Turku Centre for Computer Science

Annual Report 2013

Turku Centre *for* Computer Science

TUCS General Publication
No 61, April 2013

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1. Foreword

Where Academic Tradition Meets the Exciting Future

Due to a major reform of organization and responsibilities of TUCS, its role, activities, and even structures have been under reconsideration in 2013. The traditional pillar of collaboration at TUCS, doctoral training, was reorganized due to changes at both universities according to the renewed national system for doctoral education. Computer Science and Engineering and Information Systems Science are now accompanied by Mathematics and Statistics in newly established doctoral programs at both University of Turku and Åbo Akademi University. Moreover, both universities granted sufficient resources to their respective programmes for doctoral training in these fields, so that joint activities at TUCS can continue. The outcome of this reorganization has the potential of proving out to be a success in terms of scientific profile as well as the quality and quantity of scientific and educational results.

International activities that have been characteristic to TUCS since its inception continue strong. TUCS' participation in European collaboration through EIT ICT Labs Master's and Doctoral School is now more active than ever. The new double degree programs at MSc and PhD level between University of Turku and Fudan University in Shaghai, P.R.China were succesfully set up and are now running for their first year. The joint students will add to the already international athmosphere of the ICT House.

The four new thematic reseach programmes set up acccording to the decision by the TUCS Board have now established themselves, and a number of events and other activities saw the light in 2013. The TUCS Distinguished Lecture Series managed to gather a large audience with its several prominent speakers. The development of these and other research centre activities continue, and new practices and structures will be initiated to support the tradition of close academic collaboration.

The TUCS' slogan Where Academic Tradition Meets the Exciting Future has proven true throughout these changes. Despite of the dark clouds on the national and European economic sky, science and higher education in the field have managed to retain all the key ingredients for success. Indeed, the future of ICT and Mathematics in Turku seems exciting.

Professor Tapio Salakoski
Chairman of TUCS Board

Professor Johan Lilius
TUCS Director

2. TUCS in 2013

2.1 TUCS Board and directors

The Members of the TUCS Board in 2012 were (deputy members in brackets):

- Barbro Back, Åbo Akademi University, Department of Information Technologies (Tomas Eklund)
- Ralph-Johan Back, Åbo Akademi University, Department of Information Technologies (Jan Westerholm)
- Juhani Karhumäki, University of Turku, Department of Mathematics and Statistics (Iiro Honkala)
- Marko Puhtila (up until 14.1. Janne Lahtiranta), Turku Science Park (Rikumatti Levomäki)
- Ivan Porres, Åbo Akademi University, Department of Information Technologies (Hannu Toivonen)
- Olli Mertanen, AMK (Juha Kontio)
- Tapio Salakoski, University of Turku, Department of Information Technology (Jouni Isoaho)
- Reima Suomi, University of Turku, Turku School of Economics, Institute of Information System Sciences (Hannu Salmela)
- Sami Hyrynsalmi, Student, University of Turku, Department of Information Technology (Pekka Rantala)
- Niclas Jern, Student, Åbo Akademi University (Guopeng Yu)

Chairman of the Board: Tapio Salakoski

Director of TUCS: Johan Lilius

Vice Director of TUCS: Ion Petre

2.2 TUCS GP Committee

The members of the TUCS GP Committee in 2012 were (deputy members in brackets):

- Barbro Back, Åbo Akademi University, Department of Information Technologies (Tomas Eklund)
- Ralph-Johan Back, Åbo Akademi University, Department of Information Technologies (Jan Westerholm)
- Juhani Karhumäki, University of Turku, Department of Mathematics and Statistics (Iiro Honkala)
- Ivan Porres, Åbo Akademi University, Department of Information Technologies (Hannu Toivonen)
- Tapio Salakoski, University of Turku, Department of Information Technology (Jouni Isoaho)
- Reima Suomi, University of Turku, Turku School of Economics, Institute of Information System Sciences (Hannu Salmela)

2.3 New developments

TUCS organization

In 2013 TUCS was focusing it's efforts further into the joint coordination of research and education of computer sciences withing Åbo Akademi University and University of Turku. Both universities established their own graduate programmes in the subject: The Doctoral Programme in

Mathematics and Computer Sciences in University of Turku, and the Doctoral Network in Information Technologies and Mathematics in Åbo Akademi University. The developed best practises of TUCS Graduate Programme are contributing to the construction of these two new programmes.

In research, the four TUCS Research Programmes, established in 2012, keep running.

TUCS Publication Database

Since August 2012 the TUCS Publication Database has stored the Publication Forum levels for the publications as well. As of April 2013 these levels are displayed in the TUCS PDB search results and on the publication detail pages for publications of level one or higher. Also, it is possible to refine a publication search to only include publications of level 1, 2 or 3.

The publication input interface guides the user to input their publications properly and especially assists in assigning the publications to the correct forums for showing the correct level. This feature has been warmly welcomed by the users and has attracted attention even outside of Turku.

TUCS Day

TUCS Day was organised on Friday 4 October 2013. All TUCS PhD students, supervisors and researchers in TUCS research programmes and research units were invited to learn about and discuss the latest developments in TUCS and spend a relaxing day at the Naantali Spa.

About sixty people from all around TUCS participated in the event. The day started with presentations of the TUCS Research Programmes (unfortunately due to scheduling difficulties TISRA was not represented) and the new graduate school system in both universities. Good questions were asked and interesting facts were learned. The EIT ICT Labs was also presented. Juha Plosila gave a short talk about the Master School, Natalia Diaz Rodriguez told about her experiences as a student in the EIT ICT Labs Doctoral School and Pasi Liljeberg spoke about the projects organised within the EIT ICT Labs. After the more informative side of the day the participants enjoyed a fabulous and plenty buffet lunch with starters, mains and desserts at the restaurant Le Soleil. Especially the dessert table with countless different little cakes was exquisite. The afternoon was reserved for relaxation at the pool area of the spa with free use of the saunas, pools and hot tubs. All in all the day was both informative and fun, filled with good discussion, new ideas and relaxation.

2.4 ICT-Showroom

ICT ShowRoom is an exhibition and a competition, in which students of the ICT Building present their project work done during the past year. ICT Showroom has been running since year 2008, hence 2013 was the 6th time it was arranged. The basic format of the event has remained the same. The event increases students' motivation for their study projects, and visibility. Having a jury of corporate people also works for the Innovation & Entrepreneurship ideology and it helps introducing students to the upcoming work life.

In year 2013 all together 39 teams participated in the event of which 29 teams were student teams, 10 was research teams. 177 persons where contributing to the exhibition as team members, more than 300 persons took part in the public voting as visitors. From the Åbo Akademi, Turun yliopisto and Turun ammattikorkeakoulu some 10 persons contributed to the arrangements. The jury of the competitions consisted of representatives from the organisations Accenture Oy, BoostTurku, eCraft, Hibox Systems Oy and Vaadin. The winners of year 2013 was a team from Åbo Akademi; the Remote Alert System project.

The main organizers committee have since the beginning consisted of Jerker Björkqvist (Åbo Akademi), Seppo Virtanen (Turun Yliopisto) and Janne Roslöf (Turun ammattikorkeakoulu).

2.5 Conferences

AcMuC 2013, May 30–31, 2013

1st International Accessibility and Multimodality in Communication -symposium. A forum for discourse between academia and 3rd sector professionals.

Website: http://tucs.fi/conferences/acmuc2013/

Conversation and talking to each other are a clear example of human activities that are above all interactive and social, which are challenged by hearing and visual impairments. We invite papers relating to accessibility, multimodality and technological aids in communication with a focus on sensory impairments and their effect on communication. While there are well-established conferences on various aspects of human communication, such as speech (Interspeech and ICPhS among others), signing (TISLR), interpreting (EFSLI, ECOS), and information society adaptation for the sensory impaired (WIS) this symposium contributes to the combination of the previous aspects. This combination has not been in focus of conferences previously.

Our symposium provides a forum for researchers from various fields, such as human-computer interaction, computing, linguistics, phonetics, interpreting, speech therapy, social science and medical professionals with interested 3rd sector professionals, such as associations with target group users to discuss various related issues together. Symposium consists of keynote talks, workshops and poster sessions. The event is an intensive two-day meeting in Turku, Finland, May 2013.

Conference themes

The areas of interest and themes touched upon within the conference are face-to-face communication, mediated discourse, different languages, different modalities, combining modalities, augmented and assisted communication (AAC) and shared space, technical aids, and assistive technology. Recent technological development has increased accessibility, however, there are many areas of human communication spectra not yet fully understood.

Tivit's Cloud Software Program annual Computer Science Event and Future of Software Business Seminar, Oulu, June 3–4, 2013

The Finnish Society for Computer Science (TKTS) organises in collaboration with Tivit's Cloud Software Program (www.cloudsoftwareprogram.org) annual Computer Science Event and Future of Software Business Seminar in Oulu 3rd–4th June, 2013.

iFM 2013, June 10–14, 2013

Applying formal methods may involve the modeling of different aspects of a system that are expressed through different paradigms. Correspondingly, different analysis techniques will be used to examine differently modeled system views, different kinds of properties, or simply in order to cope with the sheer complexity of the system. The iFM conference series seeks to further research into hybrid approaches to formal modeling and analysis; i.e., the combination of (formal and semi-formal) methods for system development, regarding modeling and analysis, and covering all aspects from language design through verification and analysis techniques to tools and their integration into software engineering practice.

Plenary speakers

- Jean-Raymond Abrial, Marseille, France
- Cosimo Laneve, University of Bologna, Italy
- Susanne Graf, VERIMAG, France
- Kim Larsen, Aalborg University, Denmark

The conference is organized at Department of IT, Åbo Akademi University and it will take place in the ICT Building. The PC is chaired by Einar Broch Johnsen (University of Oslo) and Luigia Petre (Åbo Akademi University).

Link: http://www.it.abo.fi/iFM2013/

CompMod 2013, June 11, 2013

4th International Workshop on Computational Models for Cell Processes

Turku, Finland, June 11, 2013

http://combio.abo.fi/compmod13/

In conjunction with iFM 2013

Invited speakers

- Daniela Besozzi, Universita degli Studi di Milano, Italy: Computational methods in systems biology: case studies and biological insights
- Juho Rousu, Aalto University: Computational methods for metabolic networks

IWSSU'13, Potsdam, June 11–14, 2013

First International Workshop on Software Start-ups (IWSSU'13)

June 11–14. 2013, Potsdam, Germany

Co-located with 4th International Conference on Software Business

http://iwssu.wordpress.com/

ICEC2013, August 13–15, 2013

The 15th International Conference on Electronic Commerce (ICEC2013) August 13–15, 2013 Turku, Finland http://icec2013.net/

The International Conference on Electronic Commerce (ICEC) annually brings together the leaders of the scientific research community in e-commerce and e-business from all over the world. Having travelled across the globe from Hawaii to Liverpool and Singapore, the conference returns to Europe, first time to Fenno-Scandia, a medieval Capital of Finland and Hansa-city of Turku, Finland.

The theme of ICEC 2013 is Effective, Agile and Trusted eServices Co-creation. The theme reflects alignment between computerized, formalized business procedures with the need for innovating business genuinely onthe-spot, or ad-hoc, to the needs of a customer.

This year in Turku we have presentations on following topics:

- Mobile services
- Social media
- Online advertising and recommender systems
- IT services in the context of eCommerce
- Strategic issues related to eCommerce

WORDS 2013, September 16–20, 2013

The central topic of the conference is combinatorics on words: the study of finite and infinite sequences of symbols from varying points of view, including their combinatorial, algebraic and algorithmic aspects, as well as their applications. The conference is organized by FUNDIM and Department of Mathematics and Statistics at University of Turku.

Invited speakers

- Julien Cassaigne (University of Aix-Marseille - France)
- Frederik Michel Dekking (Delft University of Technology - Netherlands)
- Vesa Halava (University of Turku - Finland)
- Gilbert Levitt (University of Caen - France)

- Narad Rampersad (University of Winnipeg - Canada)
- Marinella Sciortino (University of Palermo - Italy)

http://www2.math.utu.fi/projects/words13/

2.6 TUCS Publication Series

TUCS is a publisher of five series. Most publications from TUCS are available for download on the TUCS web site, as well as the National Library of Finland Doria service. (http://www.doria.fi) The TUCS Publication Series are the following:

- TUCS Dissertations with 168 publications,
- TUCS Technical Reports with 1098 publications,
- TUCS General Publications with 59 publications,
- TUCS National Publications with 19 publications, and
- TUCS Lecture Notes with 21 publications.

2.7 Awards

MODELS 2013

Dr. Marcus Alanen and Prof. Ivan Porres received the most influential paper award at the MODELS 2013 Conference for their work on "Difference and Union of Models". This award is given to the authors of the paper to have the most impact 10 years after publication. Porres is also the recipient of the 10 year most influential paper award at MODELS 2009.

SOFSEM 2013

Mikhail Barash, a TUCS PhD student at Department of Mathematics and Statistics, University of Turku, has received the "Best poster award" at the SOFSEM 2013 conference for his article on "Recursive descent parsing for grammars with contexts".

Taltioni Codefest

Turku Science Park Oy arranged as part of the VARMO-initiative Taltioni Codefest, event focused on the development of applications capitalizing on the Microsoft technology. Teams of five had 24 hours to create a personal health - & wellbeing application to the Taltioni service with Microsoft technologies. Best ideas were awarded. Awards were granted in two categories; Best concept and Best technical solution. IKITIK-researchers were involved in both winning teams.

The Best concept was awarded for an application focused on the development of the self-care of asthma. The winning team included IKITIK-researcher Heidi Parisod, Oskari Honkonen, Jaani Ketonen, Mikko Rajala and Juuso Salminen.

The winning technical application was developed by students of the Åbo Akademi University Natalia Diaz Rodriguez (also IKITIK-researcher), Stefan Grönroos, Peter Garfield, Shohreh Hosseinzadeh and Anders Berg. The application allows you to monitor your alcohol consumption. The application also included a breath analyzer.

2.8 TUCS recreational activities

TUCS Christmas lunch was held at Hotel Julia on Thursday, December 5th 2013 at 14.00–17.00.

Wednesday, November 20th, TUCS organized a screening of the PHD Movie that is based on the popular webcomic PHD Comic, where PHD is opened as “Piled Higher and Deeper”. It is a comic focused on all aspects of graduate student life. The author is Ph.D. Jorge Cham who got his Ph.D.

in Mechanical Engineering at Stanford University, and was a full-time Instructor and researcher at the California Institute of Technology (Caltech) from 2003–2005.

The screening gathered a good crowd in the Auditorium Alpha of the ICT Building. The movie was received very positively and gave the audience good laughs and “good therapy”.

2.9 TUCS 2013 in numbers

- 270 publications,
- 82 TUCS GP students,
- 12 Ph.D. theses,
- 4 TUCS Distinguished Lectures
- 13 guest talks
- 6 TUCS short courses

3. Research at TUCS

3.1 TUCS Research Programmes

In an effort to create clearer profile for TUCS and a larger critical mass within TUCS, the TUCS Board decided to create a number of research programmes, which are awarded support from TUCS. The Board reserved a total of 60.000€ of support for these research programmes.

Four proposals were accepted as TUCS Research Programmes:

- Combinatorics, Complex Systems and Computability (Com^3)
- From Computational Biology and Medical Informatics to Health and Wellbeing (BioHealth)
- Resilient IT Infrastructures (RITES)
- Turku Information Systems Research Alliance (TISRA)

The research programmes started their activities on 1st of May 2012. The reserved support was split evenly between the four programmes.

Every research programme also has its own email lists to announce and discuss related issues. The list addresses are biohealth@abo.fi, com3@abo.fi, rites@abo.fi, and tisra@abo.fi. The lists are public and promoted on the Åbo Akademi mailman service page. Any list member can post to the list freely. External senders' postings are moderated.

3.1.1 COM^3 – Combinatorics, Complex Systems and Computability

Com3 carries out basic research in discrete mathematics and computing. More specifically research topics cover automata theory, coding theory, models of computation, cellular automata and complex systems, tilings, combinatorics on words, discrete dynamical systems and unconventional computation. Research is typically done in cooperation with foreign partners.

Research area

This research programme ties together several related projects in discrete mathematics and theory of computation. The involved projects investigate combinatorics on words, coding theory, cryptography, automata theory, cellular automata, unconventional computation, tilings and symbolic dynamics. A common theme is the discreteness of the studied objects, which leads to the employment of combinatorial methods. Computability aspects are also central in many of the projects.

Combinatorics is heavily used in the research of coding theory (Iiro Honkala's group) and cryptography (Valtteri Niemi's group). Combinatorics on words (Juhani Karhumäki, Tero Harju, and their groups) concerns the structure of finite or infinite sequences of symbols, in one or more dimensions. The topic of complexity and combinatorics of infinite words is investigated also by the FiDiPro group, led by Luca Zamboni. In the spirit of symbolic dynamics, infinite words can be seen to model complex dynamical systems. Much can be said concerning global regularities that arise from local rules on the words. Multidimensional words are related to tilings and cellular automata, studied by Jarkko Kari and his group. In higher dimensions, simple tiling systems become computationally universal, and computability questions become central. Cellular automata and tilings are archetypical examples of discrete complex systems with simple individual components but complex overall behaviour. Tiling systems provide an expressive model of self-assembly, capable of producing complex structures found in nature. Cellular automata and tilings constitute unconventional methods to perform computation. Other such methods include biologically inspired computational models, studied by Ion Petre and his group. Biological systems provide a fascinating

example of global complexity arising from simple local behaviour. They are a rich source of inspiration for new models of computing, including DNA-based computing, molecular self-assembly, computing through gene assembly, and computing through reaction and membrane systems.

Research goal

The goal of the research programme is to increase our understanding of complexity and the relationship between local and global structures in discrete systems and models, may it be a communications network, a biological system, or an abstraction such as a cellular automaton or simply a sequence or an array of symbols. Understanding the emergence of complex behaviour and the computational capabilities in large systems consisting of very simple interacting components is of particular interest. The programme also investigates algorithmic questions concerning such systems. One frequently encounters uncomputability, and in many instances the aim is to clarify the borderline between decidable and undecidable. Specific research problems can be found in the research statements of the participating groups.

Programme leader

Jarkko Kari

Participating TUCS Research Units

- FUNDIM, Fundamentals of Computing and Discrete Mathematics
- Computational Biomodeling Laboratory

Steering group

Tero Harju, Iiro Honkala, Juhani Karhumäki, Jarkko Kari, Valtteri Niemi, Ion Petre and Luca Zamboni

Activities

14.10.2013: FiDiPro Distinguished lecture: Mike Boyle (University of Maryland, USA): *"Strong shift equivalence and the algebraic K-theory of endomorphisms"*

Square matrices A,B are elementary strong shift equivalent (ESSE) over a ring R if there are (not necessarily square) matrices U,V such that A=UV and B=VU. Strong shift equivalence (SSE) over R is the transitive closure of this relation. Shift equivalence (SE) of matrices over R is a more tractable relation. For every ring, SSE over R imples SE over R.

Theorem: for every square matrix over R, the SSE-R classes within its SE-R class are in bijective correspondence with the algebraic K-theory group NK_1(R).

I'll explain the statement of the theorem, its motivation from symbolic dynamics, and state some applications to positive matrices, group extensions of shifts of finite type and the algebraic K-theory of endomorphisms.

This is joint work with Scott Schmieding.

9.10.2013: Guest lecture: Abuzer Yakaryilmaz (The University of Latvia): *"Automata and complexity theory"*

23.9.2013: M. Keane (Wesleyan University): Distinguished FiDiPro lecture in Publicum, Lecture Hall 3, at 12.

The recurrence-transience dichotomy

In 1920, Georg Pólya taught us, in the later words of Shizuo Kakutani, that "A drunken man will eventually find his way home, but a drunken bird may be lost forever."

In more mathematical terminology, simple random walk in one or two dimensions is recurrent, but in three or more dimensions transient. When, in the well-known nursery rhyme, Gretel leaves a trail of bread crumbs to help find her way home from the forest, one would expect that her "risk-reduced" random walk is also recurrent. It is interesting that we cannot prove this yet. More

puzzling yet is that in the general elementary situation, we are not sure that there is a dichotomy at all - for once reinforced random walks on locally finite connected countable graphs the possibility of partial recurrence has not yet been excluded.

In this lecture I want to try to explain possible reasons for the behaviour Pólya discovered, at a leisurely pace, and the conjectures, now over twenty years old, concerning reinforced random walks on ladders. I'll finish then, time permitting, with a new dichotomy conjecture which, if true, would allow us to classify graphs into recurrent and transient ones.

24.–26.9.2013: M. Keane (Wesleyan University): TUCS Short Course "Topics in ergodic theory" in Publicum, seminar room of psychology (second floor), at 14.

27.9.2013: Guest lecture: M. Volkov (Ural Federal University, Ekaterinburg) in Publicum, seminar room of psychology, at 10.

4.6.2013: Guest lecture: Solomon Marcus

Going Beyond

Trying to go beyond classical logic, Archimedes axiom, Fifth Postulate in Euclid's Elements, the Galileo-Newtonian representation of phenomena related to time and energy, the macroscopic universe, the choice axiom, von Neumann's axiom of foundation, continuum hypothesis, Turing's computability, the field of competence of human language and human semiosis, the representation of artistic beauty as based on order, simplicity, harmony and symmetry means to transgress the borders of the common perception of the world according to our senses. We try to obtain the picture of these enterprises and to point out their meaning and their relevance, as components of a new, anti intuitive world emerging in the last decades. In a second step, we try to bridge this view with another one, coming from the way transcendence is emerging in mathematics, logic, music, philosophy.

3.1.2 BioHealth – From Computational Biology and Medical Informatics to Health and Wellbeing

Research area

During recent decades, computational biology, bioinformatics, medical, and health informatics have claimed and successfully established their status as scientific disciplines. They are considered highly relevant for the wellbeing of modern information society. Traditionally, however, these disciplines have focused on different research topics and they have not maintained a dialogue resulting in satisfactory interaction from the point of view of health and wellbeing, the ultimate goals of both individuals and society at large. This TUCS Research Programme aims at establishing such a dialogue by setting up joint activities for the scientific disciplines as well as supporting interaction between academia and the rest of the society.

Research goal

The scope addressed in this initiative stretches over three tiers of varying levels of abstraction. The lowest level is the molecular level, where the research focus is on the interactions of various biomolecules, drugs, and conditions. The next layer is focused on medical and health related phenomena concerning a certain individual. Finally, the uppermost layer is concerned with societal aspects of ICT in health and wellbeing, such as health information systems. Currently, we witness a strong trend towards integrating these aspects, resulting in highly personalized medical treatments and active participation in the preventive, diagnostic, curative, and other processes of the health care system by empowered individuals.

Programme leader

Tapio Salakoski and Ion Petre

Participating TUCS Research Units

- Turku BioNLP Group

- Computational Biomodeling Laboratory
- Biomathematics Research Unit (BIOMATH)
- Algorithmics and Computational Intelligence Group (ACI)
- Data Mining and Knowledge Management Laboratory
- UTU Information Systems Science (ISSR)
- Software Construction Laboratorium

External partners

- Department of Nursing Science at University of Turku (Sanna Salanterä)
- Genetic interactions and network medicine at FIMM (Tero Aittokallio)
- Turku Proteomics Facility (Garry Corthals)
- Bioinformatics Core Facility at Turku Centre for Biotechnology (Attila Gyenesei)
- Bioenergy group at Turku Centre for Biotechnology (Patrik Jones)

Steering group

Tero Aittokallio, Barbro Back, Ralph-Johan Back, Garry Corthals, Attila Gyenesei, Jukka Heikkonen, Patrik Jones, Olli Nevalainen, Kalle Parvinen, Ion Petre, Tapio Salakoski, Sanna Salanterä and Reima Suomi

Activities

14.11.2013: guest talk: Dr. Katalin Lazar (Eötvös Loránd University, Budapest)

Computational models in distributed environments

The aim of this talk is to demonstrate how computational devices can be used to describe complex, distributed networks. With the advancement of new technologies in distributed computing, the need to integrate computing resources of many types into ongoing computations has become an increasingly difficult task to manage. Furthermore, availability on demand, robustness and fault tolerance have to be guaranteed. We summarize our results obtained in the past few years in the areas of peer–to–peer networking and web search and propose some further research directions. The targeted applications would benefit early disease detection, medical treatment (e.g. controlled drug delivery) and at–a–distance diagnosis (personalised health care). In these systems, biological hardware offers an alternative to silicon hardware and ensures energy–efficiency. The modelling techniques applied in nature–motivated computing assist us in developing architectural ideas for robust distributed systems exploiting chemical reactions and the robustness of living systems with respect to the possible failure of their components.

Host: Computational Biomodeling Laboratory

17.–22.6.2013: 13th International Summer School Formal Methods for the Design of Computer, Communication and Software Systems: Dunamical Systems, Bertinoro, Italy.

11.6.2013: 4th International Workshop on Computational Models for Cell Processes, Turku, Finland.

Host: Computational Biomodeling Laboratory

14.5.2013: guest talk: Professor John D. Nagy (Scottsdale Community College and Arizona State University, USA)

Evolution of Proliferation and the Angiogenic Switch in Phenotypically Diverse Tumors

Cancer therapy is most commonly complicated by an incipient treatment resistance that eventually overwhelms all attempts at clinical intervention. This process is widely recognized as an evolutionary phenomenon in which treatment-resistant cells are favored by natural selection in the environment generated by therapy. Therefore, clinical strategies that harness natural selection – in contrast to current protocols that either ignore it or attempt to avoid it – may offer improved outcomes. One intriguing possibility in this direction is to force the tumor to evolve its own tumor, or ``hypertumor," generated by runaway selection for either extreme vascular hypo- or hyperplasia.

This phenomenon is predicted by models of tumor angiogenesis studied with the techniques of adaptive dynamics. However, such techniques are predicated on two key assumptions: (i) no more than two distinct clones or evolutionary strategies can exist in the tumor at any given time; and (ii) mutations only have small effects on the evolutionary strategy. Here we relax these assumptions at the expense of mathematical tractability and show, using a stochastic simulation of angiogenesis evolution, that the predictions of the adaptive dynamics model do not depend on the adaptive dynamics assumptions. In particular, the evolutionary stable strategy for angiogenesis remains an evolutionary repeller. Furthermore we implement the use of the Shannon diversity index to measure convergence towards an evolutionary endpoint in phenotypically diverse tumors. Future numerical investigations will be directed towards identifying evolutionary stable strategies in a two dimensional strategy space where both proliferation and angiogenic commitment strategies are allowed to evolve. These predictions may allow better understanding of tumor progression through evolutionary mechanisms allowing for therapeutics that better utilize natural selection.

Host: Biomathematics Research Unit

8.5.2013: Guest talk: Dr. Andrzej Mizera (University of Luxemburg)

Host: Computational Biomodeling Laboratory

3.1.3 RITES – Resilient IT Infrastructures

Research area

Our society is becoming increasingly dependent on complex IT infrastructures and services. IT systems are already the most complex systems built by mankind, and their scale and complexity is increasing all the time. Complexity is escalating at all levels of technology stack — from application and service level till underlying implementation technology. Currently, the underlying technologies (i.e. processor architectures, and silicon technologies) are undergoing big leaps, from comparatively straightforward architectures (single-core) with deterministic behaviour, to complex architectures (heterogeneous many-core) with non-deterministic behaviour, due to changes in silicon yield etc.

TUCS is in a unique position to address these challenges in a unified way, since TUCS possesses competence of a cross-cutting nature that spans from highly abstract service modelling level to the hardware implementation platform. The partners of the research programme have strong track record in the corresponding fields.

Research goal

The research programme aims to address the challenges of complex IT infrastructures by targeting solutions along the following important themes, for which the participating research groups have a long track record of research achievements.

Adaptability

The challenge in future ICT-systems is that their application loads will vary highly at the same time as the available computing capabilities may vary over time. To achieve efficiency in different areas (energy, performance, cost, etc.), the application must be able to adapt itself to the environment, and to the capabilities available. The main challenges in this area lie in designing adaptable system architectures, as well as coming up with good adaptation strategies.

Future multi-core systems will exploit heterogeneous networked architectures and run dynamic loads created by future application scenarios. Run-time management of these systems requires a high degree of scalability and adaptivity from both the underlying hardware platform and the operating system or middle-ware of the platform. Distributed (decentralized) solutions need to be found for implementing such management functions. We focus on self-aware computing platforms and embedded storage systems that are energy proportional, i.e., their energy-efficiency remains high independently of the offered load. More specifically, we develop adaptive control and management approaches that enable efficient self-adaptation of the platform according to the dynamically changing computational load.

Efficiency

Efficiency is a key constraint in the construction of future ICT-systems. The construction itself must be cost efficient (lean), that is one should both do the right system and do the system in a right way, and avoid all unnecessary costs to achieve good time to market. This requires lean processes, but also cost effective approaches to verify and validate the proposed solutions. Lean processes, model-driven design, and formal methods are all part of the palette of approaches that have been successfully applied to system construction by the partners.

Efficiency is also important in the deployment of the system. This is specially challenging in the case of adaptable systems that need to provision resources dynamically based on the current needs. The system must be energy-efficient, and it must not underprovision or overprovision resources because this leads to low performance or high operation costs.

Foundations of Software Engineering

Theoretically well-founded techniques for software construction, both in the large and in the small, are a necessity for the production of highly reliable and functionally correct software systems. Our research in this area concerns program correctness, semantics, and formal methods. We focus on two main techniques: invariant-based programming, a correct-by-construction imperative programming methodology, and stepwise feature introduction, a rigorous extension mechanism for layered software architectures. These techniques are based on lattice theory, and provide a sound theoretical foundation on which applied software engineering methods can be built.

Teaching Programming

New correctness-oriented programming paradigms (such as invariant-based programming) coupled with the powerful automatic reasoning tools, promise to increase the quality of software but at the same time demand stronger mathematical and logical reasoning skills from the practitioner compared to the traditional approaches. Our focus in this area is on increasing the role of formal specification and verification techniques in the skillset of the next generation of software engineers. We strive towards this goal by teaching hands-on methods for correct-by-construction program development as early as possible, and couple them with strong theorem prover support to automate the verification process as far as possible.

Intentionality

To achieve efficiency in design and implementation, the description languages and abstractions used for describing systems need to be more problem oriented. The description language is the user-interface to the problem domain, and must be able to describe all the knowledge about the system available to the designer. More importantly it must be possible to describe the design intent of the designer. Therefore new paradigms for programming (e.g. dataflow languages, PRAM models), and new paradigms for system specification (e.g. event-B, metamodelling based DSL's) have been introduced. Such paradigms are being actively developed within the programme, and they form one of the basic building blocks for the efficient development of scalable, resilient and adaptable IT-systems.

Scalability

Scalability is the ability of a system to handle growing amount of work in a capable manner or its ability to be enlarged to accommodate that growth. The scalability requirement is challenging because for a system to be scalable on both of these axes, the system platform must provide efficient ways of adapting to the current workload, something that requires run-time monitoring, and learning from past behaviours, while at the same time be implemented in a way that when new capacity (hardware) is added the system automatically takes this into account. Solutions already exists for some of these issues in the domain of web-services, while for other areas, e.g. radio algorithms the problem is yet unsolved. In particular for radio algorithms, improvements in architecture and hardware capacity usually result in a redesign of the whole system. Indeed one of the big challenges in this area is Performance Portability the ability to provide solutions that retain their performance over several hardware generations.

Resilience

Resilience is a central issue for the dependable systems. It is on the one hand a design problem, where one needs to handle system complexity, to secure the safety-critical and fault tolerant functioning, and on the other hand a platform problem, where the system should provide a number of implementation primitives to handle faults.

The work in this theme will focus on modelling safety-critical and fault tolerant systems from various domains – from traditional control systems to self-adapting multi-agent applications. We work on interfacing formal models with safety analysis techniques, creating patterns and process guidelines for modelling various aspects of dependability as well as proof-based verification and model-checking of essential dependability properties. We are also actively involved into extending refinement-based development method with stochastic reasoning and integration with probabilistic model checking. Furthermore the work will involve research around specific implementation techniques that the platform can provide to guarantee certain resiliency properties. Such techniques include forms of task migration and run-time updating, virtualization, and hardware fault detection.

Programme leader

Juha Plosila and Ivan Porres

Participating TUCS Research Units

- Embedded Computer and Electronic Systems – ECES
- Embedded Systems Laboratory – ESLAB
- Distributed Systems Laboratory (DS Lab)
- Software Construction Laboratorium
- Software Development Laboratory (SwDev)
- Software Engineering Laboratory – SE Lab

Steering group

Ralph-Johan Back, Ville Leppänen, Johan Lilius, Luigia Petre, Juha Plosila, Ivan Porres, Kaisa Sere, Elena Troubitsyna, Marina Waldén and Jan Westerholm

Activities

4.12.2013: guest lecture: Dr. Jeanette Heidenberg (Ericsson)

On Software Architecture

Host: DS Lab

21.11.2013: guest lecture: Prof. Kai Koskimies (University of Tampere)

Software architecture evaluation – methods, experiences, issues

Host: DS Lab

11.11.–11.12.2013: research visit: M.Sc. Iulia Banu (University of Bucharest, Romania)

Host: DS Lab

7.11.2013: guest lecture: Dr. Joonas Lehtinen (Vaadin)

Notes on Architecture

Host: DS Lab

9.10.2013: Turku Game Lab opening event. http://turkugamelab.fi/

10.–14.6.2013: conference: iFM 2013: 10th International Conference on integrated Formal Methods

Applying formal methods may involve modeling different aspects of a system which are best expressed using different formalisms. Correspondingly, different analysis techniques may be used to examine different system views, different kinds of properties, or, simply in order to cope with the

sheer complexity of the system. The iFM conference series seeks to further research into hybrid approaches to formal modeling and analysis; i.e., the combination of (formal and semi-formal) methods for system development, regarding modeling and analysis, and covering all aspects from language design through verification and analysis techniques to tools and their integration into software engineering practice.

http://www.it.abo.fi/iFM2013/

Host: DS Lab

22.4.2013: Guest lecture: Professor Thomas Hollstein (Tallin University of Technology, Estonia):

Challenges for Application Deployment on Many-Core Architectures under Mixed Criticality Aspects

Abstract: Currently computer architectures are ungoing one of the largest paradigm shifts since the invention of the microprocessor. The scaling of classical computer architectures (based on concentrated multi-core processors) is limited due to the bottleneck of sharing one common DRAM interface. New developments in IC manufacturing technologies allow 3D chip stacking, using Through-Silicon-Vias (TSVs). This enables distributed shared memory (DSM) architectures for NoC based scalable many-core architectures, providing local DRAM access for every processor tile. Scalability, sophisticated dependability concepts and suitable programming models are essential requirements for successfull introduction and application of these new architectures.

In this presentation we will approach the whole topic area from the point of view of application mapping under mixed criticality constraints. From this perspective we will draw conclusions on necessary implications related to NoC properties, dependability concepts and application deployment on many core architectures.

About the lecturer: Thomas Hollstein is Professor in the Department of Computer Engineering at Tallinn University of Technology (TTU). He graduated from Darmstadt University of Technology in Electrical Engineering / Computer Engineering in 1991. In 2000 he received his Ph.D. on ìDesign and interactive Hardware/Software Partitioning of complex heterogeneous Systemsî at Darmstadt University of Technology. He has an extensive industrial background in the field of embedded HW/SW systems and printable electronics. Since September 2010 Thomas Hollstein is a full professor at TTU leading the research team "Dependable Embedded Systems". His research interests are in the fields Dependable Embedded Systems, System-on-Chip Design, Networks-on-Chip, MPSoCs (Programming Models, APIs, Mixed criticality application mapping and depenability management), Reconfigurable Systems and Printed Electronics. Thomas Hollstein has published over 60 peer-reviewed papers and is member of the programme committees of several international conferences and workshops.

Host: ES Lab

4.4.2013: Guest lecture: M.Sc. Markus Stocker (UEF)

Wavellite: A software framework for the representation of knowledge about real-world phenomena observable by a sensor network

Host: DS Lab

17.–18.1., 25.–27.11.2013: research visit: M.Sc. Markus Stocker (UEF)

Host: DS Lab

17.–18.1., 12.–13.9., 25.–27.11.2013: research visit: Dr Mauno Rönkkö (UEF)

Host: DS Lab

3.1.4 TISRA – Turku Information Systems Research Alliance

Research area

The TISRA research programme combines the university resources of Information Systems Science in Turku to a critical mass of research resources. The research programme is focused on several themes of Information Systems Science:

- Soft Computing with approximate reasoning, real options, multiple criteria optimisation and logistics optimisation (Christer Carlsson, Robert Fullér, Mario Fedrizzi, Kaj-Mikael Björk, Matteo Brunelli, Markku Heikkilä, Jozsef Mezei),
- ICT-management and -governance including governance of data and information (Tomi Dahlberg, Jukka Heikkilä, Hannu Salmela, Reima Suomi),
- Mobile value services (Pirkko Walden, Harry Bouwman, Christer Carlsson, Ville Harkke, Yong Liu, Anna Sell),
- Networked business and business models (Harry Bouwman, Jukka Heikkilä, Hannu Salmela, Pirkko Walden),
- Systems Sciences (Christer Carlsson),
- Work Informatics (Jukka Heikkilä),
- Healthcare information systems (Reima Suomi), and
- Information Systems research methodologies development (all).

Programme leader

Christer Carlsson and Jukka Heikkilä

Participating TUCS Research Units

- Institute for Advanced Management Systems Research – IAMSR
- UTU Information Systems Science – ISSR

External partners

- ECSC (European Centre for Soft Computing); Christer Carlsson
- ERCIS (European Research Center for Information Systems); Reima Suomi
- eBEREA (eBusiness education and Research in Europe and Asia); Jukka Heikkilä
- eBEREA IRSES (Marie Curie researcher exchange program); Jukka Heikkilä
- CIOALS (CIO-Academy LEarning Society); Jukka Heikkilä, Hannu Salmela & Tomi Dahlberg
- Technical University of Delft; Christer Carlsson, Harry Bouwman, Pirkko Walden
- University of Trento; Christer Carlsson, Mario Fedrizzi
- Obuda University, Budapest; Christer Carlsson
- Tampere University of Technology CIOALS ally; Samuli Pekkola
- International Academy of CIO (with Waseda, application pending, decision in June, 2012)

Steering group

Chair: Jukka Heikkilä

Harry Bouwman, Christer Carlsson, Tomi Dahlberg, Mike Newman, Hannu Salmela, Reima Suomi and Pirkko Walden

Activities

17.1.–23.5.2013 TISRA Postgrad Seminars Spring 2013

13.12.2013 A seminar at the Naantali Spa

3.2 TUCS Research Units

The research at TUCS is carried out through a number of research units. The units have a specific research focus and their status as a TUCS Research Unit is confirmed by the TUCS board for a period of three years. The current list of Research Units, approved for the period of 2012–2014 is:

- Algorithmics and Computational Intelligence Group (ACI)
    - Leaders: Jukka Heikkonen and Olli Nevalainen
- Biomathematics Research Unit (BIOMATH)
    - Leader: Kalle Parvinen
- Turku BioNLP Group
    - Leader: Tapio Salakoski
- Computational Biomodeling Laboratory (Combio Lab)
    - Leader: Ion Petre
- Communication Systems (ComSys)
    - Leader: Jouni Isoaho
- Data Mining and Knowledge Management Laboratory
    - Leaders: Barbro Back and Tomas Eklund
- Distributed Systems Laboratory (DS Lab)
    - Leaders: Kaisa Sere, Elena Troubitsyna and Marina Waldén
- Embedded Computer and Electronic Systems (ECES)
    - Leader: Juha Plosila
- Embedded Systems Laboratory (ESLAB)
    - Leader: Johan Lilius
- FUNDIM, Fundamentals of Computing and Discrete Mathematics
    - Leader: Juhani Karhumäki
- Institute for Advanced Management Systems Research (IAMSR)
    - Leaders: Christer Carlsson and Pirkko Walden
- Learning and Reasoning Lab
    - Leaders: Ralph-Johan Back and Tapio Salakoski
- Software Engineering Laboratory (SE Lab)
    - Leaders: Ivan Porres and Jan Westerholm
- Software Construction Laboratorium
    - Leader: Ralph-Johan Back
- Software Development Laboratory (SwDev)
    - Leader: Ville Leppänen
- Turku Optimization Group (TOpGroup)
    - Leader: Marko M. Mäkelä
- UTU Information Systems Science (ISSR)
    - Leader: Timo Leino

3.3 TUCS Distinguished Lecture Series

The TUCS TUCS Distinguished Lecture Series is a forum for public lectures by outstanding national and international researchers in all aspects of computing, coming both from academia and industry. All lectures are free and open to the public. In 2013 the lectures attracted an average of 100 attendants each.

Lectures in 2013:

26.2.2013: Kaj Arnö (SkySQL AB, Finland), "World class IT from Finland: Lessons from MySQL AB"

Abstract: Why does Linux, MySQL, IRC, ssh and other world-class Open Source software originate from Finland? Is there something special about Finnish IT know-how, attitudes, values -- and if so, what? Does Finland have a specific academic atmosphere that forms the background to Finnish IT successes? In his presentation, Kaj shares some lessons from the MySQL AB saga, including his views on the role of social media in technology development. What is the take-away of MySQL AB for today's students, when planning for the future?

Biography: Kaj Arnö is a serial entrepreneur and was part of the core team behind MySQL AB, the Scandinavian IT company which was sold for a billion dollars to Sun Microsystems in 2008. Kaj joined the management team in 2001, and served as VP of Services, VP of Engineering and VP of Community Relations. Kaj stayed with Sun as MySQL Ambassador and when Oracle bought Sun, he co-founded SkySQL Ab, leading Marketing and Engineering as Executive VP Products. Beyond IT, Kaj has held speeches and blogged in over a dozen languages and pioneered a number of Social Media communities in Finland. He is a business publication columnist, photographer, climber, kayaker, mountain biker and seven time marathon runner, spreading his running philosophy as "Runnism, the religion of running". Kaj has been based in Munich, Germany since 2006.

10.6.2013: Christos Papadimitriou (University of California at Berkeley, USA), *"Computational Insights and the Theory of Evolution"*

Abstract: Covertly computational insights have influenced the Theory of Evolution from the very start. I shall discuss recent work on some central problems in Evolution that was inspired and informed by computational ideas. Considerations about the performance of genetic algorithms led to a novel theory of the role of sex in Evolution based on the concept of mixability, while the population genetic equations describing the evolution of a species can be reinterpreted, under the neutral theory, as a repeated game between genes played through the multiplicative updates algorithm.

27.9.2013: Jan van Leeuwen (University of Utrecth, the Netherlands), *"What is Computation?"*

Abstract: Various new ideas have developed lately about computation. Do we actually know what it is, despite what Turing told us? Are ‘abstract state machines’ the answer? Do Valiant's ecorithms count as computation? We will survey a number of issues in the Philosophy of Computing and present a new, epistemological view of computation that may radically change our understanding of computational processes (joint research with J. Wiedermann). What are the challenges for computer science?

25.10.2013: Axel Jantsch (KTH, Sweden), "The Rise and Fall of System-on-Chip: Driving Concepts and Trends in the Field of Integrated Circuits Between 1990 and 2020"

4. Reports of the TUCS Research Units

4.1 Algorithmics and Computational Intelligence Group (ACI)

The research of the laboratory is centered around techniques and methods for algorithm design and computational intelligence, with the emphasis on both theory and applications. The foundations of the research are discrete mathematics, probabilistic inference, and theoretical computer science. In particular, the research of probabilistic and information-theoretical modeling, combinatorial algorithms, parallel algorithms, intelligent systems, Bayesian analysis, and algorithms for computer games has been pursued. The laboratory is based on the long tradition of active co-operation with companies and academic partners on solving real-life problems by the use of combinatorial optimization and latest techniques on software development and computational intelligence methods. The following key areas are covered:

- Computational intelligence
- Combinatorial algorithms and applications
- Information theory
- Learning and intelligent systems
- Data compression
- String algorithms
- Information retrieval
- Industrial algorithms
- Constraint programming
- Routing problems in parallel systems
- Clustering methods
- Analysis of biomedical signals
- Computer games
- Embedded algorithms
- Cross-validation methods
- Preference learning and ranking
- Feature selection

Leader of the unit

Jukka Heikkonen and Olli Nevalainen

Senior Researchers

Lassi Bergroth, Stefan Emet, Timo Knuutila, Ville Leppänen, Tapio Pahikkala, Csaba Raduly-Baka, Jussi Salmi, Jouni Smed and Jukka Teuhola

Projects

- Optimization of the control of component assembly in printed circuit board manufacturing systems
- Minimum description length and stochastic complexity
- Probabilistic modeling and Bayesian analysis with applications
- Neural networks, theory and applications
- Data analysis in proteomics

- PET image analysis
- Compression of media data

Publications

Heta Mattila, Pertti Valli, Tapio Pahikkala, Jukka Teuhola, Olli S. Nevalainen, Esa Tyystjärvi, Comparison of Chlorophyll Fluorescence Curves and Texture Analysis for Automatic Plant Identification. Precision Agriculture 14(6), 621–636, 2013.

Sebastian Okser, Tapio Pahikkala, Tero Aittokallio, Genetic Variants and Their Interactions in Disease Risk Prediction - Machine Learning and Network Perspectives. Biodata Mining 6, 1–15, 2013.

Tapio Pahikkala, Antti Airola, Michiel Stock, Bernard De Baets, Willem Waegeman, Efficient Regularized Least-Squares Algorithms for Conditional Ranking on Relational Data. Machine Learning 93(2-3), 321–356, 2013.

Antti Airola, Tapio Pahikkala, Heljä Lundgrén-Laine, Anne Santalahti, Päivi Rautava, Sanna Salanterä, Tapio Salakoski, A Machine Learning Approach Towards Early Detection of Frequent Health Care Users. In: Hanna Suominen (Ed.), Proceedings of the 4th International Louhi Workshop on Health Document Text Mining and Information Analysis, National ICT Australia, 2013.

Fabian Gieseke, Tapio Pahikkala, Christian Igel, Polynomial Runtime Bounds for Fixed-Rank Unsupervised Least-Squares Classification. In: Cheng Soon Ong, Tu Bao Ho (Eds.), Proceedings of the 5th Asian Conference on Machine Learning, JMLR Workshop and Conference Proceedings 29, 62–71, Journal of Machine Learning Research, 2013.

4.2 Biomathematics Research Unit (BIOMATH)

Mathematical modelling methods and computing have become increasingly important in almost all branches of biology. For example, the dynamical consequences of even quite simple ecological interactions or physiological mechanisms are impossible to understand without mathematical modelling and analysis. Evolutionary problems are often analysed in theoretical models for the prohibitively long time scales involved. Abundance of data also calls for mathematical modelling: The rapidly developing experimental techniques of molecular biology and genetics produce a large amount of data, which need efficient algorithms to be handled.

The biomathematics research group does research in many diverse fields of Mathematical Biology. The projects lead by Kalle Parvinen are concentrated on modelling various phenomena occurring between individuals, covering topics such as mathematical ecology, especially metapopulation dynamics, and adaptive dynamics, mathematical evolutionary ecology. Projects lead by Tero Aittokallio model phenomena occurring within individuals, covering topics like modelling of physiological phenomena, analysis of biomedical signals, protein structure research, and computational systems biology.

Modelling and analysis in the above mentioned areas utilise the theory of dynamical systems, delayed differential equations, partial differential equations, functional analysis, graph theory, digital signal processing, statistical modelling and data mining methods, etc.

Research Unit Web Page: http://www.math.utu.fi/en/research/.groups/bio/index.html

Leader of the unit

Kalle Parvinen

Senior Researchers

Kalle Parvinen, Tero Aittokallio and Laura Elo-Uhlgren

Doctoral Students

Marja Heiskanen, Teemu Daniel Laajala, Tuomas Nurmi, Sebastian Okser, Anne Seppänen and Johannes Tuikkala

Projects

Theory of adaptive dynamics

http://www.math.utu.fi/en/research/groups/bio/projects/addyn.html

In the last decades, the evolutionarily stable strategy (ESS) has become the main modeling tool for predicting the outcome of long-term evolution. The main disadvantage of the ESS is that it is a static concept, so that it always still remains to be seen whether an ESS can actually be reached. The Adaptive Dynamics framework developed by Metz et al. (1996) and Geritz et al. (1997, 1998) can be seen as the dynamic extension of ESS-theory and provides conceptual and mathematical tools for modeling long term evolution as a dynamic process in phenotype-space.

The theory of adaptive dynamics explicitly links population dynamics to long-term evolution by natural selection. A population is represented by the set of strategies present in positive numbers, and evolution is modelled as a sequence of such sets. The transition from one set to the next is caused by a new mutant strategy invading the population from initially small numbers, and possibly by the elimination of one or more strategies that were present in the population but are driven to extinction by the invading mutant. The approach is based on a number of simplifying assumptions, to wit clonal reproduction, small mutational steps and separate time scales for ecological and evolutionary dynamics. The combination of these assumptions allows to build tractable models for evolution also in complex ecological scenarios.

One of the most exciting phenomena uncovered by adaptive dynamics is evolutionary branching, whereby a single strategy splits into two diverging lineages. Evolutionary branching is possible near specific points in strategy space, where an invading mutant can coexist with the original strategy, and the two, initially very similar, strategies become increasingly distinct from one another while intermediate strategies are eliminated. Evolutionary branching is reminiscent of speciation and highlight the ecological conditions that favour the origin of new species.

The general framework of adaptive dynamics has been applied to many different ecological models in order to investigate evolution under specific ecological circumstances. Applications concern resource competition, interference competition, predation, host- parasite systems, cannibalism, mutualism, temporally stochastic and spatially heterogeneous environments, such as metapopulations, altruism, sexual selection, sex determination, mating systems, microbial ecology, etc.

There are many open questions in the general theory of adaptive dynamics. We are especially interested in the following topics:

Adaptive dynamics of function-valued traits

Presently, the theory of adaptive dynamics is best developed for one-dimensional strategies (i.e., the evolution of one continuous trait such as body size, etc.). In many situations it is more realistic to consider function-valued traits, which naturally arise in a great variety of settings: variable or heterogeneous environments, age-structured populations, phenotypic plasticity, patterns of growth and form, resource gradients, and in many other areas of evolutionary ecology. We want to further develop methods for finding and analysing function-valued singular strategies.

Member involved: Kalle Parvinen

Collaborators: Ulf Dieckmann (IIASA, Austria), Mikko Heino (Bergen, Norway)

Evolutionary suicide

Many species that once lived on earth have gone extinct. A common explanation of such extinctions is that species have been unable to adapt to a rapid change in their environment. However, an alternative explanation exists: In some cases, even though the species in question could have persisted had it not changed its strategy, natural selection forces it to evolve, resulting in extinction. This phenomenon is known as evolutionary suicide. We want to understand better the theory and reasons behind this phenomenon, and to provide tools for management.

Member involved: Kalle Parvinen

Collaborator: Ulf Dieckmann (IIASA, Austria)

Adaptive dynamics in metapopulations

http://www.math.utu.fi/en/research/groups/bio/projects/admetapop.html

In "The Origin of Species" Darwin (1859) explained the unexpectedly wide geographical distribution of certain fresh-water species, by "...their having become fitted, in a manner highly useful to them, to short frequent migrations from pond to pond, or from stream to stream." It is clear from this quote that Darwin realized that dispersal is a life-history trait which is under selection and the change of which may have profound ecological implications. He also came very close to a verbal description of what is today known as a metapopulation. In general, a metapopulation is a population of local populations living in discrete habitat patches. By contrast, ordinary population models deal with homogeneous populations living in one habitat, and spatial structure has been neglected. As most natural populations have a hierarchical structure with several local populations, metapopulation models have a great potential of application to many types of biological systems.

Dispersal and local adaptation (specialization)

There are many ecological mechanisms which make dispersal advantageous. In a small local population, most individuals are related and therefore compete for resources among their own kin. By dispersing, an individual can avoid kin competition. Dispersal can also be seen as risk spreading. In case random catastrophes occur in the local populations, a non-dispersing species will eventually go extinct. A dispersing species can, however, be saved from such random extinction. Also if the local environment that individuals experience fluctuates in time, individuals may escape bad seasons by dispersing. There are also mechanisms making dispersal less advantageous. Dispersal often requires extra energy, which cannot be used for reproduction. Dispersal can also increases mortality risks. Also for an individual, which has specialized to the local environment, dispersing to a different environment is probably not beneficial, because by dispersing the individual may very well end up in a patch type to which it is not adapted. For a generalist individual, who performs reasonably well in all local environments, the benefit of dispersing is quite different.

As dispersal is a key trait in metapopulations, the evolution of dispersal has received a lot of interest, also among our group. Much of the literature is based on unstructured models without realistic local population growth and/or without catastrophes resulting in extinction of local populations. Including such phenomena is possible with structured metapopulation models, and therefore the group has studied them intensively. Also there is a lot of literature about the evolution of specialization. It is clear that these two life-history traits have a strong effect on the benefit of the other. However, there is only a very limited amount of research done about the co-evolution of dispersal and local adaptation, which is a target of the project. This work is needed in order to understand the dispersal and adaptation behaviour of different species observed in the nature.

Members involved: Kalle Parvinen and Tuomas Nurmi

Modelling the American pika metapopulation

The American pika (Ochotona princeps) has become a model organism in the study of vertebrate population dynamics and life history evolution. Throughout their natural range in the Rocky Mountains and Sierra Nevada, pika populations are variously structured, from large, nearly

contiguous talus habitats along portions of the Sierra Nevada crest, to almost perfect classical metapopulations, like that at Bodie, California. By using various metapopulation models, we want to understand how global climate change will affect the ecology and evolution of pikas.

Members involved: Kalle Parvinen and Anne Seppänen

Collaborator: John D. Nagy, Arizona, USA

Funding: Academy of Finland, project 128323

Data Mining and Modelling

http://www.btk.fi/research/affiliated-groups/aittokallio-tero-data-mining-and-modelling/

The large number of components together with high technical and biological variability can make it difficult to extract pertinent biological information from the background noise. This has increased the need for computational models and tools that can efficiently integrate, visualize and analyze the experimental data so that meaningful interpretations can be made. The eventual aim is to model and explain the observations as a dynamic interaction of key molecular components and mechanisms controlling the underlying system.

The data mining protocols developed by the group so far cover a wide range of high-throughput biotechnologies, including gene and exon microarrays (cDNA, Affymetrix and Illumina platforms) for global gene expression profiling, together with RNA interference (RNAi) and chromatin immunoprecipitation (ChIP) studies (ChIP-chip and ChIP-seq) for monitoring transcriptional regulation on a global scale, as well as mass-spectrometry (MS)-based assays for large-scale proteomic studies. One of the most important computational challenges is to take full advantage of all the accumulated data, both from own laboratory and from public repositories, to obtain a comprehensive view of the system under study.

We are developing data integration and data-driven optimization approaches that can effectively correct for the technical variation characteristic to various experimental platforms, and hence improve the comparability of different experiments, identification of differentially expressed genes and proteins, and inference of their interaction partners in global cellular networks. An integrative network-based modeling approach can provide robust and unbiased means to reveal the key molecular mechanisms behind the systems behavior and to predict its response to various perturbations. In clinically-oriented research, the modeling approach has the potential to improve our understanding of the disease pathogenesis and help us to identify novel molecular markers for pharmaceutical or diagnostics applications.

Members involved: Tero Aittokallio, Laura Elo-Uhlgren, Marja Heiskanen, Teemu Daniel Laajala, Sebastian Okser, Johannes Tuikkala

Collaborators: Riitta Lahesmaa (Turku Centre for Biotechnology), Tuula Nyman (University of Helsinki), Matej Oresic (VTT Biotechnology), Benno Schwikowski (Pasteur Institute, Paris), Mats Gyllenberg (University of Helsinki), Esa Uusipaikka (University of Turku), Timo Koski (Royal Institute of Technology, Stockholm), Jan Westerholm (Åbo Akademi University), Mauno Vihinen (University of Tampere), Samuel Kaski (Helsinki University of Technology), Esa Tyystjärvi (University of Turku), Eija Korpelainen (CSC - IT Center for Science).

Network-based modelling of human disease development

The objective of the present project is to construct cellular networks using data from high-throughput functional genomics and proteomics experiments and to develop computational tools for analysing their topological and dynamical properties. To aid the biological interpretation of the massive datasets, the key players and their relationships in complex human cellular processes are identified. The reliability of the computational predictions is improved by combining all available data measured at multiple levels of the system. Of particular interest are those network properties that can dissect between various cellular states or different phenotypes. In addition to graph theory, the research will benefit from the well-grounded methods and concepts from statistical modelling, information theory, optimization and pattern recognition. The particular biomedical goal of the present project is to characterise the development of diabetes-associated autoimmunity and clinical Type 1 diabetes (T1D) in the context of the multidisciplinary DIPP project (Type 1 Diabetes

Predition and Prevention Project in Finland). Understanding of the hierarchy and regulation of molecular components involved in T1D progression can provide a better basis for developing diagnostic tools and early therapies. The computational predictions serve as a basis for further experimental studies, aiming at elucidating the underlying mechanisms in more detail.

Members involved: Laura Elo-Uhlgren

Main collaborators: Benno Schwikowski (Pasteur Institute, Paris), Riitta Lahesmaa (Turku Centre for Biotechnology)

Funding: Academy of Finland, projects 127575 and 218591

Multilevel modelling of cellular processes

http://www.math.utu.fi/en/research/groups/bio/projects/cell.html

The objective of the research is to develop a multilevel modelling framework for understanding the dynamic behaviour of cellular processes at systems-level, rather than investigating snapshots of individual genes, proteins or pathways separately. High-throughput experimental technologies are increasingly being used to illuminate the molecular mechanisms involved in the control of cellular systems in various conditions. However, interpretation of the resulting lists of genes or proteins remains a labour-intensive and error-prone task, because listing the individual elements alone can provide only a limited insight into the multitude of biological processes these elements participate in under different conditions and time-points. To facilitate distinguishing elements directly involved in a particular process from bystander elements, whose expression have been altered by secondary effects or technical artefacts, the experimental measurements can be mapped onto a global interaction networks that represent all the pertinent elements and their connections in the particular system. Due to the complexity of many biological processes, however, there is a great need for mathematical modelling and computational methods to integrate the system-level measurements and explain them as an interaction of key components and mechanisms regulating the system.

The appropriate description level of the models is strongly dependent on the experimental data and biological knowledge available as well as on the specific goals of the analysis. For instance, while detailed signalling models based e.g. on differential equations provide us a means of understanding the dynamic behaviour of the system and predicting its response to perturbations, extrapolating the standard kinetic models, which describe a single gene in one signalling pathway, to a larger system involving thousands of components and multitude of interacting pathways would render the model prohibitively complicated. Moreover, many cellular mechanisms and regulatory rules are still poorly understood, especially in higher organisms like humans, complicating such modeling work. Coarsegrained graph models, on the other hand, can efficiently provide us with valuable information about the global systems behaviour and modular organization by revealing dependence relationships among the experimental measurements and their contribution to the cellular processes of interest. Gradual focusing into the relevant and active sub-systems is an important prerequisite when eventually moving towards mechanistic modelling of the particular processes.

The multilevel modelling framework is organized through the following steps. After system manipulation (A), a set of high-throughput measurements, e.g. gene and/or protein expression patterns (B), are integrated and analysed together with global interaction networks connecting relevant components of the system. The next challenging problem concerns the dissection of the network into functional modules (C), i.e. groups of physically or functionally connected elements that work together to achieve the cellular functions of interest. These sub-systems can then be used as starting points for kinetic modelling and simulations studies (D), with the aim to define regulatory mechanisms most important for the particular process. The model predictions can finally be applied to distinguishing biomedical phenotypes or suggesting novel targets and their interactions (E), which are testable by subsequent experimentation. When applied to the system-level experimental data for human cell biology, that are becoming available at an increasing rate, such a predictive modelling approach can be used for identifying key players and their dynamic relationships responsible for multi-factorial behaviour in complex human disease networks, with the

aim to provide systematic strategies to the identification of novel diagnostic and pharmaceutical targets for early detection and treatment of the diseases.

Members involved: Tero Aittokallio, Laura Elo-Uhlgren, Marja Heiskanen, Teemu Daniel Laajala, Sebastian Okser, Johannes Tuikkala

Collaborators:

Samuel Kaski (Department of Information and Computer Science, Helsinki University of Technology)

Eija Korpelainen (CSC – National IT Center for Science Ltd, Espoo)

Timo Koski (Department of Mathematics, Royal Institute of Technology, Stockholm)

Riitta Lahesmaa (Turku Centre for Biotechnology, University of Turku)

Olli Nevalainen (Department of Information Technology, University of Turku)

Tuula Nyman (Institute of Biotechnology, University of Helsinki)

Matej Orešic (Quantitative Biology and Bioinformatics, VTT Biotechnology)

Benno Schwikowski (Systems Biology Laboratory, Pasteur Institute, Paris)

Esa Tyystjärvi (Department of Biochemistry and Food Chemistry, University of Turku)

Esa Uusipaikka (Department of Statistics, University of Turku)

Mauno Vihinen (Institute of Medical Technology, University of Tampere)

Jan Westerholm (Department of Information Technologies, Åbo Akademi University)

Publications

Etsuko Nonaka, Kalle Parvinen, Åke Brännström, Evolutionary Suicide as a Consequence of Runaway Selection for Greater Aggregation Tendency. Journal of Theoretical Biology 317(21), 96–104, 2013.

Sebastian Okser, Antti Airola, Tapio Salakoski, Tero Aittokallio, Tapio Pahikkala, Parallel Feature Selection for Regularized Least-Squares. In: Pekka Manninen, Per Öster (Eds.), Applied Parallel and Scientific Computing, Lecture Notes in Computer Science 7782, 280–294, Springer, 2013.

4.3 Turku BioNLP Group

The Turku BioNLP Group is a group of researchers at the Department of Information technology at the University of Turku as well as the Turku Centre for Computer Science (TUCS) graduate school. The main focus of our research are various aspects of Natural Language Processing, ranging from corpus annotation to machine learning theory and applications. The main application area we've been focusing on is the domain of biological, biomedical, and clinical text.

Research Unit Web Page: http://bionlp.utu.fi/

Leader of the unit

Tapio Salakoski

Researchers

Jorma Boberg, Filip Ginter, Tapio Pahikkala, Antti Airola and Veronika Laippala

Doctoral Students

Jari Björne, Katri Haverinen, Juho Heimonen and Suwisa Kaewphan

Projects

BioInfer

We have created the BioInfer corpus to support the development of IE systems in the biomedical domain. The project has its own webpage http://mars.cs.utu.fi/BioInfer/ where you can find the corpus as well as the software relevant to it.

PPI Corpora

We have created and released a conversion software for five well-known protein-protein interaction corpora (AIMed, BioInfer, LLL, IEPA, and HPRD50) into a shared XML-based format. This project has its own webpage http://mars.cs.utu.fi/PPICorpora/ where you can find the software as well as a pre-processed release of BioInfer.

Ikitik

The aim of IKITIK is to support producing and using health information and communication by developing innovative, intelligent, state-of-the-art clinical information and language technology solutions. They are based on end-user needs and will be carefully tested using both statistical techniques and genuine end-user feedback. To assure their quality, international applicability, practical relevance and interoperability with existing electronic patient information systems, solutions are developed in interdisciplinary and international collaboration of care providers, clinical documentation and decision-making experts, as well as information and communication technology developers and providers. Outcomes contribute to clarity, understandability and accessibility of patient narratives. This has positive impacts on patient safety, care quality, and efficiency and profitability of health care services. Further, improved patient narratives emphasize customer orientation and individualized care. (http://www.ikitik.fi/?q=en%2Fnode%2F5)

RLScore

RLScore is a Regularized Least-Squares (RLS) based machine learning package. It contains implementations of the RLS and RankRLS learners allowing the optimization of performance measures for the tasks of regression, ranking and classification. Implementations of efficient cross-validation algorithms are integrated to the package, combined together with functionality for fast parallel learning of multiple outputs. (http://www.tucs.fi/RLScore/)

Turku Dependency Treebank

We are building a broad-coverage dependency-annotated treebank of general Finnish. The treebank is annotated in a minor revision of the Stanford dependency scheme (de Marneffe et al. [1,2]). The primary purpose of the treebank is to support Finnish NLP.

Turku Clinical Corpus

We have developed a dependency-annotated treebank of Finnish Intensive Care Nursing Narratives. The treebank is annotated in a minor revision of the Stanford dependency scheme (de Marneffe et al.). A PropBank-style predicate argument annotation is built on top of the syntactic annotation, covering 90% of all verb occurrences in the corpus. The argument annotation is tightly bound to the syntax, requiring arguments to be governed by the verb.

Biological Event Extraction

This project concerns the extraction from text of biomolecular events, which are recursively nested, typed associations of arbitrarily many participants (genes / gene products) in specific roles

Publications

Predrag Radivojac, Wyatt T. Clark, Tal Ronnen Oron, Alexandra M. Schnoes, Tobias Wittkop Wittkop, Artem Sokolov, Kiley Graim, Christopher Funk, Karin Verspoor, Asa Ben-Hur, Gaurav Pandey, Jeffrey M. Yunes, Ameet S. Talwalkar, Susanna Repo, Michael L. Souza, Damiano Piovesan, Rita Casadio, Zheng Wang, Jianlin Cheng, Hai Fang, Julian Gough, Patrik Koskinen, Petri Törönen, Jussi Nokso-Koivisto, Liisa Holm, Domenico Cozzetto, Daniel W. A. Buchan, Kevin Bryson, David T. Jones, Bhakt Limave, Harshal Inamdar, Avik Datta, Sunitha K. Manjari, Rajendra Joshi, Meghana Chitale, Daisuke Kihara, Andreas M. Lisewski, Serkan Erdin, Eric Venner, Olivier Lichtarge, Robert Rentzsch, Haixuan Yang, Alfonso E. Romero, Prajwal Bhat, Alberto Paccanaro, Tobias Hamp, Rebecca Kaßner, Stefan Seemayer, Esmeralda Vicedo, Christian Schaefer, Dominik Achten, Florian Auer, Ariane Boehm, Tatjana Braun, Maximilian Hecht, Mark Heron, Peter Hönigschmid, Thomas A. Hopf, Stefanie Kaufmann, Michael Kiening, Denis Krompass, Cedric Landerer, Yannick Mahlich, Manfred Roos, Jari Björne, Tapio Salakoski, Andrew Wong, Hagit Shatkay, Fanny Gatzmann, Ingolf Sommer, Mark N. Wass, Michael J. E. Sternberg, Nives Škunca, Fran Supek, Matko Bošnjak, Panče Panov, Sašo Džeroski, Tomislav Šmuc, Yiannis A. I. Kourmpetis, Aalt D. J. van Dijk, Cajo J. F. ter Braak, Yuanpeng Zhou, Qingtian Gong, Xinran Dong, Weidong Tian, Marco Falda, Paolo Fontana, Enrico Lavezzo, Barbara Di Camillo, Stefano Toppo, Liang Lan, Nemanja Djuric, Yuhong Guo, Slobodan Vucetic Vucetic, Amos Bairoch, Michal Linial, Patricia C. Babbitt, Steven E. Brenner, Christine Orengo, Burkhard Rost, Sean D. Mooney, Iddo Friedberg, A Large-Scale Evaluation of Computational Protein Function Prediction. Nature methods 10, 221–227, 2013.

Jyrki Tuomainen, Janne Savela, Jonas Obleser, Olli Aaltonen, Attention Modulates the Use of Spectral Attributes in Vowel Discrimination: Behavioral and Event-Related Potential Evidence. Brain Research1940, 170–183, 2013.

Antti Airola, Tapio Pahikkala, Heljä Lundgrén-Laine, Anne Santalahti, Päivi Rautava, Sanna Salanterä, Tapio Salakoski, A Machine Learning Approach Towards Early Detection of Frequent Health Care Users. In: Hanna Suominen (Ed.), Proceedings of the 4th International Louhi Workshop on Health Document Text Mining and Information Analysis, –, National ICT Australia, 2013.

Katri Haverinen, Veronika Laippala, Samuel Kohonen, Anna Missilä, Jenna Nyblom, Stina Ojala, Timo Viljanen, Tapio Salakoski, Filip Ginter, Towards a Dependency-based PropBank of General Finnish. In: Stephan Oepen, Kristin Hagen, Janne Bondi Johannesse (Eds.), Proceedings of the 19th Nordic Conference of Computational Linguistics (NODALIDA 2013), NEALT Proceedings Series 16, 41–57, Linköping University Electronic Press, 2013.

Veronika Laippala, Timo Viljanen, Antti Airola, Jenna Nyblom, Sanna Salanterä, Tapio Salakoski, Filip Ginter, Statistical Parsing of Varieties of Clinical Finnish. In: Hanna Suominen (Ed.), Proceedings of the 4th International Louhi Workshop on Health Document Text Mining and Information Analysis, 1–6, National ICT Australia, 2013.

Katri Haverinen, Syntax Annotation Guidelines for the Turku Dependency Treebank - 2nd edition, revised for the treebank release of July 2013. TUCS Technical Reports 1034, TUCS, 2013.

4.4 Computational Biomodeling Laboratory (Combio Lab)

The research of the laboratory centers on computational methods for modeling biochemical systems. The general interest of the laboratory is gaining an understanding of the fundamental computational and information-processing principles behind the functioning of bio-systems. We have considerable expertise in building discrete models, based on combinatorics, graph theory, and stochastic processes. We are also experts in evaluating such models against experimental data, discovering their control structure, quantitative model comparison and quantitative model refinement.

The laboratory has hosted in the last 6 years 8 postdoctoral students and has graduated 3 TUCS PhD students, 2 of them receiving their degrees with honors.

The scientific volume of the unit has been consistently very good, both in quality and in quantity. The laboratory is actively involved in the editorial boards of several journals and the program committees of the most relevant conference in its field of research.

Research Unit Web Page: http://combio.abo.fi/

Leader of the unit

Ion Petre

Postdoctoral researchers

Vladimir Rogojin, Cristian Gratie, Anne Seppänen andDwitiya Tyagi

Doctoral Students

Bogdan Iancu, Sepinoud Azimi, Diana-Elena Gratie and Charmi Panchal

Undergraduate Students

Romina Paturca

Projects

Network Controllability

Networks are all around us. The first example crossing one's mind might be the World Wide Web, but probably not the only one. Our world is full of social structures, networks, where individuals are connected with each other by different means such as mobile phones or transportation. A network can be represented by nodes and by edges, where edges describe connections between the nodes. Imagine airports with flight connections. There is continuous flow of people travelling through the cities, and the biggest airports are the system hubs. Networks can also be microscopic, for example metabolic networks or gene regulatory networks in a cell. Common to all is that the state of the system typically changes with time. Hence, we call them dynamic networks. With many systems, it would be in our interest to steer them or even control them toward some desired state. However, this has turned out to be a very challenging task.

Within this project we aim to better understand the fundamental principles of network controllability. We develop novel and extend the existing methods on controlling networks. In particular, we are interested in large and complex biological networks, which are extremely difficult to control. Therefore, parallel to full control we are investigating also how such systems could be controlled partially. This kind of approach might, indeed, enable many practical applications, which otherwise would be infeasible simply from engineering perspective.

We exploit the control principles in order to predict the best way to engineer the networks, which we aim to control. In particular, we apply the methodology to two biological systems, cancer and renewable energy production. Malignant growth tends to arise when there is 'too much energy in a system'. Hence, controlling cancer would mean steering the tumor towards non-growing state. Our ambition is to re-program cancer networks by identifying cell's own pathogenic addictions and other vulnerabilities. Multi-targeting those identified nodes can improve anti-cancer therapeutics. In renewable energy production we optimize the metabolic flux to obtain maximal fuel yield. While the practical goals with energy aspect are rather opposite, the ultimate goal in both systems is to be able to control them. Obviously, the generic approaches and tools can be used in other applications. They also serve as a complement to traditional micro-scale engineering.

Funding instrument: Academy of Finland, Synthetic Biology Programme (FinSynBio) 2013-2017.

Quantitative model refinement

Much effort is currently invested in developing larger, more finely-grained computational models in many branches of science, supported by developments in computing infrastructure and by advances in quantitative experimental measuring techniques. This is supported by developments in the computing infrastructure and by advances in quantitative experimental techniques.

We focus in this project on computational techniques allowing the quantitative refinement of a model without altering its numerical fit and validation. Our research addresses two main problems in the design of mathematical models in systems biology: (i) the quantitative fit and validation of a large model is a computationally difficult problem; (ii) changing a model (e.g., adding details to it) implies redoing the work on the numerical fit and validation of the model. Our proposed methodology builds on the expertise gained in computer science in (qualitative) program refinement, extending it in a fundamental way to the realm of quantitative biomodels.

Funding instrument: Academy of Finland 2013-2017.

Quantitative modeling of protein self-assembly

In our research we concentrate on the process of in vitro self-assembly of intermediate filaments from tetrameric vimentin. We investigate different plausible strategies for filament elongation through mathematical modelling, model fitting, model validation and sensitivity analysis. In the assessment of the potential variants the focus is on properties such as scalability, robustness and ability to explain experimental data. This systematic approach enables the formulation of certain hypotheses about how the still little-known process of filament self-assembly is executed. Based on this hypotheses future biological experiments that would verify them are proposed.

Boolean and multi-value logic for biological network analysis

The aim is to develop a methodology for the functional analysis of biological networks with a focus on describing the contribution of their various modules to the global quantitative behavior of the networks. The formalism we develop aims to describe how a (quantitative) property of a biological network in terms of combinations of modules being knocked-in or –our (through Boolean logic) or in terms of combination of different levels of activity for the modules (through multi-valued logic). The approach is highly relevant for reverse engineering of biological networks, in an effort to identify their functional motifs, as well as for synthetic biology, for engineering a desired behavior from a given library of modules. Our analysis will first consider two case studies: (i) EGFR (Epidermal growth factor receptor) signaling pathway which is essential for normal cell growth and development; (ii) a computational platform for high-throughput vaccine development.

Computational gene assembly

The process of gene assembly has the attention of the Biocomputing community for several years already. It is by now clear that the process of gene assembly in ciliates is highly computational: it turns out that ciliates "know" one of the basic data structures of Computer Science - the linked list - and use it in a very elegant pattern matching manner in the process of gene assembly! We are investigating a set of three molecular operations that accomplishes the gene assembly through the "fold and recombine" paradigm. We introduced the mathematical model of pointer reduction systems to formalize the micronuclear gene patterns (through permutations, strings and graphs) and the gene assembly process. Our investigation of these systems resulted in a uniform explanation of all known experimental results concerning gene assembly in ciliates.

Computational modelling with reaction systems

A biochemical network consists of a great number of reactions that cooperate with one another with the fundamental goal of keeping the cell alive. Reaction systems consider only two possible regulatory mechanisms: facilitation and inhibition. A biochemical reaction concerns a finite set of reactants provided that all the reactants involved in that particular reaction are present in a given state and all of its inhibitors are absent. We demonstrate that reaction systems are rich enough to capture the essential characteristics of quantitative models (e.g., ODE-based models) and also show the expressive power of reaction systems when dealing with wide range of problems from biology to computer science (e.g., exact pattern matching in strings). Our aim is also to introduce a

methodology that enables us to translate a quantitative model to a qualitative reaction system based one without losing any essential characteristics of the former one.

Publications

Proceedings of the Fourth International Workshop on Computational Models for Cell Processes, EPTCS 116, EPTCS, 2013.

Riku Louhimo, Marko Laakso, Tuomas Heikkinen, Susanna Laitinen, Pekka Manninen, Vladimir Rogojin, Minna Miettinen, Carl Blomqvist, Jianjun Liu, Heli Nevanlinna, Sampsa Hautaniemi, Identification of Genetic Markers with Synergistic Survival Effect in Cancer. BMC Systems Biology 7(1), S2, 2013.

Diana-Elena Gratie, Bogdan Iancu, Ion Petre, ODE analysis of biological systems. In: Marco Bernardo, Erik de Vink, Alessandra Di Pierro, Herbert Wiklicky (Eds.), Formal Methods for Dynamical Systems, Lecture Notes in Computer Science 7938, 29–62, Springer, 2013.

Diana-Elena Gratie, Bogdan Iancu, Sepinoud Azimi, Ion Petre, Quantitative Model Refinement in Four Different Frameworks, with Applications to the Heat Shock Response. TUCS Technical Reports 1067, TUCS, 2013.

Sepinoud Azimi, Bogdan Iancu, Ion Petre, Reaction Systems Models for the Heat Shock Response. TUCS Technical Reports 1075, TUCS, 2013.

Emilian Dobrescu, Dumitru Nastac, Elena Pelinescu, Are the Neural Networks ‘Immune’ from Database's Properties?. TUCS Technical Reports 1093, TUCS, 2013.

Diana-Elena Gratie, Bogdan Iancu, Ion Petre, ODE Analysis of Biological Systems. TUCS Technical Reports 1072, TUCS, 2013.

Diana-Elena Gratie, Ion Petre, Quantitative Petri Nets Models for the Heat Shock Response. TUCS Technical Reports 1068, TUCS, 2013.

4.5 Communication Systems (ComSys)

We study the future internet with focus on three viewpoints: information security, interactive applications and embedded/distributed implementations. Communication systems are viewed as whole entities and the three viewpoints are all addressed in our research as we take on the challenges met in future networked multimedia and communication applications found in embedded systems. The cloud computing paradigm is bringing forth completely new challenges to the information security field both in terms of hand-held embedded communication systems and the distributed processing cloud. Currently our special interests are in self-aware approach for future communication and interdisciplinary applications including information security and dependability aspects.

Information security research in Communication Systems concentrates on researching information security technologies for networked systems and applications of the communication-intensive future from the engineering and human points of view. The strategic goal in our research is to apply research and technological development to building the secure information society. We consider the basic elements for human well-being as the most fundamental drivers for pursuing this strategic goal, in which the technology driven and human driven development directions meet. This is pursued with an interdisciplinary approach, where new innovations create active interaction between traditional scientific areas.

The communication systems laboratory is responsible of two laboratories: information security and AV laboratories. They are used both for our research and education.

Leader of the unit

Jouni Isoaho

Unit Members

Seppo Virtanen and Ethiopia Nigussie

Publications

Seppo Virtanen (Ed.), Adoption and Optimization of Embedded and Real-Time Communication Systems, IGI Global, 2013.

Khalid Latif, Amir-Mohammad Rahmani, Ethiophia Nigussie, Tiberiu Seceleanu, Martin Radetzki, Hannu Tenhunen, Partial Virtual Channel Sharing: A Generic Methodology to Enhance Resource Management and Fault Tolerance in Networks-on-Chip. Journal of Electronic Testing: Theory and Applications 29(3), 431–452, 2013.

Khalid Latif, Amir-Mohammad Rahmani, Tiberiu Seceleanu, Hannu Tenhunen, Cluster Based Networks-on-Chip: An Efficient and Fault-Tolerant Architecture using Network Interface Assisted Routing. International Journal of Adaptive, Resilient and Autonomic Systems 4(3), 25–41, 2013.

Anil Kanduri, Amir-Mohammad Rahmani, Pasi Liljeberg, Kaiyu Wan, Ka Lok Man, Juha Plosila, A Multicore Approach to Model-Based Analysis and Design of Cyber-Physical Systems. In: Seoung HO Hawang (Ed.),Proc. of IEEE International SoC Design Conference (ISOCC'13), 278–281, IEEE, 2013.

Sanaz Rahimi Moosavi, Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Enhancing Performance of 3D Interconnection Networks Using Efficient Multicast Communication Protocol. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), 21st Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, 294–300, IEEE/Euromicro, 2013.

Sanaz Rahimi Moosavi, Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, An Efficient Implementation of Hamiltonian Path Based Multicast Routing for 3D Interconnection Networks. In: Reza Lotfi (Ed.), Proc. of 21st IEEE Iranian Conference on Electrical Engineering (ICEE'13), 1–6, IEEE, 2013.

Jari Tissari, Tero Hurnanen, Jussi Poikonen, Adaptive Algorithm and Parameter Optimization for Distributed Beamforming in OFDM Systems. In: Jari Tissari, Tero Hurnanen, Jussi Poikonen (Eds.), Wireless Communication Systems (ISWCS), 2012 International Symposium on , 1–5, IEEE, 2013.

4.6 Data Mining and Knowledge Management Laboratory

Research

The amount of data and text has increased considerably during the last ten years and we are already talking about a future data amount of peta (10^{15}) or even yotta (10^{24}) bytes on the Internet. Today, many organizations struggle with vast amounts of data. Worldwide, computers have turned into massive data tombs. It is possible to capture and store data, but it has become difficult to utilize it effectively and efficiently.

The overall research goal is to search for, find, model and systemize/analyze knowledge in very large sets of data using data- and text mining, so that organizations can use this knowledge in decision making.

Systematizing knowledge using data and in particular text mining is new and demanding. Focus is on the following application areas

- Financial benchmarking and performance analysis
- Bankruptcy prediction
- Corporate taxation and tax auditing
- Customer profiling
- Market basket analysis
- Modeling customers in electricity retailing markets
- Monitoring financial stability
- Electronic patient records

Other areas of interest are:

- Customer participation in agile software development
- End-user development support through Virtual Communities

Doctoral degrees during 2013

- Peter Sarlin
- Zhiyuan Yao

Education based on research

Regular advanced courses in IS:

- Data Mining and Text Mining, Autumn 2013
- Business Intelligence, Autumn 2013

Research Unit Web Page:

https://research.it.abo.fi/research/data-mining-and-knowledge-management-laboratory

Leader of the unit

Barbro Back

Co-leader of the unit

Tomas Eklund

Senior Researchers

Tomas Eklund, Dorina Marghescu, Peter Sarlin and Zhiyuan Yao

Doctoral Students

Piia Hirkman, Minna Kallio, Henri Korvela, Annika H. Holmblom, Hongyan Liu and Samuel Rönnqvist

Projects

Market Basket Analysis and CRM 2.0

Liikesivistysrahasto 2013–2014.

Publications

Peter Sarlin, Self-Organizing Time Map: An Abstraction of Temporal Multivariate Patterns. Neurocomputing99(1), 496–508, 2013.

Peter Sarlin, On Policymakers' Loss Functions and the Evaluation of Early Warning Systems. Economics Letters 119(1), 1–7, 2013.

Peter Sarlin, Exploiting the Self-Organizing Financial Stability Map. Engineering Applications of Artificial Intelligence 26(5), 1532–1539, 2013.

Peter Sarlin, Tuomas A. Peltonen, Mapping the State of Financial Stability. Journal of International Financial Markets, Institutions and Money 26, 46–76, 2013.

Peter Sarlin, Decomposing the Global Financial Crisis: A Self-Organizing Time Map. Pattern Recognition Letters 34, 1701–1709, 2013.

Peter Sarlin, Tomas Eklund, Financial Performance Analysis of European Banks using a Fuzzified Self-Organizing Map. International Journal of Knowledge Based and Intelligent Engineering Systems 17(3), 223–234, 2013.

Peter Sarlin, Zhiyuan Yao, Clustering of the Self-Organizing Time Map. Neurocomputing 121, 317–327, 2013.

Annika Holmbom, Samuel Rönnqvist, Peter Sarlin, Tomas Eklund, Barbro Back, Green vs. Non-Green Customer Behavior: A Self-Organizing Time Map Over Greenness. In: Wei Ding, Takashi Washio (Eds.), IEEE 13th International Conference on Data Mining Workshops, IEEE International Conference on Data Mining, 1–7, IEEE, 2013.

Annika Holmbom, Peter Sarlin, Zhiyuan Yao, Tomas Eklund, Barbro Back, Visual Data-Driven Profiling of Green Consumers. In: Proceedings of the International Conference on Information Visualization, 291–298, IEEE, 2013.

Henri Korvela, Plz Urgent Help Needed!1!! – Aspects of On-Line Knowledge Sharing in End-User Development Support. In: J.P. Shim, Yujong Hwang, Stacie Petter (Eds.), AMCIS 2013 Proceedings, 1–10, Association for Information Systems, 2013.

Hongyan Liu, Jüri Vain, An Agent-Based Modeling for Price-Responsive Demand Simulation. In: Slimane Hammoudi, Leszek Maciaszek, Jose Cordeiro, Jan Dietz (Eds.), 15th International Conference on Enterprise Information Systems (ICEIS 2013), 436–443, SCITEPRESS (Science and Technology Publications), 2013.

Peter Sarlin, A Weighted SOM for Classifying Data with Instance-Varying Importance. In: Jilles Vreeken, Charles Ling (Eds.), Proceedings of the IEEE 12th International Conference on Data Mining Workshops (ICDMW), 187–193 , IEEE, 2013.

Peter Sarlin, A Self-Organizing Time Map for Time-to-Event Data. In: Proceedings of the IEEE Symposium on Computational Intelligence and Data Mining, 230–237, IEEE, 2013.

Peter Sarlin, Replacing the time dimension: A Self-Organizing Time Map over any variable. In: Barbara Hammer, Thomas Martinetz, Thomas Villman (Eds.), Proceedings of the Workshop on New Challenges in Neural Computation (NC^2), 17–24, Machine Learning Reports, 2013.

Peter Sarlin, Samuel Rönnqvist, Cluster Coloring of the Self-Organizing Map: An Information Visualization Perspective. In: Proceedings of the International Conference on Information Visualization, 532–538, IEEE, 2013.

Peter Sarlin, Mapping Financial Stability. TUCS Dissertations 159. Åbo Akademi University, 2013.

Zhiyuan Yao, Visual Customer Segmentation and Behavior Analysis – A SOM-Based Approach. TUCS Dissertations 163. 2013.

Hongyan Liu, Jüri Vain, An Agent-Based Modeling for Price-Responsive Demand Simulation. TUCS Technical Reports 1065, ISBN 978-952-12-2843-8, 2013.

Zhiyuan Yao, Peter Sarlin, Tomas Eklund, Barbro Back, Visualizing Dynamics in Customer Behavior with the Self-Organizing Time Map. TUCS Technical Reports 1085, TUCS, 2013.

4.7 Distributed Systems Laboratory (DS Lab)

The Distributed Systems Laboratory is a research laboratory within the Turku Centre for Computer Science (TUCS). It involves a group of researchers from the Department of Information Technologies at Åbo Akademi University. The laboratory is multidisciplinary with background in computer science, software engineering, and mathematics. The mission of the Distributed Systems Laboratory is to develop methods, techniques and tools that help in the design of correct and dependable distributed systems. The Distributed Systems Design Laboratory was a part of the Centre of Excellence in Formal Methods in Programming, Academy of Finland 2002-07.

Our main areas of expertise are formal methods, control systems, dependable systems, fault tolerance, automated reasoning, verification, trusted networks and services, formal hardware design and quality measurement.

Two research groups

Formal Methods and Networks group (FormNet)

In this group we focus on modeling, analyzing, and developing networked systems, from both a qualitative and a quantitative point of view. We are interested in wireless sensor networks, mobile networks, peer-to-peer networks, multi-core systems, network-on-chip architectures and study trustworthiness as well as location-, context-, and energy-awareness. We are working on discovering suitable language abstractions for capturing contemporary networked systems and protocols. Our main tools at the moment consist of formal approaches such as the action systems formalism, Event-B, and statistical model checking. Our favorite modeling methods consist of abstraction and refinement. We use the Rodin platform to correctly model networked systems and to prove various properties for the systems we model.

Leader: Doc. Luigia Petre

Research Themes

- Formal and semi-formal methods
    - Action systems
    - Refinement calculus
    - Event-B
    - Uppaal
    - Statistical model checking
    - UML
    - Integrating formal methods

- Networked systems
    - Wireless sensor (and actor) networks
    - Peer-to-peer networks
    - Mobile networks
    - Network-on-chip architectures

    - Multicore systems
    - Network protocols (eg AODV)

- Extra functional properties
    - Network availability
    - Energy-awareness
    - Context-awareness
    - Trustworthiness
    - Quantitative evaluations

Integrated Design of Quality Systems group (InDeQS)

The Integrated Design of Quality Systems Group is a research group within the Distributed Systems laboratory. We focus our research on integrating methods and tools in the development of high quality systems. In order to ensure the quality of the systems, we use formal verification techniques to guarantee their correctness. We are also interested in increasing the flexibility and maintainability of formal methods in the design process and to evaluate the benefit of this via metrics and measurements.

Leader: Doc. Marina Waldén

Research interests

Integrated

Integrating methods, tools, platforms and architectures for formal system design

- Action Systems
- Refinement calculus
- Event-B
- Simulink
- UPPAAL
- UML
- VHDL
- NoC (Tilera)

Design

Increasing the flexibility of Formal Methods

- Adaptive design
- Patterns
- Visualisations
- Fault tolerance methods

Quality

Ensuring and monitoring quality

- Formal methods
- Verification and validation
    - Functional properties
    - Real-time properties

- Metrics and measurements
- Maintainability and complexity issues

Systems

Application of Formal Methods to industrial case studies

- Control software, e.g. digital hydraulics
- Safety-critical systems
- Cyber-physical systems

Leader of the unit

Doc. Luigia Petre and Doc. Marina Waldén

Senior researchers

Doc. Linas Laibinis (until 31.8.2013) and Doc. Elena Troubitsyna (until 31.8.2013)

Postdoctoral researchers

Dr. Petr Alexeev (until 31.7.2013), Dr. Mats Neovius, Dr. Maryam Kamali, Dr. Pontus Boström, Dr. Marta Olszewska, Dr. Anton Tarasyuk (until 31.8.2013) and Dr. Leonidas Tsiopoulos (until 15.4.2013)

Doctoral students

M.Sc. Inna Pereverzeva (until 31.8.2013), M.Sc. Yuliya Prokhorova (until 31.8.2013), M.Sc. Petter Sandvik, M.Sc. Sergey Ostroumov and M.Sc. Jonatan Wiik

Unit members

- Formal Methods and Networks (FormNet)
  Doc. Luigia Petre, Dr. Mats Neovius, Dr. Maryam Kamali and M.Sc. Petter Sandvik

- Integrated Design of Quality Systems (InDeQS)
  Doc. Marina Waldén, Dr. Pontus Boström, Dr. Marta Olszewska, M.Sc. Sergey Ostroumov and M.Sc. Jonatan Wiik

Projects

EFFIMA/DiHy+Digihybrid (2009 – 2014, FIMECC SHOK)

- Faul-tolerant and reliable controllers for digital hydraulic valves
- Partners: TUT/IHA, VTT, Aalto, Cargotec, Metso Automation, Metso Paper, Norrhydro, Nurmi Hydraulics, Wärtsilä
- Digihybrid: This is a Fimecc/EFFIMA/MeKo SHOK project financed during 2011-2014. The goal of the project is to reduce hydraulic losses using a regenerative, multi-chamber cylinder approach and to prove safety and reliability of the software for the digital hydraulic technology. Moreover, the project aims at implementing a fault-tolerant, general purpose platform for digital hydraulic accumulators.

- DiHy: This is a project within Fimecc/EFFIMA/MeKo SHOK for the period 2009-2014. The goal of the project is to develop second generation digital hydraulic valves that are energy efficient, as well as to improve controllability and fault tolerance of control systems via developing modular control code.

eDiHy (2011 – 2014, Academy of Finland)

- Contract based design of control systems relying on simulation tools
- Consortium: TUT/IHA
- Within this project we investigate a contract-based methodology for the design of control systems relying on formal software construction techniques and simulation tools, as well as building fault-tolerant platforms for reliable software.

FResCo (2013 – 2015, Academy of Finland)

- High-quality Measurement Infrastructure for Future Resilient Control Systems
- Consortium: UEF/Kuopio and Digile, Fimecc, Cleen SHOKs
- The control system paradigm, where action is determined based on sensing, monitoring, and measuring, forms a fundamental part of our contemporary and envisioned software-intensive infrastructures. This is illustrated, for instance, by the advent of sensor networks, the growing interest in location- and context-aware computing, and the promotion of the so-called cyber-physical systems that network together computational elements with physical inputs and outputs. Measuring systems will form a critical infrastructure for decision making in novel production planning systems for many industrial sectors and therefore, the high-quality of these systems is of utmost importance. In this project, we focus on high-quality environmental measuring for future resilient control systems and study the contribution of formal methods in devising high-quality solutions. One of the novelties of our project consists in proposing measurement infrastructures for novel control methods. Measuring extends the concept of monitoring currently associated to contemporary control systems and aligns suitably with our proposed focus on environmental systems. Interoperability of environmental systems is a key feature we address, by proposing the use of a top-down, correct-by-construction method instead of the more traditional attempt to integrate various existing (and partial) solutions to interoperability. Our formal approach allows for reliable measuring that, in its turn, provides for resilient future control methods. Hence, our project aims at stretching current knowledge boundaries in a feasible manner and at providing new results to be next experimented with, for further innovations and applicability in industry.

ADVICeS (2013 – 2017, Academy of Finland)

- Adaptive Integrated Formal Design of Safety-Critical Systems
- Co-operation: Eindhoven Univ. of Techn. (NL), Southampton Univ. (UK)
- The main objective of the project ADVICeS is to develop a collection of tactics for system modelling that is based on formal methods. The aim is to make the formal design process more efficient, flexible and maintainable for developing complex, dependable software systems that are correct by construction. A combination of an adaptive design framework with formal methods is meant to augment the development flexibility and give faster response to changes and, hence, will aid to achieve a feasible formal development process that enhances maintainability. Integrating metrics and quality measurements with the formal design will provide additional development guidelines to support the modelling and enable the assessment of the suitability of the proposed hybrid method.

Publications

Einar Broch Johnsen, Luigia Petre (Eds.), Integrated Formal Methods, 10th International Conference, IFM 2013, Turku, Finland, June 10-14, 2013. Proceedings, Lecture Notes in Computer Science 7940, Springer, 2013.

Alexei Iliasov, Elena Troubitsyna, Linas Laibinis, Alexander Romanovsky, Kimmo Varpaaniemi, Dubravka Ilic, Timo Latvala, Developing Mode-Rich Satellite Software by Refinement in Event-B. Science of Computer Programming 78(7), 884–905, 2013.

Maryam Kamali, Linas Laibinis, Luigia Petre, Kaisa Sere, A Distributed Design of a Network Recovery Algorithm. International Journal of Critical Computer-Based Systems 4(1), 45–68, 2013.

Maryam Kamali, Mats Neovius, Luigia Petre, Petter Sandvik, Formal Development of System of Systems.ISRN Software Engineering 2013, 1–10, 2013.

Kristian Lumme, Luigia Petre, Petter Sandvik, Kaisa Sere, A Formal Approach to H.264 Video Decoding on Multicore Systems. International Journal of Critical Computer-Based Systems 4(1), 3–26, 2013.

Mats Neovius, Kaisa Sere, Mastering the Relevance of Subjective Information in Ubiquitous Computing.Journal of Communications and Information Sciences (JCIS) 3(4), 27 – 44, 2013.

Sergey Ostroumov, Leonidas Tsiopoulos, Juha Plosila, Kaisa Sere, Formal Approach to Agent-Based Dynamic Reconfiguration in Networks-On-Chip. Journal of Systems Architecture 59(9), 709–728, 2013.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, A Refinement-Based Approach to Developing Critical Multi-Agent Systems. International Journal of Critical Computer-Based Systems 4(1), 69–91, 2013.

Yuliya Prokhorova, Elena Troubitsyna, A Survey of Safety-Oriented Model-Driven and Formal Development Approaches. International Journal of Critical Computer-Based Systems 4(2), 93–118, 2013.

Petr Alexeev, Pontus Boström, Marina Waldén, Mikko Huova, Matti Linjama, Kaisa Sere, Fault-tolerant Scheduling of Stateful Tasks in Uniprocessor Real-time Systems. In: César Benavente-Peces, Joaquim Filipe (Eds.), Proceedings of the 3rd International Conference on Pervasive Embedded Computing and Communication Systems, 189 – 194 , SCITEPRESS, 2013.

Ansger Fehnker, Peter Höfner, Maryam Kamali, Vinay Mehta, Topology-based Mobility Model for Wireless Networks. In: Kaustubh R Joshi, Markus Siegle, Mariëlle Stoelinga, Pedro R. D'Argenio (Eds.), 10th International conference on Quantitative Evaluation of Systems, Lecture Notes in Computer Science 8054, 389–404, Springer-Verlag, 2013.

Peter Höfner, Maryam Kamali, Quantitative Analysis of AODV and its Variants on Dynamic Topologies using Statistical Model Checking. In: Víctor Braberman, Laurent Fribourg (Eds.), 11th International Conference on Formal Modeling and Analysis of Timed Systems, Lecture Notes in Computer Science 8053, 121–136, Springer-Verlag, 2013.

Sergey Ostroumov, Leonidas Tsiopoulos, Juha Plosila, Kaisa Sere, Generation of Structural VHDL Code with Library Components. In: José Silva, Francesco Leporati (Eds.), 16th Euromicro Conference on Digital System Design DSD 2013, 111–118, IEEE Conference Publishing Services (CPS), 2013.

Inna Pereverzeva, Linas Laibinis, Elena Troubitsyna, Markus Holmberg, Mikko Pöri, Formal Modelling of Resilient Data Storage in Cloud. In: Lindsay Groves, Jing Sun (Eds.), Proceedings of 15th 1. 15th International Conference on Formal Engineering Methods, Lecture Notes in Computer Science, 364–380, Springer-Verlag Berlin Heidelberg, 2013.

Paul Pop, Leonidas Tsiopoulos, Sebastian Voss, Oscar Slotosch, Christoph Ficek, Ulrik Nyman, Alejandra Ruiz,Methods and Tools for Reducing Certification Costs of Mixed-Criticality Applications on Multi-Core Platforms: The RECOMP Approach. In: WICERT 2013 Workshop on Industry-Driven

Approaches for Cost-effective Certification of Safety-Critical, Mixed-Criticality Systems, 1–6, University of Granada, 2013.

Yuliya Prokhorova, Elena Troubitsyna, Linas Laibinis, Supporting Formal Modelling in Event-B with Safety Cases. In: Michael Butler, Stefan Hallerstede, Marina Waldén (Eds.), Proceedings of the 4th Rodin User and Developer Workshop, TUCS Lecture Notes 18, 8–11, TUCS, 2013.

Yuliya Prokhorova, Elena Troubitsyna, Linas Laibinis, A Case Study in Refinement-Based Modelling of a Resilient Control System. In: Anatoliy Gorbenko, Alexander Romanovsky, Vyacheslav Kharchenko (Eds.),Proceedings of the 5th International Workshop on Software Engineering for Resilient Systems (SERENE 2013), Lecture Notes in Computer Science 8166, 79–93, Springer-Verlag Berlin Heidelberg, 2013.

Yuliya Prokhorova, Elena Troubitsyna, Linas Laibinis, Dubravka Ilić, Timo Latvala, Formalisation of an Industrial Approach to Monitoring Critical Data. In: Friedemann Bitsch, Jérémie Guiochet, Mohamed Kaâniche (Eds.), Proceedings of the 32nd International Conference on Computer Safety, Reliability and Security (SAFECOMP 2013), Lecture Notes in Computer Science 8153, 57–69, Springer-Verlag Berlin Heidelberg, 2013.

Faezeh Siavashi, Marina Waldén, Leonidas Tsiopoulos, Jüri Vain, Modelling Critical Systems with Time Constraints in Event-B. In: Tarmo Uustalu, Jüri Vain (Eds.), Proceedings of the 25th Nordic Workshop on Programming Theory, NWPT '13, 1–3, Tallin University of Technology, 2013.

Anton Tarasyuk, Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, Formal Development and Quantitative Assessment of a Resilient Multi-Robotic System. In: Anatoliy Gorbenko, Alexander Romanovsky, Vyacheslav Kharchenko (Eds.), Proceedings of the 5th International Workshop on Software Engineering for Resilient Systems (SERENE 2013), Lecture Notes in Computer Science 8166, 109–124, Springer-Verlag Berlin Heidelberg, 2013.

Elena Troubitsyna, Towards Formal Specification of Autonomic Control Systems. In: Dini Petre, Elena Troubitsyna (Eds.), The Fourth International Conference on Adaptive and Self-Adaptive Systems and Applications, 109–114, IEEE Computer Press, 2013.

Elena Troubitsyna, Safety Analysis for Architecting Safety-Critical Systems. In: Dave West (Ed.),Proceedings of 30th International System Safety Conference, 250–261, System Safety Society, 2013.

Michael Butler, Stefan Hallerstede, Marina Waldén (Eds.), Proceedings of the 4th Rodin User and Developer Workshop, TUCS Lecture Notes 18, TUCS, 2013.

Maryam Kamali, Reusable Formal Architectures for Networked Systems. TUCS Dissertations 162. 2013.

Anton Tarasyuk, Formal Development and Quantitative Verification of Dependable Systems. TUCS Dissertations 156. 2013.

Seppo Horsmanheimo, Maryam Kamali, Mikko Kolehmainen, Mats Neovius, Luigia Petre, Mauno Rönkkö, Petter Sandvik, On Providing Recoverability of Smart Electrical Grids. TUCS Technical Reports 1096, TUCS, 2013.

Mats Neovius, Formal Stepwise Development of an In-House Temperature Control System. TUCS Technical Reports 1078, TUCS, 2013.

Sergey Ostroumov, Leonidas Tsiopoulos, Juha Plosila, Kaisa Sere, Generation of Structural VHDL Code with Library Components from Formal Event-B Models. TUCS Technical Reports 1073, TUCS, 2013.

Inna Pereverzeva, Linas Laibnis, Elena Troubitsyna, Markus Holmberg, Mikko Pöri, Formal Modelling of Resilient Data Storage in the Cloud. TUCS Technical Reports 1076, 978-952-12-2887-2, 2013.

Yuliya Prokhorova, Elena Troubitsyna, Linas Laibinis, A Case Study in Refinement-Based Modelling of a Resilient Control System. TUCS Technical Reports 1086, TUCS, 2013.

Yuliya Prokhorova, Elena Troubitsyna, Linas Laibinis, Dubravka Ilic, Timo Latvala, Formalisation of an Industrial Approach to Monitoring Critical Data. TUCS Technical Reports 1070, TUCS, 2013.

Mauno Rönkkö, Markus Stocker, Mats Neovius, Mikko Kolehmainen, Luigia Petre, Programming by Construction. TUCS Technical Reports 1092, TUCS, 2013.

Petter Sandvik, Formal Stepwise Development of an In-House Lighting Control System. TUCS Technical Reports 1079, TUCS, 2013.

4.8 Embedded Computer and Electronic Systems (ECES)

ECES focuses in its research on Internet of Things (IoT), novel massively parallel computing platforms and paradigms, as well as autonomous embedded and cyber physical systems (CPS). ECES publishes annually 30-40 peer-reviewed research papers. The unit collaborates especially with the Embedded Systems Lab and Distributed Systems Lab at TUCS. The key application domains for the research are personal health, safety and well-being. The focus is on application development and implementation tools for multiprocessor platforms developed within the laboratory and wireless sensor networks. Sensors are developed in international cooperation with Royal Institute of Technology (KTH) (Stockholm, Sweden) and Fudan University (Shanghai, PRC). In addition to international collaboration, ECES cooperates with multiple disciplines within University of Turku to achieve a true multidisciplinary research environment.

Leader of the unit

Juha Plosila

Senior Researchers

Pasi Liljeberg, Juha Plosila, Hannu Tenhunen and Tomi Westerlund

Researchers

Masoud Daneshtalab, Thomas Canhao Xu, Liang Guang, Amir-Mohammad Rahmani and Masoumeh Ebrahimi

Doctoral Students

Fahimeh Farahnakian, Mohammad Fattah, Hashem Haghbayan, Syed Mohammad Asad Jafri, Rajeev Kumar Kanth, Khalid Latif, Marco Ramirez, Kameswar Rao Vaddina, Bo Yang and Alexander Wei Yin

Projects

Data Management of 3D Systems for the Dark Silicon Age (MANAGE)

Academy of Finland, Hannu Tenhunen, 2013–2017.

Agent Based Management of Embedded Data Reserves (AMEBA)

Academy of Finland, Juha Plosila, 2012–2014.

Agent Based Management of CMOS Hyper-Corse (AGENT)

Academy of Finland, Juha Plosila, 2011–2013

Publications

Bo Yang, Liang Guang, Tero Säntti, Juha Plosila, Mapping Multiple Applications with Unbounded and Bounded Number of Cores on Many-Core Networks-on-Chip. Microprocessors and Microsystems 37(4-5), 460–471, 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Cluster-Based Topologies for 3D Networks-on-Chip Using Advanced Inter-Layer BUS Architecture. Journal of Computer and System Sciences 79(4), 475–491, 2013.

Masoumeh Ebrahimi, Hannu Tenhunen, Masoud Dehyadegari, Fuzzy-based Adaptive Routing Algorithm for Networks-on-Chip. Journal of Systems Architecture 59(7), 516–527, 2013.

Syed M. A. H. Jafri, Liang Guang, Ahmed Hemani, Kolin Paul, Juha Plosila, Hannu Tenhunen, Energy-aware fault-tolerant NoCs addressing multiple traffic classes. Microprocessors and Microsystems- Embedded Hardware Design 10.1016/j.micpro.2013.04.005, 1–13, 2013.

Khalid Latif, Amir-Mohammad Rahmani, Ethiophia Nigussie, Tiberiu Seceleanu, Martin Radetzki, Hannu Tenhunen, Partial Virtual Channel Sharing: A Generic Methodology to Enhance Resource Management and Fault Tolerance in Networks-on-Chip. Journal of Electronic Testing: Theory and Applications 29(3), 431–452, 2013.

Khalid Latif, Amir-Mohammad Rahmani, Tiberiu Seceleanu, Hannu Tenhunen, Cluster Based Networks-on-Chip: An Efficient and Fault-Tolerant Architecture using Network Interface Assisted Routing. International Journal of Adaptive, Resilient and Autonomic Systems 4(3), 25–41, 2013.

Moazzam Fareed Niazi, Tiberiu Seceleanu, Hannu Tenhunen, A Development and Verification Framework for the SegBus Platform. Journal of Systems Architecture 59(10, Part C), 1015–1031, 2013.

Pekka Nikander, Kameswar Rao Vaddina, Petri Liuha, Hannu Tenhunen, Ell-I: An Inexpensive Platform For Fixed Things. SCPE journal 14(3), 155–167, 2013.

Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Developing a Power-Efficient and Low-Cost 3D NoC Using Smart GALS-Based Vertical Channels. Journal of Computer and System Sciences79(4), 440–456, 2013.

Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Design and Implementation of Reconfigurable FIFOs for Voltage/Frequency Island-Based Networks-on-Chip. Journal of Microprocessors and Microsystems 37(4-5), 432–445, 2013.

Kameswar Rao Vaddina, Pasi Liljeberg, Juha Plosila, Exploration of Temperature- Aware Placement Approaches in 2D and 3D Stacked Systems. International Journal of Adaptive, Resilient and Autonomic Systems 4(3), 61–81, 2013.

Kameswar Rao Vaddina, Amir-Mohammad Rahmani, Mohammad Fattah, Pasi Liljeberg, Juha Plosila, Design space exploration of thermal-aware many-core systems. Journal of Systems Architecture 59(10), 1197–1213, 2013.

Thomas Canhao Xu, Gert Schley, Pasi Liljeberg, Martin Radetzki, Juha Plosila, Hannu Tenhunen, Optimal Placement of Vertical Connections in 3D Network-on-Chip. Journal of Systems Architecture 59(7), 441–454, 2013.

Yasar Amin, Rajeev Kumar Kanth, Pasi Liljeberg, Adeel Akram, Qiang Chen, Li-Rong Zheng, Hannu Tenhunen, Printable RFID Antenna with Embedded Sensor and Calibration Functions. In: He Sailing (Ed.),Progress In Electromagnetics Research Symposium , 567–570, Proceedings of PIERS, 2013.

Jesus Carabaño, Francisco Dios, Masoud Daneshtalab, Masoumeh Ebrahimi, An Exploration of Heterogeneous Systems. In: Manfred Glesner, Alberto Garcia-Ortiz, Gert Jervan (Eds.), Reconfigurable and Communication-Centric Systems-on-Chip (ReCoSoC), 2013 8th International Workshop on , 1–7, IEEE, 2013.

Masoumeh Ebrahimi, Xin Chang, Masoud Daneshtalab, Juha Plosila, Pasi Liljeberg, Hannu Tenhunen,DyXYZ: Fully Adaptive Routing Algorithm for 3D NoCs. In: peter Kilpatrick (Ed.), 21th

IEEE Euromicro Conference on Parallel, Distributed and Network-Based Computing (PDP), 499–503, IEEE, 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Juha Plosila, Fault-Tolerant Routing Algorithm for 3D NoC Using Hamiltonian Path Strategy. In: Erik Jan Marinissen (Ed.), 16th Design, Automation, and Test in Europe (DATE), 1–4, ACM/IEEE , 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Juha Plosila, High Performance Fault-Tolerant Routing Algorithm for NoC-based Many-Core Systems. In: Peter Kilpatrick (Ed.), Euromicro Conference on Parallel, Distributed and Network-Based Computing (PDP), 462–469, IEEE, 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Juha Plosila, Farhad Mehdipour, MD: Minimal Path-Based Fault-Tolerant Routing in On-Chip Networks. In: Yuan Xie (Ed.), in Proceedings of 18th Asia and South Pacific Design Automation Conference (ASP-DAC), 35–40, 2013, 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Juha Plosila, Hannu Tenhunen, Minimal-Path Fault-Tolerant Approach Using Connection-Retaining Structure in Networks-on-Chip. In: Natalie Jerger (Ed.), The International Symposium on Networks-on-Chip (NOCS), 1–7, IEEE/ACM, 2013.

Masoumeh Ebrahimi, Masoud Daneshtalab, Juha Plosila, Hannu Tenhunen, CARS: Congestion-Aware Request Scheduler for Network Interfaces in NoC-based Manycore Systems. In: Erik Jan Marinissen (Ed.), in Proceedings of 16th ACM/IEEE Design, Automation, and Test in Europe (DATE), 1–4, ACM/IEEE, 2013.

Mohammad Fattah, Masoud Daneshtalab, Pasi Liljeberg, Juha Plosila, Smart Hill Climbing for Agile Dynamic Mapping in Many-Core Systems. In: Mohammad Fattah (Ed.), DAC '13 Proceedings of the 50th Annual Design Automation Conference, 1–6, ACM, 2013.

Fahimeh Farahnakian, Pasi Liljeberg, Juha Plosila, LiRCUP: Linear Regression based CPU Usage Prediction Algorithm for Live Migration of Virtual Machines in Data Centers. In: Ivan Porres (Ed.), Cloud Software (CS), 358–364, IEEE Computer society, 2013.

Georgakarakos Georgios,, Daneshtalab Masoud, Plosila Juha, Efficient Application Mapping in Resource Limited Homogeneous NoC-Based Manycore Systems. In: Smari Waleed W,, Zeljkovic Vesna (Eds.),Proceedings of the 2013 International Conference on High Performance Computing & Simulation, 207–212, IEEE, 2013.

Liang Guang, Syed Jafri, Bo Yang, Juha Plosila, Hannu Tenhunen, Hierarchical Supporting Structure for Dynamic Organization in Many-Core Computing Systems. In: César Benavente-Peces, Joaquim Filipe (Eds.),Proceedings of the 3rd International Conference on Pervasive Embedded Computing and Communication Systems, 252–261, SCITEPRESS – Science and Technology Publications, 2013.

Syed M. A. H. Jafri, Ozan Ozbak, Ahmed Hemani, Nasim Farahini, Kolin Paul, Juha Plosila, Hannu Tenhunen Tenhunen, Energy-Aware CGRAs Using Dynamically Re-Configurable Isolation Cells. In: Mark Budnik (Ed.),in Proc. International Symposium for Quality and Design (ISQED), 1–8, IEEE, 2013.

Syed M. A. H. Jafri, Stanislaw Piestrak, Kolin Paul, Ahmed Hemani, Juha Plosila, Hannu Tenhunen, Energy-Aware Fault-Tolerant CGRAs Addressing Application with Different Reliability Needs. In: Eugenio Villar (Ed.),in Proc. Euromicro Conference on Digital System Design (DSD), 1–9, IEEE, 2013.

Syed M. A. H. Jafri, Stanislaw Piestrak, Kolin Paul, Ahmed Hemani, Juha Plosila, Hannu Tenhunen,Implementation and Evaluation of Configuration Scrubbing on CGRAs: A Case Study. In: Jari Nurmi (Ed.),International Symposium on System on Chip, 1–8, IEEE, 2013.

Syed M. A. H. Jafri, Muhammad Adeel Tajammul, Ahmed Hemani, Juha Plosila, Hannu Tenhunen, Energy Aware Task Parallelism for Efficient Dynamic Voltage and Frequency Scaling in CGRAs. In: Olli Silvén (Ed.),in Proc. International Conference on Embedded Computer Systems Architecture, Modeling and Simulations (SAMOS) , 1–9, IEEE, 2013.

Rajeev Kumar Kanth, Pasi Liljeberg, Harish Kumar, Li-Rong Zheng, Hannu Tenhunen, Nanotechnology, Life Cycle Assessment and Green ICT. In: Theodora Issa (Ed.), Sustainability,

Technology and Education Conference Proceedings, Iadis International Conference WWW/Internet, 1–5, IADIS, 2013.

Rajeev Kumar Kanth, Pasi Liljeberg, Hannu Tenhunen, Qiang Chen, Axel Janstch, Lirong Zheng, Harish Kumar, Design of Sierpinski Grid Patch Antenna for Multiband Application . In: He Sailing (Ed.), Progress In Electromagnetics Research Symposium Proceedings, 577–582, PIER Proceedings, 2013.

Anil Kanduri, Amir-Mohammad Rahmani, Pasi Liljeberg, Kaiyu Wan, Ka Lok Man, Juha Plosila, A Multicore Approach to Model-Based Analysis and Design of Cyber-Physical Systems. In: Seoung HO Hawang (Ed.),Proc. of IEEE International SoC Design Conference (ISOCC'13), 278–281, IEEE, 2013.

Olli Lahdenoja, Tero Säntti, Jonne Poikonen, Mika Laiho, Paasio,Ari, Characterizing Spatters in Laser Welding of Thick Steel Using Motion Flow Analysis. In: Erkki Oja, Matti Pietikäinen (Eds.), SCIA : 18th Scandinavian Conference on Image Analysis, Springer Lecture Notes in Computer Science (LNCS), 675–686, Springer Berlin Heidelberg, 2013.

Marco Ramirez, Masoud Daneshtalab, Pasi Liljeberg, Juha Plosila, Towards a Configurable Many-Core Accelerator for FPGA-based Embedded Systems . In: Manfred Glesner, Alberto Garcia-Ortiz, Gert Jervan (Eds.), Reconfigurable and Communication-Centric Systems-on-Chip (ReCoSoC), 2013 8th International Workshop on , 1–4 , IEEE, 2013.

Sanaz Rahimi Moosavi, Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Enhancing Performance of 3D Interconnection Networks Using Efficient Multicast Communication Protocol. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), 21st Euromicro International Conference on Parallel, Distributed, and Network-Based Processing, 294–300, IEEE/Euromicro, 2013.

Sanaz Rahimi Moosavi, Amir-Mohammad Rahmani, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, An Efficient Implementation of Hamiltonian Path Based Multicast Routing for 3D Interconnection Networks. In: Reza Lotfi (Ed.), Proc. of 21st IEEE Iranian Conference on Electrical Engineering (ICEE'13), 1–6, IEEE, 2013.

Thomas Schildknecht, Andreas Hinze, Juhani Peltonen, Tero Säntti, Tim Flohrer, Improved Space Object Observation Techniques using CMOS Detectors. In: Heiner Klinkrad, Holger Krag (Eds.), 6th European Conference on Space Debris, , ESA/ESOC, 2013.

Muhammad Adeel Tajammul, Syed M. A. H. Jafri, Ahmed Hemani, Juha Plosila, Hannu Tenhunen, Private Configuration Environments for Efficient Configuration in CGRAs. In: Tarek El-Ghazawi (Ed.), in Proc. Application Specific Systems Architectures and Processors (ASAP), 1–10, IEEE, 2013.

Tomi Westerlund, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, From Traditional VLSI Education to Embedded Electronics. In: Tina Hudson (Ed.), IEEE International Conference on Microelectronic Systems Education, 32–35, IEEE, 2013.

Thomas Canhao Xu, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Evaluate and Optimize Parallel Barnes-Hut Algorithm for Emerging Many-Core Architectures. In: Juha Plosila, Mads Nygård, Mohamed Bakhouya (Eds.), Proceedings of the 11th International Conference on High Performance Computing and Simulation (HPCS), 421–428, IEEE, 2013.

Thomas Canhao Xu, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, MMSoC: A Multi-Layer Multi-Core Storage-on-Chip Design for Systems with High Integration. In: Boris Rachev, Angel Smrikarov (Eds.),Proceedings of the 14th International Conference on Computer Systems and Technologies (CompSysTech), 67–74, ACM, 2013.

Thomas Canhao Xu, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, OPTNOC: An Optimized 3D Network-on-Chip Design for Fast Memory Access. In: Victor Malyshkin (Ed.), Proceedings of the 12th International Conference on Parallel Computing Technologies (PaCT), 7979, 436–441, Springer, 2013.

Thomas Canhao Xu, Tapio Pahikkala, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Optimized Multicore Architectures for Data Parallel Fast Fourier Transform. In: Boris Rachev, Angel

Smrikarov (Eds.), Proceedings of the 14th International Conference on Computer Systems and Technologies (CompSysTech), 75–82, ACM, 2013.

Rajeev Kumar Kanth, Analysis and Life Cycle Assessment of Printed Antennas for Sustainable Wireless Systems. TUCS Dissertations 165. University of Turku, 2013.

Khalid Latif, Design Space Exploration for MPSoC Architectures. TUCS Dissertations 166. 2013.

Bo Yang, Towards Optimal Application Mapping for Energy-Efficient Many-Core Platforms. TUCS Dissertations 167. 2013.

4.9 Embedded Systems Laboratory (ESLAB)

The Embedded Systems Laboratory does research on the practice and theory of embedded and automation systems. A central vision of the laboratory is to contribute to development of solutions for improving energy-efficiency and reliability of systems, both traditional ICT systems (mobile, Green-ICT), as well as automation systems for energy production.

The laboratory has strong research cooperation with the Distributed Systems Lab, the Embedded Computer and Electronic Systems Lab, and the Software Engineering Lab, through joint research projects.

The laboratory is hosting 2 International Masters programmes in cooperation with ECES, Embedded Computing, and EIT ICTLabs Master School Embedded Computing Specialisation on Energy-Efficient Compting, and a double-degree with ESIGELEC in Rouen, France.

The laboratory consists of 4 research groups:

Systems and Control Engineering (Lead: Hannu Toivonen): The group is involved in both applied and theoretical research. The latter is partly done within the OSE (Optimization and Systems Engineering) group at Åbo Akademi. In theoretical research, the current focus is on system modeling and identification methods, and control methods for periodically time-varying systems. In applied research, the group currently focuses on issues in intelligent automation and control of combustion engines and power plants.

Embedded Systems (Lead: Johan Lilius): The current focus of research on the development of new methods and tools for energy-efficient system implementation, including dataflow-languages, many-core operating systems and the use of mobile technologies in data-centers.

Communication and Signal Processing (Lead: Jerker Björqkvist): The communcations and signal processing group currently focuses on development and implemention issues for wireless broadbad communication systems. This includes Software Defined Radio (SDR) implementation of relevant communication kernels, such as forward error correction and symbol demapping, implemented on various computing architectures.

Resilient Systems Engineering (Lead: Elena Troubitsyna) The group has a strong track record in developing formal design theories for highly dependable systems. We focus on modelling safety, fault tolerance and resilience of systems from a broad range of domains -- from traditional control systems to self-adaptive multi-agent applications and big data in cloud. Our core expertise is in high-assurance systems engineering that includes proof-based verification, model-checking, safety analysis and advanced system adaptation technologies.

Research Unit Web Page: https://research.it.abo.fi/research/embedded-systems-laboratory

Leader of the unit

Johan Lilius

Senior Researchers

Jerker Björkqvist, Linas Laibinis (as of 1.9.2013), Hannu Toivonen and Elena Troubitsyna (as of 1.9.2013)

Researchers

Tom Fredman, Sébastien Lafond, Kristian Nybom and Leonidas Tsiopoulos (as of 16.4.2013)

External Docents

João Miguel Fernandes and Lionel Morel

Doctoral Students

Andreas Dahlin, Tewodros Deneke, Natalia Dáz Rodríguez, Johan Ersfolk, Stefan Grönroos, Simon Holmbacka, Fredric Hällis, Kashif Javed, Fareed Joksio, Inna Pereverzeva (as of 1.9.2013), Yuliya Prokhorova (as of 1.9.2013), John-Eric Saxén, Georgios Georgakarakos, Sudeep Kanur, Wictor Lund.

Projects

AMEBA

Agent Based Management of Embedded Data Reserves, Academy of Finland, 2012-2014

ASSURE

Autonomic software-intensive systems – foundations of safety and resilience, Academy of Finland, 2009-2013

CLOUD

Cloud Software Programme, TIVIT SHOK Research Programme, 2010-2013

DORADO

Dataflow Oriented Automated Design Toolchain, Academy of Finland, 2011-2015

FCEP

Future Combustion Engine Power Plant programme, CLEEN SHOP Research Programme, 2011-2014

ParallaX

Parallel Acceleration Project, TEKES, 2013-2016

RECOMP

Reduced Certification Costs for Trusted Multi-core Platforms, ARTEMIS, 2010-2013

Publications

Natalia Díaz Rodríguez, Manuel Pegalajar Cuéllar, Johan Lilius, Miguel Delgado Calvo-Flores, A Survey on Ontologies for Human Behaviour Recognition. ACM Computing Surveys 46, 1–32, 2013.

Adnan Ashraf, Fareed Jokhio, Tewodros Deneke, Sebastien Lafond, Ivan Porres, Johan Lilius, Stream-Based Admission Control and Scheduling for Video Transcoding in Cloud Computing. In: Pavan Balaji, Dick Epema, Thomas Fahringer (Eds.), 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid), 482–489, IEEE Computer Society, 2013.

Anders Berg, Petteri Karvinen, Stefan Grönroos, Frank Wickström, Natalia Díaz Rodríguez, Shohreh Hosseinzadeh, Johan Lilius, A Scalable Distributed M3 Platform on a Low-Power Cluster. In: Juha-Pekka Soininen Soininen, Sergey Balandin, Johan Lilius, Petri Liuha, Tullio Salmon Cinotti (Eds.), Open International M3 Semantic Interoperability Workshop , TUCS Proceedings 21, 49–58, TUCS , 2013.

Jani Boutellier, Amanullah Ghazi, Olli Silvén, Johan Ersfolk, High-Performance Programs by Source-Level Merging of RVC-CAL Dataflow Actors. In: Signal Processing Systems (SiPS), 2013 IEEE Workshop on, 360–365, IEEE, 2013.

Natalia Díaz Rodríguez, Robin Wikström, Johan Lilius, Manuel Pegalajar Cuéllar, Miguel Delgado Calvo-Flores,Understanding Movement and Interaction: An Ontology for Kinect-Based 3D Depth Sensors. In: José Bravo, Sergio Ochoa, Gabriel Urzaiz, Liming Luke Chen, Jonice Oliveira (Eds.), Ubiquitous Computing and Ambient Intelligence. Context-Awareness and Context-Driven Interaction, Lecture Notes in Computer Science 8276, 254–261, Springer, 2013.

Natalia Díaz Rodríguez, Stefan Grönroos, Franck Wickström, Petteri Karvinen, Anders Berg, Shohreh Hosseinzadeh, Marion Karppi, Johan Lilius, M3 Interoperability for Remote Rehabilitation with Kinect. In: Juha-Pekka Soininen Soininen, Sergey Balandin, Johan Lilius, Petri Liuha, Tullio Salmon Cinotti (Eds.), Open International M3 Semantic Interoperability Workshop, 21, 153–163, TUCS Lecture Notes, 2013.

Natalia Díaz Rodríguez, Johan Lilius, Manuel Pegalajar Cuéllar, Miguel Delgado Calvo-Flores, An Approach to Improve Semantics in Smart Spaces Using Reactive Fuzzy Rules. In: Witold Pedrycz, Marek Z. Reformat (Eds.), IFSA World Congress - NAFIPS Annual Meeting (IFSA/NAFIPS), 436–441, IEEE, 2013.

Natalia Díaz Rodríguez, Johan Lilius, Manuel Pegalajar Cuéllar, Miguel Delgado Calvo-Flores, Rapid Prototyping of Semantic Applications in Smart Spaces with a Visual Rule Language. In: Jonna Häkkila, Kamin Whitehouse, Antonio Krüger, Yoshito Tobe, Otmar Hilliges, Koji Yatani, Anind K. Dey, Hans-Werner Gellersen, Elaine M. Huang, Timo Ojala, Silvia Santini, Friedemann Mattern (Eds.), Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication, UbiComp '13 Adjunct, 1335–1338, ACM, 2013.

Johan Ersfolk, Ghislain Roquier, Johan Lilius, Marco Mattavelli, Modeling Control Tokens for Composition of CAL Actors. In: Adam Morawiec, Jinnie Hinderscheit (Eds.), Design and Architectures for Signal and Image Processing (DASIP), 2013 Conference on , 71–78, IEEE, ECSI, 2013.

Johan Ersfolk, Ghislain Roquier, Wictor Lund, Marco Mattavelli, Johan Lilius, Static and Quasi-static Compositions of Stream Processing Applications from Dynamic Dataflow Programs. In: Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing, 2620–2624, IEEE, 2013.

Stefan Grönroos, Kristian Nybom, Jerker Björkqvist, DVB-T2 Rotated Constellation Demapping on a GPU. In: John Glossner, Lee Pucker, Stephanie Hamill (Eds.), Proceedings of SDR-WinnComm 2013: Wireless Innovation Conference and Product Exposition, 233–238, The Wireless Innovation Forum, 2013.

Simon Holmbacka, Dag Ågren, Sébastien Lafond, Johan Lilius, QoS Manager for Energy Efficient Many-Core Operating Systems. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), Proceedings of the 21st International Euromicro Conference on Parallel, Distributed and Network-based Processing, 318–322, IEEE Computer society, 2013.

Simon Holmbacka, Sébastien Lafond, Johan Lilius, Power Optimized Many-Cores with User Centric Notion of Parallelism. In: Tomas Nordström, Zain-ul Abdin (Eds.), Sixth Swedish Workshop on Multicore Computing, 57 – 50, Swedish Multicore Initiative, 2013.

Simon Holmbacka, Wictor Lund, Sébastien Lafond, Johan Lilius, Task Migration for Dynamic Power and Performance Characteristics on Many-Core Distributed Operating Systems. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), Proceedings of the 21st International Euromicro Conference on Parallel, Distributed and Network-based Processing, 310–317, IEEE Computer society, 2013.

Simon Holmbacka, Wictor Lund, Sébastien Lafond, Johan Lilius, Lightweight Framework for Runtime Updating of C-Based Software in Embedded Systems. In: Rik Farrow (Ed.), 5th Workshop on Hot Topics in Software Upgrades, 1–6, Usenix association, 2013.

Fredric Hällis, Simon Holmbacka, Wictor Lund, Robert Slotte, Sébastien Lafond, Johan Lilius, Thermal Influence on the Energy Efficiency of Workload Consolidation in Many-Core Architecture. In: Raffaele Bolla, Franco Davoli, Phuoc Tran-Gia, Tuan Trinh Anh (Eds.), Proceedings of the 24th Tyrrhenian International Workshop on Digital Communications, 1–6, IEEE, 2013.

Fareed Jokhio, Adnan Ashraf, Sébastien Lafond, Johan Lilius, A Computation and Storage Trade-Off Strategy for Cost-Efficient Video Transcoding in the Cloud. In: Onur Demirors, Oktay Turetken (Eds.), 39th EUROMICRO Conference on Software Engineering and Advanced Applications, 365–372, IEEE Computer Society, 2013.

Fareed Ahmed Jokhio, Adnan Ashraf, Sébastien Lafond, Ivan Porres, Johan Lilius, Prediction-Based Dynamic Resource Allocation for Video Transcoding in Cloud Computing. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), Proceedings of the 21st International Euromicro Conference on Parallel, Distributed and Network-based Processing, Belfast, UK 27 February - 1 March 2013, 254–261, IEEE Computer society, 2013.

Sudeep Kanur, Georgios Georgakarakos, Antti Siirilä, Jérémie Lagravière, Kristian Nybom, Sébastien Lafond, Johan Lilius, Parallel Decoder for Low Density Parity Check Codes: A MPSoC Study. In: Waleed W. Smari (Ed.), High Performance Computing and Simulation (HPCS), 2013 International Conference on, 202–206, IEEE, 2013.

Natalia Díaz Rodríguez, Johan Lilius, Manuel Pegalajar Cuéllar, Miguel Delgado Calvo-Flores, Extending Semantic Web Tools for Improving Smart Spaces Interoperability and Usability. In: Sigeru Omatu, José Neves, Juan M. Corchado, Juan F. De Paz Santana, Sara Rodríguez González (Eds.), Distributed Computing and Artificial Intelligence, 10th International Conference, Advances in Intelligent Systems and Computing 217, 45–52, Springer , 2013.

Paul Pop, Leonidas Tsiopoulos, Sebastian Voss, Oscar Slotosch, Christoph Ficek, Ulrik Nyman, Alejandra Ruiz,Methods and Tools for Reducing Certification Costs of Mixed-Criticality Applications on Multi-Core Platforms: The RECOMP Approach. In: WICERT 2013 Workshop on Industry-Driven Approaches for Cost-effective Certification of Safety-Critical, Mixed-Criticality Systems , 1–6, University of Granada, 2013.

Sébastien Lafond, Tuan Trinh Anh, Energy Efficient Thresholds for Cached Content in Content Centric Networking. In: Raffaele Bolla, Franco Davoli, Phuoc Tran-Gia, Tuan Trinh Anh (Eds.), Proceedings of the 24th Tyrrhenian International Workshop on Digital Communications , 1–6, IEEE, 2013.

Fareed Jokhio, Adnan Ashraf, Tewodros Deneke, Sebastien Lafond, Ivan Porres, Johan Lilius, Proactive Virtual Machine Allocation for Video Transcoding in the Cloud. In: Ivan Porres, Tommi Mikkonen, Adnan Ashraf (Eds.), Developing Cloud Software: Algorithms, Applications, and Tools, TUCS General Publication 60, 113–143, TUCS, 2013.

Juha-Pekka Soininen, Sergey Balandin, Johan Lilius, Petri Liuha, Tullio Salmon Cinotti (Eds.), Proceedings of the Open International M3 Semantic Interoperability Workshop, TUCS Lecture Notes, TUCS, 2013.

Muhammad Mohsin Saleemi, Towards Combining Interactive Mobile TV and Smart Spaces: Architectures, Tools and Application Development. TUCS Dissertations 157. 2013.

Fareed Jokhio, Adnan Ashraf, Sébastien Lafond, Ivan Porres, Johan Lilius, Cost-Efficient Dynamically Scalable Video Transcoding in Cloud Computing. TUCS Technical Reports 1098, TUCS, 2013.

Coralie Saysset, H.264 Decoding Performance on DSP Architectures. TUCS Technical Reports 1089, TUCS, 2013.

Frank Wickström, Getting Started with Smart-M3 Using Python. TUCS Technical Reports 1071, TUCS, 2013.

4.10 FUNDIM, Fundamentals of Computing and Discrete Mathematics

FUNDIM Centre carries out basic research in discrete mathematics and computing. More specifically research topics cover

- automata theory
- models of computations
- cellular automata and complex systems
- tilings
- combinatorics on words
- discrete dynamical systems

Research is typically in cooperation with foreign partners.

Research Unit Web Page: http://www.math.utu.fi/projects/fundim/

Leader of the unit

Juhani Karhumäki

Teams

Automata and Combinatorics on Words

Leaders:	Juhani Karhumäki
	Tero Harju
Senior researchers:	Juha Honkala
	Alexander Okhotin
	Vesa Halava
	Tomi Kärki
Researchers:	Svetlana Puzynina
	Elena Pribavkina
Doctoral students:	Alexi Saarela
	Mari Huova
	Markku Laine
	Tommi Lehtinen
	Mikhail Barash
	Jarkko Peltomäki

Coding Theory Group

Leaders:	Iiro Honkala
Senior researchers:	Jyrki Lahtonen
	Tero Laihonen
Researchers:	Camilla Hollanti
	Roope Vehkalahti
	Ville Junnila
	Petri Rosendahl
Doctoral students:	Mikko Pelto
	Toni Ernvall

Discrete Complex Systems

Leaders:	Jarkko Kari
Senior researchers:	Mika Hirvensalo
Researchers:	N. Aubrun
Doctoral students:	S. Carlampos
	Ville Salo
	Ilkka Törmä

FiDiPro group

Leaders:	Luca Zamboni
Researchers:	Michelangelo Bucci
	Alessandro De Luca
	Elise Vaslet
Doctoral students:	Jetro Vesti

Cryptography and Data Security

Leaders:	Valtteri Niemi
Researchers:	Tommi Meskanen
Doctoral students:	Noora Nieminen

Projects

FiDiPro project on Words, Numbers and Tilings with applications

2010-2015, Total budget 2.500.000 euros (1.400.000 from the Academy of Finland)

Research grant (Jarkko Kari)

2010-2013, from the Academy of Finland, 357.000 euros

Research grant (Juhani Karhumäki)

2012-2016, from the Academy of Finland, 500.000 euros

Two post doc grants (R. Vehkalahti and S. Puzynina)

2011-2014, from the Academy of Finland

Colloquim researcher of the University (A. Okhotin)

2012-2014, from University of Turku

Two sabbatical grants (Tero Harju, Iiro Honkala)

Post doc scholarships (Ville Junnila, Mikko Pelto)

2013 Finnish Academy of Sciences (Väisälä Foundation)

Publications

Erzsébet Csuhaj-Varjú, Marian Gheorghe, Grzegorz Rozenberg, Arto Salomaa, Vaszil,György (Eds.),Membrane Computing, CMC 2012, Budapest, Lecture Notes in Computer Science 7762, Springer Publishing Company, 2013.

Silvio Capobianco, Pierre Guillon, Jarkko Kari, Surjective Cellular Automata Far from the Garden of Eden.Discrete Mathematics & Theoretical Computer Science 15(3), 41–60, 2013.

Mari Huova, Juhani Karhumäki, On the Unavoidability of k-Abelian Squares in Pure Morphic Words. Journal of Integer Sequences 16, 1–11, 2013.

Jarkko Peltomäki, Introducing Privileged Words: Privileged Complexity of Sturmian Words. Theoretical Computer Science 500, 57–67, 2013.

Arto Salomaa, Functional Constructions Between Reaction Systems and Propositional Logic. International Journal of Foundations of Computer Science 24, 147–159, 2013.

Arto Salomaa, Minimal and Almost Minimal Reaction Systems. Natural Computing 12(3), 369–376, 2013.

Arto Salomaa, Kai Salomaa, Sheng Yu, Undecidability of State Complexity. International Journal of Computer Mathematics 90(6), 1310–1320, 2013.

Ville Salo, Ilkka Törmä, Constructions with Countable Subshifts of Finite Type. Fundamenta Informaticae126(2-3), 263–300, 2013.

Nathalie Aubrun, Jarkko Kari, Tiling Problems on Baumslag-Solitar Groups. In: Turlough Neary, Matthew Cook (Eds.), Proceedings Machines, Computations and Universality 2013, Electronic Proceedings of Theoretical Computer Science 128, 35–46, Springer, 2013.

Mikhail Barash, Recursive Descent Parsing for Grammars with Contexts. In: Peter van Emde Boas, Frans C.A. Groen, Giuseppe F. Italiano, Jerzy Nawrocki, Harald Sack (Eds.), SOFSEM 2013: Theory and Practice of Computer Science, II, 10–21, Institute of Computer Science AS CR, 2013.

Mikhail Barash, Programming Language Specification by a Grammar with Contexts. In: Suna Bensch, Frank Drewes, Rudolf Freund, Friedrich Otto (Eds.), Fifth Workshop on Non-Classical Models of Automata and Applications - NCMA 2013, Umeå, Sweden, August 13 - August 14, 2013, Proceedings, books@ocg.at 294, 51–67, Österreichische Computer Gesellschaft, 2013.

Pierre Guillon, Charalampos Zinoviadis, Densities and Entropies in Cellular Automata. In: S. Barry Cooper, Anuj Dawar, Benedict Löwe (Eds.), How the world computes, 253–263, Springer, 2013.

Mari Huova, Aleksi Saarela, Strongly k-Abelian Repetitions. In: Juhani Karhumäki, Arto Lepistö, Luca Q. Zamboni (Eds.), Combinatorics on Words, LNCS 8079, 161–168, Springer, 2013.

Ville Salo, Ilkka Törmä, Topology Inspired Problems for Cellular Automata, and a Counterexample in Topology . In: Enrico Formenti (Ed.), Proceedings 18th international workshop on Cellular Automata and Discrete Complex Systems and 3rd international symposium Journées Automates Cellulaires, 53–68 , Open Publishing Association, 2013.

Ville Salo, Ilkka Törmä, Commutators of Bipermutive and Affine Cellular Automata. In: Jarkko Kari, Martin Kutrib, Andreas Malcher (Eds.), 19th International Workshop, AUTOMATA 2013, Gießen, Germany, September 17-19, 2013. Proceedings, Lecture Notes in Computer Science 8155, 155–170, Springer Berlin Heidelberg, 2013.

Ville Salo, Ilkka Törmä, Color Blind Cellular Automata. In: Jarkko Kari, Martin Kutrib, Andreas Malcher (Eds.),19th International Workshop, AUTOMATA 2013, Gießen, Germany, September 17-19, 2013. Proceedings, Lecture Notes in Computer Science 8155, 139–154, Springer Berlin Heidelberg, 2013.

Heikki Partanen, Matematiikan johtaminen luonnollisten lukujen teoriasta. TUCS General Publication 59, 2013.

Juhani Karhumäki, Whiteland Markus, Luca Zamboni (Eds.), Local Proceedings of WORDS 2013, TUCS Lecture Notes, 2013.

Timo Jolivet, Combinatorics of Pisot Substitutions. TUCS Dissertations 164. 2013.

Tommi J. M. Lehtinen, Numbers and Languages. TUCS Dissertations 158. University of Turku, 2013.

Mikhail Barash, Alexander Okhotin, Linear Grammars with One-Sided Contexts and Their Automaton Representation. TUCS Technical Reports 1088, TUCS, 2013.

Mikhail Barash, Alexander Okhotin, Grammars With Two-Sided Contexts. TUCS Technical Reports 1090, Turku Centre for Computer Science, 2013.

Vesa Halava, Tero Harju, Mari Huova, On n-permutation Post Correspondence Problem. TUCS Technical Reports 1084, TUCS, 2013.

Alexander Okhotin, Inverse Homomorphic Characterizations of Conjunctive and Boolean Grammars. TUCS Technical Reports 1080, TUCS, 2013.

Jarkko Peltomäki, Introducing Privileged Words: Privileged Complexity of Sturmian Words. TUCS Technical Reports 1081, TUCS, 2013.

4.11 Institute for Advanced Management Systems Research (IAMSR)

The research focus of IAMSR (as defined in its strategic plan for 2010-15) is on supporting people in expanding the limits of the possible in the structures of everyday life, which is guiding both fundamental and applied research and the development and use of soft computing and intelligent systems technologies. IAMSR builds on research traditions in management science and information systems research.

Soft Computing

Soft Computing builds on fuzzy sets theory, fuzzy logic, optimisation, neural nets, evolutionary algorithms, macro heuristics and approximate reasoning. Soft Computing is a new and innovative area of research which is focused on the design of intelligent systems to process uncertain, imprecise and incomplete information. Soft Computing methods applied to real-world problems offer more robust, tractable and less costly solutions than those obtained by more conventional mathematical techniques.

IAMSR was working on a Tekes strategic research project Knowledge Mobilisation [40211/08] in partnership with VTT 2008-2011 and in cooperation with UC Berkeley and five Finnish industrial partners. The theme of the project was knowledge mobilisation (“to make knowledge available for real-time use in a form which is adapted to the context of use and to the needs and cognitive profile of the user”); this sounds reasonable enough but contains a number of themes that contain unsolved research problems: (i) creating, building & forming knowledge; (ii) activating latent knowledge; (iii) searching for, finding and systematising hidden knowledge; (iv) distributing knowledge; (v) expanding the limits of the possible in everyday life routines for users of mobile

knowledge technology. The project developed a fuzzy ontology as a basis for building knowledge and fuzzy optimisation and approximate reasoning models for activating latent knowledge, for systematising hidden knowledge and for distributing knowledge on mobile technology platforms.

A fuzzy ontology is better than a classical ontology for work with knowledge formation, activation and systematisation as the ontology does not grow as large and as fast, which is significantly important for working with real world knowledge in a dynamic context and especially if we want to make knowledge available through smart mobile phones. The results we have showed that a fuzzy ontology can be built and implemented and that it actually works as envisioned.

The results of the Knowledge Mobilisation projects were further developed in the Dyscotec project with partners Kemira, Metso Automation, Rautaruukki and UPM and research partner VTT. These results, again, are now being reused in the Data to Intelligence [D2I] SHOK-program with 57 partners. The research direction with knowledge mobilisation and fuzzy ontology is producing several doctoral theses and a good series of papers in journals and conference proceedings.

Multiple criteria and robust optimisation, logistics optimisation and real option valuation

The primary aim of the research is to investigate the links between robust and multiple objective optimisations. The ultimate goal is to propose effective solution methodologies for multiple objective discrete optimisation problems utilizing the computational success of the discrete robust optimisation techniques. The main scientific intention is to bridge the gap between the two separate fields so that each can benefit from the developments that take place in the other. The main intended result of the research is to create a new methodology for multi-objective robust optimisation problems. The development of this methodology will require an intelligent synthesis of multi-objective optimisation techniques and robustness models. This idea is novel and challenging but it has a strong theoretical background supported by previous original research. The theoretical and practical models are computationally very challenging and to tackle them efficiently in practice will require the use of soft computing methods as efficient methodological tools.

Mobile service systems and mobile value services with soft computing methods

IAMSR has carried out research on the design and implementation of mobile services for more than a decade, and IAMSR has developed, tested, validated and published models for mobile services for the consumer markets. In the years 2003-11 empirical studies have been carried out each year on how Finnish consumers use mobile services with random samples of 1000-1300 consumers; these samples are representative for the Finnish population and with high answering rates (~50%) IAMSR has been able to create a unique longitudinal database for systematic statistical modelling of the adoption of mobile services; the results have gained widespread international recognition and prompted benchmarking in a number of countries. The research direction is now expanding with work on developing and implementing digital services for young elderly [the age group 60-75 years] in the BeWell research program, which is part of the D2I SHOK-program and is being developed to become its own SRA from 2015. The BeWell is a partnership within the TISRA network that has been developed with the Information Systems Science at Turku School of Economics and Business Administration; the BeWell now has 12 company partners and 6 research partners and an international network with research partners in China, Germany, Italy, Sweden and The Netherlands.

Partnerships

IAMSR was a partner in the TUCS Graduate Program and in the Graduate Program for Systems Analysis, Decision Making and Risk Management (joint for Aalto University, University of Jyväskylä, University of Turku and Åbo Akademi University) but is now running its doctoral program as part of the TISRA, which is the Turku Information Systems Research Alliance formed with the Information Systems Science of Turku School of Economics and Busines Administration. IAMSR has an international network of cooperating research groups which includes City University of Hong Kong, TU Delft, University of Koblenz, UC Berkeley, Obuda University, University of Granada, University of Trento and the SRI of the Polish Academy of Sciences. The cooperation builds on research visits by doctoral students, postdocs and senior researchers for periods ranging

from 1-2 weeks up to 4-6 months; joint research projects (e.g. the comparative studies of mobile services in Finland, Holland and Greece) and joint papers for conferences and journals. IAMSR is a partner in the eBerea network that develops research cooperation and researcher exchange with seven Chinese universities; the network is funded through the Marie Curie program and includes also Aalto University, University of Turku and University of Jyväskylä as Finnish partners and TU Delft and University of Trento as European partners.

Professor Harry Bouwman (FiDiPro through 2015) is a key resource for the research work in the Mobile Value Services group (headed by Prof Pirkko Walden). Professor Robert Fullér and his research group at Obuda University in Budapest continue their cooperation with IAMSR (Professor Fullér was a FidiPro at IAMSR 2008-2012). Since 2009 Professor Mario Fedrizzi, University of Trento, is a Docent at Åbo Akademi University and works at IAMSR on fuzzy optimisation and multiple criteria group decisions problems.

Niklas Eriksson defended his doctoral thesis in 2013 and Sonja Leskinen her thesis in January 2014; there are two more theses ready for pre-evaluation.

Leader of the unit

Christer Carlsson

Co-leader of the unit

Pirkko Walden

Senior Researchers

Harry Bouwman, Christer Carlsson, Mario Fedrizzi, Eija Karsten and Pirkko Walden

Researchers

Kaj-Mikael Björk, Markku Heikkilä, Jozsef Mezei, Shahrokh Nikou and Anna Sell

Doctoral Students

Hans Allmér, Eyal Eshet, Jaana Kallio-Gerlander, Jie Guo, Karri Hautanen, John Jeansson, Jani Kinnunen, Sonja Leskinen, Mohammad Nazrul, Hjalte Nerdrum, Henrik Nyman, Peter Strandvik, Michael Råberg, Guopeng Yu, Camilla Walden, Xiaolu Wang, Magnus Westerlund and Robin Wikström

Projects

FiDiPro

Professor Harry Bouwman, 2011-2015. Professor Robert Fullér, -2012

DYSCOTEC

Tekes, 2011-2013

D2I

Tekes SHOK, 2012–2014

eBerea

Marie Curie 2011-13

MobiRoad

Tekes 2013-14

Publications

Heli Ansio, Piia Hirkman (Eds.), Työ ja johtajuus liminaalitilassa, Raportteja 6, Tekes, 2013.

Carlsson Christer (Ed.), On the Relevance of Fuzzy Sets in Analytics, Studies in Fuzziness and Soft Computing 298, Springer Berlin Heidelberg, 2013.

Harry Bouwman, Mark de Reuver, Nico Heerschap, Hannu Verkasalo, Opportunities and problems with automated data collection via smartphones. Mobile Media & Communication 1(1), 63–68, 2013.

Matteo Brunelli, József Mezei, How different Are Ranking Methods for Fuzzy Numbers? A Numerical Study.International Journal of Approximate Reasoning 54(5), 627–639, 2013.

Christer Carlsson, Jozsef Mezei, Matteo Brunelli, Fuzzy Ontology Used for Knowledge Mobilization .International Journal of Intelligent Systems 28(1), 52–71, 2013.

Christer Carlsson, Robert Fuller, Probabilistic Versus Possibilistic Risk Assessment Models for Optimal Service Level Agreements in Grid Computing. Information Systems and E-Business Management 11(1), 13–28, 2013.

Dave Daas, Toine Hurkmans, Sietse Overbeek, Harry Bouwman, Developing a Decision Support System for Business Model Design. Electronic Markets 23(3), 251–265, 2013.

Mark de Reuver, Mark Bouwman, TIMBER HAAKER, Business Model Roadmapping: A Practical Approach to Come from an Existing to a Desired Business Model. International Journal of Innovation Management 17(1), 1–18, 2013.

Mark de Reuver, Guido Ongena, Harry Bouwman, Should Mobile Internet be an Extension to the Fixed Web? A Consumer Survey on Fixed-Mobile . Telematics and Informatics 30(2), 111–120, 2013.

Soebhaash Dihal, Harry Bouwman, Mark de Reuver, Martijn Warnier, Christer Carlsson, Mobile Cloud Computing: State of the Art and Outlook. Info 15(1), 4–16, 2013.

Muhammad Nazrul Islam, A Systematic Literature Review of Semiotics Perception in User Interfaces.Journal of Systems and Information Technology 15(1), 45–77, 2013.

Tina George Karippacherila, Fatemeh Nikayinb, Mark de Reuver, Harry Bouwman, Serving the Poor: Multisided Mobile Service Platforms, Openness, Competition, Collaboration and the Struggle for Leadership.TELECOMMUNICATIONS POLICY 37(1), 24–34, 2013.

Tiina Kontinen, Pia Houni, Helena Karsten, Heikki Toivanen, Liminaalitilan käsite työn muutosten jäsentäjänä. Aikuiskasvatus 2013(4), 252–264, 2013.

António Madureira, Frank den Hartog, Harry Bouwman, Nico Baken, Empirical Validation of Metcalfe's Law: How Internet Usage Patterns Have Changed Over Time. Information Economics and Policy 25(4), 246–256, 2013.

Shahrokh Nikou, Harry Bouwman, Ubiquitous Use of Mobile Social Network Services. Telematics and Informatics ?, 1–12, 2013.

Shahrokh Nikou, József Mezei, Evaluation of mobile services and substantial adoption factors with Analytic Hierarchy Process (AHP). TELECOMMUNICATIONS POLICY 2013(2013), 15, 2013.

Albert Plugge, Harry Bouwman, Fit Between Sourcing Capabilities and Organizational Structure on IT Outsourcing Performance. Production Planning & Control. The Management 24(4-5), 375–387, 2013.

Albert Plugge, Harry Bouwman, Francisco-Jose Molina-Castillo, Outsourcing Capabilities, Organizational Structure and Performance Quality Monitoring: Towards a Fit Model. Information and Management 50(6), 275–284, 2013.

Albert Pugge, Harry Bouwman, Fit Between Sourcing Capabilities and Organizational Structure on IT Outsourcing Performance. Production Planning and Control 24(4-5), 375–387, 2013.

Ignacio J. Perez, Robin Wikström, József Mezei, Christer Carlsson, Enrique Herrera-Viedma, A New Consensus Model for Group Decision Making Using Fuzzy Ontology. Soft Computing 17(9), 1617–1627, 2013.

Sam Solaimani, Harry Bouwman, Fernando Secomandi, Critical Design Issues for development of Smart Home Technologies. Journal of Design Research 11(1), 72–90, 2013.

Harry Bouwman, Mark De Reuver, Shahrokh Nikou, Mixed Method Research: Combining Mobile Log Data and Questionnaires. In: Leibniz Gemeinschaft (Ed.), 24th European Regional ITS Conference, Florence, Italy, 20th-23rd October 2013, 24th European Regional Conference of the International Telecommunication Society, Florence, Italy, 20-23 October 2013, 1–10, ECONSTOR, 2013.

Natalia Díaz Rodríguez, Robin Wikström, Johan Lilius, Manuel Pegalajar Cuéllar, Miguel Delgado Calvo-Flores,Understanding Movement and Interaction: An Ontology for Kinect-Based 3D Depth Sensors. In: José Bravo, Sergio Ochoa, Gabriel Urzaiz, Liming Luke Chen, Jonice Oliveira (Eds.), Ubiquitous Computing and Ambient Intelligence. Context-Awareness and Context-Driven Interaction, Lecture Notes in Computer Science 8276, 254–261, Springer, 2013.

Jie Guo, Shahrokh Nikou, Harry Bouwman, Analyzing the Business Model for Mobile Payment from Banks' Perspective: An Empirical Study. In: leibniz Gemeinschft (Ed.), 24th European Regional ITS Conference, Florence, Italy, 20th-23rd October 2013, 1–10, ECONSTOR, 2013.

Muhammad Nazrul Islam, Towards Determinants of User-Intuitive Web Interface Signs. In: Aaron Marcus (Ed.), 15th International Conference on Human-Computer Interaction, Lecture Notes in Computer Science 8012, 84–93, Springer, 2013.

József Mezei, Robin Wikström, Aggregation Operators and Interval-Valued Fuzzy Numbers in Decision Making. In: Álvaro Rocha, Ana Maria Correia, Tom Wilson, Karl A. Stroetmann (Eds.), Advances in Information Systems and Technologies, Advances in Intelligent Systems and Computing 206, 535–544, Springer, 2013.

József Mezei, Robin Wikström, OWAD Operators in Type-2 Fuzzy Ontologies. In: Witold Pedrycz, Marek Reformat (Eds.), Joint IFSA World Congress and NAFIPS Annual Meeting (IFSA/NAFIPS), 848–853, IEEE, 2013.

Shahrokh Nikou, Harry Bouwman, The Diffusion of Mobile Social Network Service in China: The Role of Habit and Social Influence. In: Roy Sterritt (Ed.), 2013 46th Hawaii International Conference on System Sciences, 1073–1081, IEEE Computer Society, 2013.

Ignacio J. Perez, Robin Wikström, József Mezei, Christer Carlsson, Karina Anaya, Enrique Herrera-Viedma,Linguistic Consensus Models Based on a Fuzzy Ontology. In: Yong Shi, Youmin Xi, Peter Wolcott, Yingjie Tian, Jianping Li, Daniel Berg, Zhengxin Chen, E Herrera-Viedmnriquea, Gang Kou, Heeseok Lee, Yi Peng, Lean Yu (Eds.), Proceedings of the First International Conference on Information Technology and Quantitative Management, Procedia Computer Science, 498–505, Elsevier, 2013.

Muhammad Nazrul Islam, Towards Exploring Web Interface Sign Ontology: A User Study. In: Constantine Stephanidis (Ed.), 15th International Conference on Human-Computer Interaction, Communications in Computer and Information Science 373, 41–45, Springer, 2013.

Robin Wikström, Ontology of Imprecision and Fuzzy Ontology Applications. In: Karl-Heinz Krempels, Alexander Stocker (Eds.), In Proceedings of the 9th International Conference on Web Information Systems and Technologies, 284–287, SCITEPRESS, 2013.

Piia Hirkman, Henrik Nyman, Helena Karsten, Kankea, kankeampi, projekti? Projektit ja joustavan johtajuuden puitteet. In: Heli Ansio, Piia Hirkman (Eds.), Työ ja johtajuus liminaalitilassa, Raportteja 6, 48–55, Tekes, 2013.

Pia Houni, Tiina Kontinen, Helena Karsten, Heikki Toivanen, Työ ja johtajuus liminaalitilassa: uusia johtamiskäytäntöjä katsastamassa. In: Heli Ansio, Piia Hirkman (Eds.), Työ ja johtajuus liminaalitilassa, Raportti 6, 8–14, Tekes, 2013.

Muhammad Nazrul Islam, Franck Tetard, Integrating Semiotics Perception in Usability Testing to Improve Usability Evaluation. In: Miguel A. Garcia-Ruiz (Ed.), Cases on Usability Engineering: Design and Development of Digital Products, 145–169, IGI Global, 2013.

Helena Karsten, Muuttuva, jaettu johtajuus. In: Heli Ansio, Piia Hirkman (Eds.), Työ ja johtajuus liminaalitilassa, Raportti 6, 56–60, Tekes, 2013.

Kaj-Mikael Björk, Markus Holopainen, Robin Wikström, Henrik Saxen, Christer Carlsson, Miika Sihvonen,Analysis of Blast Furnace Time Series Data with ANFIS. TUCS Technical Reports 1094, TUCS, 2013.

4.12 Learning and Reasoning Lab

The Learning and Reasoning laboratory studies and develops new methods and tools for teaching mathematics and programming. The target group is junior high school students, high school students and introductory level university and polytechnic students. The research method used is both constructive and empirical. We develope new methods, together with computer based tools to support the methods, and then try them out in practical empirical studies, usually courses that are taught with these new methods and tools.The feedback from the empirical studies is then used to improve the methods and tools. We specifially concentrated on four topics: (a) teaching mathematics using structured derivations, (b) teaching formal methods in programming using invariant based programming, (c) developing tutoring systems for programming courses, and (d) teaching practical programming skills using Python. The laboratory is shared between Åbo Akademi University and University of Turku.

Research Unit Web Page: https://research.it.abo.fi/research/learning-and-reasoning-laboratory

Leader of the unit

Ralph-Johan Back and Tapio Salakoski

Researchers

Johannes Eriksson, Mikko Laakso, Linda Mannila, Patrick Sibelius and Petri Salmela

Doctoral Students

Teemu Rajala, Mia Peltomäki and Erkki Kaila

Unit Members

Petri Sallasmaa, Siiri Kunnapas, Mari Pöld, Kaj Giersberg, Terhi Hovi, Saara Mäkinen, Topi Hurtig, Stefan Asikainen, Eva Rönnqvist and Lars Wingård

Projects

Improving Competence in Mathematics using New Teaching Methods and ICT [E-math]

(EU Central Baltic project, 2011-2013)

4.13 Software Engineering Laboratory (SE Lab)

The mission of the Software Engineering Laboratory is to research, develop and evaluate processes, methods and tools to engineer high-quality software-intensive systems, with a focus on software performance and developer productivity.

Software Performance Engineering

High Performance Computing. Research on parallel programming and code optimization using supercomputers and general purpose computation graphics processing units GPUs. Application areas include bioinformatics, nuclear fusion plasma physics, fluid dynamics and computer graphics.

Cloud Software. Research on automatic resource allocation and software scalability to balance application performance, reliability and computing infrastructure costs. Application areas include web applications and services.

Developer Productivity

Software Design. Metamodeling languages, domain-specific languages, model repositories, model transformation and model editors to facilitate the design of software-intensive systems. Application areas include the design of embedded systems and web applications and services.

Software Testing. Modeling requirements and modeling for test generation. Automated model-based testing of web services and telecommunication software.

Software development process improvement and supporting metrics. Improving the way of working when developing different types of software with a focus on agile and lean methods. Measuring the impact of process change on different attributes, ranging from technical attributes, such as software maintainability, to business attributes, such as business value creation.

Research Unit Web Page: https://research.it.abo.fi/research/high-performance-computing

Research Unit Web Page: https://research.it.abo.fi/research/software-engineering-laboratory

Leader of the unit

Ivan Porres

Co-leader of the unit

Jan Westerholm

Senior Researchers

Mats Aspnäs, Jeanette Heidenberg, Ivan Porres, Dragos Truscan and Jan Westerholm

Projects

CRESTA

An EU-funded FP7 project

Cloud Software Program

DISCO

Extension of grid computation to GP-GPU devices

DIEM

Device and Interoperability and Ecosystems

EUFORIA

EU Fusion fOR Iter Applications

PAM

Practical Applications of Model-based technologies to continuous integration & testing methodologies

RECOMP

Reduced Certification Costs Using Trusted Multi-core

SimITER

A problem-driven computational project within fusion physics

VAMOLA

Validation of Many Models in Many Languages

Publications

Ville Timonen, Line-Sweep Ambient Obscurance. Computer Graphics Forum 32(4), 97–105, 2013.

Fredrik Abbors, Tanwir Ahmad, Dragos Truscan, Ivan Porres, Model-Based Performance Testing in the Cloud Using the MBPeT Tool. In: Seelam Seetharami (Ed.), Proceedings of the 4th ACM/SPEC International Conference on Performance Engineering (ICPE '13), ACM/SPEC International Conference on Performance Engineering 1, 423–424, ACM, 2013.

Fredrik Abbors, Tanwir Ahmad, Dragos Truscan, Ivan Porres, Model-based Performance Testing of Web Services using Probabilistic Timed Automata. In: Karl-Heinz Krempels, Alexander Stocker (Eds.), Proceedings of the 9th International Conference on Web Information Systems and Technologies, 99–104, Webist, 2013.

Adnan Ashraf, Cost-Efficient Virtual Machine Provisioning for Multi-tier Web Applications and Video Transcoding. In: Pavan Balaji, Dick Epema, Thomas Fahringer (Eds.), 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid), 66–69, IEEE Computer Society, 2013.

Adnan Ashraf, Fareed Jokhio, Tewodros Deneke, Sebastien Lafond, Ivan Porres, Johan Lilius, Stream-Based Admission Control and Scheduling for Video Transcoding in Cloud Computing. In: Pavan Balaji, Dick Epema, Thomas Fahringer (Eds.), 13th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid), 482–489, IEEE Computer Society, 2013.

Jeanette Heidenberg, Max Weijola, Kirsi Mikkonen, Ivan Porres, A Metrics Model to Measure the Impact of an Agile Transformation in Large Software Development Organizations. In: Hubert Baumeister, Barbara Weber (Eds.), Agile Processes in Software Engineering and Extreme Programming, Lecture Notes in Business Information Processing 149, 165–179, Springer Heidelberg, 2013.

Fareed Jokhio, Adnan Ashraf, Sébastien Lafond, Johan Lilius, A Computation and Storage Trade-Off Strategy for Cost-Efficient Video Transcoding in the Cloud. In: Onur Demirors, Oktay Turetken (Eds.), 39th EUROMICRO Conference on Software Engineering and Advanced Applications, 365–372, IEEE Computer Society, 2013.

Fareed Ahmed Jokhio, Adnan Ashraf, Sébastien Lafond, Ivan Porres, Johan Lilius, Prediction-Based Dynamic Resource Allocation for Video Transcoding in Cloud Computing. In: Peter Kilpatrick, Peter Milligan, Rainer Stotzka (Eds.), Proceedings of the 21st International Euromicro

Conference on Parallel, Distributed and Network-based Processing, Belfast, UK 27 February - 1 March 2013, 254–261, IEEE Computer society, 2013.

Ali Hanzala Khan, Irum Rauf, Ivan Porres, Consistency of UML Class and Statechart Diagrams with State Invariants. In: Joaquim Filipe, Rui César das Neves (Eds.), First International Conference on Model-Driven Engineering and Software Development, MODELSWARD 2013, 1, 1–11, SciTePress Digital Library, 2013.

Martin Koskinen, Dragos Truscan, Tanwir Ahmad, Niklas Grönblom, Combining Model-Based Testing and Continuous Integration. In: Luigi Lavazza, Roy Oberhauser, Adriana Martin, Jameleddine Hassine, Michael Gebhart, Marko Jäntti (Eds.), ICSEA 2013: The Eighth International Conference on Software Engineering Advances, 65–71, IARIA, 2013.

Risto Nevalainen, Uwe Kremer, Oscar Slotosch, Dragos Truscan, Vicky Wong, Impact of multicore platforms in hardware and software certification. In: International Workshop on Industry-Driven Approaches for Cost-effective Certification of Safety-Critical, Mixed-Criticality Systems (WICERT), 1–6, online, 2013.

Mehdi Nobakht, Dragos Truscan, An Approach for Validation, Verification, and Model-Based Testing of UML-Based Real-Time Systems. In: Luigi Lavazza, Roy Oberhauser, Adriana Martin, Jameleddine Hassine, Michael Gebhart, Marko Jäntti (Eds.), ICSEA 2013, The Eighth International Conference on Software Engineering Advances, 79–85, IARIA, 2013.

Ivan Porres, Jeanette Heidenberg, Max Weijola, Kristian Nordman, Dragos Truscan, Authoring IEC 61508 Based Software Development Process Models. In: Jens Heidrich, Markku Oivo, Andreas Jedlitschka, Maria Teresa Baldassarre (Eds.), Product-Focused Software Process Improvement, LNCS 7983, 268–282, Springer Berlin Heidelberg, 2013.

Faezeh Siavashi, Marina Waldén, Leonidas Tsiopoulos, Jüri Vain, Modelling Critical Systems with Time Constraints in Event-B. In: Tarmo Uustalu, Jüri Vain (Eds.), Proceedings of the 25th Nordic Workshop on Programming Theory, NWPT '13, 1–3, Tallin University of Technology, 2013.

Ville Timonen, Screen-Space Far-Field Ambient Obscurance. In: Steve Molnar, Jens Krüger (Eds.), High Performance Graphics, 33–43, ACM, 2013.

Fredrik Abbors, Tanwir Ahmad, Dragos Truscan, Ivan Porres, Performance Testing in the Cloud using MBPeT. In: Ivan Porres, Tommi Mikkonen, Adman Ashraf (Eds.), Developing Cloud Software, 191–225, Turku Centre for Computer Science, 2013.

Adnan Ashraf, Benjamin Byholm, Ivan Porres, Prediction-Based Virtual Machine Provisioning and Admission Control for Multi-Tier Web Applications. In: Ivan Porres, Tommi Mikkonen, Adnan Ashraf (Eds.), Developing Cloud Software: Algorithms, Applications, and Tools, TUCS General Publication 60, 71–112, TUCS, 2013.

Adnan Ashraf, Mikko Hartikainen, Usman Hassan, Keijo Heljanko, Johan Lilius, Tommi Mikkonen, Ivan Porres, Mahbubul Syeed, Sasu Tarkoma, Introduction to Cloud Computing Technologies. In: Ivan Porres, Tommi Mikkonen, Adnan Ashraf (Eds.), Developing Cloud Software: Algorithms, Applications, and Tools, TUCS General Publication 60, 1–41, TUCS, 2013.

Fareed Jokhio, Adnan Ashraf, Tewodros Deneke, Sebastien Lafond, Ivan Porres, Johan Lilius, Proactive Virtual Machine Allocation for Video Transcoding in the Cloud. In: Ivan Porres, Tommi Mikkonen, Adnan Ashraf (Eds.), Developing Cloud Software: Algorithms, Applications, and Tools, TUCS General Publication 60, 113–143, TUCS, 2013.

Ivan Porres, Tommi Mikkonen, Adnan Ashraf (Eds.), Developing Cloud Software: Algorithms, Applications, and Tools, TUCS General Publication, TUCS, 2013.

Ali Hanzala Khan, Consistency of UML Based Designs using Ontology Reasoners. TUCS Dissertations 168. 2013.

Tanwir Ahmad, Fredrik Abbors, Dragos Truscan, Ivan Porres, Model-Based Performance Testing Using the MBPeT Tool. TUCS Technical Reports 1066, Turku Centre for Computer Science, 2013.

Fareed Jokhio, Adnan Ashraf, Sébastien Lafond, Ivan Porres, Johan Lilius, Cost-Efficient Dynamically Scalable Video Transcoding in Cloud Computing. TUCS Technical Reports 1098, TUCS, 2013.

Mehdi Nobakht, Dragos Truscan, Tool Support for Transforming UML-Based Specifications to UPPAAL Timed Automata. TUCS Technical Reports 1087, TUCS, 2013.

Irum Rauf, Faezeh Siavashi, Dragos Truscan, Ivan Porres, An Integrated Approach to Design and Validate REST Web Service Compositions. TUCS Technical Reports 1097, TUCS, 2013.

4.14 Software Construction Laboratorium

The Software Construction Laboratory studies techniques and methods for software construction, both in the small and in the large, with particular emphasis on the construction of highly reliable and functionally correct software systems. Our research encompasses analysis and design methods, programming methodology, development tools, and software processes. The laboratory conducts both basic and applied research in the area of software construction.

The basic research concerns program correctness, semantics, and formal methods. Our focus is on programming logics, in particular refinement calculus, action systems and separation logic. We study several different programming paradigms, including imperative, functional, parallell and invariant based programs.

The applied research concerns the integration of formal techniques into software development tools and processes. We also conduct empirical evaluation of new methods and tools.

Leader of the unit

Ralph-Johan Back

Researchers

Johannes Eriksson, Linda Mannila and Viorel Preoteasa

Doctoral Students

Mikolaj Olszewski and Charmi Panchal

4.15 Software Development Laboratory (SwDev)

The research unit broadly covers topics related to software development. In particular, we are interested in

- Cloud service architectures and business models
- Game development and gamification
- Software business, special focus on start-ups
- Software development methodologies and processes
- Software ecosystems
- Software metrics, testing and security
- Software productization
- Software techniques, especially related to parallelism
- Software technology-enabled services and managing technology-service convergences

Research Unit Web Page: http://soft.utu.fi/swdev

Leader of the unit

Ville Leppänen

Senior Researchers

Timo Knuutila and Jouni Smed

Researchers

Arho Suominen and Tuomas Mäkilä

Doctoral Students

Harri Hakonen, Johannes Holvitie, Sami Hyrynsalmi, Antero Järvi, Jari-Matti Mäkelä, Sami Mäkelä, Sanna Mäkelä, Jurka Rahikkala, Sampsa Rauti, Kalle Rindel and Kai Saarinen

Projects

REPLICA

REPLICA is a 3-year (2011–2013) project funded by VTT. VTT collaborates with University of Linköping, Sweden, and University of Turku, Finland. The removing performance and programmability limitations of chip multiprocessor architecture (REPLICA) project aims at developing a CESM architecture and methodology that would enable radically easier programming and higher performance based on synchronous shared memory model of computation. Web page: http://staff.cs.utu.fi/research/REPLICA/.

Game Tech & Arts Lab

(led by Jouni Smed), 2009-2011, funded by Teknologiateollisuuden 100-vuotsissäätiö. Web page: http://www.gametecharts.fi/en/

Publications

Martti Forsell, Ville Leppänen, An Extended PRAM-NUMA Model of Computation for TCF Programming.International Journal of Networking and Computing 3(1), 98–115, 2013.

Johanna Hunt, Olumide Akerele, Tomi Juhola, Michael Waterman, Report from the PhD Symposium At XP2013: An Adaptive Experiment in Feedback. ACM SIGSOFT Software Engineering Notes 38(5), 59–62, 2013.

Johannes Holvitie, Mikko-Jussi Laakso, Teemu Rajala, Erkki Kaila, Ville Leppänen, The Role of Dependency Propagation in the Accumulation of Technical Debt for Software Implementations. In: Ákoss Kiss (Ed.), 13th Symposium on Programming Languages and Software Tools, 61–75, University of Szeged, 2013.

Johannes Holvitie, Ville Leppänen, DebtFlag: Technical Debt Management with a Development Environment Integrated Tool. In: Philippe Kruchten, Robert Nord, Ipek Ozkaya (Eds.), 2013 4th International Workshop on Managing Technical Debt (MTD), 20–27, IEEE, 2013.

Sami Hyrynsalmi, Arho Suominen, Tuomas Mäkilä, Antero Järvi, Analyzing Developers' Challenges in Mobile Application Marketplaces. In: Peter Buxmann, Slinger Jansen, Thomas Kude, Karl Michael Popp, Martin Przewloka (Eds.), Proceedings of the European Workshop on Software Ecosystems 2012, 32–37, Synomic Academy, 2013.

Sami Hyrynsalmi, Arho Suominen, Marko Seppänen, Tuomas Mäkilä, The Relevance of Customer Reviews in the Mobile Application Marketplaces. In: Proceedings of the 22nd International Conference on Management of Technology, 1–12, International Association of Management of Technology, 2013.

Tomi Juhola, Sami Hyrynsalmi, Ville Leppänen, Tuomas Mäkilä, Agile Software Development and Innovation: A systematic Literature Review. In: Proceedings of 6th ISPIM Innovation Symposium: Innovation in the Asian century, 1–19, ISPIM, 2013.

Tomi Juhola, Sami Hyrynsalmi, Tuomas Mäkilä, Ville Leppänen, Agile Methodologies as Process Innovation Drivers. In: Proceedings of the XXIV ISPIM Conference – Innovating in Global Markets: Challenges for Sustainable Growth, 1–7, Aalto University, 2013.

Antero Järvi, Tuomas Mäkilä, Sami Hyrynsalmi, Game Development Accelerator — Initial Design and Research Approach. In: Sami Hyrynsalmi, Krzysztof Wnuk, Maya Daneva, Tuomas Mäkilä, Andrea Herrmann (Eds.), Proceedings of From Start-ups to SaaS Conglomerate: Life Cycles of Software Products, Ceur Workshop Proceedings 1095, 47–58, CEUR-WS, 2013.

Jussi Laasonen, Jouni Smed, Detecting a Colluding Subset in a Simple Two-Dimensional Game. TUCS Technical Reports 1074, TUCS, 2013.

Ville Leppänen, Agile Methodologies as Process Innovation Drivers. In: ISPIM, 2013.

Ville Leppänen, Agile Software Development and Innovation: A Systematic Literature Review. In: LUT Scientific and Expertise Publications, 2013.

Ville Leppänen, An Extended PRAM-NUMA Model of Computation for TCF Programming. In: International Journal of Networking and Computing, 3(1), 2013.

Ville Leppänen, Composable Hierarchical Synchronization Support for REPLICA. In: Kiss Ákos (Ed.), Proceedings of SPLST13, 2013.

Ville Leppänen, DebtFlag: Technical Debt Management with a Development Environment Integrated Tool. 2013.

Ville Leppänen, Event-Driven Asynchronous Method Calls with the D-Bus Message System. In: Software: Practice and Experience, 2013.

Ville Leppänen, Hardware and Software Support for NUMA Computing on Configurable Emulated Shared Memory Architectures. In: IPDPSW, 2013.

Ville Leppänen, Reducing the Complexity of Debugging Parallel REPLICA Programs with Pluggable Abstraction Patterns. In: Tomas Nordström, Zain-ul-Abdin (Eds.), Proceedings of the Sixth Swedish Workshop on Multicore Computing, 2013.

Ville Leppänen, Synchronization Property Checking and Inference in a Lock-Step Synchronous Parallel Replica Language. In: Uustalu Tarmo, Vain Jüri (Eds.), Proceedings fo the Nordic Workshop on Programming Theory, 2013.

Ville Leppänen, The Role of Dependency Propagation in the Accumulation of Technical Debt for Software Implementations. In: Kiss Ákos (Ed.), Proceedings of SPLST13, 2013.

Ville Leppänen, Towards a Parallel Debugging Framework for the Massively Multi-Threaded, Step-Synchronous REPLICA Architecture. 2013.

Jari-Matti Mäkelä, Ville Leppänen, Martti Forsell, Composable Hierarchical Synchronization Support for REPLICA. In: Kiss Ákos (Ed.), 13th Symposium on Programming Languages and Software Tools, 230–244, University of Szeged, 2013.

4.16 Turku Optimization Group (TOpGroup)

The mathematical and computational tools in optimization are used more frequently these days, as they provide efficient tools with negligible costs for many industries in the race for greater profits and better efficiency. The optimization group does research in both modeling and implementation

of practical problems from industry and further development of algorithms. The following areas of optimization are at focus:

Theory

- nonsmooth analysis
- generalized convexity
- optimality conditions
- multiobjective optimization
- combinatorial optimization
- parametrization and regularization
- sensitivity analysis

Methods

- mixed-integer nonlinear programming
- robust optimization
- scheduling and resource allocation
- heuristics and evolutionary optimization
- derivative free optimization
- multicriteria decision-making
- global optimization

Applications

- transport networks and logistics
- maritime routing and flight scheduling
- meteorology and climate analysis
- chemical engineering
- electronic industry and circuit design

Research Unit Web Page: http://www.math.utu.fi/en/research/groups/opt/

Leader of the unit

Marko M. Mäkelä

Senior Researchers

Yury Nikulin, Napsu Karmitsa and Stefan Emet

Projects

Large Scale Mixed Integer Global Optimization

With Åbo Akademi University

Modeling the Ferry Services of the Archipelago

With the Centre for Maritime Studies

Publications

Nikulin Yury, Karelkina Olga , Mäkelä Marko, On Accuracy, Robustness and Tolerances in Vector Boolean Optimization. European Journal of Operational Research 224, 449–457, 2013.

Seppo Pulkkinen, Marko M. Mäkelä, Napsu Karmitsa, A Continuation Approach to Mode-Finding of Multivariate Gaussian Mixtures and Kernel Density Estimates. Journal of Global Optimization 56(2), 459–487, 2013.

Vladimir Emelichev, Vladimir Korotkov, Yury Nikulin, Stability Analysis of One Portfolio in Multicriteria Markowitz's Investment Problem with Savage's Risk Criteria Endowed with Hölder Metric. TUCS Technical Reports 1077, TUCS, 2013.

Kirill Kuzmin, Yury Nikulin, On Necessary and Sufficient Conditions of Stability and Quasistability in a Vector Combinatorial Optimization Problem with Partial Criteria Processing Some Regularity Properties. TUCS Technical Reports 1095, TUCS, 2013.

Yury Nikulin, Quality of Solutions in Combinatorial Optimization Models Involving Substitutions. TUCS Technical Reports 1064, TUCS, 2013.

Sergii Pidlisnyi, Marko M. Mäkelä, Yuri Nikulin, Effects of Implementation Quasiinvertion and Optimization Methods for Nonlinear Boundary Inverse Heat Conduction Problems. TUCS Technical Reports 1083, TUCS, 2013.

Seppo Pulkkinen, Incremental Low-Rank SDP Approach to Finding Graph Embeddings. TUCS Technical Reports 1069, TUCS, 2013.

Seppo Pulkkinen, Ridge Curve Approach to Extraction of Curvilinear Structures from Noisy Data. TUCS Technical Reports 1082, TUCS, 2013.

Seppo Pulkkinen, A Probabilistic Approach to Nonlinear Principal Component Analysis With Applications. TUCS Technical Reports 1091, TUCS, 2013.

4.17 UTU Information Systems Science (ISSR)

The focus of the research activities within the institute lies within understanding the utilization of information and communication technology in enterprises and other organizations. The research conducted within the institute covers most of the key areas of information systems. The research activities can be classified into four themes:

- Management of Information Systems and Business Information Systems
- Networks and Business Models
- Work Informatics
- Healthcare Information Systems

Leader of the unit

Timo Leino

Senior Researchers

Tomi Dahlberg, Jukka Heikkilä, Najmul Islam, Jonna Järveläinen, Kai Kimppa, Eija Koskivaara, Timo Leino, Hongxiu Li, Matti Mäntymäki, Markku I. Nurminen, Hannu Salmela and Reima Suomi

Researchers

Antti Tuomisto and Pekka Reijonen

Doctoral Students

Mikko Hallanoro, Eeva Heiro, Ari Helin, Tuomo Helo, Juha Kinnunen, Jussi Karttunen, Timo Kestilä, Jani Koskinen, Janne Lahtiranta, Katja Laitinen, Jari Lehtonen, Tingting Lin, Jani Merikivi,

Jaana Mäkinen, Marko Niemimaa, Jussi Nissilä, Janne Ohtonen, Pasi Ojala, Pirjo Rosti, Neeraj Sachdeva, Juha Sainio, Outi Seppä, Jorma Sieviläinen, Hannu Siikaluoma, Olli Sjöblom, Nina Suvanto, Kimmo Tarkkanen, Jose Teixeira, Anne-Marie Tuikka, Markku Tuomola and Xiaoyu Xu

Projects

4D Space

Innovations in retailing industry program. See http://mide.aalto.fi/4D-Space

Coper

European Regional Development Fund, 2011-2014, co-supported by City of Turku, Logica Inc. and Turku Science Park Inc. See http://workinformatics.utu.fi/eng/research_projects.html

EATku

Enterprise Architecture education workshops for the municipalities of Kaarina, Lieto, Naantali, Paimio, Turku, Health District of Finland Proper, Medbit Ltd.

ICTSTR

Turun seudun IT-strategia; ICT-services co-operation strategy and roadmap for the municipalities of Kaarina, Lieto, Naantali, Paimio, Turku, Health District of Finland Proper, Medbit Ltd., and University of Turku.

ICT-Portti

European Social Fund, 2008-2011; Technology Industries of Finland Centennial Foundation (2009-2013), co-supported by Trivore Inc., ElanIT Resources, Fujitsu Services, the City of Salo, and numerous companies and organizations.

See http://workinformatics.utu.fi/eng/research_projects.html and http://www.ictportti.fi/

OPAL

Process Maturity Modeling (with Outotech Ltd)

SHOK Tivit D2I

(Data to Intelligence) Business modeling and master data management best practices and evaluation, about 40 partners in consortium. See http://www.datatointelligence.fi/

ULETS

Use and Learning evaluation of Small, Enhanced Touch Screen.

WIUX

Development of user experience evaluation process and methodology for healthcare information systems, Logica Plc.

Publications

Sami Hyrynsalmi, Krzysztof Wnuk, Maya Daneva, Tuomas Mäkilä, Andrea Herrmann (Eds.), Proceedings of From Start-Ups to SaaS Conglomerate: Life Cycles of Software Products Workshop (IW-LCSP 2013), Ceur Workshop Proceedings 1095, CEUR-WS, 2013.

A.K.M. Najmul Islam, Investigating E-learning System Usage Outcomes in the University Context.Computers and Education 69, 387–399, 2013.

Matti Kaisti, Ville Rantala, Tapio Mujunen, Sami Hyrynsalmi, Kaisa Könnölä, Tuomas Mäkilä, Teijo Lehtonen,Agile Methods for Embedded Systems Development - a Literature Review and a Mapping Study. EURASIP Journal of Embedded Systems 2013(15), 1–16, 2013.

Janne Lahtiranta, Jani Koskinen, Electronic Health Services for Cardiac Patients: A Salutogenic Approach.Finnish Journal of eHealth and eWelfare 5(2-3), 55–62, 2013.

Elina Laaksonen, Marko Niemimaa, Dan Harnesk, Influences of Frame Incongruence on Information Security Policy Outcomes: An Interpretive Case Study. International Journal of Social and Organizational Dynamics in IT 3(3), 33–50, 2013.

Sami Hyrynsalmi, Arho Suominen, Tuomas Mäkilä, Antero Järvi, Analyzing Developers' Challenges in Mobile Application Marketplaces. In: Peter Buxmann, Slinger Jansen, Thomas Kude, Karl Michael Popp, Martin Przewloka (Eds.), Proceedings of the European Workshop on Software Ecosystems 2012, 32–37, Synomic Academy, 2013.

Sami Hyrynsalmi, Arho Suominen, Marko Seppänen, Differentation within Mobile Ecosystems — The Unspecialized Marketplaces. In: Proceedings of the 22nd International Conference on Management of Technology, 1–17, International Association of Management of Technology, 2013.

Sami Hyrynsalmi, Arho Suominen, Marko Seppänen, Tuomas Mäkilä, The Relevance of Customer Reviews in the Mobile Application Marketplaces. In: Proceedings of the 22nd International Conference on Management of Technology, 1–12, International Association of Management of Technology, 2013.

A.K.M. Najmul Islam, Conceptualizing Perceived Usefulness In E-Learning Context And Investigating Its Role in Improving Students' Academic Performance. In: None None (Ed.), European Conference on Information Systems, Paper 8, AIS, 2013.

A.K.M. Najmul Islam, M. Fakhrul Onik, Nasreen Azad, Comparing the Post-Adoption Perceptions of Educators and Students with an E-Learning Platform. In: European Conference on Information Systems, Paper 4, AIS, 2013.

Tomi Juhola, Sami Hyrynsalmi, Ville Leppänen, Tuomas Mäkilä, Agile Software Development and Innovation: A systematic Literature Review. In: Proceedings of 6th ISPIM Innovation Symposium: Innovation in the Asian century, 1–19, ISPIM, 2013.

Tomi Juhola, Sami Hyrynsalmi, Tuomas Mäkilä, Ville Leppänen, Agile Methodologies as Process Innovation Drivers. In: Proceedings of the XXIV ISPIM Conference – Innovating in Global Markets: Challenges for Sustainable Growth, 1–7, Aalto University, 2013.

Antero Järvi, Tuomas Mäkilä, Sami Hyrynsalmi, Game Development Accelerator — Initial Design and Research Approach. In: Sami Hyrynsalmi, Krzysztof Wnuk, Maya Daneva, Tuomas Mäkilä, Andrea Herrmann (Eds.), Proceedings of From Start-ups to SaaS Conglomerate: Life Cycles of Software Products, Ceur Workshop Proceedings 1095, 47–58, CEUR-WS, 2013.

Tingting Lin, IT Outsourcing at the Stage of Psychological Contract: Governance-in-Practice and Governance-in-Contract. In: Sjaak Brinkempper (Ed.), ECIS 2013 Proceedings, Paper 168, AIS Electronic Library (AISeL), 2013.

Matti Mäntymäki, A.K.M. Najmul Islam, Continued Social Virtual World Use among Teens: Examining the Moderating Role of Perceived Network Exposure. In: R. H. Jr. Sprague (Ed.), Hawaii International Conference on System Sciences, 3252–3261, IEEE, 2013.

Marko Niemimaa, Jonna Järveläinen, IT Service Continuity: Achieving Embeddedness Through Planning. In: Juan Guerrero (Ed.), Proceedings of the 8th International Conference on Availability, Reliability and Security (ARES), 1–19, IEEE Computer Society, 2013.

Marko Niemimaa, Elina Laaksonen, Dan Harnesk, Interpreting Information Security Policy Outcomes: A Frames of Reference Perspective. In: 46th Hawaii International Conference on System Sciences, 4541–4550, IEEE Computer & Society, 2013.

Joni Salminen, Jose Teixeira, Fool's Gold? Developer Dilemmas in a Closed Mobile Application Market Platform. In: Jonna Järveläinen, Hongxiu Li, Anne-Marie Tuikka, Tiina Kuusela (Eds.), 15th International Conference on Electronic Commerce, ICEC 2013, Turku, Finland, August 13-15,

2013. Proceedings, Lecture Notes in Business Information Processing 155, 121–132, Springer Berlin Heidelberg, 2013.

Jose Teixeira, A Review on Open-Source and Proprietary Software Technologies Practised by Finnish Computer-Engineering Students. In: Hamadou Saliah-Hassane, Amine Berqia (Eds.), Proceedings of ICEER 2013, 1071, INEER, 2013.

Jose Teixeira, Developing mobile software applications for centralized applications stores: Great entrepreneurial opportunities or fool's gold?. In: D. Bazylevych, O. Lutyi, O. Starostina, N. Butenko (Eds.),Proceedings of Shevchenkivska Vesna 2013: Economics, 414–520, Taras Shevchenko National University of Kyiv, 2013.

Jose Teixeira, Open-Source Platform-Based Strategies: Multiple Case Studies in the Mobile Devices Industry. In: Klaas-Jan Stol, Björn Lundell, Gregory Madey (Eds.), Proceedings of the Doctoral Consortium of the 9th International Conference on Open Source Systems, 27–36, Skövde University, 2013.

Jose Teixeira, Open-Source Based Platforms/Ecosystems: Multiple Case Studies in the Mobile Devices Industry. In: Heinz Dreher, Doug Vogel, Andreja Pucihar (Eds.), 26th Bled eConference, 26 Research Volume, 222–233, University of Maribor , 2013.

Anne-Marie Tuikka, Sami Hyrynsalmi, Kai K. Kimppa, Arho Suominen, Challenges in Entering Application Markets among Software Producers in Developing Countries. In: Terrell Ward Bynum, William Fleishman, Anne Gerdes, Gitte Møldrup Nielsen, Simon Rogerson (Eds.), The possibilities of ethical ICT, 478–487, Print & Sign University of Southern Denmark, 2013.

Hongxiu Li, Jonna Järveläinen (Eds.), Effective, Agile and Trusted eServices Co-Creation – Proceedings of the 15th International Conference on Electronic Commerce ICEC 2013, TUCS Lecture Notes, 2013.

5. Education at TUCS

5.1 TUCS Graduate Programme

TUCS Graduate Programmes continue the long-standing cooperation in PhD education and research in Information Technologies and Mathematics in the Turku region, formalized through the Turku Centre for Computer Science (TUCS). TUCS is involved in two doctoral programmes: Doctoral Programme in Mathematics and Computer Sciences at the University of Turku and Doctoral Network in Information Technologies and Mathematics at the Åbo Akademi University.

TUCS Graduate Programmes offer a framework for studying for the doctoral (Ph.D.) degree in Computer Science, Mathematics, Information Systems, Computer Engineering, Communication Systems, and Microelectronics. Study time for a full-time student is expected to be four years. The language of instruction is English.

The cooperation between the University of Turku and Åbo Akademi University gives TUCS students the possibility to participate in courses at both universities. In addition, TUCS cooperation offers active exchange programmes with other leading European research groups.

In Doctoral Programme in Mathematics and Computer Sciences the following academic disciplines are represented: Mathematics, Statistics and ICT from three different viewpoints: natural sciences, technical sciences as well as economics. More information on the programme is presented on the website of the doctoral programme: http://www.utu.fi/matti

In the Doctoral Network in Information Technologies and Mathematics the research at the Department of Information Technologies is coordinated through the TUCS research programmes, BioHealth – From Computational Biology and Medical Informatics to Health and Wellbeing, Com3 – Combinatorics, Complex Systems and Computability and RITES – Resilient IT Infrastructures. The research in mathematics at ÅAU is concentrated in mathematical analysis, in particular, functional analysis, complex analysis, probability theory and stochastics. Researchers are participating in the activities of the national doctoral programmes in Mathematics and its Applications and in Stochastics and Statistics.

5.2 TUCS GP Ph.D. defences

Maryam Kamali

Reusable Formal Architectures for Networked Systems

Åbo Akademi University, Department of Information Technologies

Opponent: Tiziana Margaria-Steffen, University of Potsdam, Germany

Supervisors: Luigia Petre and Kaisa Sere

Today's networked systems are becoming increasingly complex and diverse. The current simulation and runtime verification techniques do not provide support for developing such systems efficiently; moreover, the reliability of the simulated/verified systems is not thoroughly ensured. To address these challenges, the use of formal techniques to reason about network system development is growing, while at the same time, the mathematical background necessary for using formal techniques is a barrier for network designers to efficiently employ them. Thus, these techniques are not vastly used for developing networked systems.

The objective of this thesis is to propose formal approaches for the development of reliable networked systems, by taking efficiency into account. With respect to reliability, we propose the architectural development of correct-by-construction networked system models. With respect to efficiency, we propose reusable network architectures as well as network development. At the core of our development methodology, we employ the abstraction and refinement techniques for the development and analysis of networked systems. We evaluate our proposal by employing the

proposed architectures to a pervasive class of dynamic networks, i.e., wireless sensor network architectures as well as to a pervasive class of static networks, i.e., network-on-chip architectures. The ultimate goal of our research is to put forward the idea of building libraries of pre-proved rules for the efficient modelling, development, and analysis of networked systems. We take into account both qualitative and quantitative analysis of networks via varied formal tool support, using a theorem prover the Rodin platform and a statistical model checker the SMC-Uppaal.

Rajeev Kumar Kanth

Analysis and Life Cycle Assessment of Printed Antennas for Sustainable Systems

University of Turku, Department of Information Technology

Opponent: Shaufang Gong, Linnköping University, Sweden.

Supervisors: Pasi Liljeberg and Hannu Tenhunen

In recent years, green design approaches and environment friendly ICT systems have become one of the major driving forces in ICT industry and academia. Along with the expansion of functional capability, design for low emissive manufacturing, reliability and adaptability emerge as critical concerns for ICT researchers. The goal of this research work is to design low profile, single and multiple band microstrip and fractal antennas, and to carry out an extensive study on their sustainability and life cycle assessment. This innovatively incorporates the issues such as wireless communication design paradigms, concept of conventional and modern printing methods, and environmentally friendly approaches during design and development. ICT for environmental sustainability is a vague field of scientific research. In this research work, we have carried out design, analysis and life cycle assessment of printed antennas.

This work has accomplished an integrated platform to create a concrete RF simulation, design and development of microstrip, fractal antenna and RFID tag based applications along with their environmental sustainability and life cycle analysis. The environmentally friendly design would be the prime objectives for each component of RF systems. An attempt has been made to demonstrate a quantitative picture of environmental emissions particularly emissions to air, fresh water, sea water and industrial soil in manufacturing process of ICT based applications. The core focus is to analyze the comparative environmental emissions between polymer and paper substrate printed antennas' production processes and also to carry out an extensive investigation on the life cycle stages including raw material preparation, production and end-of-life stage. This research work also includes a study on resources utilization for each antenna systems.

Specifically, effort has been made to resolve the following research questions through this work. What are the green and sustainable design methodologies for manufacturing microstrip, fractal and RFID based applications? What are the quantitative emissions in each life cycle stages of printed antennas? How severe are the impacts of environmental emissions? Based on this research experience, we have made an effort to formulate a course curriculum for ``Green ICT'' as one of the courses in engineering education.

Khalid Latif

Design Space Exploration for MPSoC Architectures

University of Turku, Department of Information Technology

Opponent: Koen Bertels, Delft University of Technology, The Netherlands.

Supervisors: Ethiopia Nigussie, Tiberiu Seceleanu and Hannu Tenhunen.

Multiprocessor system-on-chip (MPSoC) designs utilize the available technology and communication architectures to meet the requirements of the upcoming applications. In MPSoC, the communication platform is both the key enabler, as well as the key differentiator for realizing efficient MPSoCs. It provides product differentiation to meet a diverse, multi-dimensional set of design constraints, including performance, power, energy, reconfigurability, scalability, cost, reliability and time-to-market. The communication resources of a single interconnection platform cannot be fully utilized by all kind of applications, such as the availability of higher communication

bandwidth for computation but not data intensive applications is often unfeasible in the practical implementation.

This thesis aims to perform the architecture-level design space exploration towards efficient and scalable resource utilization for MPSoC communication architecture. In order to meet the performance requirements within the design constraints, careful selection of MPSoC communication platform, resource aware partitioning and mapping of the application play important role. To enhance the utilization of communication resources, variety of techniques such as resource sharing, multicast to avoid re-transmission of identical data, and adaptive routing can be used. For implementation, these techniques should be customized according to the platform architecture. To address the resource utilization of MPSoC communication platforms, variety of architectures with different design parameters and performance levels, namely Segmented bus (SegBus), Network-on-Chip (NoC) and Three-Dimensional NoC (3D-NoC), are selected. Average packet latency and power consumption are the evaluation parameters for the proposed techniques.

In conventional computing architectures, fault on a component makes the connected fault-free components inoperative. Resource sharing approach can utilize the fault-free components to retain the system performance by reducing the impact of faults. Design space exploration also guides to narrow down the selection of MPSoC architecture, which can meet the performance requirements with design constraints.

Tommi Lehtinen

Numbers and Languages

University of Turku, Department of Mathematics and Statistics

Opponent: Juha Kortelainen, University of Oulu, Finland.

Supervisor: Alexander Okhotin.

The thesis presents results obtained during the authors PhD-studies. First systems of language equations of a simple form consisting of just two equations are proved to be computationally universal. These are systems over unary alphabet, that are seen as systems of equations over natural numbers. The systems contain only an equation X+A=B and an equation X+X+C=X+X+D, where A, B, C and D are eventually periodic constants. It is proved that for every recursive set S there exists natural numbers p and d, and eventually periodic sets A, B, C and D such that a number n is in S if and only if np+d is in the unique solution of the abovementioned system of two equations, so all recursive sets can be represented in an encoded form. It is also proved that all recursive sets cannot be represented as they are, so the encoding is really needed.

Furthermore, it is proved that the family of languages generated by Boolean grammars is closed under injective gsm-mappings and inverse gsm-mappings. The arguments apply also for the families of unambiguous Boolean languages, conjunctive languages and unambiguous languages.

Finally, characterizations for morphisims preserving subfamilies of context-free languages are presented. It is shown that the families of deterministic and LL context-free languages are closed under codes if and only if they are of bounded deciphering delay. These families are also closed under non-codes, if they map every letter into a submonoid generated by a single word. The family of unambiguous context-free languages is closed under all codes and under the same non-codes as the families of deterministic and LL context-free languages.

Jani Merikivi

Still Believing in Virtual Worlds: A Decomposed Approach

University of Turku, Turku School of Economics

Opponent: Anssi Öörni, Aalto University, Finland.

Supervisors: Tommi Hoikkala and Jussi Puhakainen.

Mikolaj Wladyslaw Olszewski

Scaling Up Stepwise Feature Introduction to Construction of Large Software Systems

Åbo Akademi University, Department of Information Technologies

Opponent: Kai Koskimies, Tampere University of Technology, Finland.

Supervisor: Ralph-Johan Back

Developing software is a difficult and error-prone activity. Furthermore, the complexity of modern computer applications is significant. Hence,an organised approach to software construction is crucial.

Stepwise Feature Introduction – created by R.-J. Back – is a development paradigm, in which software is constructed by adding functionality in small increments. The resulting code has an organised, layered structure and can be easily reused. Moreover, the interaction with the users of the software and the correctness concerns are essential elements of the development process, contributing to high quality and functionality of the final product.

The paradigm of Stepwise Feature Introduction has been successfully applied in an academic environment, to a number of small-scale developments. The thesis examines the paradigm and its suitability to construction of large and complex software systems by focusing on the development of two software systems of significant complexity.

Throughout the thesis we propose a number of improvements and modifications that should be applied to the paradigm when developing or reengineering large and complex software systems. The discussion in the thesis covers various aspects of software development that relate to Stepwise Feature Introduction. More specifically, we evaluate the paradigm based on the common practices of object-oriented programming and design and agile development methodologies. We also outline the strategy to testing systems built with the paradigm of Stepwise Feature Introduction.

Muhammad Mohsin Saleemi

Towards Combining Interactive Mobile TV and Smart Spaces: Architectures, Tools and Application Development

Åbo Akademi University, Department of Information Technologies

Opponent: Jouni Smed, University of Turku, Finland.

Supervisor: Johan Lilius

Technological developments in microprocessors and ICT landscape have made a shift to a new era where computing power is embedded in numerous small distributed objects and devices in our everyday lives. These small computing devices are _ne-tuned to perform a particular task and are increasingly reaching our society at every level. For example, home appliances such as programmable washing machines, microwave ovens etc., employ several sensors to improve performance and convenience. Similarly, cars have on-board computers and sensors to perform different tasks such as fuel consumption. These individual devices make life easy by helping in taking decisions and removing the burden from their users. All these objects and devices obtain some piece of information about the physical environment. Each of these devices is an island with no proper connectivity and information sharing between each other. Sharing of information between these heterogeneous devices could enable a whole new universe of innovative and intelligent applications. The information sharing between the devices is a difficult task due to the heterogeneity and interoperability of devices.

Smart Space vision is to overcome these issues of heterogeneity and interoperability so that the devices can understand each other and utilize services of each other by information sharing. This enables innovative local mashup applications based on open, shared data and devices. Smart homes are one such example of smart spaces which facilitate to bring the health care system to the patient, by intelligent interconnection of resources and their collective behavior, as opposed to bringing the patient into the health system.

In addition, the use of mobile handheld devices has risen at a tremendous rate during the last few years and they have become an essential part of everyday life. Mobile phones offer a wide range of different services to their users including text and multimedia messages, Internet, audio, video, email applications and most recently TV services. The interactive TV provides a variety of applications for the viewers. The combination of interactive TV and the smart spaces could give innovative applications that are personalized, context-aware and intelligent. There are many challenges in designing the frameworks and application development tools for rapid and easy development of these applications. The research work presented in this thesis addresses these issues. The original publications presented in the second part of this thesis propose architectures for interactive and context-aware applications and tools for the development of these applications.

Peter Sarlin

Mapping Financial Stability

Åbo Akademi University, Department of Information Technologies

Opponent: Barbara Hammer, CITEC centre of excellence, Germany.

Supervisors: Barbro Back and Tomas Eklund.

The ongoing global financial crisis has demonstrated the importance of a systemwide, or macroprudential, approach to safeguarding financial stability. An essential part of macroprudential oversight concerns the tasks of early identification and assessment of risks and vulnerabilities that eventually may lead to a systemic financial crisis. Thriving tools are crucial as they allow early policy actions to decrease or prevent further build-up of risks or to otherwise enhance the shock absorption capacity of the financial system. In the literature, three types of systemic risk can be identified: i) build-up of widespread imbalances, ii) exogenous aggregate shocks, and iii) contagion. Accordingly, the systemic risks are matched by three categories of analytical methods for decision support: i) early-warning, ii) macro stress-testing, and iii) contagion models. Stimulated by the prolonged global financial crisis, today's toolbox of analytical methods includes a wide range of innovative solutions to the two tasks of risk identification and risk assessment. Yet, the literature lacks a focus on the task of risk communication.

This thesis discusses macroprudential oversight from the viewpoint of all three tasks: Within analytical tools for risk identification and risk assessment, the focus concerns a tight integration of means for risk communication. Data and dimension reduction methods, and their combinations, hold promise for representing multivariate data structures in easily understandable formats. The overall task of this thesis is to represent high-dimensional data concerning financial entities on lowdimensional displays. The low-dimensional representations have two subtasks: i) to function as a display for individual data concerning entities and their time series, and ii) to use the display as a basis to which additional information can be linked. The final nuance of the task is, however, set by the needs of the domain, data and methods. The following ve questions comprise subsequent steps addressed in the process of this thesis:

1. What are the needs for macroprudential oversight?

2. What form do macroprudential data take?

3. Which data and dimension reduction methods hold most promise for the task?

4. How should the methods be extended and enhanced for the task?

5. How should the methods and their extensions be applied to the task?

Based upon the Self-Organizing Map (SOM), this thesis not only creates the Self-Organizing Financial Stability Map (SOFSM), but also lays out a general framework for mapping the state of financial stability. This thesis also introduces three extensions to the standard SOM for enhancing the visualization and extraction of information: i) fuzzifications, ii) transition probabilities, and iii) network analysis. Thus, the SOFSM functions as a display for risk identification, on top of which risk assessments can be illustrated. In addition, this thesis puts forward the Self-Organizing Time Map (SOTM) to provide means for visual dynamic clustering, which in the context of macroprudential oversight concerns the identification of cross-sectional changes in risks and vulnerabilities over time. Rather than automated analysis, the aim of visual means for identifying

and assessing risks is to support disciplined and structured judgmental analysis based upon policymakers' experience and domain intelligence, as well as external risk communication.

Anton Tarasyuk

Formal Development and Quantitative Verification of Dependable Systems

Åbo Akademi University, Department of Information Technologies

Opponent: Aad van Moorsel, Newcastle University, United Kingdoms.

Supervisors: Kaisa Sere and Elena Troubitsyna.

Modern software-intensive systems are becoming increasingly complex. Yet we are observing the pervasive use of software in such critical infrastructures as transportation systems, healthcare, telecommunication, energy production, etc. Consequently, we tend to place increasing reliance on computer-based systems and the software that they are running. The degree of reliance that we can justifiably place on a system is expressed by the notion of dependability.

Designing highly-dependable systems is a notoriously difficult task. It requires rigorous mathematical methods to prevent design errors and guarantee the correct and predictable system behaviour. However, fault prevention via rigorous engineering still cannot ensure avoidance of all faults. Hence we need powerful mechanisms for tolerating faults, i.e., the solutions that allow the system to confine the damage caused by fault occurrence and guarantee high reliability and safety. Traditionally, such dependability attributes are assessed probabilistically. However, the current software development methods suffer from discontinuity between modelling the functional system behaviour and probabilistic dependability evaluation. To address these issues, in the thesis we aim at establishing foundations for a rigorous dependability-explicit development process. In particular, we propose a semantic extension of Event-B – an automated state-based formal development framework – with a possibility of quantitative (probabilistic) reasoning. Event-B and its associated development technique – refinement – provide the designers with a powerful framework for correct-by-construction systems development. Via abstract modelling, proofs and decomposition it allows the designers to derive robust system architectures, ensure predictable system behaviour and guarantee preservation of important system properties.

We argue that the rigorous refinement-based approach to system development augmented with probabilistic analysis of dependability significantly facilitates development of complex software systems. Indeed, the proposed probabilistic extension of Event-B allows the designers to quantitatively assess the effect of different fault tolerance mechanisms and architectural solutions on system dependability. Moreover, it enables the stochastic reasoning about the impact of component failures and repairs on system reliability and safety from the early design stages. The proposed enhanced version of the standard Event-B refinement allows the designers to ensure that the developed system is not only correct-by-construction but also dependable-by-construction, i.e., it guarantees that refinement improves (or at least preserves) the probabilistic measure of system dependability. The proposed extension has been validated by a number of case studies from a variety of application domains, including service-oriented systems, aerospace, railways and communicating systems. We believe that the research presented in the thesis contributes to creating an integrated dependability-explicit engineering approach that facilitates rigorous development of complex computer-based systems.

Bo Yang

Towards Optimal Application Mapping for Energy-Efficient Many-Core Platforms

University of Turku, Department of Information Technology

Opponent: Jesús Barbra Romero, University of Castilla-La Macha, Spain.

Supervisors: Juha Plosila and Tero Säntti.

As massively parallel computing on many-core platforms has become the state-of-the-art, application mapping is widely researched as an important step to minimize the energy consumption and improve the system performance. Conventional algorithms are prohibitively expensive for the application mapping problem, if even possible. To find the optimal application

mapping, the frameworks and algorithms which optimize the allocation of large amount of computation and communication resources on many-core platforms, have to be innovated. This thesis proposes systematic frameworks for single-/multi-application mapping, and innovates on conventional and evolutionary algorithms for energy minimization on many-core platforms.

Firstly, an application mapping framework which integrates both computation and communication resource allocations is proposed. In this threestage framework, IP selection aims to minimize the energy consumed for the computation of tasks. Tile assignment and communication mapping focus on the minimization of the energy consumed for the inter-core communication. In addition to investigating and formulating the individual operation of each individual stage, the framework emphasizes on the interaction of the three stages. With each individual stage addressing a particular resource allocation problem, the collective effort of the three stages results in an overall optimized mapping from the system's point of view.

For the three stages in the framework, tree-model and simulated annealing (SA) based algorithms are proposed in this thesis. By utilizing the tree-model of a network-on-chip (NoC) in the mapping, the tree-model based algorithm is time- and energy-efficient. To improve the optimality of the mapping solutions, two SA-based algorithms are developed for application mapping. Compared to the generic SA algorithm, the first one, the parameter-optimized SA (POSA) algorithm, utilizes a set of optimized parameters which speeds up the convergence to the global optimal mappings. Furthermore, the tk-SA algorithm starts the annealing from an already optimized initial solution, with the appropriate initial temperature. The quantitative evaluations show that both SA-based algorithms need significantly fewer iterations to converge to the optimal mappings, without loss of mapping quality.

While the previous framework and algorithms address the mapping problem of a single application, a novel framework for mapping multiple applications adaptively with unbounded or bounded number of cores is presented. Consisting of two steps, application mapping and task mapping, the proposed mapping method finds an area on a many-core NoC for each application and then maps all tasks of the application into the area. A weighted node average distance (WNAD) based algorithm is proposed for application mapping. The proposed tk-SA algorithm is applied to the task mapping in the case of unbounded number of cores. A task-sequence based (TSB) algorithm is proposed for the task mapping in the case of bounded number of cores. The quantitative comparisons show that the WNAD+tk-SA mapping algorithms achieves the lowest communication energy consumption in all combinations of application mapping and task mapping algorithms evaluated.

Zhiyuan Yao

Visual Customer Segmentation and Behavior Analysis – A SOM-Based Approach

Åbo Akademi University, Department of Information Technologies

Opponent:Ranjan Kini, Indiana University Northwest, United States.

Supervisor: Barbro Back

The importance of customer relationship management (CRM), a management principle for transforming organizations from being product-oriented to customer centric, has attracted interest from both academia and industry. Today, customers' behaviors and activities can be easily recorded and stored through Enterprise Resource Planning (ERP) systems and data warehousing. Customers are continuously creating a "customer signature" that lends itself to analysis. It is not uncommon that customers differ in various aspects, and have contrasting preferences and buying behavior. A widely used approach for gaining insight into the heterogeneity of customer behavior and profitability is customer segmentation, i.e., the division of customers into groups based on similarity.

Conventional customer segmentation solutions are often stand-alone analytical models, derived based on a specific time frame, which thereby often disregard the fact that customers' behavior may evolve over time. In order to provide a holistic view of customers' characteristics and purchasing behavior, two dynamics in a customer segmentation model will be examined in this

thesis in addition to the conventional segmentation models based on customers' aggregate information of a specific time frame.

The two possible dynamics of a customer segmentation model include changes in segment structures and composition and changes in segment memberships of individual customers. The first dynamic is addressed using temporal customer segmentation where temporal changes in segment structures and profiles are visualized, while the second dynamic is addressed using segment migration analysis, where customers with similar switching patterns among segments are identified visually.

Visualization can assist in the interpretation of the discovered patterns and facilitate the process of knowledge transfer between analysts and decision makers. Visual data mining techniques, e.g., the Self-Organizing Map (SOM) and its extensions, will be used to demonstrate their usefulness in the context of CRM in general and in the task of customer segmentation in particular.

Wei Yin

On Energy Efficient Computing Platforms

University of Turku, Department of Information Technology

Opponent: Zheng Yan, Xician University, China.

Supervisors: Jouni Isoaho, Pasi Liljeberg and Hannu Tenhunen.

In accordance with the Moore's law, the increasing number of on-chip integrated transistors has enabled modern computing platforms with not only higher processing power but also more affordable prices. As a result, these platforms, including portable devices, work stations and data centres, are becoming an inevitable part of the human society. However, with the demand for portability and raising cost of power, energy efficiency has emerged to be a major concern for modern computing platforms.

As the complexity of on-chip systems increases, Network-on-Chip (NoC) has been proved as an efficient communication architecture which can further improve system performances and scalability while reducing the design cost. Therefore, in this thesis, we study and propose energy optimization approaches based on NoC architecture, with special focuses on the following aspects.

As the architectural trend of future computing platforms, 3D systems have many benefits including higher integration density, smaller footprint, heterogeneous integration, etc. Moreover, 3D technology can significantly improve the network communication and effectively avoid long wirings, and therefore, provide higher system performance and energy efficiency.

With the dynamic nature of on-chip communication in large scale NoC based systems, run-time system optimization is of crucial importance in order to achieve higher system reliability and essentially energy efficiency. In this thesis, we propose an agent based system design approach where agents are on-chip components which monitor and control system parameters such as supply voltage, operating frequency, etc. With this approach, we have analysed the implementation alternatives for dynamic voltage and frequency scaling and power gating techniques at different granularity, which reduce both dynamic and leakage energy consumption.

Topologies, being one of the key factors for NoCs, are also explored for energy saving purpose. A Honeycomb NoC architecture is proposed in this thesis with turn-model based deadlock-free routing algorithms. Our analysis and simulation based evaluation show that Honeycomb NoCs outperform their Mesh based counterparts in terms of network cost, system performance as well as energy efficiency.

5.3 Cooperation networks

5.3.1 EIT ICT Labs

EIT ICT Labs is one of the first three Knowledge and Innovation Communities (KICs) selected by the European Institute of Innovation & Technology (EIT) to accelerate innovation in Europe. EIT is a new independent community body set up to address Europe's innovation gap. It aims to rapidly emerge as a key driver of EU's sustainable growth and competitiveness through the stimulation of world-leading innovation.

European organisations are considered to deliver excellence in research and top-level scientific output, but lag behind in the ability of converting these into wealth-generating innovations and service ready for the market.

The goal of EIT ICT Labs is to bring more innovation in the domain of Information and Communication Technologies (ICT) to market. To reach this goal they connect excellent European organisations in Education, Research and Industry to speed up innovation. There are similar KICs on Energy and Climate changes.

EIT ICT Labs is EIT's KIC for the Information Society. They breed entre-preneurial ICT top talent by transforming higher education towards promoting innovation and entrepreneurial spirit. Our Co-location Centres and mobility programs help bring people from different countries, disciplines and organisations together.

EIT ICT Labs will equip students, researchers, academics and business people with skills for applying creativity, risk-taking spirit and entrepreneurial capa-city. EIT ICT Labs empowers top talents to lead Europe into a new ICT age.

By developing and applying catalysts EIT ICT Labs leverages on existing regional, national and EU-level funding instruments to speed up innovation in Europe. Their catalysts focus on integrating the three elements of the knowledge triangle - Education, Research and Business.

5.3.2 EIT ICT Labs Doctoral School

TUCS is also a partner in the EIT ICT Labs Doctoral School, http://doctoralschool.eitictlabs.eu. After completing the program, participants will be commercially aware research leaders who understand current and future challenges, as well as the opportunities that these present to industry. To achieve this goal, the program concept provides standardized I&E education that complements the ordinary doctoral studies.

On top of the doctoral degree, awarded by the host university, according to their local or national regulations, the EIT ICT Labs will award a certificate. Doctoral candidates that fully comply with the requirements of the EIT ICT Labs Doctoral School will receive the EIT ICT Labs Doctoral School on ICT Innovation certificate.

In 2013, four TUCS PhD students were accepted to the EIT ICT Labs Doctoral School.

5.3.3 INFORTE

15 TUCS students participated INFORTE courses in 2013.

INFORTE.fi project started in 2012, being a state wide programme for ICT professionals. It is designed to offer networking and education events to Ph.D. students and professionals working in Finnish companies, polytechnics and public administration. Invited speakers are some of the top international researchers or industry representatives in their field.

INFORTE.fi will annually offer about 15 workshops and seminars on diverse areas of ICT. The main areas of focus are:

- Software systems
- Information systems
- Telecommunications
- ICT & Business
- HCI

These intensive events can be used as tools for professional education, or as parts of doctoral education. INFORTE programme delivers certificates of participation, and participants negotiate how these achievements can be included in their studies with their home universities.

INFORTE events are a way to connect with other ICT professionals and academics in the same field, and build important social networks. INFORTE events allow to update ones knowledge and keep on track with the latest scientific and practical knowledge in the ICT field.

5.3.4 ICCES Erasmus Intensive Programme

TUCS participates in the ERASMUS Intensive Programme (ICCES - Innovation and Creativity for Complex Engineering Systems) along with seven European universities. The overall objective of this ERASMUS IP is to upgrade the industry relevance of European Ph.D. education in engineering and technology, in order to produce Ph.D. graduates who are better equipped to participate in all aspects of innovation and product development in industry. The main objective is to train Ph.D. students on how to tackle problems of high complexity in an innovative and research-oriented perspective within industrial contexts.

During a three week period Ph.D. students will be confronted with real (and complex) engineering problems owned by the industrial partner acting as the local host of the delivery of this ERASMUS IP. The students, organised in multi-disciplinary teams, are expected to propose a research plan that adequately tackles a given problem, with both a scientific perspective and a busi-ness/market one. The plan must include issues like intellectual property rights, patents, industrial innovation, funding for innovation projects, market needs, research collaborations, publication of industrial case studies and demon-stra-tion cases, etc.

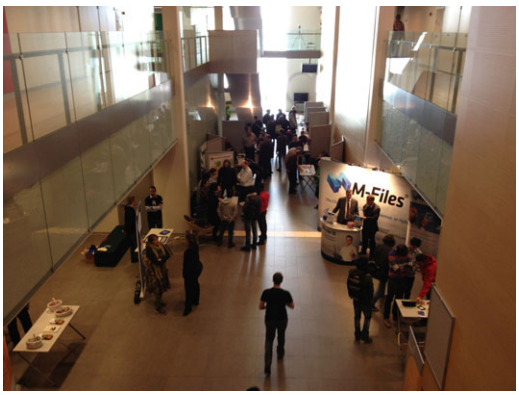
In 2013, the 2nd edition of the ICCES Programme was hosted in Portugal by Bosch Car Multimedia Portugal (http://www.bosch.pt), located in the north of Portugal, more specifically in the city of Braga.

5.3.5 EUROWEB

EUROWEB, European Research and Educational Collaboration with Western Balkans, is a scholarship programme for students on undergraduate, master, doctoral and post-doctoral level as well as for university staff in academic or administrative positions, financed by the European Commission. The Erasmus Mundus EUROWEB scholarship offers a unique opportunity for full-financed academic mobility for individuals from the EU and Western Balkans partner countries. The project is a part of the large-scale, EU-funded programme Erasmus Mundus Action 2.

The EUROWEB Scholarship Programme is open to selected nationals in EU countries and Western Balkans who want to study or work at one of the partner institutions (see Applicant information). The overall objective of EUROWEB project is to create a partnership in research and education that will strengthen the ties between EU and Western Balkans.

6. The year 2013 in pictures

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