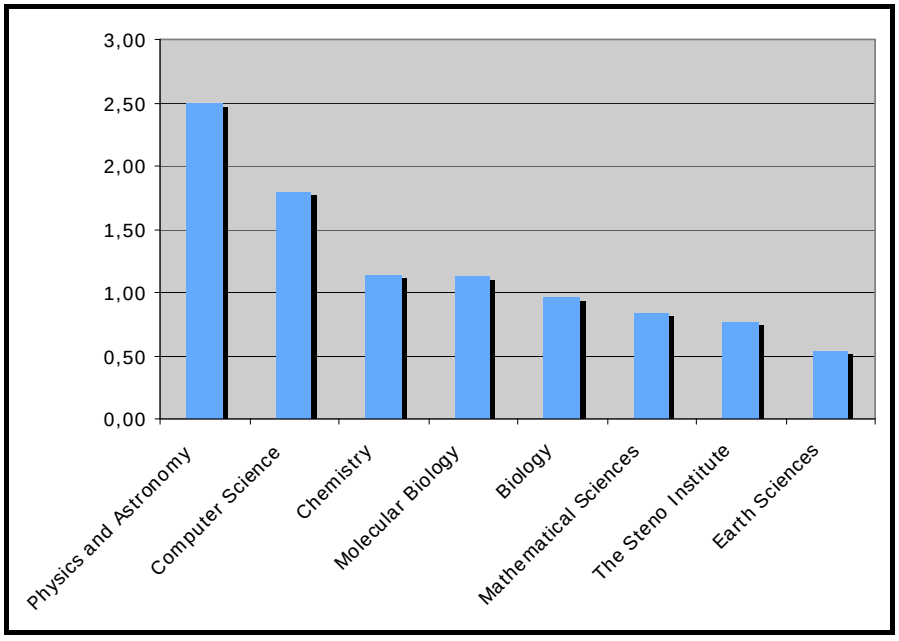


The department has for several years put specific emphasis on PhD education. All PhD students at the department are affiliated with the BRICS research school, which also covers parts of computer science in Aalborg and information sciences in Aarhus. BRICS started as a research centre and research school in theoretical computer science. It has become a well known “brand” in computer science and has been praised in several international evaluations for the quality of its students and the timely completion of PhD theses. The academic staff at the department put a significant amount of work into supervision of PhD students. This is illustrated by the graphs below. Measured relative to the total academic staff the department has the highest number of PhD students in the faculty and measured relative to the permanent academic staff the second highest.

Number of PhD students relative to total academic staff (2006)



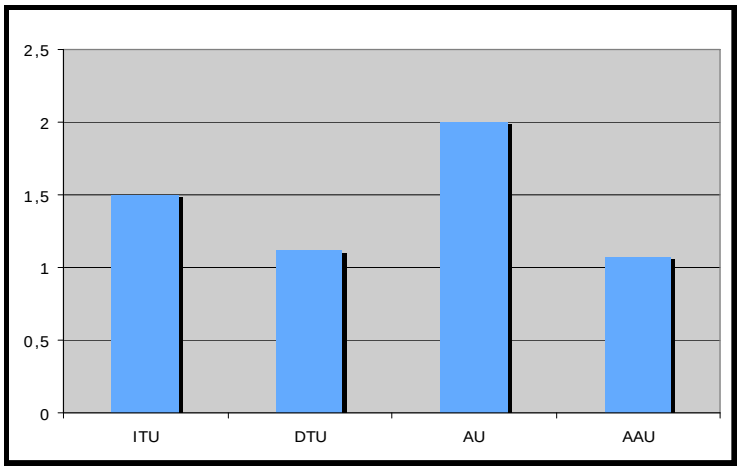
Number of PhD students relative to permanent academic staff (2006)



The graph below shows that the department also compares favourably to other Danish computer science departments. The numbers are from a joint benchmarking project with the following participants:

- IT University of Copenhagen (ITU).
- Institute for Mathematical Modelling at the Danish Technical University, Lyngby (IMM).
- Department of Computer Science at the University of Aarhus (AU).
- Department of Computer Science at the Aalborg University (AAU).

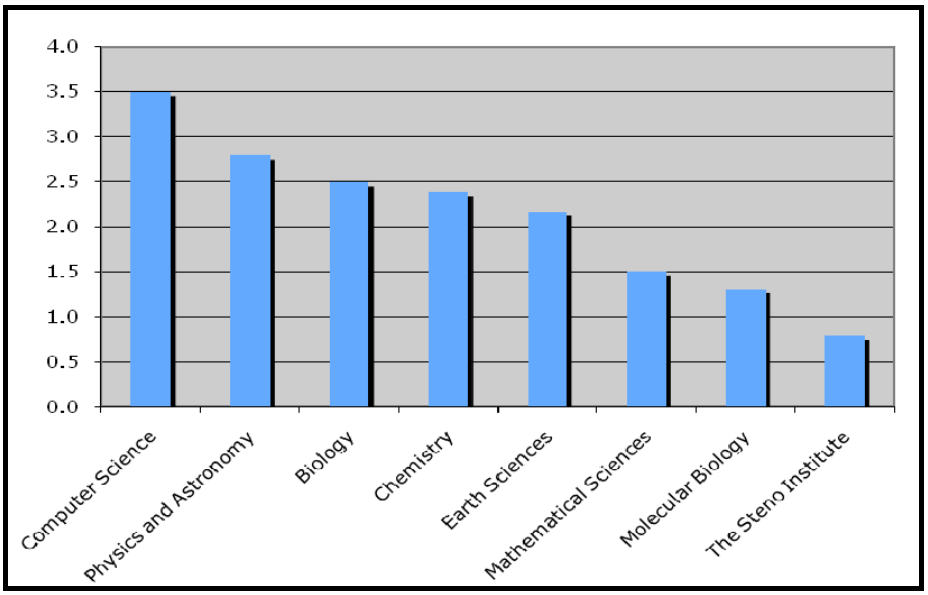
Number of PhD students relative to permanent academic staff (2006)



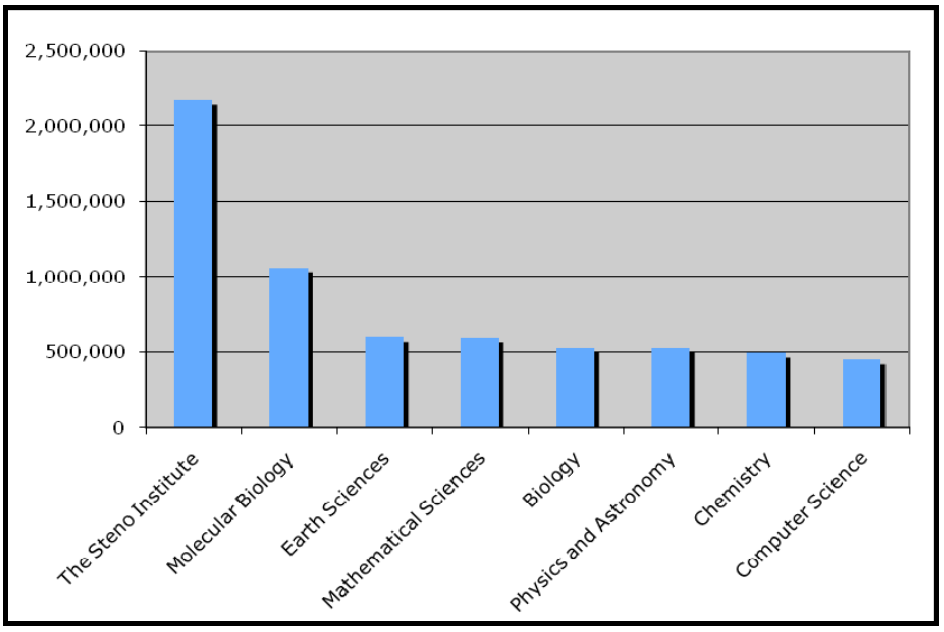
Research

Measured by the number of refereed publications, the department is a very productive part of the faculty. Relative to the size of academic staff, we are the most productive department in the faculty, and we also have the lowest “price” per refereed publication.

Number of refereed publications relative to total academic staff (2006)

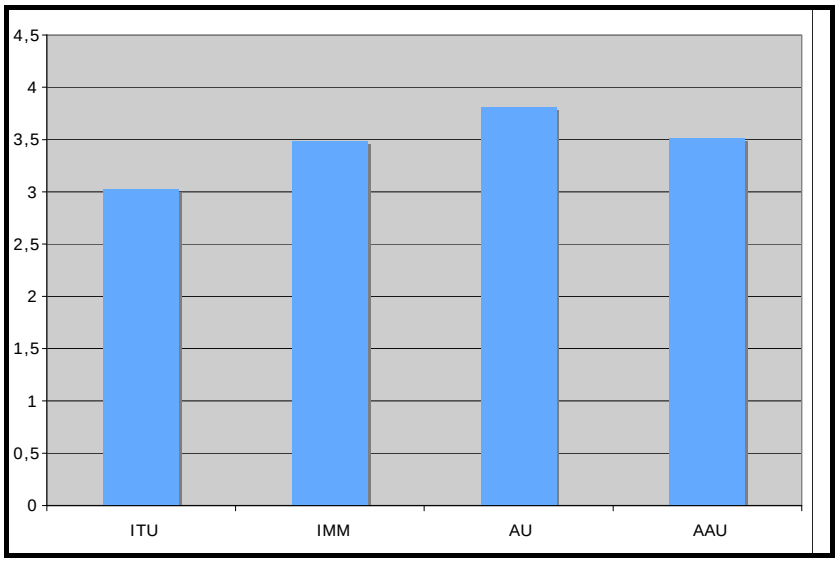


Running costs (in DKK) relative to number of refereed publications (2006)



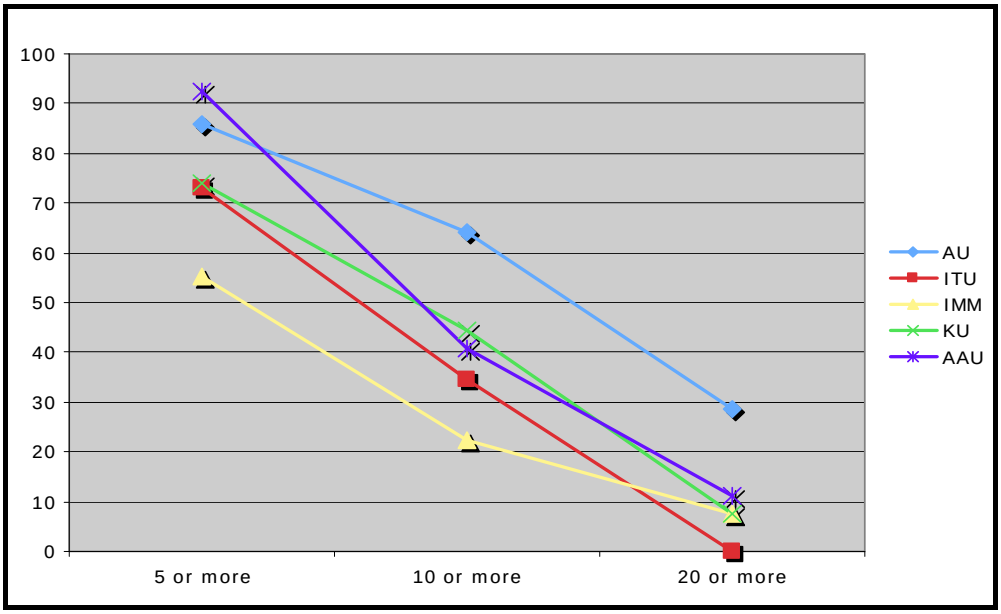
The graph below shows that the department also compares favourably to other Danish computer science departments. The numbers are from a joint benchmarking project mentioned above.

Number of refereed publications and books relative to total academic staff (2006)



We have also (via Google Scholar) compiled (approximate) statistics for the H-index of the permanent staff at different Danish computer science departments. The H-index is a well-known indicator for the impact of a researcher's work. Hirsch, who proposed the H-index, suggests that a researcher with an H-index of 20 or more can safely be assumed to be a very successful scientist. In our department, about 28% of the permanent academic staff have an H-index of 20 or more, while this fraction ranges from 0 to about 10% at the other Danish computer science departments. In addition to the participants in the joint benchmarking project, the H-index statistics includes the Department of Computer Science at the University of Copenhagen (KU).

Percentage of permanent academic staff with H-index above 5, 10 and 20.



Dissemination

A very substantial part of the department's dissemination of knowledge and research results takes place via a close cooperation with the Alexandra Institute – a company founded with the purpose of doing match-making between researchers and companies in the IT sector. A substantial part of the research projects with co-financing from industry is based on contacts established through the Alexandra Institute. The projects are usually related to innovation and some of them have lead to start-up companies. It is noteworthy that several recent projects of this type include researchers from the part of the department that has traditionally been focused on basic research in theoretical computer science. At the same time, this cross-fertilisation between theory and practice has not lead to any substantial decrease in theoretical research.

The department also collaborates with the Alexandra Institute and other institutions on Katrinebjerg in more traditional PR efforts to disseminate knowledge about the department, our educations, and IT in general. This has lead to improved dissemination websites, press-releases, electronic newsletters with a wide distribution, and several issues of "Katrinebjergmagasinet" that are widely distributed to the public, in particular partners of the Alexandra Institute.

Research Groups

This section provides a brief description of all current research groups in our department. Permanent academic staff is listed by names, where we put in parentheses people who are formally in the group, but in reality are assigned to other tasks in the university. For each group we provide statistics for the number of PhD students, publications, citations, memberships of editorial boards and programme committees, and for the amount of external funding spent at our department.

Algorithms and Data Structures

Focus: The group works on improved algorithms and data structures for fundamental problems in classical computational models, as well as in newer models such as the cache-oblivious model that takes the hierarchical memory of modern machines into account. It especially works on so-called I/O-efficient algorithms, that is, algorithms that are designed to efficiently process truly massive datasets that must reside on slow secondary storage devises. It also has a focus on algorithm engineering. In recent years a "generation change" has taken place within the group and recently the group was awarded a Center of Excellence (Center for Massive Data Algorithms, or MADALGO) from the Danish National Research Foundation.

Academic staff:

Permanent: Lars Arge, Gerth Stølting Brodal, (Erik Meineche Schmidt).

Temporal: Mohammad Adam, Henrik Blunck, Srinivasa Rao.

PhD students: 6

Publications and citations for LA and GSB:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
35	103	11	0	6	3

Citations based on Google Scholar: 2500+ | H-Index ≥ 20: LA

Editorial boards and PC memberships since 2004 for LA and GSB:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	4	6	31

External funding for LA and GSB:

2004–2007: 8.8 mio DKK	2008–: 35.2 mio DKK.

Cooperation: Strong international research cooperation, heavily engaged in international conferences and journals. Good cooperation with local industry and a beginning strong multidisciplinary collaboration with biological and environmental researchers.

Bioinformatics

Focus: The group is part of the Bioinformatics Research Center (BiRC) at the University of Aarhus. Focus is on algorithms for large biological data sets, including classical as well as genetic algorithms.

Academic staff:

Permanent: Christian Nørgaard Storm Pedersen.

Temporal: Mette Alstrup Lie, Thomas Mailund, Lea Thøgersen.

PhD students: 4

Publications and citations for CNSP:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
16	22	0	0	0	4

Citations based on Google Scholar: 100+	H-Index ≥ 20: None

Editorial boards and PC memberships since 2004 for CNSP:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	0	0	6

External funding for CNSP:

2004–2007: 1.4 mio DKK	2008–: 1.6 mio DKK.

Cooperation: Good local cooperation with other departments under the Faculty of Science.

Complexity Theory

Focus: Cell probe complexity; bounded width and bounded depth computation; computational mathematics; algorithmic game theory.

Academic staff:

Permanent: Gudmund Frandsen, Peter Bro Miltersen, (Sven Skyum).

Temporal: Maurice Janssen, Orestis Telelis, Nikolaos Triandopoulos (with Cryptography & Sec.)

PhD students: 4

Publications and citations for GF and PBM:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
34	49	4	0	2	0

Citations based on Google Scholar: 1000+	H-Index ≥ 20: None

Editorial boards and PC memberships since 2004 for GF and PBM:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	1	1	20

External funding for GF and PBM:

2004–2007: 0.7 mio DKK	2008–: 7.1 mio DKK.

Cooperation: The group has close connections to the Department of Mathematical Sciences and organises a joint seminar with the algebra group there. The group is also heavily involved in the "Center for Theoretical Science", where Miltersen is a board member and collaborates with the School of Economics and Management on game theory and auction theory. Strong international research cooperation; few industrial contacts.

Computer Graphics and Scientific Computing

Focus: Physically based simulation of deformable surfaces and fluids; biomedical simulation and visualisation; medical image processing on graphics hardware. Biomedical simulation; finance theory; diffusion equations and parameter correlation.

Academic staff:

Permanent: Ole Østerby, Peter Møller-Nielsen, (Ken Museth, adjunct prof).

Temporal: Michael Bang Nielsen, Thomas Sangild.

PhD students: 2.

Publications and citations for OØ and PMN:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
19	12	0	2	0	10

Citations based on Google Scholar: 125+ | H-Index ≥ 20: None

Editorial boards and PC memberships since 2004 for OØ and PMN:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	0	0	0

External funding for OØ and PMN:

2004–2007: 0.0 mio DKK	2008–: 0.0 mio DKK.

Cooperation: Good local cooperation with Centre for Advanced Visualisation and Interaction (CAVI), other departments under the Faculty of Science, and departments under the Faculty of Health Sciences. Some, emerging, international cooperation in the computer graphics area.

Cryptography and Security

Focus: Public-key cryptography, cryptographic protocols, and quantum cryptography. Public-key cryptography draws inspiration from both complexity theory and algebra, more specifically number theory and algebraic geometry, and is extremely useful in practice. The cryptographic protocol research area is experiencing an extremely fast development, where the group contributes both to the basic theory of the field and to efficient constructions and implementations. In quantum cryptography, the group contributes with efficient experimental implementations as well as theoretical work.

Academic staff:

Permanent: Ivan Bjerre Damgård, Louis Salvail.

Temporal: Jesper Buus Nielsen, Nikos Triandopoulos (with Complexity Theory)

PhD students: 9

Publications and citations for IBD and LS:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
5	129	0	0	5	10

Citations based on Google Scholar: 4000+ | H-Index ≥ 20: IBD

Editorial boards and PC memberships since 2004 for IBD and LS:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	2	2	8

External funding for IBD and LS:

2004–2007: 15.2 mio DKK	2008–: 10.3 mio DKK.

Cooperation: Good international research cooperation and very good involvement with the industry, e.g. through the Alexandra Institute via the Centre for IT Security.

Human-Computer Interaction

Focus: Empirical and theoretical research in participatory design; theories and methods for user interface design and evaluation; theories, technologies and applications of computer support for collaborative work; theories, standards, and technologies for open hypermedia and advanced Web-technology; methods, technologies and applications that integrate physical and digital environments and material, and embed ICT-capabilities in artefacts and in the human environment. Historically, this group started in the mid seventies as a systems development and user-centred design group. The group has developed new methods for system development with active user participation. It has had a strong influence on the agenda of HCI second-generation theory and methodology, hypermedia, and is among the founders of participatory design (PD) and computer supported cooperative work (CSCW).

Academic staff:

Permanent: Olav Wedege Bertelsen, Susanne Bødker, Kaj Grønbæk, Morten Kyng, Preben Holst Mogensen.

Temporal: Niels Olof Bouvin, Frank Allan Hansen, Thomas Riisgaard Hansen, Simon Bo Larsen, Marianne Graves Pedersen, Lisa Wells.

PhD students: 8.

Publications and citations for OWB, SB, KG, MK and PHM:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
57	112	60	2	21	101

Citations based on Google Scholar: 6000+	H-Index ≥ 20: SB,KG,MK

Editorial boards and PC memberships since 2004 for OWB, SB, KG, MK and PHM:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	5	2	27

External funding for OWB, SB, KG, MK and PHM:

2004–2007: 39.4 mio DKK	2008–: 22.3 mio DKK.

Cooperation: Many international long-term visitors; strong cooperation with international partners, in particular in Europe. Heavy engagement in organisation of international conferences and journals. Cooperation with many other groups at Katrinebjerg including the Alexandra Institute.

Modelling and Validation of Distributed Systems

Focus: Coloured Petri Net modelling language, analysis methods, and supporting computer tools; use of models in software engineering and specification of IT systems; construction and validation of communication infrastructures and protocols, with focus on network-layer Internet protocols, and protocols for mobile ad-hoc networks and sensor networks; algorithms and data structures for formal verification of finite-state distributed systems; simulation-based performance analysis of distributed systems. In recent years a “generation change” has taken place and the group has broadened its scope to include areas outside Petri Nets.

Academic staff:

Permanent: Lars Michael Kristensen, Søren Christensen (half-time), (Kurt Jensen).

Temporal: Sami Evangeliste, Michael Westergaard.

PhD students: 5

Publications and citations for LMK, SC and KJ:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
20	76	18	5	19	27

Citations based on Google Scholar: 4500+	H-Index ≥ 20: KJ

Editorial boards and PC memberships since 2004 for LMK, SC and KJ:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
1	2	7	23

External funding for LMK, SC and KJ:

2004–2007: 8.1 mio DKK	2008–: 5.5 mio DKK.

Cooperation: Very well-developed international research network and heavily engaged in international conferences and journals. Distributes a computer tool with 6.000 licenses in 130 countries.

Object-Oriented Software Systems

Focus: Object-technology and experimental software architecture. The group originally focused on object-oriented programming language and environment research. It has had a major impact on modern main-stream programming languages like Java and C#, as well as in the focus of object-oriented language constructs for modelling rather than reuse applied in object-oriented software design. Most permanent members of the group have been hired rather recently.

Academic staff:

Permanent: Henrik Bærbak Christensen, Erik Ernst, Klaus Marius Hansen, Klaus Ostermann, (Ole Lerhmann Madsen).

Temporal: Mads Ingstrup, Kari Rye Schougaard, Weishan Zhang.

PhD students: 9.

Publications and citations for HBC, EE, KHM, KO and OLM:

Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
19	68	22	1	4	101

Citations based on Google Scholar: 3500+	H-Index ≥ 20: None

Editorial boards and PC memberships since 2004 for HBC, EE, KHM, KO and OLM:

Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)
0	1	2	30

External funding for HBC, EE, KHM, KO and OLM:

2004–2007: 17.3 mio DKK	2008–: 18.4 mio DKK.

Cooperation: The group has a very good record of cooperation with industry, nationally and internationally. The group has a good international network. Ole Lehrmann Madsen has in his role as managing director of the Alexandra Institute over the last 8-9 years managed networks and research projects with governmental support for more than 120 mio DKK. The activities have involved more than 50 Danish IT companies, which have supported research at Katrinebjerg in general and the Department of Computer Science in particular with a co-funding amounting to 94 mio DKK. These activities have lead to the formation of several spin-off companies and new applications of pervasive computing in existing industries.

Programming Languages and Formal Models					
Focus: Semantics, logics, and implementations of programming languages (interpreters, compilers, and virtual machines); domain-specific languages; program analysis and transformations; web programming; concurrency; embedded systems; global computing, mobility, and security; specification and verification of software.					
Academic staff:					
Permanent: Olivier Danvy, Anders Møller, Michael I. Schwartzbach, (Mogens Nielsen).					
Temporal: None.					
PhD students: 3.					
Publications and citations for OD, AM, MIS and MN:					
Journal Papers	Reviewed Papers	Book Chapters	Books	Volumes Edited	Workshops, panels, etc.
92	106	11	3	38	27
Citations based on Google Scholar: 7500+			H-Index ≥ 20: OD, MIS		
Editorial boards and PC memberships since 2004 for OD, AM, MIS and MN:					
Editorial Boards (as editor-in-chief)	Editorial Boards (as member)	PCs (as chair or co-chair)	PCs (as member)		
1	13	4	25		
External funding for OD, AM, MIS and MN:					
2004–2007: 21.0 mio DKK		2008–: 5.9 mio DKK.			
Cooperation: Good international and national research cooperation.					

Ole Caprani is the only permanent academic staff member who does not belong to one of the groups mentioned above. His main areas of interest are: use of simple robot technology in multi-agent systems for entertainment and artistic expression in physical installations; use of LEGO robotics for teaching at a wide range of levels; sound as media, between signal and music.

3. Strategic Opportunities

Part 1 of this document has identified a number of trends in computer science, within other sciences and in our society that have important consequences for the future development of computer science. Computers pervade more and more aspects of our lives and at the same time computer science pervades other sciences to an ever increasing extent. One consequence of this is that the challenges computer scientists are facing can no longer be overcome by using expertise from only one part of computer science. Interdisciplinary and multidisciplinary research is a key to progress, and this calls for collaboration between different parts of computer science as well as collaboration with other sciences. At the same time, political priorities on national and regional levels put computer science in a central position, thus creating a potential which the department should be ready to exploit.

In this part, we point out a number of strategic opportunities in various areas of computer science. These have been chosen such that:

- they fit into the general picture outlined in part 1 (e.g., many of them are interdisciplinary and multidisciplinary).
- the department is in a position to exploit these opportunities (given its current strengths and competencies).

Opportunities within the Department

Among those areas that are already strongly represented in our department, a number of opportunities for joint research ventures are currently being investigated or have already manifested themselves through research grants and publications, e.g. in projects like: Secure Information Management and Processing (SIMAP), Palpable Computing (PALCOM), and IT Security for Citizens (ITSCI). Thus, the department has proved to be capable of exploiting opportunities for synergies between existing groups, and we believe the same can be done between existing groups and new related areas which we wish to develop. Such a strategy seems much more feasible than attempts at developing completely new groups: it will in general be easier to attract highly qualified people when they can relate to researchers already in the department.

Below, we give a list of strategic opportunities, many of which are possible synergies where substantial related expertise already exists in our department.

- Efficient algorithms for handling massive amounts of data is an increasingly important research area with strong connections to, e.g., pervasive computing. In addition to the importance as a core area, it also offers excellent possibilities for multidisciplinary collaboration. For instance, the area of databases acts as a catalyst between algorithms and data structures on one side and programming languages and formal models on the other side. Key researchers in the department contribute to research in databases from distinct angles: algorithms for massive data sets vs. XML technology. They both regularly publish in and are represented in program committees for international database conferences. Thus, it seems that an incoming database researcher will easily recognise that a research platform can be built in this as yet vacant room for synergies.
- The algorithmics and complexity community has recently taken an interest in game theory, resulting in the development of algorithmic game theory. This is very much in line with the trend towards widespread use of computers, which naturally implies that we think of computers, not as stand-alone, but as entities that interact with others who may, however, have conflicting interests. This puts a new focus and perspective on the core areas of algorithms and data structures and complexity theory. In addition, and at the same time, the analysis of cryptographic protocols has started using game theory to analyse adversarial behaviour, so called rational cryptography. A large potential for synergy exists here.
- The development of pervasive computing has long been a focus area for our department. Pervasive computing often depends on the ad-hoc deployment of a large number of small-scale systems and devices. The success of such configurations depends crucially on their user interfaces, the software architecture, their efficiency and the networks/protocols by which computers may dynamically utilise resources available at other computers. In addition, the reliability of such systems is a crucial factor, and hence being able to validate and verify a system before deployment is an important goal. There is therefore an important border area between: modelling and validation of distributed systems; object-oriented software systems; human-computer interaction; and algorithms and data structures.
- More widespread use of computers naturally means that IT-security becomes an even more important issue. Specifying and designing secure systems requires ability to express desired security goals and analyse whether they have been achieved. Therefore, the border area between programming languages and formal methods and cryptography and security is very promising. In practice, security of a system depends, not only on technical soundness, but also on its usability. If users fail to understand relevant security aspects of a system, they will make bad decisions and security may be lost. Solving such problems requires both technical and human-computer interaction skills, and hence security in practice is to a large extent a border area between cryptography and security and human-computer interaction. This means that we have synergies between three areas in which our department has a strong position.
- Finally, computer graphics is an area in which the department wants to build a new group. Also this is an area with strong connections to other activities and groups in the department. For instance, graphical representation of medical data is an important application area, and the department already houses a Center for Pervasive Healthcare. Computer graphics is obviously also of great importance in human-computer interaction. Computational geometry, one of the strengths of the algorithms and data structure group, is also important for computer graphics.

Opportunities with Other Partners

There are still many unexplored opportunities in the relationships with other departments and institutions at Katrinebjerg, e.g. Centre for Advance Visualisation and Interaction (CAVI), Department of Information and Media Sciences (IMV), Aarhus School of Architecture (AAA) and the Engineering College of Aarhus (IHA). Similarly, the department has good relationships with the other science departments in our faculty which can still be expanded.

Opportunities within the Faculty of Science

Our department has been quite successful in discovering and exploiting opportunities for joint research ventures with other areas within the faculty. Some significant cases include:

- Algorithm and data structures with bio-sciences (this has already become an established discipline anchored in the Bioinformatics Research Center (BiRC) focused on analysis of genetic sequences).
- Cryptography and security with physics (producing joint research projects in quantum cryptography).
- Algorithm and data structures with earth sciences and biology (developing frameworks for applications of geographical information systems (GIS)).
- Complexity theory and algorithm and data structures with mathematics (investigating opportunities for joint research within scientific computing).

We think that such multidisciplinary initiatives are very important. However, they should be planned and coordinated at the faculty level, and hence they are not directly reflected in our hiring plan Presented in part 4.

Opportunities with other Institutions

In addition to internal synergies, the department has established collaboration with a number of institutions external to the Faculty of Science.

The department is heavily involved in engineering education initiatives, where a graduate program in computer engineering has been established within the Aarhus Graduate School of Engineering (AGSE) at the Faculty of Science. In this area there is already a number of professorships announced, of which two are relevant to our department. The involvement in the engineering initiative is expected to contribute to the general activities of our department. Subareas of particular interest are: embedded systems, networks/protocols, signal processing, sensors, software engineering, and real time systems. The initiative has so far not been supported by tenured positions.

We have also been expanding our activities within the area of Pervasive Healthcare, i.e. the use of pervasive computing to provide healthcare. The work is lead by the human-computer interaction group and has generated activities for more than 50 million DKK. The main external partners are the University Hospital, the Institute of Experimental Clinical Research and the County. The Engineering College of Aarhus is also involved. The primary health care areas addressed are: home care, independent living, acute medicine, chronic diseases and medical image processing. Furthermore we have recently begun to work with concepts for "the hospital of the future", integrating design of the physical buildings with design of ICT and new ways of organizing health care. The Aarhus School of Architecture is a very active partner in this. The initiative has so far not been supported by tenured positions.

Another growing area of external collaboration is the relationship to Aarhus School of Architecture. There has been more than eight years of research collaboration between our human-computer interaction group and the Department of Industrial Design (within the joint Centre for Interactive Spaces). This centre has until now generated research and development activities amounting to 50 million DKK (including the industrial contributions). The cooperation has also manifested itself in a branch of the newly established IT-bachelor education (with focus on IT-product design). These research and education initiatives have so far not yet been supported by tenured positions.

A third area of recently established external collaboration is with the Aarhus School of Business (ASB) as part of their recent fusion with our university. Research activities in the area of business development are being sketched, and the Aarhus School of Business is going to contribute to one of the branches on the newly established IT-bachelor education (with focus on business). A new collaboration with researchers at the Universities School of Economics and Management on game theory is also taking shape.

Researchers from our department also collaborate with two of the other institutions which have recently been fused with our university. We collaborate with researchers at the Faculty of Agricultural Sciences around massive terrain processing and more broadly Geographic Information Systems (GIS). New collaboration with researchers at the National Environmental Research Institute is also taking shape. This includes a broad initiative, which also involves researchers from the Department of Biological Sciences, about climate change, as well as an initiative around GIS also involving researchers from the Department of Earth Sciences.

A final area of external collaboration is with the Faculty of Humanities, where the Department of Information and Media Sciences (IMV) is involved in our joint multimedia education and in the BRICS2 PhD School. This has given rise to a number of Master's thesis and PhD thesis projects bridging between the two departments. The number of students on the multimedia education has decreased compared to the early years to a fairly stable level with 20-25 students taking the supplementary year of their bachelor's and 10-15 students continuing on the Master's level. This initiative has not yet been supported by tenured positions.

Other Strategic Considerations

Refocusing Resources

Computer science is an evolving field and the department is similarly not a static organisation. Our interests and expertises change through the years, partly prompted by developments in our field and partly by changes in our academic staff. Loss of permanent staff members has significantly reduced some of our groups. We do not propose that such areas should invariably be re-staffed. Rather, we view this as an opportunity to refocus our resources. As an early example, the department used to have significant expertise in VLSI design and development, but the persons in this area have left the department and it has been decided not to rebuild this area. In more recent times, an active research group within complex systems and artificial intelligence has been completely depopulated. At present, the activities within semantics and logic have suffered a similar loss, and we do not envision a strategic plan that includes rebuilding this area to its former strength. Rather, we will refocus and consolidate our resources in the related areas of programming languages and mobile computing. A similar refocusing has already taken place for the area of systems development, where our resources have been consolidated within the areas of human-computer interaction and pervasive computing.

Quality Assurance

The department has a very high scientific production with a high international recognition –resulting in high citation counts. During the envisioned expansion process, we will focus on maintaining and strengthening the publication and citation levels. Nevertheless, we remain to have researchers among the very highest scores internationally. To reach this goal we can either try to hire one or two researchers at this level, or we can support existing academic staff in progressing to this level. Finally, to obtain a more uniform level, an effort should be put into helping some of the research groups in targeting higher quality conferences and journals.

Gender Issue

The department has, similarly to many other computer science departments world wide, serious problems in recruiting female students and, in turn, female researchers. The department has already made initiatives for recruiting more female students by running IT-camps for girls every fall, targeting primary school and high school girls. But it is a long term effort to increase the amount of female students, and it is a process that requires explicit resources for campaigns.

With respect to recruiting researchers we also need to make an active gender policy, that makes it attractive for female students to enter PhD studies, and we need an employment policy that balances the evaluation of research merits with e.g. maternity leave periods. Among possible new initiatives, we may establish search committees to find female researchers for specific subject areas, or we may consider hiring an "extra" female applicant when a female applicant for a position has got excellent evaluations without being the one chosen for the position.

International Staff

Over the years the department has had a large number of non-Danish members of its permanent academic staff. This has been extremely fruitful and has significantly contributed to the success of the department. Unfortunately, it turns out that there is a higher turn-over rate for this group – in the sense that most of them have returned to their home countries after a period of 5-10 years (primarily for family reasons or because they have won attractive professorships there).

The department wants to increase the number of non-Danish academic staff members, which has now become rather low due to the reasons mentioned above. To do this it will be necessary to use search committees and to use our network to attract top-qualified staff from abroad (and from other Danish computer science departments).

Synergies with other IT Educations

At the University of Aarhus, the IT-research (and research based teaching) is taking place in many different locations and departments such as: Institute of Business and Technology (AU-IBT, Herning), Aarhus School of Business (ASB), School of Economics and Management (Økonomisk Institut), Department of Information and Media Studies (IMV), and our Department of Computer Science. This provides many strategic opportunities, and the department welcomes a strategic discussion on this at university level.

4. Development Plan for Permanent Academic Staff

As described in the previous parts of this document, the department has established itself as one of the very best Danish computer science departments with an excellent international reputation. It is a natural goal for the Department to maintain and improve this position by exploiting some of those strategic opportunities that were pointed out in the part 3 – opportunities that fit into the academic and political context we live in, and where scientific potential exists in the department. In order to pursue this goal, it will be necessary to open a number of new permanent positions. Below, we argue why this is the case, and suggest a detailed list of positions over the coming five years.

More Permanent Academic Staff is needed

The shortage of permanent academic staff at the professor and associate professor level is increasingly becoming a serious bottleneck for further expansion of our activities. The department has a much smaller percentage of permanent academic staff than other comparable departments within Denmark and abroad. This means that the permanent academic staff uses a very substantial part of their time for project applications, project administration, and project leadership. This obviously decreases the incitement and possibilities to start new projects.

Hence, the department proposes to increase the permanent academic staff from the present 26 people to 35 people in 2018. This is consistent with the vision of the department which says: “Over a period of 10 years the number of permanent academic members of staff should increase by 10, at least, half of them preferably from other institutions.”

To reach this goal the staff must be extended with an average of one person per year. As argued above, it is highly desirable that a significant part of these persons come from other universities in Denmark or abroad and we also want to be able to attract more women. To fulfil these objectives the department wants to follow a more active hiring strategy, including search committees and other proactive initiatives, to locate highly qualified researchers who may be interested in joining the department. As part of this, it will be desirable to be able to open positions to “scan” a research area. We only want to fill such positions if top-quality candidates apply. Hence, we foresee that some of our announcements will turn out not to lead to employment. This is in contrast with the present hiring strategy where announcements have only been made when well-qualified applicants were known prior to the announcement.

Permanent Academic Staff are leaving for other Jobs

Since 1995 the department has hired a total of 19 new permanent professors and associate professors: Klaus Ostermann 2008, Lars M. Kristensen 2007, Lars Arge 2007, Anders Møller 2006, Jakob Bardram 2005, Olav Wedege Bertelsen 2005, Erik Ernst 2005, Louis Salvail 2004, Klaus Marius Hansen 2004, Gerth Stølting Brodal 2004, Christian N. Storm Pedersen 2004, Henrik Bærbak Christensen 2003, Thiemo Krink 2001, Kasper Østerbye 1999, Ulrich Kohlenbach 2000, Preben Mogensen 1999, Søren Christensen 1997, Peter Bro Miltersen 1996, Olivier Danvy 1995.

In this period, the permanent academic staff only increased by 5 persons. There has been one retirement due to age: Brian Mayoh. This means that the department in the period has lost 13 members of its permanent staff. Most of these have won professorships at other universities in Denmark and abroad (or joined the management of our faculty). This is a clear witness of the excellent qualifications of our staff.

There is no reason to believe that this trend will change over the next years (and we already know of one associate professor who will leave the department in 2008). Moreover, there will be at least two retirements due to age within the next 5 year period: Ole Østerby (born 1939) and Peter Møller-Nielsen (born 1942). Hence, the department must hire more than two persons per year to fulfil its goal of growing with one person per year, reaching 35 permanent staff members in 2018.

Detailed Plan

The department has made a plan where we propose 16 new positions for the coming 5 year period. It is our experience from the previous plans that when it is time for the concrete decisions to be made the announcement and hiring for some of these positions will be postponed or cancelled for different reasons. On the other hand, there may also be situations in which we want to add a new position to the plan, e.g. if we loose existing staff with competences in critical areas or if we get the possibility to attract top-quality researchers within other interesting areas. As an example it would make a lot of sense to try to strengthen the department's competences within operating systems. However, it is difficult to attract good researchers within this area unless they can be associated with related groups.

We believe that the proposed plan is likely to result in an actual net growth of approximately one person per year over the five year period covered in this plan. If the actual net growth turns out to be significantly larger, the plan should be reconsidered.

The department also wants to repeat the request for a more aggressive professor policy. As it can be seen from the large number of highly qualified people leaving associate professorships at the department, there is a serious need for a possibility to offer more prestigious positions and also better salaries.

For each position we list the "area". This is not necessarily the final area to be specified in the job announcement. We also list the "main group", i.e. the group which we think it is most likely that the new staff member will belong to socially, and we list a number of "other groups" which are interested in and related to the area and which the new staff member is expected to cooperate with. This is followed by a brief motivation for the area. The year indicates the planned time for the announcement of the position. Typically the hiring will be up to one year later.

2007

Area: Software architecture for distributed embedded systems.
Main group: Object-oriented software systems.
Other groups: Modelling and validation of distributed systems.
Motivation: Software architecture for distributed embedded systems is an important area for development of products with embedded information technology. Such systems must be dependable, flexible, efficient (with respect to speed, size and sometimes real time requirements) and maintainable and they often exist in a number of different variants. This poses a large number of challenging research questions. The area is currently not covered by the department, but it will supplement existing research in object-oriented software systems and modelling and validation of distributed systems. Moreover, it is a central discipline within the area of computer engineering. External funding for 50% of the first 3 years exists.

2008

Area: Computer graphics.
Main group: Start of new group.
Other groups: Possible cooperation with many of the existing groups.
Motivation: Computer Graphics is an area of growing importance for a range of application domains such as scientific visualisation, medical imaging, filmmaking, computer games, as well as virtual and augmented reality. Technologies are ranging from real-time rendering utilising modern parallel graphics board, over polygonal modelling tools, to implicit mathematical models for batch rendering of complex simulations and transformations of graphics. There are many possible synergies between computer graphics, algorithms and data structures and Human-Computer Interaction. The department has a number of young researchers in the area, thus the department wishes to establish a group with a couple of senior researchers

Area: Databases.
Main group: Start of new group.
Other groups: Algorithms and data structures, programming languages and formal models, and many of the other existing groups.
Motivation: Databases is a traditional and important area that is undergoing continuous development through novel challenges from technology and application areas. The department is currently hosting at least two areas of active research that significantly overlap with modern database research, namely XML processing and massive data sets. Thus, there is fertile ground for growing an independent research profile in databases. The area is also highly relevant for bioinformatics.

Area: Interaction design.
Main group: Human-computer interaction.
Other groups: Object-oriented software systems.
Motivation: Interaction design is a growing research area within human-computer interaction and pervasive computing with focus on new interaction paradigms beyond the traditional keyboard, mouse and desktop. There are many interaction design challenges related to the growing number of devices such as cell phones, interactive surfaces, etc. New types of sensors making it possible for users to utilise their senses beyond seeing and hearing are emerging, but they are still poorly supported. Interaction design is well suited to address technologies as well as concepts and design methods in the area of pervasive computing.

2009

Area: Complexity theory.
Man group: Complexity theory.
Other groups: Programming languages and formal models, cryptography and security, algorithms and data structures.
Motivation: The department already has a small but very active group within complexity theory. Recently this group has broadened its scope to include game theory. We want to extend the group in order to obtain critical mass and in order to maintain competences within the more core disciplines of complexity theory. Natural subareas to strengthen include Boolean and arithmetic circuit complexity, lower bounds in combinatorial and algebraic models of computation and algebraic methods in computational complexity in general.

Area: Cryptographic protocols.
Main group: Cryptography and security.
Other groups: Computational complexity, algorithms and data structures.
Motivation: The theory and practice of cryptographic protocols have undergone an explosive development, making connections to several other areas. As an example, concepts from game theory can be used to analyse attacks on protocols, and concepts from quantum information can be used to construct and analyse protocols with completely new properties. The department has excellent expertise within all these areas, so it is a natural strategic move to hire a person that can develop the border areas.

Area: Massive data algorithms.
Main group: Algorithms and data structures.
Other groups: Complexity theory, modelling and validation of distributed systems, computer graphics, bioinformatics.
Motivation: Efficient handling of massive data is an increasingly important research area with strong connections to e.g. pervasive computing and excellent possibilities for multidisciplinary collaboration. The department already has a strong group in this area, which hosts the newly established Danish National Research Foundation Centre MADALGO. The possibilities for synergy with computer graphics, databases, and many of the existing research groups, make it natural to extend the scope of our expertise within massive data algorithms to include new subareas such as distributed, routing and online algorithms (which e.g. are also all important for the development of networks expertise), as well as approximation algorithms or more generally optimisation algorithms.

Area: Software architecture for mobile computing.
Main groups: Object-oriented software systems, human-computer interaction.
Other groups: The position will establish synergies between several existing research groups.
Motivation: With the explosion in the number of different programmable mobile devices and the multitude of different networking possibilities, mobile computing software has become a central research area. Mobile web applications, mobile games, mobile media, mobile payment, RFID tag applications etc. provide many research challenges. These include understanding and building infrastructure as well as web-services and peer-2-peer services for mobile devices. Among the hard problems are application level handling of varying network availability and bandwidth. The department has had a number of projects within this area and we now want to establish a more permanent competence. The area is also highly relevant for the teaching and research within computer engineering.

2010

Area: Computer graphics.
Main group: Start of new group.
Other groups: Possible cooperation with many of the existing groups.
Motivation: Similar to the 2008 position within computer graphics. The position should be announced and filled in such a way that it complements the other position.

Area: Databases.
Main group: Start of new group.
Other groups: Algorithms and data structures, programming languages and formal models, and many of the other existing groups.
Motivation: Similar to the 2008 position within databases. The position should be announced and filled in such a way that it complements the other position.

Area: Massive data algorithms.
Main group: Algorithms and data structures.
Other groups: Complexity theory, modelling and validation of distributed systems, computer graphics, databases, and bioinformatics.
Motivation: Similar to the 2009 position within massive data algorithms. The position should be announced and filled in such a way that it complements the other position.

Area: Modern computer networks.
Main group: Modelling and validation of distributed systems.
Other groups: Object-oriented software systems, human computer interaction, computer engineering, algorithms and data structures.
Motivation: The development, validation and application of new kinds of computer networks, such as ad-hoc networks, sensor networks and peer-2-peer networks are crucial to most modern computer systems since they usually operate on a distributed set of computing devices. The department already has activities in this border area and we want to extend and strengthen these. The area is also highly relevant for the teaching and research within computer engineering.

2011 and 2012

Area: Context awareness and multi-sensory systems.
Main groups: Object-oriented software systems.
Other groups: Human computer interaction, modelling and validation of distributed systems.
Motivation: A core area in pervasive computing is systems based on multi-sensory input to provide relevant support either directly to a user and/or to actuators in the environment. Context-awareness includes location-aware systems based on positioning technology such as GPS or Galileo. However, modern pervasive computing applications, e.g. at hospitals, for rescue workers or in precision farming, need a wider definition of context and further possibilities for handling and interpreting a multiplicity of different sensors. The department has had a number of projects within this area and we now want to establish a more permanent competence. The area is also highly relevant for the teaching and research within computer engineering.

Area: Model checking.
Main group: Modelling and validation of distributed systems.
Other groups: Algorithms and data structures, programming languages and formal models.
Motivation: Due to their concurrency and non-determinism, distributed systems are inherently much more complicated to design and validate than centralised systems. Moreover they are difficult to test and they become increasingly complex. Hence, it is desirable to model and validate such systems before the more detailed construction begins. The department already have two groups with strong competences within formal modelling and verification. We want to build on these competences and combine them with the competences from algorithms and massive data sets, since this is needed for effective model checking of industrial-size systems.

Area: Programming languages and security.
Main group: Programming languages and formal models.
Other groups: Cryptography and security.
Motivation: Security of applications may be studied at several different levels, including cryptographic security, type-based security, and model-based security. Common to these approaches is the integration of these concepts into programming languages and the development of both specialised notations and validation tools that ensures such security. The department has excellent expertise in both programming languages and security, and it is therefore natural to expand in this hybrid area.

Area: Security.
Main group: Cryptography and security.
Other groups: Object-oriented software systems, human-computer interaction.
Motivation: Security of a system depends not only on technical soundness but also on its usability. If users do not understand relevant security aspects of a system, they will make uninformed decisions and security may be lost. Therefore, security in practice is to a large extent a border area between cryptography and human-computer interaction. The department has excellent expertise in both these areas, and it is therefore natural to expand in this area.