Turku Centre for Computer Science

Annual Report 2003

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TUCS General Publication
No 30, June 2004

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Foreword

TUCS was started in March 1994 and it has published annual reports since then. The form of reports has been the same and when the number of activities has increased the report has become too comprehensive. Now we have lightened the contents without losing too many details.

TUCS has already reached a steady stage and year 2003 can be considered as a normal one. As the functions of TUCS had become so various, TUCS made a strategy for the first time. The strategy was accepted by the board.

TUCS also has acquired a new visual image which can be seen in this publication.

On the other hand dark clouds were gathering on the sky: the Ministry of Education announced to discontinue the Information Industry program earlier than was supposed. This threatened one source of funding in TUCS. TUCS arranged negotiations between the Ministry of Education and the computer science departments in universities where a smooth ending of the program was agreed. Anyhow, TUCS had to cut down its budget for year 2004 and start downsizing some of its operations.

I thank the present staff of TUCS, which form the editorial board of this report, for fast and professional work. Also the officers of the departments have gathered information for the publication, which is gratefully acknowledged.

Turku March 16, 2004
Timo Järvi
Acting director

1. TUCS in Brief

Turku Centre for Computer Science (TUCS) is a joint research and education centre between the University of Turku, Åbo Akademi University, and the Turku School of Economics and Business Administration.

TUCS coordinates research and education in the field of Information Technology. The activities are carried out in the TUCS Master's and Graduate schools, and in the centre's own research laboratories. The main areas of research are algorithmics, bioinformatics, communication systems, discrete mathematics, embedded systems, information systems, mathematical modelling, microelectronics and software engineering.

1.1 The Development of TUCS

TUCS was started in March 1994 in cooperation between the three universities mentioned above. The purpose was to combine the research, the advanced level teaching and the doctoral education of the participating departments into a joint research centre, with a Graduate School as a central component. TUCS Graduate School (TUCS GS) was the first one to start in Finland. The graduate school model was considered very successful by the Ministry of Education, and in the next two years altogether 93 graduate schools were formed in Finland, in all areas of science.

During the years 1995–1999 TUCS was selected as a Centre of Excellence in research by the Academy of Finland. This was recognition of the strong research carried out by the research groups at TUCS. Especially the research group of Prof. Arto Salomaa in formal languages and cryptology at the University of Turku and the research group of Prof. Ralph-Johan Back in programming methodology at the Åbo Akademi University were mentioned.

In 1998, TUCS assumed the role of the local coordinating organ for a large national expansion program, with the goal of increasing the intake to the education programmes in Computer Science and Electronic Engineering in the Finnish universities by 1000 students annually. For the departments taking part in the cooperation within TUCS, this meant that the total annual student intake increased from 180 to over 300 during the years 1998–2000. The main part of the expansion was directed to the programme in Computer Science and Engineering, leading to a Master's of Science in Technology. The expansion program also included a four-year programme for professional upgrading, with a student intake of over 200 per year. The expansion resulted in a considerable change in the organization of TUCS, since its responsibilities were extended also to cover coordination of

basic education. The Ministry of Education, together with the cities and municipalities in the Turku region, financed the program.

In 2000, the discipline Electronics and Telecommunications Technology, which belonged to the Department of Applied Physics at the University of Turku, joined TUCS. Electronics and Telecommunication is actively involved in the education programme in Computer Science and Engineering, which is carried out in co-operation between Åbo Akademi University and the University of Turku.

The Department of Information Technology at the University of Turku was formed in the beginning of 2002 by combining the discipline Computer Science, which formerly belonged to the Department of Mathematical Sciences, and the discipline Electronics and Telecommunication Technology, which formerly was part of the Department of Applied Physics. The discipline mathematics, which belonged to the Department of Mathematical Sciences, formed an own department, the Department of Mathematics.

The Centre for Reliable Software Technology, CREST, was formed in 2002. CREST is a research centre within Åbo Akademi University and TUCS and consists of four research laboratories or groups: Distributed Systems, Embedded Systems, Mechanized Reasoning and Software Construction. CREST is a Centre of Excellence for Formal Methods in Programming, appointed by the Academy of Finland.

1.2 Premises

TUCS premises are presently in DataCity (5^{th} floor), which is situated in the Turku Science Park area. The department of information technology (University of Turku) is situated in the same floor.

TUCS takes part in coordinating and planning the new building in which most of the departments participating in TUCS will be located. The planning started already in 1999 but came to an end without any decision to build the house. The planning was resumed in 2003 and the new ICT-house is now expected to be ready in the summer of 2006. TUCS, the department of Information Technology (University of Turku), the department of Computer Science (Åbo Akademi University), the department of Information Systems (Åbo Akademi University), telecommunications and electronic commerce (Turku Polytechnic), and ICT Turku will move to the new building.

2. Year 2003

This section gives a short overview of the most important events at TUCS in the year 2003.

2.1 Conferences

The following conferences have been arranged by the departments belonging to TUCS during the year 2003:

The European Molecular Computing Consortium (EMCC) spring meeting was held in Turku May 15–17. Tero Harju from the Department of Mathematics at the University of Turku and Ion Petre from the Department of Computer Science at Åbo Akademi University were responsible for the organization of the meeting.

The 3rd International Conference of B and Z users (ZB 2003) was held in Turku June 4-6. Marina Walden from the Department of Computer Science at Åbo Akademi University was chair of the local organizing committee. The conference gathered about 80 participants.

The 4th International Conference on Words was arranged in Turku September 10-13 by the Department of Mathematics at the University of Turku. Professor Juhani Karhumäki was the chairman of the program committee. About 90 researchers took part in the conference.

The 15th Nordic Workshop on Programming Theory (NWPT'03) was arranged by the Department of Computer Science at Åbo Akademi University October 29th–31st. Professor Kaisa Sere was responsible for the workshop, which gathered around 40 participants.

2.2 Thesis awards

Kalle Ranto from the Department of Mathematics at the University of Turku was awarded the prize for the best Mathematics Ph.D. thesis in Finland 2002 by the research foundation of the Rolf Nevanlinna Institute. The title of the thesis is "Z4-Goethals Codes, Decoding and Designs".

The Research Foundation of the Finnish Society for Computer Science awarded the prize for the best doctoral dissertation in 2002 to Vesa Halava from the De-

partment of Mathematics at the University of Turku for his dissertation titled "The Post Correspondence Problem for Marked Morphisms".

2.3 University of Turku obtained the right to grant M. Sc. Tech degrees

Starting from August 2004, the University of Turku will have the right to grant Master of Science degrees in Technology. The study programme in Computer Engineering, which leads to a Master of Science in Technology, is currently organized in close cooperation with Åbo Akademi University. Both universities have their own intake to the programme, but Åbo Akademi University grants the degree.

2.4 Master's School

The development of the Master's School continued during 2003. TUCS coordinates four Master's programmes: "Information Technology" at the University of Turku, "Software Engineering" and "Electronic and Mobile Commerce" at Åbo Akademi University, and "Global IT Management" at the Turku School of Economics and Business Administration. The Master's programmes accept students with a Bachelor's degree and lead to a Finnish Master's degree after about two years of study. A part-time administrative officer was employed from March to October 2003 to coordinate the activities in the Master's School.

2.5 Financing

A new financing model for TUCS for the coming three year period (2004–2006) was accepted in the result negotiations with the universities in the fall 2003. As the expansion programme in Computer Science and Electronics Engineering is coming to an end, the special financing from the Ministry of Education will also gradually decrease. This makes it necessary to cut down the expenses during the following years by concentrating on the core activities of TUCS. A strategy outlining this development was presented and accepted by the TUCS board.

3. Organization

The education and research activities at TUCS are carried out within the Master's and Graduate Schools and the Research Laboratories. Decisions are primarily made in the TUCS board, while planning and execution is carried out in the workgroups, the Graduate School Committee and the Advisory Committee. By the end of 2003 there were about 35 professors, 50 Ph.D. level researchers and 90 doctoral students at TUCS.

3.1 The Director, the Vice-director, and the TUCS Board

The board is the organ with the highest authority in TUCS. The director and the vice-director of TUCS are responsible to the board. They are also responsible for the activities carried out within TUCS. During 2003, Prof. Timo Järvi (University of Turku, Dept. of Information Technology) acted as director, and Prof. Kaisa Sere (Åbo Akademi University, Dept. of Computer Science) was the vice-director.

TUCS board consists of professors from the participating departments, students and a representative from the local IT enterprises. The board has the following members (deputy members in brackets) for the period 1.1.2003-31.12.2005:

- Chairman: Prof. Ralph-Johan Back, Åbo Akademi University, Dept. of Computer Science (Prof. Jan Westerholm)
- Vice-chairman: Prof. Reima Suomi, Turku School of Economics and Business Administration, Inst. of Information Systems Science (Prof. Hannu Salmela)
- Prof. Christer Carlsson, Åbo Akademi University, Inst. for Advanced Management Systems Research (Prof. Pirkko Walden)
- CEO Jaakko Kuosmanen, ICT Turku Oy (CEO Tarmo Hahto, Business to Business Mediat Oy)
- Prof. Jouni Isoaho, University of Turku, Dept. of Information Technology (Lecturer Risto Punkkinen)
- Prof. Juhani Karhumäki, University of Turku, Dept. of Mathematics (Prof. Mats Gyllenberg)
- Prof. Tapio Salakoski, University of Turku, Dept. of Information Technology (Prof. Markku Nurminen)
- Prof. Kaisa Sere, Åbo Akademi University, Dept. of Computer Science (Prof. Johan Lilius)
- Doctoral Student Paula Steinby, University of Turku (Doctoral Student Eugen Czeizler)

- Master's Student Henry Lönnbäck, Åbo Akademi University (Master's Student Jaana Nylund)
- Master's Student Niko Railo, Turku School of Economics and Business Administration (Master's Student Tarja Viskari)

3.2 Advisory Committee

TUCS advisory committee (TUCS AC) is an expert body consisting of representatives from the industrial and economic sectors within the field of Information Technology, the public sector and the universities. The advisory committee arranges four meetings per year, and its main task is to increase cooperation between TUCS and its external partners. At this moment, the advisory committee consists of 23 members appointed for the period 1.6.2003-31.5.2006. The members of the Advisory Committee are listed below:

- Tarmo Hahto, Business to Business Mediat Oy, Chairman of the Advisory Committee
- Teemu Hovi, TeliaSonera, Vice Chairman of the Advisory Committee
- Jaakko Astola, Tampere University of Technology
- Roger Broo, Åbo Akademi University
- Kari Bäckman, B & B Solutions Oy
- Osmo Eerola, Elcotec Design Center
- Raimo Hyvönen, Turku Polytechnic
- Jouko Häyrynen, Nokia Mobile Phones
- Juha Immonen, Siemens Oy
- Jaakko Kuosmanen, ICT Turku Oy
- Reino Kurki-Suonio, Tampere University of Technology
- Riitta Lahesmaa, Centre of Biotechnology
- Armas Lahoniitty, The City of Turku
- Hannu Lehtinen, Ericsson
- Harri Lönnberg, The University of Turku
- Jukka Mäki, Tekes/V-S TE-keskus
- Jorma Nieminen, Benefon Oyj
- Tim Olin, Kuulalaakeri Oy
- Matti Rasila, The City of Salo
- Tapio Reponen, Turku School of Economics and Business Administration
- Ilkka Ritakallio, Teleste Oyj
- Arto Salomaa, University of Turku, Department of Mathematics, TUCS
- Juho Savo, Regional Council of Southwest Finland (Varsinais-Suomen Liitto)

3.3 Master's School Workgroup

The Master's School workgroup handles most of the questions related to the Master's School. The main responsibilities are the coordination and planning of the joint activities for the programmes, as well as the application procedure. The Master's School workgroup consists of representatives from the departments, faculties and other units involved with the Master's School activities. The workgroup is headed by Prof. Jan Westerholm.

3.4 Educational Workgroups

The administrative work at TUCS is partly organized through workgroups. There are three educational workgroups whose preliminary task is to coordinate the advanced level studies in their field: The Computer Engineering workgroup, the Computer Science workgroup and the Information Systems workgroup. The educational workgroups consist of teachers and professors from the participating departments, student representatives and administrative staff. The workgroups each arrange 2-4 meetings per year.

3.5 Graduate School Committee

The Graduate School committee handles most of the questions regarding TUCS GS. The main responsibilities are the handling of study reports, the evaluation of applicants and decision making about principles concerning the supervision of students. The members of the Graduate School committee are professors (and supervisors) from the participating departments. The Committee is headed by Prof. Juhani Karhumäki.

3.6 Research Laboratories

Research at TUCS is organized into research laboratories and centres, which may consist of several laboratories. There are currently 16 research laboratories and three centres within TUCS.

The research laboratories are independent and choose their own research topics. The laboratories are organized around one to three professors and, in addition to these, consist of senior researchers, postdoctoral researchers, doctoral students and Master students. A research laboratory may be shared between more than one university (or department).

3.7 Research Centres

3.7.1 Centre for Reliable Software (CREST)

The Centre for Reliable Software (CREST) is a research centre within Åbo Akademi University and TUCS, and it consists of four research groups: Distributed Systems, Embedded Systems, Mechanised Reasoning, and Software Construction. For the years 2002-2007 the CREST research groups have been nominated by the Academy of Finland as a Centre of Excellence for Formal Methods in Programming.

The mission of CREST is to develop, verify, and validate techniques to build and maintain reliable software systems. Typical research topics in CREST are software models and software development models to construct reliable software, theoretical frameworks to check and ensure correctness requirements of software, tools to support these frameworks, applications in which they test and develop these models and frameworks.

3.7.2 Institute for Advanced Management Systems Research (IAMSR)

The Institute for Advanced Management Systems Research (IAMSR) is a research institute within Åbo Akademi University and TUCS. IAMSR is carrying out theory-driven and applied research in approximate reasoning and fuzzy logic, real options, self-organizing maps and neural nets, interdependent multiple criteria optimization, software agents, mobile and electronic commerce methods and technology, industry foresight methods, scenario technologies, knowledge based support systems and hyper knowledge.

3.7.3 Software Development Centre

The Software Development Centre was started as a co-operation between TUCS and the Turku polytechnic in the autumn 2000 and it was a part of TUCS during 2002-2003. From the beginning of 2004 the centre will be part of ICT Turku Oy. The mission of the centre is to bridge the requirements of IT-companies' product development with the applied and scientific know-how of the universities and the polytechnic in the area. The centre carries out software development projects together with industry and employs students doing their thesis (both from TUCS and the polytechnic) as project workers. The main competence areas of the Software Development Centre are embedded systems, broadband and computer networks, user interfaces and databases, as well as the quality and methods for practical software production process management.

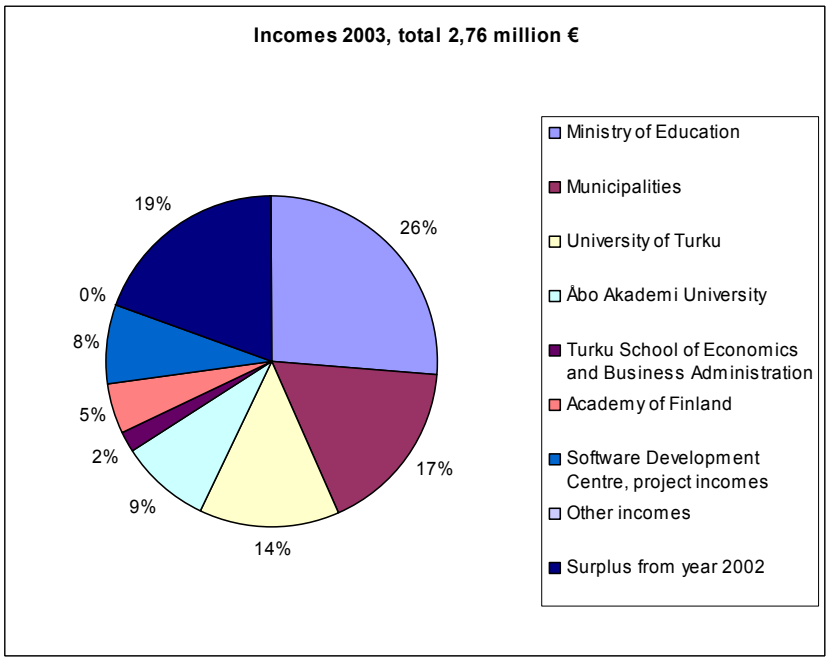
4. Financing

The activities of TUCS are mainly funded by the Ministry of Education, the Academy of Finland, the municipalities and the three universities of Turku: University of Turku, Åbo Akademi University and the Turku School of Economics and Business Administration.

The total funding for 2003 was 2,76 million euros (including the surplus from 2002). The Ministry of Education financed 28 Ph.D. student positions and the Academy of Finland financed three postdoctoral researcher positions. The Academy of Finland also appropriated TUCS 31.000 euros for researcher training courses (TUCS short courses) and for Ph.D. students' conference trips. The appropriation from the Ministry of Education covered 26 % of the total funding and the appropriation from the Academy of Finland 5 %.

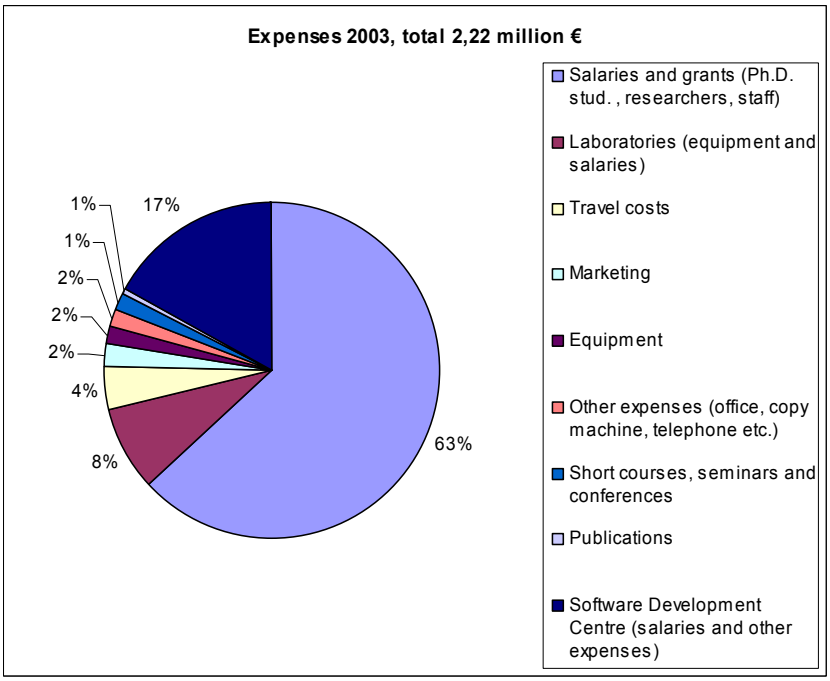
The appropriation from the municipalities was 473.000 euros or 17 % of the total funding. The participating municipalities were Turku, Salo, Raisio, Kaarina, Naantali, Lieto and Uusikaupunki.

The surplus from year 2002 covered a substantial amount of the total funding, a total of 19 %.



The total expenses for year 2003 were 2,22 million euros. Salaries and grants expenses (for Ph.D. students, Post Doc researchers, TUCS research fellow and TUCS Staff) were 63 % of the total. The laboratories spent 8 % of the total and 4 % was used on travel costs.

Projects belonging to the Software Development Centre, which is a joint research laboratory of the TUCS, are included in the total expenses. The total expenses of these projects were 17 % of the total. The surplus 2003 was about 534.000 euros.



5. Research

During 2003 there were 16 independent research laboratories and three centres within TUCS. The laboratories are involved in specific research projects, which are most often financed by the Academy of Finland (basic research), TEKES (industrial applied research), EU or directly by industry. The laboratories provide supervision for both Ph.D. and M.Sc. students, they are responsible for teaching advanced level courses within their own specific research area and they may also offer postdoctoral positions.

5.1 Independent Laboratories

5.1.1 Algorithmics Laboratory

There are altogether 23 members of the Algorithmics Laboratory: five professors, three senior researchers and 15 doctoral students. The laboratory is part of the department of Information Technology. In 2003 the laboratory got external funding from industry and Tekes for a total amount of 41.500 euros.

Laboratory Leaders:
Professor Risto Lahdelma (industrial algorithms)
Professor Olli Nevalainen (industrial algorithms, data analysis)

Professors:
Timo Knuutila (industrial algorithms, logic programming)
Ville Leppänen (programs, software)
Jukka Teuhola (data mining)

5.1.1.1 Background and Mission

The research laboratory of algorithmics has been organized to support the research on design and analysis of efficient algorithms in TUCS. Our mission is to develop efficient algorithms for Finnish industry. Our research covers both theory and applications. While many of the interesting problems are hard to solve to optimality, practical solutions can often be found by novel problem solving techniques relying on combinatorial optimization, parallelization, and heuristic and approximative techniques.

The laboratory has been formed around the research activity of five senior researchers in the field. This increases the coverage of the broad topic. Recently, advanced programming and software techniques along with research on computer games have become active research topics besides core algorithmics.

5.1.1.2 Research

The research can be divided into the following areas:

Industrial Algorithmics

The laboratory works currently in co-operation with Valor Finland, Kone Oyj, Teleste and Process Vision. Production control problems of electronics industry have been solved during the last 15 years. The main goal is to develop efficient methods for the assembly of printed circuit boards with automated placement machines. The tools in use include the whole spectrum of algorithmic techniques ranging from 0/1-programming and constraint logic programming to heuristics.

A wide spectrum of industrial control, planning and decision-making problems can be solved using stochastic modelling, analysis and optimization techniques. Applications range from off-line systems for supporting strategic decision-making to on-line systems relying on embedded algorithms.

Data Analysis and Signal Processing

The group works in co-operation with numerous research laboratories, including the Turku Centre for Biotechnology, the Department of Pathology, the Department of Plant Physiology, and the Department of Medical Physiology, all at the University of Turku.

Methodologies for biological arrays have been developed, c.f. micro-array, and 2-D differential display and MS/MS- spectrometry. The group has participated in several research projects concerning the gene level data analysis of diseases (breast cancer, colon cancer, diabetes, asthma).

Data Mining

The group has developed algorithms for discovering frequent patterns from quantitative relational data sets and for solving the discretization of quantitative domains. The algorithms have been generalized to fuzzy intervals of attribute values.

Parallel Processing

During the year we have studied distributed shared memory implementation influenced routing problems. Focus has been on writing a survey on thinning protocols.

Software Techniques

The group has continued studying methods to improve software quality by introducing OO mechanisms that can be used to guarantee object integrity.

Computer Games and Graphics

The group has worked and published papers on the algorithmic and networking problems present in computer games. The two main foci have been reducing the effect of network limitations in multiplayer games and solving real-time deci-

sion-making problems. In computer graphics, the main results are related to fast computation of shadows and visibility in a 3D space.

String Algorithms
The group has developed fast algorithms for finding the longest common subsequence of strings, which is a fundamental task in many applications that need to measure the similarity of sequences.

5.1.1.3 Future goals
The research laboratory is following the modern trends in algorithmics. Previous research has concentrated on fast and powerful heuristics. Recent increase of computer power has enabled exact algorithms even for problems of practical size. Development of approximation algorithms for hard problems is also one of the new directions in the field. Among near future goals is also to study mobile and distributed software related issues, like game applications, security issues, and component techniques. The laboratory follows up-to-date programming and software techniques.

5.1.1.4 Selected Publications
During 2003 the laboratory published 49 publications (two chapters in books, 21 articles in journals, one doctoral thesis, nine articles in conference proceedings, 15 technical reports, and one miscellaneous).

Smed, J., Johnsson, M., Johtela, T. & Nevalainen, O.: Techniques and applications of production planning in electronics manufacturing systems. In Cornelius T. Leondes, editor, *Manufacturing Processes, volume 5 of Computer Aided and Integrated Manufacturing Systems*, chapter 1, pages 1–48. World Scientific Publishing, New Jersey, NJ, 2003.

Aittokallio, T., Kurki, M., Nikula, T., West, A., Lahesmaa, R. & Nevalainen, O.: Computational strategies for analyzing data in gene expression microarray experiments. *Journal of Bioinformatics and Computational Biology*, 1(3): 541–586, 2003.

Alhoniemi, E.: Simplified time series representations for efficient analysis of industrial process data. Artificial Intelligence for Engineering Design, *Analysis and Manufacturing*, 17(2): 103–114, 2003.

Codrea, M.C., Aittokallio, T., Keränen, M., Tyystjärvi, E. & Nevalainen, O.S.: Feature learning with a genetic algorithm for fluorescence fingerprinting of plant species. *Pattern Recognition Letters*, 24(15): 2663–2673, 2003.

Kangas, J., Hokkanen, J., Kangas, A., Lahdelma, R. & Salminen, P.: Applying stochastic multicriteria acceptability analysis to forest ecosystem management with both cardinal and ordinal criteria. *Forest Science*, (49): 928–937, 2003.

Kivijärvi, J., Fränti, P. & Nevalainen, O.: Self-adaptive genetic algorithm for clustering. *Journal of Heuristics*, 9(2): 113–129, 2003.

Lahdelma, R., Miettinen, K. & Salminen, P.: Ordinal criteria in stochastic multi-criteria acceptability analysis. *European Journal of Operational Research*, (147): 117–127, 2003.

Rosengren, A., Salmi, J., Aittokallio, T., Westerholm, J., Lahesmaa, R., Nyman, T. & Nevalainen, O.: Comparison of PDQuest and progenesis software packages in the analysis of two-dimensional electrophoresis gels. *PROTEOMICS*, 3(10): 1936–1946, 2003.

Smed, J., Kaukoranta, T. & Hakonen, H.: Networking and multiplayer computer games – the story so far. *International Journal of Intelligent Games & Simulation*, 2(2): 101–110, 2003.

5.1.2 Bioinformatics Laboratory

There are altogether 14 members of the Bioinformatics Laboratory: one professor, three senior researchers and ten doctoral students. The laboratory is part of the department of Information Technology. In 2003 the laboratory got external funding from industry and Tekes for a total amount of 191.100 euros.

Laboratory Leader:
Professor Tapio Salakoski

5.1.2.1 Background and Mission

The laboratory was established in 2000 as a joint initiative of TUCS and the Turku Centre for Biotechnology. The laboratory conducts and organizes interdisciplinary research and education in the field of bioinformatics and Bio-ICT.

5.1.2.2 Research

Current research projects include the development of bioinformatics databases, tools, and analysis methods for gaining better insight into cellular signaling and metabolic networks; text mining of scientific literature for knowledge discovery and information management; and the design and implementation of mobile services based on existing bioinformatics resources on the Internet. The main collaborators include Turku Centre for Biotechnology, Institute of Medical Technology, University of Tampere, and Karolinska Institutet, Stockholm. Recently, the laboratory has been active in establishing the Language Technology Cluster, a national initiative coordinated by the laboratory in collaboration with the TUCS Communication Systems laboratory and Fonetics laboratory at University of Turku. In addition to the academic collaborators, most of the current projects in-

clude several industrial partners, both software and pharmaceutical companies. A majority of the research is conducted on an external funding base.

5.1.2.3 Future Goals

A main goal for the near future is to establish the current bioinformatics education by launching a MSc degree programme. The current good level of external research funding is sustained and increased further. Collaboration with other TUCS laboratories and other academic and industrial parties will have a high priority also in the future.

5.1.2.4 Selected Publications

In the field of bioinformatics, five manuscripts were submitted to international scientific series out of which none came out in 2003.

5.1.3 Biomathematics Laboratory

There are altogether 14 members of the Biomathematics Laboratory: one professor, eight senior researchers and five doctoral students. The laboratory is part of the department of Mathematics. In 2003 the laboratory got external funding from the Academy of Finland for a total amount of 224.800 euros.

Laboratory Leader:
Professor Mats Gyllenberg

5.1.3.1 Background and Mission

Mathematical modelling has become increasingly important in many branches of biology. The dynamical consequences of even quite simple ecological interactions or physiological mechanisms are impossible to understand without mathematical modelling and analysis. Evolutionary biology relies on modelling to study phenomena that may take too long time to be directly observable. The rapidly developing techniques of molecular biology and genetics produce a large amount of data, which need efficient computer algorithms to be handled. The classification and automatic identification of micro-organisms using molecular sequence data are tasks that need sophisticated mathematical models and computer algorithms to be successful.

5.1.3.2 Research Projects and Future Goals

Adaptive dynamics

The theory of adaptive dynamics provides a framework for modelling evolution by natural selection in complex ecological systems. Adaptive dynamics originated from integrating and extending concepts and techniques from evolutionary game theory are proved to be very successful in more than 50 applications to various ecological settings. Contrary to the essentially static view of evolutionary game theory, adaptive dynamics puts special emphasis on dynamical phenomena,

such as the origin and divergence of new species (or within-species diversity) by evolutionary branching, or evolution to extinction. Currently, intense research is devoted to developing its mathematical foundation so that the range of applications significantly increases. Concrete applications in our focus are the evolution of dispersal and of ecological specialisation in metapopulations, evolutionary arms races and evolution in predator-prey systems.

Structured population dynamics
Modelling structured populations starts on the individual level, where one models mechanisms of survival, reproduction, foraging etc. The model is then lifted to the population level (this is usually a matter of straightforward book-keeping). It is the task of the mathematician to find a framework, in which this procedure leads to a well-defined (infinite-dimensional) dynamical system, and to develop a qualitative theory for this class of dynamical systems. Special interests are to connect the theory of structured populations to the theory of adaptive dynamics and to characterise species coexistence with possible limits to biodiversity.

Coexistence and evolution in plant-endophyte systems
Endophytes are fungi, which live in the tissues of agriculturally important grasses. By producing toxins, endophytes make the host plant inedible to cows and other vertebrate grazers, and therefore they appear to be symbionts. However, the occurrence of endophytes is strongly variable in natural populations, which hints at possible costs and disadvantages of the infection. In a joint project with Dr. Kari Saikkonen (MTT Agrifood Research Finland), we develop models to understand (i) the dynamics of endophyte infection within an individual plant and (ii) the dynamics of infection in structured plant populations.

Analysis of respiratory data with applications to diagnosis of sleep-disordered breathing
Sleep-disordered breathing (SDB) is a partial or complete collapse of the upper airway leading to medical conditions such as sleep apnea or heavy snorer's disease. The aim of the project is to characterize the human cardiorespiratory system as an interaction between the respiratory system (lungs and airways), the cardiovascular system (heart, arteries, capillaries and veins) and their central nervous system controllers, in particular with respect to the presence or absence of a dynamic upper airway collapse during sleep. The model uses differential equations to describe the upper airway performance and the CO_2 transport in the body. It can be used both to gain insight into the pathophysiology of SDB and to predict the outcome of medical treatment options in different conditions. The project benefits from collaboration with medical researchers and with the Department of Information Technology.

Mathematical taxonomy of micro-organisms
Microbiologists have traditionally applied hierarchical clustering algorithms as their mathematical tool of choice to unravel the taxonomic relationships between micro-organisms. However, the interpretation of such hierarchical classifications

suffers from being subjective, in that a variety of ad hoc choices must be made during their construction. One of the main goals of this project is to develop objective methods for the classification and identification of micro-organisms. In bacterial taxonomy, the taxonomic system is continuously updated as new bacteria are discovered, which poses the problem of inductive learning. Since the data bases are vast and there are many different ways to present them, machine learning, neural networks and information theory are used to compress bacterial data. From an information theoretical point of view, classification can be considered as a method of encoding information about the data and the ultimate goal is to achieve the briefest possible recording of information. Machine learning systems and neural networks are ideally suited to classification problems in which an item described by a number of features is required to be classified as belonging to one of a number of categories. A new classification and identification method, based on minimization of stochastic complexity, has been developed and successfully applied to the taxonomies of Enterobacteriaceae and Vibrionaceae.

Modelling and identification of microbial population dynamics
The main goal of the project is to find the right balance between simplicity and complexity in a class of nonlinear ODE models that describe aerobic and anaerobic wastewater treatment processes, and to investigate structural and practical identifiability, sensitivity, and optimal experimental design for parameter estimation. The future work on anaerobic wastewater treatment is related to design of different control strategies.

Protein-ligand interactions: rules for molecular recognition from mathematical modelling of protein structural data
Protein molecules in living organisms function in their three-dimensional state by recognition of other molecules, called ligands. The specific recognition of ligands requires a rough geometrical match between the surfaces of the protein and ligand molecules. However, the chemical complementarity, or fit, between the binding site and the ligand is the most important factor enabling highly specific recognition of ligand molecules. The chemical fit involves many weak noncovalent interactions at the atomic level of the molecules, such as hydrogen bonding and hydrophobic interactions. Moreover, the protein atoms and the ligand atoms can form cohesive networks of interactions so that several atoms from several sites simultaneously contribute to a molecular interaction. Consequently, it is of major importance to characterize and predict molecular interactions with mathematical models. This is a joint project with ÅA Department of Biochemistry and Pharmacy and the Department of Mathematics of Linköping University.

5.1.3.3 Selected Publications

During 2003 the laboratory published 26 publications including 15 articles in journals and one technical report.

T. Aittokallio, M. Gyllenberg, T. Saaresranta and O. Polo, Prediction of inspiratory flow shapes during sleep with a mathematical model of upper airway forces. *Sleep*, vol. 26, pp. 857-863, 2003.

T. Aittokallio, M. Kurki, T. Nikula, A. West, R. Lahesmaa and O. S. Nevalainen, Computational strategies for analyzing data in gene expression microarray experiments. *Journal of Bioinformatics and Computational Biology*, vol. 1, pp. 541-586, 2003.

O. Diekmann, M. Gyllenberg and J.A.J. Metz, Steady state analysis of structured population models. *Theoretical Population Biology* vol. 63, pp. 309-338, 2003.

M. Gyllenberg, F.J.A. Jacobs and J.A.J. Metz, On the concept of attractor for community-dynamical processes. II. The case for structured populations. *Journal of Mathematical Biology*, vol. 47, pp. 235-248, 2003.

É. Kisdi and S.A.H. Geritz, Competition-colonization trade-off between perennial plants: Exclusion of the rare species, hysteresis effects, and the robustness of coexistence under replacement competition. *Evolutionary Ecology Research*, vol. 5, pp. 529-548, 2003.

S. Q. Liu and L. S. Chen, Necessary-sufficient conditions for permanence and extinction in Lotka-Volterra system with distributed delays. *Applied Mathematics Letters*, vol. 16, 911-917, 2003.

K. Parvinen, U. Dieckmann, M. Gyllenberg and J.A.J. Metz, Evolution of dispersal in metapopulations with local density dependence and demographic stochasticity. *Journal of Evolutionary Biology* vol. 16, 143-153, 2003.

Rantanen, V-V., Gyllenberg, M., Koski, T., and Johnson, M.S., A Bayesian molecular interaction library. *Journal of Computer-Aided Molecular Design* vol. 17, 435-461, 2003.

T. Saaresranta, T. Aittokallio, P. Polo-Kantola, H. Helenius and O. Polo, Effect of medroxyprogesterone on inspiratory flow shapes during sleep in postmenopausal women. *Respiratory Physiology & Neurobiology* vol. 134(2), 131-143, 2003.

Y. Wang and X. Zhao, Convergence in monotone and subhomogenous discrete dynamical systems on product Banach spaces. *Bull. London Math. Soc*. vol. 35, pp. 681-688, 2003.

5.1.4 Discrete Mathematics for Information Technology Laboratory

There are altogether 35 members of the Discrete Mathematics for Information Technology Laboratory: two emeritus professors, three professors, eight senior researchers, five younger researchers, and 17 doctoral students. The laboratory is part of the department of Mathematics. In 2003 the laboratory got external funding from the Academy of Finland for a total amount of 284.500 euros.

Laboratory Leader:
Professor Juhani Karhumäki

Emeritus Professors:
Academician Arto Salomaa
Aimo Tietäväinen

Professors:
Magnus Steinby
Jarkko Kari

5.1.4.1 Background and Mission

The laboratory continues the research traditions of the Department of Mathematics at the University of Turku. The two research groups are Automata Theory and Coding Theory groups. In addition a more applied group searching for connections to high tech industry works on cryptography and coding theory. Recently a clear emphasis has been on combinatorics on words. Our research is, and has always been, strongly internationally oriented.

5.1.4.2 Research

The research done by the automata theory group is basic research on automata theory, combinatorics on words and models of computing. More concretely, the actively studied problems are e.g. tilings of the plane, decidability questions in automata and words, combinatorial problems on words, such as periodicity and dimension properties, and quantum computing. Problems related to DNA, especially from the point of view of computing, are also topics of the group. The research topics in coding theory include space-time codes, sequences and identifying codes.

The research is mainly supported by the Academy of Finland. The group had two academy researchers in 2003, one post doc researcher and one senior scientist. In addition, the research is supported by three projects: Automata Theory and Combinatorics on Words with Applications (1.1.2001-31.12.2003), Coding Theory and Combinatorics (1.8.2002-31.12.2005), and Finite Automata in Digital Image Processing (1.1.2003-31.12.2006). The group arranged the 4th International Conference on Words in September 2003. It attracted almost 100 experts of the field

– more than 50 per cent more than the previous meetings – and the selected papers will be published as a special issue of Theoretical Computer Science.

5.1.4.3 Future Goal

The high level basic research will be the main goal also in the future. We will have a new post doc position in 2004 and at the end we plan to hire two more post doc researchers, one from China and another from Russia. The main source of funding is the project from Academy of Finland (Words, Automata and Computing, 1.1.2004-31.12.2007, 200.000 EUR, J. Karhumäki). In the summer 2004 the group will organize the prestigious ICALP Conference (31st International Colloquium on Automata, Languages and Programming) jointly with LICS (19th Annual IEEE Symposium on Logic in Computer Science) and 11 satellite workshops. It is expected that more than 300 researchers from all over the world will attend these conferences. The main award in theoretical computer science – the Gödel Prize – is delivered in this event.

5.1.4.4 Selected Publications

During 2003 the laboratory published 68 publications (two books, 24 articles in journals, twelve articles in conference proceedings, and 30 submitted papers).

Juhani Karhumäki, Michel Latteux and Ion Petre, The commutation with codes and ternary sets of words, *Proceedings of STACS, LNCS 2607*, pp. 74-84, 2003.

Jean Berstel, Juhani Karhumäki, Combinatorics on words: a tutorial, *Bulletin of the EATCS* 79, pp. 178-229, 2003.

Juhani Karhumäki, Automata on Words, *CIAA 2003, LNCS 2759*, pp. 3-10, 2003. Invited talk.

Juhani Karhumäki, Leonid Lisovik, The equivalence problem for finite substitutions on ab*c, with applications, *IJFCS 14*, pp. 699-710, 2003.

Jarkko Kari, Infinite snake tiling problems, *Proceedings of DLT'2002, LNCS 2450*, pp. 67-77, 2003. Invited talk.

Tero Harju, Juhani Karhumäki (eds.), WORDS'03, Proceedings of 4th International Conference on Combinatorics on Words, *TUCS General Publication No 27*, 2003.

Iiro Honkala, Tero Laihonen, On the identification of sets of points in the square lattice, *Journal of Discrete and Computational Geometry*, 29, pp. 139-152, 2003.

Sanna Ranto, Optimal linear identifying codes, *IEEE Transactions on Information Theory*, 49, pp. 1544-1547, 2003.

Petri Rosendahl, On the identification of vertices using cycles, *Electronic Journal of Combinatorics* 20, no 1, Research Paper 7, 2003.

Tero Harju, Dirk Nowotka, About Duval's conjecture, DLT 2003, LNCS 2710, pp. 316 – 324, 2003.

5.1.5 Health and Medical Informatics Institute

There are altogether eleven members of the Health and Medical Informatics Institute: five professors and six doctoral students. The Laboratory is shared between the department of Information Technology and the Institute of Information Systems Sciences. In 2003 the laboratory got external funding from industry and Tekes for a total amount of 35.100 euros as well as from other external parties for an amount of 9.000 euros.

Laboratory Leader:
Professor Timo Järvi

Professors:
Eija Karsten
Olli Nevalainen
Markku Nurminen
Reima Suomi

5.1.5.1 Background and Mission

The Institute coordinates research and education in the areas of health and medical informatics. Involved are University of Turku and Turku School of Economics and Business Administration.

5.1.5.2 Research

Yearly some 15-20 projects are performed, most of them in co-operation with health care organizations active in the Turku area or nationally.

Eija Karsten and Reima Suomi have together with Jarmo Tähkäpää have run a minitrack on health care informatics issues in Hawaii International Conference on System Sciences 2004, and this will be repeated year 2005.

5.1.5.3 Future Goals

The Institute will deepen its research and education activities. Especially large research projects, which would allow for multidisciplinary and timely extended work, are looked for. For autumn 2004 a master level course on health and medical informatics is planned.

5.1.5.4 Selected Publications

Liang, Jianming, Järvi, Timo, Kiuru, Aaro, Kormano, Martti, Svedström, Erkki, Dynamic Chest Image Analysis: Model-Based Perfusion Analysis in Dynamic Pulmonary Imaging. *EURASIP Journal on Applied Signal Processing*, No 5, 437-448, 2003.

Suomi, Reima and Tähkäpää, Jarmo, Establishing a Contact Centre for Public Health Care. In Sprague, Ralph H. Jr, (Ed.), *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS-36)* 6-9.1.2003 Big Island, Hawaii, 2003.

Suomi, Reima and Tähkäpää, Jarmo, Governance Structures for IT in Health Care. In Wim Van Grembergen (Ed.), *Strategies for Information Technology Governance*, pages 357-381, Idea Group Publishing, 2003.

5.1.6 High Performance Computing and Communication Laboratory

There are altogether 4 members of the High Performance Computing and Communication Laboratory: one professor, two senior researchers and one doctoral student. The laboratory is part of the department of Computer Science, Åbo Akademi University.

Laboratory Leader:
Professor Jan Westerholm

5.1.6.1 Background and Mission

The laboratory conducts research in both software and hardware related issues in high performance computing. Traditionally this has been the study of parallel systems, but here the concept of high performance computing has been enlarged to contain any computationally intensive system where, due to hardware or software limitations, the cost of computation in time, memory, power, etc., becomes unacceptably high. The focus of our studies is on the performance of computer systems.

5.1.6.2 Research

Parallel cluster on a shoestring
The laboratory has designed and built a parallel workstation cluster of about 20 nodes. The design of the cluster is optimized for cost/performance ratio. It will initially be used for Monte Carlo simulations of a Heisenberg quantum spin model.

Shadows in computer graphics
We investigate algorithms for shadows in dynamical environments.

5.1.6.3 Selected Publications

Zhou, Xinrong, A Greedy I/O Scheduling Method in the Storage System of Clusters *TUCS Technical Report,* No 506, 2003

5.1.7 Laboris Information Systems Laboratory

There are altogether eleven members of the Laboris Information Systems Laboratory. In 2003 the laboratory got external funding for a total amount of 121.300 euros.

Laboratory Leader:
Professor Markku Nurminen

5.1.7.1 Background and Mission

Laboris was established 1993 in order to promote research on organisational usability (exploitability) of information systems and other ICT artefacts. LABOR means work and IS stands for information systems. Both basic and applied research is conducted, they often take the form of contract research and product development.

5.1.7.2 Research

Two research projects in the health care sector in collaboration with Turku City were finished, one on organisational implementation and another on diversified work practices in the use of IS. The most important achievement was the setting up of a "traditional" usability laboratory, equipped with hardware and software for running basic usability tests and analysing video and audio material. The laboratory was financed by TUCS, Department of Information Technology, IAMSR and Laboris. The laboratory will be used in student projects and research projects.

5.1.7.3 Future Goals

The future goals are to improve the applicability and transferability for dissemination of research results on organisational exploitability, organisational implementation and usability of ICT artefacts in organisations and working life.

5.1.7.4 Selected Publications

During 2003 the laboratory published ten publications (one journal article, six articles in conference proceedings, one conference proceeding, one technical report and one licentiate thesis).

Heikkilä, Jukka, Vahtera Hannu, & Reijonen, Pekka. Beliefs and perceptions on IOS adoption on a supply network. In the *Electronic Proceedings of the 26th In-*

formation Systems Research Seminar in Scandinavia (IRIS 26). Haikko Manor, Finland, 9-12 August 2003. (CD-ROM disc)

Heikkilä, Jukka, Vahtera, Hannu, & Reijonen, Pekka, Taking organizational implementation seriously: The case of IOS implementation. In the *Proceedings of IFIP 8.6. Working Conference: "The diffusion and adoption of networked information technologies"*, October 6 – 8, 2003, Elsinore, Denmark.

Järvi, Timo & Reijonen, Pekka (Editors), People and computers: Twenty-one ways of looking at information systems. TUCS General Publication, No. 26, June 2003. 345 pages.

Koivisto, Juha, Aaltonen, Satu, Nurminen, Markku I. & Reijonen, Pekka, Työkäytäntöjen yhtenäisyys tietojärjestelmän käyttöönoton jälkeen - Tapaustutkimus Turun terveystoimen kotisairaanhoidosta. *Työsuojelurahaston projektin numero 103153 loppuraportti*. 88 sivua. 30.12.2003.

5.1.8 Microelectronics Laboratory

There are altogether eleven members of the Microelectronics Laboratory: one professor, six senior researchers and four doctoral students. The laboratory is part of the department of Information Technology.

Laboratory Leader:
Lecturer Risto Punkkinen

Professor:
Ari Paasio

5.1.8.1 Background and Mission

Electronics and Information technology (started 1986) belonged up to 2001 to the department of Applied Physics and later to the new department of Information Technology. The microelectronics laboratory was established in 1990. The purpose of the laboratory is to teach and carry out scientific research mainly in the field of micro and in nano technology.

5.1.8.2 Research

The laboratory has a semiconductor processing equipment (CDV, etching, sputtering and lithography) aimed for pilot projects in science and industry. One of the main interests is the development of (Si/SiOx) structures on silicon wafer for light production by electroluminescence (EL) to achieve light emitting structures with normal IC technology. The laboratory's finding of the narrowed EL spectrum when the electric current density is increased, was the first one in the world. Similar behaviour is found in lasers. So far the main emphasis is on enhancing of

the EL intensity by structures with small surface area and higher current density and preparing a LED. We have cooperation with the University of Helsinki and Helsinki University of Technology. Applications in sensor technology (particle detectors) are other interests.

The laboratory is a leader in the research field of electronic implementations of massively parallel mixed-mode array processors. The implementation theory is heavily modified from the original Cellular Nonlinear Network (CNN) concept in order to achieve large integration density. The research in the laboratory consists of all aspects of array processing ranging from small processing primitives in hardware through the whole system implementation and covers also algorithm development for image processing using these arrays. Also few patents have been applied from this research field. A very close cooperation is done with the Electronic Circuit Design Laboratory (ECDL) at the Helsinki University of Technology (HUT).

System on package design: Packaging technology and design is an emerging area in the laboratory. Since physical architecture of interconnects and integrated circuits rapidly is gaining significance, greater attention has to be directed to signal path optimization, crosstalk and interconnect design. The laboratory is collaborating with the Royal Institute of Technology (KTH – Stockholm).

5.1.8.3 Future Goals

The construction of an electrically driven silicon solid state laser based on electroluminescent Si/SiOx active layer and a proper resonator is the ultimate goal. At least a resonance LED from silicon/silicon oxide seems possible. The structures are suitable for small electrically driven light sources with low operation voltage (below 5 V). Integration on silicon makes these light sources ideal for demanding future purposes. The first real Si-based optoelectronics applications are just emerging on the markets.

There are three primary research goals of in the field of CNNs. The first is a long range goal in designing processor arrays using nano technology (see ITRS roadmap). The second goal is to seek a large variety of application fields that can benefit from great processing power and generate processing algorithms for these fields. The final goal is to continue the research in shrinking the processor size using conventional CMOS while still maintaining high performance also in analog processing.

5.1.8.4 Selected Publications

During 2003 the laboratory published 17 publications (two articles in journals and 15 articles in conference proceedings).

Suominen, Tanja and Paturi, Petriina and Huhtinen, Hannu and Heikkilä, Lauri and Hedman, Hannu-Pekka and Punkkinen, Risto and Laiho, Reino: Conducti-

vity and Distribution of Charge on Electroluminescent Si/SiO2 Structures Investigated by Electrostatic Force Microscopy, *Applied Surface Science*, 2003.

Peltonen, Teemu and Tjukanoff, Esa and Järvinen, Jarno and Vasilyev, Sergey: A Fabry-Perot Cavity for Millimeter Wave ESR Detection of Hydrogen Atoms at Low Temperatures, In J. Mallat, A. Räisänen and J. Tuovinen (editors), *3rd ESA Workshop on Millimeter Wave Technology and Applications*, WPP-212, pp. 447-452, European Space Agency, 2003.

Heikkilä, Lauri and Punkkinen, Risto and Hedman, Hannu-Pekka: Electroluminescence in Si/SiO2 Layers. In L. Pavesi et al. (editors), *Towards the first silicon laser, NATO Science Series, II. Mathematics, Physics and Chemistry*, Volume 93, pp. 55 – 60. Kluwer Academic Publishers, 2003.

Paasio, Ari and Poikonen, Jonne: A Compact CMOS Realization for Nested CNNs, In *European Conference on Circuit Theory and Design*, 2003.

Poikonen, Jonne and Paasio, Ari: Robustness Analysis of a Physical Multi-Nested CNN Implementation, In *European Conference on Circuit Theory and Design*, 2003.

Poikonen, Jonne and Paasio, Ari: An Area-Efficient Full-Wave Current Rectifier for Analog Array Processing. In *International Symposium on Circuits and Systems*,Volume V, pp. 757-760, 2003.

Paasio, Ari and Poikonen, Jonne: An Implementation Oriented Coding System for Nested CNNs. In European Conference on Circuit Theory and Design, 2003.

Talonen, Mikko and Laiho, Mika and Paasio, Ari and Halonen, Kari: 64 x 64 Active Pixel Image Sensor With a 0.18um CMOS Process. In *21st Norchip Conference*, pp. 84-87, 2003

Hedman, Hannu-Pekka and Hirvonen, Mika and Mäkelä, Mikko and Määttänen, Jarmo and Punkkinen, Risto and Suvanto, Lasse: Flip chip -testirakenteen suunnittelu ja prosessointi. In *Elektroniikan valmistus 2003 - Elektroniikan tuotanto- ja pakkaustekniikan konferenssi Porissa 22.-23.5.2003*, Julkaisusarja A, Tampereen teknillinen yliopisto, Porin yksikkö, pp. 158 – 160, 2003.

Koskinen, Lauri and Paasio, Ari and Halonen, Kari: A Novel 3-Neighborhood for Parallel Processor Motion Estimation Implementations. In *21st Norchip Conference*, pp. 141-144, 2003.

5.1.9 Network Economics Institute

There are altogether eleven members of the Network Economics Institute: five professors, two lecturers, two senior research assistants and two research assistants. The laboratory is part of the Institute of Information Systems Sciences. In 2003 the laboratory got external funding from industry and Tekes for a total amount of 27.150 euros as well as from other external parties for an amount of 10.000 euros.

Laboratory Leader:
Professor Hannu Salmela

Professors:
Tapio Reponen
Reima Suomi
Jussi Puhakainen
Seppo Sirkemaa (Pori unit).

5.1.9.1 Background and Mission

The Network Economics Institute studies the utilisation of information and communication technology (ICT) in enterprises and organisations. Since the 1980s the research has focused on the strategic management of information resources, with a special emphasis on the exploitation of digital networks in business. The institute has also long traditions in the area of decision and learning support systems and the management of end-user computing.

5.1.9.2 Research

Most studies conducted within the institute adopt action research as the primary research method. Following the established principles of action research, the researchers aim to contribute both to the practical concerns of organizations in planning and using information systems, and to the goals of information systems research by joint collaboration within a mutually acceptable ethical framework.

Hence, the researchers participate in the planning and development of information systems in organizations and bring their perspective and theoretical knowledge to facilitate the processes. At the same time they aim to create publicly usable methods for planning, developing and using information systems. In the year 2003, the institute carried out approximately ten action research projects. A typical industry project lasted from 6 to 12 months.

The institute will organise the European Conference on Information Systems in 2004, which is one of the leading conferences in the information systems research field. In fall 2003 the conference received close to 500 submissions, out of which 180 were selected. We expect approximately 300 IS researchers and professionals to participate in the conference in next June.

5.1.9.3 Future Goals

Our intention is to continue applied and practice oriented research also in the future. Particular emphasis will be placed on IS strategy formulation and implementation in networked organisations. The objective is also to strengthen the ties with the mobile commerce laboratory in the analysis of business uses of digital networks. The donation that the institute received from Telia-Sonera enabled the establishment of a new professor chair from 2003 to 2005. This provides a good basis for increased research activity and cooperation in this field.

5.1.9.4 Selected Publications

During 2003 the laboratory published 35 publications.

Timo Lainema, Pekka Makkonen: Applying Constructivist Approach to Educational Business Games: Case Realgame. *Simulation & Gaming: An Interdisciplinary Journal of Theory, Practice and Research*., Vol. 34, No. 1, pp. 131-149, 2003.

Salmela, Hannu and Turunen, Pekka, Competitive Implications of Information Technology in the Public Sector: The Case of a City Geographic Information System, *International Journal of Public Sector Management*, 16:1, 8-26, 2003.

Reponen T. (ed), *Information Technology-Enabled Global Customer Service*. Idea Group Publishing, Hershey, USA, 2003.

Suomi, Reima and Tähkäpää, Jarmo, Governance structures for IT in the health care industry. In Van Grembergen, Wim (editor), *Strategies for Information Technology Governance*. IDEA Publishing, 357-381, 2003.

Järveläinen, J., The Impact of Prior Online Shopping Experience on Future Purchasing Channel Choice, In C. Ciborra, R. Mercurio, M. De Marco, M. Martinez and A. Carignani (eds.), *Proceedings of the 11th European Conference on Information Systems*, Naples, Italy, 2003.

Koskivaara E. and B. Back, An Artificial Neural Network Based Decision Support System for Budgeting. *Proceedings of the 5th International conference on enterprise information systems*, Volume 2, Angers, France, April 23-26, pp.108-114, 2003.

Kangas, K and Puhakainen, J., Digital Networks: In Search for Sustainable Competitive Advantage. In *Proceedings of 4th Global Information Technology Management-conference*, Calgary, 2003.

Alaranta, Maria, Valtonen, Tuomas, Isoaho, Jouni, Software for the Changing E-Business – Towards Faster and More Cost-Efficient Development Life Cycle. In

Proceedings of the 3rd IFIP Conference on E-Commerce, E-Business and E-Government, São Paulo, Brazil, September 22–24, pp. 367–379, 2003.

Nissilä, Jussi, Seizing the Opportunities of Open Source: Why Organizations Should or Shouldn't Use Open Source Software, In *Proceedings of 3rd IFIP Conference on eCommerce, eBusiness and eGovernment*, Guarujá, Brazil, September, 2003.

Lainema, Timo. Implications of Constructivism for Computer-Based Learning. In Ciborra, Mercurio, De Marco, Martinez, Carignani (eds.), *Proceedings of the European Conference on Information Systems, New Paradigms in Organizations, Markets and Society*. Universita di Napoli Federico II, 2003.

5.1.10 Telecommunication and Digital Systems Laboratory

There are altogether 24 members of the Telecommunication and Digital Systems Laboratory: three professors, six senior researchers and 15 doctoral students. The laboratory is part of the department of Information Technology. In 2003 the laboratory got external funding from industry and Tekes (47.500 euros), the European Union (146.000 euros) and other external parties (17.800 euros).

Laboratory Leader:
Professor Jouni Isoaho

Professors:
Valery Ipatov
Hannu Tenhunen (visiting, part-time)

5.1.10.1 Background and Mission

The laboratory is responsible for teaching and research of communication systems and digital systems. The target is to develop key enabling technology and competence needed for designing and implementing broadband digital communication and computation systems today and in the future. This includes integration of wireless and wired communication infrastructures with dynamic system implementation techniques and platforms. System design methodologies cover both functional and physical design and modelling issues. Research and teaching activities are strongly integrated. Also, the laboratory has taken a strong role in co-operation and networking within its key areas. The laboratory co-operates actively with Tampere University of Technology and the Royal Institute of Technology, Sweden.

5.1.10.2 Research

In research activities the laboratory has focused on three main issues:

Future communication concepts, systems and applications

- advanced techniques for air interface design for broadband communication
- interactive communication system techniques in hybrid networks
- main system applications: language technology and digital audio

System implementation platforms and design methodologies for digital communication and computation systems

- asynchronous system and component techniques in communication platform design
- physical performance and noise modelling of communication platforms
- functional and physical systems specification techniques and refinement

Nano systems design and implementation techniques

- dynamically reconfigurable error-tolerant array based implementation platforms
- dynamic system design approach for cell array platforms
- concurrent reconfigurable modular communication systems

In topic 1 we are building our profile in communication systems covering the overall infrastructure from content provider to end-user in hybrid networks. In this work we integrate our multidisciplinary University and our partners within TUCS (IT parts in Åbo Akademi University and the Turku School of Business and Administration) towards common goals to build up enablers needed for extensive use of digital media. In communication system concept studies we use several different perspectives in addition to technical aspects e.g. business models, regulation aspects and human behaviour. In topic 2 we are researching key issues needed to design and implement communication platforms using DSM VLSI technologies. These issues cover functional and physical design methodological issues needed to ensure correct functionality of very complex digital systems. In functional system design issues we are doing active co-operation with Distributed systems laboratory at Åbo Akademi University. In physical system design issues we are co-operating with Electronics and computer systems at the Royal Institute of Technology. In Communication platform development we are co-operating actively with Tampere University of Technology.

Activities in topics 1 and 2 are strategically headed towards current systems, standards and technologies while in topic 3 these issues are integrated when targeting future nano scale technologies. Reseach issues in topic 3 cover communication algorithms, system design methodology and implementation platforms needed when implementing digital communication and computation systems in nano or organic technologies. Topics 2 and 3 are covering in principle the same

topic, but having different time-scales. Therefore main focus and research issues are also clearly different. In topic 3 the principal target is to develop algorithms, design methodologies and system platforms coherently towards future application needs and implementation technologies. The telecommunication and digital systems laboratory at the University of Turku is the only research unit in Finland, which is coherently approaching problems 2 and 3.

Ongoing projects:

- Communication Platform Architectures for Gigascale Integration (COMPLAIN) TEKES, 2001-2004
- System-on-Chip for Mobile Internet (SoC Mobinet) IST, EU, 2001-2004
- Prompt-to-Implementation (P2I) Parallel processing dedicated, Rapid Optimised Mapping Platform for Telecom applications TO IMPLEMENTATION ITEA programme (EU), Nokia and TEKES

5.1.10.3 Future Goals

The current operative strategy is concentrated on balancing financial structure and establishing strategically important multidiciplinary research and educational co-operation needed for the critical mass. As the focus area two is currently on a nice growing phase, the key technical focus in the construction work is on building up overall competence needed for the focus areas one and three. The future goal is to be among world top laboratories in research and teaching in the all three focus areas presented.

5.1.10.4 Selected Publications

During 2003 the laboratory published 29 publications (one book, five articles in journals, 17 articles in conference proceedings, and six technical reports).

Juha Plosila, Tiberiu Seceleanu, and Pasi Liljeberg. Implementation of a self-timed segmented bus. *IEEE Design & Test of Computers*, 20:44-50, Nov 2003. Special issue on Clockless VLSI Design, 2003.

Imed Ben Dhaou, Mohammed Ismail, and Hannu Tenhunen. Current mode low-power on-chip signaling in deep-submicron technology. *IEEE Transactions on Circuits and Systems, Fundamental Theory and Applications*, 50(3):397-406, 2003.

Sampo Tuuna and Jouni Isoaho. Estimation of crosstalk noise for on-chip buses. In Jorge Juan Chico and Enrico Macii, editors, *Integrated Circuit and System Design - PATMOS 2003 Proceedings*, number 2799 in Lecture Notes in Computer Science, pages 111-120. Springer, Sep 2003.

Johanna Tuominen, Pasi Liljeberg, and Jouni Isoaho. Self-timed approach for reducing on-chip switching noise. In *IFIP WG 10.5 VLSI-SoC 2003*, pages 19-24, Dec 2003

T. Ahonen, T. Nurmi, J. Nurmi, J. Isoaho, Block-wise extraction of Rent's exponents for an extensible processor, *IEEE Computer Society Annual Symposium on VLSI*, Tampa, Florida, USA, February 2003, pages 193-199.

Plosila, J., Sere, K., Waldén, M.: Design with asynchronously communicating components. In Frank S. de Boer, Marcello M. Bonsangue, Susanne Graf, and Willem-Paul de Roever, editors, *FMCO 2002: First International Symposium on Formal Methods for Components and Objects*, number 2852 in Lecture Notes in Computer Science, pages 424–442. Springer-Verlag, 2003.

Valery Ipatov. *Digital Mobile Communications (Tsifrovaya Mobilnaya Sviaz).* Goriachaya liniya - Telecom, 2003. In Russian.

Jarkko Paavola and Valery Ipatov. Binary CDMA signatures for m+n users in n-dimensional global signal space. *IEE Electronics Letters*, 39(9):738-740, May 2003.

Afshin David. Wavelet-Kalman method for image compression. In *ICASSP 2003 - 2003 International Conference on Acoustics, Speech and Signal Processing*, Apr 2003.

Maria Alaranta, Tuomas Valtonen, and Jouni Isoaho. Software for the changing e-business - towards a more rapid and flexible develpoment cycle. In *Proceedings of the Third IFIP Conference on E-Commerce, E-Business and E-Government*, pages 34-50, Sep 2003.

5.2 CREST

The Centre for Reliable Software (CREST) consists of four research laboratories/groups from the department of Computer Science: Distributed Systems Design, Embedded Systems, Mechanised Reasoning, and Software Construction. In 2003 CREST got external funding for the total amount of 848.400 euros: 480.600 euros from the Academy of Finland, 217.700 euros from industry and Tekes, 5.000 euros from EU, and 145.100 euros from other external parties.

5.2.1 Distributed Systems Design Laboratory

There are altogether 15 members of the Distributed Systems Design Laboratory: one professor, one post doctoral researcher, five senior researchers, and eight doctoral students. The laboratory has an active international co-operation with Aalborg, Southampton, Newcastle, McMasters, and Leiden among others.

Laboratory Leader:
Professor Kaisa Sere (Department of Computer Science, Åbo Akademi University)

5.2.1.1 Background, Mission and Research

The Distributed Systems Laboratory, which is part of CREST and the national Centre of Excellence in Formal Methods in Programming, is formed by researchers from Åbo Akademi University, Department of Computer Science and University of Turku, Department of Information Technology.

One of the main research directions within the laboratory is the construction and use of formal specifications, and for this reason, modelling and the analysis of models. The central techniques that we have developed and investigated within this context are model decomposition and feature introduction in layers mainly using the superposition principle. These techniques were formalised within the Action Systems/Refinement Calculus framework by Back and Sere in the early 1990s. The work on modelling has lead to the study of software and systems construction processes with formal specification as a central artefact with very good results. The prime examples of this are our work within the EU FP5 IST Matisse project, lead at our site by Marina Waldén and the recent Ph.D. thesis of Mauno Rönkkö on modelling and analyzing hybrid systems. The work within Matisse is reported in the Matisse Handbook, the main deliverable of the project while the thesis was awarded the title of the best Ph.D. thesis in all computer science in Finland 2001.

Recently, the work on model decomposition has been applied within the field of computer networks. We are investigating the design of reliable peer-to-peer architectures and ad hoc networks as well as other network systems based on these ideas.

In connection to modelling and constructing formal specifications, we have particularly been studying the integration of certain informal (or semi-formal) techniques within the construction process. The Unified Modelling Language, UML, has been central to this as well as the use of hazard and safety analysis techniques. Moreover, within the Matisse project we have investigated the integration of two formal methods within the process, namely that of Action Systems and the B Method of Abrial. The basic reason for this has been the door that has opened to using the quite excellent administration, analysis and proof tools supporting the method.

Component-based systems are becoming more important within our design machinery. We are studying the formal specification and refinement of components, their interfaces and communication protocols. In addition to refinement, software architectural issues are of importance when creating systems based on some library of components. We have been following the s.c. co-ordination ideas here,

separating the correctness issues of components from the efficiency issues of their communication when studying systems and software architectures. These ideas have been particularly important when developing design abstractions for e.g. distributed and mobile components as well as digital circuits.

We have had financial support for our research via two Academy of Finland projects: Asynchronous Design of DSP Architectures 2000-02 and FOSSE: Formal Systems and Software Engineering, 2001-04) as well as EU financing (Matisse: Methodologies and Technologies for Industrial Strength Systems Engineering, 2000-03, ACiD-WG: Asynchronous Circuit Design Working Group, 2000-04) in addition to the Centre of Excellence financing.

5.2.1.2 Future Goals

In the future we plan to continue our work on the above fields. Formal modelling of communication channels in digital circuits and modern system-on-chip designs is one of our central research issues at the laboratory currently.

We have a tradition of validating our methods and techniques with case studies of various sizes. These case studies also give us inspiration for future research. Especially within the Matisse project we have investigated the design of control systems with our industrial partner, a company that manufactures equipment for drug recovery for the pharmaceutical industry. We have been studying both discrete and hybrid control systems. Another important class of case studies comes from the area circuit design. This research is continued and heavily expanded. Here we have recently focused on tools and on modelling communication on circuit boards.

Finally, we have started to investigate different protocols for peer-to-peer networking as well as routing in ad hoc networks and architectural issues of the networks. Safety and reliability as well as QoS and fault tolerance issues in a broader scale will be stressed here as well as more generally.

5.2.1.3 Selected Publications

Lu Yan, Kaisa Sere, and Xinrong Zhou. Peer-to-peer networking with firewalls. *WSEAS Transactions on Computers*, 2:566 - 571, Jul 2003.

Juha Plosila, Kaisa Sere, and Marina Waldén. Design with asynchronously communicating components. In Frank S. de Boer, Marcello M. Bonsangue, Susanne Graf, and Willem-Paul de Roever, editors, *FMCO 2002: First International Symposium on Formal Methods for Components and Objects*, number 2852 in Lecture Notes in Computer Science, pages 424-442. Springer-Verlag, 2003.

Elena Troubitsyna. Developing fault tolerant software using statecharts and FMEA. In N.C. Debnath, G. A. Montejano, and D.E. Riesco, editors, *Proceedings of the International Conference on Computer Science, Software Engineer-*

ing, Information Technology, e-Business, and applications (CSITeA 03), Rio de Janeiro, Brazil, pages 27-33, Jun 2003.

Elena Troubitsyna. Developing fault-tolerant control systems composed of self-checking components in the action systems formalism. In H.D. Van and Z. Liu, editors, *Proceedings of the Workshop on Formal Aspects of Component Software FACS'03*, Pisa, Italy, Sep 2003.

Tomi Westerlund and Tiberiu Seceleanu. Formal analysis of a local segmented bus arbiter. In *Proceedings of the 21st NORCHIP Conference*, pages 268-271, Nov 2003.

Elena Troubitsyna. Integrating safety analysis into formal specification of dependable systems. In *Proceedings of Annual IEEE Workshop on FaultTolerant Parallel and Distributed Systems*. Nice, France, Apr 2003.

Tiberiu Seceleanu and TomiWesterlund. Segment arbiter as action systems. In *Proceedings of IEEE International Symposium on Signals, Circuits & System, SCS*, volume 1, pages 249-252. IEEE, Jul 2003.

Lu Yan and Kaisa Sere. Stepwise development of peer-to-peer systems. In *Electronic Workshops in Computing (eWiC), Proceedings of the 6th International Workshop in Formal Methods (IWFM'03)*. British Computer Society (BCS), Jul 2003.

5.2.2 Embedded Systems Laboratory

There are altogether eight members of the Embedded Systems Laboratory: one professor, two senior assistants, and five doctoral students.

Laboratory Leader:
Professor Johan Lilius (Department of Computer Science, Åbo Akademi University)

5.2.2.1 Background and Mission

The Embedded Systems Laboratory was founded in 2001. It is an outgrowth of the informal embedded systems research group that existed at the Department of Computer Science at Åbo Akademi since 1998. The laboratory's main mission is to improve the methods and techniques used to develop embedded systems.

5.2.2.2 Research

The laboratory is part of the Centre of Excellency for Formal Mehtods in Programming together with the Software Construction (SC) Laboratory and the Dis-

tributed Systems (DS) Laboratory. There are strong ties to the research of these laboratories.

The main research projects in the laboratory are:

Model-Driven-Engineering
In this project we co-operate with the SC laboratory to develop UML based tools and methods for the design of embedded systems. We have extended UML to also deal with Data-flow Diagrams and developed a number of model transformations that together form the starting point of a design flow for embedded systems.

Embedded Java
The focus of this project is to look at how to improve the performance of Java in the context of embedded systems. The focus has been on the development of a tool for static memory usage analysis and on the analysis of the power-consumption of Java programs.

Digital-TV
This research is just starting. On a very practical level we have developed a prototype MHP stack, and are investigating different trans-coding algorithms.

The laboratory has been involved in the organisation of the ACSD 2003 conference in Guimarães prof. Lilius was the Academic PC Chair of the conference. The laboratory has also organised the following 2 workshops in its premises: TTA Workshop 24th Oct 2003, Static Analysis workshop 3rd Nov 2003.

5.2.2.3 Future Goals
The laboratory will continue its work on both Model Driven Engineering and Embedded Java. The main goals here are one the one hand to develop the design flow further and add tool support for it, and on the other hand to develop a static analysis framework for estimating and optimising the memory usage and power consumption of Java programs. The Digital-TV research will also continue in 2004. We are also extending our research to software process improvement.

5.2.2.4 Selected Publications
During 2003 the laboratory published 18 publications (one journal article, six articles in conference proceedings, ten technical reports, and one proceeding).

Marcus Alanen, Johan Lilius, Ivan Porres, and Dragos Truscan. Realizing a model driven engineering process. *TUCS Technical Report No 565*, Turku Centre for Computer Science, Nov 2003.

Ralph Back, Dag Björklund, Johan Lilius, Luka Milovanov, and Ivan Porres. A workbench to experiment on new model engineering applications. In Perdita Stevens, Jon Whittle, and Grady Booch, editors, *UML 2003 - The Unified Modeling*

Language, volume 2863 of Lecture Notes in Computer Science, San Francisco , CA, USA, Oct 2003.

Dag Björklund, Johan Lilius, and Ivan Porres. A unified approach to code generation from behavioral diagrams. In *Proceedings of the Forum on Specification and Design Languages FDL'03*, Sep 2003.

João M. Fernandes. Functional and object-oriented modeling of embedded software. *TUCS Technical Report 512*, Turku Centre for Computer Science, Feb 2003.

Johan Lilius, Felice Balarin, and Ricardo J. Machado, editors. In *Third International Conference on Application of Concurrency to System Design (ACSD'03)*. IEEE Computer Society, 2003.

Johan Lilius, Dragos Truscan, and Seppo Virtanen. Fast evaluation of protocol processor architectures for IPv6 routing. In *Proceedings of Design, Automation, and Test in Europe 2003 (DATE'03)*, Designer's Forum. IEEE Computer Society, Mar 2003.

Dragos Truscan, Seppo Virtanen, and Johan Lilius. SystemC simulation framework of protocol processing architectures for IPv6 routing. In *The International Symposium on Signals, Circuits and Systems SCS 2003*, pages 309–312, Jul 2003.

Dan Österberg and Johan Lilius. Rethinking software updating; concepts for improved updatability. *TUCS Technical Report 550*, Turku Centre for Computer Science, Sep 2003.

Henrik Enqvist and Johan Lilius. Region based allocation in Java. *TUCS Technical Report 510*, Turku Centre for Computer Science, Aug 2003.

5.2.3 Learning and Reasoning Laboratory

There are altogether nine members of the Learning and Reasoning Laboratory: two professors, one senior researcher and six doctoral students. The laboratory is shared between the department of Computer Science and the department of Information Technology.

Laboratory Leader:
Professor Joakim von Wright

Professor:
Tapio Salakoski

5.2.3.1 Background and mission

The TUCS Learning and Reasoning Laboratory co-ordinates research and development activities within formal reasoning, mechanised logic and with educational technology. This includes research in the use of formal reasoning in both computer science and in mathematics, but also the development of rigorous educational technology and the use of these technologies in courses within the departments at TUCS.

5.2.3.2 Research

- Formal and mechanised reasoning, with applications to programming logic
- High-school mathematics: use of structured derivations and logic in mathematics teaching
- Development and use of web-based and other educational technologies in computer science
- Algebraic structures for program refinement

5.2.3.3 Future Goals

- Further research into the use of formal reasoning methods in programming and mathematics
- Further research into teaching methods and educational technology in computer science and mathematics based on logic and rigorous reasoning

5.2.3.4 Selected Publications

The laboratory published 3 publications in 2003.

O. Celiku and J. von Wright: Implementing Angelic Nondeterminism. In *Proceedings of the 10th Asia-Pacific Software Engineering Conference (APSEC 2003)*, 10-12 December 2003, Chiang Mai, Thailand, IEEE Computer Society, 2003.

Orieta Celiku and Annabelle McIver. Cost-Based Analysis of Probabilistic Programs Mechanised in HOL. In *Proceedings of the 15th Nordic Workshop on Programming Theory* , Oct 2003.

Orieta Celiku and Joakim von Wright. Correctness and Refinement of Dually Nondeterministic Programs. *Technical Report 516*, TUCS - Turku Centre for Computer Science, Mar 2003.

5.2.4 Software Construction Laboratory

There are altogether nine members of the Software Construction Laboratory: one professor, two senior researchers and six doctoral students. The laboratory is part of the department of Computer Science.

Laboratory Leaders:
Professor Ralph-Johan Back and Acting Professor Ivan Porres

5.2.4.1 Background and Mission

The research of the laboratory centres on techniques and methods for software construction. This includes software analysis and design methods, programming methods, languages and environments and the software construction process at large. Particular emphasis is put on the construction of highly reliable and functionally correct software systems.

- Programming logics (program correctness, semantics, program refinement)
- Different kinds of programming paradigms (concurrent systems, hybrid systems, interactive systems, etc.)
- Object-oriented programming (methods, theory, semantics, correctness)
- Software development processes and Software process improvement
- Software modelling and model driven development
- Software construction tools

5.2.4.2 Research

Software Platform Construction using Stepwise Feature Introduction (SPROUT): in co-operation with Tampere University of Technology, Academy of Finland, 2001-2003
The SPROUT project studies how to develop software with underspecified, changing or evolving requirements. In this scenario, software features may be introduced stepwise, as soon as the new requirements have been defined. The project aims to define a stepwise feature introduction method for software and a collection of case studies using this method.

Tools for Reliable Software Construction (TORES)
At the Centre of Excellence for Formal Methods in Programming Tekes, 2002-2004. The goal of TORES is to develop a large and well defined part of an advanced environment to model, verify, and implement reliable software-based systems. This project is carried out with the collaboration of the Distributed Systems Laboratory, the Embedded Systems Laboratory and the Mechanized Reasoning Laboratory.

Gaudi Software Factory
The Gaudi Software Factory is our experimental software laboratory. Here is where we put in practice the ideas that emerge from our other research projects. Gaudi is organized as a software production factory: its main and only objective is to build software products that satisfy the requirements specified by a customer.

5.2.4.3 Selected Publications

During 2003 the laboratory published 21 publications (three articles in journals, one doctoral thesis, eight articles in conference proceedings, and nine technical reports).

Ralph-Johan Back and Joakim von Wright. Compositional action system refinement. *Formal Aspects of Computing*, 15(2): 103–117, 2003.

Victor Bos and Jeroen Klein. Redesign of a systems engineering language - formalisation of chi. *Formal Aspects of Computing*, 15(4): 370–389, Dec 2003.

Ivan Porres. A toolkit for model manipulation. *Springer International Journal on Software and Systems Modeling*, 2(4), 2003.

Marcus Alanen and Ivan Porres. Difference and union of models. In Perdita Stevens, Jon Whittle, and Grady Booch, editors, *UML 2003 - The Unified Modeling Language*, volume 2863 of Lecture Notes in Computer Science, pages 2–17. Spinger-Verlag, Oct 2003.

Ralph Back, Dag Björklund, Johan Lilius, Luka Milovanov, and Ivan Porres. A workbench to experiment on new model engineering applications. In Perdita Stevens, Jon Whittle, and Grady Booch, editors, *UML 2003 - The Unified Modeling Language*, volume 2863 of Lecture Notes in Computer Science, San Francisco , CA, USA, Oct 2003.

5.3 IAMSR

The Institute for Advanced Management Systems Research (IAMSR) is a research centre within Åbo Akademi University and TUCS. IAMSR is carrying out theory-driven and applied research in approximate reasoning and fuzzy logic, real options, self-organizing maps and neural nets, interdependent multiple criteria optimization, software agents, mobile and electronic commerce methods and technology, industry foresight methods, scenario technologies, knowledge based support systems and hyper-knowledge.

There are two research laboratories and several small research groups at IAMSR. In 2003 IAMSR got external funding for the total amount of 1.290.900 euros: 1.198.000 euros from industry and Tekes, 62.900 euros from EU, and 30.000 euros from other external parties.

5.3.1 Data Mining and Knowledge Management Laboratory

There are altogether 14 members of the Data Mining and Knowledge Management Laboratory: five professors, one post doctoral researcher and nine doctoral students. The laboratory is shared between IAMSR, the Department of Computer Science, and the Department of Information Technology.

Laboratory Leader:
Professor Barbro Back

Professors:
Kaisa Sere (Department of Computer Science, Åbo Akademi University)
Eija Karsten (Department of Information Technology, University of Turku)
Inger Eriksson-Dickson (North Carolina State University)

5.3.1.1 Background and Mission

At the Data Mining and Knowledge Management Laboratory we focus on research around developing, implementing and evaluating new methods for data mining and knowledge management. We also conduct practical studies in organizations. The laboratory is a joint effort between Åbo Akademi University, the University of Turku and the Turku School of Economics and Business Administration.

Information provided by different computer systems is growing with an increasing rate, day by day. In the last few years, the situation has radically changed for many actors in the business world. Scarcity of information has changed into an overload of information. Information in itself is, however, of no value, it becomes valuable only when it is turned into knowledge. It is obvious that company stakeholders, who can turn the huge amount of available quantitative and qualitative information into working knowledge, will gain a competitive advantage. Information technology has created a huge supply of information. Luckily the same technology also provides us with new tools to manage the information. Computational intelligence is a rather new research paradigm that aims at extracting knowledge from information. It refers to several computing paradigms within soft computing, in particular the use of expert systems, neural networks, and genetic algorithms. Intelligent agents, semantic web and XBRL have become important topics in this research area.

Awards: Iulian Nastac and Adrian Costea won the third prize in the Eunite competition on effective forecasting methods.

5.3.1.2 Research

The **Countess project** has aimed at building advanced computational intelligence into computer-based decision support systems, to be used by different

stakeholders in complex decision situations. The same collection of tools has been applied to different application areas the aim being to turn large amounts of information, quantitative and qualitative data, into knowledge. We have worked in four different areas within business where we have stakeholders that would need decision tools that can turn data into knowledge.

These areas are:

- analytical review processes in auditing
- financial benchmarking
- taxation
- predictions of corporate bankruptcies

Our group uses the constructive research method, i.e., we design and build new prototype systems for business applications. We usually carry out the whole system construction cycle, i.e., we analyze the problem area, we design the system, we program it, validate it, and evaluate its performance in a realistic business environment.

This project has produced a number of international publications on the applicability of computational intelligence in the analytical review process, financial benchmarking, bankruptcy predictions and taxation. The project has produced two licentiate theses. As another concrete result of the project we have produced two prototype systems in the above areas. These could later be further developed into commercial applications in co-operation with interested companies.

The **Gilta-project** focuses on managing large text masses from databases and Internet with new methods - smart encoding, self-organizing maps, and document histograms.

A self-organizing map (SOM) belongs to the family of neural network methods. The network in a self-organizing map usually consists of two layers of neurons: an input layer and an output layer. The neurons in the output layer are usually arranged in a grid and are influenced by their neighbours in this grid. The goal is to automatically cluster the input patterns in such a way that similar patterns are represented by the same output neuron, or by one of its neighbours.

The text is translated into a suitable form for clustering purposes. Before that the text is filtered, i.e. compound words and numbers are treated in a certain way. First a word map is created. The filtered text is encoded word by word. Next, a small neighbourhood of encoded words is taken as input to a second self-organizing process. The small neighbourhood glides step by step over the sentence and produces inputs to the SOM. These inputs produce a sentence map and finally a paragraph map.

We have tested the method on 270 CEOs' reports from 76 different forest companies world-wide. Typically an annual CEO-report includes information in ver-

bal form on company resources, i.e. physical capital resources, human capital resources and organizational capital resources and company outputs, i.e. financial position and profitability, market position, competitive position, manufacturing position and very often a forecast. We have also tested the method on books from the Bible.

The results have been good and a number of articles based on the results so far, have already been published and presented in international conferences.

The project is interdisciplinary and is a joint project between four universities Åbo Akademi University, Data Mining and Knowledge Management Laboratory at TUCS and IAMSR, Tampere University of Technology (Laboratory of Signal Processing), Pori School of Technology and Economics and the University of Helsinki (Department of Linguistics)

The Gilta group continued to work as a group during 2003 within the ViVaBa-project where Metso corporation was the industrial partner and within the 4M-project led by Professor Hannu Vanharanta, Pori School of Technology and Economics.

5.3.1.4 Selected Publications

During 2003 the laboratory published 22 publications (one book chapter, four articles in journals, two doctoral theses, nine articles in conference proceedings, and six technical reports.)

Antonina Kloptchenko, Tomas Eklund, Adrian Costea, and Barbro Back. A conceptual model for a multiagent knowledge building system. In *Proceedings of the 5th International Conference on Enterprise Information Systems* (ICEIS 2003), volume 2, pages 223-228, Apr 2003.

Adrian Costea and Tomas Eklund. A two level approach to making class predictions. In *Proceedings of the 36th Hawaii International Conference on Systems Sciences* (HICSS-36), Jan 2003.

Eija Koskivaara and Barbro Back. An artificial neural network based decision support system for budgeting. In *Proceedings of the 5th International conference on enterprise information systems*, Angers, France, April 23-26, 2003, volume 2, pages 108-114, Apr 2003.

Tomas Eklund, Barbro Back, Hannu Vanharanta, and Ari Visa. Financial benchmarking using self-organizing maps – studying the international pulp and paper industry. In John Wang, editor, *Data Mining: Opportunities and Challenges*, chapter 14, pages 323-349. Idea Group Publishing, 2003.

Adekunle Okunoye and Helena Karsten. Global access to knowledge: Findings from academic organisations in sub-saharan africa. *Information Technology and People*, 16(3), Sep 2003.

Adekunle Okunoye. Implementation and use of global intranet: Case of a distributed international research organisation. In P. Palvia and X. Liu, editors, *Proceedings of 4th Annual Global Information Technology Management World Conference*. Global Information Technology Management Association, Jun 2003.

Adekunle Okunoye. Large-scale sustainable information systems development in a developing country: The making of an islamic banking package. *Annals of Cases on Information Technology*, V:168-183, Jan 2003.

Adekunle Okunoye. Organizational information technology infrastructure in developing countries: A comparative analysis of national vs. international research organizations in two sub-Saharan african countries. *Journal of Information Technology Cases and Applications*, 5(2), Jun 2003.

Tomas Eklund, Barbro Back, Hannu Vanharanta, and Ari Visa. Using the self-organizing map as a visualization tool in financial benchmarking. *Information Visualization*, 3(2):171-181, Sep 2003.

Eija Koskivaara. Visualisation of complex business data: A neural neworks approach. In *16th Bled Electronic Commerce Conference eTransformation*, Bled, Slovenia, June 9-11, 2003, pages 67-69, Jun 2003.

5.3.2 Mobile Commerce Laboratory

There are altogether 15 members of the Mobile Commerce Laboratory: three professors, two senior researchers, eight doctoral students and two research assistants.

Laboratory Leader: Professor Pirkko Walden

5.3.2.1 Background and Mission

The Mobile Commerce laboratory was founded in 2001. The research program started with 3 separate projects on virtual mobile platforms, mobile commerce industry foresight and empirical market studies in Europe and Asia. The laboratory's mission is to find new, effective mobile products and services, which will offer everyday support for individuals in a way which will permanently change their everyday routines. As part of this process the mission is also to create a basis for building a growing and profitable service business on a global scale.

5.3.2.2 Research

The laboratory is working on both (i) theory-oriented research in user interfaces, software agents technology and support systems, and (ii) applied research, which is focused on planning and problem solving with mobile technology applications for and with corporate partners.

The following research objectives have been specified:

- Find, identify potential customer groups for fast-growing value added mobile technology applications
- Design, develop and implement mobile technology solutions for selected customer groups
- Test and evaluate systems solutions for an integrated production and distribution of products and services which are enabled by mobile technology. Find bottlenecks and modify and enhance service capacity with intelligent information systems and agent technology
- Design and test value added user interfaces and user support systems for mobile technology customers
- Find value added services for customer groups and evaluate them; test the service concepts in different potential markets; revise or design services

The main research projects in the laboratory are:

- Mobile technology applications (Tekes)
- Mobile e-Health (Duodecim)
- Mobile Technology Acceptance Models
- Mobile Content Quality (Pär Landor)
- Intelligent Agents and Industry Foresight
- Mobile Solutions for Time Management in Knowledge Work (Anna Sell)
- Enhanced Mobile Solutions for Customer Care (Vaida Kadyte)
- Individual Adoption Processes and the Foresight Approach for Strategy Making (Shengnan Han)
- Mobility in Health Care (Ville Harkke)

5.3.2.3 Future Goals

The laboratory has built and will continue developing a network of research partners in Europe, Asia and North America. It will continue its work on both theory-oriented research in user interfaces, software agent technology and support systems, and applied research, which is focused on planning and problem solving with mobile technology applications for and with corporate partners. There are a number of new research areas continuously being explored and prepared, among these mobile applications in tourism and health care are in active preparation.

5.3.2.4 Selected Publications

During 2003 the laboratory published 30 publications (three articles in journals, eighteen articles in conference proceedings, one book chapter and eight technical reports).

Anckar B., Carlsson C. and Walden P., Factors Affecting Consumer Adoption Decisions and Intents in Mobile Commerce: Empirical Insights, *16th Bled eCommerce Conference*, Bled, Slovenia, June 9-11, 2003.

Anckar B. and Eriksson N., Mobility: The Basis for Value Creation in Mobile Commerce? *Proceedings of the SSGRR Conference*, L'Aquila, Italy, July 28-August 3, 2003.

BenMoussa C., Workers on the Move: New Opportunities through Mobile Commerce, *Proceedings of the IADIS Conference*, Lisbon, Portugal, 2003.

Carlsson C. and Walden P., Going Mobile in the Åland Archipelago – Perceived Barriers and Inhibitors, *Proceedings of the 13th eChallenges Conference*, Bologna, Italy, 22-24 October 2003.

Carlsson C. and Walden P., Mobile Commerce – Empirical Results on Value-Added Products and Services, *Proceedings of the Second mBusiness 2003*, 23/24 June 2003, Vienna, Austria.

Han S., Individual Adoption of Mobile Commerce Products and Services: A Proposed Framework, *Proceedings of the 24th McMaster World Congress*, Hamilton, Ontario, Canada, January 15-17, 2003.

Harkke V., Alessi D. and Collan M., IT and Institutional Constraints: Effects of Legal and Administrative Constraints to Use of IT, *Proceedings of the 36th Hawaii International Conference on System Sciences*, Hawaii, USA, January 6-9, 2003.

Kadyte V., A Consumer Centric Framework for Mobile Services and Applications, *Proceedings of the 13th eChallenges Conference*, Bologna, Italy, 22-24 October 2003.

Kangas K. and Puhakainen J. Digital Networks: In Search for Sustainable Competitive Advantage. *Proceedings of the 4th Global Information Technology Management Conference*, Calgary, Canada 2003.

Landor P., Understanding the Foundation of Mobile Content Quality – A Presentation of a New Research Field, *Proceedings of the 36th Hawaii International Conference on System Sciences*, Hawaii, USA, January 6-9, 2003.

5.3.3. Other selected publications from IAMSR

Carlsson, C., Fedrizzi M. and Fullér, R., *Fuzzy Logic in Management*, International Series in Operations Research and Management Science, Vol. 66, Kluwer Academic Publishers, Boston, November 2003, 296 pages.

Carlsson, C. and Fullér, R., Optimization with linguistic variables, in: J.L. Verdegay ed., *Fuzzy Sets based Heuristics for Optimization,* Studies in Fuzziness and Soft Computing. Vol. 126, Springer Verlag, [ISBN 3-540-00551-X], 2003 113-121.

Alcaraz, F. and Heikkilä, M., Improving Investment Decision Making by Expanding Key Knowledge with Real Option Tools, *Journal of Decision Systems*, Volume 12, 3-4/2003, p. 345-368.

Carlsson, C., Collan, M. and Majlender, P., Fuzzy Black and Scholes Real Option Pricing, J*ournal of Decision Systems*, Vol. 12, No. 3-4, November 2003.

Carlsson, C., Fullér, R. and Majlender, P., A note on constrained OWA aggregations, *Fuzzy Sets and Systems*, 139(2003) 543-546.

Carlsson, C. and Fullér, R., A fuzzy approach to real option valuation, *Fuzzy Sets and Systems*, 139(2003) 297-312.

Collan, M. and Liu, S., 2003, Fuzzy Logic and Intelligent Agents: Towards the Next Step of Capital, *Industrial Management and Data Systems*, Vol. 103, No. 6, p. 410-422.

Fullér, R. and Majlender, P., On weighted possibilistic mean and variance of fuzzy numbers, *Fuzzy Sets and Systems*, 136(2003) 363-374.

Fullér, R. and Majlender, P., On obtaining minimal variability OWA operator weights, *Fuzzy Sets and Systems*, 136(2003) 203-215.

Georgescu, I., Compatible extensions of fuzzy relations, in *Proceedings of The 24th Linz Seminar on Fuzzy Set Theory and Its Applications*, Linz, Austria, February 2003, 133-135.

6. Publications

6.1 TUCS Publication Series

TUCS has four publication series:

TUCS Dissertations

(ISSN 1239-1883) contains doctoral dissertations by researchers affiliated with TUCS.

TUCS Technical Reports

(ISSN 1239-1891) contains technical reports from TUCS.

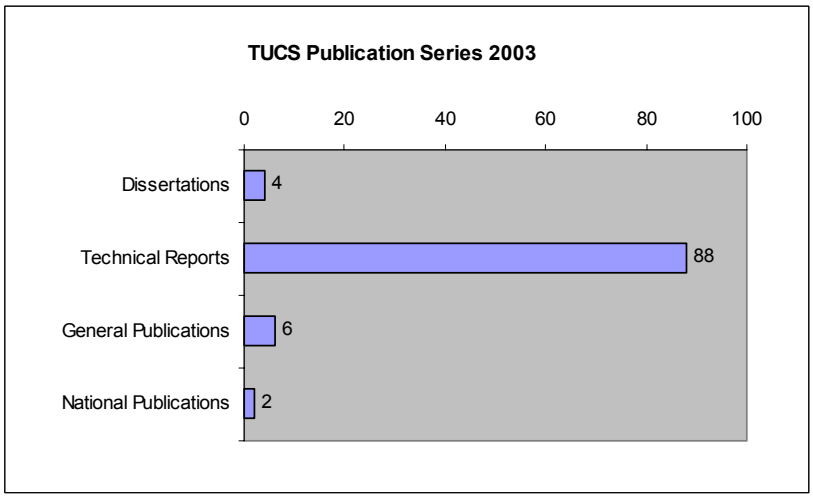
TUCS General Publications

(ISSN 1239-1905) contains all other publications from TUCS, like proceedings from conferences organized by TUCS, annual reports, etc.

TUCS National Publications

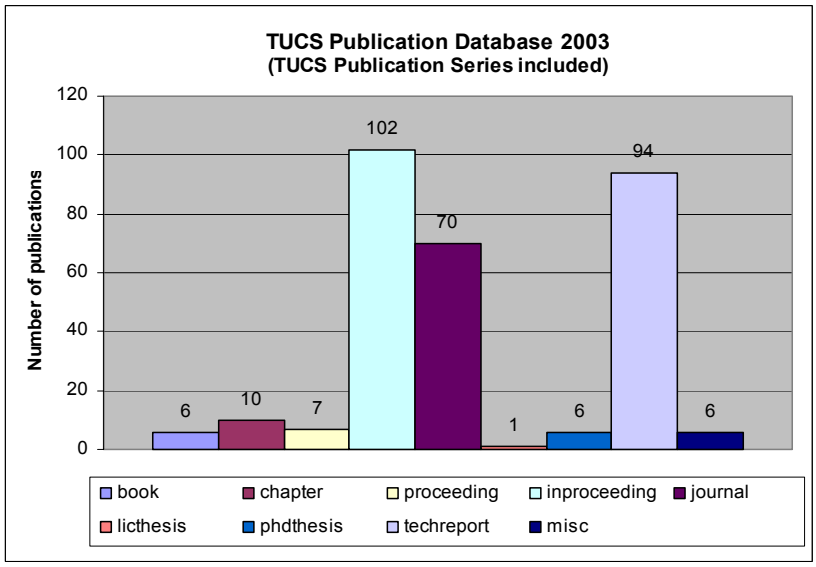
(ISSN 1457-8301) is intended for similar types of publications as the general publication series, but the publication language is either Finnish or Swedish.

During 2003, TUCS has published 4 Doctoral dissertations, 88 technical reports, 6 general publications and 2 national publications. Most of the TUCS publications are available online in electronic format from the TUCS World Wide Web pages.

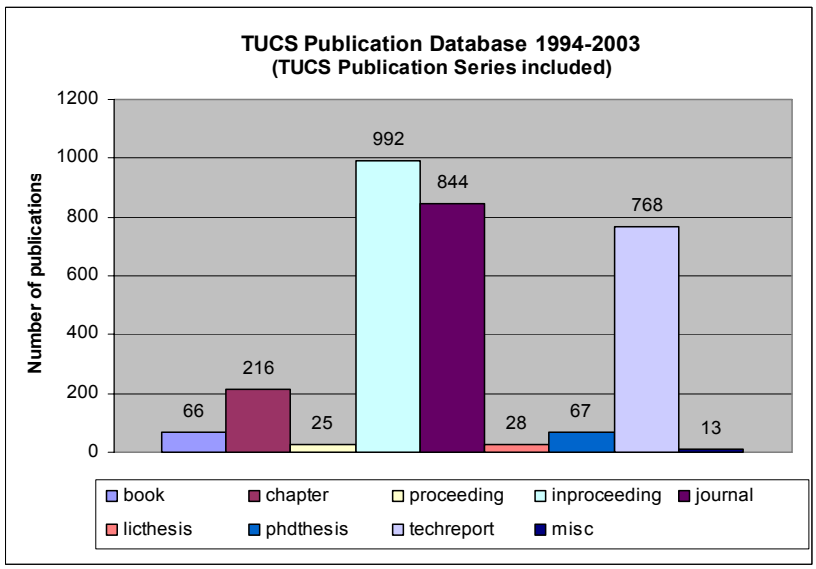


6.2 TUCS Publication Database

This section contains all publications from the researchers within TUCS during the year 2003, organized by type of the publication. The information is gathered from the TUCS bibliographical database.



In 31.12.2003 there were 3019 publications in the database.



7. Graduate School

TUCS Graduate School was the first Graduate School appropriated by the Ministry of Education in Finland. It offers a framework for studying for the Doctoral degree in Computer Science, Mathematics, Information Systems, Computer Engineering, Communication Systems, and Microelectronics. It is open for students from everywhere. Prerequisites are either a Master's or a Bachelor's degree in a relevant field. Study time is expected to be four years.

The Graduate School offers supervision of students within existing research projects: each student is assigned a personal supervisor from one of the five departments participating in TUCS. The students can attend all advanced level courses within the field of Information Technology offered by the participating departments. The language of instruction of the advanced level courses is English.

The deadline for applications has been twice a year: May 15th for studies starting in September, and September 30th for studies starting in January. Students applying to the TUCS Graduate School can apply for a student position within the Graduate School with or without financing from TUCS.

Number of Graduate School Students 31.12.2003:

Åbo Akademi University	36
University of Turku	48
Turku School of Economics and Business Administration	8
TUCS Graduate students 31.12.2003	**92**

7.1 Curriculum Requirements

The curriculum for the Master's degrees and the Doctor's degrees follows the Finnish standard requirements. The Doctor's degree normally requires a Master's degree. The Master's degree requires 40 credits in addition to the Bachelor's exam. For the Doctor's degree, in addition to the Master's degree, the student must take 40 credits of courses and carry out research leading up to a Ph.D. thesis. The students within TUCS Graduate School are expected to take courses from at least two of the research areas represented in TUCS.

7.2 New Students 2003

The following 28 doctoral students began their studies at TUCS Graduate School in 2003:

- ALANEN, Marcus, M.Sc. in Technology (Computer Engineering), Åbo Akademi University, Finland
- ALARANTA, Maria, M.Sc. in Information Systems, Turku School of Economics and Business Administration, Finland
- BJÖRK, Kaj-Mikael, Ph.D. in Chemical Engineering, Åbo Akademi University, Finland
- BOSTRÖM, Pontus, M.Sc. in Software Engineering, Åbo Akademi University, Finland
- HIRVIKORPI, Mika, M.Sc. in Electronics and Communication Technology, University of Turku, Finland
- HUHTANEN, Tuomas, M.Sc. in Mathematics, University of Turku, Finland
- ILIC, Dubravka, M.Sc., Technical Faculty Mihajlo Pupin, Zrenjanin, Yugoslavia
- ISOMÄKI, Petri, M.Sc. in Electronics and Communication Technology, University of Turku, Finland
- KALLIO, Minna, M.Sc. in Information Systems, Turku School of Economics and Business Administration, Finland
- KEMPPAINEN, Ilkka, M.Sc. in Computer Science, University of Turku, Finland
- KUUSISTO, Sami, M.Sc. in Electronics and Communication Technology, University of Turku, Finland
- LÖFMAN, Robert, M.Sc., Åbo Akademi University, Finland
- MATEI, Razvan C., M.Sc. in Microelectronic Computing Systems, Polytechnic University of Bucharest, Romania
- NISSILÄ, Jussi, M.Sc. in Information Systems, Turku School of Economics and Business Administration, Finland
- NORDLUND, Eija, M.Sc. in Computer Science, University of Turku, Finland
- PAAVOLA, Jarkko, M.Sc. in Electronics and Communication Technology, University of Turku, Finland

- PAHIKKALA, Tapio, M.Sc. in Computer Science, University of Turku, Finland
- POIKONEN, Jonne, M.Sc. in Electronics and Communication Technology, University of Turku, Finland
- PYYSALO, Sampo, M.Sc. in Computer Science, University of Oulu, Finland
- RANTALA, Pekka, M.Sc. in Electronics and Communication Technology, University of Turku, Finland
- RONG, Aiying, M.Sc. in Industrial Engineering & Engineering Management, Hong Kong University of Science and Technology, Hong Kong
- SAARI, Kalle, M.Sc. in Mathematics, University of Turku, Finland
- SALMELA, Petri, M.Sc. in Mathematics, University of Turku, Finland
- SALMIVALLI, Lauri, M.Sc. in Information Systems, Turku School of Economics and Business Administration, Finland
- SALONEN, Kari, M.Sc. in Computer Science, University of Turku, Finland
- SOLIN, Kim, B.Sc. in Computer Science, Åbo Akademi University, Finland
- TÄHKÄPÄÄ, Jarmo, M.Sc.Econ., Turku School of Economics and Business Administration, Finland
- VEHKALAHTI, Roope, M.Sc. in Mathematics, University of Turku, Finland

7.3 Dissertations 2003

In 2003 TUCS produced 6 Ph.D. theses:

Mika Hirvensalo. *Studies on Boolean Functions Related to Quantum Computing.* PhD thesis, University of Turku, Jan 2003.

Antonina Kloptchenko. *Text Mining Based on the Prototype Matching Method.* PhD thesis, Åbo Akademi University, 2003.

Timo Lainema. *Enhancing Organizational Business Process Perception – Experiences from Constructing and Applying a Dynamic Business Simulation Game.* PhD thesis, Turku School of Economics and Business Administration, 2003.

Timo Mantere. *Automatic Software Testing by Genetic Algorithms.* PhD thesis, University of Vaasa, University of Vaasa, May 2003.

Adekunle Okunoye. *Knowledge Management and Global Diversity - A Framework to Support Organisations in Developing Countries.* PhD thesis, University of Turku, May 2003.

Pentti Virtanen. *Measuring and Improving Component-Based Software Development.* PhD thesis, University of Turku, Mar 2003.

7.4 Conference Participation

During the year 2003, TUCS has financed conference participation and other travel expenses for a total of 93.840 EUR, of which 74.390 EUR has been used on journeys made by postgraduate students, 12.430 EUR by postdoctoral researchers and 7.020 EUR by others.

The following laboratories have received travel grants from TUCS during the year:

Postgraduate Students
(The total number of TUCS Postgraduate Students/Laboratory in brackets)

Laboratory	Trips	Amount (euros)
Algorithmics (11)	5	5.050
Bioinformatics (4)	4	1.040
Biomathematics (1)	0	0
Data Mining and Knowledge Management (7)	11	9.450
Discrete Mathematics for Information Technology (13)	21	9.880
Distributed Systems Design (4)	5	2.720
Embedded Systems (4)	9	4.250
Health and Medical Informatics Institute (3)	3	3.490
IAMSR (4)	11	8.190
Laboris Information Systems (1)	3	2.780
Learning and Reasoning (3)	5	5.740
Mobile Commerce (5)	11	9.610
Network Economics Institute (4)	8	6.450
Software Construction	5	4.510
Telecommunication and Digital Systems (5)	3	1.230
Total	**104**	**74.390**

Postdoctoral Researchers
(The total number of TUCS Postdoctoral Researchers/Laboratory in brackets)

Laboratory	Trips	Amount (euros)
Algorithmics (2)	2	3.480
Biomathematics (1)	1	2.980
Communication Systems (1)	1	900
Data Mining and Knowledge Management (1)	2	3.500
Discrete Mathematics for Information Technology (1)	2	860
Distributed Systems Design (1)	1	710
Total	**9**	**12.430**

Travel destinations

Destination	Number of trips
Finland	34
Europe	47
USA	13
Other	19
Total	**113**

8. Master's School

TUCS Master's School was established in the autumn of 2002 and presently consists of four master's programmes. These two-year master's programmes, which are taught in English, are awarded by a Finnish Master's degree from one of the participating universities. Prerequisites are a Bachelor's degree equivalent to a Finnish university Bachelor's degree in a relevant field and a certificate of knowledge of English. There are no tuition fees for the Master's School, but the Student Union membership is compulsory for Master's degree students. In 2003, 31 students were admitted to the Master's programmes.

TUCS role within the Master's School project is to co-ordinate the planning of the project, provide information about the Master's School - mainly on the Internet and through e-mail - as well as to co-ordinate the application procedure.

8.1 Study Programmes

The master's programmes within the Master's School are:

- Master's Programme in Information Technology (University of Turku, Faculty of Mathematics and Natural Sciences, Dept. of Information Technology and Dept. of Mathematics)
  - Computing
  - Electronics and Communication Systems
  - Mathematics

- Master's Programme in Software Engineering (Åbo Akademi University, Faculty of Mathematics and Natural Sciences, Dept. of Computer Science)

- Master's Programme in Electronic and Mobile Commerce (Åbo Akademi University, Faculty of Economics and Social Sciences, Dept. of Information Systems)

- Master's Programme in Global IT Management (Turku School of Economics and Business Administration, Dept. of Management, Inst. of Information Systems Science)

9. Courses and seminars

The collection of advanced level and research courses given in English, forms a central part of the TUCS Graduate School. Approximately 30 courses on this level are given each year, mostly as part of the ordinary teaching duties of the TUCS faculty and researchers. The courses can be taken by all TUCS students (and also M.Sc. students at the departments), independently of which department or university they belong to.

The following courses have been given during the year. The courses are classified into the main research areas of TUCS as follows:

A - Algorithmics
BIO - Bioinformatics
COM - Communication Systems
DM - Discrete Mathematics
ES - Embedded Systems
IS - Information Systems
ME - Microelectronics
MM - Mathematical Modelling
SE - Software Engineering

9.1 Regular Courses

Spring 2003

Advanced Computer Architecture, 4-5 cu, A (17)[1]
Timo Järvi, University of Turku, Department of Information Technology

Advanced IT in Accounting - ERP and Internet Accounting, 5 cu, IS (25)
Barbro Back, Åbo Akademi University, Department of Information Systems

Computational Processes in Living Cells, 3 cu, MM, DM, A (30)
Ion Petre, Åbo Akademi University, Department of Computer

Computer Networks and Security, 3 cu, A, ES (52)
Risto Lahdelma, University of Turku, Department of Information Technology

[1] Number of students marked in brackets

Computer System Design, 3 cu, ES, ET, SE (8)
Seppo Virtanen, University of Turku, Department of Information Technology

Corporate Information Technology, 5 cu, IS (26)
Christer Carlsson, Åbo Akademi University, Department of Information Systems

Discrete Dynamical Systems, 5 cu, DM (5)
Stefan Geritz, University of Turku, Department of Mathematics

Ethical Decision Making and Information Technology, 2 cu (12)
Annamari Soini, Åbo Akademi University, Department of Computer Science

Evaluation of Information Systems, 3/5 cu, IS (21)
Jarmo Tähkäpää, Timo Kestilä and Jukka Heikkilä, Turku School of Economics and Business Administration, Information Systems Science

Finite Automata, 2,5 cu, DM (18)
Tatjana Petkovic, University of Turku, Department of Mathematics

Hardware/Software Codesign, 3 cu, ES (15)
Johan Lilius, Åbo Akademi University, Department of Computer Science

Human-Computer Interaction, 5 cu, IS (37)
Franck Tétard, Åbo Akademi University, Department of Information Systems

Management of IS Projects, 3/5 cu, IS (25)
Hannu Salmela, Turku School of Economics and Business Administration, Information Systems Science

Management of IT, 3 cu, IS (14)
Dr. Gary W. Dickson and Dr. Inger V. Eriksson, North Carolina State University (University of Turku, Department of Information Technology)

Mobile Commerce, 5 cu, IS (29)
Christer Carlsson, Åbo Akademi University, Department of Information Systems

Monads, 2 cu, DM (6)
Patrik Eklund, Åbo Akademi University, Department of Computer Science

Pattern Recognition, 3 cu, A (49)
Esa Alhoniemi, University of Turku, Department of Information Technology

Process Algebra, 3 cu, MM (5)
Victor Bos, Åbo Akademi University, Department of Computer Science

Programming III, 3 cu (65)
Antero Järvi, University of Turku, Department of Information Technology

Programming Language Concepts, 3 cu (37)
Timo Knuutila, University of Turku, Department of Information Technology

Real-time Systems, 3 cu (26)
Xinrong Zhou, Åbo Akademi University, Department of Computer Science

SoC Design/ASIC-Design, 5 cu, ET (10)
Tiberiu Seceleanu, University of Turku, Department of Information Technology

Software Safety, 5 cu, ES, SE (30)
Elena Troubitsyna, Åbo Akademi University, Department of Computer Science

Special course on Embedded Systems, 3 cu, ES (16)
Jerker Björkqvist, Åbo Akademi University, Department of Computer Science

Special Course on Embedded Systems: Algorithms in Dimensional Measurement Systems, 3 cu, ES (8)
Risto Lahdelma, University of Turku, Department of Information Technology

Spread Spectrum and CDMA, 5 cu, ET (13)
Valery Ipatov, University of Turku, Department of Information Technology

Telecommunications Protocols, 5 cu, SE (17)
Aulis Pirinen, Åbo Akademi University, Department of Computer Science

Tree Automata and Tree Languages, 2,5 cu, DM (13)
Magnus Steinby, University of Turku, Department of Mathematics

Fall 2003

Adaptive Dynamics, 2,5 cu (6)
Stefan Geritz, University of Turku, Department of Mathematics

Advanced Course in Computer Networks and Internets, 3 cu (35)
Victor Bos, Åbo Akademi University, Department of Computer

Advanced Course on Operating Systems, 3 cu, A (5)
Olli Nevalainen, University of Turku, Department of Information Technology

Algorithms for Computer Games, 2 cu, A, IS (60)
Jouni Smed, University of Turku, Department of Information Technology

Asynchronous System Design, 5 cu, COM (13)
Juha Plosila, University of Turku, Department of Information Technology

Code Optimization, 3 cu (58)
Mats Aspnäs, Åbo Akademi University, Department of Computer Science

Coding and Encryption in Telecommunication, 5 cu, COM (12)
Valery Ipatov, University of Turku, Department of Information Technology

Design and Analysis of Algorithms, 3 cu, A, IS (40)
Olli Nevalainen, University of Turku, Department of Information Technology

Digital Communication Systems, 5 cu, COM (26)
Jouni Isoaho, University of Turku, Department of Information Technology

Electronic Business, 5 cu, IS (53)
Jussi Puhakainen, Turku School of Economics and Business Administration, Institute of Information Systems Sciences

Electronic Commerce: Strategic Consulting in an Electronic Environment, 3/5 cu, IS (14)
Pirkko Walden, Åbo Akademi University, Department of Information Systems

Information Economics, 5 cu, IS (10)
Jonna Järveläinen, Turku School of Economics and Business Administration, Institute of Information Systems Sciences

Intelligent Systems in Business, 3/5 cu, IS (32)
Iulian Nastac, Åbo Akademi University, Department of Information Systems

Introduction to Biocomputing, 3 cu, A, DM, MM (60)
Ion Petre, Åbo Akademi University, Department of Computer Science

Introduction to Modern Convex Geometry, 2.5 cu (3)
Milla Kibble, University of Turku, Department of Mathematics

Introduction to Qualitative Research in Information Systems, 3 cu, IS (9)
Eija Karsten, University of Turku, Department of Information Technology

Linux and System Programming, 3 cu, A (97)
Risto Lahdelma, University of Turku, Department of Information Technology

Logic Programming, 3 cu (24)
Timo Knuutila, University of Turku, Department of Information Technology

Multimedia Databases, 3 cu, A, IS (59)
Jukka Teuhola, University of Turku, Department of Information Technology

Multimedia Systems, 5 cu, COM (9)
Nastooh Avessta, University of Turku, Department of Information Technology

Project Course, 5 cu, ES, SE (37)
Elena Troubitsyna, Åbo Akademi University, Department of Computer Science

Radio Systems, 5 cu, COM (20)
Esa Tjukanoff, University of Turku, Department of Information Technology

Self-Organizing Systems, 5 cu, COM (21)
Juhani Peltonen, University of Turku, Department of Information Technology

Semigroups, 5 cu, DM (10)
Tatjana Petkovic, University of Turku, Department of Mathematics

Special Course in Embedded Systems, 3 cu, ES (4)
Xinrong Zhou, Åbo Akademi University, Department of Computer Science

Special Course in Software Engineering, 3 cu, SE (26)
Iván Porres, Åbo Akademi University, Department of Computer Science

Special Course in Telecommunication, 3 cu (11)
Aulis Pirinen, Åbo Akademi University, Department of Computer Science

Specification Methods, 3 cu (22)
Linas Laibinis, Åbo Akademi University, Department of Computer Science

Support Vector Machines, 3 cu, A, BIO (11)
Aleksandr Mylläri, University of Turku, Department of Information Technology

Topics in Logic, 2,5 cu (15)
Magnus Steinby, University of Turku, Department of Mathematics

User-Centered Design for Information Systems, 5 cu, IS (26)
Franck Tétard, Åbo Akademi University, Department of Information Systems

9.2 Short Courses

Spring 2003

Soft Decision Analysis, 2 cu, A, IS, MM (5)
Robert Fuller, Eötvös Lorand University, Budapest

eCRM - Course on Electronic Customer Relationship management, 2/3/5 cu, IS (65)
Michael Rebstock, University of Koblenz-Landau, Germany

Fall 2003

Global IT Management: International IS Management - The Strategic Issues, 3 or 5 cu, IS (59)
Dan Remenyi, Trinity College, Dublin

Usability Testing, 3 + 2 cu, IS (22)
Pekka Reijonen, University of Turku, Department of Information Technology and Franck Tétard, Åbo Akademi University, Department of Information Systems

10 Personnel

10.1 TUCS Staff

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10.2 University of Turku

10.2.1 Department of Information Technology

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10.2.2 Department of Mathematics

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