Department of Computer Science
Annual Report 2016

Editor: Pirjo Moen
Picture: *The best young programmers around the Baltic Sea gathered at the University of Helsinki, Department of Computer Science, to compete in Baltic Olympiad in Informatics (BOI) in May 2016.*
Photographer: Toni Annala

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1.   *Thoughts of the Head of Department in 2016*

I started as the Head of Department in January 2016 after serving two years as Deputy Head. The year was unusual and hectic due to the cost cutting program and the Big Wheel educational reform. Our Department has performed very well across the board and we should be very proud of the community and the achievements.

We received very good news in the Fall 2016 when Times Higher Education University Ranking placed us top in the Nordic Countries and later we learned that the Department was ranked as #1 in Finland in the QS World University Rankings.

The Big Wheel education reform has progressed well. We have our own B.Sc., M.Sc., and PhD programs in Computer Science and we are also coordinating the multidisciplinary Data Science program. Data Science is an exciting new opening that is attracting a lot of attention.

Our MOOC activity is doing also well. Our programming MOOC is unique, because it can open the door to the university for students of high performance. In addition to the programming MOOC, we have a new security MOOC with F-Secure. This new MOOC is very popular: over 50 000 people have viewed the course and over 5000 students started the course with about 1000 receiving study credit points. The Department will continue to develop MOOCs and aim for an offering of complementary courses.

Overall, Computer Science is a very popular choice for the students. 173 new students started at the Department in 2016, which is 96% of the maximum intake. We had 71 approved international students of which 29 (41%) started the studies. These numbers are excellent; we are among the most popular disciplines at the Kumpula campus.

In 2016, we had 83 M.Sc. degrees, and 93 B.Sc. degrees. We are meeting the objectives. We are lacking a bit in the PhD targets (six PhD theses completed in 2016), but the prediction is that 2017 will be a very good year.

Overall, our total budget was 8% smaller in 2016 than in 2015. We had 23% more Academy of Finland funding than the previous year. Our Tekes funding decreased 24%.

*Our recruitment plan lists over 10 tenure track/professor positions that we are opening in the 2017 and 2018. The Department has been successful in the Academy of Finland profiling calls that provide support for the recruitment of tenure track professors. We have also successfully recruited professor **Tommi Mikkonen** from Tampere University of Technology and **Ville Mustonen** from the Sanger Institute. We are recruiting professor **Pan Hui** from Hong Kong University of Science and Technology. He is invited to a Nokia Chair position based on the significant donation made by Nokia in the spring of 2016.*

We have a university structural reform coming in 2018. In the reform, the Faculty will have a more decisive role in financial matters. The details are now being planned. Our aim is to have an excellent department (the new research unit is called osasto in Finnish) and environment within this new structure.

We celebrated the 25 years of Linux in 2016, and in 2017 we will celebrate the 50 years of the Department.

To summarize the results, the Department is doing very well in terms of education, research, and impact. The future outlook is bright and I believe that our recruitment plan will enable to department to grow.

Sasu Tarkoma
Professor, Head of Department 2016

The basic degrees of the educational programme of computer science are the Bachelor of Science (BSc) and Master of Science (MSc) degrees. The Bachelor's degree consists of a comprehensive education in computer science offering a solid basis for the specialisation built during the Master's stage and preparing for work in the field of ICT. At the Master's stage, the teaching at the department branches into four different subprogrammes; "Algorithmic Bioinformatics," "Algorithms, Data analytics and Machine Learning," and "Networking and Services" taught in English, and "Software Systems" taught in Finnish. The department also coordinates the "Bioinformatics" Master's programme taught in English; the last admissions to the programme were in 2014.

The higher degrees in computer science are the Licentiate (PhLic) and the Doctoral (PhD) degrees. The new postgraduate schools and doctoral programmes at the University of Helsinki started on 1 January 2014. Among these doctoral programmes is the doctoral programme in computer science, DoCS.

The department has made a sustained investment in teaching and its development. In 2012, the department was still one of ten national Centres of Excellence in higher education. After year 2012, centres of excellence have not been elected nationally, nor within the University of Helsinki. However, the rising appreciation of teaching has become evident since the establishment of the Teachers' Academy at the University of Helsinki in 2013. University Lecturer Matti Luukkainen from the CS Department was elected among the founding members, and since 2014, other members have been University Lecturer, Head of Studies Jaakko Kurhila (resigned from the department on 28 February 2015) and Lecturer Heikki Lokki (retired on 1 August 2016).

With the coming of the Big Wheel programme, there will be some extensive changes to the teaching arrangements, as the teaching becomes the responsibility of separate education programmes. Students who have been admitted earlier can, if they so wish, continue in accordance with the old system during a transit period up until 31 July 2020.

In our courses, students can work with programming Lego robots.
Photographer: Veikko Somerpuro

2.1. Algorithmic Bioinformatics

The subprogramme educates experts that can turn biological questions into appropriate computational data analysis challenges. Students of this subprogramme get a view of current hot-topics in molecular biology and learn general principles and methods for formulating and solving computational problems. In addition to the core methodological studies in algorithms and machine learning, particularly for biological data, students are encouraged to get experience and take courses in molecular biology and related areas.

The subprogramme operates in an umbrella manner, combining courses offered by several departments and universities. Namely, the compulsory courses are the same as in the subprogramme of Algorithms, Data-analytics and Machine Learning and advanced studies in bioinformatics are collected from the internal offerings of the subprogramme, as well as from the offerings of the Department of Mathematics and Statistics at the University of Helsinki) and the Department of Information and Computer Science at the Aalto University. The subprogramme together with its counterparts (namely, biometry and bioinformatics, biomathematics, and life science technologies) in the collaborating departments replaces the MBI programme, that has acted in the similar umbrella manner since 2006: MBI still works in parallel to these subprogrammes, but organizes no longer student admissions.

2.2. Algorithms, Data Analytics and Machine Learning

Information technology is increasingly based on intelligent components that are based on complex mathematical models constructed automatically by machine learning methods. The problems faced in this type of machine learning tasks are computationally challenging, and the constantly increasing amounts of data in applications create additional demands for algorithmic performance. The focus of the subprogramme is on efficient algorithms for intelligent systems and their applications in analyzing data stemming from other sciences or the industry. The theory and applications of efficient algorithms and intelligent systems are also studied from a more general point of view.

Students graduating from the subprogramme are typically employed as technical specialists or scientists. The general methodological skills learned during the studies are useful not only in tasks that require development of new information processing methods, but also in projects that apply information technology, both in industry and academia.

2.3. Software Systems

The focus of the subprogramme of Software Systems is in methods for producing large and complex software in a systematic way. The development of this kind of software requires technical skills; other focuses include group and project work, disciplined high-quality development processes, documentation, and reuse. Students graduating from the subprogramme are typically appointed as technical software or database system experts or software development project managers.

In the advanced studies of the subprogramme, students can specialize in software engineering, service-oriented software engineering, and database systems. The goal of software-engineering education is to train students in processes needed in producing large high-quality software. The goal of the education in service-oriented software engineering is to train experts at producing and managing inter-organizational service networks or at development of the software tools needed in these tasks. The goal of the database-systems education is to train experts at software systems that make use of database systems.

2.4. Networking and Services

The Networking and Services subprogramme focuses on the foundations of modern distributed applications and services on different levels of abstraction ranging from networking and data transport to user interaction and inter-enterprise computing. Central focus areas include Internet technologies that form the basis for networking, network architecture, mobile computing, interoperable systems, and interactive systems.

The group combines the departmental tradition of wireless and mobile computing in new research themes. The focus of the group is expanding from platform protocols to solving application layer challenges.

The subprogramme educates experts and strategic renovators of global architectures.

2.5. Master's Degree Programme in Bioinformatics

Bioinformatics is a field of science seeking to answer biological and medical research questions by methods of computer science and statistics. The Master's degree programme in bioinformatics (MBI) is a two-year MSc programme offered jointly by the University of Helsinki and Aalto University School of Science. MBI graduates will be able to obtain positions in industrial and academic facilities such as biomedical companies, universities and research institutions. The major subject courses of the programme focus on the core bioinformatics methods such as the analysis of biosequences and the modelling of gene function. Minor subject studies include studies in biosciences, computer science, mathematics and statistics. The core courses have been designed to support courses across disciplines. For instance, on measurement technique courses, students will collect data which can then be analysed in methodological courses. In particular, an MBI student will learn the bioinformatics process all the way through from planning the experiments to data analysis and verification of hypotheses.

The last admission to this programme was in 2014, but teaching of bioinformatics continues in the Algorithmic Bioinformatic subprogramme.

2.6. Data Science Study Profile

Data scientists help organizations make sense of their data. As data collection grows in speed, size and complexity, new challenges emerge in dealing with this so called "big data". These range from efficient algorithms to analyze the data to the design of large, distributed systems to acquire and manage the data. The Data Science study profile is an MSc level programme that combines elements from different subfields of computer science, from machine learning to distributed systems, to train new generations of data scientists for the industry, academia, and administration.

The Data Science study profile is organized together by the Algorithms, Data Analytics and Machine Learning and the Networking and Services subprogrammes of the department. Students can take the Data Science profile under either subprogramme. The language of education is English. In 2017, the study profile will be replaced by a new master's degree programme in Data Science.

The greenhouse on the roof of Exactum is used both in teaching and research.
Photographer: Linda Tammisto

2.7. Doctoral Programme DoCS

At the beginning of 2014, the University of Helsinki introduced a new doctoral education system consisting of four doctoral schools, one of which operates in the field of natural sciences. These schools consist of doctoral programmes. All the doctoral students in computer science will belong to the Doctoral Programme in Computer Science (DoCS). This programme is a part of the Doctoral School of Natural Sciences that is formed by seven doctoral programmes operating mainly within the Faculty of Science.

During 2016, DoCS had a total of 67 doctoral students. 27 (40.3 %) of them were foreign students, and 15 (22.4 %) were female. During 2016, six DoCS students graduated. In addition to that, one doctoral student defended his doctoral thesis at the end of 2016.

3. Research 2016

During strategy period 2013-16, the department has profiled itself in three main areas: machine learning and algorithms, data networks and services, and software systems. In research, the following key areas will be emphasized in the strategy period:

- *algorithms theory and new computation paradigms,*
- *'big data',*
- *computational creativity,*
- *neuroinformatics,*
- *data security,*
- *ubiquitous computing and interactive technologies, and*
- *development of software systems, coaching developers, and software measurement.*

Machine learning and algorithms. *The research includes method development in modern data analysis, machine learning, data mining, and information-theoretical modelling. Strong application fields of this research are, for example, data analysis of biological data, and computational creativity. At the department, this research is largely concentrated to the Helsinki Institute for Information Technology, a joint venture between the University of Helsinki and Aalto University. In addition to that, some research groups of the department are participating in three other centres of excellence: Cancer Genetics Centre of Excellence, Computational Inference Centre of Excellence (COIN), and Inversion Problems Centre of Excellence.*

Networking and services*. The research pertains to networked systems and their premises: middleware (including service and application platforms, management of middleware, trust, and safety), mobility (independence of device and location, wireless communications), information networks, service networks, context-awareness, ubiquitous computing and interaction research. This area combines the department's traditional research into wireless and mobile computing with new emerging research themes on interactive systems and ubiquitous computing.*

Software systems. *The main challenge in the research on software systems is how we can develop large and complicated software systems to fullfill the requirements and expectations put onto them. The focus of the software research at the department is on empirical software engineering, especially its certain subareas like requirement management and understanding of user needs, software architectures, variability modelling and management, software measurement, and rationalisation of software development.*

In 2016, 25 research groups were working in these focal areas at the department.

3.1. Research units and networks

3.1.1. The Finnish Centre of Excellence in Cancer Genetics Research (CoECGR)

Cancer is a disease involving two unique genomes – germline, and that of the respective tumor. This setting represents a key challenge for medical research, deeply involving multiple disciplines. We and others have made seminal discoveries in identification of major human cancer genes, thus increasing our understanding on the basic concepts of malignant growth. The rapid advances in genomic technologies are now enabling full genome analysis of individuals and cancers. This will finally allow complete dissection of germline and somatic genetic variation contributing to neoplasia. Genetics of cancer is a key field of medical research, in which Finland and this consortium have excellent traditions at the highest international level.

Contact person: Professor Veli Mäkinen
Home page: http://www.helsinki.fi/coe/cancer-genetics/index.html

The CoE in Cancer Genetics Research is led by Academy Professor Lauri Aaltonen from Faculty of Medicine, University of Helsinki. Other participating research groups from Faculty of Medicine are the groups of Academy Professor Jussi Taipale and Professor Sampsa Hautaniemi. The group of Professor Eero Pukkala represents the Cancer Registry. Department of Computer Science and HIIT are represented by Genome-scale Algorithmics research group.

3.1.2. The Finnish Centre of Excellence in Computational Inference Research (COIN)

The COIN CoE develops methods for transforming the data produced by the current big data revolution into useful information. The key methodology for achieving this goal is statistical and computational inference based on the data. The emphasis is on large data collections and computationally demanding modelling and inference algorithms. Our mission is to push the boundary towards both more complex problems, requiring more structured data models, and towards extremely rapid inference. COIN brings in expertise on several different approaches to inference, with a unique opportunity to address the core computational challenges with combinations of machine learning, computational statistics, statistical physics, and constraint-based search and optimization. In addition to deep methodological work, we work on several applications in collaboration with selected top-level application partners from science and industry.

Contact person: Professor Petri Myllymäki
Home page: http://research.ics.tkk.fi/coin/

The COIN CoE is a joint effort by Aalto University and University of Helsinki, and is led by Professor Samuel Kaski from Aalto university. The participating groups at University of Helsinki are the Complex Systems Computation (CoSCo) group led professor Myllymäki at the Department of Computer Science and the Bayesian Statistics group led by professor Corander at the Department of Mathematics and Statistics. Both groups belong also in the COIN research programme of HIIT.

3.1.3. The Finnish Centre of Excellence in Inverse Problems

The Finnish Centre of Excellence in Inverse Problems is internationally recognized as the world's leading unit in the field. It specializes in the theory, implementation and application of inversion methods. The objective is to create fundamentally new, efficient, and theoretically sound solutions to practical inverse problems, especially in following application areas: medical imaging, geophysics and space research, and remote sensing and modelling in enviromental and climate research.

Contact person: Professor Aapo Hyvärinen
Home page: https://wiki.helsinki.fi/display/inverse/Home

The CoE in Inverse Problems Research is a network comprising research groups in seven institutions in six Finnish universities: University of Helsinki (Department of Mathematics and Statistics), University of Eastern Finland (Department of Applied Physics), University of Jyväskylä (Department of Mathematics and Statistics), Lappeenranta University of Technology (Department of Mathematics and Physics), University of Oulu (Department of Mathematical Sciences, and Sodankylä Geophysical Observatory), and Tampere University of Technology (Institute of Mathematics). The director of the CoE is Academy Professor Matti

Lassas from University of Helsinki. The Neuroinformatics group at the Department of Computer Science and HIIT is participating this CoE.

3.1.4. Helsinki Institute for Information Technology HIIT

HIIT is a joint venture between the University of Helsinki and Aalto University. Its mission is to carry out internationally prominent basic and strategic research in information technology and to promote the competitiveness of the IT industry in the long run by connecting Finnish university research with the innovative process in the industries, especially in the area of long-term strategic R&D. The institute also counts multi-disciplinary research cooperation with universities and other research institutes as one of its missions.

In 2016, HIIT continued the following research programmes: Algorithmic Data Analysis (ADA), Computational Inference (CI), Distributed and Mobile Cloud Systems (DMC), and Network Society (NS). In addition, HIIT coordinated as a research spearhead an HIIT Wide Focus Area "Augmented Science". The above programmes were discontinued at the end of 2016.

In August 2016, HIIT launched the following four new fixed-term programmes that all include research groups both from the University of Helsinki and Aalto University:

- *Augmented research, program director Giulio Jacucci*
- *Building Trust in Secure Computing Systems, program director Valtteri Niemi*
- *Computational Inference, program director Samuel Kaski (Aalto)*
- *Foundations of Computational Health, program director Juho Rousu (Aalto)*

Contact person: Professor Petri Myllymäki
Home page: http://www.hiit.fi

3.1.5. Networking in Open Distributed Environments (NODES)

The NODES research network and community consists of interacting research groups in the field of distributed systems and data communication, ranging from the design and implementation of Internet protocols and wireless solutions to new challenges pertaining to globally interoperating business services and interactive systems. The focus areas are networked systems and their enablers: interoperability (e.g., service and software platforms, trust management, privacy), mobility (technology and location independence, wireless computing), information networks, ubiquitous computing, and interactive systems. NODES combines the departmental tradition of wireless and mobile computing with new emerging research themes. The focus of the group is expanding from platform protocols to solving application layer challenges.

Contact person: Professor Sasu Tarkoma
Home page: http://www.cs.helsinki.fi/research/nodes

Research groups in NODES:

- *Collaborative and Interoperable Computing (CINCO)*
- *Collaborative Networking (CoNe)*
- *Content-centric structures and networking (COSN)*
- *Secure Systems*

- *Ubiquitous Interaction*
- *Wireless Internet (WInt)*
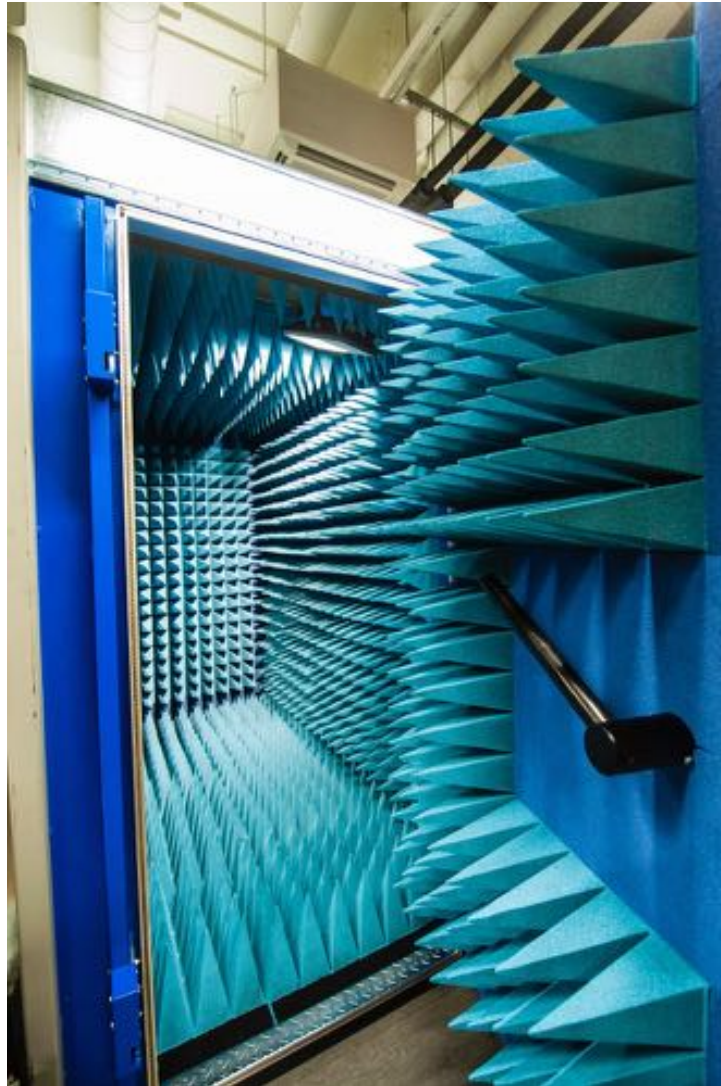
In the Nodes laboratory.
Photographer: Veikko Somerpuro

3.2. Research groups

3.2.1. Collaborative and Interoperable Computing (CINCO)

The CINCO group develops solutions for service interoperability and management of dynamically formed collaborations for increased automation of multi-party, subjective management of inter-enterprise collaborations comprising of business services.

The solutions become

- enabled by mature, open service ecosystem architecture and governance;

- *supported by a global infrastructure that supports interoperability and contract-based collaboration management (establishment, control and breach recovery; trust, privacy, NFP); and*
- *complemented with service-oriented software engineering, MDE and BPM based system composition practices.*

Contact person: University Lecturer Lea Kutvonen
Home page: http://cinco.cs.helsinki.fi

3.2.2. Collaborative Networking (CoNe)

The Collaborative Networking (CoNe) group's research focuses on large-scale distributed systems and network applications which are based on nodes cooperating voluntarily. Examples of such systems are information-centric networks, mobile opportunistic networks, and cloud and edge computing. The work focuses on investigating architectures and mechanisms for designing, prototyping, and testing of future networks. The goal of the work is to understand how future networks should be designed and built. The group has also worked on data center energy efficiency and green networking.

Contact person: Professor Jussi Kangasharju
Home page: http://www.helsinki.fi/collaborative-networking/

3.2.3. Combinatorial Pattern Matching

The combinatorial pattern-matching group develops combinatorial algorithms for pattern search and synthesis problems for sequential and higher-dimensional data. The group is interested in the basic research of the theoretical aspects of the area as well as in various applications, mostly in bioinformatics and information retrieval. Recent results of the group include a very accurate error correction method for the so-called long reads in DNA sequencing as well as a new type of probabilistic model and learning algorithm for DNA motifs of transcription factor binding.

Contact person: Professor Esko Ukkonen
Home page: http://www.cs.helsinki.fi/research/algodan/cpm/

3.2.4. Complex Systems Computation (CoSCo)

The CoSCo research group investigates computational problems related to complex systems, focusing on prediction and modeling tasks. The basic research areas addressed include machine learning, probabilistic modeling and data analysis, information theoretical approaches to inference and constraint reasoning and optimization. Central themes in the applied research include methods for analyzing and visualizing multidimensional and multimodal Big Data, intelligent information retrieval and context-awareness for ubiquitous computing. The group is a member of the Finnish Center of Excellence in Computational Inference Research (COIN).

Contact person: Professor Petri Myllymäki
Home page: http://cosco.hiit.fi

3.2.5.   Computational Linguistics

The Computational Linguistics group works on analyzing language and modeling linguistic processes. Human language is very effective at encoding and communicating information, fundamental to our way of perceiving and interacting with the world. Yet the existing models of language fall short of explaining various aspects of its functioning, or of enabling computers to deal adequately with linguistic content. The PULS project builds systems for news surveillance, which aim to extract factual information from on-line news streams. The systems' goal is to understand meaning in text, to provide maximum utility to the end-user, as well as to enhance the base of background knowledge. Etymon is a project on modeling the relationships within a language family, and the etymological processes that underlie language evolution.

Contact person: University Researcher Roman Yangarber
Home page: http://puls.cs.helsinki.fi
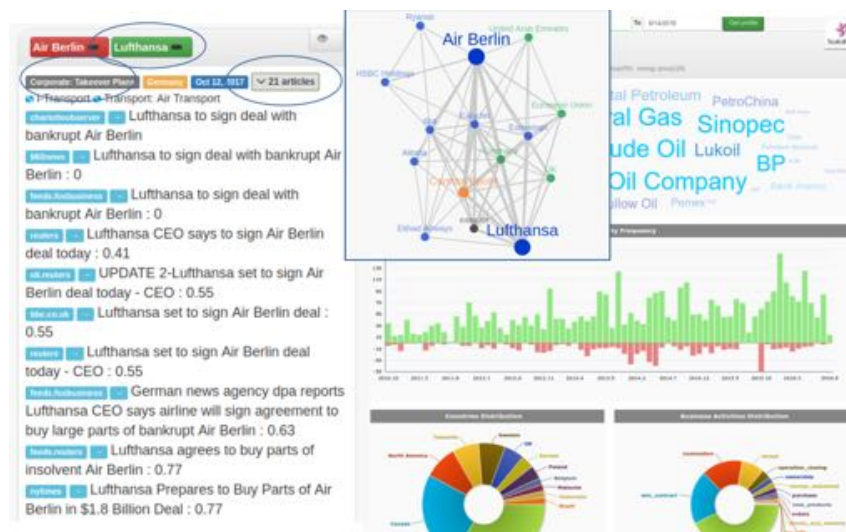
Snapshots from the PULS system build by the Computational Linguistics group.
Photographer: Roman Yangarber

3.2.6.   Computer-Assisted Music Analysis, Comparison and Retrieval

The C-BRAHMS project aims at designing and developing efficient methods for computational problems arising from music comparison, retrieval, and analysis. Particularly, the project concentrates on retrieving polyphonic music in large-scale music databases containing symbolically encoded music. The project uses the findings in musicology and music psychology to achieve musically meaningful methods and results. All the project's outputs are exhibited in a freely available query engine.

Contact person: University Lecturer Kjell Lemström
Home page: http://www.cs.helsinki.fi/group/cbrahms/

3.2.7.   Constraint Reasoning and Optimization (CoReO)

The Constraint Reasoning and Optimization group focuses on the development and analysis of state-of-the-art decision, search, and optimization procedures, and their applications in computationally hard problem

domains with real-world relevance. The group contributes especially to the development state-of-the-art Boolean satisfiability (SAT) solvers, their extensions to Boolean optimization, and applications of SAT-based and other types of discrete search and optimization procedures in exactly solving intrinsically hard (NP-complete and beyond) computational tasks. Recent domain-specific studies include exactly solving machine learning problems (different types of clustering, classification, and structure learning tasks) via constrained optimization, and computational aspects of argumentation theory.

Contact person: Academy Research Fellow Matti Järvisalo
Home page: http://www.hiit.fi/cosco/coreo/

3.2.8. Content-centric Structures and Networking (COSN)

Content delivery and dissemination dominate Internet traffic. This is exemplified by the popularity of peer-to-peer software. On the other hand, the current networking protocol stack, TCP/IP, was not originally engineered for this kind of data exchange. The research group investigates new solutions for content-centric data delivery.

Contact person: Professor Sasu Tarkoma
Home page: http://www.cs.helsinki.fi/research/nodes

3.2.9. Discovery Group: Data Mining and Computational Creativity

The Discovery research group develops novel methods and tools for data science and for computational creativity. Our focus is on algorithmic methods for discovering links and patterns in data, and on automated creativity in different areas. In the intersection of these fields, we develop creative systems and applications that learn to create.

Contact person: Professor Hannu Toivonen
Home page: http://www.cs.helsinki.fi/en/discovery

Discovery Group.
Photographer: Veikko Somerpuro

3.2.10.   Empirical Software Engineering (ESE)

Empirical Software Engineering Helsinki (ESE) is a research group at the University of Helsinki. We address software engineering research problems and challenges with industrial relevance or origin. We emphasise the empirical aspect of the research, in particular by applying research methods that enable us gaining deep understanding of software development and creating novel means that have impact on both research and industry.

Contact person: Professor Tomi Männistö
Home page: https://www.cs.helsinki.fi/group/ese/

Members of the ESE group.
Photographer: Veikko Somerpuro

3.2.11.   Genome-scale Algorithmics

We develop algorithms and data structures for the analysis of genome-scale data. Such data is abundant due to modern molecular biology measurement techniques like high-throughput sequencing. We are especially interested in applications of compressed data structures, that make it possible to analyse the often highly redundant data within the space of their information content. We also study other scalability aspects like distributed computation/storage around genome-scale data.

Contact person: Professor Veli Mäkinen
Home page: http://www.cs.helsinki.fi/gsa/

3.2.12.   Information, Complexity and Learning (ICL)

The Information, Complexity and Learning research group is a part of the Cosco research group and studies the theory and applications of probabilistic models, especially graphical models. A particular area of interest is information theoretic methods.

Contact person: Assistant Professor Teemu Roos
Home page: http://www.hiit.fi/node/1566

Researchers from the ICL group.
Photographer: Veikko Somerpuro

3.2.13.   Intelligent Interactive Information Access (INTENT)

The INTENT research group is the name of the CoSCo subgroup working in particular with the TEKES project Revolution of Knowledge Work (Re:Know). The research topic is information retrieval in symbiotic interaction, using machine learning methods.

Contact person: University Lecturer Patrik Floréen
Home page: http://www.hiit.fi/intent

3.2.14.   Machine Learning

The main focus of the team is in machine learning, especially on-line learning and kernel methods. In particular, the team studies theoretically well-founded methods and rigorous performance bounds for them. This includes analyzing the methods both in the classic statistical setting and in an online setting, where many of the classic assumptions can be avoided.

Contact person: Professor Jyrki Kivinen
Home page: http://www.cs.helsinki.fi/tutkimus/machine-learning

3.2.15.   Multi-source Probabilistic Inference (MUPI)

The Multi-source Probabilistic Inference (MUPI) group studies statistical machine learning methods and inference techniques for analyzing and understanding heterogeneous data collections. The group develops both new theory and practical computational tools for joint analysis of multi-source data for various application fields. MUPI is part of the CoSCo group.

Contact person: Academy Research Fellow Arto Klami
Home page: https://www.hiit.fi/cosco/mupi

3.2.16. Neuroinformatics

Neuroinformatics is a combination of computer science and neuroscience, and the interface between them. We work in computational neuroscience where the goal is to build simulation models of brain functions, as well as in data analysis methods of e.g. brain-imaging data. On a more theoretical level, we investigate statistical multivariate modelling based on non-Gaussianity.

Contact person: Professor Aapo Hyvärinen
Home page: http://www.cs.helsinki.fi/u/ahyvarin/group.shtml

3.2.17. Practical Algorithms and Data Structures on Strings (PADS)

We develop efficient and practical algorithms and data structures for fundamental problems arising in sequence analysis. The research is based on thorough understanding of both the combinatorial properties of the problems and the properties of modern computers. The goal is not only to obtain better algorithms but to understand why they are better.

Contact person: University Lecturer Juha Kärkkäinen
Home page: http://www.cs.helsinki.fi/group/pads/

3.2.18. Probabilistic Inference and Computational Biology (PROBIC)

We develop methods for efficient probabilistic inference in complex modelling problems. We develop models for genomic time series data using Gaussian processes and methods for quantitative analysis of sequencing data. We also develop theory and methods for efficient differentially private Bayesian inference. We are a part of the Probabilistic Machine Learning group at HIIT.

Contact person: Academy Research Fellow Antti Honkela
Home page: http://www.hiit.fi/node/2629

3.2.19. RAGE - Agile Education Research

RAGE (Agile Education Research) builds research-based agile, lightweight and reactive structures for organizational learning, in addition to increasing interaction between the learners and educators.

Contact person: University Lecturer Matti Luukkainen
Home page: http://www.cs.helsinki.fi/rage/

3.2.20. Secure Systems

The Secure Systems research group investigates how to make it possible to build systems that are simultaneously easy-to-use and inexpensive to deploy while still guaranteeing sufficient protection. We design, implement and analyze basic building blocks for system- and network security informed by usability

and deployability considerations. Our current research topics include mobile platform security, contextual security, and security/privacy issues in specific application areas like social networks.

Contact persons: Professor N. Asokan and Professor Valtteri Niemi
Home page: http://www.cs.helsinki.fi/group/secures/

3.2.21.   Sums of Products

Non-standard methods to evaluate large and structured sums of products - especially ones involving moderately-exponential-time algorithms - have great prospects to significantly advance the state of the art in algorithm theory and computational statistics. The group's mission is to implement this vision in a prototyping manner by studying (a) algorithm theory of computing sums of products, (b) sums of products in computational statistics, and (c) applications in science and technology.

Contact person: Assistant Professor Mikko Koivisto
Home page: http://www.cs.helsinki.fi/u/mkhkoivi/sopu.shtml

3.2.22.   Ubiquitous Interaction

Ubiquitous Interaction investigate new forms of Human-Computer relations developing techniques and systems that utilise affective, adaptive, multimodal, and tangible computing. Application areas include search and information exploration, sustainability, home computing, walk-up-and-use displays, and collaborative knowledge work.

Contact person: Professor Giulio Jacucci
Home page: https://www.cs.helsinki.fi/en/nodes/ubiquitous-interaction

3.2.23.   Ubiquitous Sensing

The Ubiquitous Sensing research group conducts basic research on extracting meaningful information about human behavior and characteristics, and on developing novel system/platform level solutions for performing the sensing tasks as accurately, robustly and resource-efficiently as possible. Examples of the kind of information that the sensing research focus on include personal characteristics (e.g., personality), social behavior (e.g., co-presence of people), competence or skillfulness of the person (e.g., fuel-efficiency in driving behavior), and so forth. Most of the research focuses on using smartphones as the sensing platform, but also the potential of new sensing technologies, such as Kinect or smartwatches, are topics of investigation.

Contact person: Senior Researcher Petteri Nurmi
Home page: https://www.cs.helsinki.fi/ubiquitous-sensing

3.2.24.   Unified Database Management Systems (UDBMS)

As more businesses have realized that data, in all forms and sizes, is critical to making the best possible decisions, we see the continued growth of systems that support massive volume of non-relational

or unstructured forms of data. The research focus of UDBMS is to develop a novel unified database management system to manage both well-structured data and NoSQL data. Our approach will reduce integration issues, simplify operations, and eliminate migration issues between relational and NoSQL data.

Contact person: Associate Professor Jiaheng Lu
Home page: http://udbms.cs.helsinki.fi/

3.2.25. Wireless Internet (WInt)

The group explores the impact of the wireless and mobile networks to the behaviour and performance of Internet protocols and develops new protocols and protocol enhancements for seamless connectivity and efficient communication in the future wireless and mobile Internet.

Contact person: Lecturer Markku Kojo
Home page: http://www.cs.helsinki.fi/research/nodes/wireless.shtml

3.3. Research and teaching laboratories

3.3.1. Interaction Lab

Interaction Lab was initiated and founded by Ubiquitous Interaction research group in 2014. It is a reconfigurable space aimed for research in Human-Computer Interaction. In particular design and evaluation activities are organised in the Interaction Lab, which is equipped with state of the art technologies: stationary and wearable eye trackers, physiological sensors (EDA, HRV, fEMG), EEG equipment, large multitouch screens, haptic devices, and gesture tracking sensors.

Contact person: Professor Giulio Jacucci
Home page: No official home page, but more information on the Interaction Lab can be found from the news related to its grand opening.

3.3.2. Linkki centre

The Linkki centre of the Department of Computer Science at the University of Helsinki is a resource centre that organises activities for children and young people in computer science, in order to increase the interest for seeking future careers and common skills on the area. The Linkki centre is also a contact point for school teachers for their own update education, pre-graduation education, and creating facilities to be used by teachers in schools. The Linkki centre is one of the resource centres of the Finland's Science Education Centre LUMA.

Contact person: University Lecturer Lea Kutvonen
Home page: http://linkki.cs.helsinki.fi

Linkki centre.
Photographer: Veikko Somerpuro

3.3.3.   NODES laboratory

The NODES laboratory is a facility for supporting networking and services related research and teaching activities. The laboratory includes crucial equipment for the research of network protocols, routing algorithms, and ubiquitous and mobile computing. The laboratory highlights include software-defined networking equipment, a home gateway testbed, a mesh network, a shielded EMC chamber, and multitouch displays for interaction research.

Contact person: Professor Sasu Tarkoma
Home page: http://www.cs.helsinki.fi/en/nodes/nodes-laboratory

3.3.4.   Software Factory

Software Factory creates a common, cooperative platform for software business, basic & applied software development research and education. Software Factory is an experimental software R&D laboratory aiming at stimulating education, cross-disciplinary research and high-expectation entrepreneurships.

Contact person: Post-doctoral Researcher Fabian Fagerholm
Home page: http://www.softwarefactory.cc

3.3.5.   Ukko cluster

The Department of Computer Science purchased the high-performance cluster Ukko at the end of 2009, and the cluster was taken into use in summer 2010. The Ukko cluster is used by the research projects of the department for solving highly computationally intensive tasks. These tasks include, for example, evaluating the performance of network algorithms and applications in practice, using the cluster as a network

emulator. The cluster is available for all the users of the department, and the IT support group of the department is responsible for the maintenance of the cluster.

Contact person: IT Manager Petri Kutvonen
Home page: http://www.cs.helsinki.fi/en/compfac/high-performance-cluster-ukko

4.   *Publications 2016*

Type of publication	2012	2013	2014	2015	2016
A1 Refereed journal articles	59	57	75	72	69
A2 Reviews in scientific journals	2	3	0	3	2
A3 Contributions to books/other compilations (refereed)	2	7	3	8	3
A4 Articles in conference publication (refereed)	114	131	110	103	103
B1 Unrefereed journal articles	4	1	8	5	5
B2 Contributions to books/other compilations (non-refereed)	12	3	6	4	1
B3 Unrefereed articles in conference proceedings	15	4	0	5	10
C1 Published scientific monographs	8	2	2	1	0
C2 Edited books, compilations, conference proceedings or special issue of journals	7	9	9	6	5
D1 Articles in professional journals	2	0	0	1	1
D3 Articles in professional conference proceedings	1	3	0	1	4
D4 Published development or research reports	1	2	5	1	0
D5 Text book or professional handbook or guidebook or dictionary	0	1	0	0	1
E1 Popular contributions to journals, books or other compilations	2	1	1	0	1
E2 Popular monograph	0	0	1	0	0
F2 Public contributions to artistic work	1	8	1	2	0
F3 Public artistic play or exhibition	0	2	1	0	0
G3 Licentiate theses	0	0	1	0	0
G4 Doctoral theses, monographs	4	2	0	2	2
G5 Doctoral theses, article-based	5	12	4	5	4
I2 ICT programs or applications	1	0	0	6	4
Total Count	**240**	**248**	**227**	**225**	**215**

*The head and the deputy heads of department are responsible for the work of the department. In 2016, Professor **Sasu Tarkoma** was the head of the department, and the deputy heads were Professor **Veli Mäkinen** and Professor **Valtteri Niemi**. In addition, the department has a department council comprising three professors, three representatives of other staff, and three students. The members of the department council are elected every four years. The department council has a secretary who handles the distribution of the documents for the council meetings.*

*The instruction at the department is divided into four sub-programmes and a course profile combining two sub-programmes. The supervisors heading the sub-programmes in 2016 were Professor **Veli Mäkinen** (algorithmic bioinformatics), Professor **Jyrki Kivinen** (algorithms, data analytics and machine learning), Professor **Valtteri Niemi** (networking and services), and Professor **Tomi Männistö** (software systems). Professors Kivinen and Tarkoma are the liaisons for the new data science course profile. Professor **Petri Myllymäki** acted as Director of the department's own doctoral programme (DoCS) in 2016.*

*Research at the department is ordered into research units and groups. The Helsinki Institute for Information Technology HIIT (in collaboration with Aalto University) operates in conjunction with the department; in 2016, HIIT was headed by Professor **Petri Myllymäki**. Some of the department's research groups work within HIIT. In addition, some of the department's research groups are part of Finnish Academy centres of excellence.*

*In 2016, the department administration was divided into (1) teaching administration, with Head of Studies **Kjell Lemström** in charge, (2) general, HR and financial administration, with Office Manager **Tiina Väisänen** in charge (until 30.4.2016), (3) research and doctoral education administration, with Research Coordinator **Pirjo Moen** in charge, and (4) information technology, with IT Manager **Petri Kutvonen** in charge. Since 1.5.2016, the new Service Organisation of the University of Helsinki took care of the general, HR and financial administration. Furthermore, the department comprised a steering committee, a teaching administration committee, the board for the DoCS programme, the workforce for improving teaching, and the wellbeing-at-work team. The department staff is also represented in numerous faculty and university committees, as well as external organisations.*

The strategy seminar of the Department of Computer Science was held in Gustavelund, Tuusula, in 2016.
Photographer: Antti Honkela

5.1. Department council 2016

The 2016 department council comprised the following members:

Chair	Professor Sasu Tarkoma
Member	**Deputy**
Professor Jussi Kangasharju	Professor Valtteri Niemi
Professor Jyrki Kivinen	Professor Aapo Hyvärinen
Professor Tomi Männistö	Professor Veli Mäkinen
Amanuensis Teija Kujala (until 31.5.2016), IT Specialist Jani Jaakkola (from 1.6.2016 on)	IT Specialist Jani Jaakkola (until 31.5.2016), Amanuensis Reijo Sivèn (from 1.6.2016 on)
University Instructor Tiina Niklander	University Lecturer Antti-Pekka Tuovinen
Doctoral Student Ella Peltonen	Research Coordinator Pirjo Moen
Student Keinänen	Student Vili Hätönen
Student Ville-Veikko Saari	Student Joel Nummelin
Student Henna Warva	Student Heikki Ahonen
Secretary Tiina Väisänen (until 31.5.2016), Pirjo Mulari (from 1.6.2016 on)	

5.2. Committee memberships 2016

Department steering committee
- Sasu Tarkoma (pj)
- Jyrki Kivinen
- Veli Mäkinen
- Tomi Männistö
- Valtteri Niemi
- Kjell Lemström
- Pirjo Moen
- Petri Kutvonen
- Tiina Väisänen (until 31.5.2016), Pirjo Mulari (starting 1.6.2016)

Steering group of DoCS
- Petri Myllymäki (director)
- Jyrki Kivinen
- Tomi Männistö
- Sasu Tarkoma
- Otto Waltari
- Pirjo Moen (coordinator)

Taskforce for education improvement

- *Jukka Paakki (chair)*
- *Staff representatives*
  - *Kjell Lemström*
  - *Matti Luukkainen*
  - *Ella Peltonen*
  - *Teemu Roos*
- *Students*
  - *Juho Esselström, Joel Nummelin*
  - *(deputies Eetu Mattila, Essi Salmenkivi)*

Communications group

- *Lea Kutvonen (pj)*
- *Jani Jaakkola*
- *Pirjo Moen*
- *Hanna Mäenpää*
- *Arto Vihavainen*
- *Ping Xiao*
- *Pauliina Pajunen (until 31.5.2016)*

Group for wellbeing at work

Finnish group
- *Jani Jaakkola*
- *Tiina Niklander*
- *Antti-Pekka Tuovinen (chair)*
- *Pauliina Pajunen (until 31.5.2016)*

International group
- *Kumaripaba Athukorala*
- *Ella Peltonen*
- *Roman Yangarber*

5.3. Department representatives and liaison officers 2016

University of Helsinki

- *University collegium: Hannu Toivonen (deputy)*
- *Scientific council of the university (TINE): Esko Ukkonen*
- *University committee for health and safety: Tiina Niklander*
- *Advisory board for cooperation proceedings at the University: Tiina Niklander*
- *Library steering committee: Esko Ukkonen*
- *IT centre steering committee: Esko Ukkonen*
- *Teachers' Academy: Heikki Lokki (until 31.7.2016), Matti Luukkainen*
- *Taskforce for evaluation of instruction and research staff for adapting the salary system: Tiina Niklander*

Faculty of Science

- *Members of the faculty council:*
  - *Petri Myllymäki (deputy Sasu Tarkoma)*
  - *Tiina Väisänen (deputy Petri Kutvonen)*
  - *Olli Vanhoja (student member; deputy Jonne Airaksinen)*
  - *(Jukka Corander) (deputy Tomi Männistö)*
- *Scientific specialists of the Faculty (MATIAS): Esko Ukkonen (chair), Aapo Hyvärinen (until 31.7.2016), Petri Myllymäki (starting 1.8.2016)*
- *Faculty steering committee: Esko Ukkonen, Sasu Tarkoma*
- *Faculty taskforce for social interaction: Jyrki Kivinen*
- *Faculty taskforce for student affairs: Kjell Lemström (deputy Matti Luukkainen); (student member deputy Olli Vanhoja)*
- *Faculty admissions committee: Veli Mäkinen (deputy Jyrki Kivinen)*
- *Faculty committee pool for pedagogical skills:*
  - *Professors: Jukka Paakki, Sasu Tarkoma, Hannu Toivonen*
  - *Other instructors and researchers: Kjell Lemström*
  - *Students: Jonne Airaksinen, Juho Esselström, Tero Keinänen, Mikko Kumara, Kati Kyllönen, Paula Lehtola, Juhani Leppänen, John Lindert, Viivi Nissilä, Joel Nummelin, Taneli Pirinen, Thomas Tontchev, Olli Vanhoja, Johannes Verwijnen, Kalle Viiri*
- *Faculty facilities committee: Teija Kujala (until 30.4.2016)*
- *Steering group of the Doctoral School in Natural Sciences: Petri Myllymäki*
- *Taskforce for developing bilingual instruction at the Faculty: Patrik Floréen (deputy Pirjo Moen)*
- *Steering committee for LUMA centre: Sasu Tarkoma*
- *LUMA resource centre Linkki: Lea Kutvonen (director)*

Kumpulan campus

- *Kumpula campus library advisory board : Jyrki Kivinen (deputy Sasu Tarkoma)*
- *Kumpula campus infra-structure taskforce: Sasu Tarkoma*
- *Kumpula health and safety committee: Tiina Niklander (vice chair, staff representative)*
- *Kumpula deputy health-and-safety officer: Antti-Pekka Tuovinen*
- *Building manager of Exactum: Jyrki Kivinen*
- *Safety manager of Exactum: Pekka Niklander*

Other organisations

- *Taskforce for national admission exam: Timo Karvi*
- *Publication forum panel for data-processing and information sciences: Esko Ukkonen (chair)*
- *HIIT board: Sasu Tarkoma (deputy Valtteri Niemi)*
- *Executive committee for the HICT doctoral education network: Petri Myllymäki (chair), Pirjo Moen*
- *Advisory Committee of the Helsinki Doctoral Training Centre of the EIT ICT Labs Doctoral School: Petri Myllymäki*
- *IFIP WG 2.10 Software Architecture: Tomi Männistö*
- *IFIP WG 6.1 Architectures and Protocols for Distributed Systems: Lea Kutvonen*
- *IFIP WG 5.8 Enterprise interoperability: Lea Kutvonen (vice chair)*
- *Finnish Committee for Research Data: Petri Myllymäki*
- *Scientific advisory board for national defence (MATINE): Sasu Tarkoma*

- *Tekes 5th Gear Research Programme Steering Group: Sasu Tarkoma*
- *Technology Industries, Innovation taskforce 2014: Hannu Toivonen (expert member)*
- *Scientific Computing Forum: Petri Myllymäki (chair)*
- *The Finnish Society for Computer Science: Mikko Koivisto*

Department liaison officers

- *Library liaison: Teija Kujala (until 30.4.2016), Minna Lauri (starting 1.5.2016)*
- *Accidents liaison (CS Dept. and HIIT): Tiina Väisänen (deputy Päivi Kuuppelomäki)*
- *Equality liaison: Veli Mäkinen*
- *TKO-äly (student organisation) and tutor liaison: Johannes Verwijnen*

6. Department statistics

6.1. Staff

In 2016, a total of 157.1 person-years was completed at the department, which is 21 less than the previous year. The decrease in person-years targeted person-years carried out on basic allocated funds. In contrast, somewhat more person-years were carried out on external funding than the previous year.

The year 2016 was exceptional for the whole university, since the dismissals following the cooperation negotiations in autumn 2015 were put into action in spring 2016. At the same time, an organisational reshuffle was carried out so that the administrative staff at the departments transferred to the new university services on 1 May 2016. A large part of the IT team at the department transferred to the IT Centre in August 2016. Besides the transferrals of the administrative and IT staff, the person-year statistics are affected by the decrease in teaching and research staff (14.5 p-y). New recruitments started up slowly after the cooperation negotiations.

When considered from the viewpoint of the four-tier scale of teaching and research posts, the majority of person-years are still carried out on the 1st, lowest tier of the tenure track (research assistants and doctoral students), which has been strengthened in the past years through the increase in external funding. In accordance with the HR plan, the number of research assistants went down and postdoctoral researchers and doctoral students were hired in projects on external funding. Doctoral students are also supported by basic funding, but the majority of basic funding is directed towards person-years carried out on the higher, 2nd-4th tiers of the tenure track (professors, university lecturers, and post-doctoral researchers).

The department staff has become increasingly international during the past five years. By the end of 2016, the percentage of foreigners among teaching and research staff was 33.73%, while in 2011, it was 12.33%. The percentage of females fell to 17.6% of the person-years.

Archives of the Department.
Photographer: Susanna Kutvonen

Person-years per staff category

	2012	2013	2014	2015	2016
Teaching and research staff	**142.3**	**146.4**	**152.9**	**163.4**	**148.9**
Professors	11.7	13.5	12.9	13.3	10.9
Research directors	0.6	0.4	0.0	0.3	0.6
Associate and assistant professors	0.0	0.6	2.0	2.4	3.0
University lecturers, lecturers	16.3	15.4	15.5	14.8	13.5
Researchers (academy researchers, university researchers, senior researchers, research coordinators)	7.5	7.4	7.6	10.4	10.1
Postdoctoral researchers	17.6	21.9	24.5	25.3	22.9
University teachers	2.0	1.0	1.4	2.0	2.0
Doctoral students, assistants	35.4	37.6	36.6	44.4	43.8
Research support staff	43.6	40.8	43.7	40.8	34.8
Other teaching and research staff (part-time teachers, project planners)	7.6	8.0	8.7	9.6	7.3
Other staff	**16.6**	**16.6**	**15.8**	**14.7**	**8.2**
Administrative staff	8.3	8.3	8.0	7.5	3.2
IT staff	7.5	7.6	7.8	7.0	5.0
Other (trainees)	0.8	0.7	0.0	0.2	0.0
Total	**158.9**	**163.0**	**168.7**	**178.1**	**157.1**

Gender of staff

	2012	2013	2014	2015	2016
Female (% of person-years)	18.3	18.3	20.3	21.8	17.55
Male (% of person-years)	81.7	81.7	79.7	78.2	82.45

Foreign employees

	2012	2013	2014	2015	2016
Percentage of staff	18.2	28.6	32.4	31.8	33.1
Percentage of teaching and research staff	20.0	31.4	35.5	35.0	33.7

Person-years per funding source

	2012	2013	2014	2015	2016
Internal funding	**86.7**	**91.7**	**100.6**	**99.5**	**77.0**
Allocated funding (incl. HIIT)	75.5	74.8	76.4	83.9	66.8
Graduate schools, CoEs and performance-based funding	11.2	16.9	24.2	15.6	10.2
External funding	**72.2**	**71.3**	**68.1**	**78.6**	**80.1**
Academy of Finland	33.5	27.2	13.8	27.9	32.9
Tekes	21.9	25.2	30.9	25.3	19.2
Finnish companies	1.2	3.4	2.9	6.7	6.2
EU funding	5.3	5.7	10.8	11.9	9.6
Other foreign funding	3.5	3.2	6.2	4.6	6.7
UH foundations	2.0	2.8	1.2	0.0	0.0
Other funding	4.7	3.8	2.2	2.2	5.5
Total	**158.9**	**163.0**	**168.7**	**178.1**	**157.1**

* Situation on 31.12.2016

6.2. Funding

In 2016, total funding reached MEUR11.91. It decreased with 1 Million Euros from the previous year. Basic allocated funding fell by MEUR1.24 and external funding increased by 0.24. Most of the funding was spent on staff expenses and facilities. The changes in basic funding mostly followed from the changes in the administration of the university.

In 2016, on top of basic funding, the department received funding for the doctoral programme, three centres of excellence, and two research groups that had been very successful in the evaluation of research. The faculty granted strategic funding for a project to develop teaching and research in information security, as well as Medium-infra funding.

In 2016, external funding for the department reached MEUR6.48. The funding from the Finnish Academy continued to rise, while the funding from Tekes fell by nearly 1 Million Euros. National corporate funding grew, while EU funding fell slightly from the previous year. Besides being important financially for the department, the external funding is also an indicator of the department's competitive edge. However, when external funding makes up a large part of the department's funding while projects run for shorter periods of time, it brings insecurity especially to long-term planning.

Total funding and external funding (Million Euros)

	2012	2013	2014	2015	2016
Internal funding	**6.45**	**6.54**	**6.77**	**6.67**	**5.43**
Allocated funding (incl. HIIT)	5.38	5.35	5.44	5.73	4.60
Graduated schools, CoEs and performance-based funding	1.08	1.18	1.33	0.94	0.83
External funding	**4.79**	**5.16**	**5.42**	**6.24**	**6.48**
Academy of Finland	2.26	2.19	1.09	2.39	2.94
Tekes	1.55	1.72	2.61	2.12	1.61
Finnish companies	0.11	0.30	0.17	0.51	0.56
EU funding	0.39	0.41	0.81	0.85	0.76
Other foreign funding	0.20	0.19	0.45	0.29	0.41
UH foundations	0.09	0.10	0.06	0.00	0.00
Other funding	0.21	0.26	0.25	0.08	0.20
Total	**11.24**	**11.70**	**12.19**	**12.91**	**11.91**

6.3. Teaching

In autumn 2016, the department produced a new six-part series of MOOC courses on security in cooperation with F-Secure. The online material of the course has been accessed some 277,000 times by over 50,000 unique users. Some 5,000 students signed up for the courses and over 1,000 of them finished at least one part of the series. These MOOCs generated a total of some 3,000 credits by May 2017, out of which some 2,000 credits were registered as Open University credits. The rest of the credits were registered for students who have not been admitted to either the University of Helsinki or the Open University.

The department was active in competitive programming again. In January, the department organised the finals of the Datatähti (data star) 2016 competition, where the best programmers from Finnish schools were invited to participate. The department's own competitive programming team, Game of Nolife, attended the finals in the ICPC competition in Phuket, Thailand on the strength of its regional competition win the previous year. In this world final, the team consisting of Otte Heinävaara, Olli Hirviniemi, and Tuukka Korhonen, supervised by Mikko Sysikaski, reached the respectable place 13/56.

Game of Nolife, the competetive programming team of the department in the finals of the ICPC competition.
Photo: ACM ICPC

When analysing teaching statistics, we can see that our students and teachers reached another record for this period in number of credits completed. Department students completed 909 credits per person-year of teaching staff, which means a staggering 21% increase from our previous record last year. In reality, the number is even higher, since it does not include the credits from the above-mentioned security MOOCs produced by our teachers. The new record is primarily explained by the cut-backs in teaching resources after the cooperation process (the number of person-years in teaching decreased by 12.8%). However, at the same time, the number of credits increased by 6.4%.

The long-lasting decrease in the number of international students, which started in 2011, finally took a new turn; the previous year, only 17 started their studies, and this year, the number was already up to 29. The number of completed basic degrees exceeded both that of the previous year and the goals set for 2016. The goal for BSc degrees was 90, and exceeded by three. A whole 83 MSc degrees were completed, 12 more than the target. The total number of completed basic degrees has not been so high since 2011.

Number of students

	2012	2013	2014	2015	2016
Main admissions	130	130	130	130	130
Accepted main admissions	133	142	158	143	119
Accepted international admissions	29	25	22	17	29
All students	1692	1584	1727	1688	1736

Teaching and credits

	2012	2013	2014	2015	2016
Teacher person-year	37.5	38.5	40.5	42.1	36.7
Credits total	25 665	26 684	29 954	31 636	33 364
Credits per person-years	684	693	740	751	909

Number of degrees

	2012	2013	2014	2015	2016
Bachelor's degrees	80	56	76	80	93
Master's degrees	65	71	51	63	83
Licentiate degrees	-	-	1	-	-
Doctoral degrees	9	11	8	6	6

6.4. Research

In the strategy for 2013-2016, the research at the department continues to focus on three main areas: machine learning and algorithms, networks and services, and software systems. As in previous years, the results from all these research fields were actively discussed in writing in 2016. In 2016, researchers at the department published 177 refereed articles and a total of 215 publications, so the number of publications decreased somewhat compared to previous years, but not much.

Researchers from the department continued to participate in various conference programme committees and editorial staff of journals, as well as acting as referees to articles, during 2016. Further, some researchers acted as chair of programme committees and editors of special issues of scientific journals. Researchers from the department were also invited speakers at international conferences and national events.

International mobility has gained significance in research in the past years. Department researchers made several longer or shorter research visits to universities and scientific institutes abroad in 2016. In addition, some foreign visitors came for short research stays at the department.

The research of the department gained some visibility in public media in 2016. The most publicity was generated by the BCDC Energia project, where the department's Professor Jussi Kangasharju and his group are participating, as well as Professor Sasu Tarkoma's and his group's research into the Internet of Things.

The department and its staff also gained recognition from other sources. In the Times Higher Education assessment of 2016, the department gained 69th place of all the computer science departments in the world, 25th among European, and 1st among Scandinavian departments. Valtteri Niemi was elected security researcher of the year, and Sasu Tarkoma received the University of Helsinki 2016 reward for promoting corporate cooperation. Some of the department's conference papers received honourable mention, and Professor Jussi Kangasharju won the ninth Helsinki Science Slam competition. Among former doctoral students of the department, Teppo Niinimäki received the thesis reward of the Finnish information-processing research

foundation, and Dominik Kempa the thesis reward of the Doctoral School in Natural Sciences. Furthermore, Peter Hedman received an award for his MSc thesis from the Academic Association for Mathematics and Natural Sciences MAL and Academic Engineers and Architects in Finland TEK. Ella Peltonen received a second thesis grant from the Nokia Foundation.

In 2016, the department had research groups in three of the Finnish Academy's national centres of excellence. These units are COIN (The Finnish Centre of Excellence in Computational Inference Research), CoECGR (The Finnish Centre of Excellence in Cancer Genetics Research), and The Finnish Centre of Excellence in Inverse Problems. From the department, Professor Petri Myllymäki and his team participate in the COIN unit, Professor Veli Mäkinen and his team in CoECGR, and Professor Aapo Hyvärinen and his team in the Inverse Problems unit.

Publications 2016

	2012	2013	2014	2015	2016
Refereed journal articles (A1)	59	57	75	72	69
Refereed conference and compilation articles, evaluations (A2-A4)	118	141	113	114	108
Other publications (all other categories)	63	50	39	39	38
Total	**240**	**248**	**227**	**225**	**215**

7. Awards and recognitions 2016

7.1. Awards given by the Department of Computer Science

The Department of Computer Science has given some annual awards to its staff members since 2001. During the Department's Christmas Coffee for staff these awards for 2016 were given to the following persons:

- *Junior Good Teacher: Instructor Kati Kyllönen*
- *Senior Good Teacher: University Lecturer Juha Kärkkäinen*
- *Junior Good Researcher: Doctoral student Juho-Kustaa Kangas*
- *Senior Good Researcher: University Researcher Leena Salmela*
- *Person of the year: Project accountant Leena Kekäläinen*

Staff member receiving the annual awards 2016:
Kati Kyllönen (left), Juha Kärkkäinen, Leena Salmela, Leena Kekäläinen and Juho-Kustaa Kangas.
Photographer: Antti Moilanen

7.2. Awards and recognitions given to the Department and its staff or students

- *Awards related to publications:*
  - *Matti Järvisalo, Andreas Niskanen, and Johannes Wallner received the ECAI 2016 Runner-Up Best Student Paper Award of the ECAI 2016 conference for their article Synthesizing Argumentation Frameworks from Examples.*
  - *Petri Kettunen together with Susanna Teppola, Mari Matinlassi and Jari Partaken received the Mariano Corso Best Practical Implications Award 2016 of the CINet 2016 conference for their article Transparency of Information to Improve Continuous Innovation Experimentation Performance.*
  - *Baris Serim and Giulio Jacucci received the Honorable Mention of the CHI 2016 conference on their article Pointing while Looking Elsewhere: Designing for Varying Degrees of Visual Guidance during Manual Input.*

- *Thesis awards*
  - *Teppo Niinimäki got the 2016 Dissertation Award of the Finnish Information Processing Research Foundation (Tietotekniikan tutkimussäätiö) for his doctoral thesis Approximation Strategies for Strucuter Learning in Bayesian Networks.*
  - *Dominik Kempa got the Doctoral School in Natural Sciences outstanding doctoral dissertation award 2016 for his doctoral thesis Efficient Construction of Fundamental Data Structures in Large-Scale Text Indexing*
  - *Peter Hedman got the 2016 master's thesis award of Matemaattis-luonnontieteellisten alojen Akateemiset ry MAL and Tekniikan akateemiset TEK for his master's thesis Sequential Monta Carlo Instant Radiosity.*

- *Awards and recognitions related to teaching and studies:*
  - *Team Game of Nolife (Otte Heinävaara, Olli Hirviniemi, and Tuukka Korhonen) from the University of Helsinki ranked 14th in the World Finals 2016 of the ICPC programming contest in Thailand.*
  - *Team TKT-Akat (Henna Kalliokoski, Ronja Oja, Tintti Rahikainen, Pihla Toivanen, and Jenny Tyrväinen) won both main categories in the Reittiopas event of HSL with their Stop 2.0 service. In addition to that, the team's game Tram Challenge got an honorable mention for gamification.*
  - *University Instructor Arto Hellas received the Good Teacher - Magister Bonus prize 2016 of the Student Union of the University of Helsinki (HYY).*
  - *Ella Peltonen received the Nokia Scholarship 2016 for her doctoral studies.*

- *Other awards and recognitions*
  - *Professor Jussi Kangasharju was the winner of the 9th Helsinki Science Slam Competition.*
  - *Academy researcher Matti Järvisalo was invited to deliver one of the Early Career Spotlight Talks at the IJCAI 2016 conference.*
  - *Professor Valtteri Niemi was nominated as the Data Security Researcher of Year 2016.*
  - *Professor Sasu Tarkoma got the University of Helsinki prize 2016 for promoting the corporate collaboration.*

The winning team TKT-Akat (Henna Kalliokoski left, Tintti Rahikainen and Pihla Toivanen; missing Ronja Oja and Jenni Tyrväinen) in the Reittiopas event of HSL.

8. *Events 2016*

Defences of Theses

01.04.2016 M.Sc. Teppo E. Ahonen: [*Cover Song Identification Using Compression-based Distance Measures*](#)

06.05.2016 M.Sc. Oskar Gross: [*Word Associations as a Language Model for Generative and Creative Tasks*](#)

27.05.2016 M.Sc. Jussi Määttä: [*Model Selection Methods for Linear Regression and Phylogenetic Reconstruction*](#)

03.06.2016 M.Sc. Jukka Toivanen: [*Methods and Models in Linguistic and Musical Computational Creativity*](#)

12.10.2016 M.Sc. Kumaripaba Athukorala: [*Information Search as Adaptive Interaction*](#)

09.12.2016 M.Sc. Juho-Kustaa Kangas: [*Combinatorial Algorithms with Applications in Learning Graphical Models*](#)

Docent lectures

23.02.2016 PhD Roman Yangarber: [*Morphological analysis in NLP*](#)

01.03.2016 PhD Indre Zliobaite: [*Classifier Evaluation*](#)

09.05.2016 PhD Alexandru Tomescu: [*Assembly of RNA reads and minimum-cost flows*](#)

15.08.2016 PhD Esa Pitkänen: [*Computational Methods of Cancer Genomics*](#)

Guest lectures

29.04.2016 Professor Andrew Hopper, University of Cambridge, Iso-Britannia: [*Computing for the Future of the Planet*](#)

23.05.2016 Professor Tok Wang Ling, National University of Singapore: [*From Structure-based to Semantic-based: Towards Effective XML Keyword Search*](#)

23.06.2016 Professor Tommi Mikkonen, Tampereen teknillinen yliopisto: [*From Mobile Apps to Multi-Device Experience Roaming*](#)

15.08.2016 Dr. Liang Zheng, Princeton University, USA: [*The Economics of Cloud Computing*](#)

15.09.2016 Dr. Rob Saunders, Falmouth University, Iso-Britannia: [*Motivated, Social and Embodied: Three Perspectives on Computational Creativity*](#)

11.10.2016 Professor Kalervo Järvelin, University of Tampere, professor Andrew Howes, University of Birmingham, UK, and Assistant Professor Rob Capra, University of North Caroline at Chapel Hill, USA: [*Search & Beyond*](#)

Seminars

19.08.2016 Summer Intern Project Presentations 1

01.09.2016 Summer Intern Project Presentations 2

22.08.2016 LINUX 25 YEARS - Jubilee Seminar

Scientific conferences and meetings

16.05.2016 The First Europe-China Workshop on Big Data Management

19.-20.05.2016 BREW 2016: Bioinformatics Research and Education Workshop

20.05.2016 KEYS 2016: Workshop on Keyword Search and Data Exploration on Structured Data

27.-29.07.2016 Mobile and Edge Computing Workshop 2016

09.-12.08.2016 Summer School on Bioinformatics Data Structures

17.-19.08.2016 IWOCA 2016: 27th International Workshop on Combinatorial Algorithms

Staff meetings and events

12.02.2016 Monthly meeting for staff

29.02.2016 Morning coffee for staff: Data Science I

04.03.2016 Departments winter sport day

11.03.2016 Unit meeting for staff and students

04.04.2016 Morning coffee for staff: Data Science II

25.04.2016 Morning coffee for staff: Data Science III

29.04.2016 Perjantai Pulla: Farewell party of administration team

24.-25.05.2016 Strategy seminar

14.06.2016 Summer walking trip for staff

30.08.2016 Opening of the academic year

02.09.2016 General Assembly for staff and students

14.10.2016 Department celebrates success in the Times Higher Education ranking

24.10.2016 [Morning coffee for staff](#)

25.11.2016 [Afternoon coffee for staff](#)

29.11.2016 [Monthly meeting for staff](#)

02.12.2016 [Department pre-christmas party](#)

16.12.2016 [Department Christmas Coffee](#)

Other events

17.03.2016 [Alumni day at the University of Helsinki / Kumpula ScienceSLAM](#)

11.-15.05.2016 [BOI 2016: Baltic Olympiad in Informatics](#)

16.05.2016 [Movie screening of Gender and Coding](#)

31.07.2016 ["Song of Summer": a composition for a choir with lyrics written by a computer](#)

Department council meetings

25.01.2016, 01.03.2016, 05.04.2016, 03.05.2016, 07.06.2016, 04.-09.08.2016 (e-mail meeting), 06.09.2016, 04.10.2016, 01.11.2016, 05.12.2016

[Meeting agendas and protocols](#) (login required)

A1 Refereed journal articles

1. *Ahonen, L, Cowley, B, Torniainen, J, Ukkonen, A, Vihavainen, A & Puolamäki, K, Cognitive Collaboration Found in Cardiac Physiology: Study in Classroom Environment. PLoS One, vol. 11, no. 7, 2016, Article no. 0159178.*

2. *Athukorala, KM, Glowacka, D, Jacucci, G, Oulasvirta, A & Vreeken, J, Is Exploratory Search Different? A Comparison of Information Search Behavior for Exploratory and Lookup Tasks. Journal of American Society for Information Science and Technology, vol. 65, no. 11, 2016, pp. 2635-2651.*

3. *Badkobeh, G, Bannai, H, Goto, K, I, T, Iliopoulos, CS, Inenaga, S, Puglisi, SJ & Sugimoto, S, Closed factorization. Discrete Applied Mathematics, vol. 212, 2016, pp. 23-29.*

4. *Barral Mery de Bellegarde, O, Kosunen, IJ, Ruotsalo, T, Spapé, M, Eugster, M, Ravaja, JN, Kaski, SJI & Jacucci, G, Extracting relevance and affect information from physiological text annotation. User Modeling and User-Adapted Interaction, vol 26, no. 5, 2016, pp. 493-520.*

5. *Bayhan, S, Hyytiä, E, Kangasharju, J & Ott, J, Search in Digital Pockets: Retrieving Remote Content in Mobile Opportunistic Networks. IEEE Wireless Communications Magazine, vol. 23, no. 3, 2016, pp. 10-18.*

6. *Belazzougui, D & Venturini, R, Compressed String Dictionary Search with Edit Distance One. Algorithmica, vol. 74, no. 3, 2016, pp. 1099-1122.*

7. *Bellucci, A, Vianello, A, Florack, Y & Jacucci, G, Supporting the Serendipitous Use of Domestic Technologies. IEEE Pervasive Computing, vol. 15, no. 2, 2016, pp. 16-25.*

8. *Björklund, A, Husfeldt, T, Kaski, P, Koivisto, M, Nederlof, J & Parviainen, P, Fast Zeta Transforms for Lattices with Few Irreducibles. ACM Transactions on Algorithms, vol. 12, no. 1, 2016, Article no. 4.*

9. *Castillo, S, Barth, D, Arvas, M, Pakula, TM, Pitkänen, E, Blomberg, P, Seppanen-Laakso, T, Nygren, H, Sivasiddarthan, D, Penttila, M & Oja, M, Whole-genome metabolic model of Trichoderma reesei built by comparative reconstruction. Biotechnology for Biofuels, vol. 9:252, 2016.*

10. *Dargahi, T, Ambrosin, M, Conti, M & Asokan, N, ABAKA: A novel attribute-based k-anonymous collaborative solution for LBSs. Computer Communications, vol. 85, 2016, pp. 1-13.*

11. *Dittmann, C, Kreutzer, S & Tomescu, AI, Graph operations on parity games and polynomial-time algorithms. Theoretical Computer Science, vol. 614, 2016, pp. 97-108.*

12. *Dolev, D, Heljanko, K, Järvisalo, M, Korhonen, JH, Lenzen, C, Rybicki, J, Suomela, J & Wieringa, S, Synchronous counting and computational algorithm design. Journal of Computer and System Sciences, vol. 82, no. 2, 2016, pp. 310-332.*

13. *Drawert, B, Trogdon, M, Toor, S, Petzold, L & Hellander, A, Molns: A cloud platform for interactive, reproducible, and scalable spatial stochastic computational experiments in systems biology using PyURDME. SIAM Journal on Scientific Computing, vol. 38, no. 3, 2016, pp. C179-C202.*

14. *Eryigit, S, Bayhan, S, Kangasharju, J & Tugcu, T, Optimal Cooperator Set Selection in Social Cognitive Radio Networks. IEEE Transactions on Vehicular Technology, vol. 65, no. 8, 2016, pp. 6432-6443.*

15. *Eugster, MJA, Ruotsalo, T, Spape, MM, Barral, O, Ravaja, N, Jacucci, G & Kaski, S, Natural brain-information interfaces: Recommending information by relevance inferred from human brain signals. Scientific Reports, vol. 6, 2016, Article no. 38580.*

16. *Find, M, Göös, M, Järvisalo, M, Kaski, P, Koivisto, M & Korhonen, JH, Separating OR, SUM, and XOR Circuits. Journal of Computer and System Sciences, vol. 82, no. 5, 2016, pp. 793-801.*

17. *Heer, T & Varjonen, SKL, Host Identity Protocol Certificates. RFC series, no. 8002, 2016.*

18. *Heikkilä, T & Roos, T, Thematic Section on Studia Stemmatologica. Digital Scholarship in the Humanities (DSH), vol. 31, no. 3, 2016, pp. 520-522.*

19. *Heinävaara, O, Leppä-Aho, J, Corander, J & Honkela, A, On the inconsistency of ℓ1-penalised sparse precision matrix estimation. BMC Bioinformatics, vol. 17, suppl. 16, 2016, pp. 99-107.*

20. *Hirayama, J, Hyvarinen, A & Ishii, S, Sparse and low-rank matrix regularization for learning time-varying Markov networks. Machine Learning, vol. 105, no. 3, 2016, pp. 335-366.*

21. *Hirayama, J, Hyvarinen, A, Kiviniemi, V, Kawanabe, M & Yamashita, O, Characterizing Variability of Modular Brain Connectivity with Constrained Principal Component Analysis. PLoS One, vol. 11, no. 12, 2016, Article no. 0168180.*

22. *Hoque, MA & Tarkoma, SAO, Sudden Drop in the Battery Level? Understanding Smartphone State of Charge Anomaly. Operating systems review, vol. 49, no. 2, 2016, Article no. 2883606, pp. 70-74.*

23. *Hosoya, H & Hyvärinen, A, Learning Visual Spatial Pooling by Strong PCA Dimension Reduction. Neural Computation, vol. 28, no. 7, 2016, pp. 1249-1264.*

24. *Hyvärinen, A, Hirayama, J, Kiviniemi, V & Kawanabe, M, Orthogonal Connectivity Factorization: Interpretable Decomposition of Variability in Correlation Matrices. Neural Computation, vol. 28, no. 3, 2916, pp. 445-484.*

25. *Hyytiä, E, Bayhan, S, Ott, J & Kangasharju, J, On search and content availability in opportunistic networks. Computer Communications, vol. 73, Part A, 2016, pp. 118-131.*

26. *Hämäläinen, W, Ruuska, S, Kokkonen, T, Orkola, S & Mononen, J, Measuring behaviour accurately with instantaneous sampling: A new tool for selecting appropriate sampling intervals. Applied Animal Behaviour Science, vol. 180, 2016, pp. 166-173.*

27. *Hämäläinen, W, New upper bounds for tight and fast approximation of Fisher's exact test in dependency rule mining. Computational Statistics & Data Analysis, vol. 93, 2016, pp. 469–482.*

28. *Kopotev, M, Pivovarova, L & Kormacheva, D, Constructional generalization over Russian collocations. Mémoires de la Société néophilologique de Helsinki, Tome C, Collocations Cross-Linguistically, 2016, pp. 121-140.*

29. *Korhonen, JH, Palin, K, Taipale, J & Ukkonen, E, Fast motif matching revisited: high-order PWMs, SNPs and indels. Bioinformatics, vol. 33, no. 4, 2016, pp. 514-521.*

30. *Korpela, J, Henelius, A, Ahonen, L, Klami, A & Puolamäki, K, Using regression makes extraction of shared variation in multiple datasets easy. Data Mining and Knowledge Discovery, vol. 30, no. 5, 2016, pp. 1112-1133.*

31. *Kulmala, L-M, Zliobaite, I, Nikinmaa, EH, Nöjd, P, Kolari, PP, Kabiri Koupaei, K, Hollmen, J & Mäkinen, H, Environmental control of growth variation in a boreal Scots pine stand: a data-driven approach. Silva Fennica, vol. 50, no. 5, 2016, Article no. 1680.*

32. *Kurki, I, Hyvärinen, A & Saarinen, J, Template optimization and transfer in perceptual learning. Journal of Vision, vol. 16, no. 10, 2016, Article no. 16.*

33. *Kärkkäinen, J & Kempa, D, LCP Array Construction in External Memory. ACM Journal of Experimental Algorithmics, vol. 21, no. 1, 2016, Article no. 1.7.*

34. *Kärkkäinen, J, Alatabbi, A, Daykin, JW, Rahman, MS & Smyth, WF, V-Order: New combinatorial properties & a simple comparison algorithm. Discrete Applied Mathematics, vol. 215, 2016, pp. 41-46.*

35. *Kärkkäinen, J, Kempa, D & Puglisi, SJ, Lazy Lempel-Ziv Factorization Algorithms. ACM Journal of Experimental Algorithmics, vol. 21, no. 2, 2016, Article no. 2.4.*

36. *Kärkkäinen, J, Kempa, D & Piatkowski, M, Tighter bounds for the sum of irreducible LCP values. Theoretical Computer Science, vol. 656, 2016, pp. 265-278.*

37. Le Bras, Y, Collin, O, Monjeaud, C, Lacroix, V, Rivals, E, Lemaitre, C, Miele, V, Sacomoto, G, Marchet, C, Cazaux, B, El Aabidine, AZ, Salmela, L, Alves-Carvalho, S, Andrieux, A, Uricaru, R & Peterlongo, P, Colib'read on galaxy: a tools suite dedicated to biological information extraction from raw NGS reads. GigaScience, vol. 5, no. 1, 2016.

38. Lees, JA, Vehkala, M, Välimäki, N, Harris, SR, Chewapreecha, C, Croucher, NJ, Marttinen, P, Davies, MR, Steer, AC, Tong, SYC, Honkela, A, Parkhill, J, Bentley, S & Corander, J, Sequence element enrichment analysis to determine the genetic basis of bacterial phenotypes. Nature Communications, vol. 7, 2016, Article no. 12797

39. Leppänen, J, Pelkonen, M, Guo, H, Hemminki, S, Nurmi, P & Tarkoma, S, Collaborative and Energy-Efficient Speech Monitoring on Smart Devices. Computer, vol. 49, no. 12, 2016, pp. 22-30.

40. Li, M, Lukyanenko, A, Ou, Z, Ylä-Jääski, A, Tarkoma, S, Coudron, M & Secci, S, Multipath Transmission for the Internet: A Survey. Communications Surveys & Tutorials, vol. 18, no. 4, 2016, pp. 2887-2925.

41. Lindgren, E & Münch, J, Raising the odds of success: the current state of experimentation in product development. Information and Software Technology, vol. 77, 2016, pp. 80-91.

42. Lintusaari, J, Gutmann, MU, Kaski, S & Corander, J, On the Identifiability of Transmission Dynamic Models for Infectious Diseases. Genetics, vol. 202, no. 3, 2016, pp. 911-918.

43. Llarena, A-K, Zhang, J, Vehkala, M, Välimäki, N, Hakkinen, M, Hänninen, M-L, Roasto, M, Mäesaar, M, Taboada, E, Barker, D, Garofolo, G, Cammà, C, Di Giannatale, E, Corander, J & Rossi, M, Monomorphic genotypes within a generalist lineage of Campylobacter jejuni show signs of global dispersion. Microbial Genomics, vol. 2, 2016.

44. Marchall, T, Marz, M, Abeel, T, Dijkstra, L, Dutilh, BE, Ghaffaari, A, Kersey, P, Kloosterman, WP, Mäkinen V, Novak, AM, Paten, B, Porubsky, D, Rivals, E, Alkan, C, Baaijens, JS, De Bakker, PIW, Boeva, V, Bonnal, RJP, Chiaromonte, F, Chikhi, R, Ciccarelli, FD, Cijvat, R, Datema, E, Van Duijn, CM, Eichler, EE, Ernst, C, Eskin, E, Garrison, E, El-Kebir, M, Klau, GW, Korbel, JO, Lameijer, E-W, Langmead, B, Martin, M, Medvedev, P, Mu JC, Neerincx, P, Ouwens, K, Peterlongo, P, Pisanti, N, Rahmann, S, Raphael, B, Reinert, K, de Ridder, D, de Ridder J, Schlesner, M, Schulz-Trieglaff, O, Sanders, AD, Sheikhizadeh, S, Shneider, C, Smit, S, Valenzuela, D, Wang, J, Wessels, L, Zhang, Y, Guryev, V, Vandin, F, Ye, K & Schonhuth, A (The Computational Pan-Genomics Consortium), Computational pan-genomics: status, promises and challenges. Briefings in Bioinformatics, 2016.

45. Mineraud, J, Mazhelis, O, Su, X & Tarkoma, S, A gap analysis of Internet-of-Things platforms. Computer Communications, vol. 89-90, 2016, pp. 5-16.

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47. Mäkinen, S, Leppänen, M, Kilamo, T, Mattila, A-L, Laukkanen, E, Pagels, M & Männistö, T, Improving the delivery cycle: A multiple-case study of the toolchains in Finnish software intensive enterprises. Information and Software Technology, vol. 80, 2016, pp. 175-194.

48. Määttä, J, Schmidt, DF & Roos, T, Subset Selection in Linear Regression using Sequentially Normalized Least Squares: Asymptotic Theory. Scandinavian Journal of Statistics, vol. 43, no. 2, 2016, pp. 382-395.

49. Määttä, J & Roos, T, Maximum Parsimony and the Skewness Test: A Simulation Study of the Limits of Applicability. PLoS One, vol. 11, no. 4, 2016, Article no. e0152656.

50. Nelimarkka, M, Kansalaisjärjestöt ja osallistumisvälineiden kehitys verkkosivuilla 1990-luvulta 2010-luvulle. WiderScreen, vol. 18, no. 1-2, 2016.

51. Niinimaki, T, Parviainen, P & Koivisto, M, Structure Discovery in Bayesian Networks by Sampling Partial Orders. Journal of Machine Learning Research, vol. 17, no. 1, 2016, pp. 2002-2048.

52.   Nykänen, M, Hakli, R, Eloranta, S & Niinivaara, O, *How to Deal with Unbelievable Assertions. Annals of Mathematics and Artificial Intelligence, vol. 78, no. 3-4, 2016, pp. 323-360.*

53.   Orso, V, Gamberini, L, Mazza, R, Hsieh, Y-T, Jacucci, G, Jensen, W & Morrison, A, *Follow the vibes: a comparison between two tactile displays in a navigation task in the field. PsychNology, vol. 14, no. 1, 2016, pp. 61-79.*

54.   Peltonen, E, Lagerspetz, E, Nurmi, P & Tarkoma, S, *Constella: Crowdsourced system setting recommendations for mobile devices. Pervasive and Mobile Computing, vol. 26, 2016, pp. 71-90.*

55.   Rastas, P, Calboli, FCF, Guo, B, Shikano, T & Merilä, J, *Construction of Ultradense Linkage Maps with Lep-MAP2: Stickleback F-2 Recombinant Crosses as an Example. Genome Biology and Evolution, vol. 8, no. 1, 2016, pp. 78-93.*

56.   Reason, M, Jola, C, Kay, R, Reynolds, D, Kauppi, J-P, Grobras, M-H, Tohka, J & Pollick, FE, *Spectators' Aesthetic Experience of Sound and Movement in Dance Performance: A Transdisciplinary Investigation. Psychology of Aesthetics, Creativity and the Arts, vol. 10, no. 1, 2016, pp. 42-55.*

57.   Riungu-Kalliosaari, L, Taipale, O, Smolander, K & Richardson, I, *Adoption and use of cloud-based testing in practice. Software Quality Journal, vol. 24, no. 2, 2016, pp. 337-364.*

58.   Salmela, L, Sahlin, K, Mäkinen, V & Tomescu, AI, *Gap Filling as Exact Path Length Problem. Journal of Computational Biology, vol. 23, no. 5, 2016, pp. 347-361.*

59.   Sankar, A, Malone, BM, Bayliss, SC, Pascoe, B, Méric, G, Hitchings, MD, Sheppard, SK, Feil, EJ, Corander, JI & Honkela, AJH, *Bayesian identification of bacterial strains from sequencing data. Microbial Genomics, vol. 2, no. 8, 2016.*

60.   Siekkinen, M, Hoque, MA & Nurminen, JK, *Using Viewing Statistics to Control Energy and Traffic Overhead in Mobile Video Streaming. IEEE/ACM Transactions on Networking, vol. 24, no. 3, 2016, pp. 1489-1503.*

61.   Tehrani, J, Nguyen, Q & Roos, T, *Oral fairy tale or literary fake? Investigating the origins of Little Red Riding Hood using phylogenetic network analysis. Digital Scholarship in the Humanities (DSH), vol. 31, no. 3, 2016, pp. 611-636.*

62.   Topa, H & Honkela, A, *Analysis of differential splicing suggests different modes of short-term splicing regulation. Bioinformatics, vol. 32, no. 12, 2016, pp. 147-155.*

63.   Valitutti, A, Doucet, A, Toivanen, J & Toivonen, H, *Computational Generation and Dissection of Lexical Replacement Humor. Natural Language Engineering, vol. 22, no. 5, 2016, pp. 727–749.*

64.   Veale, T & Al-Najjar, K, *Grounded for life: creative symbol-grounding for lexical invention. Connection Science, vol. 28, no. 2, 2016, pp. 139-154.*

65.   Vepsäläinen, J, Savolainen, P, Ojala, J, Rienzo, AD, Nelimarkka, M, Kuikkaniemi, K, Tarkoma, S & Jacucci, G, *Web-Based Public-Screen Gaming: Insights from Deployments. IEEE Pervasive Computing, vol. 15, no. 3, 2016, pp. 40-46.*

66.   Wang, L, Tasoulis, S, Roos, T & Kangasharju, J, *Kvasir: Scalable Provision of Semantically Relevant Web Content on Big Data Framework. IEEE Transactions on Big Data, vol. 2, no. 3, 2016, pp. 219-233.*

67.   Yan, Z, Ding, W, Niemi, V & Vasilakos, AV, *Two Schemes of Privacy-Preserving Trust Evaluation. Future Generation Computer Systems, vol. 62, 2016, pp. 175-189.*

68.   Ylirisku, S, Jacucci, G, Sellen, A & Harper, R, *Design Research as Conceptual Designing: The Manhattan Design Concept. Interacting with Computers, vol. 28, no. 5, 2016, pp. 648-663.*

69.   Zliobaite, I & Custers, B, *Using sensitive personal data may be necessary for avoiding discrimination in data-driven decision models. Artificial Intelligence and Law, vol. 24, no. 2, 2016, pp. 183-201.*

A2 Reviews in scientific journals

1. *Cowley, BU, Filetti, M, Lukander, K, Torniainen, J, Helenius, A, Ahonen, L, Barral Mery de Bellegarde, O, Kosunen, IJ, Valtonen, T, Huotilainen, MJ, Ravaja, JN & Jacucci, G, The psychophysiology primer: A guide to methods and a broad review with a focus on human-computer interaction. Foundations and Trends in Human-Computer Interaction, vol. 9, no. 3-4, 2016, pp. 151-308.*
2. *Ilomäki, L, Paavola, S, Lakkala, M & Kantosalo, A, Digital competence – an emergent boundary concept for policy and educational research. Education and Information Technologies, vol. 21, no. 3, 2016, pp. 655-679.*

A3 Contributions to books or other compilations (refereed)

1. *Marttila, M, Laaksonen, S-M, Kekkonen, A, Tuokko, M & Nelimarkka, M, Digitaalinen vaaliteltta: Twitter politiikan areenana eduskuntavaaleissa 2015. K Grönlund & H Wass (eds), Poliittisen osallistumisen eriytyminen: eduskuntavaalitutkimus 2015. Oikeusministeriön julkaisu, no. 28/2016, Oikeusministeriö, Helsinki, 2016, pp. 117-137.*
2. *Roos, T, Minimum Description Length Principle. C Sammut & G Webb (eds), Encyclopedia of Machine Learning and Data Mining. Springer Science+Business Media, New York, 2016.*
3. *Seppälä, O, Sorva, J & Vihavainen, A, Designing the First Finnish MOOCs. H Niemi & J Jia (eds), New Ways to Teach and Learn in China and Finland: Crossing Boundaries with Technology. Peter Lang, Bern, 2016, pp. 279-300.*

A4 Articles in conference publications (refereed)

1. *Ahadi, A, Behbood, V, Vihavainen, A, Prior, J & Lister, R, Students' Syntactic Mistakes in Writing Seven Different Types of SQL Queries and Its Application to Predicting Students' Success. Proceedings of the 47th ACM Technical Symposium on Computing Science Education, Memphis, USA, March 2-5, 2016, pp. 401-406.*
2. *Ahadi, A, Hellas, A, Ihantola, P, Korhonen, A & Petersen, A, Replication in Computing Education Research: Researcher Attitudes and Experiences. Proceedings of the 16th Koli Calling International Conference on Computing Education Research, Lieksa, Finland, November 24-27, 2016, pp. 2-11.*
3. *Ahadi, A, Lister, R & Vihavainen, A, On the Number of Attempts Students Made on Some Online Programming Exercises During Semester and Their Subsequent Performance on Final Exam Questions. Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education, Arequipa, Peru, July 11-13, 2016, pp. 218-223.*
4. *Ahmed, I, Harjunen, VJ, Jacucci, G, Hoggan, E, Ravaja, JN & Spapé, M, Reach out and touch me: effects of four distinct haptic technologies on affective touch in virtual reality. Proceedings of the 18th ACM International Conference on Multimodal Interaction, Tokyo, Japan, November 12-16, 2016, pp. 341-348.*
5. *Armano, G, Marchal, S & Asokan, N, Real-Time Client-Side Phishing Prevention Add-on. Proceedings of the 2016 IEEE 36th International Conference on Distributed Computing Systems (ICDCS 2016), Nara, Japan, June 27-30, 2016, pp. 777-778.*
6. *Athukorala, K, Medlar, A, Jacucci, G, Oulasvirta, A & Glowacka, D, Beyond Relevance: Adapting Exploration/Exploitation in Information Retrieval. Proceedings of the 21st International Conference on Intelligent User Interfaces, Sonoma, USA, March 7-10, 2016, pp. 359-369.*

7.   Austrin, P, Kaski, P, Koivisto, M & Nederlof, J, Sharper Upper Bounds for Unbalanced Uniquely Decodable Code Pairs. Proceedings of the 2016 IEEE International Symposium on Information Theory, Barcelona, Spain, July 10-15, 2016, pp. 335-339

8.   Austrin, P, Kaski, P, Koivisto, MKH & Nederlof, J, Dense Subset Sum May Be the Hardest. Proceedings of the 33rd Symposium on Theoretical Aspects of Computer Science (STACS 2016), Orléans, France, February 17-20, 2016, Leibniz International Proceedings in Informatics (LIPIcs), vol. 47.

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2. *Jacucci, G, Beyond Search Queries. Computer, vol. 49, no. 10, 2016, IEEE Computer Society, pp. 90-93.*

3. *Mishra, A, Munch, J, Lassenius, C & Mishra, D, Information Systems in Distributed Environment. Computer Standards & Interfaces, vol. 48, 2016, pp. 183-183.*

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2. Balyo, T, Heule, MJH & Järvisalo, MJ (ed.), Proceedings of SAT Competition 2016: Solver and Benchmark Descriptions. Department of Computer Science Series of Publications B, vol. B-2016-1, University of Helsinki, Helsinki, Finland, 2016.

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3. *Määttä, J, Model Selection Methods for Linear Regression and Phylogenetic Reconstruction. Series of Publications A, no. A-2016-3, University of Helsinki, Helsinki, 2016.*
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