Department of Computer Science

Annual Report

2015

Editors: Pirjo Moen and Pauliina Pajunen
Picture: Veikko Somerpuro

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1. THOUGHTS OF THE HEAD OF DEPARTMENT 2015

Year 2015 at the department was divided into a good deal of success along with some setbacks. As quantitative successes, we could mention the number of MSc and BSc degrees and credits (63; 80; 31,636), which increased significantly from the previous year (51; 76; 29,954), and external research funding received from the Finnish Academy (MEUR2.39), also a considerable increase (MEUR1.09). Along with the increase in external funding, the number of person-years completed at the department rose to 178.1. When it comes to person-years, the department has continued growing since 2011, when they numbered 140.

However, setbacks included the number of doctoral degrees (6), compared to the 9, 11, and 8 finished in 2012-2014. One reason for this is that the HeCSE doctoral programme ended by the end of 2015, but this negative trend must be turned as soon as possible. There was also a slight decrease in number of publications (225), while there were a total of 240, 248, and 227 in 2012-2014.

In 2015, the department participated in three national research centres of excellence, 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. The department did not have its own centre of excellence to lead, but we will attempt to rectify that in the next CoE programme starting in 2018.

A few considerable changes happened with the staff of the department. After Jaakko Kurhila had been appointed head of the Open University, University Lecturer Kjell Lemström was appointed to be his successor as Head of Studies at the department on 1 March. Valtteri Niemi entered his post as professor of information security on 1 January, and Jiaheng Lu his post as assistant professor in information management on 1 August. Pauliina Pajunen returned from parenting leave on 1 September and started working with PR and communications at the department. Petri Myllymäki was elected director of HIIT for the five-year period starting on 1 August. Besides Jaakko Kurhila, another loss was Jürgen Münch, who returned to Germany after his FiDiPro (Finland Distinguished Professor Programme) period ended.

The university's wellbeing-at-work enquiry in autumn showed that the staff at the department still fares relatively well. The wellbeing team led by Inka Kujala deserve big thanks for their Work. The building of community spirit at the department was furthered by the establishment of a women's network. It is headed by Lea Kutvonen, who also took responsibility for the Linkki resource centre. The women's network has had an immediate effect, since the percentage of person-years completed by female staff at the department rose to a record high, 21.8%, in 2015.

Researchers, instructors, and students at the department received several awards and commendations in 2015. Eemil Lagerspetz was awarded the PhD thesis award of the University of Helsinki, and the student team Game of Nolife won in the NWERC programming competition, to name a few.

In 2015, many measures that will affect the university, faculties, and departments in coming years were set in motion, thanks to the current Finnish government cutting back basic university funding considerably; The so-called Big Wheel education reform will rearrange basic teaching

into comprehensive bachelor's and master's programmes on 1 August 2017; the cooperation negotiations will cut back university staff during 2016; administrative staff will be reorganised into a centralised service organisation from 1 May 2016, faculties will be combined and departments discontinued. The department should stay on its toes and be pro-active while these operations are on-going.

The reforms will put pressure on both staff and students, as well as the directors of the university. It is thus that I wish all the luck, success and patience to Sasu Tarkoma, whom the Rector appointed head of the department for 2016-2017.

Jukka Paakki

Professor, Head of Department 2015

2. TEACHING

The basic degrees in computer science are Bachelor of Science (BSc) and Master of Science (MSc). The major subject in both the degrees is Computer Science. The common ground of the BSc is followed by four separate subprogrammes at the MSc level. Three of these, namely "Algorithmic Bioinformatics", "Algorithms, Data-analytics and Machine Learning" and "Networking and Services" are completely in English; "Software systems" remains to be in Finnish. In addition, there is a separate "Master Programme in Bioinformatics" coordinated at the department; the last admission to this programme was in 2014.

The postgraduate degrees in computer science are Licentiate of Philosophy (Ph.Lic.) and Doctor of Philosophy (PhD). Due to the change in the funding system of the Finnish doctoral programmes at the end of 2013, the former programmes do not provide any new funded positions. The new doctoral schools and doctoral programmes of the University of Helsinki were established at the beginning of 2014.

The department has made a long-term investment in teaching and its improvement. In 2012, the department was still one of ten national Centres of Excellence in higher education. After 2012, these CoEs have not been elected nationally or internally at the University of Helsinki. However, the increasing appreciation of instruction at the University of Helsinki is evident with the establishment of the Teachers' Academy in 2013. University Lecturer Matti Luukkainen of the department was elected as one of the founding members, and University Lecturer, Head of Studies Jaakko Kurhila (at the department until 28.2.2015) and Lecturer Heikki Lokki are also members in the Academy since 2014. This means that the Department of Computer Science is very well represented in the Teachers' Academy.

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 gradually 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

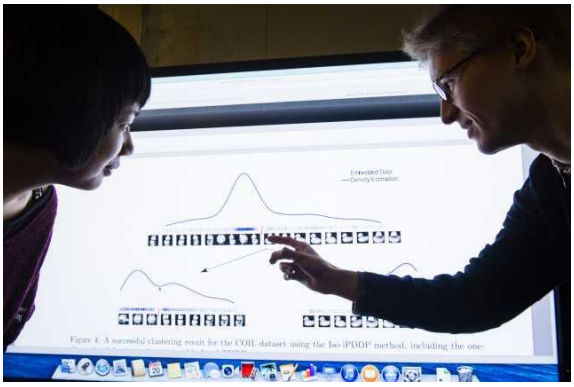
Bioinformatics is a field of science seeking to answer biological and medical research questions by methods of computer science and statistics. The Master's degree programme in bioinformatics (MBI) is a two-year MSc programme offered jointly by the University of Helsinki and Aalto University School of 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. From now on, the programme will be replaced by the collaborating (sub)programmes in bioinformatics at the University of Helsinki and Aalto University School of Science.

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.

2.7. Doctoral programmes

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.

In 2015, DoCS had a total of 55 doctoral students. 21 (38.2 %) of them were foreign students, and 10 (18.2 %) were female. During 2015, six DoCS students graduated. In addition to that, one doctoral student defended his doctoral thesis at the end of 2015.

FICS

The Finnish Doctoral Programme in Computational Sciences (FICS) was a network of 22 departments in 9 universities in Finland. The Graduate School in Computational Biology, Bioinformatics, and Biometry (ComBi) co-ordinated by the Department of Computer Science joined with FICS in 2010. FICS was co-ordinated by the Helsinki Institute of Information Technology (HIIT) at Aalto University. Due to the change in the funding system of the Finnish doctoral programmes at the end of 2013, FICS did not provide any new funded positions since then.

Computational science forms a new "third pillar" of scientific inquiry, complementing theory and experimentation. FICS brought together the core methodological topics and important fields of application of computational sciences: (1) Computational Statistics and Information Technology (2) Numerical and Applied Mathematics (3) Computational Physics (4) Computational Biology and (5) Future Computational Sciences (economics, medicine, agriculture, humanities, ecology, neuroscience etc.). FICS educated doctors with high-end methodical expertise, who apply it in their thesis work while developing methods for solving computational, data-analysis and modelling issues in application areas. This work was carried out in close co-operation with one or more research groups in the application fields. The programme was finished by the end of 2015, and no students from the Department of Computer Science at the University of Helsinki were in FICS anymore during the last year of operation.

HeCSE

The Helsinki Doctoral Programme in Computer Science - Advanced Computing and Intelligent Systems was a post-graduate programme jointly offered by the University of Helsinki and Aalto University. Year 2014 was the 21st year that this school was in operation. The focal areas were Algorithms, structures and complexity (algorithm design and mathematical methods, basic research and innovative methods for novel applications), Pattern Analysis and Intelligent Systems (methods for finding meaningful patterns from and modelling of large data sets, intelligent interfaces) and System Software (operating systems, database systems, middleware, and compilers). Due to the change in the funding system of the Finnish doctoral programmes at the end of 2013, Hecse did not provide any new funded positions since then. The programme was finished by the end of 2015.

Hecse offered the post-graduates various benefits, such as advanced courses, funding for participation in summer schools and conferences, research visits, and annual student meetings. At the end of the year, there were 39 doctoral students in the school, 125 (12.8%) of which had funding from the school. Of these 39, 13 (33.3 %) were foreign students and 6 (15.4 %) were women. The Hecse post-graduates attended numerous international courses and conferences. During 2015, 17 Hecse research students graduated.

3. RESEARCH

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:

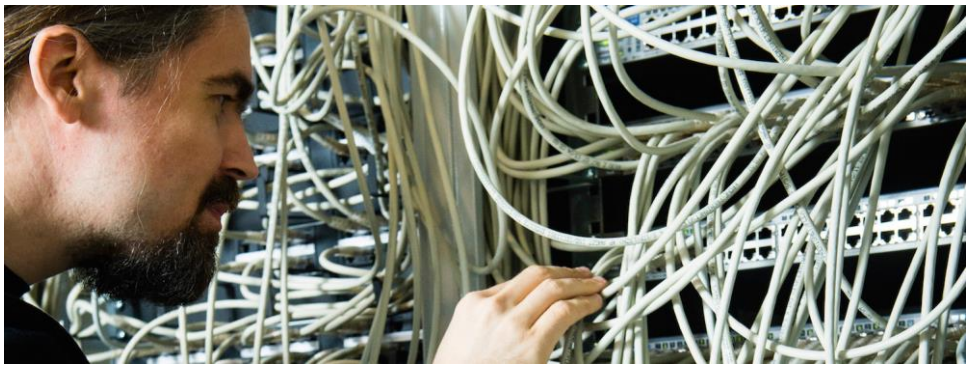
- algorithms theory and new computation paradigms,
- 'big data',
- computational creativity,
- neuroinformatics,
- data security,
- ubiquitous computing and interactive technologies, and
- development of software systems, coaching developers, and software measurement.

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.

Nearly 30 research groups are working in these focal areas at the department.

3.1. Research units and networks

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/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.

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 Erkki Oja from Aalto university. The participating groups at University of Helsinki are the Complex Systems Computation (CoSCo) group at the Department of Computer Science and HIIT, the Bayesian Statistics group at HIIT and the Department of Mathematics and Statistics, and the Statistical Machine Learning and Bioinformatics group at HIIT.

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.

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 2015, HIIT was carrying out the following research programmes: Algorithmic Data Analysis (ADA), Computational Inference (CI), Distributed and Mobile Cloud Systems (DMC), and Network Society (NS). In addition, HIIT has a research spearhead of HIIT Wide Focus Area: Augmented Science.

Contact person: Professor Samuel Kaski (at Aalto University; until 31.7.2015) and Professor Petri Myllymäki (from 1.8.2015)
Home page: http://www.hiit.fi

Research groups in HIIT at the department:

- Combinatorial Pattern Matching (CPM)
- Complex Systems Computation Group (CoSCo)
    - Adaptive Computing (AC)
    - Constraint Reasoning and Optimization (CoReO)
    - Information, Complexity and Learning (ICL)
    - Intelligent Interactive Information Access (INTENT)
    - Multi-source Probabilistic Inference (MUPI)
- Discovery Group: Data Mining and Computational Creativity
- Distributed and Mobile Cloud Systems
    - Collaborative Networking (CoNe)
    - Mobile Computing (connected to group Content-centric Structures and Networking (COSN))
- Genome-scale Algorithmics
- Neuroinformatics
- New Paradigms in Computing (also at Aalto University)
    - Sums of Products
- Statistical Machine Learning and Bioinformatics (also at Aalto University)
    - Probabilistic Inference and Computational Biology (PROBIC)
- Ubiquitous Interaction

There are also several other research groups in HIIT located in Otaniemi.

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
Homepage: 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)

3.2. Research groups

Adaptive Computing (AC)

The group works on ubiquitous computing in mobile environments, in particular on context recognition and personalisation. The group works in a multidisciplinary environment in close collaboration with other research groups of HIIT and in national and international collaborative projects, also contributing to the HIIT Wide Focus Area work. In 2015, this research group was divided into two groups, Intelligent Interactive Information Access (INTENT) and Ubiquitous Sensing, which started in August 2015.

Contact persons: University Lecturer Patrik Floréen and Senior Researcher Petteri Nurmi
Home page: http://www.hiit.fi/adaptive-computing/

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

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/

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.cs.helsinki.fi/research/nodes/

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

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

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/

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/

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

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/

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/

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

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

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/

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

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

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/

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

Probabilistic Inference and Computational Biology (PROBIC)

We develop methods for efficient probabilistic inference in complex modelling problems. Our main applications are in developing statistical methods for modelling molecular biology time series using Gaussian processes, as well as methods for quantitative analysis of sequencing data (e.g. RNA-sequencing and metagenomic sequencing). Developing methods for privacy-aware modelling is an emerging focus area. We are a part of the Statistical Machine Learning and Bioinformatics group at HIIT.

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

Product Requirements and Architecture (Preago)

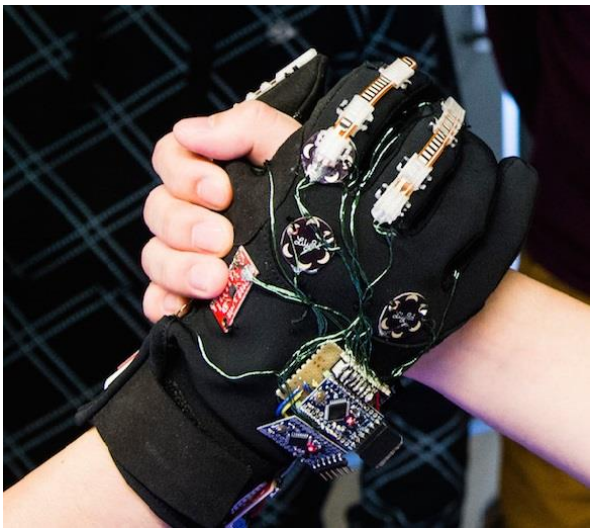
The Preago research themes of interest include software products, software intensive services and product variability in particular from the perspectives of requirements engineering (e.g., user needs and value), software architecture (e.g., product family architecture and quality variability) and conceptual modelling.

Contact person: Professor Tomi Männistö
Home page:
http://www.cs.helsinki.fi/u/tomimann/

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



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 persons: University Lecturer Jaakko Kurhila and University Lecturer Matti Luukkainen
Home page: http://www.cs.helsinki.fi/rage/

Software Systems Engineering

SSE (Software Systems Engineering) focuses on planning, development, management, and operation of complex software-intensive systems and services. Hereby, the systematic development, maintenance, and evolution of software is of significant importance. The research areas include cloud-based software engineering, global software engineering, software measurement, and process and quality engineering. Current application areas range from traditional information systems and web software to embedded software and systems of systems in different industry sectors.

Contact person: Professor Jürgen Münch
Home page: http://www.sserg.org

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

Ubiquitous Interaction

Ubiquitous Interaction studies the design, development and evaluation of interactivity with users in ubiquitous and mobile computing systems. The research is carried out coupling in-depth user studies with design in the area of novel interfaces. The goal is to contribute to technology development efforts by deepening understanding of human and design perspectives. Currently, research is conducted in different areas: multitouch displays, adaptivite and affective interfaces, multimodal interaction, exploratory search and social computing. Application areas range from sustainability and environmental awareness, home computing, walk-up-and-use display, information exploration, art and culture, scientific and knowledge work.

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

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/

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

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

Interaction Lab

Interaction Lab was initiated and founded by Ubiquitous Interaction research group in 2014. Interaction Lab is aimed for providing a space where novel interaction in between human, computer, and the physical environment can be developed and experimented.

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.

Linkki centre

The Linkki centre of the Department of Computer Science at the University of Helsinki is a resource centre that organises different activities for children and young people in computer science. The Linkki centre is one of the resource centres of the Finland's Science Education Centre LUMA.

Contact persons: University Lecturer Jaakko Kurhila and University Lecturer Lea Kutvonen
Home page: http://linkki.cs.helsinki.fi

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

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: Professor Jürgen Münch
Home page: http://www.softwarefactory.cc

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

TYPE OF PUBLICATION	2011	2012	2013	2014	2015
A1 Refereed journal articles	49	59	57	75	72
A2 Reviews in scientific journals	0	2	3	0	3
A3 Contributions to books/other compilations (refereed)	8	2	7	3	8
A4 Articles in conference publication (refereed)	86	114	131	110	103
B1 Unrefereed journal articles	4	4	1	8	5
B2 Contributions to books/other compilations (non-refereed)	0	12	3	6	4
B3 Unrefereed articles in conference proceedings	11	15	4	0	5
C1 Published scientific monographs	4	8	2	2	1
C2 Edited books, compilations, conference proceedings or special issue of journals	9	7	9	9	6
D1 Articles in professional journals	1	2	0	0	1
D3 Articles in professional conference proceedings	1	1	3	0	1
D4 Published development or research reports	2	1	2	5	1
D5 Text book or professional handbook or guidebook or dictionary	0	0	1	0	0
E1 Popular contributions to journals, books or other compilations	2	2	1	1	0
E2 Popular monograph	1	0	0	1	0
F2 Public contributions to artistic work	0	1	8	1	2
F3 Public artistic play or exhibition	0	0	2	1	0
G3 Licentiate theses	1	0	0	1	0
G4 Doctoral theses, monographs	2	4	2	0	2
G5 Doctoral theses, article-based	2	5	12	4	5
I2 ICT programs or applications	4	1	0	0	6
TOTAL COUNT	**187**	**240**	**248**	**227**	**225**

See Appendix 1 for list of publications

5. ORGANISATION

The head and the deputy heads of department are responsible for the work of the department. In 2015, Professor **Jukka Paakki** was the head of the department, and the deputy heads were Professor **Jyrki Kivinen** and Professor **Sasu Tarkoma**. 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 2015 were Professor **Veli Mäkinen** (algorithmic bioinformatics), Professor **Jyrki Kivinen** (algorithms, data analytics and machine learning), Professor **Sasu Tarkoma** (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 head of the department's own doctoral programme (DoCS) in 2015. Furthermore, the department participated in two research schools in 2015, with professor Myllymäki also acting as director of the Hecse graduate school.

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 2015, HIIT was headed by Professor **Samuel Kaski** of Aalto University (until 31.7.2015) and Professor **Petri Myllymäki** (from 1.8.2015 on). 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 2015, the department administration was divided into (1) teaching administration, with Head of Studies **Jaakko Kurhila** (until 28.2.2015) and Head of Studies **Kjell Lemström** (from 1.3.2015 on) in charge, (2) general, HR and financial administration, with Office Manager **Tiina Väisänen** in charge, (3) research and graduate-school administration, with Research Coordinator **Pirjo Moen** in charge, and (4) information technology, with IT Manager **Petri Kutvonen** in charge. 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.

5.1. Department council 2015

Chair: Professori Jukka Paakki	
Secretary: Tiina Väisänen	
Member	**Deputy**
Professor Jussi Kangasharju	Professor Sasu Tarkoma
Professor Jyrki Kivinen (vice-chair)	Professor Aapo Hyvärinen
Professor Tomi Männistö	Professor Veli Mäkinen
Amanuensis Teija Kujala	IT-SpecialistJani Jaakkola
University Insturctor Tiina Niklander	University Lecturer Antti-Pekka Tuovinen
Doctoral Student Ella Peltonen	Research Coordinator Pirjo Moen
Student Paula Lehtola	Student Kati Kyllönen
Student Thomas Tontchev	Student Tero Keinänen
Student Johannes Verwijnen	Student Juho Esselström

5.2. Committee memberships

Department steering committee	**Steering group of DoCS**
Jukka Paakki (chair)	Petri Myllymäki (director)
Jyrki Kivinen	Jyrki Kivinen
Veli Mäkinen	Tomi Männistö
Tomi Männistö	Sasu Tarkoma
Sasu Tarkoma	Arto Vihavainen
Jaakko Kurhila (until 28.2.2015)	Pirjo Moen (coordinator)
Kjell Lemström (starting 1.3.2015)	
Pirjo Moen	**Taskforce for education improvement**
Petri Kutvonen	Jukka Paakki (chair)
Tiina Väisänen	***Staff representatives***
	Jaakko Kurhila (until 28.2)
Group for wellbeing at work	Kjell Lemström (starting 1.3)
Finnish group	Matti Luukkainen
Inka Kujala (chair)	Ella Peltonen
Jani Jaakkola	Teemu Roos
Teija Kujala	***Students***
Tiina Niklander	Mikko Kumara
Antti-Pekka Tuovinen	Joel Nummelin
Pauliina Pajunen (starting 1.9)	(deputies Juho Esselström, Viivi Nissilä)
International group	
Yi (Aaron) Ding (chair)	**Communications group**
Kumaripaba Athukorala	Lea Kutvonen (chair)
Ella Peltonen	Aaron Yi Ding
Roman Yangarber	Jani Jaakkola
Inka Kujala, contact person	Pirjo Moen
	Hanna Mäenpää
	Tomi Pasanen
	Reijo Sivén
	Arto Vihavainen
	Ping Xiao
	Pauliina Pajunen (starting 1.9)

5.3. Department representatives and liaison officers

University of Helsinki

- University collegium: Hannu Toivonen (deputy)
- Scientific council of the university (TINE): Esko Ukkonen
- University committee for health and safety: Jukka Paakki
- Library steering committee: Esko Ukkonen
- IT centre steering committee: Esko Ukkonen
- Teachers' Academy: Jaakko Kurhila (chair 2015-16), Heikki Lokki, Matti Luukkainen
- The taskforces for the UH 375th jubilee project organisation:
    - Sisältö pintaan (Contents to the top) taskforce: Matti Luukkainen
    - Yhteisöllisyys (Collectivity) taskforce: Tiina Niklander
- 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
- Faculty steering committee: Esko Ukkonen, Jukka Paakki
- Faculty taskforce for social interaction: Jyrki Kivinen
- Faculty taskforce for student affairs: Jaakko Kurhila (until 28.2) , Kjell Lemström (starting 1.3) (deputy Matti Luukkainen); (student member deputy Olli Vanhoja)
- Faculty admissions committee: Jyrki Kivinen (deputy Otto Nurmi)
- Faculty committee pool for pedagogical skills:
    - Professors: Jukka Paakki, Sasu Tarkoma, Hannu Toivonen
    - Other instructors and researchers: Jaakko Kurhila (until 28.2), Kjell Lemström (starting 1.3), Harri Laine (until 31.7)
    - Students: Juhani Leppänen, Joel Nummelin, Olli Vanhoja, Mikko Kumara, Jonne Airaksinen, Viivi Nissilä, Kalle Viiri, Juho Esselström, Thomas Tontchev, Tero Keinänen, Kati Kyllönen, Johannes Verwijnen, Paula Lehtola, John Lindert, Taneli Pirinen
- Faculty facilities committee: Teija Kujala
- 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: Jukka Paakki
- LUMA resource centre Linkki: Jaakko Kurhila (director, until 28.2), Lea Kutvonen (director, starting 1.3)

Kumpula campus

- Kumpula campus library advisory board: Jyrki Kivinen (deputy Sasu Tarkoma)
- Kumpula campus infra-structure taskforce: Sasu Tarkoma
- Kumpula health and safety committee: Jukka Paakki (pj)
- 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)
- Executive committee for the HICT doctoral education network: Petri Myllymäki (chair), Pirjo Moen
- LUMA centre Finnish board: Jaakko Kurhila (until28.2)
- Scientific advisory board for national defence (MATINE): Sasu Tarkoma
- HIIT board: Jukka Paakki (deputy Jyrki Kivinen)
- The Finnish Society for Computer Science: Sasu Tarkoma / Mikko Koivisto- PM?
- Taskforce for national admission exam: Timo Karvi
- COST ICT Domain Committee: Sasu Tarkoma (representative of Finland)
- 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)
- Advisory Committee of the Helsinki Doctoral Training Centre of the EIT ICT Labs Doctoral School: Petri Myllymäki
- Steering Committee of the National D2I SHOK Research Program: Petri Myllymäki (Academic Coordinator)
- Steering Committee of the National IoT SHOK Research Program: Sasu Tarkoma (Academic Coordinator)
- Technology Industries, Innovation taskforce 2014: Hannu Toivonen (assessor)

Department liaison officers

- Library liaison: Teija Kujala
- Accidents liaison (CS Dept. and HIIT): Tiina Väisänen (deputy Päivi Kuuppelomäki)
- Equality liaison: Veli Mäkinen
- TKO-äly (student organisation) and tutor liaison: Ella Peltonen

6. DEPARTMENT STATISTICS

6.1. Staff

In 2015, a total of 178.1 person-years were completed at the department, nearly ten more than the previous year. Person-years funded by basic funding remained virtually the same (99.5 in 2015, 100.6 in 2014), so the increase was funded by external funding.

When considered from the viewpoint of the four-tier tenure track of teaching and research staff, the majority of person-years are still carried out on the 1st, lowest tier of the tenure track (research assistants and doctoral students). The increase in external funding in past years has especially enforced the 1st tier of the tenure track. However, in 2015, a larger number of post-doctoral researchers and doctoral students were recruited, in accordance with the goals set in the HR plan. At the same time, the number of person-years by research assistants started falling. Doctoral students are also supported by basic funding, but the majority of basic funding is directed towards person-years carried out on the higher tiers of the tenure track, 2nd-4th (professors, university lecturers, post-doctoral researchers).

During 2015, the department finalised some important recruitment processes. On 1 January 2015, **Valtteri Niemi** started as professor of data security, and on 1 August 2015, **Jiaheng Lu** started as assistant professor in information management. After University Lecturer (Head of Studies) Jaakko Kurhila had transferred to the post of head of the Open University, he was replaced by Kjell Lemström on 1 March 2015. The initiation of new recruitment processes was especially delayed by the cooperation negotiations at the university in autumn 2015.

In 2015, the average age of the department staff was 36.2 years. During the past five years, the average age has fluctuated between 34.2 and 36.2 years. The department staff has become increasingly international in the past years. By the end of 2015, the percentage of foreigners among teaching and research staff was nearly the same as the previous year, 34.97%, while in 2011, it was 12.33%. The percentage of person-years completed by women increased a little from the previous year to 21.8%.

University of Helsinki Computer Science women was established in 2015 to build community spirit at the department
Picture by: Veikko Somerpuro

STAFF STATISTICS

Person-years per staff category

	2011	2012	2013	2014	2015
TEACHING AND RESEARCH STAFF	123.2	142.3	146.4	152.9	163.4
Professors	11.6	11.7	13.5	12.9	13.3
Research directors	0.8	0.6	0.4	0.0	0.3
Assistant professors	0.0	0.0	0.6	2.0	2.4
University lecturers, lecturers	14.8	16.3	15.4	15.5	14.8
Researchers (academy researchers, university researchers,	7.4	7.5	7.4	7.6	10.4
Postdoctoral researchers	15.0	17.6	21.9	24.5	25.3
University teachers	1.7	2.0	1.0	1.4	2.0
Doctoral students, assistants	32.7	35.4	37.6	36.6	44.4
Research support staff	32.9	43.6	40.8	43.7	40.8
Other teaching and research staff (part-time teachers, project planner)	6.3	7.6	8.0	8.7	9.6
OTHER STAFF	16.8	16.6	16.6	15.8	14.7
Administrative staff	8.2	8.3	8.3	8.0	7.5
IT staff	8.0	7.5	7.6	7.8	7.0
Other (trainees)	0.6	0.8	0.7	0.0	0.2
TOTAL	**140.0**	**158.9**	**163.0**	**168.7**	**178.1**

Person-years per funding source

	2011	2012	2013	2014	2015
INTERNAL FUNDING	77.0	86.7	91.7	100.6	99.5
Allocated (incl. HIIT)	69.4	75.5	74.8	76.4	83.9
Graduate schools, CoEs and performance-based funding	7.6	11.2	16.9	24.2	15.6
EXTERNAL FUNDING	63.0	72.2	71.3	68.1	78.6
Academy of Finland	34.4	33.5	27.2	13.8	27.9
Tekes	21.0	21.9	25.2	30.9	25.3
Finnish companies	0.7	1.2	3.4	2.9	6.7
EU-funding	1.7	5.3	5.7	10.8	11.9
Other foreign funding	0.6	3.5	3.2	6.2	4.6
UH foundations	1.2	2.0	2.8	1.2	0.0
Other funding	3.5	4.7	3.8	2.2	2.2
TOTAL	**140.0**	**158.9**	**163.0**	**168.7**	**178.1**

Gender and age of staff

	2011	2012	2013	2014	2015
Female (% of person-years)	19.1	18.3	18.3	20.3	21.8
Male (% of person-years)	80.9	81.7	81.7	79.7	78.2
Average age (years)	35.8	34.2	34.3	35.6	36.2

Foreign employees (31.12)

	2011	2012	2013	2014	2015
Percentage of staff	11.3	18.2	28.6	32.4	31.8
Percentage of teaching and research staff	12.3	20	31.4	35.5	35

6.2. Funding

In 2015, total funding reached MEUR 12.91. It increased with .72 Million Euros from the previous year. As basic funding has remained at virtually the same level as before, external funding grew significantly. Most of the funding was spent on staff expenses and facilities.

In 2015, 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 exit funding for the centre of excellence that was brought to a close, and strategic funding for a project to develop teaching and research in information security.

In 2015, external funding for the department reached MEUR 6.24. It was especially the funding from the Finnish Academy that grew significantly after the slump of the previous year. The funding from Tekes dropped slightly, but is still over MEUR 2, covering over one third of the total external funding. National corporate funding grew considerably, as did EU funding slightly from the previous year. The increases in external funding are largely due to the new professors and principal investigators succeeding in their funding applications. 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, it brings insecurity especially to long-term planning.

Total funding and external funding (Million Euros)

	2011	2012	2013	2014	2015
INTERNAL FUNDING	6.26	6.45	6.54	6.77	6.67
Allocated funding (incl. HIIT)	5.26	5.38	5.35	5.44	5.73
Graduate schools, CoEs and performance-based funding	1	1.08	1.18	1.33	0.94
EXTERNAL FUNDING	4.14	4.79	5.16	5.42	6.24
Academy of Finland	2.11	2.26	2.19	1.09	2.39
Tekes	1.48	1.55	1.72	2.61	2.12
Finnish companies	0.07	0.11	0.3	0.17	0.51
EU-rahoitus	0.14	0.39	0.41	0.81	0.85
Other foreign funding	0.03	0.2	0.19	0.45	0.29
UH foundations	0.05	0.09	0.10	0.06	0
Other funding	0.27	0.21	0.26	0.25	0.08
TOTAL	**10.4**	**11.24**	**11.7**	**12.19**	**12.91**

6.3. Teaching

The department's consistent investment in and development of teaching was fruitful again in 2015. At the international audition of the university, our BSc and MSc programmes were evaluated at the highest, advanced, level – as the only ones of the audited programmes The students, student teams, and members of staff of the department were awarded in different events related to teaching and studying. The most significant success was that of the Game of Nolife team, coached by Antti Laaksonen, which won the NWERC programming competition in Linköping. The team consisted of Tuukka Korhonen, Olli Hirviniemi, and Otte Heinävaara.

The teaching statistics of 2015 show that our students beat another record in efficiency in gathering credits after adopting the two-tier degree structure. In total, 751 credits were awarded per person-year. The statistics also show the alarming steady decrease of the number of foreign students since 2011. In this time, the number of new foreign students has fallen from 36 to 17. The number of completed basic degrees is quite positive. The numbers of both BSc (76->80) and MSc degrees (51->63) have increased since last year. The setbacks of 2013 and 2014, first in number of BSc, then MSc degrees, have now recovered to the level of 2012.

TEACHING STATISTICS

Number of students

	2011	2012	2013	2014	2015
Main admissions	130	130	130	130	130
Accepted main admissions	136	133	142	158	143
Accepted international admission to master's degree programmes	36	29	25	22	17
All students	**1719**	**1692**	**1584**	**1727**	**1688**

Teaching and credits

	2011	2012	2013	2014	2015
Teacher person-years	34.4	37.5	38.5	40.5	42.1
Credits total	22 883	25 665	26 684	29 954	31 636
Credits per person-years	665	684	693	740	751

Number of degrees

	2011	2012	2013	2014	2015
Bacherlor's degrees	134	80	56	76	80
Master's degrees	66	65	71	51	63
Licentiate degrees	1	-	-	1	-
Doctoral degrees	3	9	11	8	6
- foreigners	1	1	3	2	4

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 2015. In 2015, researchers at the department published 186 refereed articles and a total of 225 publications, so the number of publications remained the same as the previous year, on the whole. The writers of three articles received awards for best conference paper in 2015; Suzan Bayhan and Jussi Kangasharju (ACM ICN 2015), Arto Klami, Krista Longi, Juho Leinonen, Henrik Nygren, Joni Salmi and Arto Vihavainen (Koli Calling 2015), and Eemil Lagerspetz, Petteri Nurmi, Ella Peltonen and Sasu Tarkoma (IEEE PerCom 2015). In addition, awards for second best paper were received by Laila Daniel, Ilpo Järvinen and Markku Kojo (IEEE WF-IoT 2015), and Ella Peltonen (IEEE PerCom PhD Forum 2015). Eemil Lagerspetz, in his turn, received the award for best thesis at the University of Helsinki in 2015, for his PhD thesis Collaborative Mobile Energy Awareness. The new bioinformatics textbook, Genome-Scale Algorithm Design: Biological Sequence Analysis in the Ear of High-Throughput Sequencing published in 2015 was written by

the department researchers Veli Mäkinen, Djamal Bellazzougui, Fabio Cunial, and Alexandru I. Tomescu.

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 2015. 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, such as the Technology Days and the Science Forum.

International mobility has gained significance in research in the past years. Department researchers made several longer or shorter research visits to universities and scientifc institutes abroad in 2015. 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 2015. The most significant publicity showcased the research into computational creativity by the Discovery group, headed by Professor Hannu Toivonen, and the research into energy-awareness of mobile devices and the Internet of Things by Professor Sasu Tarkoma and his group. Other areas of research that gained visibility in the media included information security, big data, and the improvement of teaching.

During 2015, Professor Hannu Toivonen was elected into the Finnish Academy of Science and Letters, and Professor Esko Ukkonen as foreign fellow of the Estonian Academy of Sciences. Other awards and acknowledgements for the research at the department in 2015 were the Nokia Foundation Jorma Ollila Grant for Eemil Lagerspetz for the years 2016-2017, the Google Europe Scholarship for Students with Disabilities 2015 to Anna Kuosmanen, and the Nokia Foundation grants 2015 to Kumaripaba Athukorala, Matti Nelimarkka, and Ella Peltonen.

In 2015, department research groups were part of three national centres of excellence selected by the Finnish Academy. These units are the CoE for computational inference, COIN; the CoE for research into cancer genetics; and the CoE for inverse problems, which have been elected to the centre-of-excellence programme 2012-2017. Professor Petri Myllymäki and his team participate in the COIN unit, Professor Veli Mäkinen and his team in the cancer genetics group, and Professor Aapo Hyvärinen in the inverse-problem group.

Publications 2015

	2011	2012	2013	2014	2015
Refereed journal articles (A1)	49	59	57	75	72
Refereed conference and compilation articles, evaluations (A2-A4)	94	118	141	113	114
Other publications (all other categories)	44	63	50	39	39
TOTAL	**187**	**240**	**248**	**227**	**225**

7. AWARDS AND RECOGNITIONS

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 2015 were given to the following persons:

- Junior Good Teacher: Instructor Johannes Verwijnen
- Senior Good Teacher: Lecturer Heikki Lokki
- Junior Good Researcher: Doctoral student Ella Peltonen
- Senior Good Researcher: Academy Fellow Simon Puglisi
- Group of the year: Linkki Centre

Johannes Verwijnen ja Ella Peltonen
Photo by Pauliina Pajunen

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

Awards related to publications:

The writers of three articles received the award for best conference paper in 2015:

- Suzan Bayhan and Jussi Kangasharju together with Liang Wang, Jörg Ott, Arjuna Sathiaseelan and Jon Crowcroft got the Best Paper Award for their article *Pro-Diluvian: Understanding Scoped-Flooding for Content Discovery in ICN* in the ACM ICN 2015 conference (https://www.cs.helsinki.fi/uutiset/83559),
- Arto Klami, Krista Longi, Juho Leinonen, Henrik Nygren, Joni Salmi and Arto Vihavainen got the Best Paper Award for their article *Identification of Programmers from Typing Patterns* in the Koli Calling 2015 conference (https://www.cs.helsinki.fi/uutiset/83681), and
- Eemil Lagerspetz, Petteri Nurmi, Ella Peltonen and Sasu Tarkoma got the Marc Weiser Best Paper Award for their article *Energy Modeling of System Settings: A Crowdsourced Approach* in the IEEE PerCom 2015 conference (https://www.cs.helsinki.fi/uutiset/82194)

The writers of two articles received the runner-up award of best conference paper in 2015:

- Laila Daniel, Ilpo Järvinen and Markku Kojo received the Runner-up Best Paper Award of the IEEE WF-IoT 2015 conference for their article *Experimental Evaluation of Alternative Congestion Control Algorithms for Constrained Application Protocol (CoAP)*.
- Ella Peltonen received the Runner-up Best PhD Forum Presentation Award of the IEEE PerCom 2015 conference for her article *Iterative Data Analysis for Sensing Applications* (https://www.cs.helsinki.fi/uutiset/82194)

Thesis awards:

- Eemil Lagerspetz got the University of Helsinki Excellent Dissertation Award 2015 for his thesis *Collaborative Mobile Energy Awareness* (https://www.cs.helsinki.fi/uutiset/82572).

Awards and recognitions related to teaching and studies:

- In the International Audit of the University of Helsinki 2015, which focused on auditing the quatity system of the University, the quality management of the Bachelor's and Master's degree education programme in Computer Science was considered to be at an advanced level (https://www.cs.helsinki.fi/uutiset/82132).
- Matti Nelimarkka and Arto Vihavainen got a first phase grant in the Apps4Education competition organised by the Association of Finnish eLearning Centre for their Codeblocks application.
- 15 teams from the Department of Computer Science participated in the Nordic Collegiate Programming Contest (NCPC 2015). Four of those teams (;-;. hanekawa <33, Aina häviää ja Game of Nolife) made it to the top ten of the completion (https://www.cs.helsinki.fi/en/news/83476).
- Team Game of Nolife (Otte Heinävaara, Olli Hirviniemi, and Tuukka Korhonen) from the University of Helsinki won the Western European NWERC programming competition in Linköping in November 2015 (https://www.cs.helsinki.fi/en/news/83742).
- Kai Zhao received together with Nautiyal Sudhansu, Eranti Pradeep and Tatiraju Venkata (students from Aalto Univerisity) one of the best hack awards in the Data Science Hackathon competition (https://www.cs.helsinki.fi/uutiset/82684).
- Aditha Jitta reached the 2nd place in the Videothon competition of the COIN Centre of Excellence.
- Anna Kuosmanen received the Google Europe Scholarship for Students with Disabilities 2015 (https://www.cs.helsinki.fi/uutiset/82853).
- Kumaripaba Athukorala, Matti Nelimarkka and Ella Peltonen received the Nokia Scholarships for their doctoral studies (https://www.cs.helsinki.fi/uutiset/83728).
- Eemil Lagerspetz received the Jorma Ollila grant from Nokia Foundation for 2016-2017 (https://www.cs.helsinki.fi/uutiset/83725).

Other awards and recognitions

- Hannu Toivonen was chosen as a member of the Finnish Academy of Science and Letters in April.2015. (https://www.cs.helsinki.fi/uutiset/82670)
- Esko Ukkonen was chosen as a foreign member of the Estonian Academy of Science in December 2015.
- Valtteri Niemi was a final candidate for the Finnish Cyber Security Researcher Award of the Year awarded by Turvallisuus & Riskienhallinta -magazine.
- EASI-CLOUDS project that the Department participates, got the ITEA Award of Excellence 2015 for its business impact (https://www.cs.helsinki.fi/uutiset/82193).
- Jeremias Berg , Matti Järvisalo and Paul Saikko gained top positions with their LMHS MaxSat Solver in the MaxSAT Evalution 2015 (https://www.cs.helsinki.fi/uutiset/83401).
- Matti Järvisalo received together with Wolfgang Dvorak, Johannes Peter Wallner and Stefan Woltran the award "Honorary Mention" at the 1st International Competition on Computational Models of Argumentation (ICCMA 2015) for their Cegartix solver.

8. EVENTS

Defence of Thesis

27.03.2015: M.Sc. Kai Zhao: Understanding Urban Human Mobility for Network Applications

21.08.2015: M.Sc. Teppo Niinimäki: Approximation Strategies for Structure Learning in Bayesian Networks

02.10.2015: M.Sc. Dominik Kempa: Efficient Construction of Fundamental Data Structures in Large-Scale Text Indexing

06.11.2015: M.Sc. Kai Zhao: Understanding Urban Human Mobility for Network Applications

20.11.2015: M.Sc. Antti Laaksonen: Algorithms for Melody Search and Transcription

26.11.2015: M.Sc. Yi Ding: Collaborative Traffic Offloading for Mobile Systems

04.12.2015: M.Sc. Fabian Fagerholm: Software Developer Experience: Case Studies in Lean-Agile and Open Source Environments

Guest lectures

09.02.2015: Software Engineering Manager Andrei Laperie, Senior Software Engineer Johan Hedberg, and Patrik Flykt, Intel: Open Source Software Development at Intel

03.03.2015: Professor Ali R. Butt, Virginia Tech, USA: Simulation Driven Tools for Efficient Data Center Management

12.03.2015: Dr. Pierre Dragicevic, Inria / Aviz, France: Recent and Future Information Visualization Research at Inria / Aviz

14.04.2015: Senior advisor Pekka Forselius, FiSMA ry, 4sumpartners: Measuring the size, quality and productivity of projects

08.10.2015: Ph.D. Sini Ruohomaa, Ericsson: A PhD's experiences from industry: Security in practice

23.11.2015: D.Sc. (Tech.) Merja Oja, VTT: Metabolic modelling in industrial biotechnology

23.11.2015: Professor Juho Rousu, Aalto University: Metabolite Identification through Machine Learning

26.11.2015: FT Ph.D. Manu Tamminen, ETH Zürich, Switzerland: Why networks are useful in microbiology?

6.11.2015: Professor Harri Lähdesmäki, Aalto University: High-resolution models for transcription factor binding and transcriptional regulation

Docent lectures

26.05.2015: Dr.rer.nat. Travis Gagie: FM-Indexes

04.06.2015: Ph.D. Matti Siekkinen: Energy-efficient mobile networking

21.09.2015: Ph.D. Antti Salovaara: User research in user-centred design

23.11.2015: D.Sc. (Tech.) Leena Salmela: Algorithms for the genome reconstruction problem

Seminars

09.06.2015: Exactum Greenhouse demo day

12.08.2015: Seminar on summer work projects 1

26.08.2015: Seminar on summer work projects 2

10.12.2015: Jürgen Münch: FiDiPro Seminar

Staff meetings and events

23.01.2015: Department's general assembly

27.02.2015: Department's monthly assembly

04.03.2015: Department's Winter Sport Day 2015

30.03.2015: Morning coffee for the department staff

22.05.2015: Strategy seminar

14.08.2015: Summer trip for the department staff to Porvoo

04.09.2015: Opening of the academic year

25.09.2015: Department's general assembly

23.10.2015: Department's monthly assembly

16.11.2015: Morning coffee for the department staff

03.12.2015: "Opening of Christmas Street"

04.12.2015: Department's Pre-Christmas party for the staff

17.12.2015: Department's Christmas coffee

Other events

29.01.2015: Alumni day

25.08.2015: Orientation event for new students in Autumn 2015 (in Finnish)

27.08.2015: Orientation for MSc and exchange students in Autumn 2015

28.09.2015: Computer science women at the department - get-together event (in Finnish)

05.10.2015: Computer science women at the department- get-together event

07.10.2015: Alumni event: Startup 2015

29.10.2015: Computer science women at the department- get-together event

12.11.2015: Open hearing of candidates for the Head of Department

Department council meetings

05.-08.01.2015 (e-mail meeting), 27.01.2015, 05.02.2015, 03.03.2015, 13.04.2015, 05.05.2015, 02.06.2015, 01.09.2015, 29.09.2015, 03.11.2015, 20.11.2015, 01.12.2015

Agendas and minutes (in Finnish)

Picture from department summertrip to Porvoo by Arto Wikla

APPENDIX 1: List of Publications

A1 Refereed journal articles

1. Ariyawansa, HA, Hyde, KD, Jayasiri, SC, Buyck, B, Chethana, KWT, Dai, DQ, Dai, YC, Daranagama, DA, Jayawardena, RS, Luecking, R, Ghobad-Nejhad, M, Niskanen, T, Thambugala, KM, Voigt, K, Zhao, RL, Li, G-J, Doilom, M, Boonmee, S, Yang, ZL, Cai, Q, Cui, Y-Y, Bahkali, AH, Chen, J, Cui, BK, Chen, JJ, Dayarathne, MC, Dissanayake, AJ, Ekanayaka, AH, Hashimoto, A, Hongsanan, S, Jones, EBG, Larsson, E, Li, WJ, Li, Q-R, Liu, JK, Luo, ZL, Maharachchikumbura, SSN, Mapook, A, McKenzie, EHC, Norphanphoun, C, Konta, S, Pang, KL, Perera, RH, Phookamsak, R, Phukhamsakda, C, Pinruan, U, Randrianjohany, E, Singtripop, C, Tanaka, K, Tian, CM, Tibpromma, S, Abdel-Wahab, MA, Wanasinghe, DN, Wijayawardene, NN, Zhang, J-F, Zhang, H, Abdel-Aziz, FA, Wedin, M, Westberg, M, Ammirati, JF, Bulgakov, TS, Lima, DX, Callaghan, TM, Callac, P, Chang, C-H, Coca, LF, Dal-Forno, M, Dollhofer, V, Fliegerova, K, Greiner, K, Griffith, GW, Ho, H-M, Hofstetter, V, Jeewon, R, Kang, JC, Wen, T-C, Kirk, PM, Kytovuori, I, Lawrey, JD, Xing, J, Li, H, Liu, ZY, Liu, XZ, Liimatainen, K, Lumbsch, HT, Matsumura, M, Moncada, B, Nuankaew, S, Parnmen, S, de Azevedo Santiago, ALCM, Sommai, S, Song, Y, de Souza, CAF, de Souza-Motta, CM, Su, HY, Suetrong, S, Wang, Y, Wei, S-F, Wen, TC, Yuan, HS, Zhou, LW, Reblova, M, Fournier, J, Camporesi, E, Luangsa-ard, JJ, Tasanathai, K, Khonsanit, A, Thanakitpipattana, D, Somrithipol, S, Diederich, P, Millanes, AM, Common, RS, Stadler, M, Yan, JY, Li, X, Lee, HW, Nguyen, TTT, Lee, HB, Battistin, E, Marsico, O, Vizzini, A, Vila, J, Ercole, E, Eberhardt, U, Simonini, G, Wen, H-A, Chen, X-H, Miettinen, O, Spirin, V & Hernawati, T, *Fungal diversity notes 111-252-taxonomic and phylogenetic contributions to fungal taxa*. Fungal diversity: an international journal of mycology, vol. 75, no. 1, 2015, pp. 27-274.
2. Arroyuelo, D, Claude, F, Maneth, S, Mäkinen, V, Navarro, G, Nguyen, K, Sirén, J & Välimäki, N, *Fast in-memory XPath search using compressed indexes*. Software: Practice & Experience, vol. 45, no. 3, 2015, pp. 399-434.
3. Audrito, G, Tomescu, AI & Wagner, S, *Enumeration of the adjunctive hierarchy of hereditarily finite sets*. Journal of Logic and Computation, vol. 25, no. 3, 2015, pp. 943-963.
4. Balint, A, Belov, A, Järvisalo, M & Sinz, C, *Overview and Analysis of the SAT Challenge 2012 Solver Competition*. Artificial Intelligence, vol. 223, 2015, pp. 120-155.
5. Belazzougui, D, *Improved Space-Time Tradeoffs for Approximate Full-Text Indexing with One Edit Error*. Algorithmica, vol. 72, no. 3, 2015, pp. 791-817.
6. Belazzougui, D & Navarro, G, *Optimal Lower and Upper Bounds for Representing Sequences*. ACM Transactions on Algorithms, vol. 11, no. 4, 2015, Article no. 31.
7. Bender, MA, Fekete, SP, Kroeller, A, Liberatore, V, Mitchell, JSB, Polishchuk, V & Suomela, J, *The minimum backlog problem*. Theoretical Computer Science, vol. 605, 2015, pp. 51-61.
8. Bhattacharya, S, Blunck, H, Kjaergaard, MB & Nurmi, P, *Robust and Energy-Efficient Trajectory Tracking for Mobile Devices*. IEEE Transactions on Mobile Computing, vol. 14, no. 2, 2015, pp. 430-443.
9. Björklund, A, Husfeldt, T, Kaski, P, Koivisto, MKH, Nederlof, J & Parviainen, PJ, *Fast zeta transforms for lattices with few irreducibles*. ACM Transactions on Algorithms, vol. 12, no. 1, 2015, Article no. 4.
10. Crochemore, M, Grossi, R, Kärkkäinen, JT & Landau, GM, *Computing the Burrows-Wheeler transform in place and in small space*. Journal of Discrete Algorithms, vol. 32, 2015, pp. 44-52.
11. Dikmen, O, Yang, Z & Oja, E, *Learning the Information Divergence*. IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 37, no. 7, 2015, pp. 1442-1554.
12. D'Agostino, G, Omodeo, EG, Policriti, A & Tomescu, AI, *Mapping Sets and Hypersets into Numbers*. Fundamenta Informaticae, vol. 140, no. 3-4, 2015, pp. 307-328.
13. Eggeling, R, Roos, T, Myllymäki, P & Grosse, I, *Inferring intra-motif dependencies of DNA binding sites from ChIP-seq data*. BMC Bioinformatics, vol. 16, 2015, Article no. 375.
14. Fagerholm, F, Ikonen, M, Kettunen, P, Münch, J, Roto, V & Abrahamsson, P, *Performance Alignment Work: How software developers experience the continuous adaptation of team performance in Lean and Agile environments*. Information and Software Technology, vol. 64, 2015, pp. 132-147.
15. Flores, H, Hui, P, Tarkoma, S, Li, Y, Srirama, S & Buyya, R, *Mobile Code Offloading: From Concept to Practice and Beyond*. IEEE Communications Magazine, vol. 53, no. 3, 2015, pp. 80-88.
16. Flouri, T, Giaquinta, E, Kobert, K & Ukkonen, E, *Longest common substrings with k mismatches*. Information Processing Letters, vol. 115, no. 6-8, 2015, pp. 643-647.
17. Gaggl, SA, Manthey, N, Ronca, A, Wallner, JP & Woltran, S, *Improved Answer-Set Programming Encodings for Abstract Argumentation*. Theory and Practice of Logic Programming, vol. 15, no. 4-5, 2015, pp. 434-448.
18. Gagie, T, Gawrychowski, P & Puglisi, SJ, *Approximate pattern matching in LZ77-compressed texts*. Journal of Discrete Algorithms, vol. 32, 2015, pp. 64-68.
19. Gagie, T, Navarro, G, Nekrich, Y & Ordonez, A, *Efficient and Compact Representations of Prefix Codes*. IEEE Transactions on Information Theory, vol. 61, no. 9, 2015, pp. 4999-5011.
20. Gaspers, S, Koivisto, MKH, Liedloff, M, Ordyniak, S & Szeider, S, *On finding optimal polytrees*. Theoretical Computer Science, vol. 592, 2015, pp. 49-58.
21. Golovin, D, Goyal, V, Polishchuk, V, Ravi, R & Sysikaski, M, *Improved approximations for two-stage min-cut and shortest path problems under uncertainty*. Mathematical Programming, vol. 149, no. 1-2, 2015, pp. 167-194.
22. Heikkinen, T, *(De)growth and welfare in an equilibrium model with heterogeneous consumers*. Ecological Economics, vol. 116, 2015, pp. 330-340.
23. Hella, L, Järvisalo, M, Kuusisto, A, Laurinharju, J, Lempiäinen, T, Luosto, K, Suomela, J & Virtema, JT, *Weak models of distributed computing, with connections to modal logic*. Distributed Computing, vol. 28, no. 1, 2015, pp. 31-53.

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25. Herbec, A, Kauppi, J-P, Jola, C, Tohka, J & Pollick, FE, *Differences in fMRI intersubject correlation while viewing unedited and edited videos of dance performance*. Cortex, vol. 71, 2015, pp. 341-348.
26. Heule, M, Järvisalo, M, Lonsing, F, Seidl, M & Biere, A, *Clause Elimination for SAT and QSAT*. Journal of Artificial Intelligence Research, vol. 53, 2015, pp. 127-168.
27. Hirayama, J, Ogawa, T & Hyvärinen, A, *Unifying Blind Separation and Clustering for Resting-State EEG/MEG Functional Connectivity Analysis*. Neural Computation, vol. 27, no. 7, 2015, pp. 1373-1404.
28. Honkela, A, Peltonen, J, Topa, H, Charapitsa, I, Matarese, F, Grote, K, Stunnenberg, HG, Reid, G, Lawrence, ND & Rattray, M, *Genome-wide modeling of transcription kinetics reveals patterns of RNA production delays*. Proceedings of the National Academy of Sciences of the United States of America, vol. 112, no. 42, 2015, pp. 13115-13120.
29. Hoque, MA, Siekkinen, M, Khan, K, Xiao, Y & Tarkoma, SAO, *Modeling, Profiling, and Debugging the Energy Consumption of Mobile Devices*. ACM Computing Surveys, vol. 48, no. 3, Article no. 39.
30. Hoque, MA, Siekkinen, M, Nurminen, JK, Aalto, M & Tarkoma, SAO, *Mobile Multimedia Streaming Techniques: QoE and Energy Saving Perspective*. Pervasive and Mobile Computing, vol. 16, Part A, 2015, pp. 96–114.
31. Hosoya, H & Hyvärinen, A, *A Hierarchical Statistical Model of Natural Images Explains Tuning Properties in V2*. Journal of Neuroscience, vol. 35, no. 29, 2015, pp. 10412-10428.
32. Kauppi, J-P, Hahne, J, Müller, K-R & Müller, K-R, *Three-Way Analysis of Spectrospatial Electromyography Data: Classification and Interpretation*. PLoS One, vol. 10, no. 6, 2015, Article 0127231.
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34. Klami, A, Virtanen, S, Leppäaho, E & Kaski, S, *Group Factor Analysis*. IEEE Transactions on Neural Networks and Learning Systems, vol. 26, no. 9, 2015, pp. 2136-2147.
35. Kurhila, J & Vihavainen, A, *A Purposeful MOOC to Alleviate Insufficient CS Education in Finnish Schools*. ACM Transactions on Computing Education, vol. 15, no. 2, 2015, pp. 10:1-10:18.
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38. Leppänen, M, Makinen, S, Lahtinen, S, Sievi-Korte, O, Tuovinen, A-P & Mannisto, T, *Refactoring: a Shot in the Dark?* IEEE Software, vol. 32, no. 6, 2015, pp. 62-70.
39. Leppänen, M, Mäkinen, S, Pagels, M, Eloranta, V-P, Itkonen, J, Mäntylä, MV & Männistö, T, *The Highways and Country Roads to Continuous Deployment*. IEEE Software, vol. 32, no. 2, 2015, pp. 64-72.
40. Liikkanen, LA, Jakubowski, K & Toivanen, JM, *Catching Earworms on Twitter: Using Big Data to Study Involuntary Musical Imagery*. Music Perception, vol. 33, no. 2, 2015, pp. 199-216.
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