Department of Computer Science

Faculty of Science and Technology
Aarhus University

Strategy 2016-2020

1. Introduction

This document describes the strategy of the Department of Computer Science at Aarhus University for the years 2016–2020. The strategy has been formulated in 2015, as a result of a joint effort involving all scientific permanent staff. The contents have been discussed with:

- The department's faculty members.
- The department's Joint Cooperation Committee.
- The department's Research Committee.
- The Dean and the Vice Deans.

2. Vision, Mission, Executive Summary and Overall Goals

Vision
The Department of Computer Science is recognized as one of Europe's leading departments in computer science.[1]

Mission
To conduct computer science research of the highest international calibre with societal and industrial as well as to educate outstanding students who will be leaders of the next generation.

Executive Summary
Computer Science is very important for the development of all sectors of society. Indeed, the use of IT is the key factor for increasing productivity in Denmark (see, e.g., Danske Erhverv, 2015; It er hovednøgle til øget dansk produktivitet). The importance is also reflected in the fact that the graduates from our two Master's degree programmes and our PhD students are in high demand - there is no unemployment among our graduates and our graduates get jobs where they make use of the competences they have obtained during their studies. To help meet this big demand, the Department of Computer Science has increased the intake of students considerably over the last 10 years. Establishing the IT product development programme has played a key role in this. Unfortunately, the number of faculty members has not increased correspondingly (indeed it has decreased slightly) and therefore we are now challenged by a very high number of students per faculty member. Another key challenge is to increase the number of bachelor students who complete a degree. To address this challenge we will be more selective with the students we admit (possibly admitting fewer students which would lead to an increase in the time available per student) and revise and improve our study programmes.

The department has several high-profile research groups and high-profile individual researchers, as evidenced by the impact of our research, awards, and the fact that we have been able to attract elite funding, such as individual ERC grants (at all levels: advanced, consolidator, and starting); DFF Sapere Aude grants (at all levels: advanced, starting, research talent); and Centers of Excellence from the Danish National Research Foundation. In the coming period we will continue to strengthen and support the development of our core research areas. In addition, we have also identified two "flagship areas", which combine world-class research competences from several research groups and whose development will be prioritized in the coming period: the flagship areas will be used to identify new research areas to be built up in the future. The flagship areas are "Big Data and Data Analytics" and "Cyber-Security".

We propose to create a cross-departmental interdisciplinary theme at the Faculty of Science and Technology (ST) on Big Data and Data Analytics, led by the Department of Computer Science, and combining research and education. This initiative is contingent on allocation of additional resources.

[1] Currently, we are ranked at number 34 on QS World University Rankings by Subjet 2015 – Computer Science and Information Systems. It is our ambition to enter into top 10: http://www.topuniversities.com/university-rankings/university-subject-rankings/2015/computer-science-information-systems - sorting=rank+region=140+country=+faculty=+stars=false+search=

2.1. Overall Goals

- Develop flagship research and education activities within “Big Data and Data Analytics” and ”Cyber-Security”.
- Interdisciplinary theme on “Big Data and Data Analytics” at ST.
- Strengthen and support the development of our core research areas.
- Revise and improve the computer science and IT programmes and increase the percentage of computer science and IT students who pass a bachelor’s degree within four years.
- Attract better students.
- Strengthen the collaboration with industry and public institutions.

3. Physical Environment and Organization

The department is located in the IT City Katrinebjerg. The majority of the buildings are relatively new and of high quality. The entire staff is located in the same building complex with short distances between offices. Master’s thesis students are located together with their research groups while other students are located in nearby buildings.

The department has a flat organization. The Head of Department and the Vice Head of Department have weekly work meetings with the Head of Secretary. Strategic issues are discussed at meetings with the leaders of the research groups. Finally there are monthly meetings with the permanent academic staff, twice a month with the permanent non-academic staff, and quarterly meetings with postdocs, PhD students and the Joint Cooperation Committee. In addition to this there are committees for:

- Research
- Business
- Postdocs studies
- PhD studies
- Bachelor and master studies
- Part-time supplementary studies
- PR and recruitment
- Offices
- Labs
- Seminars
- Library
- Occupational Health and Safety

Each committee is responsible for the daily decisions within their specific area. Larger and more political decisions are discussed with the department leaders, who meet with each committee 1-2 times a year to discuss the strategy, action plans and resources of the committee.

3.1. Research Groups

The current research groups of the department are listed below. A typical research group consists of 2-4 permanent faculty members and a number of postdocs and PhD students. A more detailed description of the fall 2015 status of the different research groups can be found in Appendix 8.1. See http://cs.au.dk/research-at-cs/ for a description of current activities.

The department is strong in both theoretical and experimental Computer Science. In recent years we have seen a closer cooperation between different research groups – even those that have traditionally been perceived as being far from each other (with respect to scientific goals/methods). Partly, as a result of this, many projects at the department have targeted research themes and application areas that are interdisciplinary and multidisciplinary in nature.

Algorithms and Data Structures
Algorithms and data structures (in classical computational models, as well as newer models that take the hierarchical memory of modern machines into account), algorithm engineering. The group hosts a Danish National Research Foundation Center (MADALGO).

Data-Intensive Systems
Database and data management, including efficient query processing and indexing, as well as clustering, outlier detection, classification, and similarity search.

Cryptography and Security
Public-key cryptography, cryptographic protocols, quantum cryptography, secure multiparty computation.

Mathematical Computer Science
Computational complexity theory, combinatorial optimization, algebraic algorithms, algorithmic game theory and mechanism design. Together with cryptography and security the group hosts a Danish National Research Foundation Center (CTIC).

Logic and Semantics
Models and logics for programming languages and type theories, modular reasoning about concurrent, higher-order, imperative programs, and language-based security.

Programming Languages
Design and analysis of languages and tools, functional languages and formal semantics, object-oriented languages and type systems.

Ubiquitous Computing and Interaction
Ubiquitous and mobile computing, positioning and context awareness, user interface technologies, interaction design for ubiquitous computing (including theoretical foundations, design methods and emerging interaction technologies). The group manages several large strategic research projects with industrial participation.

Computer-Mediated Activity
New interaction techniques, methods and theories for computer-mediated activities of work and everyday life, mechanisms that support human development and appropriation of IT.

Use, Design and Innovation
Design methods for systems covering work places, public spaces and private homes. Most of the research is accomplished through large projects, where users, companies and researchers cooperate on analysing, designing, constructing and evaluating prototypes and use-processes.

Bioinformatics
Development and application of computational methods for analysis of biological and biomedical data. The group is part of the Bioinformatics Research Centre (BiRC) which is an independent centre within our faculty.

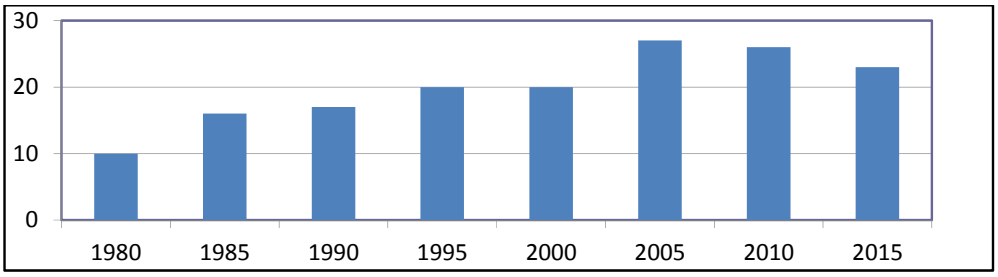
Goal:	In the coming strategy period we will consider a revision of the current group structure, possibly reorganizing some of them. We will also be more explicit about what it means to be in charge of a research group.

When revising the groups, we will use group names that are internationally well understood (e.g., at the moment we have a lot of research in human-computer interaction (HCI), but no group called HCI).

4. Employees and Culture

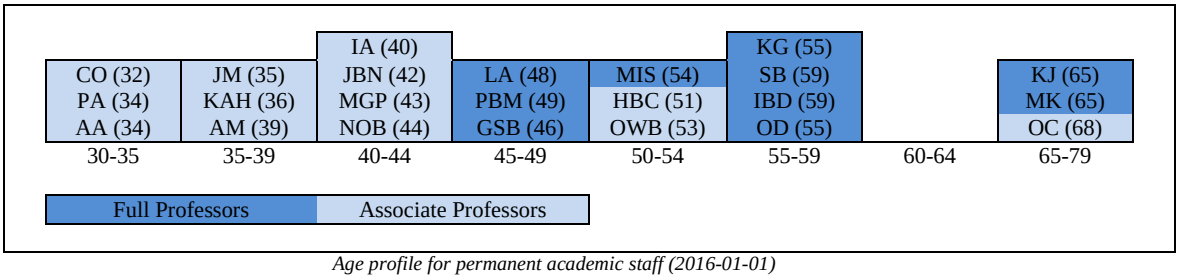
4.1. Permanent staff

Permanent Academic Staff
As the graph below illustrates, the number of permanent faculty members has been rather stable over the last 15 years. From 1995 to 2003 there were around 20 permanent faculty members. Thereafter, the number was increased to 25. Today it is 23 (of which three are working part-time).



Number of permanent academic staff (1980-2015)

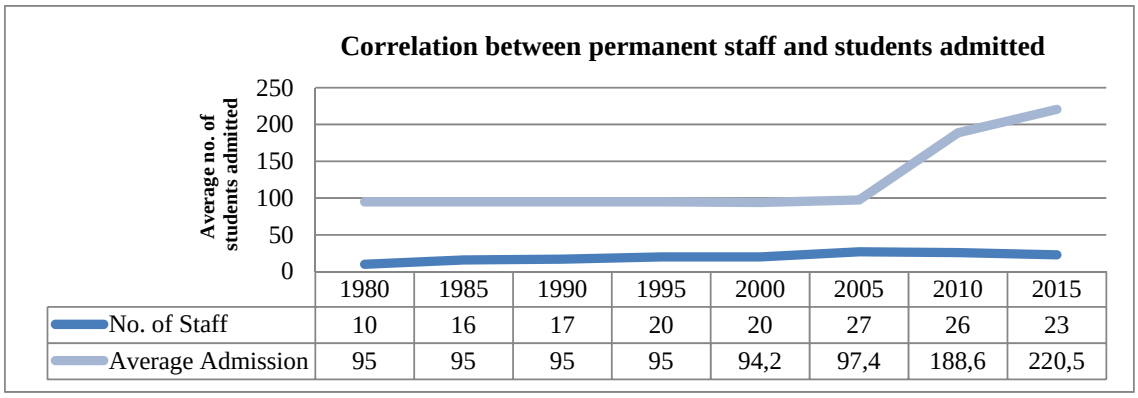
The graph below shows the age profile for the permanent academic staff. With an expected retirement age of 67 years, we will only have three retirements due to age within the next five years. It should be noted that the department has "exported" a significant number of its permanent academic staff, who have won professorships at other universities in Denmark and abroad. During the last 20 years, we have lost 20 associate professors in this way. This is a clear witness to the excellent qualifications of our staff. There is no reason to believe that this trend will change over the next years, and hence we need to expect one career-motivated resignation per year.



Age profile for permanent academic staff (2016-01-01)

Development in permanent academic staff in relation to student admittance 1980 – 2015

The graph below depicts the development in the number of permanent academic staff and the number of students admitted. The average number of students is based on active students registered in October each year (for example the 2000 admission is the average admission over the five year period 1998 - 2002). It should be noted that detailed student data only goes back to 1998; from 1980 to 1995 we admitted approximately 95 new students per year. From the year 2007 where we introduced the new IT-product development education admitting 70 students, we have managed to make a continuing increase in student admission at the department for both the new education and computer science. The conclusion is clear: the number of students admitted has increased considerable (more than doubled) without an increase in the number of permanent faculty (despite the fact that we introduced an entire new educational program in 2007).



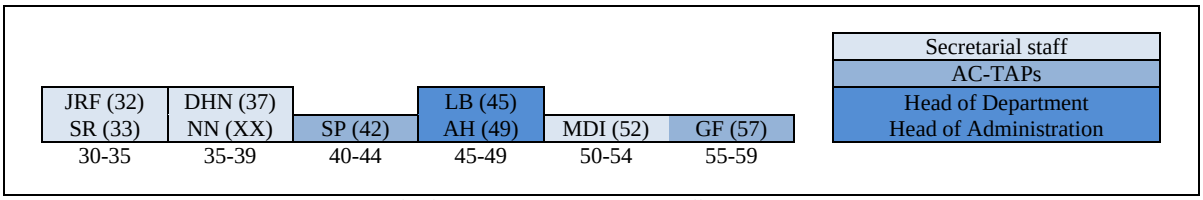
	1980	1985	1990	1995	2000	2005	2010	2015
No. of Staff	10	16	17	20	20	27	26	23
Average Admission	95	95	95	95	94,2	97,4	188,6	220,5

Development in permanent academic staff and admission (1980-2015)

Permanent Non-academic Staff

The permanent non-academic staff consists of: Head of Department (Lars Birkedal), Head of Administration (Annemette Hammer), five secretarial staff (AC/HK, of which 0.4 are paid by funding related to large externally

funded centres), and two AC-TAPs. The department wishes to maintain a high administrative service level, so that academic staff can concentrate on core business.



Age profile for permanent non-academic staff (2016-01-01)

Overview of Staff

Professors	10	One professor is part-time (0,32 FTE)
Associate Professors	13	Two associate professors are part-time (0,5 FTE and 0,4 FTE)
Assistant Professors/researchers	1	
Postdocs	25	
PhD students	52	
Administrative TAPs/AC-TAPs	9	Head of Department, Head of Administration and five secretarial staff, and two Scientific AC's
Total	110	

4.2. Culture

The Department of Computer Science recognizes and appreciates the multitude of different ways that the employees of the department contribute to the goals of the department. The department is characterised by a shared responsibility and solidarity in solving the tasks of the department. The management style is appreciative and delegating – many decisions are delegated to committees.

Moving forward, the department will benefit from a more diverse group of employees coming with different backgrounds from all over the world. It is our expectation that the entire staff will contribute equally in shaping the department and making it their own. In particular, the department will work wholeheartedly on getting a more gender balanced employee profile.

The department will continue to work systematically with improving the work environment based on the mandatory regular psychological workplace evaluations. In recent years this has led to efforts to recognise stress and improve acknowledgement. The department will continue that endeavour. The size of the department enables us to have monthly joint faculty lunch meetings, thereby ensuring and developing the sense of belonging to one department with mutual interests. Annual two-day seminars for permanent academic and non-academic staff have, over the years, contributed to the development of a joint sense of direction among the employees; this tradition will continue. In addition to the faculty seminars, the department now has annual retreats for postdocs and PhD students and quarterly meetings with PhD students and postdocs. The recent establishment of a CS Staff Club, which organises social activities, has proved to be promising and will be developed in the coming years.

The department recognises a challenge regarding student culture and the students' sense of belonging to the department. Traditionally, many CS students have jobs where they spend many hours per week. Thus, many students only come to the department when they have classes. The department strives to ensure that all classes for CS students take place in IT-parken. Furthermore, the student facilities continuously need to be developed in order to ensure that it seems attractive to the students to become a daily part of the department culture. Students are frequently encouraged to seek influence in relevant committees at the department and their participation is highly acknowledged.

Finally, we are on an experimental basis trying to make an environment for creating an entrepreneurial culture at the department through a physical space and light weight mentoring programme for students and graduates that wish to make a start-up. The initiative is called the HatchIT lab, and it has created a vibrating environment and many of our students win entrepreneurial competitions and and hackatons in Denmark as well as internationally.

5. SWOT Analysis

This subsection contains a SWOT analysis identifying the strengths, weaknesses, opportunities and threats of the department.

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Strengths (external)

- Strong international reputation.
- Well-developed network of international contacts.
- Many interdisciplinary projects.
- Several strong centers of Excellence.
- Close contact and cooperation with the IT industry.
- Qualified and committed academic staff.
- Competent and efficient administrative support staff.
- Uniform age profile for the academic staff.
- Many PhD students.
- Many bachelor and master's students.
- Many students on part-time supplementary education.

Strengths (internal)

- Mutual respect between individual research groups and between academic and administrative staff.
- High degree of delegation to and involvement of the individual research groups and committees.
- Rapid and non-bureaucratic decision processes.
- No bickering over minor problems and procedures.
- Many initiatives to ensure good social contact.

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Weaknesses

- Small permanent academic staff.
- Few foreigners in the academic staff.
- Few women in the academic staff.
- Few female students at all levels.
- High drop-out rate for bachelor students.

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Opportunities

- High demand for high-qualified IT-professionals such as our bachelors, masters and PhDs.
- High demand for computer science competences in interdisciplinary projects.
- Entrepreneurship through incubator for master's students / graduates who have established or work on establishing their own company.
- Co-location with information science, IT engineering and other organizations in the IT City Katrinebjerg.
- Cooperation with the Alexandra Institute.
- Tenure track makes it easier to offer attractive career tracks for the best young international researchers.
- Nice buildings where all staff and students are located close to each other.

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Threats

- Fierce competition with other universities and IT industry to hire the most talented young people.
- Inadequate IT support.
- Request for more teaching hours.
- A growing extent of self-satisfaction.

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6. Strategy 2016-2020

In this section we describe the strategy for the period 2016-2020, covering flagships (interdisciplinary research activities), Goals for Research, Goals for Education, Goals for Collaboration with Industry and Public Institutions. We mention several indicators and actions for each sub goal along the way. Some of the indicators are qualitative and hard to measure, but we believe they are useful to include nevertheless (since it will be useful to discuss progress on these indicators internally in the department). Our "official" Key Performance Indicators, which we will measure once a year, are described in Appendix 8.6.

6.1. Flagships

The department has several high-profile research groups and high-profile individual researchers, as evidenced by the impact of the research, awards, and the fact that we have been able to attract elite funding, such as individual ERC grants (at all levels: advanced, consolidator, and starting); DFF Sapere Aude grants (at all levels: advanced, starting, research talent); and Centers of Excellence from the Danish National Research Foundation. In the coming period we will continue to strengthen and support the development of our core research areas. In addition, we have also identified two "flagship areas", which combine research competences from several research groups and whose development will be prioritized in the coming period. In particular, the flagship areas will be used to identify new research areas to be built up in the future. The flagship areas are "Big Data and Data Analytics" and "Cyber-Security".

6.1.1. Big Data and Data Analytics

The digitalization of society has radically transformed work and life throughout the world. Computer Science and Engineering have been important enablers of this transformation. Today we are experiencing an exponential growth in digital data that is projected to reach a level of 40 Zettabytes in 2020, up from 2.7 Zettabytes in 2012; in two days we now produce just as much data as we did from the start of civilisation and until 2003! There is an increasing awareness that efficient use and analysis of this data can lead to radical new value for society, industry and businesses. For example, special issues of both Nature and Science have highlighted the immense opportunities Big Data provides in the sciences, e.g. highlighting how a paradigm shift is taking place triggered by the explosion in the availability of high-quality scientific data. While in the past, individual researchers meticulously planned their experiments and recorded and analysed their results, we now see a shift towards the accumulation of datasets from different sources in massive databases, and mining of these datasets to obtain new scientific results: Science is increasingly about information (data collection, organization and transformation). Similarly, a special issue of The Economist has highlighted the immense business opportunities in Big Data, and we have already seen examples of new disruptive businesses based on Big Data. However, many (perhaps most) opportunities in Big Data are not yet being realised. For example, it is estimated that of the 2.7 Zettabytes of data in 2012 only 3% was tagged with metadata and far less than 3% analysed. That so little of the available data is being examined points to both an underutilization of existing data analysis capabilities and a need for new efficient and effective analysis methods and techniques. Thus computer science research and innovation is paramount in order to take advantage of the scientific and commercial opportunities that lie in Big Data. By combining existing research strength in several relevant areas, the Department of Computer Science is very well-positioned to become a flagship department in terms of Big Data collection, organization and analysis.

Computer Science Big Data Strength

The Department of Computer Science has significant strength in several Big Data relevant areas, most notably in the areas of algorithms, data-intensive systems, and in ubiquitous computing and interaction.

The field of algorithms deals with finding efficient solutions to computational problems, where efficiency often is measured in terms of how fast a given problem can be solved. The department hosts the Center for Massive Data Algorithmics (MADALGO), which is the only Center of Excellence in computer science of the Danish National Research Foundation. The center was established in 2007 (before the term "Big Data" was coined) and recently extended after an international evaluation panel concluded that the center "no doubt (is) the world-leading center in massive dataset algorithmics". MADALGO covers many fundamental algorithms research areas in relation to Big Data, but is also involved in several more applied interdisciplinary and industry projects, as well as a big data startup.

In the data-intensive systems area focus is on systems for storing (indexing) data such that relevant data for a given task can be found efficiently (such that queries can be answered efficiently). The young and small, but strong, group in the department works on a range of topics relating to indexing and query processing and on data mining and clustering using novel indexing and subspace-based techniques. The group consists of one associate professor, 3 postdocs and 3 PhD students.

The areas of ubiquitous computing deals with systems support for a future where computing appears everywhere and anywhere. The ubiquitous computing and interaction group in the department has a strong international track record in the ubiquitous computing and human-computer-interaction communities. It works on methods and tools for collecting, analysing and visualizing Big Data from mobile sensing, and more generally from the Internet of Things. The group is also involved in several applied projects in, e.g., the areas of position-based logistics and environmental foot-printing through mobile sensing, as well as in several startups. The group consists of 4 faculty members, 4 postdocs and 12 PhD students.

Apart from the international strong groups in algorithms, data intensive systems and in ubiquitous computing and interaction, the department also has very strong groups in other Big Data relevant areas such as cryptography, security and privacy, as well as in human-computer interaction. Additionally, other ST departments, most notably BiRC and Mathematics/Statistics, also have relevant Big Data research strengths.

Big Data Flagship

Given the department's existing strong research areas in relation to Big Data, we believe that we are well-positioned to establish what would be the Big Data research center in Denmark, and that the center would have significant international visibility. This ambitious overall goal could be met by strengthening the collaboration between the groups in (and outside) the department with strong big data activities. The flagship would have a strong focus on basic research on efficient computational methods for collecting, organising and analysing data – including areas such as sensor support, database organization, machine learning, efficient algorithms, and visual analytics – and on building a data scientist education (master level specialisation). Additional focus would be on multidisciplinary collaboration and on innovation in collaboration with industry, in order to use efficient computational techniques on societal challenge problems and to develop new products and services, respectively. Natural initial multidisciplinary collaboration could be with biology researchers (e.g. building on existing collaboration with BiRC and Biodiversity researchers), engineering researchers (e.g. on analysing data from cyber-physical systems), as well as researchers from Food and Agriculture. The innovation efforts would also build on the participating researchers experience and existing collaboration, and even more importantly on collaboration with the Alexandra Institute, which has strong competences in applied research, development and innovation.

Resources for Big Data Flagship

Although the department has strength in a range of Big Data relevant research areas, it is lacking in one important area namely machine learning. Broadly speaking, this area deals with making data-driven predictions using models based on previous (example) data. The department has already taken steps to building up in the area, e.g. by encouraging junior faculty and postdocs to acquire expertize in the area and by designing a (very popular) master level class. However, build-up through strong hires in the area is imperative in order to be competitive nationally and internationally.

Apart from the lack of strength in machine learning, the main threat to the success of a Big Data flagship initiative is faculty resources (time). Additional faculty resources are needed in order to drive the initiative, including building inter- and multidisciplinary collaboration, designing the new data science specialisation, and securing additional funding, while at the same time making sure that the strength in the individual core areas are not compromised. Apart from the already planned build-up in the data-intensive systems area, additional hires are needed in the ubiquitous computing and interaction and in the algorithms areas. In the first area, additional expertize in visual analytics (which e.g. deals with development of tools that allow humans to visually explore data for interesting patterns) would be beneficial. In the second area, both theoretical and more practical expertise is needed, more precisely on the theory of machine learning algorithms and on algorithm engineering (that is, implementation of and experimentation with theoretical algorithms).

It is our experience that in order to effectively develop true interdisciplinary, multidisciplinary and industry collaboration it is crucial to have staff – in particular postdocs – that are specifically tasked with developing the

collaboration on an ongoing basis. Thus, additional staff and postdoc resources are needed for the flagship to be successful. The level of postdoc and staff resources will directly affect the level of collaboration activities achievable by the flagship. To some extent, the flagships innovation and industry collaboration efforts can be boosted by a close collaboration with the Alexandra Institute. Still at least two dedicated staff and five postdocs will initially be needed in order to spearhead collaboration. These staff and postdoc recourses will obviously also support the educational agenda of the flagship.

6.1.2. Cyber-Security

The fabric of today's society is woven with the threads of complex IT systems. While these systems tremendously improve the quality of our lives, they also come at a risk. A single vulnerability in a modern IT system can lead to critical disruptions in telecommunications, banking, utilities, transportation services, and national security. In addition, bulk data collection by government entities, brought into public attention after recent Snowden revelations, also raises issues of democracy and personal freedoms.

Securing an IT infrastructure is a challenging task. A common wisdom in cyber security is that "a system is as secure as its weakest link". In practice, the weakest links in large IT systems can turn out almost anywhere – from poorly designed user interfaces, to programmer errors in the kernels of operating systems, to subtle flaws in cryptographic protocols. Moreover, an apparent improvement along one of these aspects may compromise security along the others. For example, switching to a novel, theoretically stronger, cryptographic protocol in a banking application can result in a confusing user interaction that is susceptible to social engineering attacks. In similar manner, an improvement in the user interface can introduce programmer errors that inadvertently leak user confidential information, such as passwords or personal data. These and many other examples suggest that a comprehensive approach to cyber security not only requires deep expertise in the core areas of computer science, but also requires understanding of security concerns across the areas.

The Department of Computer Science at AU is in unique position to form a flagship research area in cyber-security. There is a strong presence in many of the necessary research areas, but there is also an opportunity to build upon the individual strength towards focused and principled effort on cyber security.

Computer Science Cyber-Security Strengths

The Department of Computer Science has been working for many years on several important aspects of cyber-security, both on the theoretical and the practical side.

The cryptography group consists of 3 faculty members, 5 postdocs and 6 PhD students and is one of the leading cryptography groups in the world. The group focuses on cryptographic algorithms and protocols, in particular distributed secure computation, where the idea is to distribute an IT system over several separated machines such that an adversary must break into almost all machines in order to compromise the system.

The two groups in programming languages and logic and semantics consist in total of 4 faculty members, 7 postdocs and 8 PhD students. The logic and semantics group works on models and logics for verification of software and on language-based security. The programming languages group works on automatic verification of software and on functional programming. Security in programming languages and verification are extremely important since a very large number of security breaches in real systems come from implementation errors that can be exploited by an adversary.

The computer mediated activity group consists of 2 faculty members, 2 postdocs and 2 PhD students. The group works on several projects in the field of human-computer interaction, and has pioneered the idea of participatory design, where end users are involved as an integrated part of the design of a system. Such ideas can be vital to security of real systems: for instance, if the end user does not understand the consequences of the choices he is asked to make, the security of a system may break down, even if it is well designed from a theory point of view.

Cyber-Security Flagship

Given the department’s existing strong research areas in relation to Cyber-Security, we believe that we are well-positioned to establish what would be the Cyber-Security research center in Denmark, and that the center would have significant international visibility. This ambitious overall goal could be met by strengthening the collaboration between the, so far independent, groups in (and outside) the department with strong cyber-security

activities. The flagship would have a strong focus on basic research on the science of cyber-security, researching principles, abstractions, and trade-offs for building secure systems – including areas such as cryptography, program logics and automated verification, language-based security, system security, and human interaction with secure systems. There is a natural "supply chain" here that goes from cryptographic protocols to programming languages and implementation, on to computer systems, and finally to interfaces used by human users. We need to build models allowing us to identify which information needs to be passed up and down this chain in order for the resulting system to be secure. Based on this we can go on to designing and building tools that will facilitate development of secure systems on all levels. This is a major challenge that has never been addressed before, and is therefore both high risk and high gain.

We will also consider building a master level specialisation in cyber-security. Additional focus would be on multidisciplinary collaboration and on innovation in collaboration with private companies and the public sector, to address societal challenges on cyber-security. Multidisciplinary research could be done with economists (on private transactions), engineers (combining physical and software security aspects in connection with data collection, smart metering, etc.), researchers doing research on humans (ensuring privacy of collected data), law and ethics researchers (on policies for privacy), etc. The innovation efforts would also build on the participating researchers experience and existing collaboration, and even more importantly on collaboration with the Alexandra Institute, which has strong competences in applied research, develop and innovation.

Resources for Cyber-Security

Although the department has strength in a range of Cyber-Security relevant research areas, it is lacking in one important area namely experimental systems building. Broadly speaking, this area develops actual systems, deploy them in real-world environments and experiment with them to characterize and explain their behaviour and inform theory. While some faculty members do build systems for automated verification and experiments with language-based security, additional build up through strong hires in the area is imperative in order to be competitive nationally and internationally.

Apart from the lack of strength in experimental systems building, the main threat to the success of a Cyber-Security flagship initiative is faculty resources (time). In order to drive the initiative, including building inter- and multidisciplinary collaboration, designing the new Cyber-Security specialisation, and securing additional funding, while at the same time making sure that the strength in the individual core area is not compromised, additional faculty resources are needed.

It is our experience that in order to effectively develop true interdisciplinary, multidisciplinary and industry collaboration it is crucial to have staff – in particular postdocs – that are specifically tasked with developing the collaboration on an ongoing basis. Thus additional staff and postdoc resources are needed for the flagship to be successful. The level of postdoc and staff resources will directly affect the level of collaboration activities achievable by the flagship. To some extent, the flagships innovation and industry collaboration efforts can be boosted by a close collaboration with the Alexandra Institute. Still at least two dedicated staff and five postdocs will initially be needed in order to spearhead collaboration. These staff and postdoc recourses will obviously also support the educational agenda of the flagship.

6.2. ST Interdisciplinary Theme on Big Data and Data Analytics

We propose to create a cross-departmental interdisciplinary theme at ST on Big Data and Data Analytics, led by the Department of Computer Science, and rooted in our flagship on Big Data and Data Analytics, described above. There are obvious synergy possibilities with the research being done in other departments at ST. We propose that the theme involves both research and teaching. Regarding teaching, we propose (in addition to the data science specialisation at the master's level at CS) that the Department of Computer Science offers courses in computational thinking and data analytics aimed at bachelor students in other fields of study at ST, e.g., along the lines of such courses offered at MIT (see course1 and course2).

This proposal is contingent on ST allocating additional resources (for several additional permanent faculty members) to the Department of Computer Science to run and lead the initiative and teach the new courses.

6.3. Strengthen and Support Core Research Areas

As mentioned in section 2.1 we will continue to strengthen and support our core research areas.

Thus our goals include continuing to conduct and publish research at highest international level, to maintain leadership and impact in national and international research, to maintain a high volume of research per FTE faculty member, and to strengthen the research environment.

The department has a long tradition for engaging in collaborative interdisciplinary projects with researchers from other departments. Current collaborations include the AU Interdisciplinary Center on Participatory Information Technology (PIT); the Center for Research in Foundations of Electronic Markets (CFEM); collaborations between the Algorithms and Data Structures group and Bioscience and Bioinformatics; the EcoSense project combining ubiquitous computing and mobile sensing with environmental science, MADE (SPIR) combining computer science with Engineering, etc. We wish to continue such interdisciplinary collaborative projects.

As mentioned above, the flagships are used to identify which new areas to prioritise. When it comes to the existing core research areas, we will prioritise based on teaching needs, generational considerations, and to maintain a balance between theoretical and experimental computer science.

6.4. Goals for Research

Goal:	Continue to conduct and publish research at highest international level.

Indicators

- Number of publications in top-level conferences and journals.
- Number of software artefacts made available to the research community.
- Total number of peer-reviewed publications.
- Citations and H-indexes.
- Number of international research visitors.
- Research Awards.

Actions

- Recruit the most qualified people for our positions. We will continue our policy of advertising positions using open calls covering most of computer science. Positions will be announced internationally, of course.

Goal:	Maintain impact and leadership in national and international research.

Indicators

- Serving as editors of journals.
- Serving as program committee members and program chairs of conferences.
- Serve on national and international research related committees (Danish Research Council, ERC evaluation boards, H2020 boards, etc.)
- Participation and leadership of joint national and international research projects.

Actions

- Support (e.g., through Staff Development Dialogues) faculty involvement in research related committees.

Goal:	Maintain a high volume of research per FTE permanent faculty member.

Indicators

- Number of publications in top-level conferences and journals per FTE faculty member.
- Number of software artefacts made available to the research community per FTE faculty member.
- Total number of publications per FTE faculty member.

Actions

- Secure external funding for postdocs and PhD students.
- Encourage academic leadership training for faculty members, who have not already participated in such.
- Maintain a high administrative service level, so that the academic staff can concentrate on core business.

Goal:	Maintain and further strengthen the research environments in all research groups.

Indicators

- International research visitors.
- The quality and quantity of international applicants for new faculty positions. The extent to which we can attract exceptional research stars.
- The ability to attract high-quality PhD students.
- The job satisfaction of the members of the department.
- Organization of conferences, workshops, etc. by the members of the department.

Actions

- Strengthen international research collaborations with research visits and visitors.
- Support organization of conferences and summer schools in Aarhus.
- Organise research talks, seminars, mini-courses.
- Increase the number of collaborative interdisciplinary projects with researchers from other departments at AU.

Goal:	Maintain the high number of collaborative interdisciplinary projects with researchers from other departments at AU.

Indicators

- Number of interdisciplinary research projects with researchers from other departments.
- Number of publications with researchers from other departments.
- Amount of external funding spent on research projects with researchers from other departments.

Actions

- Secure funding for an increase in permanent faculty members.
- Secure external funding for postdocs and PhD students.
- Experiment with different models for facilitating such collaborative projects.

6.5. Talent and Recruitment

6.5.1. PhD Education

PhD education is a key element of research and education at the department, and the department has a long history of educating PhDs at a high international level and with a good number of students. Our PhDs are in high demand in both industry and academia.

Goal:	To continue to strengthen the PhD programme in computer science, both in quality and quantity.

Indicators

- The number of PhD students per FTE faculty members.
- The ability to attract highly qualified PhD students, both from Denmark and from abroad.
- The number and quality of PhD courses, seminars, and summer schools offered by the department.
- The quality of our PhDs - the extent to which our PhDs are able to compete with PhDs from international top schools when applying for jobs internationally and nationally.

Actions

- Secure external funding for PhD students via research grants.
- Improve recruitment of PhD students.
- Offer a variety of PhD courses.
- Continue efforts to improve the research environment, such as the PhD retreat.

See appendix 8.4 for more on the focus points of the PhD committee.

6.5.2. Postdocs

Postdocs are very important for the research and research environment at the department.

Goal:	To attract and recruit the best talents from Denmark and from abroad.

Indicators

- The number of postdocs per FTE faculty members.

Actions

- Secure external funding for postdocs.
- The postdoc committee will focus on supporting postdocs in advancing their careers, be it in industry or academia - in Denmark and abroad - and on creating an attractive working environment for postdocs.

  See appendix 8.5 for more on the focus points of the postdoc committee.

6.5.3. Recruitment of Faculty

In the last couple of years, the department has had good success with attracting a large number of qualified applicants to our faculty positions. But it is still important to recognise that, as pointed out in the SWOT analysis, it is challenging to recruit top faculty members, since the international competition is stiff, so we have to work hard on this.

Goal:	To attract and recruit excellent faculty members.

Indicators

- Number of new faculty members.
- Recruitment of international faculty members.
- Recruitment of female faculty members.

Actions

- Positions should be announced via open calls, with some prioritised areas.
- Form search committee(s) consisting of faculty members to search for qualified applicants.
- Ensure that all faculty members help in recruitment of new faculty members.
- Ensure a steady stream of international research visitors who could be potential future faculty members.
- Align announcement of positions with the US system and speed up the hiring process.
- Make use of the tenure-track system recently implemented at AU. In computer science, it is generally difficult to attract senior faculty members, so we expect most positions will be tenure-track positions.

6.6. Education

The department runs two Bachelor's degree programmes (one in "computer science" and one in "IT-product development", and two Master's degree programmes (one in "computer science" and one in "IT-product development"), both with a high number of students. We also have a Master's degree programme within part-time supplementary education. This means that the teaching load on the academic staff is high, and hence we have no plans to extend (or reduce) the number of study programmes. In 2015, more than 14% of all new bachelors at ST enroll at our department. In 2015, more than 90 students graduate with a Master's degree. In total, we have 591 active bachelor students (399 computer science, 192 IT) and 260 master students (185 computer science, 75 IT) as of October 2014. In addition to that comes exchange-, part-time students, etc. Thus our student per FTE faculty member is high - indeed it is substantially higher than the other science departments at AU– and that limits the available time per student. A related challenge is that for several years it has been difficult to man the courses in the IT study programs.

A key challenge for us is that we have an above-average drop-out rate. We have analysed why that is the case and we believe we can reduce the drop-out rate by being more selective with the students we admit (possibly admitting fewer students which would lead to an increase in the time available per student) since our students have a lower GPA than students on other study programs at ST. We also wish to improve our study programmes expecting this effort to support our goal.

The latter fits well with the fact that we also believe that it is time to revisit the computer science study programme, which has not been fundamentally revised for some years. It is foreseen that in the beginning of summer 2017 the semester structure will change at ST, so it makes sense to align the revision in order for us to be able to implement the new program in the beginning of the new academic year 2017.

Goal:	Increase the percentage of students who obtain a bachelor's degree within four years.

Indicators

- Percentage of students who complete a Bachelor's degree within four years.

Actions

- Implement more selective admittance requirements, possibly using a combination of requirements based on high-school GPA and individual interview/entry exam.
- Improve the study programs by using a larger variety of teaching methods, by increasing the contact between faculty and students, and by improving the physical study environment (so that students can work more efficiently at the department).
- Revise the computer science and IT study programmes.

Goal:	Revise and improve the computer science and IT study programmes.

Indicators

- The number of contact hours between students and teachers (faculty and TAs).
- Maintain the high employment rate of recent graduates.
- The breadth and depth of programming experience students get during their studies.
- More written reports with feedback, training the students' writing skills.
- A reasonable number of suggested study specialisations ensuring progression.
- Ensure alignment between specialisation courses and Master's theses.
- Scores in the evaluation of the physical and psychological study environment.

Actions

- Revise the computer science and IT study programmes.
- Consider making more use of project-oriented teaching with supervision from senior scientific staff, bringing students close to staff.
- The department has active student associations (DSAU for the Computer Science students and SOFA for the IT students). In addition to this, there is an active student association UNITY that bridges all students at Katrinebjerg. We will continue the active cooperation with the student associations and support them as much as possible. They constitute an invaluable part of establishing a good study environment.

Goal:	Initiate an elite program for talented students.

Indicators

- The number of students following our elite program (we should probably aim for 10-20% of the student population).
- The number of students who wish to pursue a PhD.

Actions

- Further develop the CS challenge program initiated for new bachelor students since 2015.
- Design and implement the elite program, using the experiences obtained in other departments at ST.

Goal:	Ensure that our faculty teaching resources are spent wisely.

Indicators

- The number of students per specialisation should be reasonable (small enough to have sufficient teaching resources per student and large enough to have a reasonable number of students per course).
- Number of courses that can be used across several education programs.
- Ensure that there is a more long term plan for the manning of the courses in the IT study lines.

Actions

- Revise the computer science and IT study programmes.
- Management focus on manning of courses.

6.7. Collaboration with Industry and Public Institutions

The department has a long and solid tradition for interaction and knowledge exchange with private companies and public institutions. Over the last thirty years, there have been numerous research projects with external participants. Thus, our research has been made available to the Danish and international society. There have been approximately 18 spin-off companies (including Mjølner, Cryptomathic, Cetrea, and SCALGO) and a number of patent applications. We want to maintain the high level of interaction with private companies and public institu-

tions. This produces a lot of interesting research themes ranging from smaller problems, which can be tackled with innovative use of existing knowledge, to more challenging problems that require long-term basic research.

Industry and public institutions also contribute to the education programmes at the department, e.g., via joint courses or student projects, and by their involvement in the advisory boards for our study programmes.

As highlighted in the SWOT analysis, we should be able to further leverage the collaboration with the Alexandra Institute, which works with applied IT research, development and innovation. Collaboration with the Alexandra Institute can help to maintain a portfolio of more applied activities and, when it works well, make it easier for faculty members to maintain industry collaborations.

Many of our faculty members and students are interested in innovation and in starting up new companies. The department does not have resources on our own to create a full-fledged incubator environment, but we wish to experiment with ways in which we can support our students and staff's' entrepreneurial activities, in collaboration with related activities at the University or in the IT-City Katrinebjerg. Therefore, we have recently created an experimental innovation lab, called Hatchit Lab, and one of our goals is to support the entrepreneurial activities of our students and recent graduates.

Goal:	Strong collaboration with industry and public institutions.

Indicators

- The number of projects with active participation from private companies or public institutions. By active participation we mean that the company/institution either sponsors part of the project or has employees who work in the project. Participation in reference groups etc. is not sufficient to count.

Actions

- Support joint research applications with industry.
- Strengthen the collaboration with the Alexandra Institute and establish a governance model for the collaboration between the department and the Alexandra Institute. Investigate whether all research groups can have a designated “partner person” at the Alexandra Institute.

Goal:	Support entrepreneurial activities of students, staff, and recent graduates.

Indicators

- Number of successful start-up companies by students, staff, and recent graduates from the department.

Actions

- Evaluate the Hatchit Lab and explore the relationship to other entrepreneurial activities at ST.

6.8. Outreach

The department is involved in variety of PR and outreach activities covering initiatives such as student recruitment, development of skills among high school and primary school teachers, career services and news/media production.

The planning and coordination of the outreach activities are carried out by the PR-committee and the Outreach committee in cooperation with ST, AU and external partners.

Goal:	To attract the best high school students to our degree programmes.

Indicators

- GPA of students admitted from high school.
- Number of CS popular science articles in national media.

Actions

- Host a yearly career event (kdag.au.dk).
- Continue to expand and develop events and initiatives in close dialogue with the high school system and ST (SRP, ATU, Sub-University, Master Classes etc.)
- Support education of informatics teachers in high schools by contributing to the development of teaching resources for high school teachers and to the continued education high school teachers.

Goal:	To raise the general awareness of computer science education and research in the public but also within academia, industry and the educational system.

Indicators

- Number of CS popular science articles in national media.
- Number of interdisciplinary research projects with external partners.

Actions

- Establish a business club.
- Host at least one in-house alumni event every year and improve relationships with alumni.
- Reinforce the visibility of our department in the media by producing more focused and application-oriented articles about our research activities and education.
- Support and develop alumni activities/initiatives.
- Actively engage in industrial matchmaking.