



Editorial Board:

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Turku Centre for Computer Science Annual Report 2012

TURKU CENTRE *for* COMPUTER SCIENCE

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Annual Report 2012

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Contents

| | |
|--|----|
| 1. Foreword | 1 |
| 2. TUCS 2012 in brief | 3 |
| 2.1 TUCS Board and directors | 3 |
| 2.2 TUCS GP Committee | 3 |
| 2.3 New developments..... | 3 |
| 2.4 Conferences | 5 |
| 2.5 TUCS Publication Series | 6 |
| 2.6 Awards..... | 6 |
| 2.7 TUCS 2012 in numbers | 6 |
| 3. Research at TUCS..... | 7 |
| 3.1 TUCS Research Programmes | 7 |
| 3.1.1 COM ³ – Combinatorics, Complex Systems and Computability..... | 8 |
| 3.1.2 BioHealth – From Computational Biology and Medical Informatics to Health and Wellbeing | 12 |
| 3.1.3 RITES – Resilient IT Infrastructures | 15 |
| 3.1.4 TISRA – Turku Information Systems Research Alliance | 19 |
| 3.2 TUCS Research Units..... | 20 |
| 3.3 TUCS Distinguished Lecture Series | 21 |
| 4. Reports of the TUCS Research Units..... | 23 |
| 4.1 Algorithmics and Computational Intelligence Group (ACI)..... | 23 |
| 4.2 Biomathematics Research Unit (BIOMATH) | 25 |
| 4.3 Turku BioNLP Group | 31 |
| 4.4 Computational Biomodeling Laboratory (Combio Lab) | 34 |
| 4.5 Communication Systems (ComSys)..... | 37 |
| 4.6 Data Mining and Knowledge Management Laboratory..... | 40 |
| 4.7 Distributed Systems Laboratory (DS Lab)..... | 43 |
| 4.8 Embedded Computer and Electronic Systems (ECES)..... | 48 |
| 4.9 Embedded Systems Laboratory (ESLAB) | 55 |
| 4.10 FUNDIM, Fundamentals of Computing and Discrete Mathematics | 58 |
| 4.11 Institute for Advanced Management Systems Research (IAMSR)..... | 64 |
| 4.12 Learning and Reasoning Lab | 69 |
| 4.13 Software Engineering Laboratory (SE Lab)..... | 70 |
| 4.14 Software Construction Laboratorium | 72 |
| 4.15 Software Development Laboratory (SwDev)..... | 74 |
| 4.16 Turku Optimization Group (TOpGroup)..... | 76 |

| | |
|---|----|
| 4.17 UTU Information Systems Science (ISSR)..... | 78 |
| 5. Education at TUCS..... | 82 |
| 5.1 TUCS Graduate Programme..... | 82 |
| 5.1.1 TUCS Student Toolkit..... | 82 |
| 5.1.2 TUCS Short Courses | 82 |
| 5.1.3 Cooperation networks | 83 |
| 5.2 TUCS Ph.D. defences..... | 85 |
| 6. TUCS Highlights | 93 |
| 6.1 Fudan University delegation visiting University of Turku Department of Information Technology | 94 |
| 6.2 Early-warning model for European banks | 95 |
| 7. TUCS in pictures | 96 |

1. Foreword

A Year of Strategic Changes for TUCS

2012 was a year of strategic changes for TUCS. Throughout the history of TUCS, the doctoral programs have played a major role as TUCS activities. The doctoral education at the participating universities is currently going through a major change due to a fundamental reorganization in the national structure of doctoral education. The TUCS community decided to continue the established collaboration between two universities and three fields of IT education: science, business, and technology. Plans for reorganizing TUCS activities within the new structure of doctoral education are currently being formed jointly by the participating departments. This calls not only for reorganizing the existing programs but also for extending the scope of TUCS-affiliated doctoral programs.

International activities have been characteristic to TUCS since its inception. The number of international PhD and MSc students remains high and today, our research and teaching collaboration at an institutional level is more active than ever. Especially, TUCS is now actively participating in European collaboration through EIT ICT Labs Master's and Doctoral School.

To further enhance the role of TUCS in the scientific activities within the community, the Board decided to develop TUCS towards a research center. This was manifested in the introduction of four thematic research programs. To promote activities within the programs, a budget for supporting research coordination and organizing various events was set up. To increase our world-class educational supply, TUCS Distinguished Lecture Series was introduced. These ideas have been warmly received among the TUCS community and the activities have started well at all the three major higher education institutes in Turku.

It seems that despite the major changes, the very idea behind TUCS is very much alive. Our challenge is to maintain innovative thinking and keep updating that idea according to the developments in our operational environment.

Professor Tapio Salakoski
Chairman of TUCS Board

Professor Johan Lilius
TUCS Director

2. TUCS 2012 in brief

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)
- 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 2012 TUCS reorganized its research from the old laboratory structure to a new structure of TUCS Research Units and TUCS Research Programmes. This was an effort to create a clearer research profile for TUCS and a larger critical mass within TUCS. The TUCS Board decided to create 4 research programmes,

which are awarded support from TUCS. For this purpose, a total of 60.000€ was reserved.

TUCS Publication Database

In 2012 TUCS improved the TUCS Publication Database service. Both the input and output of the service were improved.

The service now outputs search results in a format readily copy-pasteable as a reference list. Also the output can be sorted by year and by type.

The search parameters were revised to serve better the users of the database. The search can be performed by authors names, research unit, or department, and the search results can be delimited by publication type and year, for example.

The publication input interface now guides the user to input their publications properly. People are asked to enter the proper affiliation for the publication, and the publication details are divided into optional and obligatory. The system also helps user to properly insert the names of publication forums. The system can be used to assist with the entry of this information, based on the Ministry of Education lists of publication forums. The user is also shown the point value of the entered publication forum. There is also an online guide now available for the input system.

The improvements on the TUCS Publication Database were a part of a general restructuring of the TUCS website.

TUCS Distinguished Lectures

TUCS launched on October 1st the TUCS Distinguished Lecture Series. The 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. The TUCS Distinguished Lecture Series is described in section 3.3.

TUCS PhD student toolkit

TUCS introduced the TUCS PhD student toolkit on May 25th. This course is a graduate course targeted for doctoral students and researchers. The aim of the course is to provide an intensive information package for successful Ph.D. studies, research funding possibilities, innovation processes, communication skills and R&D activities in both academy and business environment. The TUCS PhD student toolkit is described in section 6.1.1.

TUCS Graduate Programme

The TUCS Graduate Programme had a deadline for applications on March 30th. The response to the call was enthusiastic, with 56 applications being sent before the deadline. 37 of the applications were from foreign applicants.

TUCS Board granted 14 funded positions with 2 years of funding and 2 funded positions with 1 year of funding.

TUCS Graduate Programme Public Register

A new service on the TUCS website is a public register of the TUCS GP Students, Alumni and Supervisors. This service lists the supervisors and the current and graduated students of the TUCS Graduate Programme. TUCS staff is regularly finding updates to the lists, and requests for updates to the information are welcome by e-mail to tucs@abo.fi.

TUCS GP Recreational activities

The TUCS Ph.D. students organized an informal get-together to which all TUCS Ph.D. students and supervisors were welcome.

NMS iICT

The first NMS iICT certificates were granted on February 20th, 2012. The certificates are granted for students that now have graduated and qualify according to the certificate criteria.

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. This was the sixth year the ICT ShowRoom was arranged. 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.

TUCS Newsletter

TUCS began publishing a monthly TUCS Newsletter. This newsletter was sent through the tucsnews-emailing list. It gathered together current information relevant to TUCS, such as available external courses, latest publication submissions in the TUCS Publication Database, new travel reports from TUCS GP students, etc.

2.4 Conferences

The following conferences were sponsored by TUCS in 2012:

- 4th International Conference on Well-Being in the Information Society – WIS 2012
 - 22.–24.7. at Turku School of Economics
 - General Chairs: Reima Suomi (TUCS Research Unit UTU Information Systems Science, University of Turku) and Sakari Suominen (University of Turku)
 - Web: http://www.marebalticum.org/brehca/index.php?option=com_content&view=article&id=116&Itemid=131
- RuFiDiM 2012
 - 25.–28.9. at PharmaCity
 - Organizers: Juhani Karhumäki (TUCS Research Unit FUNDIM, Fundamentals of Computing and Discrete Mathematics, University of Turku) and Yuri Matiyasevich (Steklov Institute, St. Petersburg, Russia)
 - Web: <http://www.math.utu.fi/projects/RuFiDiM/committees.php>
- International Conference on Engineering Education – ICEE 2012
 - 30.7.–3.8. at the ICT Building
 - General Chairs: Olli Mertanen, Johan Lilius and Tapio Salakoski.
 - Web: <http://www.icee2012.fi/>
- NODES Winter School and Seminar
 - 1.–3.2. at the ICT Building
 - Organizing committee: Luigia Petre, Kaisa Sere, Elena Troubitsyna, Veli-Matti Reitti, Magnus Dahlvik, Christel Engblom, Nina Rytönen, Tove Österroos.
 - Web: <http://www.it.abo.fi/NODESWinterSchool/>

2.5 TUCS Publication Series

The TUCS Publication Series are currently the following:

- TUCS Dissertations: 11 books were published in 2012.
- TUCS Technical Reports: 28 books were published in 2012.
- TUCS General Publications.
- TUCS National Publications.
- TUCS Lecture Notes: 2 books were published in 2012.



2.6 Awards

Best Dissertation Award

Pattern Recognition Society of Finland (Hatutus ry) has awarded TUCS GP Dr. Antti Airola for the best dissertation of the year in 2012. The award was granted in Helsinki on May 28th as a part of a symposium held there.

Best Paper Award

Peter Sarlin and Tuomas Peltonen received the "Best Paper Award" at Bank of Finland Institute for Economies in Transition (BOFIT) in 2011 for the paper entitled "Mapping the State of Financial Stability". The award was announced on April 24th, 2012.

IAMOT 2012 Best Student Paper Award

The publication of TUCS GP students Sami Hyrynsalmi and Tuomas Mäkilä entitled as "The Emerging Mobile Ecosystems: An Introductory Analysis of Android Market" was selected as the Best student paper in the 21st International Conference on Management of Technology (IAMOT 2012) held in Hsinchu, Taiwan in March 18th–22nd. The coauthors of the paper are Arho Suominen and Timo Knuutila.

Best Doctoral Research Proposal Award

TUCS GP student Adnan Ashraf got the Best Doctoral Research Proposal Award at the 38th Euromicro Conference on Software Engineering and Advanced Application (SEAA), Cesme, Turkey, September 5th–8th, 2012.

2.7 TUCS 2012 in numbers

- 193 publications,
- 93 GP students,
- 11 Ph.D. theses,
- 14 new Ph.D. students
- 3 TUCS Distinguished Lectures
- 11 guest talks
- 5 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 (Com³)
- 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 COM³ – Combinatorics, Complex Systems and Computability

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

25.–28.9.2012: RuFiDiM 2012 – Russian Finnish Symposium on Discrete Mathematics

The second RuFiDiM conference, Russian-Finnish Symposium in Discrete Mathematics, took place in Turku on September 25th to 28th, 2012. The meeting was organized as a part of the research activities in the framework of cooperation between Russian Academy of Sciences and the Academy of Finland. The cooperation is between the Steklov Institute of Mathematics at St. Petersburg and FUNDIM Centre at University of Turku. The goal of the series of these symposiums is to increase cooperation between Finnish and Russian mathematicians in discrete mathematics, but the symposium is open for a broader international audience. Indeed, in the present event there were contributions from over 10 different nations.

RuFiDiM 2012 consisted of six invited talks and 31 contributed presentations. The program was chosen by an international program committee. Abstracts/extended abstracts of the lectures are presented in these proceedings.

Host: Juhani Karhumäki, Yuri Matiyasevich

4.10.2012: FiDiPro distinguished lecture: Aldo de Luca

A palindromization map on free monoids and its generalizations

This talk is a survey of several results of combinatorial nature which have been obtained starting from a palindromization map ψ on a free monoid A^* introduced by the author in 1997 in the case of a binary alphabet, and successively generalized by other authors for arbitrary finite alphabets. If one extends the action of the palindromization map to infinite words, one can generate the class of all standard episturmian words, introduced by Droubay, Justin and Pirillo in 2001, which includes standard Sturmian words and Arnoux-Rauzy words. A noteworthy generalization of the palindromization map is obtained starting with a given code X over A . The new operator ψ_X maps X^* to the set of palindromes of A^* ; some properties of ψ are lost and some are saved in a weak form. When X has a finite deciphering delay one can extend ψ_X to X^ω , generating a class of infinite words much wider than standard episturmian words. For a finite and maximal code X over A , a suitable generalization of standard Arnoux-Rauzy words is obtained. Finally, one can generalize further ψ_X by replacing palindromic closure with ϑ -palindromic closure, where ϑ is any involuntary antimorphism of A^* . This yields an extension of the class of ϑ -standard words introduced by the author and Alessandro De Luca in 2006.

Host: Juhani Karhumäki

2.10.2012: guest lecture: Academician Yuri Matiyasevich (Steklov Institute of Mathematics, St. Petersburg, Russia)

Calculating approximate values of zeros of Riemann's zeta function via interpolating determinants

Abstract in

<http://logic.pdmi.ras.ru/~yumat/personaljournal/artlessmethod/artlessmethod.php>

Host: Juhani Karhumäki

7.8.2012: guest talk: Dr. Mathieu Sablik (Aix-Marseille Universite, France)

Which measure can be obtained as limit of an iteration of a measure by a cellular automaton?

A computable measure iterated by a cellular automaton stay computable. Thus the limit of an iteration of a measure by a cellular automaton is a semi-computable measure, that is to say that we can approximate this measure with a Turing machine without necessary know the rate of the approximation. In this talk we show that in fact all such measure can be obtained by a cellular automaton starting from an ergodic measure of full support. Better, we can construct a "metrical universal cellular automaton" in the sense that for this cellular automata, every semi-computable measure can be obtained following the initial measure chosen.

Host: Jarkko Kari

8.6.2012: guest talk: Dr. Igor Potapov (University of Liverpool, UK)

Computational Complexity of Identity Problem for Words and Matrices

Most computational problems for matrix semigroups and groups are inherently difficult to solve and in many cases can even be impossible, due to a number of undecidability results which have been shown for high dimensional matrices. Some examples of such problems are the membership problem (including the special cases of the mortality and identity problems), vector reachability, freeness problems and emptiness of semigroup intersections.

There are various techniques and methods for embedding universal computation into three and four dimensional matrix semigroups. In particular, in dimension three, problems such as membership, vector reachability and freeness are undecidable for integral matrices.

In this talk several closely related fundamental problems for words and matrices will be considered. First, we introduce the Identity Correspondence Problem (ICP): whether a finite set of pairs of words (over a group alphabet) can generate an identity pair by a sequence of concatenations. We prove that ICP is undecidable by a reduction of Post's Correspondence Problem via several new encoding techniques. Then we use ICP to answer a long standing open problem concerning matrix semigroups: "Is it decidable for a finitely generated semigroup S of integral square matrices whether or not the identity matrix belongs to S ?". Also we investigate the complexity status of the Identity Problem for 2×2 matrix semigroups and a lower bound on the minimum length solution to the Identity Problem for a constructible set of instances, which is shown to be exponential.

Host: Mika Hirvensalo

4.6.2012: guest talk: Academician Solomon Marcus (Academy of Romania)

From Turing to Von Neumann

They interacted and inspired each other. We focus main attention on their work on the brain and, more generally, on their interest in biology, trying to situate historically and conceptually John von Neumann's unfinished research program towards the unification of discrete and continuous involvement of mathematics in the study of biological systems. Turing was involved in a similar program. An evolutionary trajectory of theories from Leibniz, Boole, Bohr and Turing to Shannon, McCulloch-Pitts, Wiener and von Neumann powered the emergence of the information paradigm. As both Turing and von Neumann were interested in automata, they were deeply challenged by seeing the brain as an automaton. Turing's research was done in the context of the achievements in logic (formalism, intuitionism, logicism, constructivism, Hilbert's, Kleene's and Gödel's work). Turing's 1937 paper, proposing a theoretical machine exclusively built on the paper, has been the preliminary theoretical step towards von Neumann's 1948 programmable electronic computer. John von Neumann's research program is outlined in "The general and logical theory of automata" (1951), "Probabilistic logics and the synthesis of reliable organisms from unreliable components" (1956) and his posthumous book *The Computer and the Brain* (1958) and in his unfinished book *The theory of Self-Reproducing Automata*, completed and published by A. Burks (1966).

Inspired by Turing's universal machine, von Neumann described in 1948, i.e., five years before Watson and Crick, the structure of the DNA copying mechanism for biological self-reproduction. A lot of questions and problems appear when confronting these historical facts with the evolution of ideas in the contemporary fields of computational biology and biological computing. Some of them are pointed out in this presentation.

Host: Juhani Karhumäki, Ion Petre

31.5.2012: guest talk: Artur Jez

Fully compressed pattern matching by recompression

In this talk I will consider the a fully compressed pattern matching problem. The compression is represented by straight-line programs (SLPs), i.e. context-free grammars generating exactly one string; the term fully means that both the pattern and the text are given in the compressed form. The problem is approached using a recently developed technique of local recompression: the SLPs are refactored, so that subwords of the pattern and text are encoded in both SLPs in the same way. To this end, the SLPs are locally decompressed and then recompressed in a uniform way. Thus, in the end, the pattern matching reduces to a search of a particular nonterminal in the derivation tree for the text.

This technique yields an $O((n+m) \log M)$ algorithm for compressed pattern matching, where n (m) is the size of the compressed representation of the text (pattern, respectively), while M is the size of the decompressed pattern. Since M is at most 2^m , this substantially improves the previously best $O(m^2n)$ algorithm.

Since LZ compression standard reduces to SLP with $\log(N/n)$ overhead and in $O(n \log(N/n))$ time (where N is the size of the decompressed text and n the size of the LZ representation), the presented algorithm can be applied also to the fully LZ-compressed pattern matching problem, yielding an $O((n \log(N/n) + m \log(M/m)) \log M)$ running time.

Host: Juhani Karhumäki

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 Heikkinen, Patrik Jones, Olli Nevalainen, Kalle Parvinen, Ion Petre, Tapio Salakoski, Sanna Salanterä, and Reima Suomi

Activities

12.10.2012: guest talk: Dr. Vladimir Rogojin (University of Helsinki)

Cancer Related Studies in Cellular Signalling Networks: Identifying Essential Nodes Via Feedback Loops.

Feedback loops are an inherent part of cell signalling networks and are responsible in maintaining robustness in cells. We present here a score that indicates the importance of the nodes in a signalling network based on their participation in feedback loops. Due to the high number of feedback loops in a signalling network, we have employed a graph compression technique to reduce the size and the complexity of the network.

We used two network models to generate random networks and compared our feedback loop centrality score with some classical node centrality measures. Our results indicate that the feedback loop based score identifies nodes that would have left undetected with the existing centrality measures.

We considered gene expression data from 384 glioblastoma multiforme patients and constructed a comprehensive intra-cellular signalling network based on genes with the survival effect. Interestingly, a survival associated gene STAT3 has the highest feedback loop score and participates in 95% of all the feedback loops in our network, which may explain its central role in the highly aggressive nature of glioblastoma multiforme cells.

Host: Ion Petre

18.6.2012: guest talk: Dr. David Safranek (Masaryk University Brno, Czech Republic)

Parameter Identification in Biochemical Dynamic Systems: The Model Checking Approach

Kinetic models reconstructing dynamics of biological processes, modeled at several levels of abstraction starting with purely qualitative discrete models and ending with quantitative deterministic or even stochastic ones, provide the corner-stone tool in systems biology. A very important issue is that of parameter uncertainty. Parameters appear in dynamical models of all kinds. Examples are kinetic rate coefficients driving the dynamics of quantitative models or kinetic logic parameters which set the dynamics of discrete models. In all cases, it is difficult to find robust parametrizations of models. Additionally to experimental data, known static and dynamic constraints significantly limit the possible model behaviour and help in searching for good and realistic parametrizations. In this talk we will present an approach to parameter identification based on model checking. Emphasis will be given to efficient and automatable methods. Presented techniques will target discrete and continuous models supplied with linear temporal specifications (constraints).

Host: Ion Petre

7.6.2012: guest talk: Dr. Sergey Verlan (University of Paris 12, France)

Applications of the Theory of Formal Languages for the Design of Fast Hardware Implementations of Parallel Multiset Rewriting

In this talk we present the design of a fast hardware simulator for parallel multiset rewriting using the field-programmable gate array (FPGA) technology. The simulator is non-deterministic and it uses a constant time procedure to choose one of the computational paths. The obtained strategy is equitable and it is based on a pre-computation of all possible rule applications. This pre-com-

putation is obtained by using the representation of all possible multisets of rules' applications as context-free languages. Then using the Schutzenberger technique for the computation of the generating series for context-free languages it is possible to construct the structure representing all possible rule applications for any configuration.

We give a hardware design implementing some concrete examples and present the obtained experimental results which feature an important speed-up.

Host: Ion Petre

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 the levels of the technology stack – from application and service level till underlying implementation technology. Moreover, the underlying technologies such as processor architectures and silicon technologies are undergoing big transformations, 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.

The RITES programme is in a unique position to address these challenges in a unified way, since we possess competence of a cross-cutting nature that spans from highly abstract service modelling to the hardware implementation platform.

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

20.9.2012: guest lecture: Olli-Pekka Lehto (CSC - IT Center for Science)

Future of High Performance Computing Resources at CSC

Olli-Pekka Lehto from CSC - IT Center for Science will give a presentation of the Cray Cascade supercomputer, which was selected as the next generation national supercomputing resource.

Host: Mats Aspnäs

10.–31.8.2012: research visit: Prof. Gheorghe Stefanescu (University of Bucharest, Romania)

Gheorghe Stefanescu is a professor of Computer Science at the University of Bucharest and the head of their Department of Computer Science. His research interests include parallel and distributed computing, process and network algebra, semantics of programming languages, object-oriented programming, algebraic and categorical logic, applications of category theory in logic and computer science.

Host: Luigia Petre

15.8.2012: guest talk: Dr. Dejan Vuokbratovic (University of Novi Sad, Serbia)

Fountain Codes and Applications

Invented about a decade ago, fountain (or rateless) codes still attract a lot of attention due to their efficiency, flexibility and versatility. In this talk, we shortly review the basic properties of fountain codes and some of their interesting applications that include fountain code design for multimedia delivery, distributed storage and multiple access control deployed as part of various real-world packet-based network protocols.

Host: Kristian Nybom

10.8.2012: guest talk: Prof. Maurizio Palesi (Kore University, Italia)

Some Research Topics on Networks on Chip: Routing Algorithms, Low Power, and Fault Tolerance

Host: Masoud Daneshtalab

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

Steering group

Harry Bouwman, Christer Carlsson, Tomi Dahlberg, Jukka Heikkilä, Hannu Salmela, Reima Suomi, and Pirkko Walden

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



TUCS launched a new TUCS Distinguished Lecture Series from fall 2012. The 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.

The lectures of the series left few seats empty in the 150-seat auditorium Lambda in the ICT Building.

Lectures in 2012:

1.10.2012: Yuri Matiyasevic (Steklov Institute of Mathematics, Saint Petersburg, Russia), "*Turing Machines vs. Diophantine Machines*".

Biography: Yuri Matiyasevitch is a very well known Russian mathematician and computer scientist, famous for his solution to Hilbert's tenth problem. The problem had been proposed in 1900 by one of the most famous mathematicians of that time, David Hilbert, as part of his list of 23 great challenges for mathematics for the 20th century. Several of the problems on that list, including the 10th one, turned out very influential for 20th century mathematics. Hilbert's 10th problem was concerned with seemingly simple equations (so called Diophantine equations) and was asking to "devise a process" (an algorithm in modern computer science terminology) to answer whether a given such equation has a solution over rational integers or not. Hilbert's 10th problem caught the attention of remarkable mathematicians during 20th century, including Martin Davis, Hilary Putnam and Julia Robinson. It was however Yuri Matiyasevich who gave the final solution to the problem in 1970, when he was only 23 years old. Matiyasevich's solution was remarkable both for solving such a long-standing open problem, but also because it established that the great David Hilbert had been wrong: there exists no such algorithm as the one he proposed to look for.

9.11.2012: Esko Ukkonen (University of Helsinki), "*Stringology and Bioinformatics*".

Abstract: Since the invention of DNA sequencing in the 1970's, the analysis of molecular biological sequences has been an inspiring source of computational problems. Unlike most data in natural sciences, the biological sequence data such as DNA and amino acid sequences is discrete rather than continuous by nature. Hence biological sequence analysis is, in addition to fields like text processing and information retrieval, another natural application area of combinatorial algorithms for strings (stringology). A new discipline, called bioinformatics or computational biology has emerged. With the advent of high-throughput sequencing the amount of sequence data has exploded, making molecular biology research totally dependent on efficient computation. The talk will discuss some computational problems, algorithmic techniques and future goals of bioinformatics, ranging from the genome reconstruction and sequence indexing to the analysis of gene regulation.

Biography: Esko Ukkonen is a professor of Computer Science at University of Helsinki and a former Academy Professor of the Academy of Finland. He has been the director of the Academy of Finland's Centers of Excellence in Research "Algorithmic Data Analysis" (2008-2013) and the "From Data to Knowledge" (2002-2007), as well as the leader of several other national and

European research projects. He has played a major role in the development and the advancement of computer science in Finland, especially in the development of the school of algorithmic research. His research covers very diverse areas, including algorithmics, numerical methods, complexity theory, theoretical aspects of compiler construction, and logic programming. In particular, Ukkonen is a world leading expert in combinatorial pattern matching. Esko Ukkonen's work has found applications in several areas: computational methods for the analysis of DNA sequences, information search on the Internet, information retrieval from image and music databases, and computational modeling in biology. He has published about 200 articles, including more than 150 papers in refereed international journals and conference proceedings, and several articles in Finnish media popularizing computer science.

3.12.2012: Masakachu Ohashi Chuo (Chuo University, Japan), "*Business and IT Operations Continuance in Japan After the 2011 Earthquake*".

Abstract: A survey conducted local governments and enterprises in disaster-damaged and other areas in Japan concerning the Great East Japan Earthquake and business continuity, looking into how business operations were continued on the occasion of the disaster and what challenges emerged then. Given that the disaster affected business continuity in many cases, local governments and private enterprises both in the disaster-damage areas and others have grown more conscious of business continuity. Many of them have prepared and are considering preparing business continuity plans. However, BCP consciousness and effort gaps have emerged between size groups – between prefectural and municipal governments and between large enterprises and small and medium-sized ones. We must appropriately address these gaps in order to enhance the entire society's resistance to disasters. In order to revive societies and economies and reconstruct the livelihood in the disaster-damaged areas and revitalize the entire Japan, the government must make all-out efforts to promote restoration from the Great East Japan Earthquake and far-sighted reconstruction efforts including the creation of safe, secure and future-oriented towns using sophisticated ICT technologies.

Biography: Masakazu Ohashi is a professor at Graduate School and Faculty of Policy Studies, Chuo University, Japan. His research activity covers the system for the next generation networking social systems and Social Design. He is a chair of International Standardization Committee of e-Tendering and Procurement, Executive Board Member of Foundation, Japan Construction of Information Center and Service Center of Port Engineering (e-Tendering and Procurement Center of Public Work) and the top executive of Time Business Form (Time Authentication). He is a vice-president of The Infosociomics Society in Japan and a member of UN/CEFACT TBG6. He was a president of Web Services Initiative (2004-2007) and Internet Data Center Initiative (2000-2007) in Japan. He published many books and presents papers at the international conferences and journals regarding Authentication and the next generation social systems.

4. Reports of the 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 Research Units have been approved for the period of 2012–2014.

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

Leader of the unit

Jukka Heikkonen and Olli Nevalainen.

Senior Researchers

Lassi Bergroth, Stefan Emet, Timo Knuutila, Ville Leppänen, Tapio Pahikkala, 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 in 2012

Edited proceedings (1):

Sasu Tarkoma, Joni-Kristian Kämäräinen, Tapio Pahikkala (Eds.), *The Federated Computer Science Event*, Unigrafia Oy, 2012.

Articles in journals (8):

Fabian Gieseke, Oliver Kramer, Antti Airola, Tapio Pahikkala, Efficient Recurrent Local Search Strategies for Semi- and Unsupervised Regularized Least-Squares Classification. *Evolutionary Intelligence* 5(3), 189–205, 2012.

Kai Kallio, Mika Johnsson, Olli S. Nevalainen, Estimating the Operation Time of Flexible Surface Mount Placement Machines. *Production Engineering, Research and Development*, 1–10, 2012.

Tapio Pahikkala, Antti Airola, Thomas Canhao Xu, Pasi Liljeberg, Hannu Tenhunen, Tapio Salakoski, Parallelized Online Regularized Least-Squares for Adaptive Embedded Systems. *International Journal of Embedded and Real-Time Communication Systems* 3(2), 73–91, 2012.

Tapio Pahikkala, Sebastian Okser, Antti Airola, Tapio Salakoski, Tero Aittokallio, Wrapper-based selection of genetic features in genome-wide association studies through fast matrix operations. *Algorithms for Molecular Biology* 7, 1–11, 2012.

Tapio Pahikkala, Hanna Suominen, Jorma Boberg, Efficient Cross-Validation for Kernelized Least-Squares Regression with Sparse Basis Expansions. *Machine Learning* 87(3), 381–407, 2012.

Robert D. Scott, Jukka Heikkonen, Estimating Age at First Maturity in Fish from Change-Points in Growth Rate. *Marine Ecology-Progress Series* 450, 147–157, 2012.

Maaria Tringham, Johanna Kurko, Laura Tanner, Johannes Tuikkala, Olli S. Nevalainen, Harri Niinikoski, Kirsti Näntö-Salonen, Marja Hietala, Olli Simell, Juha Mykkänen, Exploring the Transcriptomic Variation Caused by the Finnish Founder Mutation of Lysinuric Intolerance (LPI). *Molecular genetics and metabolism (IF3.539)* 105, 408–415, 2012.

Willem Waegeman, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Michiel Stock, Bernard De Baets, A Kernel-based Framework for Learning Graded Relations from Data. *IEEE Transaction on Fuzzy Systems* 20(6), 1090–1101, 2012.

Articles in proceedings (6):

Amr Elmasry, Jyrki Katajainen, Jukka Teuhola, Improved Address-Calculation Coding of Integer Arrays. In: Liliana Calderón-Benavides, Cristina González-Caro, Edgar Chávez, Nivio Ziviani (Eds.), *String Processing and Information Retrieval, 19th International Symposium, SPIRE 2012, Cartagena de Indias, Colombia, October 21–25, 2012. Proceedings, LNCS 7608*, 205–216, Springer, 2012.

Fabian Gieseke, Antti Airola, Tapio Pahikkala, Oliver Kramer, Sparse Quasi-Newton Optimization for Semi-Supervised Support Vector Machines. In: Pedro Latorre Carmona, J. Salvador Sánchez, Ana L. N. Fred (Eds.), *Proceedings of*

the 1st International Conference on Pattern Recognition Applications and Methods (ICPRAM), 45–54, SciTePress, 2012.

Tapio Pahikkala, Antti Airola, Fabian Gieseke, Oliver Kramer, Unsupervised Multi-Class Regularized Least-Squares Classification. In: Mohammed J. Zaki, Arno Siebes, Jeffrey Xu Yu, Bart Goethals, Geoff Webb, Xindong Wu (Eds.), The 12th IEEE International Conference on Data Mining (ICDM 2012), 585–594, IEEE Computer Society, 2012.

Michiel Stock, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Bernard De Baets, Willem Waegeman, Learning Monadic and Dyadic Relations: Three Case Studies in Systems Biology. In: Oliver Ray, Katsumi Inoue (Eds.), Proceedings of the ECML/PKDD 2012 Workshop on Learning and Discovery in Symbolic Systems Biology, 74–84, ECML/PKDD 2012 Workshop on Learning and Discovery in Symbolic Systems Biology, 2012.

Willem Waegeman, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Bernard De Baets, Learning Valued Relations from Data. In: Pedro Melo-Pinto, Pedro Couto, Carlos Serôdio, János Fodor, Bernard De Baets (Eds.), Eurofuse 2011, Advances in Intelligent and Soft Computing 107, 257–268, Springer, 2012.

Willem Waegeman, Michiel Stock, Bernard De Baets, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Conditional Ranking Algorithms for Efficient Object Retrieval and Object Querying on Relational Data. In: Thomas Demeester, Johannes Deleu, Laurent Mertens, Dieter Plaetinck, An De Moor, Thong Hoang, Tim Wauters, Chris Develder, Brecht Vermeulen, Piet Demeester (Eds.), Proceedings of the 12th Dutch-Belgian Information Retrieval Workshop (DIR 2012), 59–60, Ghent University, 2012.

Chapters in edited books (2):

Jukka Heikkonen, Domenico Perrotta, Marco Riani, Francesca Torti, Issues on Clustering and Data Gridding. In: Antonio Giusti, Gunter Ritter, Vichi Maurizio (Eds.), Classification and Data Mining, Studies in classification, Data analysis and knowledge organization, 37–44, Springer, 2012.

Jussi Laasonen, Jouni Smed, Co-ordinating Formations: A Comparison of Methods. In: Ashok Kumar, Jim Etheredge, Aaron Boudreaux (Eds.), Algorithmic and Architectural Gaming Design: Implementation and Development, 1–22, IGI Global, 2012.

Ph.D. thesis (1):

Lasse Bergroth, Kahden merkkijonon pisimmän yhteisen alijonon ongelma ja sen ratkaiseminen. TUCS Dissertations 146. University of Turku, 2012.

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 increase 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 Prediction 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 di-

agnostic 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 Orešič (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 in 2012

Articles in journals (3):

Tapio Pahikkala, Sebastian Okser, Antti Airola, Tapio Salakoski, Tero Aittokallio, Wrapper-based selection of genetic features in genome-wide association studies through fast matrix operations. *Algorithms for Molecular Biology* 7, 1–11, 2012.

Kalle Parvinen, Anne Seppänen, John D. Nagy, Evolution of complex density-dependent dispersal strategies. *Bulletin of Mathematical Biology* 74(11), 2622–2649, 2012.

Anne Seppänen, Kalle Parvinen, John D. Nagy, Evolution of Dispersal in American Pika (*Ochotona princeps*) Metapopulations. *Evolutionary Ecology Research* 14, 1–29, 2012.

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 Timo Viljanen

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 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 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. (Webpage)

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. (Webpage)

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. [1,2]). 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 in 2012

Edited proceedings (1):

Sasu Tarkoma, Joni-Kristian Kämäräinen, Tapio Pahikkala (Eds.), *The Federated Computer Science Event*, Unigrafia Oy, 2012.

Articles in journals (5):

Fabian Gieseke, Oliver Kramer, Antti Airola, Tapio Pahikkala, Efficient Recurrent Local Search Strategies for Semi- and Unsupervised Regularized Least-Squares Classification. *Evolutionary Intelligence* 5(3), 189–205, 2012.

Tapio Pahikkala, Antti Airola, Thomas Canhao Xu, Pasi Liljeberg, Hannu Tenhunen, Tapio Salakoski, Parallelized Online Regularized Least-Squares for Adaptive Embedded Systems. *International Journal of Embedded and Real-Time Communication Systems* 3(2), 73–91, 2012.

Tapio Pahikkala, Sebastian Okser, Antti Airola, Tapio Salakoski, Tero Aittokallio, Wrapper-based selection of genetic features in genome-wide association studies through fast matrix operations. *Algorithms for Molecular Biology* 7, 1–11, 2012.

Tapio Pahikkala, Hanna Suominen, Jorma Boberg, Efficient Cross-Validation for Kernelized Least-Squares Regression with Sparse Basis Expansions. *Machine Learning* 87(3), 381–407, 2012.

Willem Waegeman, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Michiel Stock, Bernard De Baets, A Kernel-based Framework for Learning Graded Relations from Data. *IEEE Transactions on Fuzzy Systems* 20(6), 1090–1101, 2012.

Articles in proceedings (9):

Antti Airola, Machine Learning and Performance Estimation Methods for Ranking Problems. In: Sasu Tarkoma, Joni-Kristian Kämäräinen, Tapio Pahikkala (Eds.), *Proceedings of the Federated Computer Science Event 2012*, 8–14, University of Helsinki, 2012.

Fabian Gieseke, Antti Airola, Tapio Pahikkala, Oliver Kramer, Sparse Quasi-Newton Optimization for Semi-Supervised Support Vector Machines. In: Pedro Latorre Carmona, J. Salvador Sánchez, Ana L. N. Fred (Eds.), *Proceedings of the 1st International Conference on Pattern Recognition Applications and Methods (ICPRAM)*, 45–54, SciTePress, 2012.

Kai Hakala, Sofie van Landeghem, Suwisa Kaewphan, Tapio Salakoski, Yves van de Peer, Filip Ginter, CyEVEX: Literature-Scale Network Integration and Visualization Through Cytoscape. In: Sophia Ananiadou, Sampo Pyysalo,

Dietrich Rebholz-Schuhmann, Fabio Rinaldi, Tapio Salakoski (Eds.), Proceedings of the 5th International Symposium on Semantic Mining in Biomedicine, 91–96, ACM Press, 2012.

Juho Heimonen, Tapio Salakoski, Sanna Salanterä, An Ontology to Improve Accessibility and Quality of Patient Instructions. In: Pamela Forner, Jussi Karlgren, Christa Womser-Hacker (Eds.), Proceedings of CLEF 2012 Evaluation Labs and Workshop, 137, Fondazione Bruno Kessler Press, 2012.

Suwisa Kaewphan, Sanna Kreula, Sofie Van Landeghem, Yves Van de Peer, Patrik R. Jones, Filip Ginter, Integrating Large-Scale Text Mining and Co-Expression Networks: Targeting NADP(H) Metabolism in *E. coli* with Event Extraction. In: Sophia Ananiadou, Kevin Cohen, Dina Demner-Fushman, Paul Thompson (Eds.), Third Workshop on Building and Evaluating Resources for Biomedical Text Mining, 8–15, European Language Resources Association (ELRA), 2012.

Olli Sjöblom, Juho Heimonen, Lotta Kauhanen, Veronika Laippala, Heljä Lundgrén-Laine, Laura-Maria Murtola, Tapio Salakoski, Sanna Salanterä, Avoiding Hazards - What Can Health Care Learn from Aviation?. In: Kristina Eriksson-Backa, Annika Luoma, Erica Krook (Eds.), Exploring the Abyss of Inequalities - Proceedings of the 4th International Conference on Well-Being in the Information Society, Communications in Computer and Information Science 313, 119–127, Springer, 2012.

Michiel Stock, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Bernard De Baets, Willem Waegeman, Learning Monadic and Dyadic Relations: Three Case Studies in Systems Biology. In: Oliver Ray, Katsumi Inoue (Eds.), Proceedings of the ECML/PKDD 2012 Workshop on Learning and Discovery in Symbolic Systems Biology, 74–84, ECML/PKDD 2012 Workshop on Learning and Discovery in Symbolic Systems Biology, 2012.

Willem Waegeman, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Bernard De Baets, Learning Valued Relations from Data. In: Pedro Melo-Pinto, Pedro Couto, Carlos Serôdio, János Fodor, Bernard De Baets (Eds.), Eurofuse 2011, Advances in Intelligent and Soft Computing 107, 257–268, Springer, 2012.

Willem Waegeman, Michiel Stock, Bernard De Baets, Tapio Pahikkala, Antti Airola, Tapio Salakoski, Conditional Ranking Algorithms for Efficient Object Retrieval and Object Querying on Relational Data. In: Thomas Demeester, Johannes Deleu, Laurent Mertens, Dieter Plaetinck, An De Moor, Thong Hoang, Tim Wauters, Chris Develder, Brecht Vermeulen, Piet Demeester (Eds.), Proceedings of the 12th Dutch-Belgian Information Retrieval Workshop (DIR 2012), 59–60, Ghent University, 2012.

Technical reports (1):

Katri Haverinen, Syntax Annotation Guidelines for the Turku Dependency Treebank. TUCS Technical Reports 1034, Turku Centre for Computer Science, 2012.

4.4 Computational Biomodeling Laboratory (Combio Lab)

The research of the laboratory centers on computational methods for modelling 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 ex-

perimental data, discovering their control structure, quantitative model comparison and quantitative model refinement.

The laboratory has hosted in the last 5 years 5 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

Doctoral Students

Bogdan Iancu, Sepinoud Azimi, and Diana-Elena Gratie

Projects

Quantitative strategies for the self-assembly of intermediate filaments

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. This project is an example of a hypothesis-driven research in the field of systems biology.

Quantitative model refinement

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.

Computational modeling of the eukaryotic heat shock response

Cells exposed to elevated temperature or other stress stimuli respond by increased expression of heat shock proteins (HSPs). The heat shock response and the proteins involved have been highly conserved throughout evolution from *Escherichia coli* to human. In addition to heat, a wide variety of biological (infection, inflammation), physical (radiation, hypoxia) and chemical (alcohols, metals) stressors can induce the response. This is why the heat shock response is also called "stress response" and the heat shock proteins, in consequence, "stress proteins". We investigate in this project a new molecular model for the heat shock response including the stress-induced response and its self-regulation. We focus on: (i) understanding the main control mechanisms in the architecture of the heat shock response and (ii) new modeling methods to allow the integration of the phosphorylation-based control mechan-

isms for the heat shock response, while addressing the problem of the combinatorial explosion of the model size.

Funded by Academy of Finland, 2008-2010.

Computing at nano-scale

We investigate mathematical models for self-assembly, contributing to laying solid foundations for nano-science, that are still missing to a large extent at this time. Based on such foundations, we seek to clarify several central questions: e.g., what can be effectively self-assembled (and thus nano-fabricated), how complex is it to self-assemble a given shape, or what initial structures can self-assemble into a certain shape.

Funded by Academy of Finland, 2005-2010

Computational processes in living cells

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.

Funded by Academy of Finland, 2004-2007, within the research program for Systems Biology and Bioinformatics.

Molecular computing network

Molecular computing is a novel, exciting and a genuinely interdisciplinary research area which lies at the boundary of Computer Science and Molecular Biology. An important advantage offered by computations with bio-molecules is the massive parallelism: the number of operations that can be executed at the same time is proportional to the number of molecules involved, which is of the order of 10 to the power 19 . Also, operations which involve bio-molecules are over a billion times more energy efficient with respect to electronic chips, and the information can be stored at a density of about a billion times higher than in usual electronic computers. The major applications to massively-parallel molecular computation range from novel computer architectures in conventional hardware and novel algorithmic solutions to difficult problems to self-assembling technology and intelligent nano-scale construction. The theoretical studies involve the investigation of new computational models based on paradigms coming from bio-chemistry: the complementarity of the two strands of a DNA molecule, the signaling within and between cells, or the structural organization of cells.

Funded by European Union IST FP5, 2002-2004.

Publications in 2012

Edited special issues of journals (3):

Giorgio Ausiello, Hendrik Jan Hoogeboom, Juhani Karhumäki, Ion Petre, Arto Salomaa (Eds.), *Magic in Science. Theoretical Computer Science* 429, 2012.

Jarkko Kari, Ion Petre (Eds.), Special Issue on Unconventional Computing. *Natural Computing* 11(4), 2012.

Ion Petre, Corrado Priami, Erik de Vink (Eds.), Special Issue on Computational Models for Cell Processes. *Transactions on Computational Systems Biology Lecture Notes in Computer Science* 7625, 2012.

Articles in journals (7):

Sepinoud Azimi, Tero Harju, Miika Langille, Ion Petre, Simple Gene Assembly as a Rewriting of Directed Overlap-Inclusion Graphs. *Theoretical Computer Science* 454, 30–37, 2012.

Elena Czeizler, Eugen Czeizler, Bogdan Iancu, Ion Petre, Quantitative Model Refinement as a Solution to the Combinatorial Size Explosion of Biomodels. *Electronic Notes in Theoretical Computer Science* 284, 35–53, 2012.

Elena Czeizler, Andrzej Mizera, Ion Petre, A Boolean Approach for Disentangling the Roles of Submodules to the Global Properties of a Biomodel. *Fundamenta Informaticae* 116(1-4), 51–63, 2012.

Eugen Czeizler, Andrzej Mizera, Elena Czeizler, Ralph-Johan Back, John E. Eriksson, Ion Petre, Quantitative Analysis of the Self-Assembly Strategies of Intermediate Filaments from Tetrameric Vimentins. *Transactions on Computational Biology and Bioinformatics* 9(3), 885–898, 2012.

Eugen Czeizler, Vladimir Rogojin, Ion Petre, The Phosphorylation of the Heat Shock Factor as a Modulator for the Heat Shock Response. *IEEE-ACM Transactions on Computational Biology and Bioinformatics* 9(5), 1326–1337, 2012.

Andrzej Mizera, Eugen Czeizler, Ion Petre, Self-Assembly Models of Variable Resolution. *Transactions on Computational Systems Biology XIV(7625)*, 181–203, 2012.

Ion Petre, Sergey Verlan, Matrix Insertion–Deletion Systems. *Theoretical Computer Science* 456, 80–88, 2012.

Chapters in edited books (2):

Robert Brijder, Mark Daley, Tero Harju, Natasha Jonoska, Ion Petre, Grzegorz Rozenberg, Computational Nature of Gene Assembly in Ciliates. In: Grzegorz Rozenberg, Thomas Bäck, Joost N. Kok (Eds.), *Handbook of Natural Computing*, 1233–1280, Springer, 2012.

Andrzej Mizera, Elena Czeizler, Ion Petre, Computational methods for quantitative submodel comparison. In: Evgeny Katz (Ed.), *Biomolecular Information Processing. From Logic Systems to Smart Sensors and Actuators*, 323–346, Wiley-VCH Verlagsgesellschaft, 2012.

Technical reports (1):

Eugen Czeizler, Vladimir Rogojin, Ion Petre, The Phosphorylation of the Heat Shock Factor as a Modulator for the Heat Shock Response. *TUCS Technical Reports* 1041, Turku Centre for Computer Science, 2012.

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 in 2012

Edited books (1):

Seppo Virtanen (Ed.), Innovations in Embedded and Real-Time Systems Engineering for Communication, IGI Global, 2012.

Edited special issues of journals (1):

Tapani Ahonen, Seppo Virtanen (Eds.), Special Theme Issue on Perspectives on Signal Processing Megatrends. International Journal of Embedded and Real-Time Communication Systems 3(1), 2012.

Edited proceedings (2):

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), Abstract Book, Research Reports from Turku University of Applied Sciences 37, Turun ammattikorkeakoulu, 2012.

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), Proceedings, Research reports from Turku University of Applied Sciences 38, Turun ammattikorkeakoulu, 2012.

Articles in journals (8):

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Liang Guang, Ethiopia Nigussie, Juha Plosila, Hannu Tenhunen, Dual Monitoring Communication for Self-Aware Network-on-Chip: Architecture and

Case Study. *International Journal of Adaptive, Resilient and Autonomic Systems* 3(3), 73–92, 2012.

Olli I. Heimo, Antti Hakkala, Kai K. Kimppa, How to Abuse Biometric Recognition Systems. *Journal of Information, Communication & Ethics in Society* 10(2), 68–81, 2012.

Rajeev Kumar Kanth, Pasi Liljeberg, Hannu Tenhunen, Qiang Chen, Lirong Zheng, Haris Kumar, Study on Glass Epoxy Based Low Cost and Compact Tip-Truncated Triangular Printed Antenna . *International Journal of Antennas and Propagation* 2012(184537), 1–8, 2012.

Ethiopia Nigussie, Liang Guang, Alexey Boyko, Antti Hakkala, Petri Sainio, Seppo Virtanen, Jouni Isoaho, Incubator Platform for Multidisciplinary Innovation in Research and Education. *International Journal of Knowledge Society Research* 3(3), 29–44, 2012.

Ethiopia Nigussie, Sampo Tuuna, Juha Plosila, Jouni Isoaho, Hannu Tenhunen, Semi-Serial On-Chip Link Implementation for Energy Efficiency and High Throughput. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems* 20(12), 2265 – 2277, 2012.

Sampo Tuuna, Ethiopia Nigussie, Jouni Isoaho, Hannu Tenhunen, Modeling of Energy Dissipation in RLC Current-Mode Signaling. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems* 20(6), 1146–1151, 2012.

Tibert Verhagen, Frans Feldberg, Bart van den Hooff, Selmar Meents, Jani Merikivi, Understanding Users' Motivations to Engage in Virtual Worlds: A Multipurpose Model and Empirical Testing. *Computers in Human Behavior* 28(2), 484-495, 2012.

Articles in proceedings (5):

Liang Guang, Ethiopia Nigussie, Juha Plosila, Jouni Isoaho, Hannu Tenhunen, Coarse and Fine-Grained Monitoring and Reconfiguration for Energy-Efficient NoCs. In: Jari Nurmi, Olli Vainio, Jussi Raasakka (Eds.), *International Symposium on System-on-Chip*, 1–7, IEEE, 2012.

Liang Guang, Ethiopia Nigussie, Juha Plosila, Jouni Isoaho, Hannu Tenhunen, HLS-DoNoC: High-Level Simulator for Dynamically Organizational NoCs. In: Jaan Raik, Viera Stopjaková, Heinrich Vierhaus, Witold Pleskacz, Raimund Ubar, Maksim Jenihhin (Eds.), *IEEE 15th International Symposium on Design and Diagnostics of Electronic Circuits and Systems*, 89–94, IEEE, 2012.

Antti Hakkala, Seppo Virtanen, University-industry collaboration in network security education for engineering students. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *Proceedings of International conference on engineering education 2012, Research reports from Turku University of Applied Sciences* 38, 204–210, Turun ammattikorkeakoulu, 2012.

Rajeev Kumar Kanth, Pasi Liljeberg, Hannu Tenhunen, Qiang Chen, Lirong Zheng, Harish Kumar, Comparative Toxic Emission Analysis in Production Process of Polymer and Paper Based RFID Tags. In: M. Caciotta, Zbigniew Leonowicz (Eds.), *11th International Conference on Environment and Electrical Engineering*, 184–187, IEEE, 2012.

Petri Sainio, Seppo Virtanen, Structured Learning Journal Based Method for Lecture Courses in Engineering Education. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *Proceedings of International Conference on Engineering Education 2012, Research reports from Turku University of Applied Sciences* 38, 939–944, Turun ammattikorkeakoulu, 2012.

Chapters in edited books (2):

Jouni Isoaho, Seppo Virtanen, Juha Plosila, Current Challenges in Embedded Communication Systems. In: Seppo Virtanen (Ed.), Innovations in Embedded and Real-Time Systems Engineering for Communication, 1–21, IGI Global, 2012.

Janne Roslöf, Jerker Björkqvist, Seppo Virtanen, Supporting student innovation through project-based learning and industry co-operation. In: Win Aung, Vojislav Ilic, Olli Mertanen, Jerzy Moscinski, James Uhomobhi (Eds.), Innovations 2012: World Innovations in Engineering Education and Research, iNEER Innovations 2012, 207–215, iNEER (International Network For Engineering Education and Research), 2012.

Ph.D. Thesis (1):

Guang Liang, Hierarchical Agent-Based Adaptation for Self-Aware Embedded Computing Systems. AI osa 452. University of Turku, 2012.

Technical reports (1):

Kimberly Lukin, Requirements for Finland's National Cyber Security Strategy. TUCS Technical Reports 1037, Turku Centre for Computer Science, 2012.

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 segmentation
- 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 the Web

Education based on research

Regular advanced courses in IS:

- Data Mining and Text Mining, Autumn 2011
- Business Intelligence, Autumn 2011

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 and Dorina Marghescu

Doctoral Students

Piia Hirkman, Minna Kallio, Henri Korvela, Annika H. Holmblom, Hongyan Liu, Zhiyuan Yao, Peter Sarlin, and Samuel Rönqvist

Projects

Kermit

(Knowledge mining in organizations) 2009-2012. Academy of Finland.

UnHide

(BI for competitor analysis) 2009-2012. Academy of Finland

Titan

2008-2011. Tekes.

Publications in 2012

Articles in journals (3):

Tomas Eklund, Petri Paajanen, Jussi Kantola, Hannu Vanharanta, Knowledge Creation and Learning in Organizations – Measuring Proactive Vision Using the Co-Evolute Methodology. *International Journal of Strategic Change Management* 4(2), 190–201, 2012.

Peter Sarlin, Visual Tracking of the Millennium Development Goals with a Fuzzified Self-Organizing Neural Network. *International Journal of Machine Learning and Cybernetics* 3(3), 233–245, 2012.

Peter Sarlin, Zhiyuan Yao, Tomas Eklund, A Framework for State Transitions on the Self-Organizing Map: Some Temporal Financial Applications. *Intelligent Systems in Accounting, Finance and Management* 19(1), 189–203, 2012.

Articles in proceedings (10):

Henri Korvela, Barbro Back, The Impact of Skills and Demographics on End-User Developers' Use of Support. In: Len Jessup, Joe Valacich (Eds.), *AMCIS 2012 Proceedings, End-user Information Systems, Innovation, and Change (SIGOSRA)*, 1–9, Association for Information Systems, 2012.

Hongyan Liu, Zhiyuan Yao, Tomas Eklund, Barbro Back, From Smart Meter Data to Pricing Intelligence – Visual Data-Mining towards Real-Time BI. In: K.D. Joshi, Youngjin Yoo (Eds.), *AMCIS*, 1–10, AISEL, 2012.

Hongyan Liu, Zhiyuan Yao, Tomas Eklund, Barbro Back, Electricity Consumption Time Series Profiling: A Data Mining Application in Energy

Industry. In: Petra Perner (Ed.), *Advances in Data Mining: Applications and Theoretical Aspects*, LNAI 7377, 52–66, Springer, 2012.

Henrik J. Nyman, Piia Hirkman, On the Nature of Supply Chain Management Projects and how to Manage Them. In: J. Pries-Heje, M. Chiasson (Eds.), *ECIS 2012 Proceedings*, 1–12, AISel, 2012.

Peter Sarlin, Decomposing the Global Financial Crisis: A Self-Organizing Time Map. In: Manuel Graña, Carlos Toro, Jorge Posada, Robert Howlett, Lakhmi Jain (Eds.), *Proceedings of the 16th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES'12)*, 798–806, IOS Press, 2012.

Peter Sarlin, Exploiting the Self-Organizing Financial Stability Map. In: Manuel Graña, Carlos Toro, Jorge Posada, Robert Howlett, Lakhmi Jain (Eds.), *Proceedings of the 16th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems (KES'12)*, 248–257, IOS Press, 2012.

Peter Sarlin, On Biologically Inspired Predictions of the Global Financial Crisis. In: Klaus G. Troitzsch, Michael Möhring, Ulf Lotzmann (Eds.), *Proceedings of the 26th European Conference on Modelling and Simulation*, 253–259, European Council for Modelling and Simulation, 2012.

Peter Sarlin, Zhiyuan Yao, Tomas Eklund, Probabilistic Modeling of State Transitions on the Self-Organizing Map: Some Temporal Financial Applications. In: Ralph H. Jr. Sprague (Ed.), *Proceedings of the 45th Hawaii International Conference on System Sciences*, 1128-1137, IEEE Press, 2012.

Zhiyuan Yao, Peter Sarlin, Tomas Eklund, Barbro Back, Combining Visual Customer Segmentation and Response Modelling. In: *ECIS 2012 Proceedings*, 1–10, AIS Electronic Library (AISel), 2012.

Zhiyuan Yao, Peter Sarlin, Tomas Eklund, Barbro Back, Temporal Customer Segmentation Using the Self-Organizing Time Map. In: Ebad Banissi, Stefan Bertschi, Camilla Forsell, Jimmy Johansson, Sarah Kenderdine, Francis T. Marchese, Muhammad Sarfraz, Liz Stuart, Anna Ursyn, Theodor G. Wyeld, Hanane Azzag, Mustapha Lebba, G. Venturini (Eds.), *Proceedings of the 2012 16th International Conference on Information Visualisation (IV)*, 234–240, IEEE Press, 2012.

Chapters in edited books (3):

Hongyan Liu, Tomas Eklund, Barbro Back, Smart Metering and Customer Consumption Behavior Profiling: Exploring Potential Business Opportunities for DSOs and Electricity Retailers. In: Jussi Kantola, Waldemar Karwowski (Eds.), *Knowledge Service Engineering Handbook*, Page 179-189, Taylor & Francis, 2012.

Peter Sarlin, Chance Discovery with Self-Organizing Maps: Discovering Imbalances in Financial Networks. In: Yukio Ohsawa, Akinori Abe (Eds.), *Advances in Chance Discovery*, 49–61, Springer, 2012.

Hannu Vanharanta, Camilla Magnusson, Kari Ingman, Annika H. Holmbom, Jussi Kantola, Strategic Knowledge Services. In: Jussi Kantola, Waldemar Karwowski (Eds.), *Knowledge Service Engineering Handbook*, 529-557, CRC Press, Taylor and Francis Group, 2012.

Technical reports (5):

Hongyan Liu, Zhiyuan Yao, Thomas Eklund, Barbro Back, From Smart Meter Data to Pricing Intelligence: Real Time BI for Business Innovation. TUCS Technical Reports 1035, Turku Centre for Computer Science, 2012.

Peter Sarlin, Data and Dimension Reduction for Visual Financial Performance Analysis. TUCS Technical Reports 1049, TUCS, 2012.

Peter Sarlin, On Policymakers' Loss Functions and the Evaluation of Early Warning Systems. TUCS Technical Reports 1054, TUCS, 2012.

Peter Sarlin, A Weighted SOM for Classifying Data with Instance-Varying Importance. TUCS Technical Reports 1060, TUCS, 2012.

Peter Sarlin, Zhiyuan Yao, Clustering of the Self-Organizing Time Map. TUCS Technical Reports 1062, TUCS, 2012.

4.7 Distributed Systems Laboratory (DS Lab)

The Distributed Systems Laboratory has been a research laboratory within the Turku Centre for Computer Science (TUCS) from the beginning. The researchers belong to the Department of Information Technologies at Åbo Akademi University and their background is in computer science and software engineering. The mission of the Distributed Systems Laboratory is to develop methods, techniques and tools facilitating the design of correct and dependable parallel and distributed systems. The Distributed Systems Laboratory was a part of the Centre of Excellence in Formal Methods in Programming, Academy of Finland during 2002-07. We apply our modelling and verification methods to systems ranging from distributed algorithms to large distributed networks, processor farms, and multi-core architectures. Our research involves a significant range of industrial software-intensive systems in areas such as communication technology, digital hydraulics, satellite software, and various control systems.

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

Formal Methods. Our laboratory has a long experience on working in the field of formal methods – precise analysis frameworks for developing reliable software and systems. We have traditionally based our research on the Action Systems/Refinement Calculus framework for distributed systems proposed by Back, Sere and Waldén. This framework especially supports the stepwise refinement approach to the design of correct systems. The related formal method Event-B, that was developed based on Action Systems, provides tool support (the Rodin platform) for correct-by-construction system development.

Control Systems. Our expertise related to control systems consists in modelling and analysing the control loop via the so-called system approach. The system approach is firmly based on stepwise refinement techniques. It gives structure to the design of complex distributed and control systems and helps in managing the derivation task. The approach turned out to be extremely successful and was further developed from theory to practice in a series of EU projects (FP5 MATISSE 2000-2003, FP6 RODIN 2004-2007, FP7 DEPLOY 2008-2012) into a method ready to be deployed by industrial users. A more recent application of the system approach is on developing digital hydraulic controllers, based on Simulink and Contract-Based Design.

Dependable Systems. We have a strong track record in developing formal design theories for highly dependable systems. We 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 extension refinement-based development method with stochastic reasoning and integration with probabilistic model checking.

Automated Reasoning. We heavily employ and contribute to the development of the Rodin platform, a theorem prover tool for the correct development of systems in Event-B. In addition to providing a user interface for editing Event-B models, the proving process is closely integrated with the modelling process, encouraging proof-based model improvement. We also work with model-based verification in the Event-B model checker ProB and experiment with existing probabilistic model checkers. Moreover, we use simulation together with formal modelling based on the Simulink tool. Recently we have also developed tool support (VERSÅA) to verify Simulink models.

Trusted Networks and Services. As pervasive computing, mobile agent systems and services are becoming a part of our everyday life, the correctness and trustworthiness of such systems needs to be ensured. We apply our expertise in rigorous software development methods to such diverse topics as service-oriented development of (mobile) distributed systems, ad hoc, peer-to-peer and sensor networks, grid computing, component-based design etc. In particular, we propose an approach to deriving fault tolerant middleware for mobile agent systems and demonstrate how to reason about safety and data integrity of critical multi-agent system by refinement.

Formal Hardware Design. Formal hardware verification has become increasingly popular in industry, where new methods and tools are now in demand for the formal verification of digital circuits. Our work focuses on developing new hardware design and verification methods for both asynchronous and synchronous circuits as well as such novel hardware platforms as system-on-chips (SoC), 2D and 3D network-on-chips (NoC), and Multi-core. We have a strong cooperation with the (forthcoming) Embedded Computer and Electronic Systems laboratory at University of Turku in this area.

Research Unit Web Page: <https://research.it.abo.fi/research/distributed-systems-laboratory>

Leader of the unit

Kaisa Sere

Co-leader of the unit

Elena Troubitsyna and Marina Waldén

Senior Researchers

Linas Laibnis and Luigia Petre

Researchers

Petr Alexeev, Pontus Boström, Marta Olszewska, and Leonidas Tsiopoulos

Doctoral Students

Fredrik Degerlund, Kashif Javed, Maryam Kamali, Mats Neovius, Sergey Ostroumov, Inna Pereverzeva, Yuliya Prokhorova, Petter Sandvik, and Anton Tarasyuk

Projects

DEPLOY

Industrial deployment of system engineering methods providing high dependability and productivity, 2008-2012. This EU FP7 IP project focuses on major industrial deployment of formal methods.

RECOMP

Reduced Certification Costs for trusted Multi-core Platforms. The project is an ARTEMIS Joint Undertaking project during 2010-2013 financed by EU. Our laboratory is responsible for the component based design methods for trusted multi-core based systems relying on contract based component models, as well as utilisation of formal methods with respect to safety critical standards.

NODES

Nordic Network on Dependable Systems. The project is a cooperation initiative supported by Nordforsk during 2007-2012 with the explicit aim of promoting dependability in the Nordic universities curricula and postgraduate education.

ASSURE

Autonomic Software-intensive Systems: foundations of safety and resilience. The goal of this project funded by the Academy of Finland during 2010 – 2013 is to enhance safety and resilience of critical software-intensive systems via creating a system-health monitoring framework.

DECO

Formal Dependability-Explicit development model for Complex software-intensive systems. The Academy of Finland funded project (2011 – 2012) aims at creating a formal model-driven approach that facilitates design of highly dependable systems.

eDiHy

Energy Efficient Digital Hydraulic Hybrid Machines. The project is funded by the Academy of Finland during 2011-2014. 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.

EFFIMA/DiHy

Digital Microhydraulics. This is a project within Fimecc/EFFIMA/MeKo SHOK for the period 2009-2013. 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.

EFFIMA/Digihybrid

Regenerative hydraulic hybrid with digi-valve and multi chamber cylinder technology. 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.

Publications in 2012

Edited special issues of journals (1):

Marina Waldén, Luigia Petre (Eds.), The 22nd Nordic Workshop on Programming Theory (NWPT 2010). *The Journal of Logic and Algebraic Programming* 81(3), 2012.

Articles in journals (2):

Masoud Daneshtalab, Maryam Kamali, Masoumeh Ebrahimi, Siamak Mohammadi, Ali Afzali-Kusha, Juha Plosila, Adaptive Input-Output Selection Based On-Chip Router Architecture. *Journal of Low Power Electronics (JOLPE)* 8(1), 11–29, 2012.

Sergey Ostroumov, Leonidas Tsiopoulos, Formal Development of Hierarchical Agent-Based Monitoring Systems for Dynamically Reconfigurable NoC Platforms. *International Journal of Embedded and Real-Time Communication Systems (IJERTCS)* 3(2), 40–72, 2012.

Articles in proceedings (19):

Jesper Berthing, Pontus Boström, Kaisa Sere, Leonidas Tsiopoulos, Jüri Vain, Refinement-Based Development of Timed Systems. In: Diego Latella, Helen Treharne (Eds.), 9th International Conference on Integrated Formal Methods (iFM 2012), *Lecture Notes in Computer Science* 7321, 69–84, Springer, Heidelberg, 2012.

Jerker Björkqvist, Luigia Petre, Karl Rönholm, Dragos Truscan, Integrating Innovation Activities in a Master Level Capstone Project Course. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *International Conference on Engineering Education, Research Reports* 38, 1065–1072, Turku University of Applied Sciences, 2012.

Fredrik Degerlund, Scheduling of Compute-Intensive Code Generated from Event-B Models: An Empirical Efficiency Study. In: Karl Göschka, Seif Haridi (Eds.), *Distributed Applications and Interoperable Systems (Proc. of DAIS 2012)*, *Lecture Notes in Computer Science* 7272, 177–184, Springer, 2012.

Denisa Diaconescu, Ioana Leustean, Luigia Petre, Kaisa Sere, Gheorghe Stefanescu, Refinement-Preserving Translation from Event-B to Register-Voice Interactive Systems. In: Diego Latella, Helen Treharne (Eds.), 9th International Conference on Integrated Formal Methods (iFM 2012), *Lecture Notes in Computer Science* 7321, 221–236, Springer, Heidelberg, 2012.

Mikko Huova, Miikka Ketonen, Petr Alexeev, Pontus Boström, Matti Linjama, Marina Waldén, Kaisa Sere, Simulations with Fault-Tolerant Controller Software of a Digital Valve. In: Arto Laamanen (Ed.), *Proceedings of the Fifth Workshop on Digital Fluid Power - DFP12*, Tampere, Finland, 223–242, Tampere University of Technology, Finland, 2012.

Kashif Javed, Elena Troubitsyna, Modelling a Fault-Tolerant Distributed Satellite System. In: Lasse Berntzen, Katya Toneva, Abdulrahman Yarali (Eds.), *The Second International Conference on Advanced Collaborative Networks, Systems and Applications*, 35 to 41, IEEE Computer Press, 2012.

Kashif Javed, Elena Troubitsyna, Designing a Fault-Tolerant Satellite System in SystemC. In: Hermann Kaindl, Leszek Koszalka, Herwig Mannaert, Marko Jäntti, Petre Dini (Eds.), *ICONS 2012, The Seventh International Conference on Systems*, 49–54, IEEE Computer Press, 2012.

Kashif Javed, Elena Troubitsyna, A Case Study in Modeling a Fault-tolerant Satellite System Through Implementation of Dynamic Reconfiguration via

Handshake. In: Mannaert, Herwig, Luigi Lavazza, Roy Oberhauser, Elena Troubitsyna, Michael Gebhar, Osamu Takaki (Eds.), *The Seventh International Conference on Software Engineering Advances*, 44 to 49, IEEE Computer Press, 2012.

Maryam Kamali, Luigia Petre, Kaisa Sere, Masoud Daneshtalab, Refinement-Based Modeling of 3D NoCs. In: Farhad Arbab, Marjan Sirjani (Eds.), *4th IPM International Conference on Fundamentals of Software Engineering*, 7141, 236–252, Springer, LNCS, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, Formal Development of Critical Multi-Agent Systems: A Refinement Approach. In: *9th European Dependable Computing Conference (EDCC 2012)*, 156–161, IEEE Computer Society, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, A Case Study in Formal Development of a Fault Tolerant Multi-Robotic System. In: Paris Avgeriou (Ed.), *Proceedings of the 4th International Workshop on Software Engineering for Resilient Systems (SERENE 2012)*, *Lecture Notes in Computer Science 7527*, 16–31, Springer-Verlag Berlin Heidelberg, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, Formal Goal-Oriented Development of Resilient MAS in Event-B. In: Mats Brorsson, Luís Miguel Pinho (Eds.), *17th International Conference on Reliable Software Technologies (Ada-Europe 2012)*, *Lecture Notes in Computer Science 7308*, 147–161, Springer, Heidelberg, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, Development of Fault Tolerant MAS with Cooperative Error Recovery by Refinement in Event-B. In: Fuyuki Ishikawa, Alexander Romanovsky (Eds.), *Proceedings of DS-Event-B 2012: Workshop on the experience of and advances in developing dependable systems in Event-B*, 1–7, ACM CoRR, 2012.

Luigia Petre, Petter Sandvik, Kaisa Sere, Node Coordination in Peer-to-Peer Networks. In: Marjan Sirjani (Ed.), *COORDINATION 2012*, LNCS 7274, 196–211, Springer-Verlag GmbH Berlin Heidelberg, 2012.

Yuliya Prokhorova, Elena Troubitsyna, Linking Modelling in Event-B with Safety Cases. In: Paris Avgeriou (Ed.), *Proceedings of the 4th International Workshop on Software Engineering for Resilient Systems (SERENE 2012)*, *Lecture Notes in Computer Science 7527*, 47–62, Springer-Verlag Berlin Heidelberg, 2012.

Petter Sandvik, SPECTA: A Formal Specification Language for Content Transfer Algorithms. In: Uwe Wolter, Yngve Lamo (Eds.), *24th Nordic Workshop on Programming Theory*, *Reports in Informatics 403*, 81–83, University of Bergen, 2012.

Anton Tarasyuk, Inna Pereverzeva, Elena Troubitsyna, Timo Latvala, Laura Nummila, Formal Development and Assessment of a Reconfigurable On-Board Satellite System. In: Frank Ortmeier, Peter Daniel (Eds.), *Proceedings of 31st International Conference on Computer Safety, Reliability and Security (SAFECOMP 2012)*, *Lecture Notes in Computer Science 7612*, 210–222, Springer-Verlag Berlin Heidelberg, 2012.

Anton Tarasyuk, Elena Troubitsyna, Linas Laibinis, Formal Modelling and Verification of Service-Oriented Systems in Probabilistic Event-B. In: John Derrick, Stefania Gnesi, Diego Latella, Helen Treharne (Eds.), *Integrated Formal Methods - 9th International Conference, IFM 2012, Pisa, Italy, June 18–21, 2012*, *Lecture Notes in Computer Science 7321*, 237–252, Springer, 2012.

Elena Troubitsyna, Dependability-Explicit Engineering with Event-B: Overview of Recent Achievements. In: Fuyuki Ishikawa, Alexander Romanovsky (Eds.), *Proceedings of DS-Event-B 2012: Workshop on the experience of and*

advances in developing dependable systems in Event-B, 1–7, ACM CoRR, 2012.

Chapters in edited books (1):

Luigia Petre, Kaisa Sere, Marina Waldén, Location-Awareness with Action Systems. In: Paulo Alencar, Donald Cowan (Eds.), Handbook of Research on Mobile Software Engineering - Design, Implementation, and Emergent Applications, 1, 463–483, IGI Global, 2012.

Ph.D. thesis (2):

Fredrik Degerlund, Scheduling of Guarded Command Based Models. TUCS Dissertations 152. 2012.

Mats Neovius, Trustworthy Context Dependency in Ubiquitous Systems. TUCS Dissertations 151. 2012.

Technical reports (7):

Fredrik Degerlund, Scheduling Performance of Compute-Intensive Concurrent Code Developed Using Event-B. TUCS Technical Reports 1051, Turku Centre for Computer Science, 2012.

Radu Gramatovici, Luigia Petre, Kaisa Sere, Alin Stefanescu, Gheorghe Stefanescu, Synchronization in Timed Interactive Systems. TUCS Technical Reports 1047, 2012.

Kashif Javed, Elena Troubitsyna, Ensuring Mode Consistency for a Complex Fault-Tolerant Distributed Satellite System. TUCS Technical Reports 1040, Turku Centre for Computer Science, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, Formal Goal-Oriented Development of Resilient MAS in Event-B. TUCS Technical Reports 1033, Turku Centre for Computer Science, 2012.

Inna Pereverzeva, Elena Troubitsyna, Linas Laibinis, A Case Study in a Formal Development of a Fault Tolerant Multi-Robotic System. TUCS Technical Reports 1052, Turku Centre for Computer Science, 2012.

Luigia Petre, Petter Sandvik, Kaisa Sere, A Modular Approach to Formal Modelling of Peer-to-Peer Networks. TUCS Technical Reports 1039, Turku Centre for Computer Science, 2012.

Anton Tarasyuk, Inna Pereverzeva, Elena Troubitsyna, Timo Latvala, Laura Nummila, Formal Development and Assessment of Reconfigurable On-Board Satellite System. TUCS Technical Reports 1038, Turku Centre for Computer Science, 2012.

4.8 Embedded Computer and Electronic Systems (ECES)

ECES focuses in its research on development of novel massively parallel computing platforms and paradigms, and on engineering of advanced embedded systems based on such platforms and paradigms. The emphasis in current research activities is in intelligent dynamic monitoring and control of 2D and 3D Network-on-Chip (NoC) based systems. ECES publishes annually 30-40 peer-reviewed research papers. The unit collaborates especially with the Embedded Systems Lab and Distributed Systems Lab at TUCS.

Research Unit Web Page: <http://computersystems.utu.fi>

Leader of the unit

Juha Plosila

Senior Researchers

Hannu Tenhunen, Pasi Liljeberg, and Tomi Westerlund

Researchers

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

Doctoral Students

Masoumeh Ebrahimi, Alexander Wei Yin, Kameswar Rao Vaddina, Fahimeh Farahnakian, Mohammad Fattah, Bo Yang, Syed Mohammad Asad Jafri, Rajeev Kumar Kanth, and Marco Ramirez

Projects

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

Embedded Multicore Systems Using Virtual Machine Approach (VIRTUES)

Academy of Finland, Juha Plosila, 2009-06/2012

Fault Tolerant Self-Timed Communication Platform for Future Nano-scale Systems (FASTCOP)

Academy of Finland, Pasi Liljeberg, 2008-2011

MyGoogle-on-Chip (MyGoC)

Academy of Finland, Hannu Tenhunen, 2009-2011

Distributed Jointly Operating Networks (DIJON)

Academy of Finland, Juha Plosila, 2008-2011

Fault-Tolerant Nano-Scale Network-on-Chip Platform: Enabling Technologies and Design Methods

Academy Research Fellow's project. Academy of Finland, Juha Plosila, 2006-2011.

Autonomous Voltage and Clock Frequency Scaling Using Sub-Threshold Operation and Task Sharing (AUTOSUB)

Academy of Finland, Hannu Tenhunen, 2008-2010

Self-Timed Intelligent Communication Structures for Network-on-Chip (STCSN)

Academy of Finland, Pasi Liljeberg, 2007-2009

Ultra Wideband Wireless interconnects (UWI)

Academy of Finland, Hannu Tenhunen, 2007-2009

Low-Power Java Co-Processor with Improved Real Time Performance and Predictability (REAL-JAVA)

Centennial Foundation of the Federation of Finnish Technology Industries, Juha Plosila, 2006-2008

Publications in 2012

Articles in journals (16):

Yasar Amin, Rajeev Kumar Kanth, Pasi Liljeberg, Qiang Chen, Lirong Zheng, Hannu Tenhunen, Green Wideband RFID Tag Antenna for Supply Chain Applications. *IEICE Electronics Express* 9(24), 1861–1866, 2012.

Masoud Daneshtalab, Masoumeh Ebrahimi, Pasi Liljeberg, Juha Plosila, Hannu Tenhunen, Memory-Efficient On-Chip Network with Adaptive Interfaces. *IEEE Transaction on Computer-Aided Design of Integrated Circuits and Systems (IEEE-TCAD)* 31(1), 146–159, 2012.

Masoud Daneshtalab, Maryam Kamali, Masoumeh Ebrahimi, Siamak Mohammadi, Ali Afzali-Kusha, Juha Plosila, Adaptive Input-Output Selection Based On-Chip Router Architecture. *Journal of Low Power Electronics (JOLPE)* 8(1), 11–29, 2012.

Masoumeh Ebrahimi, Masoud Daneshtalab, Pasi Liljeberg, Juha Plosila, Jose Flich, Hannu Tenhunen, Path-based Partitioning Methods for 3D Networks-on-Chip with Minimal Adaptive Routing. *IEEE Transactions on Computers* 99, 1–16, 2012.

Liang Guang, Rajeev Kumar Kanth, Juha Plosila, Hannu Tenhunen, Hierarchical Monitoring in Smart House: Design Scalability, Dependability and Energy-Efficiency. *Communications in Information Science and Management Engineering* 2(11), 46–51, 2012.

Liang Guang, Ethiopia Nigussie, Juha Plosila, Jouni Isoaho, Tenhunen, Hannu, Survey of Self-Adaptive NoCs with Energy-Efficiency and Dependability. *International Journal of Embedded and Real-Time Communication Systems (IJERTCS)* 3(2), 1–22, 2012.

Liang Guang, Ethiopia Nigussie, Juha Plosila, Hannu Tenhunen, Dual Monitoring Communication for Self-Aware Network-on-Chip: Architecture and Case Study. *International Journal of Adaptive, Resilient and Autonomic Systems* 3(3), 73–92, 2012.

Rajeev Kumar Kanth, Pasi Liljeberg, Yasar Amin, Qiang Chen, Lirong Zheng, Hannu Tenhunen, Comparative End-of-Life Study of Polymer and Paper Based Radio Frequency Devices. *International Journal of Environmental Protection* 2(8), 23–27, 2012.

Rajeev Kumar Kanth, Pasi Liljeberg, Hannu Tenhunen, Qiang Chen, Lirong Zheng, Haris Kumar, Study on Glass Epoxy Based Low Cost and Compact Tip-Truncated Triangular Printed Antenna. *International Journal of Antennas and Propagation* 2012(184537), 1–8, 2012.

Rajeev Kumar Kanth, Qiansu Wan, Harish Kuamr, Pasi Liljeberg, Qiang Chen, Lirong Zheng, Hannu Tenhunen, Evaluating Sustainability, Environment Assessment and Toxic Emissions in Life Cycle Stages of Printed Antenna. *Procedia Engineering* 30(1), 508–513, 2012.

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Tuomas Poikela, Juha Plosila, Tomi Westerlund, Jan Buytaert, Michael Campbell, Xavier Llopart, Richard Plackett, Ken Wyllie, Martin van Beuzekom, Vladimir Gromov, Ruud Kluit, Francesco Zappon, Vlad Zivkovic, Architectural Modeling of Pixel Readout Chips Velopix and Timepix3. In: Topical Workshop on Electronics for Particle Physics 2011 (TWEPP-11), 7, 1-7, Journal of Instrumentation, 2012.

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Ph.D. thesis (4):

Guang Liang, *Hierarchical Agent-Based Adaptation for Self-Aware Embedded Computing Systems*. AI osa 452. University of Turku, 2012.

Amir-Mohammad Rahmani, *Exploration and Design of Power-Efficient Networked Many-Core Systems*. TUCS Dissertations 153. University of Turku, 2012.

Ville Rantala, *On Dynamic Monitoring Methods for Networks-on-Chip*. TUCS Dissertations 154. 2012.

Thomas Canhao Xu, *Hardware/Software Co-Design for Multicore Architectures*. TUCS Dissertations 147. University of Turku, 2012.

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 of systems, both traditional ICT systems (mobile, Green-ICT), as well as automation systems for energy production.

The laboratory has strong reserach 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 Computing, and a double-degree with ESIGELEC in Rouen, France.

The laboratory consists of 3 research groups:

Systems and Control Engineering (Lead: Prof. 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: Prof. 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: Doc. Jerker Björkqvist): The communications and signal processing group currently focuses on development and implementation issues for wireless broadband 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.

Research Unit Web Page:

<https://research.it.abo.fi/research/embedded-systems-laboratory>

Leader of the unit

Johan Lilius

Senior Researchers

Jerker Björkqvist and Hannu Toivonen

Researchers

Sebastien Lafond, Kristian Nybom, and Tom Fredman

External Docents

João Miguel Fernandes and Lionel Morel

Projects

AMEBA

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

CLOUD

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

DORADO

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

ENGINES

Enabling Next Generation Networks for broadcast Services, CELTIC, 2010-2012

FCEP

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

RECOMP

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

Publications in 2012

Edited proceedings (2):

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), Abstract Book, Research Reports from Turku University of Applied Sciences 37, Turun ammattikorkeakoulu, 2012.

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), Proceedings, Research reports from Turku University of Applied Sciences 38, Turun ammattikorkeakoulu, 2012.

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Stefan Grönroos, Kristian Nybom, Jerker Björkqvist, Efficient GPU and CPU-Based LDPC Decoders for Long Codewords. *Analog Integrated Circuits and Signal Processing* 73(2), 583–595, 2012.

Articles in proceedings (9):

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Johan Ersfolk, Ghislain Roquier, Johan Lilius, Marco Mattavelli, Scheduling of Dynamic Dataflow Programs Based on State Space Analysis. In: *Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing*, 1661–1664, IEEE, 2012.

Mohammad Fattah, Masoud Daneshtalab, Pasi Liljeberg, Juha Plosila, Transport Layer Aware Design of Network Interface in Many-Core Systems. In: *Reconfigurable Communication-centric Systems-on-Chip (ReCoSoC), 2012 7th International Workshop on Reconfigurable and Communication-Centric Systems-on-Chip*, 1–7, IEEE, 2012.

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Haitham Habli, Johan Ersfolk, Johan Lilius, Tomi Westerlund, Jari Nurmi, Optimizing Off-Chip Memory Access Costs in Low Power MPEG-4 Decoder. In: *Proceedings of the 3rd International Conference on Information and Communication Systems, ICICS '12*, 17:1–17:5, ACM, 2012.

Fareed Ahmed Jokhio, Tewodros Deneke, Sébastien Lafond, Johan Lilius, Bit Rate Reduction Video Transcoding with Distributed Computing. In: Stotzka Rainer, Schiffers Michael, Cotronis Yiannis (Eds.), Proceedings of the 20th Euromicro International Conference on Parallel, Distributed and Network-Based Computing, 206 – 212, IEEE Computer society, 2012.

Sébastien Lafond, Cecilia Brunel, Double Master Degree Programme: Enhancing Multicultural Engineering and Mobility between France and Finland. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), International Conference on Engineering Education 2012 - Proceedings, Research reports, 570–576, Turun Ammattikorkeakoulu, 2012.

Kristian Nybom, Stefan Grönroos, Jerker Björkqvist, Field Measurement Based SVC Performance Analysis Over DVB-T2 Lite . In: Yves Lostanlen, Charles Yaacoub (Eds.), 2012 19th International Conference on Telecommunications (ICT), 1–6, IEEE, 2012.

M. Mohsin Saleemi, Natalia Díaz Rodríguez, Johan Lilius, Towards Ontology-Driven Development of Ubiquitous and Intelligent interactive TV Applications. In: Stephen S. Yau, Witold Pedrycz, Vincenzo Piuri (Eds.), The 10th IEEE International Conference on Pervasive, Intelligence and Computing (PiCom 2012), 1–8, IEEE, 2012.

Chapters in edited books (3):

David Gomez-Barquero, Peter Unger, Karim Nasr, Jussi Poikonen, Kristian Nybom, Hybrid Cellular and Broadcasting Networks. In: Roberto Verdone, Alberto Zanella (Eds.), Pervasive Mobile and Ambient Wireless Communications, 547–576, Springer, 2012.

Janne Roslöf, Jerker Björkqvist, Seppo Virtanen, Supporting student innovation through project-based learning and industry co-operation. In: Win Aung, Vojislav Ilic, Olli Mertanen, Jerzy Moscinski, James Uhomobhi (Eds.), Innovations 2012: World Innovations in Engineering Education and Research, iNEER Innovations 2012, 207–215, iNEER (International Network For Engineering Education and Research), 2012.

M. Mohsin Saleemi, Natalia Díaz Rodríguez, Espen Suenson, Johan Lilius, Ivan Porres, Ontology Driven Smart Space Application Development. In: Salvatore F. Pileggi, Carlos Fernandez-Llatas (Eds.), Semantic Interoperability: Issues, Solutions, and Challenges, 101–125., 1–25, River Publishers, 2012.

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.

A few highlights of year 2012. The center organized the second RuFiDiM symposium (Russian Finnish Symposium in Discrete Mathematics) attended by around 70 scientists in more than 10 countries. There will be a special issue of Fundamenta Informaticae devoted to the meeting. Also the international CSR

congress (Computer Science in Russia) was chaired by a member of FUNDIM, and a special issue of Theory of Computing Systems will be published. As a constant international activity we recall that the members of the center serve in editorial boards of altogether 18 international journals.

One of visible activities of the center has few special distinguished lectures. In 2012 there were three such FiDiPro lectures given by Neil Hindman, Teturo Kamae and Aldo de Luca, and one TUCS research programme lecture given by Yuri Matiyasevich.

The center received very good evaluations in the recent centre of excellence competitions: it was placed to top 5% internationally by both reviewers and even in top 1% by one reviewer on the central topics of the centre.

In 2012 the centre produced two Ph.D's, Aleksi Saarela and Mikko Pelto.

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

Coding Theory Group

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

Discrete Complex Systems

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

FiDiPro group

Leaders: Luca Zamboni
Researchers: Michelangelo Bucci, Alessandro De Luca, and 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

Research grant (Camilla Hollanti)

2009-2012, from the Academy of Finland 443.000 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)

2012 Finnish Academy of Sciences (Väisälä Foundation)

2013 Finnish Academy of Sciences (Väisälä Foundation)

Publications in 2012

Edited special issues of journals (3):

Giorgio Ausiello, Hendrik Jan Hoogeboom, Juhani Karhumäki, Ion Petre, Arto Salomaa (Eds.), *Magic in Science. Theoretical Computer Science* 429, 2012.

Jarkko Kari, Ion Petre (Eds.), *Special Issue on Unconventional Computing. Natural Computing* 11(4), 2012.

Grzegorz Rozenberg, Arto Salomaa (Eds.), *Formal and Natural Computing. Theoretical Computer Science* 454C, 2012.

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TUCS Lecture Notes (1):

Vesa Halava, Juhani Karhumäki, Yuri Matiyasevich (Eds.), *RuFiDiM II, Proceedings of the Second Russian Finnish Symposium on Discrete Mathematics 2012, TUCS Lecture Notes*, 2012.

Ph.D. thesis (2):

Mikko Pelto, *On Identifying and Locating-Dominating Codes in the Infinite King Grid. TUCS Dissertations 155*. 2012.

Aleksi Saarela, *Word Equations and Related Topics: Independence, Decidability and Characterizations. TUCS Dissertations 145*. University of Turku, 2012.

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Anna Frid, Svetlana Puzynina, Luca Q. Zamboni, *On Minimal Factorizations of Words as Products of Palindromes. TUCS Technical Reports 1063*, 2012.

Vesa Halava, Tero Harju, *Word Problem for Deterministic and Reversible Semi-Thue Systems. TUCS Technical Reports 1044, TUCS*, 2012.

Vesa Halava, Tero Harju, *New Proof for the Undecidability of the Circular PCP. TUCS Technical Reports 1059, TUCS*, 2012.

Artur Jez, Alexander Okhotin, *Unambiguous Conjunctive Grammars Over a One-Letter Alphabet. TUCS Technical Reports 1043, Turku Centre for Computer Science*, 2012.

Michal Kunc, Alexander Okhotin, *Making Graph-Walking Automata Reversible. TUCS Technical Reports 1042, Turku Centre for Computer Science*, 2012.

Alexander Okhotin, Mikhail Barash, *Defining Contexts in Context-Free Grammars. TUCS Technical Reports 1025, Turku Centre for Computer Science*, 2012.

Svetlana Puzynina, Luca Q. Zamboni, *Abelian Returns in Sturmian Words. TUCS Technical Reports 1046, TUCS*, 2012.

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 [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.

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.

Partnerships

IAMSR is 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). 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 Robert Fullér (FiDiPro through 2012) is a key resource for the research work in soft computing. He and his research group at Obuda University in Budapest continue their cooperation with IAMSR. 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. Professor Harry Bouwman, Delft University of Technology, is a FiDiPro (with Tekes-funding) 2011-2015 and works at IAMSR with the Mobile Value Services research group (headed by Prof Pirkko Walden); his work in mobile services research has gained international recognition for systematic studies and new results on mobile services.

IAMSR graduated three doctoral students in 2012 (Shahrokh Nikou, Alessandro Buoni and Siw Lundqvist) which was the same as in 2011 (Matteo Brunelli (now at Aalto), Yong Liu and Jozsef Mezei).

Leader of the unit

Christer Carlsson

Co-leader of the unit

Pirkko Walden

Senior Researchers

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

Researchers

Kaj-Mikael Björk, Markku Heikkilä, Yong Liu, Jozsef Mezei, Shahrokh Nikou, Anna Sell, and Franck Tétard

Doctoral Students

Hans Allmér, Niklas Eriksson, Eyal Eshet, Jaana Kallio-Gerlander, Karri Hautanen, John Jeansson, Jani Kinnunen, Sonja Leskinen, Mohammad Nazrul, Hjalte Nerdrum, Henrik Nyman, Peter Strandvik, Mikael Råberg, Guopeng Yu, Xiaolu Wang, and Magnus Westerlund

Projects

FiDiPro

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

DYSCOTEC

Tekes, 2011-2012

D2I

Tekes SHOK, 2012

Redevelop

Tekes -2011

ICT CompEdge

EU Regional -2011

Quadruple

EU Baltic -2011

eBerea

Marie Curie 2011-13

Publications in 2012

Edited proceedings (4):

Mihai Constantinescu, Ertan Onur, Harry Bouwman, Mark de Reuver, Yunus Durmus (Eds.), Cooperative Networks: The Mobile Tethering Game, ACM, 2012.

Mark de Reuver, Harry Bouwman (Eds.), Smartphone Measurement: Do People Use Mobile Applications Like They Think They Do?, AIS electronic library, 2012.

Jacco Schoonewille, Harry Bouwman (Eds.), Contextual Aspects in Enterprise Integration, IEEE, 2012.

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Articles in journals (11):

Harry Bouwman, Christer Carlsson, Carolina López-Nicolás, Bob McKenna, Francisco Molina-Castillo, Tuure Tuunanen, Pirkko Walden, Mobile Travel Services - The Effect of Moderating Context Factors. *Journal of Information Technology and Tourism* 13(2), 57–74 , 2012.

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Christer Carlsson, Matteo Brunelli, József Mezei, Decision Making with a Fuzzy Ontology. *Soft Computing* 16(7), 1143–1152, 2012.

Eyal Eshet, Human-Centered Design in Mobile Application Development: Emerging Methods. *International Journal of Mobile Human Computer Interaction* 4(4), 1–21, 2012.

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Anna Sell, Mark de Reuver, Pirkko Wlden, Christer Carlsson, Context, Gender and Intended Use of Mobile Messaging, Entertainment and Social Media Services. *International Journal of Systems and Service-Oriented Engineering (IJSSOE)* 3(1), 1–15, 2012.

Sam Solamani, Harry Bouwman, A Framework for the Alignment of Business Model and Business Processes: A Generic Model for Trans-Sector Innovation. *Business Process Management Journal* 18(4), 655–679, 2012.

Articles in proceedings (14):

Mark de Reuver, Harry Bouwman, Schalk Stalman, Mobile TV: The Search for a Holy Grail that isn't. Lisboa: Euro TV. In: Manuel José Damásio, Gustavo Cardoso (Eds.), *Proceedings of the 9th European Interactive TV Conference*, 185-193, EuroITV'11, 2012.

Muhammad Nazrul Islam, Towards Designing Users' Intuitive Web Interface. In: Barolli, Leonard, Xhafa, Fatos, Vitabile, Salvatore, Uehara, Minoru (Eds.), *6th International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS 2012)*, 513 – 518, IEEE Computer Society, 2012.

Muhammad Nazrul Islam, Semiotics Perception in Designing Users' Intuitive Web Interface: A Study on Web Sign Redesign. In: Mitsuru Minakuchi, Hidehiko Okada, Yu Suzuki, Linmi Tao (Eds.), *The 10th Asia Pacific Conference on Computer Human Interaction (APCHI 2012)*, 757–758, APCHI, 2012.

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Sonja Leskinen, Veterinarian Work, Enhanced by Mobile Technology—An Empirical Study. In: Ralph H. Jr. Sprague (Ed.), 2012 45th Hawaii International Conference on System Sciences, 1403-1412, Conference Publishing Services (CPS), 2012.

Sonja Leskinen, Veterinarians' Attitudes Towards Digital Technology: An Empirical Study. In: Machteld Dr. van Dierendonck, Patricia Drs. de Cocq, Kathalijne Dr. Visser (Eds.), 7th International Equitation Science Conference. Equitation Science: principles and practices - science at work, 44, Wageningen Academic Publishers, 2012.

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Shahrokh Nikou, Harry Bouwman, Mark de Reuver, Mobile Converged Rich Communication Services: A Conjoint Analysis. In: Roy Sterritt (Ed.), 2012 45th Hawaii International Conference on System Sciences, 1353-1362, IEEE Computer Society, 2012.

Shahrokh Nikou, Jie Guo, Harry Bouwman, Mobile Social Network Services: Chinese Users' Adoption Patterns. In: Proceedings 11th ICMB 2012, 217–228, TuDelft, 2012.

Henrik J. Nyman, An Exploratory Study of Supply Chain Management IT Solutions. In: Lisa O'Conner (Ed.), Proceedings of the 45th Annual Hawaii International Conference on System Sciences, 4747–4756, IEEE Computer Society, 2012.

Henrik J. Nyman, Piia Hirkman, On the Nature of Supply Chain Management Projects and how to Manage Them. In: J. Pries-Heje, M. Chiasson (Eds.), ECIS 2012 Proceedings, 1–12, AISel, 2012.

Anna Sell, Pirkko Walden, Segmentation Bases in the Mobile Services Market: Attitudes In, Demographics Out. In: Ralph H. Jr. Sprague (Ed.), Proceedings of the 45th Annual Hawaii International Conference on System Sciences (CD-ROM), 10 pages, IEEE Computer Society Press, 2012.

Anna Sell, Pirkko Walden, Christer Carlsson, I am a Smart Phone User - Key Insights from the Finnish Market. In: Harry Bouwman, Virpi Tuunainen (Eds.), Proceedings of the ICMB 2012, 265–276, IEEE Computer Society, 2012.

Chapters in edited books (1):

Muhammad Nazrul Islam, Semiotics Perception towards Designing Users' Intuitive Web User Interface: A Study on Interface Signs. In: Hakikur Rahman, Anabela Mesquita, Isabel Ramos, Barbara Pernici (Eds.), Knowledge and Technologies in Innovative Information Systems, Lecture Notes in Business Information Processing (LNBIP) 129, 139–155, Springer Verlag, 2012.

Ph.D. thesis (2):

Alessandro Buoni, Fraud Detection in the Banking Sector: A Multi-Agent Approach. TUCS Dissertations 150. 2012.

Shahrokh Nikou, Opening the Black-Box of IT Artifacts: Looking into Mobile Service Characteristics and Individual Perception. TUCS Dissertations 149. 2012.

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 develop 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 specifically 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 and Back 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 Rönqvist, and Lars Wingård

Projects

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

(EU Central Baltic project, 2011-2013)

Improving mathematics and programming education [Imped 2]

(Finnish Technology Industry Foundation 2009-2010)

Improving mathematics and programming education [Imped 1]

(Finnish Technology Industry Foundation 2007-2008)

Opetusteknologia koulun arjessa [Optek]

(Tekes 2009-2011)

Teachers education courses in structured derivations

(National Board of Education 2008 - 2010)

Centre of Excellence in Formal Methods [CREST]

(Academy of Finland, 2002 - 2007)

Publications in 2012

Edited proceedings (2):

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *Abstract Book, Research Reports from Turku University of Applied Sciences 37*, Turun ammattikorkeakoulu, 2012.

Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *Proceedings, Research reports from Turku University of Applied Sciences 38*, Turun ammattikorkeakoulu, 2012.

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 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 Pages:

<https://research.it.abo.fi/research/high-performance-computing>

<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 Asp nas, 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 in 2012

Articles in journals (2):

Espen Suenson, Method and Fieldwork in a Hermeneutical Perspective. RMN Newsletter 4, 23–31, 2012.

Ville Timonen, Low-Complexity Intervisibility in Height Fields. Computer Graphics Forum 31(8), 15, 2012.

Articles in proceedings (8):

Fredrik Abbors, Tanwir Ahmad, Dragos Truscan, Ivan Porres, MBPeT – A Model-Based Performance Testing Tool. In: Amir Alimohammad, Petre Dini

(Eds.), 4th International Conference on Advances in System Testing and Validation Lifecycle, 1–8, IARIA, 2012.

Adnan Ashraf, Cost-Efficient Resource Allocation for Multi-tier Web Applications in a Cloud Environment. In: Erwin Grosspietsch, Konrad Klöckner (Eds.), Work in Progress Session held in connection with the 38th EUROMICRO Conference on Software Engineering and Advanced Applications, 1–2, Institute for Systems Engineering and Automation, Johannes Kepler University Linz, Austria, 2012.

Adnan Ashraf, Benjamin Byholm, Joonas Lehtinen, Ivan Porres, Feedback Control Algorithms to Deploy and Scale Multiple Web Applications per Virtual Machine. In: Vittorio Cortellessa, Henry Muccini, Onur Demirors (Eds.), 38th Euromicro Conference on Software Engineering and Advanced Applications, 431–438, IEEE Computer Society, 2012.

Adnan Ashraf, Benjamin Byholm, Ivan Porres, A Session-Based Adaptive Admission Control Approach for Virtualized Application Servers. In: Carlos Varela, Manish Parashar (Eds.), The 5th IEEE/ACM International Conference on Utility and Cloud Computing, 65–72, IEEE Computer Society, 2012.

Adnan Ashraf, Benjamin Byholm, Ivan Porres, CRAMP: Cost-Efficient Resource Allocation for Multiple Web Applications with Proactive Scaling. In: Tomasz Wiktor Wlodarczyk, Ching-Hsien Hsu, Wu-chun Feng (Eds.), 4th IEEE International Conference on Cloud Computing Technology and Science (CloudCom), 581–586, IEEE Computer Society, 2012.

Jerker Björkqvist, Luigia Petre, Karl Rönholm, Dragos Truscan, Integrating Innovation Activities in a Master Level Capstone Project Course. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), International Conference on Engineering Education, Research Reports 38, 1065–1072, Turku University of Applied Sciences, 2012.

Jeanette Heidenberg, Max Weijola, Kirsi Mikkonen, Ivan Porres, A Model for Business Value in Large-Scale Agile and Lean Software Development. In: Dietmar Winkler, Rory V. O’Connor, Messnarz Richard (Eds.), Systems, Software and Services Process Improvement, Communications in Computer and Information Science 301, 49–60, Springer, 2012.

Irum Rauf, Ali Hanzala Khan, Ivan Porres, Analyzing Consistency of Behavioral REST Web Service Interfaces. In: Josep Silva, Francesco Tiezzi (Eds.), The 8th International Workshop on Automated Specification and Verification of Web Systems, 1–15, Electronic Proceedings in Theoretical Computer Science (EPTCS). , 2012.

Chapters in edited books (1):

M. Mohsin Saleemi, Natalia Díaz Rodríguez, Espen Suenson, Johan Lilius, Ivan Porres, Ontology Driven Smart Space Application Development. In: Salvatore F. Pileggi, Carlos Fernandez-Llatas (Eds.), Semantic Interoperability: Issues, Solutions, and Challenges, 101–125., 1–25, River Publishers, 2012.

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, parallel 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

Projects

Invariant based programming

(Academy of Finland 2009-2012)

Automatics checking of structured derivations

(Technology Industry Foundation, 2010-2012)

Biologically guided nanoparticles – targeting, safety and imaging technology [Biotarget]

(Academy of Finland 2007-2010)

Centre of Excellence in Formal Methods of Programming [CREST]

(Academy of Finland 2002-2007)

Tools for reliable software construction [Tores II]

(Tekes 2005-2007)

Tools for reliable software construction [Tores I]

(Tekes 2002-2004)

Software platform construction using Stepwise feature introduction [Sprout]

(Academy of Finland 2001-2003)

Software construction site [Socos]

(Academy of Finland 2000-2002)

Publications in 2012

Articles in journals (1):

Viorel Preoteasa, Ralph-Johan Back, Invariant Diagrams with Data Refinement. Formal Aspects of Computing 24(1), 67-95, 2012.

Technical reports (2):

Mikołaj Olszewski, Ralph-Johan Back, Scrum-Based Agile Development with Stepwise Feature Introduction. TUCS Technical Reports 1045, TUCS, 2012.

Viorel Preoteasa, Ralph-Johan Back, Johannes Eriksson, Verification and Code Generation for Invarian Diagrams in Isabelle. TUCS Technical Reports 1058, TUCS, 2012.

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/>

MOTH

Moving threads realization study (led by Ville Leppänen), 2009-2011, funded by the Academy of Finland.

Web page: <http://staff.cs.utu.fi/research/MOTH/>

Game Tech & Arts Lab

(led by Jouni Smed), 2009-2011, funded by Teknologiateollisuuden 100-vuotissäätiö.

Web page: <http://www.gametecharts.fi/en/>

SaaS in Finland

("SaaS suomalaisessa liiketoiminnassa"; led by Antero Järvi), 2010-2011, funded by VERSO program of Tekes.

Web page: <http://soft.utu.fi/saas/>

Publications in 2012

Articles in journals (2):

Risto Honkanen, Ville Leppänen, Routing in Coloured Sparse Optical Tori by Using Balanced WDM and Network Sparseness. *International Journal of Distributed Systems and Technologies* 3(4), 52–62, 2012.

Ville Leppänen, Jari-Matti Mäkelä, Security Monitors for Java Programs with MPL. *International Journal on Information Technologies and Security* 4(1), 35–50, 2012.

Articles in proceedings (11):

Martti Forsell, Ville Leppänen, An Extended PRAM-NUMA Model of Computation for TCF Programming. In: Behrooz Shirazi, Alexey Lastovetsky (Eds.), *IEEE 26th International Parallel and Distributed Processing Symposium Workshops & PhD Forum*, 786–793, IEEE Computer Society, 2012.

Anita Gajurel, Jarno Kankaanranta, Arho Suominen, Analyzing Mobile Phone Use: The Adoption of Technologies and Services by Young People. In: *The 21st International Conference on Management of Technology (IAMOT 2012)*, 1–12, International Association for Management of Technology, 2012.

Aki Halonen, Sami Hyrynsalmi, Kai K. Kimppa, Timo Knuutila, Jouni Smed, Harri Hakonen, Towards Usability Heuristics for Games Utilizing Speech Recognition. In: Mitsuyuki Inaba, Koichi Hosoi, Ruck Thawonmas, Akinori Nakamura, Masayuki Uemura (Eds.), *4th Asian Conference on Simulation and AI in Computer Games & 4th Asian Simulation Technology Conference*, 65–69, Eurosis-ETI, 2012.

Risto Honkanen, Ville Leppänen, Work-Optimal Two-Phase Routing in a Sparse Optical Torus. In: Boris Rachev, Angel Smrikarov (Eds.), *Proceedings of the 13th International Conference on Computer Systems and Technologies*, ACM ICPS 630, 30–36, ACM, 2012.

Sami Hyrynsalmi, Tuomas Mäkilä, Antero Järvi, Arho Suominen, Marko Seppänen, Timo Knuutila, App Store, Marketplace, Play! An Analysis of Multi-Homing in Mobile Software Ecosystems. In: Slinger Jansen, Jan Bosch, Carina Alves (Eds.), *Proceedings of the Fourth International Workshops on Software Ecosystems*, CEUR Workshop Proceedings 879, 59–72, CEUR-WS, 2012.

Sami Hyrynsalmi, Arho Suominen, Tuomas Mäkilä, Antero Järvi, Timo Knuutila, Revenue Models of Application Developers in Android Market Ecosystem. In: Michael Cusumano, Bala Iyer, N. Venkatraman (Eds.), *ICSOB 2012*, LNBIP 114, 209–222, Springer, Heidelberg, 2012.

Sami Hyrynsalmi, Arho Suominen, Tuomas Mäkilä, Timo Knuutila, The Emerging Mobile Ecosystems: An Introductory Analysis of Android Market. In:

The 21st International Conference on Management of Technology (IAMOT 2012), 1–16, International Association for Management of Technology, 2012.

Jari-Matti Mäkelä, Erik Hansson, Daniel Åkeson, Martti Forsell, Christoph Kessler, Ville Leppänen, Design of the Language Replica for Hybrid PRAM- NUMA Many-Core Architectures. In: Bob Werner (Ed.), 10th IEEE International Symposium on Parallel and Distributed Processing with Applications, ISPA 2012, 697–704, IEEE, 2012.

Jari-Matti Mäkelä, Ville Leppänen, Martti Forsell, Preliminary Analysis of Feasible Benchmark Problems for the Hybrid PRAM/NUMA REPLICIA Architecture. In: Boris Rachev, Angel Smrikarov (Eds.), Proceedings of the 13th International Conference on Computer Systems and Technologies, ACM ICPS 630, 37–44, ACM, 2012.

Sampsa Rauti, Ville Leppänen, Browser Extension-Based Man-in-the-Browser Attacks Against Ajax Applications with Countermeasures. In: Boris Rachev, Angel Smrikarov (Eds.), Proceedings of the 13th International Conference on Computer Systems and Technologies, 251–258, ACM Press, 2012.

Sampsa Rauti, Ville Leppänen, Man-in-the-browser -hyökkäyksistä Ajax-sovelluksissa. In: Sasu Tarkoma, Joni-Kristian Kämäräinen, Tapio Pahikkala (Eds.), Proceedings of Federated Computer Science Event 2012, 58–59, University of Helsinki, 2012.

Chapters in edited books (2):

Aki Halonen, Sami Hyrynsalmi, Jouni Smed, Puheentunnistusteknologian nykytilanne ja mahdollisuudet elektronisissa peleissä. In: Jaakko Suominen, Raine Koskimaa, Frans Mäyrä, Riikka Turtiainen (Eds.), Pelitutkimuksen vuosikirja 2012, 92–98, Tampereen yliopisto, 2012.

Jussi Laasonen, Jouni Smed, Co-ordinating Formations: A Comparison of Methods. In: Ashok Kumar, Jim Etheredge, Aaron Boudreaux (Eds.), Algorithmic and Architectural Gaming Design: Implementation and Development, 1–22, IGI Global, 2012.

Ph.D. thesis (1):

Tuomas Mäkilä, Software Development Process Modeling – Developers Perspective to Contemporary Modeling Techniques. TUCS Dissertations 148. 2012.

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 in 2012

Articles in journals (6):

Emelichev Vladimir, Karelkina Olga, Kuzmin Kirill, Qualitative Stability Analysis of Multicriteria Combinatorial Minimin Problems. *Control and Cybernetics* 1, 57–79, 2012.

Vladimir Emelichev, Volha Karelkina, Postoptimal Analysis of the Multicriteria Combinatorial Median Location Problem. *Optimization* 61(9), 1151–1167, 2012.

Mäkelä Marko, Nikulin Yury, Mezei Jozsef, Generalizing Trade-Off Directions in Multiobjective Optimization. *Control and Cybernetics* 3, 561–576, 2012.

Marko Mäkelä, Yury Nikulin, Jozsef Mezei, A Note on Extended Characterization of Generalized Trade-Off Directions in Multiobjective Optimization. *Journal of Convex Analysis* 19, 91–111, 2012.

Yury Nikulin, Kaisa Miettinen, Marko Mäkelä, A New Achievement Scalarizing Function Based on Parameterization in Multiobjective Optimization. *OR Spectrum* 34, 69–87, 2012.

Yury Nikulin, Zuhair Iftikhar, A Note on Different Modelling Approaches for the Robust Shortest Path Problem. *International Journal of Mathematical Modelling and Numerical Optimisation* 3(3), 141–157, 2012.

Technical reports (7):

Vladimir Emelichev, Vladimir Korotkov, Yury Nikulin, On a Multicriteria Investment Problem with Wald's Maximin Criteria – Stability Analysis of Pareto-Optimal Portfolio in the Hölder Metric. TUCS Technical Reports 1050, TUCS, 2012.

Ville-Pekka Eronen, Marko M. Mäkelä, Tapio Westerlund, Nonsmooth Extended Cutting Plane Method for Generally Convex MINLP Problems. TUCS Technical Reports 1055, TUCS, 2012.

Sami Hokuni, Kaisa Joki, Sari Yli-Sipilä, Marko M. Mäkelä, Yury Nikulin, Minimum Spanning Tree Problem with Fuzzy Intervals. TUCS Technical Reports 1048, TUCS, 2012.

Olga Karelkina, An Interactive Approach to Solve Multicriteria Median Location Problem. TUCS Technical Reports 1053, TUCS, 2012.

Marko M. Mäkelä, Ville-Pekka Eronen, Napsu Karmitsa, On Nonsmooth Optimality Conditions with Generalized Convexities. TUCS Technical Reports 1056, TUCS, 2012.

Seppo Pulkkinen, Marko M. Mäkelä, Napsu Karmitsa, Integral Transformation for Box-Constrained Global Optimization of Decomposable Functions. TUCS Technical Reports 1036, Turku Centre for Computer Science, 2012.

Seppo Pulkkinen, Marko M. Mäkelä, Napsu Karmitsa, A Generalized Trust Region Newton Method Applied to Noise Reduction. TUCS Technical Reports 1061, TUCS, 2012.

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, Honxiu 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, Jari 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 Kaaarina, Lieto, Naantali, Painio, 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 cosortium.

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 in 2012

Monographs (1):

Ritesh Serene, Eija Koskivaara, Turku Taking Steps Towards Future: Technology Supports Physical Activity. Lampert Academic Publishing, 2012.

Articles in journals (4):

Feng Hu, Yong Liu, Hongxiu Li, Bei Xiao, Modeling Consumers' Acceptance of Tuangou in China. *International Journal of Digital Content Technology & its Application* 6(4), 9–14, 2012.

A.K.M. Najmul Islam, The Role of Perceived System Quality as Educators' Motivation to Continue E-learning System Use. *AIS Transaction of Human-Computer Interaction* 4(1), 25-43, 2012.

Reima Suomi, Telework in Finland. *Journal of Japan Telework Society* 1+(1), 44–47, 2012.

Bo Yang, Ying Liu, Tingting Lin, Operational Capabilities Redeployment in Information Technology Outsourcing: from Chinese Vendor's Perspective. *International Journal of Information Processing and Management* 3(2), 98–105, 2012.

Articles in proceedings (12):

Eija Koskivaara, Leena Haanpää, Harri Helajärvi, Raija Laukkanen, Olli J. Heinonen, How Many Steps – Do They Count? Experiments on Pedometer Use. In: Karl-Heinz Krempels, José Cordeiro (Eds.), *8th International Conference on Web Information Systems and Technologies*, ISBN: 978-989-8565-08-2, 1–4, SciTePress – Science and Technology Publications, 2012.

Hongxiu Li, Yong Liu, Predicting and Explaining Use Intention and Purchasing Intention in Online Group Shopping. In: U. Lechner, D. Wigand, A Pucihar (Eds.), *eDependability: Reliable and Trustworthy eStructure, eProdeses, eOperations and eServices for the Future*, 1–9, AIS eL, 2012.

Hongxiu Li, Yong Liu, Reima Suomi, Exploring the Different Roles of Service Quality, Satisfaction and Perceived Usefulness in Generating WOM in E-Service Context. In: Wilfred V. Huang (Ed.), *proceedings of the 11th Wuhan International Conference on E-business*, 1–10, AIS eL, 2012.

Yong Liu, Yongqing Yang, Hongxiu Li, A Unified Risk-Benefit Analysis Framework for Investigating Mobile Payment Adoption. In: Harry Bouwman (Ed.), *11th International Conference on Mobile Business*, 1–12, AIS eL, 2012.

Neeraj Sachdeva, Socio-Psychological Barriers in Assistive Technology Adoption for Totally Blind People. In: Neeraj Sachdeva, Honxiu Li (Eds.), *Well-Being in the Information Society*, 145–158, Springer, 2012.

Joni Salminen, Jose Teixeira, Critical Assessment of Value Propositions and Marketing of Technology Startups: Evidence from Finland. In: Bostjan Antoncic (Ed.), *Proceedings of the ABSRC 2012 (Venice)*, 89–101, Edukator, 2012.

Olli Sjöblom, Juho Heimonen, Lotta Kauhanen, Veronika Laippala, Heljä Lundgrén-Laine, Laura-Maria Murtola, Tapio Salakoski, Sanna Salanterä, Avoiding Hazards - What Can Health Care Learn from Aviation?. In: Kristina Eriksson-Backa, Annika Luoma, Erica Krook (Eds.), *Exploring the Abyss of Inequalities - Proceedings of the 4th International Conference on Well-Being in the Information Society, Communications in Computer and Information Science* 313, 119–127, Springer, 2012.

Kimmo Tarkkanen, Variation of Work Practices in Technology-Mediated Environment—Knowledge Work Activity Framework Perspective. In: Ralph H. Jr. Sprague (Ed.), *Proceedings of the 45th Annual Hawaii International Conference on System Sciences (CD-ROM)*, 3837-3846, IEEE Computer Society, 2012.

Jose Teixeira, Steering an Open-Source Platform-Based Strategy in a Hybrid Corporation. Enhancing R&D or Organizational Conflicts?. In: D. Bazylevych, O.

Lutyi, O. Starostina, N. Butenko (Eds.), *Proceedings of Shevchenkivska Vesna 2012: Economics*, 98–104, Taras Shevchenko National University of Kyiv, 2012.

Jose Teixeira, *Open-Source Technologies Realizing Social Networks: A Multiple Descriptive Case-Study*. In: I. Hammouda, B. Lundell, T. Mikkonen, W. Scacchi (Eds.), *8th IFIP WG 2.13 International Conference, OSS 2012*, Hammamet, Tunisia, September 10-13, 2012, *Proceedings, IFIP Advances in Information and Communication Technology 378/2012*, 250–255, Springer, 2012.

Jose Teixeira, Joni Salminen, *Open-Source as Enabler of Entrepreneurship Ambitions Among Engineering Students – A Study Involving 20 Finnish Startups*. In: Jerker Björkqvist, Mikko-Jussi Laakso, Janne Roslöf, Raija Tuohi, Seppo Virtanen (Eds.), *International Conference on Engineering Education 2012 – Proceedings, Research reports 38*, 623–629, Turku University of Applied Sciences, 2012.

Bo Yang, Tingting Lin, *IT and IS Outsourcing Research in International and Chinese Academia: A Comparative Literature Review*. In: Gabriel Ogunmokun, Rony Gabbay, Janelle Rose (Eds.), *Managing, Marketing and Financing Organizations in an Era of Economic Uncertainty*, 512–523, The Academy of World Business, Marketing, and Management Development, 2012.

TUCS Lecture Notes (1):

Studies on Inequalities in Information Society – Proceedings of the Conference, Well-Being in the Information Society. WIS 2012, TUCS Lecture Notes, 2012.

5. Education at TUCS

5.1 TUCS Graduate Programme

TUCS Graduate Programme offers a framework for studying for the doctoral (Ph.D.) degree in Computer Science, Mathematics, Information Systems, Computer Engineering, Communication Systems, and Microelectronics. It truly is an international hot-spot for the latest developments in ICT. Study time for a full-time student is expected to be four years. The Graduate Programme provides additional instruments and training for preparedness of our students for challenges in working life, like mentorship and internship programmes and MBA programme.

There are presently about 100 students at TUCS Graduate Programme. As the programme is open for students from everywhere and almost half of the students come from abroad, the environment of TUCS Graduate Programme is highly international. There are no tuition fees at Finnish universities at the moment. Doctoral students are entitled, but not obliged, to join the Student Union of their university, and this involves a minor annual fee.

Each student who is accepted to the TUCS Graduate Programme is placed in one of the TUCS research units and is assigned a personal supervisor, typically a professor. The students are expected to take advanced level courses from at least two of the TUCS main research areas. 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 Graduate Programme provides active exchange programmes with other leading European research groups.

The TUCS staff and directors met with the new TUCS GP students in an annual information meeting on Thursday, 4.10.2012. The TUCS staff and directors introduced themselves and explained some of the practical issues concerning the Ph.D. studies, benefits and duties related to the graduate programme, traveling instruction, TUCS Publication Series, and so on. Also the new students introduced themselves shortly.

5.1.1 TUCS Student Toolkit

Turku Centre for Computer Science (TUCS) hosted a two-day course on practical aspects of research and the academic vs. enterprise R&D (25.5. & 1.6.2012). "TUCS PhD Student Toolkit" is a graduate course targeted for doctoral students and researchers. The aim of the course is to provide an intensive information package for successful PhD studies, research funding possibilities, innovation processes, communication skills and R&D activities in both academia and business environment. The course language was English.

5.1.2 TUCS Short Courses

TUCS short course by Teturo Kamae

Dr. Teturo Kamae gave a TUCS short course consisting of three lectures: "Maximal pattern complexity applied to pattern recognition problems" (23.5), "Uniform sets and uniform complexity" (24.5), "Characterizations of super-

stationary sets" (29.5). He also gave a Fidipro distinguished lecture on "Superstationary structure of dynamical systems" (30.5). All these events took place at Department of Mathematics, University of Turku.

Partition Regularity of Matrices

Neil Hindman (Howard University, Washington D.C.) gave a short course and a distinguished lecture in Turku in March 2012 on Ramsyan type theorems.

Project management theories and tools applied to ICT

Prof. Andrea Molinari (University of Trento), 16.-20.4.2012

Multicriteria Decision modeling in Problem Solving

Prof. Mario Fedrizzi (University of Trento), 2.-14.5.2012

5.1.3 Cooperation networks

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 entrepreneurial 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 capacity. 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.

INFORTE

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.

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 business/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 demonstration cases, etc.

TUCS GP students had the possibility to apply to attend the programme. The programme took place in Porto, Portugal on 30.1.-18.2.2012.

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.

5.2 TUCS Ph.D. defences

Aleksi Saarela

Word Equations and Related Topics: Independence, Decidability and Characterizations

University of Turku, Department of Mathematics and Statistics

Opponent: Dominique Perrin, Laboratoire d'informatique Gaspard-Monge, France.

Supervisor: Juhani Karhumäki

The three main topics of this work are independent systems and chains of word equations, parametric solutions of word equations on three unknowns, and unique decipherability in the monoid of regular languages.

The most important result about independent systems is a new method giving an upper bound for their sizes in the case of three unknowns. The bound depends on the length of the shortest equation. This result has generalizations for decreasing chains and for more than three unknowns. The method also leads to shorter proofs and generalizations of some old results.

Hmelevksii's theorem states that every word equation on three unknowns has a parametric solution. We give a significantly simplified proof for this theorem. As a new result we estimate the lengths of parametric solutions and get a bound for the length of the minimal nontrivial solution and for the complexity of deciding whether such a solution exists.

The unique decipherability problem asks whether given elements of some monoid form a code, that is, whether they satisfy a nontrivial equation. We give characterizations for when a collection of unary regular languages is a code. We also prove that it is undecidable whether a collection of binary regular languages is a code.

Thomas Canhao Xu

Hardware/Software Co-Design for Multicore Architectures

University of Turku, Department of Information Technology

Opponent: Per Gunnar Kjeldsberg, Norwegian University of Science and Technology, Norway.

Supervisors: Hannu Tenhunen and Pasi Liljeberg.

The integration of multiple cores on a single chip leads to the concept of chip multiprocessor. We have already witnessed multicore processors emerging with increasing number of cores and complex on-chip interconnect in the past few years. Network-on-Chip (NoC) architecture was proposed as a promising solution for future multicore processors with hundreds or even thousands of cores. In this regard, hardware/software co-design of NoC based multicore architectures are presented in this dissertation.

Three dimensional (3D) integration has the potential to increase device density, providing higher efficiency compared with two dimensional (2D) integration. Moreover, the combination of 3D integration and NoC architecture provides the benefits of both. Here, 2D/3D multicore processors with integrated and split core/cache architectures are analyzed based on non uniform cache architecture. In addition, a 3D multicore design with on-chip dynamic random access memories is also introduced to alleviate the memory bandwidth wall.

There are many hardware resources in a multicore processor, for example caches and memory controllers. If the resources, e.g. memory controllers, are attached to all nodes, the utilization of resources can be low, and therefore leading to a poor system efficiency. One solution is to distribute a limited number of resources. However, in this case, multiple requesters have to share a resource, leading to possible traffic contention. To alleviate the problem of performance degradation by reduced amount of resources, intelligent placement of resources for a mesh-based on-chip networks is introduced. Three hardware resources are used as case studies, including through silicon vias, memory controllers and cores/caches.

Two operating system scheduling algorithms are presented in order to improve performance and efficiency of multicore systems. We propose a minimal average access time scheduler to reduce on-chip communication latencies for 2D multicore processors. A greedy heuristic approximation scheduling algorithm is presented for resource constrained 3D multicore processors. Current parallel applications are designed and optimized for conventional bus or cross-bar based multicore architectures. Without the collaboration of software, the processing ability of NoC based multicore systems can be limited. Three applications are analyzed for the NoC platform, including H.264, FFT and two hierarchical N-Body methods. Optimization suggestions are given both on hardware and software.

Tuomas Mäkilä

Software Development Process Modeling – Developers Perspective to Contemporary Modeling Techniques

University of Turku, Department of Information Technology

Opponent: Hannu Jaakkola, Tampere University of Technology, Finland.

Supervisors: Timo Knuutila and Ville Leppänen.

Formal software development processes and well-defined development methodologies are nowadays seen as the definite way to produce high-quality software within time-limits and budgets. The variety of such high-level methodologies is huge ranging from rigorous process frameworks like CMMI and RUP to more lightweight agile methodologies. The need for managing this variety and the fact that practically every software development organization has its own unique set of development processes and methods have created a profession of software process engineers. Different kinds of informal and formal software process modeling languages are essential tools for process engineers. These are used to define processes in a way which allows easy management of processes, for example process dissemination, process tailoring and process enactment.

The process modeling languages are usually used as a tool for process engineering where the main focus is on the processes themselves. This dissertation has a different emphasis. The dissertation analyses modern software development process modeling from the software developers' point of view. The goal of the dissertation is to investigate whether the software process modeling and the software process models aid software developers in their day-to-day work and what are the main mechanisms for this. The focus of the work is on the Software Process Engineering Metamodel (SPEM) framework which is currently one of the most influential process modeling notations in software engineering.

The research theme is elaborated through six scientific articles which represent the dissertation research done with process modeling during an approximately five year period. The research follows the classical engineering research disci-

pline where the current situation is analyzed, a potentially better solution is developed and finally its implications are analyzed. The research applies a variety of different research techniques ranging from literature surveys to qualitative studies done amongst software practitioners.

The key finding of the dissertation is that software process modeling notations and techniques are usually developed in process engineering terms. As a consequence the connection between the process models and actual development work is loose. In addition, the modeling standards like SPEM are partially incomplete when it comes to pragmatic process modeling needs, like light-weight modeling and combining pre-defined process components. This leads to a situation, where the full potential of process modeling techniques for aiding the daily development activities can not be achieved.

Despite these difficulties the dissertation shows that it is possible to use modeling standards like SPEM to aid software developers in their work. The dissertation presents a light-weight modeling technique, which software development teams can use to quickly analyze their work practices in a more objective manner. The dissertation also shows how process modeling can be used to more easily compare different software development situations and to analyze their differences in a systematic way. Models also help to share this knowledge with others.

A qualitative study done amongst Finnish software practitioners verifies the conclusions of other studies in the dissertation. Although processes and development methodologies are seen as an essential part of software development, the process modeling techniques are rarely used during the daily development work. However, the potential of these techniques intrigues the practitioners.

As a conclusion the dissertation shows that process modeling techniques, most commonly used as tools for process engineers, can also be used as tools for organizing the daily software development work. This work presents theoretical solutions for bringing the process modeling closer to the ground-level software development activities. These theories are proven feasible by presenting several case studies where the modeling techniques are used e.g. to find differences in the work methods of the members of a software team and to share the process knowledge to a wider audience.

Shahrokh Nikou

Opening the Black-Box of IT Artifacts: Looking into Mobile Service Characteristics and Individual Perception

Åbo Akademi University, Department of Information Technologies

Opponent: Lieven De Marez, University of Ghent, Belgia.

Supervisors: Christer Carlsson and Harry Bouwman.

The exponential growth in the mobile telecommunications has created fierce competition for all participants in the mobile industry and enabled service and application providers to develop mobile services that can be used by a large number of users. From the users' perspective, the services should be innovative, useful and fit into their daily routines. From the network operators and service providers' perspectives services should be adopted by a critical mass of users and be used in a global scale to earn back huge investments made in network licenses and technology. The core objective of the current dissertation is to create an understanding of individual acceptance of IT artifacts i.e., mobile services and provide insight to the characteristics of the IT artifacts. Moreover, consumers' awareness of mobile service platforms is explored. To do so, empirical studies using various statistical methods and

tools are conducted to evaluate service characteristics and investigate users' perceptions and acceptance toward IT artifacts. In addition, an experimental study is also conducted to investigate users' perceptions towards usefulness of the converged rich communication services which have recently been developed by a number of telecommunication companies, as an alternative to the dominant iOS and Android platforms.

The findings indicate that mobile services have to be evaluated and judged on their own merits, and not only with established acceptance theories. The results show that service characteristics such as innovativeness, usefulness, ease of use and context of use influence individual perceptions and these characteristics are highly relevant criteria toward the acceptance, adoption and use of mobile services. The results show that application costs are by far the most relevant criterion for selecting a service regardless of the platform. Furthermore, operating systems offered by Apple (iOS) and Google (Android) are preferred over other operating systems offered by Nokia (Symbian) and BlackBerry. New innovative services have to be developed while taking into account the differences in daily routines, frequency, urgency and intensity of use. Presumably, device manufacturers can win the platform battle against their rival 'Telecom operators', if they can provide innovative services and applications that fit into users' daily routines. In particular, this dissertation suggests that Telecom operators should settle for becoming a bit-pipe provider and let other market participants i.e., large companies e.g., Google and device manufacturers e.g., Apple be involved in the mobile service market.

The findings contribute to the discussion on mobile service platforms by suggesting that service platforms need to be aligned with users' preferences and devices they already use. In future research, researchers should pay more attention to issues such as service functionality and simplicity that play a significant role in consumers' decisions and refrain from research that only discusses mobile services and applications in generic terms. If scholars pay more attention to techno-economics e.g., service characteristics, innovativeness, service platforms, payment, and context-of-use, new theories can be developed that might be relevant to study the next generation of mobile service.

Alessandro Buoni

Fraud Detection in the Banking Sector: A Multi-Agent Approach

Åbo Akademi University, Department of Information Technologies

Opponent: Colin Eden, University of Strathclyde, United Kingdom.

Supervisors: Christer Carlsson and Mario Fedrizzi.

Fraud is an increasing phenomenon as shown in many surveys carried out by leading international consulting companies in the last years. Despite the evolution of electronic payments and hacking techniques there is still a strong human component in fraud schemes.

Conflict of interest in particular is the main contributing factor to the success of internal fraud.

In such cases anomaly detection tools are not always the best instruments, since the fraud schemes are based on faking documents in a context dominated by lack of controls, and the perpetrators are those ones who should control possible irregularities.

In the banking sector audit team experts can count only on their experience, whistle blowing and the reports sent by their inspectors.

The Fraud Interactive Decision Expert System (FIDES), which is the core of this research, is a multi-agent system built to support auditors in evaluating suspicious behaviours and to speed up the evaluation process in order to detect or prevent fraud schemes. The system combines Think-map, Delphi method and Attack trees and it has been built around audit team experts and their needs.

The output of FIDES is an attack tree, a tree-based diagram to "systematically categorize the different ways in which a system can be attacked". Once the attack tree is built, auditors can choose the path they perceive as more suitable and decide whether or not to start the investigation.

The system is meant for use in the future to retrieve old cases in order to match them with new ones and find similarities.

The retrieving features of the system will be useful to simplify the risk management phase, since similar countermeasures adopted for past cases might be useful for present ones.

Even though FIDES has been built with the banking sector in mind, it can be applied in all those organisations, like insurance companies or public organizations, where anti-fraud activity is based on a central anti-fraud unit and a reporting system.

Mats Neovius

Trustworthy Context Dependency in Ubiquitous Systems

Åbo Akademi University, Department of Information Technologies

Opponent: Christian Damsgaard Jensen, Technical University of Denmark, Denmark.

Supervisors: Luigia Petre and Kaisa Sere.

The modern society is getting increasingly dependent on software applications. These run on processors, use memory and account for controlling functionalities that are often taken for granted. Typically, applications adjust the functionality in response to a certain context that is provided or derived from the informal environment with various qualities. To rigorously model the dependence of an application on a context, the details of the context are abstracted and the environment is assumed stable and fixed. However, in a context-aware ubiquitous computing environment populated by autonomous agents, a context and its quality parameters may change at any time. This raises the need to derive the current context and its qualities at runtime. It also implies that a context is never certain and may be subjective, issues captured by the context's quality parameter of experience-based trustworthiness.

Given this, the research question of this thesis is: In what logical topology and by what means may context provided by autonomous agents be derived and formally modelled to serve the context-awareness requirements of an application? This research question also stipulates that the context derivation needs to incorporate the quality of the context. In this thesis, we focus on the quality of context parameter of trustworthiness based on experiences having a level of certainty and referral experiences, thus making trustworthiness reputation based. Hence, in this thesis we seek a basis on which to reason and analyse the inherently inaccurate context derived by autonomous agents populating a ubiquitous computing environment in order to formally model context-awareness.

More specifically, the contribution of this thesis is threefold: (i) we propose a logical topology of context derivation and a method of calculating its trust-

worthiness, (ii) we provide a general model for storing experiences and (iii) we formalise the dependence between the logical topology of context derivation and its experience-based trustworthiness. These contributions enable abstraction of a context and its quality parameters to a Boolean decision at runtime that may be formally reasoned with. We employ the Action Systems framework for modelling this.

The thesis is a compendium of the author's scientific papers, which are republished in Part II. Part I introduces the field of research by providing the mending elements for the thesis to be a coherent introduction for addressing the research question. In Part I we also review a significant body of related literature in order to better illustrate our contributions to the research field.

Tommi Tapanainen

Information Technology (IT) Managers' Contribution to IT Agility in Organizations – Views from the Field

University of Turku, Turku School of Economics

Opponent: Celeste Wilderom, University of Twente

Supervisor: Hannu Salmela

Fredrik Degerlund

Scheduling of Guarded Command Based Models

Åbo Akademi University, Department of Information Technologies

Opponent: Einar Broch Johnsen, University of Oslo, Norway.

Supervisors: Marina Waldén and Kaisa Sere.

Formal methods provide a means of reasoning about computer programs in order to prove correctness criteria. One subtype of formal methods is based on the weakest precondition predicate transformer semantics and uses guarded commands as the basic modelling construct. Examples of such formalisms are Action Systems and Event-B. Guarded commands can intuitively be understood as actions that may be triggered when an associated guard condition holds. Guarded commands whose guards hold are nondeterministically chosen for execution, but no further control flow is present by default. Such a modelling approach is convenient for proving correctness, and the Refinement Calculus allows for a stepwise development method. It also has a parallel interpretation facilitating development of concurrent software, and it is suitable for describing event-driven scenarios. However, for many application areas, the execution paradigm traditionally used comprises more explicit control flow, which constitutes an obstacle for using the above mentioned formal methods. In this thesis, we study how guarded command based modelling approaches can be conveniently and efficiently scheduled in different scenarios. We first focus on the modelling of trust for transactions in a social networking setting. Due to the event-based nature of the scenario, the use of guarded commands turns out to be relatively straightforward. We continue by studying modelling of concurrent software, with particular focus on compute-intensive scenarios. We go from theoretical considerations to the feasibility of implementation by evaluating the performance and scalability of executing a case study model in parallel using automatic scheduling performed by a dedicated scheduler. Finally, we propose a more explicit and non-centralised approach in which the flow of each task is controlled by a schedule of its own. The schedules are expressed in a dedicated scheduling language, and patterns assist the developer in proving correctness of the scheduled model with respect to the original one.

Amir-Mohammad Rahmani-Sane

Exploration and Design of Power-Efficient Networked Many-Core Systems

University of Turku, Department of Information Technology

Opponent: José L. Ayala, Complutense University of Madrid, Spain.

Supervisor: Hannu Tenhunen.

Multiprocessing is a promising solution to meet the requirements of near future applications. To get full benefit from parallel processing, a manycore system needs efficient, on-chip communication architecture. Network-on-Chip (NoC) is a general purpose communication concept that offers highthroughput, reduced power consumption, and keeps complexity in check by a regular composition of basic building blocks. This thesis presents power efficient communication approaches for networked many-core systems. We address a range of issues being important for designing power-efficient manycore systems at two different levels: the network-level and the router-level.

From the network-level point of view, exploiting state-of-the-art concepts such as Globally Asynchronous Locally Synchronous (GALS), Voltage/Frequency Island (VFI), and 3D Networks-on-Chip approaches may be a solution to the excessive power consumption demanded by today's and future many-core systems. To this end, a low-cost 3D NoC architecture, based on high-speed GALS-based vertical channels, is proposed to mitigate high peak temperatures, power densities, and area footprints of vertical interconnects in 3D ICs. To further exploit the beneficial feature of a negligible inter-layer distance of 3D ICs, we propose a novel hybridization scheme for interlayer communication. In addition, an efficient adaptive routing algorithm is presented which enables congestion-aware and reliable communication for the hybridized NoC architecture. An integrated monitoring and management platform on top of this architecture is also developed in order to implement more scalable power optimization techniques.

From the router-level perspective, four design styles for implementing power-efficient reconfigurable interfaces in VFI-based NoC systems are proposed. To enhance the utilization of virtual channel buffers and to manage their power consumption, a partial virtual channel sharing method for NoC routers is devised and implemented.

Extensive experiments with synthetic and real benchmarks show significant power savings and mitigated hotspots with similar performance compared to latest NoC architectures. The thesis concludes that careful codesigned elements from different network levels enable considerable power savings for many-core systems.

Ville Rantala

On Dynamic Monitoring Methods for Networks-on-Chip

University of Turku, Department of Information Technology

Opponent: Timo D. Hämäläinen, Tampere University of Technology, Finland.

Supervisors: Juha Plosila and Pasi Liljeberg.

Rapid ongoing evolution of multiprocessors will lead to systems with hundreds of processing cores integrated in a single chip. An emerging challenge is the implementation of reliable and efficient interconnection between these cores as well as other components in the systems. Network-on-Chip is an interconnection approach which is intended to solve the performance bottleneck caused by traditional, poorly scalable communication structures such as buses. However, a large on-chip network involves issues related to congestion

problems and system control, for instance. Additionally, faults can cause problems in multiprocessor systems. These faults can be transient faults, permanent manufacturing faults, or they can appear due to aging. To solve the emerging traffic management, controllability issues and to maintain system operation regardless of faults a monitoring system is needed. The monitoring system should be dynamically applicable to various purposes and it should fully cover the system under observation. In a large multiprocessor the distances between components can be relatively long. Therefore, the system should be designed so that the amount of energy-inefficient long-distance communication is minimized.

This thesis presents a dynamically clustered distributed monitoring structure. The monitoring is distributed so that no centralized control is required for basic tasks such as traffic management and task mapping. To enable extensive analysis of different Network-on-Chip architectures, an in-house SystemC based simulation environment was implemented. It allows transaction level analysis without time consuming circuit level implementations during early design phases of novel architectures and features.

The presented analysis shows that the dynamically clustered monitoring structure can be efficiently utilized for traffic management in faulty and congested Network-on-Chip-based multiprocessor systems. The monitoring structure can be also successfully applied for task mapping purposes. Furthermore, the analysis shows that the presented in-house simulation environment is flexible and practical tool for extensive Network-on-Chip architecture analysis.

Mikko Peltö

On Identifying and Locating-Dominating Codes in the Infinite King Grid

University of Turku, Department of Mathematics and Statistics

Opponent: Olivier Hudry, CNRS & Télécom ParisTech, France.

Supervisor: Iiro Honkala.

6. TUCS Highlights

The TUCS Highlights is a series of stories intended to promote our work to the public. The stories aim to have a core, whose impact on the society is easy to grasp. To this end, the text aims to be simple and easy to read, and the stories are made even more attractive by related photographs. The photos should be of the people involved, or something else that is recognizable, easily approached and appealing.

During 2012 we have published two stories in this series. In future, we wish to continue the series once in every two months or so.

6.1 Fudan University delegation visiting University of Turku Department of Information Technology

A delegation from the Fudan University, Shanghai, PRC was visiting the University of Turku from Sunday to Tuesday August 26th to Aug 28th. The visit was very fruitful, and concentrated on engineering education and especially interdisciplinary ICT education issues. The delegation consisted of University administration management and leading senior faculty from the engineering education of

Fudan University.

The delegation:

Prof. Ying Wang, Teaching Affairs Office at Fudan,

Prof. Bo Hu, School of Information Science and Engineering, delegation leader,

Prof. Jia Zhou, Department of Microelectronics,

Prof. Yong Wang, Department of Electronic Engineering,

Prof. Heyuan Zhu, Department of Optical Science and Engineering,

Prof. Yaojie Sun, Department of Illuminating Engineering and Light Sources,

Prof. Weiming Ni, Department of Communication Science and Engineering,

Prof. Jiang Yu-long, School of Microelectronics

The hosts:

Prof. Tapio Salakoski, Director of the Department of Information Technology,

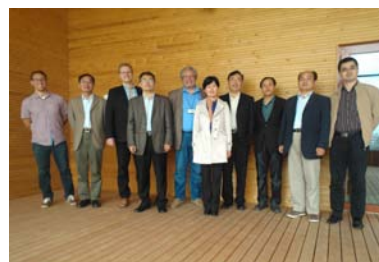
Prof. Hannu Tenhunen, Computer Systems Laboratory, Department of Inf. Tech.,

Proj.Manag. Ville Taajamaa, Department of Information Technology

The delegation members and the personnel of the Department of Information Technology held several workshops together about student-, researcher-, and teacher mobility issues. Possible joint degree programmes were also discussed on several occasions. The workshops were held within the premises of Turku Centre for Computer Science, in the ICT Building, where the delegation was also introduced to the TUCS community. The delegation also visited the School of Medicine, department of Nursing Sciences and The Centre for East Asian Studies in the University to Turku. The idea of interdisciplinary engineering education where "Engineer meets Human" was elaborated pragmatically. The rector of the University of Turku held a luncheon for the delegation on Monday and emphasized the importance of collaboration between the distinguished science universities in Finland and in Shanghai.

The visit was an integral part of the joint effort to create long lasting friendship and collaboration between the universities. It aims to be a road opener for cooperation between Shanghai and Turku in technological education and research. The TUCS platform provides a great variety of technological expertise. Should this venture turn out to involve topics in Fudan that are not among the core competence areas of the Department of Information Technology, they are likely to be so in the other departments within the TUCS community. In the longer run, this cooperation can be seen to grow and flourish to be a significant form of exchange between TUCS and Fudan.

For more information contact: Ville Taajamaa, ville.taajamaa@utu.fi



The Fudan University delegation and University of Turku hosts



The delegation and the hosts

6.2 Early-warning model for European banks

The rationale for developing an early-warning model for European banks is straightforward. The global financial crisis has brought a large number of European banks to the brink of collapse. Data from the European Commission shows that government assistance to stabilize the European Union (EU) banking sector peaked at €1.5 trl at the end of 2009, amounting to more than 13% of EU GDP. Beyond the enormous bailout costs of the Great Financial Crisis, there are additional reasons for developing an early-warning model for banks and banking systems, particularly for Europe. First, the estimated real costs of banking crisis are very large. The literature shows that output losses of previous banking crises have been, on average, around 20-25% of GDP. Second, recent episodes show the crucial role of the euro area banking sector on the stability of the entire European Monetary Union. Third, building an early-warning model to detect vulnerabilities in the EU banking system is further motivated by the importance of the banking sector in providing funds to the private sector, particularly to the small and medium size enterprises.



The European Central Bank headquarters. (From Wikimedia Commons user ArcCan)

Developing an early-warning model is challenging as the outbreaks of banking crises, and more generally financial crises, are difficult to predict. Recently, the earlywarning model literature has focused on detecting underlying vulnerabilities, and finding common patterns preceding financial crises, rather than trying to predict the crises themselves that could have been triggered by various factors that are hard to foresee. Thus, the project focuses on predicting vulnerable states, where one or multiple triggers could lead to bank distress events. The vulnerable states are defined as periods prior to the crisis or distress events, e.g. 8 quarters.

Peter Sarlin, a TUCS Graduate Programme student, visited the Financial Stability Surveillance Division at the European Central Bank in Frankfurt, Germany between March and June 2012. The research visit was partially funded by TUCS. Main parts of the stay, Peter spent working on a project entitled "Predicting bank distress and identifying interdependencies among European banks", a work co-authored by Frank Betz, Silviu Oprica, Tuomas Peltonen and Peter Sarlin. The key aim of the project was to build a predictive model of bank-specific vulnerabilities, as well as to assess contagion through interdependence in the European banking sector.



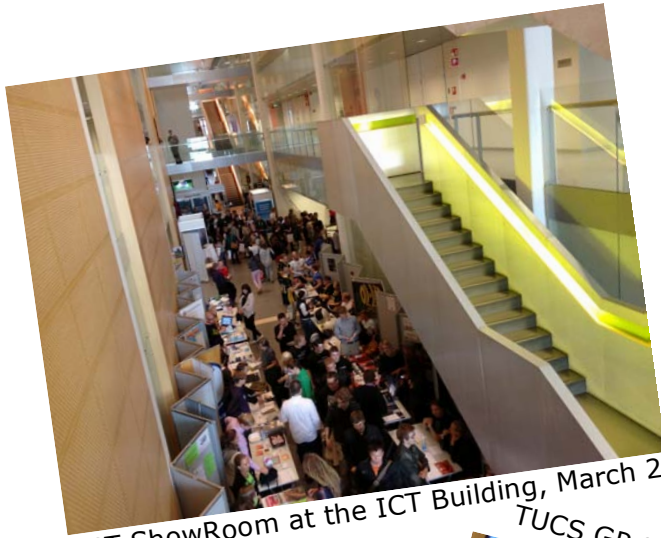
Peter Sarlin, Data Mining and Knowledge Management Laboratory

After the research visit, the main aim has been on operationalising the model for realtime use. That is, setting up an implementation focuses on collecting data, creating and combining models and producing the needed outputs to monitor highly vulnerable banks in Europe. The project endeavour was successful enough for proceeding with a follow-up project.

7. TUCS in pictures



Photos from the TUCS Distinguished Lecture Series 2012



ICT ShowRoom at the ICT Building, March 2012.



TUCS GP Spring Meetup 2012



TUCS GP activity evening, October 2011



TUCS Christmas Lunch 2012

Turku Centre for Computer Science

TUCS General Publications

1. **Joakim von Wright, Jim Grundy and John Harrison (Eds.)**, Supplementary Proceedings of the 9th International Conference on Theorem Proving in Higher Order Logics: TPHOLs'96
2. **Mikko Ruohonen and Juha Pärnistö (Eds.)**, Proceedings of the First European Doctoral Seminar on Strategic Information Management
3. **Christer Carlsson (Ed.)**, Exploring the Limits of Support Systems
4. **Mats Aspnäs, Ralph-Johan Back, Timo Järvi and Tiina Lehto (Eds.)**, Turku Centre for Computer Science, Annual Report 1996
5. **Wolfgang Weck, Jan Bosch and Clemens Szyperski (Eds.)**, Proceedings of the Second International Workshop on Component-Oriented Programming (WCOP '97)
6. Working Material from the School on Natural Computation, SNAC
7. **Mats Aspnäs, Ralph-Johan Back, Timo Järvi and Tiina Lehto (Eds.)**, Turku Centre for Computer Science, Annual Report 1997
8. **Reima Suomi, Paul Jackson, Laura Hollmén and Mats Aspnäs (Eds.)**, Teleworking Environments, Proceedings of the Third International Workshop on Telework
9. **Robert Fullér**, Fuzzy Reasoning and Fuzzy Optimization
10. **Wolfgang Weck, Jan Bosch and Clemens Szyperski (Eds.)**, Proceedings of the Third International Workshop on Component-Oriented Programming (WCOP '98)
11. Abstracts from the 10th Nordic Workshop on Programming Theory (NWPT'98)
12. **Edward M. Roche, Kalle Kangas and Reima Suomi (Eds.)**, Proceedings of the IFIP WG 8.7 Helsinki Working Conference, 1998
13. **Christer Carlsson and Franck Tétard (Eds.)**, Intelligent Systems and Active DSS, Abstracts of the IFORS SPC-9 Conference
14. **Mats Aspnäs, Ralph-Johan Back, Timo Järvi, Martti Kuutti, and Tiina Lehto (Eds.)**, Turku Centre for Computer Science, Annual Report 1998
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16. **Christer Carlsson (Ed.)**, The State of the Art of Information System Applications in 2007
17. **Christer Carlsson (Ed.)**, Information Systems Day
18. **Ralph-Johan Back, Timo Järvi, Nina Kivinen, Leena Palmulaakso-Nylund and Thomas Sund (Eds.)**, Turku Centre for Computer Science, Annual Report 1999
20. **Reima Suomi and Jarmo Tähkäpää (Eds.)**, Health and Welath through Knowledge
21. **Johan Lilius and Seppo Virtanen (Eds.)**, TTA Workshop Notes 2002
22. **Mikael Collan**, Investment Planning – An Introduction
23. **Mats Aspnäs, Christel Donner, Monika Eklund, Pia Le Grand, Ulrika Gustafsson, Timo Järvi, Nina Kivinen, Maria Prusila and Thomas Sund (Eds.)**, Turku Centre for Computer Science, Annual Report 2000-2001
24. **Ralph-Johan Back and Victor Bos**, Centre for Reliable Software Technology, Progress Report 2003
25. **Pirkko Walden, Stina Störling-Sarkkila, Hannu Salmela and Eija H. Karsten (Eds.)**, ICT and Services: Combining Views from IS and Service Research
26. **Timo Järvi and Pekka Reijonen (Eds.)**, People and Computers: Twenty-One Ways of Looking at Information Systems
27. **Tero Harju and Juhani Karhumäki (Eds.)**, Proceedings of WORDS'03
28. **Mats Aspnäs, Christel Donner, Monika Eklund, Pia Le Grand, Ulrika Gustafsson, Timo Järvi and Nina Kivinen (Eds.)**, Turku Centre for Computer Science, Annual Report 2002

29. **João M. Fernandes, Johan Lilius, Ricardo J. Machado and Ivan Porres (Eds.)**, Proceedings of the 1st International Workshop on Model-Based Methodologies for Pervasive and Embedded Software
30. **Mats Asp n, Christel Donner, Monika Eklund, Ulrika Gustafsson, Timo J rvi and Nina Kivinen (Eds.)**, Turku Centre for Computer Science, Annual Report 2003
31. **Andrei Sabelfeld (Ed.)**, Foundations of Computer Security
32. **Eugen Czeizler and Jarkko Kari (Eds.)**, Proceedings of the Workshop on Discrete Models for Complex Systems
33. **Peter Selinger (Ed.)**, Proceedings of the 2nd International Workshop on Quantum Programming Languages
34. **Kai Koskimies, Johan Lilius, Ivan Porres and Kasper  sterbye (Eds.)**, Proceedings of the 11th Nordic Workshop on Programming and Software Development Tools and Techniques, NWPER'2004
35. **Kai Koskimies, Ludwik Kuzniarz, Johan Lilius and Ivan Porres (Eds.)**, Proceedings of the 2nd Nordic Workshop on the Unified Modelling Language, NWUML'2004
36. **Franca Cantoni and Hannu Salmela (Eds.)**, Proceedings of the Finnish-Italian Workshop on Information Systems, FIWIS 2004
37. **Ralph-Johan Back and Kaisa Sere**, CREST Progress Report 2002-2003
38. **Mats Asp n, Christel Donner, Monika Eklund, Ulrika Gustafsson, Timo J rvi and Nina Kivinen (Eds.)**, Turku Centre for Computer Science, Annual Report 2004
39. **Johan Lilius, Ricardo J. Machado, Dragos Truscan and Jo o M. Fernandes (Eds.)**, Proceedings of MOMPES'05, 2nd International Workshop on Model-Based Methodologies for Pervasive and Embedded Software
40. **Ralph-Johan Back, Kaisa Sere and Luigia Petre**, CREST Progress Report 2004-2005
41. **Tapio Salakoski, Tomi M ntyl  and Mikko Laakso (Eds.)**, Koli Calling 2005 – Proceedings of the Fifth Koli Calling Conference on Computer Science Education
42. **Petri Paju, Nina Kivinen, Timo J rvi and Jouko Ruissalo (Eds.)**, History of Nordic Computing – HiNC2
43. **Tero Harju and Juhani Karhum ki (Eds.)**, Proceedings of the Workshop on Fibonacci Words 2006
44. **Michal Kunc and Alexander Okhotin (Eds.)**, Theory and Applications of Language Equations, Proceedings of the 1st International Workshop, Turku, Finland, 2 July 2007
45. **Mika Hirvensalo, Vesa Halava, Igor Potapov and Jarkko Kari (Eds.)**, Proceedings of the Satellite Workshops of DLT 2007
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