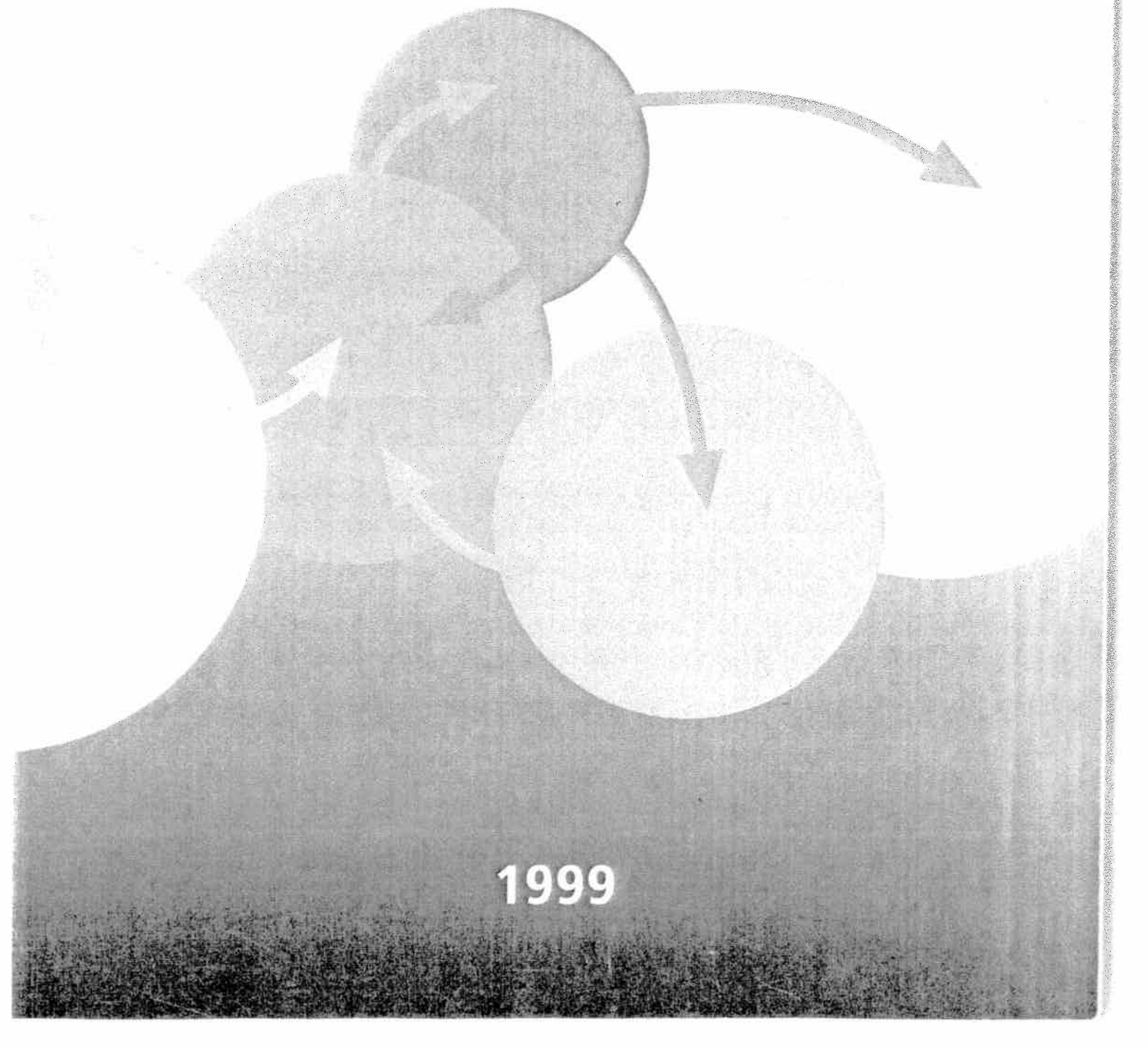
UNIVERSITY OF HELSINKI

DEPARTMENT OF COMPUTER SCIENCE

Annual Report



1999

General Information

The Department of Computer Science was founded in 1967 when the first professorship in computer science was established at the University of Helsinki. The Department belongs to the Faculty of Science, and it is located in Vallila, Helsinki. In Finland, the Department is the largest computer science department in a full-fledged university.

The educational programme of the Department is divided into three subprogrammes: Computer Science, Applied Computer Science and Teacher in Computer Science. The subprogramme Computer Science is further divided into five specialisation areas, which correspond to the research areas of the Department: algorithms and data structures, intelligent systems, software engineering, distributed systems and data communication, and information systems.

The aim of the programme is twofold. Firstly, the programme strives to provide a modern and all-round advanced level education of computer experts for the needs of the industry sector. Secondly, the Department seeks to be among the top-most research institutes within selected research areas of computer science.

Education at the Department is based on the established core computer science but adapts to new needs of the evolving discipline. The combination of theory and practice is stressed, and special emphasis is given to software design and engineering.

In research and in education, cooperation with the rest of the university and with the industry sector is considered to be of great significance. The Department has joint research activities with several departments of the University of Helsinki and with several information-technology oriented departments of other universities. In addition, the Department has research cooperation with approximately 40 different companies (1999).

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Preface

During 1999, information technology continued its expansion in all areas of society. During the late 1990's, Finnish industries have achieved a distinguished position among the leading information technology enterprises in the world. The expansion of industry has continued at a rapid rate, and the position at the leading edge, especially in the area of mobile wireless technology, has created growing requirements for domestic R&D activities. This has generated a remarkable need for new research staff in the field, and it has also opened up new opportunities for research cooperation between the university and the industries.

For the Department, a growth of all activities was the most characteristic feature in 1999. The intake of new students was kept at the level of 270, which is 50% above normal. The total number of students majoring in computer science increased to almost 2000. The amount of class-room teaching increased by 20% to 16.500 class-room hours, and the amount of credit units offered reached the level of 20.000. Total funding increased by 20%, and external research funding reached the level of the basic funding of the Department.

The growing pressures on educational staff and the increasing demand for qualified research staff for challenging industrial R&D started to lead to a severe brain drain at all levels of staff. In areas of the most vital industrial interest there is an imminent threat of draining the research completely and of limiting the education to certain undergraduate level courses. In its strategic planning, the Department has started to formulate new staff policies aiming at improved conditions for the research and for the staff.

The research of the Department is organised into five main areas of interest: algorithms and data structures, intelligent systems, software engineering, distributed systems and data communication, and information systems. The strategic goal is to maintain a high level in all the chosen areas, and to be, in certain special areas, among the leading groups in the world. In the research assessment exercise of 1999, organised by the University of Helsinki, the Department received the maximum overall rating. Especially the algorithms group and the information systems group were considered excellent.

The trends in research strategy are geared towards cooperation with external partners and towards multidisciplinary projects. Characteristic for this direction is the founding of the Helsinki Institute for Information Technology (HIIT), a joint venture between the University of Helsinki and the Technical University of Helsinki.

In postgraduate education, the Department is involved with two graduate schools, both of them multidepartmental. One is with the Helsinki University of Technology and is specialising in IT; the other one is multidisciplinary — with biological sciences — and several departments

are involved in it.

The Department emphasises the importance of high-level education. The rapid evolution in information technology and in computer science poses special requirements for the discipline. Keeping the general educational profile and even the basic individual courses at an up-to-date level requires more effort than in many other disciplines.

One of the main problems in education has been the excessive participation of students in the labour market. Although not without its own merits, this has lead to inefficient and prolonged studies. It is also typical for the students of the Department to stay involved in their professional career without finishing their formal studies.

In 1999 the curriculum of the Department was radically reorganised. The essence of the change is to make the curriculum consist of relatively small modules, which adapt themselves into more dynamic degree requirements, which are easier to modify according to the new developments in information technology. The new structure is also expected to be more compatible with the dynamic and project-oriented working style of students.

In order to engage the students more tightly with the Department and to intensify their studies, the Department has undertaken some activities. To the first year students two new courses are offered. In the first one the students are given the basic skills in working with computers. The goal of the second one is to give a broad view about computer science, with a special emphasis on the research work going on in the Department.

For the second and third year student participation in teacher-based tutoring is mandatory. The system provides a platform for student guidance and for direct feedback on educational and other activities within the Department.

The Department started a project of science education collaboration with six upper secondary schools in Helsinki. The results have been encouraging, and the collaboration will be extended within the limits of available resources.

On the initiative of the Ministry of Education a new programme of "upgrading studies" was started in the autumn of 1999. The goal is to decrease the shortage of IT staff through IT education for persons with an academic background, but in other disciplines.

Educational cooperation with the industry has lead to an increasing number of software engineering projects and M.Sc. theses that are prepared in cooperation with an industrial partner. In 1999, about 50% of the theses and projects belonged to this group.

Some changes in the staff deserve to be mentioned. Professor Esko Ukkonen, the Head of the Department, was appointed as a professor in the Academy of Finland. As new Head of the Department for the rest of the term Timo Alanko was nominated. Professor Heikki Mannila left the Department after having been appointed professor of the Technical

University of Helsinki. Professor Henry Tirri was nominated to a professorship with responsibility for teacher education. A new professorship in software engineering, with special emphasis on cooperation with industry and on technology transfer, was founded in 1999; for a period of 3,5 years the professor will work half of the time at the Nokia Research Center, which also takes over the responsibility for half of the cost of this professorship. Professor Jukka Paakki was appointed to this professorship. A new professorship, responsible for the upgrading studies, was founded. Eero Hyvönen was appointed acting professor.

In the future, we will probably see an expansion of staff members sharing their time between university and industry. This will increase exchanging ideas and transferring technology, but it will also decrease the amount of the highest-level capacities available for the academia.

As a whole, the year 1999 can be considered successful. In the future we have to intensify research in our strategic areas, we must develop a more efficient post-graduate education, and we must keep the high level of education in the chosen vital areas.

It may be worth noting that in the autumn of 1999 three TV and newspaper journalists from the Far East visited the Department to make reports about the high technology in Finland and about the education creating the basis for it. This can be considered as a challenge for the future.

Finally, I want to express my grateful thanks to all our staff — the students included — for their intensive and fruitful work benefiting the IT society and the Department of Computer Science.

Timo Alanko
Head of the Department

1 Research

1.1 Overview

Research at the Department has evolved over the years in step with the international research trends in computer science. Early work in numerical analysis in the 1960's made room for work in programming languages and compilers in the 1970's. Since then the research has diversified and its volume has increased. Today, the Department pursues research in algorithms, intelligent systems, software engineering, data communication and distributed systems and information systems.

Research at the Department are mainly funded by external resources. The main funders are the Academy of Finland, the National Technology Agency (TEKES), the Ministry of Education and the European Commission research programmes. All projects funded by TEKES also have partial funding by industrial partners.

In the research assessment exercise of 1999, the quality of the research activities of the whole University of Helsinki were assessed by international peer review panels. The Department of Computer Science was assessed together with the Departments of Mathematics and Statistics and the Rolf Nevanlinna Institute by a panel consisting of five international and national professors in the fields. The panel acquainted itself with the materials presented to it (selected publications, a publication list, research statistics, description of research fields, etc.) and visited the Department. It gave the Department an overall rating (7/7) and a short written assessment. The assessment helps the Department to organise its own research.

In their final report the panel wrote about the Department of Computer Science:

"Although it has existed only for a few decades, the computer science department is a first class academic department. The senior researchers have had a part in defining the agenda of international computer science research, they have lead and organised multidisciplinary and industrial research and they are extremely well tied in internationally. The tradition started several decades ago that the leading figures of the department sometimes work and publish together, is extremely valuable and could serve as a good example. The Department has shown, with the developments of string matching methodology, frequent episodes and Bayesian modelling in data mining, advanced modelling tools for complex stochastic systems, and the operating system LINUX, that it is a place where great ideas can be created. It addresses many pressing needs of society in its search for an academic software engineering discipline. The Ph.D.s from the Department have usually risen rapidly in the ranks of academia and industry."

More information about the research assessment exercise, including the final report, can be found on the web page

http://savotta.helsinki.fi/researcheval.

1.2 Publications

In 1999, researchers at the Department published 57 peer reviewed journal, conference and collection articles; staff members were editors of two conference proceedings, and one textbook was published. In addition, there were technical reports, articles popularising science, etc., 49 other publications altogether.

Publications (number of)	1995	1996	1997	1998	1999
Books	1	1	3	0	3
Journal articles	11	19	16	10	11
Peer reviewed conference and collection articles	41	47	70	64	46
Other publications	34	76	60	54	49
Total	87	143	149	128	109

Out of the 57 refereed articles 48 were published in high-quality publication series. In 1999, researchers at the Department gave six invited lectures at international conferences (the number is included in the number of peer reviewed conference and collection articles in the table above).

1.3 Research Personnel

The number of research staff with a Ph.D. degree was 25 persons; due to leaves this amounted to 17 manpower years. Research work done by post-graduate students amounted to 37 manpower years. This category includes those post-graduate students who are active in Departmental projects. In addition, these projects employed a remarkable number of graduate students.

1.4 External Research Funding

The main sources of research funding are the Academy of Finland, the National Technology Agency (TEKES), the Ministry of Education and the European Commission (EC) research programmes. All projects funded by TEKES also have partial funding by industrial partners.

Research funding (10^6 FIM)	1995	1996	1997	1998	1999	% (1999)
Academy of Finland	1.6	2.4	1.2	1.7	2.3	21
TEKES & industry	4.3	3.4	4.4	5.1	7.1	64
European Commission	—	0.9	1.8	1.4	1.4	12
Other	0.1	0.6	0.7	0.3	0.3	3
Total	6.0	7.3	8.1	8.5	11.1	100

In 1999, the Academy of Finland funded 8.6 manpower years, the National Technology Agency (TEKES) and industry 22.8 manpower years, the European Commission 4.5 manpower years and other funders 1.1 manpower years. All together, 37.0 manpower years were funded by these research funding institutions. As a certain metric of quality the Faculty of Science considers the amount of Academy funding per Ph.D.-level researcher, in 1999 this metric was 92.000 FIM.

1.5 Research Collaboration

A new research institute, the Helsinki Institute of Information Technology (HIIT) was founded in 1999 as a joint venture between the University of Helsinki and the Helsinki University of Technology. Its main goal is to provide facilities as well as funding for top researchers in computer science and engineering. The institute will cooperate with both national and foreign institutions.

The Department collaborated with the University of Tampere in three co-funded research projects. Other research cooperation partners are, among others, the Universities of Joensuu, Jyväskylä, Kuopio and Turku as well as other departments of the University of Helsinki. The Department also collaborates with 13 foreign research institutes and 11 foreign companies within research and development projects funded by the European Commission. The Department received partial funding from about 40 national industrial research partners in 1999.

The Department continued collaboration with the State University of Petrozavodsk. The jointly organised Annual Finnish Data Processing Week took place in Petrozavodsk for the third time as a two-day scientific seminar with presentations from both universities.

2 Education

2.1 Basic Education

In 1999, there were 1982 undergraduate students majoring in computer science and 70 post-graduate students. In the same year, 258 new students and 40 students upgrading their studies were enrolled at the Department. A total of 42 students were enrolled based on their earlier studies. These are students who wished to change their major subject to computer science or students who have been studying computer science at another university or at a vocational school. The Department has about one thousand students who take computer science as a minor subject.

Enrolment (number of students)	1995	1996	1997	1998	1999
Admission limit	260	260	260	270	270
New students enrolled	424	288	265	279	258
Students enrolled on earlier studies	26	20	22	55	42
Upgrading students enrolled	—	—	—	—	40
Total number of students enrolled	1576	1613	1688	1793	1982
Percentage of female students	26	24	22	21	22

Number of degrees

In 1999, 55 students completed their MSc degree in computer science. The number of MSc degrees has been fairly constant during recent years. During 1995-99, students completed their theses and graduated according to the following table.

Degrees and theses (number of)	1995	1996	1997	1998	1999
Master's Theses	49	63	67	53	63
MSc degrees	44	51	62	48	55

It may be worth noticing that about 10% of the students finishing their computer science studies (Master Thesis) do not take the Master's degree.

Teacher load

The number of completed credit units have been constantly rising. (Courses usually consist of two to five credit units.) The numbers of credit units in the following table also include students minoring in computer science.

Teaching	1995	1996	1997	1998	1999
Credits (credit units)	15 037	17 178	17 494	17 863	21 345
Given instruction (hours)	13 860	14 673	14 480	13 739	16 529
Teachers (manpower years)	51	49	46	43	47
Credit units/teacher years	295	350	380	415	401
Students/teacher years	31	33	37	42	43

The correspondence between credit units and the European Credit Transfer System has been somewhat vague, typically a factor of 1.5 has been used. The University of Helsinki has now decided that starting from 1.7.2000 as a rule the rate 1 cu = 2 ECTS will be used.

2.2 Evaluation of IT Education

The Evaluation of education for the information industry (1999) was organised by the Finnish Higher Education Evaluation Council, and it was performed as a self-assessment exercise. All in all, 15 universities and polytechnics with IT programmes took part in the assessment. The report was published in March 2000 including recommendations for the universities (Hara, Hyvönen, Myers, Kangasniemi: Evaluation of Education for the Information Industry. Publications of Finnish Higher Education Evaluation Council 8:2000). Some good practices were highly evaluated, like cooperation between universities, a programme designed to attract female students, academic freedom and focusing on some specialisation areas of research. The report also expressed concern about classes with too many students, and recommended the Department to improve the collecting of feedback from students. The Department was also recommended to initiate more activity related to industry and internationalisation.

2.3 Developments in Teaching

The curriculum was redesigned to remove overlaps in course contents and to remove bottlenecks increasing graduation time. Within the Computer Science subprogramme, two new specialisation areas were introduced. The former General specialisation area was split into Algorithms and Intelligent Systems, and the Software specialisation area was split into Software Engineering and Distributed Systems and Data Communication. Many courses in computer science were divided into smaller parts and the minimum requirements of mathematics (in Computer Science) were decreased from 26 to 15 credit units.

Especially with the first year students in mind two new types of courses were designed. In the first one the students are given the basic skills in working with computers. The goal of the second one is to give a broad view about computer science, with a special emphasis on the research work going on in the Department.

Two new activities were started in the autumn of 1999. In the area of science education, the Department commenced collaboration with upper secondary schools, and in order to decrease the shortage of IT staff in the industry, a new system of "upgrading studies" was started.

The Department pays attention to the quality level of teaching. In all courses the teaching assistants are supervised through an intensive and continuous interaction with the lecturer. For new teaching assistants there is an introductory seminar about university education, and further seminars are organised for all staff, typically once per semester.

In order to help the students to organise their studies in a more functional way the Department made teacher-based tutoring mandatory in 1996. The system also turned out to be an efficient way to get feedback from the students. The mandatory teacher-based tutoring was extended to cover the students of the "upgrading studies".

2.4 Collaboration and International Student Exchange

The Department cooperates with national and international institutions in both education and research.

The system of flexible study opportunities is based on a cooperation agreement (JOO) among the institutions of higher education in the Helsinki area, Turku and Jyväskylä. Students may put together a degree that best suits them by taking courses in one of the participating universities in subjects not available at their own university. Some restrictions have, however, been made due to a lack of resources.

Thesis work is performed to a large extent outside the Department in industries or commercial undertakings, or on request from outside. About 50% of the Master's Theses and of the software engineering projects were performed outside the Department in 1999.

Starting in 1999, the Department cooperates with six upper secondary schools in the Helsinki area. In all, 25 upper secondary school pupils were accepted to study some computer science courses (with screening based on a special entrance exam). They may substitute school courses with courses in computer science at the Department. If the students later decide to continue their studies at the Department, computer science courses completed at the Department during school time will become part of their degree.

The Department participates in the EC Socrates/Erasmus exchange student programme as well as the Nordic NORDplus programme. Seven foreign exchange students studied at the Department, while eleven students from the Department studied abroad in 1999.

The instruction at the Department is mostly in Finnish. However the course Introduction to the Use of Computers was given in Swedish and English, as well. Also a few seminars and course exercises were given in English.

2.5 Postgraduate Education

The Department (UH) is involved in two graduate schools, the Helsinki Graduate School in Computer Science and Engineering (HeCSE) and the Graduate School in Computational Biology, Bioinformatics, and Biometry (ComBi). Students also pursue postgraduate studies outside the schools. The following table shows some statistics for year 1999.

Postgraduate students (number of)	HeCSE	ComBi	Other	Total
Funded assistantships	12	3	11	26
Postgraduate students enrolled	30	5	35	70
Graduated students since 1995	7	0	1	7
Manpower years (of funded students)	7.3	2.1	27.7	37.1

It is to be noted that the ComBi graduate school was founded only in 1998 and no student has yet (by 1999) graduated. The HeCSE graduate school was founded in 1995. Out of the students in the category Other, some work at the Department as teaching or research assistants, or in research projects with external funding, but many also work in companies outside the university. The listed manpower years concern students working at the Department.

During the years 1995-1999, post-graduate students completed their thesis as shown in the following table.

Postgraduate degrees (number of)	1995	1996	1997	1998	1999
PhLic degrees	2	3	4	4	2
PhD degrees	1	4	3	2	3

2.5.1 HeCSE

The Helsinki Graduate School in Computer Science and Engineering (HeCSE, http://www.cs.Helsinki.FI/hecse/) is a postgraduate programme in computer science and computer engineering jointly offered by the Helsinki University of Technology and the University of Helsinki. The main areas of HeCSE are:

- Software Systems (information technology for production, multimedia, database systems, data structures),
- Software Engineering (embedded systems, specification methods),
- Telecommunication Software and Distributed Systems (formal methods, data communication software, signal processing), and
- Learning and Intelligent Systems (pattern recognition, neural networks, machine learning, knowledge-based systems).

The Finnish graduate schools in computer science (Helsinki, Jyväskylä, Turku, Tampere and Eastern Finland) cooperate. Joint courses are arranged and students of one graduate school can participate in the courses arranged by another graduate school. Also participation in some courses arranged by the industry sector is possible.

2.5.2 ComBi

The Graduate School in Computational Biology, Bioinformatics, and Biometry (ComBi) is a postgraduate programme jointly offered by the University of Helsinki, the Universities of Tampere and Turku, and the Rolf Nevanlinna Institute.

The research goal of ComBi is to develop computational, mathematical, and statistical methods and models for research in biology. To that end, ComBi will educate PhD's with high-quality methodological expertise. In their thesis work the students are expected to apply this expertise to computational, data analysis, or modelling problems in biology or in some related field. The thesis projects are carried out in close cooperation with one or more research groups in the application area.

Computational biology is a new field of research which develops models and software implementations for computational problems in molecular biology, biotechnology, and genetics. Such means are needed both in the basic research and in the industrial applications of biotechnology. Computer-aided DNA sequencing, sequence comparison, prediction of protein structures, docking of molecules, and the interpretation of electron microscopy or NMR data are examples of typical computationally intensive tasks. Bioinformatics refers to the development and use of (molecular) biology databases.

Biometry investigates statistical modeling problems related for example to genetic mapping (linkage analysis), to the genetic and environmental risk factors of complex diseases, or to the spreading of infectious diseases. Further topics include population dynamics and numerical taxonomy with applications to ecology, microbiology, and genetics. Management of spatial data (GIS) is also often needed.

The school is coordinated by the Department. Professor Esko Ukkonen is the Director of ComBi.

2.6 Upgrading Studies

A new temporary programme for upgrading studies in computer science started in the autumn of 1999. It aims at teaching IT knowledge to persons with a degree in another subject, to persons who have no degree but a certain amount of computer science studies from before, or to students who want to change their major subject into computer science. In all, 40 participants were admitted in 1999 based on a separate selection process. The

programme continues in the year 2000 when more students are admitted.

The students are divided into tutor groups. Each group has a teacher or supervisor who guides the students to set up individual study plans. The students usually start their studies with second year courses according to the model study schedule. There is also a basic course aiming at refreshing basic knowledge in programming and software implementation in a modern environment that the students should attend.

3 Events

The Department organised the Second IFIP WG 6.1 International Working Conference on Distributed Applications and Interoperable Systems (DAIS '99) on June 28 – July 1, 1999 in Helsinki. DAIS '99 was attended by about 140 participants from 15 countries. The technical programme included tutorials, invited talks, and peer reviewed papers.

In cooperation with the student organisation TKO-äly, the Department organised a seminar on the Future of the Information Society on September 22. Linus Torvalds was one of the participants, among others. The Department has also organised several internal seminars, including one of student counselling for its teachers.

The Department arranged its fifth *Open Doors* information day for students and industry on April 16. Presentations of the Department and research groups were given through the day in both formal and informal meetings. The research groups also had the possibility to demonstrate their results to a wider audience.

4 Supporting Activities

4.1 Administration

4.1.1 Department

Department Steering Committee Prof Esko Ukkonen, chairman (1.1.1999-31.7.1999), (deputy member Prof Matti Mäkelä), Prof Timo Alanko (1.8.-31.12.1999, chairman 1.8.-31.12.1999), Prof Hannu Erkiö (Prof Seppo Sippu), Prof Kimmo Raatikainen (Prof Jukka Paakki), Laboratory Engineer Lea Kutvonen (Amanuensis Tiina Niklander), Lecturer Harri Laine (Assistant Juha Gustafsson), Senior Assistant Greger Lindén (Research Assistant Mikko Mäkelä), Student Aleksi Niemelä (Student Jani Leinonen), Student Anni Rytkönen (Student Kasper Valtakari 1.1.1999-29.3.1999, Toni Kräkin 30.3.1999-31.12.1999), Student Asko Saura (Student Jonne Soininen), Amanuensis Teija Kujala, secretary (Amanuensis Reijo Sivén).

4.1.2 Departmental representatives in faculty and university governing bodies

Faculty Council Prof Hannu Erkiö (Lecturer Harri Laine), Prof Matti Mäkelä (Prof Esko Ukkonen), Student Perttu Iso-Markku (Student Jani Leinonen).

Faculty Board for Developing Education: Prof Henry Tirri, Student Perttu Iso-Markku.

Faculty Entrance Committee: Prof Hannu Erkiö, chairman of the committee (Senior Assistant Heikki Lokki), Prof Seppo Sippu, Student Mikko Ahokas.

Faculty Planning Board: Prof Esko Ukkonen (1.1.1999-31.7.1999), Prof Timo Alanko (1.8.1999-31.12.1999), Student Jani Leinonen.

Faculty Scholarship Board: Prof Kimmo Raatikainen.

Board of the Rolf Nevanlinna Institute: Prof Esko Ukkonen (Prof Matti Mäkelä)

University Information Management Board: Prof Esko Ukkonen

4.2 Library

The Department maintains a library with large collections of literature on computer science. The library is jointly financed with the University IT Department and is mainly used by the staff and advanced students of the Department.

The library now holds about 52,000 volumes of literature, making it the largest computer science library in Finland. The annual cumulative is about 1,200 monographic titles and 300 journal subscriptions. Course books are available for reading on the premises. Admission to the premises is free and the collections are freely available to all visitors. Home loans, however, are normally granted only to university personnel and advanced students of the Department.

To help users search for and locate the required literature, the library maintains a web database of its holdings. The database includes all journal titles and about 41,000 monographic titles, classified according to the CR Classification System of the ACM. The library is also responsible for the distribution of departmental reports, including PhD theses. Paper copies may be requested from the library, and electronic versions are accessible through the Department's FTP server.

The library has two full-time employees, one librarian and one secretary.

4.3 Computing Facilities

The Department is dedicated to providing a wide range of advanced high-quality computing facilities for use by computer science faculty and students. The facilities are operated by a technical staff who are not only responsible for the installation and maintenance of the systems, but who also assist faculty and students in the use and development of software systems for research projects.

Our workstation network consists of about 400 PCs (mostly Pentium II/III, nearly half of them with flat TFT monitors) running Linux. Windows (98, NT, or 2000) can be used as an alternative to Linux. More than 50 of the workstations are mobile laptops which can join and leave the network dynamically.

The general computing facilities include a farm of servers: general purpose computers, file servers and other functionally dedicated servers (mail, WWW, FTP etc.), and servers for different user groups. Linux is used almost entirely as the operating system for the servers. The centralised file servers utilise RAID technology and currently offer over 0.4 Tbytes storage space. Together these systems support a wide variety of services, languages and software tools including electronic mail and news, graphics and visualisation tools, several typesetting systems, and relational database systems. Special attention has been given to security and

reliability.

Networking is based almost entirely on a switched 100 Mbit/s Ethernet with an optical backbone. The mobile laptops can also utilise a Departmental IEEE 802.11 type radio network which currently has 12 base stations. In the the Linux (and UNIX) environment, NFS is used to share common resources. On the Windows side Samba (a Linux hosted LAN Manager Server) is utilised. The workstations are used as tools for software development, in research and on all levels of teaching.

The network of the Department is connected through a firewall to the university backbone network, giving access to general purpose UNIX computers at the University IT Department as well as to the FUNET wide area network that links Finnish universities and research establishments. The IT Department also offers a large modem and ISDN pool for remote access.

In addition, the Department has access to a number of supercomputing facilities at the Center for Scientific Computing.

The national FUNET network is further connected to the Nordic University Network, Nordunet, with a 310 Mbit/s connection. The Nordunet has a 465 Mbit/s connection capacity to the United States as well as many high-capacity connections to the European network infrastructure.

5 Resources

5.1 Personnel

The following table contains manpower years of different personnel categories. It is to be noted that several positions are open due to lack of funding. This explains the decreasing manpower for professors and assistants during these years.

Personnel (manpower years)	1995	1996	1997	1998	1999
Basic funding					
- Teachers	51	49	46	43	47
Professors	10	9	8	9	9
Senior Assistants	5	6	6	4	3
Lecturers	10	12	9	10	11
Assistants	12	14	13	8	9
Other full-time teachers	11	3	7	7	7
Part-time teachers	3	5	3	5	8
- Administrative personnel	10	9	10	11	13
Total	61	58	56	54	60
Additional funding for education					
- Postgraduate students	8	10	11	14	11
- Other	0	2	7	11	10
Total	8	12	18	15	21
External research funding					
- Researchers and research assistants	19	31	35	35	37
Total	89	102	108	113	118

5.2 Funding

Funding (million FIM)	1995	1996	1997	1998	1999	% (1999)
Basic funding	11.9	11.8	12.4	11.6	11.4	39
Additional funding	1.0	2.5	5.0	4.8	7.2	24
External research funding	6.0	7.2	8.1	8.5	11.1	37
Total	18.9	21.5	24.0	24.9	29.7	100

The additional funding for education in 1999 is divided according to the following table.

Additional funding for education (million FIM)	1999
National Information Society Programme	2.1
Graduate Schools	2.3
Upgrading studies	0.9
Other	0.5
Total	7.2

5.3 Premises

Educational facilities are available as follows. There are 8 small and 10 medium-sized lecture rooms at the Department and one bigger lecture hall seating 250. Most lecture rooms are equipped with a computer. Some also include a video projector. There are also wireless computer sets including projectors that can be used in any lecture room. There are 12 computer rooms for students containing 139 PCs in all. Faculty members have their own offices, all of which are equipped with PCs.

Both students and personnel have their own recreation rooms for informal meetings, coffee, etc. In the building, there is also a student cafeteria. The increase in premises is shown in the following table.

Premises (square meters)	1.1.1999	1.1.2000	Change
Lecture rooms	937	1 096	+17%
Computer rooms	351	534	+52%
Other premises including offices	1 213	1 461	+20%
Total	2 501	3 091	+24%

In 1999, the library of the Department moved into larger premises in the building. The old library rooms were changed into computer class rooms and a medium sized lecture hall with up-to-date facilities (computer, video projector, etc.). About 600 square meters were added for department use.

6 Research Activities

The Department has three subprogrammes and five specialisation areas responsible for planning of the curricula and for administering teaching in their specialities. The division is not strict, and several research projects span two sections. The sections cover roughly the following subject areas:

Computer Science

- Algorithms (Prof Esko Ukkonen, Prof Matti Mäkelä): algorithms and data structures, computational complexity, computational geometry, machine learning, computer graphics, numerical and symbolic computation, computational biology, geoinformatics, computationally intensive tasks.
- Intelligent Systems (Prof Henry Tirri, Prof Eero Hyvönen): Bayesian networks, intelligent and adaptive systems, artificial intelligence, computational intelligence, artificial life, interval analysis, constraint reasoning.
- Software Engineering (Prof Jukka Paakki, Prof A. Inkeri Verkamo): programming languages, compilers, software engineering, performance evaluation.
- Distributed Systems and Data Communication (Prof Kimmo Raatikainen, Prof Timo Alanko, Prof emer. Martti Tienari): mobile computing, formal specification and verification, distributed systems, computer networks, operating systems.
- Information Systems (Prof Hannu Erkiö, Prof Pekka Kilpeläinen, Prof Seppo Sippu, Prof Helena Ahonen-Myka): databases, human-computer interfaces, computer supported co-operative work, information system design methodology, design of databases, text databases, object-oriented databases, logic databases, database structures and algorithms, document management, data mining and knowledge discovery, text mining, information retrieval, management of spatial data (GIS).

Applied Computer Science

- Applied Computer Science (Prof Esko Ukkonen): computational biology, geoinformatics, computationally intensive tasks.

Teacher in Computer Science

- Teacher in Computer Science (Computer-supported education, Prof Pekka Kilpeläinen): computer-aided instruction, computers in education.

In the following, the research activities of each section of the Department are reviewed.

6.1 Algorithms

The main research areas are algorithms and data structures, machine learning, and computational biology.

Algorithms and data structures is the area with the longest tradition. The work on string matching algorithms (Ukkonen, Kärkkäinen) has been particularly successful. Theoretical work has often been conducted within the framework of systems research providing practical motivation for the problems studied. Currently, special emphasis is given to the research on algorithmic problems in computational biology and bioinformatics.

Work on machine learning (Elomaa, Kivinen, Ukkonen) is closely related to research of the Intelligent Systems section. On the algorithms side, the emphasis is on discrete methods and provable performance guarantees.

Projects

Algorithms on strings The research on string matching algorithms started at the Department in the early 1980's. The initial impulse came from computer applications in molecular genetics. The group is now one of the leaders in its special field. It has obtained several basic results, for example, on edit distance, approximate string matching, DNA sequence assembly, suffix-trees and two-dimensional string matching, many of which have been included in recent international text books.

The current research topics include text indexing for fast retrieval by content as well as generalisation of one-dimensional string matching techniques to two and three-dimensional cases. The group has developed new small index structures for full text indexing which are smaller than suffix arrays. Also several fast filtering methods allowing translations and rotations have been developed for pattern matching in high dimensional strings. The novel feature of these methods is that they make use of the pixel or voxel structure in a very precise way.

The applications and motivations of this algorithmics research come from computational biology as well as from multimedia information retrieval. For example, specialised algorithms and their prototype implementation for search by content in music databases has been developed.

The members of the group are Prof Esko Ukkonen (group leader), Jorma Tarhio, docent, Kimmo Fredriksson, Juha Kärkkäinen, PhD, Kjell Lemström, and Sami Perttu. The group was supported in 1999 by the Academy of Finland and the Nokia Company.

K. Fredriksson and E. Ukkonen: Combinatorial methods for approximate image match-

ing under translations and rotations. ***Pattern Recognition Letters*** **20,** ***11/13*** **(1999), 1249-1258.**

J. Kärkkäinen: Repetition-Based Text Indexes. PhD Thesis, Report A-1999-4, Department of Computer Science, University of Helsinki, 1999.

K. Lemström and J. Tarhio: Searching monophonic patterns within polyphonic sources. In ***Proc. Content-Based Multimedia Information Access, RIAO '2000*****, vol. 2, 2000, 1261-1279.**

Computational Biology There are several subprojects in this area. The general goal is to develop efficient algorithmic solutions to different computational problems arising in molecular biology. The special emphasis is on applications of pattern matching, machine learning, and data mining methods. The work is done in close co-operation with application partners. The group also hosts a national graduate school in this area, the Graduate School on Computational Biology, Bioinformatics, and Biometry (ComBi).

With Kirsi Tappura, PhD, (State Technical Research Centre of Finland) the group studies modelling of loops in protein structure. With Prof Dennis Bamford (Institute of Biotechnology, University of Helsinki) the group develops computer tomography methods for constructing three-dimensional structures of macromolecular complexes such as viruses from electron microscopy data. As the first step, an efficient software package has been developed for isolating virus particles from electron micrographs. Another software system for handling and analysing such reconstructed virus models has also been accomplished. Joint work on the in silico analysis of whole genomes with Alvis Brazma, PhD, (European Bioinformatics Institute, Hinxton, UK) has been continued with the aim to correlate the putative regulatory patterns in the DNA sequence with the expression patterns of the genes. A new project on the integrated analysis of DNA expression, proteomics, and metabolia data is about to start (with Prof Hans Söderlund, Aristos Aristidou, docent; State Technical Research Centre). Moreover, in a separate project the group studies hydrological modelling in co-operation with the Finnish Environmental Centre.

The members of the group are Prof Esko Ukkonen (group leader), Markus Huttunen, Teemu Kivioja, Veli Mäkinen, Taneli Mielikäinen, Janne Ravantti, Satu Sihvo, Anatoly Verkhovsky, and Jaak Vilo (EBI, Hinxton). The group was supported in 1999 by the Academy of Finland.

A. Brazma, I. Jonassen, J. Vilo and E. Ukkonen: Predicting gene regulatory elements in silico on a genomic scale. ***Genome Research*** **8,** ***11*** **(1998), 1202-1215.**

T. Kivioja, J. Ravantti, A. Verkhovsky, E. Ukkonen and D. Bamford: Local average intensity-based method for identifying spherical particles in electron micrographs. ***Journal of Structural Biology*** **(in press).**

J. Ravantti and D. Bamford: A data mining approach for analyzing density maps representing macromolecular structures. ***Journal of Structural Biology*** **125 (1999), 216-222.**

Logic-Based Query Languages for Molecular Biology Databases New application domains for database management systems demand that systems adapt to domain-specific data needs and not vice versa. In particular, databases of molecular biology data such as DNA strands encoded as strings must offer flexible tools for their manipulation. Thus we have extended the well-known relational database model to encompass strings as an independent data type, which permits user-defined string manipulation predicates within the query language. The extension draws its motivation from the concept of multiple sequence alignment employed in molecular biology, while its mathematical and computational aspects stem from temporal logic and automata theory, respectively.

The members of the group are Prof Esko Ukkonen, Matti Nykänen, PhD, Raul Hakli and Hellis Tamm. The project is supported by the Academy of Finland.

G. Grahne, M. Nykänen, E. Ukkonen: Reasoning about strings in databases. ***Journal of Computer and System Sciences*** **59,** ***1*** **(1999), 116-162.**

R. Hakli, M. Nykänen, H. Tamm, E. Ukkonen: Implementing a declarative string query language with string restructuring. ***Proc. 1st International Workshop on Practical Aspects of Declarative Languages, PADL '99,*** **Springer-Verlag 1999, 179-195.**

Algorithmic Machine Learning Machine learning is concerned with the question how to construct computer programs that automatically improve with experience. The research of the group aims at mathematically rigorous analysis and development of learning programs and understanding of the underlying theory of the learning process(es). The group approaches these topics from the empirical and theoretical viewpoints by analysing successful existing learning programs and further developing the computational theory of learning. The group has studied extensively the properties of evaluation functions that are used to partition numerical attribute domains in decision tree learning algorithms. In work with the University of California, Santa Cruz, the group has made theoretical analyses of various simple on-line learning algorithms.

The main researchers in the group are Tapio Elomaa, docent, and Jyrki Kivinen, docent. The group is a member of the Esprit Network of Excellence in Machine Learning and of the Esprit Working Group on Neural and Computational Learning Theory.

T. Elomaa and J. Rousu. General and efficient multisplitting of numerical attributes. ***Machine Learning*** **36,** ***3*** **(1999) 201-244.**

D. P. Helmbold, J. Kivinen, and M. K. Warmuth. Relative loss bounds for single neurons. *IEEE Transactions on Neural Networks* 10, *6* (1999) 1291-1304.

6.2 Intelligent Systems

Work in this research area is focused on issues related to design and analysis of computational methods for adaptive and intelligent systems. Such methods include (among many other issues) topics such as probabilistic modelling, Bayesian networks, information-theoretic approaches to modelling (e.g., MDL and MML), (Bayesian) neural networks, case-based reasoning, evolutionary computation (e.g., genetic algorithms), search methods for high-dimensional spaces (e.g., simulated annealing), intelligent interfaces and information retrieval. The work is both theoretical and empirical in nature, aiming at practical algorithms solving complex and large scale *Deep Computing* type of modelling problems with computer systems combining ultrafast processing and sophisticated analysis methods.

Most of the research in this area is associated with the Complex Systems Computation research group (CoSCo, http://www.cs.helsinki.FI/research/cosco) led by professor Henry Tirri and docent Petri Myllymäki. Basic research work by the group is supported by the Academy of Finland, European Community, University of Helsinki, and various foundations. More applied work has been performed with support from the National Technology Agency TEKES and domestic and foreign industrial partners which include Alma Media, Nokia, TietoEnator, StoraEnso, KONE Corporation, ABB, WapIT, Space Systems Finland, ESA, NASA, and AT&T. Some of the resulting software has been adopted in the industry. Current members of the group are Jussi Lahtinen, Petri Kontkanen, Petri Nokelainen, Tomi Silander, Teemu Tonteri, Antti Tuominen, Pekka Uronen, Kimmo Valtonen and Hannes Wettig.

P. Myllymäki and H. Tirri: Bayes-verkkojen mahdollisuudet (Prospects of Bayesian Networks). Technology Report 58/98. National Technology Agency (Tekes), 1998.

P. Kontkanen, P. Myllymäki, T. Silander, H. Tirri, and P. Grünwald: On Predictive Distributions and Bayesian Networks. *Statistics and Computing* 10 (2000), 39-54.

P. Kontkanen, J. Lahtinen, P. Myllymäki, and H. Tirri: Unsupervised Bayesian Visualization of High-Dimensional Data. In *Proc. 6th International Conference on Knowledge Discovery and Data Mining, KDD' 2000* (eds. R. Ramakrishnan, S. Stolfo, R. Bayardo and I. Parsa.), ACM, 2000.

P. Kontkanen, P. Myllymäki, T. Silander, and H. Tirri: On Supervised Selection of Bayesian Networks. *Proc. 15th International Conference on Uncertainty in Artificial Intelligence, UAI '99* (eds. K. Laskey, H. Prade), Morgan Kaufmann Publishers, 1999, 334-342.

P. Ruohotie, H. Tirri, P. Nokelainen and T. Silander: ***Modern modeling of Professional Growth*****. Research Center for Vocational Education, Saarijärven Offset 1999.**

Projects

Computationally Efficient Methods for Deep Computing (DeepC) Deep Computing is a term for methods solving complex and large-scale modelling and analysis problems with emerging computer systems that combine ultrafast processing with sophisticated analytical software. Deep Computing can be seen to consist of three intertwined research areas: 1. Deep modelling: prediction and data mining with very large data sets, 2. Deep optimisation: computationally efficient optimisation of complex multivariate cost functions, and 3. Deep view: interfaces for understanding high-dimensional data.

The methodological research objective of the project is to develop the theory and methods required for obtaining very large-scale computational, data and communications capabilities that can be used to solve *grand challenge*-level Deep Computing problems in business and science. The research focuses on stochastic approaches and is methodological and theoretical in nature, and aims at topics that can have a great impact in this area in the future.

The applied research objective of the project is to demonstrate solutions to previously intractable business and scientific problems by exploiting the advances in Deep Computing research in areas such as data modelling and analysis, high-end computing, search and optimisation algorithms, and high-dimensional visualisation. Such demonstrations will often be results of joint multi-disciplinary work together with scientists (scientific problems) as well as industrial partners (business problems).

The volume of the projects is FIM 1.8 million for a three year period starting in 2000. Funding is provided by the Academy of Finland.

Personalized Adaptive Interfaces (PAI) The main objective of the PAI project is to develop methods for applying probabilistic modelling techniques, such as Bayesian network models, in building and using personalised, adaptive user interfaces. Specific research problems include user data segmentation, user profiling and user identification, and location-aware computing. The associated pilot-projects focus on problems related to intelligent educational technologies, adaptive WWW services and adaptive mobile services.

In user data segmentation the goal of the project is to develop computationally efficient methods for partitioning the available data into meaningful clusters by using adaptive Bayesian network modelling techniques. In user profiling these clusters are used for producing a semantic interpretation of the domain as a set of probabilistic user profiles. These profiles can be studied by using various data mining and visualisation techniques,

and the results of this type of an analysis can be used off-line in designing personalised interfaces for WWW services or educational media. In user identification the produced probabilistic model is used for on-line identification of the user profile from partial and uncertain observations. This type of methods can be used for developing adaptive interfaces. In the area of location-aware computing, the project focuses on studying how the adaptive probabilistic modelling techniques can be used in estimating the location of a mobile user, based on the measurements provided by the mobile terminal.

The volume of the projects is FIM 1.3 million for a one year period starting in 2000. Funding is provided by the National Technology Agency and industrial partners.

Applications of Probabilistic modeling and Search Methods (PROMISE) The PROMISE project focused on two research areas: probabilistic modelling and stochastic optimisation. In probabilistic modelling, the main goal of the project was to develop computationally efficient methods for building and applying probabilistic models, such as Bayesian networks and finite mixture models. In stochastic optimisation, the goal was to empirically study and compare different stochastic search methods, such as simulated annealing and genetic algorithms, in complex, highly constrained problem domains.

In probabilistic modelling, the research concentrated on theoretical and practical issues concerning model selection with respect to predictive performance of the chosen models. The methods developed in the project were validated by using proprietary real-world problems provided by the industrial partners, as well as publicly available benchmark problems available on the Internet. In the empirical tests performed, the group was able to show that even relatively simple Bayesian models in many cases yield better results than alternative techniques, if implemented in a theoretically correct manner. Moreover, the group was able to show, theoretically and empirically, that there are several "urban legends" concerning the Bayesian methodology for model selection, and that the well-known procedures commonly used in machine learning are in many cases based on misunderstandings or theoretically invalid arguments that lead to suboptimal behaviour of the models. For some of these cases, the group was able to develop alternative model selection procedures which gave good results in the empirical results performed.

In stochastic optimisation, the group concentrated on empirical comparisons between different stochastic optimisation algorithms, such as simulated annealing and genetic algorithms. The empirical results demonstrated that, although it is possible to obtain consistently good results with genetic algorithms, similar performance was in many cases possible to achieve with much simpler and more efficient methods, such as different stochastic greedy algorithms. The group also developed a novel

version of the celebrated simulated annealing algorithm. In this algorithm the difficult problem of parameter selection is solved by adjusting the so-called cooling schedule automatically during the optimisation process.

For the empirical part of the work, the group developed software that allows the researchers to use several dozens of Linux-workstations as a single "virtual supercomputer", which has made it possible to study interesting exponential-time problems. Some of the Bayesian modelling methods developed in the project were implemented in BAYDA, a JAVA software package for flexible data analysis in classification domains. BAYDA is available free of charge for research and teaching purposes from the group's homepage. The scientific results are reported in the over 20 international scientific publications produced during the project; copies of the articles can be downloaded from the group's home site.

The results of the project are commercially exploited in several fielded applications. StoraEnso is already widely using the intelligent container packing software *Coptimi*, implemented by TietoEnator, based on the optimisation algorithms developed in the project. Some of the optimisation methods developed by the group have also been integrated into fielded telecommunications software packages developed and used by Nokia. A commercial product development project, aiming at a data analysis software suite exploiting the probabilistic modelling methods developed in the project, is also currently in progress by one of the industrial partners.

The volume of the projects is FIM 2.65 million for a three year period starting in 1998. Funding is provided by the National Technology Agency and industrial partners.

Computational Intelligence Techniques for Nonlinear modelling in Social Sciences (NONE) The general objective of this research is to develop theoretically sound computational intelligence techniques for nonlinear modelling of data, and methodologies for applying them in the domain of educational data. The research has both a strong basic research component, i.e., the development of theoretically sound probabilistic nonlinear methods, and an applied methodological component where the nonlinear techniques are applied to modelling and analysis in the educational domain.

In traditional quantitative approaches in (vocational) education, modelling is implemented either by exploratory multivariate analysis (typically factor analysis) or, if a model structure can be derived from the theory, by a confirmatory analysis using for example LISREL models. Missing data is handled by omitting the corresponding data vectors or by averaging. Prediction is typically performed with linear regression models or, in the case of comparative analysis, by discriminant analysis. Theoretical analysis of the decision-making phase is typically ignored.

In this research the nonlinear alternatives to the above linear methods are studied: probabilistic models for exploratory analysis (with a Bayesian

approach for estimating missing data), Bayesian networks for confirmatory analysis, and probabilistic predictive models for regression and discriminant analysis. In addition the little known relationship of the theoretical foundations of computational intelligence techniques and Bayesian model selection in social science is investigated.

The volume of the projects is FIM 0.6 million for a three year period starting in 1996. Funding was provided by the Academy of Finland.

6.3 Software Engineering

Software is the key element in the modern systems of the contemporary information society. The flexibility and services offered by our technical facilities are mostly implemented as software solutions on software technology. Hence software quality is the main factor of the services and systems in use.

Software quality is the general research topic of the software engineering group at the Department. The emphasis is on the technical aspects of software quality (rather than on process-centric aspects), and more precisely on the quality of the software design. The design phase of a software system, documented by such technical artifacts as software architecture, design patterns, and reference framework, is the most natural quality assurance phase in the system life cycle since it acts as a bridge between informal and imprecise user requirements and formal and precise implementation (code) of those requirements. When captured at the software design phase, potential quality problems can be solved before introducing them into the actual system.

The research carried out by the group has close contacts with the Finnish software industry. A visible example of the close cooperation is that the leader of the group works half-time in the software technology laboratory of the Nokia Research Center.

Projects

Techniques for designing and using OO frameworks (FRED) Design quality is studied by the research group in several forms. Proactive quality assurance methods are the focus in the FRED project which develops a CASE tool for application engineering based on design patterns and application frameworks. The tool helps a software (framework) designer make correct and mature decisions by assisting her in the design process and by checking that the quality restrictions embedded in the applied design patterns are not violated.

FRED is a joint research project with the Tampere University of Technology and the University of Tampere. The researchers involved are Jukka Paakki, Antti Viljamaa, and Jukka Viljamaa. A prototype of the FRED tool has been released. The volume of the project is 6 manpower years (1997-

99), and FIM 1.5 million, funded by the National Technology Agency and companies.

M. Hakala, J. Hautamäki, J. Tuomi, A. Viljamaa, J. Viljamaa, K. Koskimies, and J. Paakki: Managing Object-Oriented Frameworks with Specialization Templates. ***Proc. International Workshop on Object Technology for Product-Line Architectures, ECOOP '99*** **, European Software Institute, 1999, 87-97.**

M. Hakala, J. Hautamäki, J. Tuomi, A. Viljamaa, J. Viljamaa, K. Koskimies, and J. Paakki: Task-Driven Framework Specialization. ***Proc. Fenno-Ugric Symposium on Software Technology, FUSST '99*** **(ed. J. Penjam), Technical Report 104/99, Institute of Cybernetics, Tallinn Technical University, 1999, 65-74.**

Metrics for Analysis and Improvement of Software Architectures (MAISA) The MAISA project develops both reactive quality assurance methods for software design and associated proactive methods for software implementation. The central idea is to measure the quality of the software architecture, and use the results for predicting quality aspects, such as size, complexity and performance, of the actual system based on the architecture.

The researchers involved are Juha Gustafsson, Lilli Nenonen, Jukka Paakki, and Inkeri Verkamo. A prototype of the MAISA metrics tool has been released. The volume of the project is 3 manpower years (1999-2000) and FIM 1 million, funded by the National Technology Agency and companies.

J. Paakki, A. Karhinen, J. Gustafsson, L. Nenonen, and A. I. Verkamo: Software Metrics by Architectural Pattern Mining. To appear in ***Proc. IFIP World Computer Congress, WCC 2000*****, Beijing, China, 2000.**

L. Nenonen, J. Gustafsson, J. Paakki, and A. I. Verkamo: Measuring Object-Oriented Software Architectures from UML Diagrams. To appear in ***Proc. 4th International Workshop on Quantitative Approaches in Object-Oriented Software Engineering, QAOOSE '2000*** **(in association with ECOOP '2000).**

A. I. Verkamo, J. Gustafsson, L. Nenonen, and J. Paakki: Design Patterns in Performance Prediction. ***Proc. 2nd International Workshop on Software and Performance, WOSP 2000*****, ACM (SIGMETRICS and SIGSOFT), ACM Press, 2000, 143-144.**

Object-oriented software architectures (SAARA) The SAARA project studies after-the-fact quality assurance by reverse-engineering the software code into higher-level representations. For instance, when recovering the software architecture from its code one can conclude whether the design decisions have been followed in the implementation phase and verify that the architecture has not been decayed.

The researcher involved is Jukka Paakki. The volume of the project is 3 manpower years (1999-2001), and FIM 0.6 million, funded by the Academy of Finland.

6.4 Distributed Systems and Data Communication

The specialisation area of software systems was recently divided into two, separating out software engineering from distributed systems and data communication. However, the distributed systems and data communication group is still rather large and covers four areas of research:

- Modelling of concurrent systems studies formal specification and verification of distributed systems. The theoretical results of the group are based on process algebras and temporal logic. The results are applied to software engineering tools. The results of the MOCO project are notable and well-received by the international research community.
- Mobile data communication systems develops wireless data communication systems and applications. Basic requirements for such systems include real-time processing, capability for multimedia transfer, applicability to changing conditions on data transfer and adaptability to heterogeneous environments. The constructive results of the national MOWGLI and MONADS projects and the EC funded project MONTAGE have been well noted by Finnish companies and have been used for international standardisation in the area.
- The open distributed computing group (ODCE) investigates and develops software architectures and services for global systems. Openness in this context requires capabilities for automatic negotiation of new cooperation networks amongst independently developed and autonomously managed systems. The results of this research are both conceptual and constructive (services, software engineering tools), and have been well received in the international standardisation of this area. The most recent project in this area is CORBA-FORTE.
- The real-time systems group covers fast data storages and transfer. On real-time databases optimistic strategies, memory-based storage, and replication-based fault-tolerance are under experimentation in the RODAIN project. Fast data transfer development is taking place in the HPGIN project.

The goals of the group are twofold: On one hand, tools are developed for analysing and modelling systems based on theory. On the other hand, more powerful services are developed for the application platform based on operating systems, data communication, distribution algorithms and effective information management solutions.

The projects in this group combine modelling and constructive approaches, and have good relationships with industrial sector. Companies like Nokia and Sonera are frequent participants in the projects of this

group. The National Technology Agency and the European Commission are the major sources of funding for this research.

The group has good international relationships through EC projects, active involvement in standardisation work within ISO, IETF and OMG, and exchange of researchers. The group also organised the Second International Working Conference on Distributed Applications and Interoperable Systems, DAIS '99, in 1999.

Projects

Modelling of Concurrency (MOCO) Recently, research on the theoretical aspects of concurrency has concentrated on three areas. The theory of partially defined specifications and their refinement relations has been transferred from the bisimulation semantics to the decorated trace semantics. Secondly, the modelling and verification of timed systems has been studied. Thirdly, liveness verification with software tools has been under investigation. Besides these theoretical studies, an experimental work on specification-related algorithms has been going on. One example of this work is the determinisation of automata.

The research group consists of Prof Emer Martti Tienari, Roope Kaivola, docent, and postgraduate students Timo Karvi, Päivi Kuuppelomäki and Matti Luukkainen.

Mobile Office Workstations using GSM Links (MOWGLI) The goal of the MOWGLI project is to study, design, and test a data communication architecture for a wireless WAN, like the pan-European GSM-based mobile data service, and to develop a prototype based on that architecture. The environment of an application consists of mobile PC's that can be connected over a wireless WAN connection, for example through a mobile phone, to any part of a fixed data communication network. The work in the project concentrates on the architectural aspects that support the mobility of the client, allow client applications to operate in a disconnected or in a weakly connected mode, and hide the problems of the wireless connection. The work in the project has recently been enlarged to implement performance measurement tools for wireless networking and to contribute to international network standardisation.

The volume of the project in 1999 was 20 manpower months and FIM 1.13 million, funded by the National Technology Agency and companies. The researchers involved are Prof Timo Alanko, Prof Kimmo Raatikainen, and Markku Kojo.

T. Alanko, M. Kojo, M. Liljeberg, and K. Raatikainen: Mobile Access to the Internet: A Mediator-based Solution. ***Internet Research*** **9, *1* (1999), 58-65.**

Adaptation Agents for Nomadic Users (MONADS) http://www.cs.helsinki.fi/research/monads/

The MONADS project studies the use of adaptive agents for serving mobile users in a wireless environment. The application functionality is improved by learning agent technology and mobility adaptive protocols between the agents. Mobility aware protocols are adopted from the Mowgli data communication architecture.

The MONADS project has developed an agent-based software architecture and a prototype implementation. The prototype uses learning agents for predicting the quality of wireless links and adapts the behaviour of a WWW browser according to the prediction. The WWW agent controlling the adaptation can choose between various compression methods or even decide against transmitting large or unimportant pictures. In addition, the project has created software for more efficient JavaRMI for optimising agent communication.

The volume of the project in 1999 was 32 manpower months and the researchers involved are Prof Kimmo Raatikainen, Oskari Koskimies, Stefano Campadello, Heikki Helin, and Pauli Misikangas.

S. Campadello, H. Helin, O. Koskimies, P. Misikangas, M. Mäkelä and K. Raatikainen: Using Mobile and Intelligent Agents to Support Nomadic Users. ***Proc. 6th International Conference on Intelligence in Networks, ICIN '2000*****, 2000.**

S. Campadello, H. Helin, O. Koskimies and K. Raatikainen: Performance Enhancing Proxies for Java2 RMI over Slow Wireless Links. ***Proc. 2nd International Conference and Exhibition on the Practical Application of Java, PAJAVA '2000*****, 2000.**

K. Raatikainen, L. Hippeläinen, H. Laamanen and M. Turunen: Monads - Adaptation Agents for Nomadic Users. ***Proc. World Telecom '99*****, 1999.**

MObile INTelligent AGEnts in Accounting, Charging and Personal Mobility Support (MONTAGE) The MONTAGE project studies, evaluates and assesses the impact of agent technology to the telecommunications world. Agent technology is used to support efficient (in terms of both cost and performance) service provision to fixed and mobile users in competitive telecommunications environments.

This EC funded project contributes a TINA-compliant architecture and implementation of support services for personal mobility, accounting and charging services. The project has a strong design and implementation flavour, combined with theoretical guidance and feedback from all involved stakeholders by means of trials. The volume of the project is 22 manpower months and 0.12 million euro, and the researchers involved are Prof Kimmo Raatikainen and Stefano Campadello.

Performance and usability of the CORBA architecture in telecommunications technology (CORBA-FORTE) The CORBA-FORTE project pro-

duced a set of tools and techniques for improving the performance and usability of CORBA-based distributed systems. The results of the project were validated against a realistic information system in a CASE study.

Of particular importance for the project are performance analysis and modelling, software performance engineering (SPE), active participation in OMG work, and implementation of a performance engineering framework. The volume of the project in 1999 was 2 manpower years and FIM 0.6 million. The main researcher involved were Prof Emer Martti Tienari, Prof Kimmo Raatikainen and Pekka Kähkipuro, PhLic.

P. Kähkipuro: The Method of Decomposition for Analyzing Queuing Networks with Simultaneous Resource Possessions. ***Proc. Communications Networks and Distributed Systems modelling and Simulation Conference, CNDS '99*****, (eds. R. Simon, T. Znati), The Society for Computer Simulations International, 1999, 165-172.**

P. Kähkipuro: UML Based Performance modelling Framework for Object-Oriented Distributed Systems, ***Proc. ≪UML≫'99 — The Unified modelling Language, Beyond the Standard*** **(eds. R. France, B. Rumpe), Lecture Notes in Computer Science No. 1723, Springer-Verlag, 1999, 356-371.**

Open Distributed Computing Environments (ODCE) The ODCE group studies interoperability and federation of autonomous components in global networked environments. Standardisation work on ODP (Open Distributed Processing) in ISO with liaisons to OMG is actively participated. The group also organised the Second International IFIP Working Conference on Distributed Applications and Interoperable Systems, DAIS '99, in June. The main researcher involved is Prof Lea Kutvonen.

L. Kutvonen: Sovereign systems and dynamic federations. ***Proc. 2nd International IFIP Working Conference on Distributed Applications and Interoperable Systems, DAIS '99*****, Kluwer Academic Publishers, 1999, 77-90.**

L. Kutvonen, H. Koenig, M. Tienari (eds.): ***Proceedings of the Second International IFIP Working Conference on Distributed Applications and Interoperable Systems, DAIS '99*****, Kluwer Academic Publishers, June 1999.**

Real-Time Object-Based Database Architecture for Intelligent Networks (RODAIN) The RODAIN project series develops a real-time database based on object database standards. The database requirements are induced by telecommunication and virtual private networks. The group has produced a prototype of a database characterised by the terms real-time, object-oriented, main-memory based and distributed. The volume of the project in 1999 was 36 manpower months and FIM 0.58 million. The researchers involved were Prof Kimmo Raatikainen, Tiina Niklander, Pasi Porkka, Jan Lindström, and Juha Taina.

J. Lindström, T. Niklander, P. Porkka, K. Raatikainen: A Distributed Real-Time Main-Memory Database for Telecommunication. ***Proc. Workshop on Databases in Telecommunication*****, co-located with VLDB, 1999, 11.**

J. Lindström, K. Raatikainen: Dynamic Adjustment of Serialization Order using Timestamp Intervals in Real-Time Databases. ***Proc. 6th International Conference on Real-Time Computing Systems and Applications, RTCSA '99*****, 1999, 13-20.**

High Performance Gigabit I2O Networking Software (HPGIN) I2O (Intelligent I/O) is an essential hardware and software vendor specification for data transfer using a separate IOP processor. The HPGIN project implements I2O software for fast LAN equipment. This joint EC-funded project with SysKonnect (Germany) and XPlab (Italy) produces a new Gigabit Ethernet card and supporting software based on I2O, and I20 message passing and resource control and an I2O LAN driver for Linux and X-Polypus environments.

The Linux drivers and services are developed at the University of Helsinki, and are available in all Linux distribution versions. The kernel is available at http://www.kernel.org/. Also, an http-based configuration utility for management of software and parameters is available at http://www.cs.helsinki.fi/group/hpgin/.

The volume of the project is 30 manpower months and 0.17 million euro, and the researchers involved are Prof Kimmo Raatikainen, Prof Emer Martti Tienari, Auvo Häkkinen, and Juha Sievänen.

A. Häkkinen, J. Sievänen: Specification of the Software Package D (HPGIN-Linux). Report UHEL.03.99.01-DR-D1, Department of Computer Science, University of Helsinki, March 1999.

A. Häkkinen, J. Sievänen: HPGIN-Linux Test Specification Plan. Report UHEL.10.99.01-DR-E1, Department of Computer Science, University of Helsinki, October 1999.

Promoting Interoperability for Multimedia services in Europe (PRIME) The PRIME project is oriented at the provision of support for the development and implementation of interoperable multimedia services in Europe. Specifically the project has been looking at the requirements for achieving interoperability for multimedia services over alternative delivery platforms.

The key objective and contribution of PRIME to the ACTS programme is to improve the cross fertilisation between ACTS projects involved in interactive multimedia communications on the one hand, and interoperability initiatives in standardisation bodies and fora in the same area on the other. Among others, this will result in increased awareness on interoperability issues and opportunities in ACTS.

The volume of the project is 40,000 euro and the main researcher involved is Prof Kimmo Raatikainen.

Optimizing TCP for Wireless Links (IWTCP) The standardisation body for the Internet protocols, the Internet Engineering Task Force (IETF), is specifying various performance enhancements to TCP and is documenting the impact of problematic link-layer characteristics to the Internet protocols. In addition, mitigations to the performance implications of problematic link characteristics and approaches to enhance the performance that the Internet protocols, particularly TCP, attain in the face of particular link characteristics are being documented.

The objective of the IWTCP project is to measure the TCP performance implications of those link characteristics that are typical for wireless links. In addition, some experimental TCP performance enhancements for particular link characteristics are implemented and the impact of the enhancements is analysed. The volume of the project is 8.4 manpower months and FIM 0.18 million, and the researchers involved are Prof Kimmo Raatikainen and Markku Kojo.

6.5 Information Systems

The specialisation area of information systems gives the basic education in the areas of databases and information management for all the computer science students. However, the research in the area is not focused on the most traditional information management problems, but on areas that have mostly emerged only a few years ago. These subfields include data mining, document management, workflow management, and user interface design patterns.

Data mining (or knowledge discovery in databases) develops methods and systems for extracting interesting and useful information from large sets of data. Data mining methods developed in our group can be used in a variety of application areas, such as commercial databases, telecommunication alarm sequences, epidemiological data, etc. The area combines techniques from databases, statistics, and machine learning. The recent focus areas are inductive databases in the knowledge discovery process and applying data mining to textual data.

The accelerating development of the World Wide Web has made numerous digital document collections widely available for the public. There is a clear need for new document management tools that assist the user to gather, combine, and reuse information from existing document collections. Moreover, the amount of fine-structured documents will increase enormously in the near future, since the Extensible Markup Language (XML) is rapidly gaining popularity in various communities. Compared to HTML, XML makes more versatile processing and customisation of documents possible. However, explicit structuring using XML leads to heterogeneously structured document collections, which causes problems when combining and reusing fragments of documents. This is the central starting point in our document management research.

Workflows model business processes that consist of related tasks. The tasks can be automatic, semi-automatic, or manual. A workflow system is software that can be used to define workflows and to automatize the coordination of processing the tasks. The research in this group concentrates on methods of coordinating the tasks by transactional workflows.

User interface design is an often neglected area in software engineering. Moreover, it is often seen as specific to a software at hand, which leads to a development of solutions almost separately for each case. There are, however, user interface problems, like query interfaces or the specification of time intervals, which recur very frequently. An emerging area of user interface design, and also the focus area of our user interface group, is using pattern languages for interaction design.

Projects

Data mining The major areas of the data mining research have been the development of fast algorithms for association rule and episode rule discovery, and the application of the algorithms for finding regularities in sequential data, particularly in telecommunications alarm data. Moreover, methods for finding interesting knowledge from potentially large result sets returned by the discovery have been developed. Recently, the research has focused on four areas: inductive databases in the knowledge discovery process, measuring similarities of events and event types in sequences, biological and epidemiological applications, and knowledge discovery in text. The researchers involved are Prof Helena Ahonen-Myka, Oskari Heinonen, Mika Klemettinen, PhD, Pirjo Moen, PhD, Marko Salmenkivi, and Prof A. Inkeri Verkamo.

J.-F. Boulicaut, M. Klemettinen, and H. Mannila: modelling KDD processes within the inductive database framework. *Proc. 1st International Conference on Data warehousing and Knowledge Discovery, DaWaK '99* **(eds. M. K. Mohania and A. M. Tjoa), Lecture Notes in Computer Science, Vol. 1676, Springer 1999, 293-302.**

M. Klemettinen, H. Mannila, and H. Toivonen: Rule Discovery in Telecommunication Alarm Data. *Journal of Network and Systems Management* **7, 4 (December 1999), Plenum Press.**

H. Mannila, and P. Moen: Similarity between event types in sequences. *Proc. 1st International conference on Data warehousing and knowledge discovery, DaWaK '99*, **(eds. M. K. Mohania and A. M. Tjoa), Lecture Notes in Computer Science, Vol. 1676, Springer 1999, 1999, 271-280.**

M. Klemettinen. *A Knowledge Discovery Methodology for Telecommunication Network Alarm Databases* **PhD Thesis, Report A-1999-1, Department of Computer Science, University of Helsinki, January 1999.**

H. Ahonen-Myka, O. Heinonen, M. Klemettinen, and A. I. Verkamo: Finding co-

occurring text phrases by combining sequence and frequent set discovery. ***Proc. 16th International Joint Conference on Artificial Intelligence, IJCAI '99: Workshop on Text Mining: Foundations, Techniques and Applications*****, (ed. R. Feldman), 1999, 1-9.**

Document management (DocMan) The main focus of the document management group has been document assembly of structured (e.g. XML) documents. Document assembly is computer-aided construction of new documents from existing document collections. Such reuse includes finding relevant document fragments, modifying them as needed, and combining the fragments. If the assembled documents are to be further processed, the heterogeneous structures of the original documents also have to be unified.

The PhD thesis work of Barbara Heikkinen presents an element-type classification method, which contains a decision procedure for mapping an arbitrary structure element to a predefined generic class that describes some typical logical structure of electronic documents. The semantics of the generic classes can be utilised in unified processing (e.g. printing) of arbitrary structures.

In his PhD thesis work, Oskari Heinonen studies the problem of intelligent document fragmentation: how to find in a text self-contained multiparagraph fragments that can be used as components in the assembly process. Fragmentation is basically a problem of choosing the paragraph boundaries that make the best fragment boundaries. To get convenient-sized fragments, paragraph similarity information (based on lexical cohesion) alone is not enough; the lengths of the created fragments also have to be considered. Our fragmentation method is based on dynamic programming and is guaranteed to give an optimal solution with respect to the input and the parameters.

Besides document assembly, the group has also developed several tools for structured document management, including the search and transformation languages Sgrep and TranSID. The researchers involved are Prof Helena Ahonen-Myka, Barbara Heikkinen, PhD, Oskari Heinonen, Mika Klemettinen, PhD, Pekka Kilpeläinen, PhD, Greger Linden, PhD, and Jani Jaakkola.

H. Ahonen-Myka, B. Heikkinen, O. Heinonen, M. Klemettinen: New tools for a knowledge worker. ***Proc. XML Finland '99*****, SGML Users Group Finland, 1999, 25-32.**

B. Heikkinen: Generalization of Document Structures and Document Assembly. PhD Thesis, Report A-2000-2, Department of Computer Science, University of Helsinki, April 2000.

P. Kilpeläinen, and J. Jaakkola: Nested text-region algebra. Report No. C-1999-2, Department of Computer Science, University of Helsinki 1999.

J. Jaakkola, P. Kilpeläinen, G. Lindén, J. Niemi, and K. Paasiala: TranSID: an SGML

document manipulation language — reference manual. Report No. C-1999-35, Department of Computer Science, University of Helsinki 1999.

Workflow management (WorkMan) The automation of recurring units of tasks in the workplace is attempted with workflow systems. The processing of insurance claims or loan applications, for example, could be task units, i.e. workflow, that could be automated. Workflow systems have two purposes: they enable the specification of workflows, and they take care that each workflow task progresses. Workflow systems usually enable the specification of workflow with the help of graphical user interfaces. The specification presents the tasks that are to be carried out and their mutual dependencies, as well as possible transactional demands. The different tasks included in the workflow may be carried out in different locations. Therefore, the development of workflow systems touches on several disciplines such as combining distributed heterogeneous systems and transaction research. Research in the field of workflow systems is brisk at the moment. In the near future, we can expect commercial versions of several systems that are at an experimental level as yet.

The WorkMan project implements a prototype of a workflow system. With the help of the prototype, we are hoping to ensure a reliable execution of workflow through transactional workflows. In implementing the system, we are striving to use the services offered by database systems based on the SQL language as much as possible.

The WorkMan system has been implemented with the help of students as an exercise for the course Software Engineering Project. The research connected with the project has been carried out by Harri Laine, PhLic, and Juha Puustjärvi, PhD.

H. Laine, J. Puustjärvi: modelling Business Processes as Transactional Workflows. ***Proc. Workshop on Practical Business modelling (in conjunction with CAiSE'00)*****, 2000.**

J. Puustjärvi, H. Laine: WorkMan — a Transactional Workflow Prototype. ***Proc. DEXA '00*****, 2000.**

J. Puustjärvi: ***Transactional workflows*****. PhD Thesis, Report A-1999-2, Department of Computer Science, University of Helsinki, 1999.**

Graphical interface solutions and techniques (GIST) Many of the current software user interfaces force the user to do unnecessary work and waste his time. Good user interface solutions should be available in such a form that they could be implemented with minimal user interface design skills, quickly and cheaply. We have discovered that the same user interface problems, e.g. query formulation, visualisation and management of hierarchies, and managing complex time intervals, tend to recur in various systems and contexts. These findings have led us to develop a collection of

user interface design patterns to be used as a tool and learning aid for user interface designers. Our collection currently includes 25 patterns and pattern candidates. The researchers involved are Sari A. Laakso, Karri-Pekka Laakso, and Asko Saura.

K.-P. Laakso, A. Saura, S. A. Laakso: Position paper at the CHI 2000 Design Pattern Workshop.

6.6 Applied Computer Science

The subprogramme Applied Computer Science is aimed for students who want to specialise in some application area and study it more than in the other subprogrammes. Every student has an individual study programme. The research activities are pursued in several of the other research divisions, e.g. within the algorithms, machine learning, biocomputing, and data mining groups.

6.7 Teacher in Computer Science

Researchers associated with the Teacher in Computer Science line of specialisation have pursued research on topics in the borderland between computer science and education. Computer uses in education and visualisation have been the major areas of interest. In 1998 - 1999 the scope was extended to the use of information technology in social and human services. In general, the volume of Teacher in Computer Science related research is rather modest when compared to the main research areas of the Department.

Projects

Animation Aided Problem Solving (AAPS) Animation is a standard technique in computer-aided instruction. A project called Animation Aided Problem Solving (AAPS) aimed at applying the methods of algorithm animation in problem solving, and developed systems for fast generation of algorithm animations. Members of the AAPS group are Jorma Tarhio, docent (group leader), Prof Veijo Meisalo (Department of Teacher Education), Erkki Sutinen, PhD, Jaakko Kurhila, PhLic, Matti Lattu, MSc, Erkki Rautama, and Tommi Teräsvirta. The funding of AAPS from the Ministry of Education and from the University of Helsinki finished by the end of 1998, but the project still continued in 1999.

K. Järvinen, T. Pienimäki, J. Kyaruzi, E. Sutinen, T. Teräsvirta: Between Tanzania and Finland: learning Java over the Web. ***Proc. 13th SIGCSE Technical Symposium on Computer Science Education, SIGCSE '99*****, ACM, 1999, 217-221.**

J. Kurhila, E. Sutinen, J. Tarhio: Towards meaningful computer uses in education. ***Proc. Information Technology Shaping European Universities, EUNIS '99*** **(ed. K. Sarlin), Espoo, Finland, 1999, 261-264.**

Survey of Information Technology in Social and Human Services in Finland (SosKart) A survey of information technology in social and human services was conducted during 1998 and 1999 by Jaakko Kurhila, PhLic, Perttu Iso-Markku (student of computer science) and research assistant Saara Maalismaa (student of Social Sciences). Prof Matti Mäkelä was in charge of the project.

The aim of the first stage of the survey was to draw an overall picture of the use of IT in public and private social administration and services, and to see how it supports the policy of the Finnish information society. In the second stage, some representative examples of IT solutions were investigated more closely. The aim was to survey and evaluate the systems and software used, analyse the usability aspects and gather user experiences as well as to find out possible future directions.

The survey took 16 man months, and it is expected to lead to the MSc thesis of Mr Iso-Markku. The funding of FIM 315,000 came from OSVE (Network of Excellence Centres for Social Welfare and Health Care) through STAKES (National Research and Development Centre for Welfare and Health).

P. Iso-Markku, J. Kurhila: ***Sosiaalialan tietotekniikkakartoitus*** **(Survey of information technology in social and human services in Finland, in Finnish). Publications of the National Network of Excellence Centres 1, Helsinki 1999.**

The University of Helsinki also provided a funding of FIM 66,000 for the six-month research of Timo Muhonen (student of CS) on the topic *Internet luentosalina* (Internet as a lecture room). The leader in charge of the project was Erkki Sutinen, PhD. The project considered and developed tools for easy recording of in-class lectures and for their easy delivery on the Internet.

A Personnel

The personnel can be reached through e-mail and www, more information on http://www.cs.Helsinki.FI/userpages.html.

Basic funding

Head of the Department

Ukkonen, Esko, Prof, 1.1.-31.7.1999
Alanko, Timo, Prof, 1.8.-31.12.1999

Professors

Annual total 8.9 manpower years (ordinary: 4.7, in locum: 4.2).

Mannila, Heikki, on leave
Mäkelä, Matti, 12 months
Paakki, Jukka, joint professorship with Nokia Research Centre, 6 months
Raatikainen, Kimmo, 12 months
Sippu, Seppo, 7 months
Tirri, Henry, 12 months
Ukkonen, Esko, 7 months

Professors in locum positions

Ahonen-Myka, Helena, 5 months
Alanko, Timo, 5 months
Elomaa, Tapio, 7 months
Erkiö, Hannu, 12 months
Hyvönen, Eero, 5 months
Kilpeläinen, Pekka, 12 months
Verkamo, A. Inkeri, 5 months

Senior Assistants

Annual total 3.3 manpower years (ordinary: 1.1, in locum: 2.2).

Ahonen-Myka, Helena, on leave
Kivinen, Jyrki, 12 months
Kaivola, Roope, 1 month
Kilpeläinen, Pekka, on leave
Myllymäki, Petri, on leave
Toivonen, Hannu, on leave

Senior Assistants in locum positions

Luukkainen, Matti, 5 months
Lindén, Greger, 12 months
Kärkkäinen, Juha 5 months
Klemettinen, Mika, 5 months

Lecturers

Annual total 10.7 manpower years (ordinary: 3.8, in locum: 6.9).

Alanko, Timo, on leave
Elomaa, Tapio, 5 months
Erkiö, Hannu, on leave
Grahne, Gösta, on leave
Kerola, Teemu, 12 months
Kojo, Markku, on leave
Laine, Harri, 12 months
Lokki, Heikki, on leave
Nurmi, Otto, 5 months
Pollari-Malmi, Kerttu, on leave
Verkamo, A. Inkeri, 5 months
Vihavainen, Juha, 6 months
Wikla, Arto

Lecturers in locum positions

Elolampi, Pentti, 12 months
Karvi, Timo, 12 months
Kurhila, Jaakko, 4 months
Laakso, Karri-Pekka, 12 months
Laakso, Sari, 12 months
Marttinen, Liisa, 12 months
Puustjärvi, Juha, 7 months
Siven, Reijo, 5 months
Taina, Juha, 7 months

Assistants

Annual total 8.7 manpower years (ordinary: 0.4, in locum: 8.3).

Ahonen-Myka, Helena, on leave
Heinonen, Oskari, on leave
Kärkkäinen, Juha, on leave
Klemettinen, Mika, on leave
Lemström, Kjell, on leave
Lindén, Greger, on leave
Moen, Pirjo, on leave
Nykänen, Matti, on leave
Sutinen, Erkki, on leave
Taina, Juha, 5 months

Tuovinen, Antti-Pekka, on leave

Assistants in locum positions

Eloranta, Sari, 12 months
Eskola, Jukka, 12 months
Gustafsson, Juha, 9 months
Hakli, Raul, 12 months
Hämäläinen, Wilhelmiina, 7 months
Kuittinen, Juhani, 12 months
Kuuppelomäki, Päivi, 12 months
Laine, Tei, 7 months
Liljeberg, Mika, 1 month
Mononen, Tommi, 5 months
Salmenkivi, Markku, 5 months
Tonteri, Teemu, 5 months

Teachers in locum positions

Annual total 6.6 manpower years.

Alaluoma, Merja, 12 months
Andberg, Sami, 5 months
Kasari, Anita, 7 months
Kraft, Janne, 12 months
Nikander, Sami, 7 months
Orasaari, Marko, 7 months
Rautama, Erkki, 12 months
Rinta-Mänty, Janne, 12 months
Saura, Asko, 5 months

Administrative personnel

Annual total 7 manpower years.

Kujala, Teija, amanuensis, 12 months
Palander, Sirkka, secretary, 12 months
Pohjonen, Kirsti, librarian, 12 months
Rytkönen, Anni, amanuensis in locum position, 7 months
Salmi, Kari, library assistant, 12 months
Suontaa, Kati, secretary, 12 months
Tillonen, Sirkka, porter, 12 months

Technical personnel

Annual total 5.9 manpower years.

Abdulla, Mustafa, systems analyst in locum position, 7 months
Jaakkola, Jani, senior systems analyst in locum position, 12 months
Jokela, Mikael, senior systems analyst in locum position, 12 months
Kutvonen, Lea, laboratory engineer, 7 months
Kutvonen, Petri, chief systems analyst, 12 months
Lehtinen, Sami, senior systems analyst in locum position, 4 months
Mattila, Juhana, senior systems analyst in locum position, 12 months
Niklander, Pekka, senior systems analyst in locum position, 5 months

Additional funding for education

National Information Society Strategy

Annual total 8.7 manpower years.

Alanko, Timo, professor, 7 months
Holopainen, Jyrki, researcher, 12 months
Karjunen, Marko, research assistant, 1 month
Kivioja, Teemu, research assistant, 7 months
Kurtén, Marina, amanuensis, 5 months
Kutvonen, Lea, senior researcher, 5 months
Lehtimäki, Jarno, research assistant, 12 months
Leinonen, Jani, research assistant, 3 months
Lokki, Heikki, senior assistant, 12 months
Niklander, Tiina, laboratory engineer, 7 months
Rytkönen, Anni, amanuensis, 5 months
Sihvo, Satu, research assistant, 9.8 months
Siven, Reijo, amanuensis, 7 months
Suikkanen, Jaakko, researcher, 12 months

Graduate school students

Annual total 9.4 manpower years.

Fredriksson, Kimmo ComBi, 10 months
Hegedüs, Tibor, HeCSE, 12 months
Heikkinen, Barbara, HeCSE, 5 months
Heinonen, Jarkko, HeCSE, 7 months
Kivioja, Teemu ComBi, 3 months
Kurhila, Jaakko , HeCSE, 5 months
Kärkkäinen, Juha, HeCSE, 7 months
Lemström, Kjell , HeCSE, 7 months
Luukkainen, Matti, HeCSE, 7 months
Moen, Pirjo, HeCSE, 6 months
Mäki-Uuro, Miikka, HeCSE, 0.6 month
Pauna, Matti, HeCSE, 8 months
Sillanpää, Mikko ComBi, 12 months
Tuovinen, Antti-Pekka, HeCSE, 8 months
Wettig, Johannes, HeCSE, 11.9 months
Vilo, Jaak, HeCSE, 3 months

Other additional funding for education

Annual total 0.8 manpower years.

Muhonen, Timo, research assistant, education development, 6 months
Virtanen, Jarno, student, student trainee 3 months

External research funding

Project funding (for project acronyms, see Section 6)

Annual total 36.6 manpower years.

Academy of Finland

Annual total 8.6 manpower years.
Researcher positions

Myllymäki, Petri, senior researcher, 5 months
Nykänen, Matti, research doctor, 12 months
Ukkonen, Esko, academy professor, 5 months

Other Academy funding

Fredriksson, Kimmo, research assistant (postgraduate, BIO), 2 months
Huttunen, Markus, researcher (IHP), 6.6 months
Kivioja, Teemu, research assistant (BIO), 2 months
Korpimies, Kai, researcher (BIO), 7 months
Mielikäinen, Taneli, research assistant (BIO), 5 months
Mäkinen, Veli, researcher (BIO), 4 months
Nyqvist, Tommy, research assistant (BIO), 5.5 months
Ollikainen, Vesa, research assistant (postgraduate), 5 months
Perttu, Sami, research assistant (BIO) & SEMEX, 7 months
Sarkkinen, Jussi, research assistant (SAARA), 9 months
Silander, Tomi, researcher (NONE), 8 months
Sillanpää, Mikko, research assistant (postgraduate), 4 months
Tamm, Hellis, researcher (BIO), 12 months
Valtonen, Kimmo, researcher (NONE), 4 months

National Technology Agency and industry

Annual total 22.8 manpower years.

Campadello, Stefano, researcher (NOMADIX), 12 months
Freedman, Henry, research assistant (MONADS), 6.2 months
Gurtov, Andrei, data systems designer (MOWGLI), 7.3 months
Gustafsson, Juha, application designer (MAISA), 3 months
Kähkipuro, Pekka, systems analyst (CORBA-FORTE), 12 months

Kangasharju, Jaakko, research assistant (MONADS), 10.2 months
Kasari, Anita, research assistant (IWTCP), 3.4 months
Kätsyri, Jari, data systems designer & research assistant (CORBA-FORTE), 3.3 months
Kojo, Markku, researcher (MOWGLI), 12 months
Kontkanen, Petri, senior systems analyst, (PROMISE), 12 months
Koskimies, Oskari, researcher and project manager (MONADS), 12 months
Kuhlberg, Panu, research assistant (IWTCP), 5 months
Lahtinen, Jussi, senior systems analyst (PROMISE), 12 months
Laukkanen, Aki, research assistant (MONADS), 1 month
Lindholm, Taina, project secretary (PROMISE), 12 months
Lindström, Jan, researcher (RODAIN), 9 months
Mäkelä, Mikko, research assistant (MONADS), 12 months
Manner, Jukka, senior systems analyst (MOWGLI), 12 months
Misikangas, Pauli, researcher (MONADS), 11.5 months
Mononen, Tommi, research assistant (ÄLYJO), 7 months
Nenonen, Lilli, data systems designer (MAISA), 4 months
Niklander, Tiina, project manager (RODAIN), 5 months
Nokelainen, Petri, researcher (PROMISE), 1 month
Päiväniemi, Tomi, research assistant (MONADS), 4 months
Peri, Indrek, research assistant (MOWGLI), 2.7 months
Ponka, Ilja, data systems designer (MONADS), 3 months
Porkka, Pasi, researcher (RODAIN), 12 months
Pulli, Harri, senior systems analyst (MOWGLI), 12 months
Sarolahti, Pasi, research assistant (MONADS) & (MOWGLI), 5.9 months
Silander, Tomi, researcher (PROMISE), 8 months
Takkunen, Kimmo, senior systems analyst (MONADS), 3.3 months
Tarkoma, Sasu, research assistant (MONADS), 5.9 months
Tonteri, Teemu, research assistant (Multimeetmobile), 5 months
Tykkälä, Kimmo, research assistant (MONADS), 1 month
Valtonen, Kimmo, researcher (PROMISE) 8 months
Viljamaa, Antti, data systems designer (FRED), 12 months
Viljamaa, Jukka, data systems designer (FRED), 7 months

European Commission

Annual total 4.5 manpower years.

Durand, Bertrand, data systems designer (HPGIN), 2.2 months
Haataja, Juha-Pekka, research assistant (MONTAGE), 12 months
Huhtala, Ykä, data systems designer (KESO), 1.3 months
Häkkinen, Auvo, senior researcher (HPGIN), 12 months
Klemettinen, Mika, research assistant (KESO), 2 months
Leinonen, Jani, research assistant (MONTAGE), 9 months
Sievänen, Juha, application designer (HPGIN), 12 months
Vähäkangas, Taneli, research assistant (HPGIN), 1.7 months
Verkamo, A. Inkeri, senior researcher (KESO), 2 months

Other external funding

Annual total 1.1 manpower years.

Iso-Markku, Perttu, research assistant, STAKES (SosKart), 8 months
Kurhila, Jaakko, researcher, STAKES (SosKart), 3 months
Lattu, Matti, researcher, Ministery of Education (AAPS), 1 month
Maalismaa, Saara, research assistant, STAKES (SosKart), 1.4 months

B Research Projects

Academy of Finland

1. Algorithmic methods in biocomputing and data analysis (BIO), Prof Esko Ukkonen, 1.1-31.12.1999.
2. Combining Expert Knowledge and Observed Data in Hydrological Modeling and Optimisation (IHP), Prof Esko Ukkonen, 1.5.1994-31.12.1999.
3. Computational Intelligence Techniques for Nonlinear Modeling in Social Sciences (NONE), Prof Henry Tirri (project manager Petri Myllymäki), 1.1.1997-31.12.1999.
4. From Data to Knowledge (FDK), Prof Heikki Mannila (Hannu Toivonen) 1.10.1996-30.9.1999.
5. Object-oriented Software Architectures (SAARA), Prof Jukka Paakki, 1.1.-31.12.1999.

The National Research and Development Centre for Welfare and Health (STAKES)

1. Survey of Information Technology in Human Services in Finland (SosKart), Prof Matti Mäkelä (Jaakko Kurhila), 1.11.1998-31.7.1999.

The National Technology Agency (TEKES) & industrial partners

1. Adaption Agents for Nomadic Users (MONADS), Prof Kimmo Raatikainen (Oskari Koskimies), 1.119.98-31.12.2000.
2. Applications of Probabilistic Modeling and Search Methods (PROMISE), Prof Henry Tirri (Petri Myllymäki), 1.3.1998-31.12.1999.
3. Framework Editor for Java (FRED), Prof Jukka Paakki, 1.1.-31.12.1999.
4. Intelligent Executive Information Systems (ÄLYJO), Prof Heikki Mannila (Tommi Mononen), 1.1.-31.12.1999.
5. Metrics for Analysis and Improvement of Software Architectures (MAISA), Prof Jukka Paakki, 1.9.1999-28.2.2001.
6. Mobile Office Workstations Using GSM Link (MOWGLI), Prof Martti Tienari (Timo Alanko), 1.9.1993-31.3.2000.
7. Multimedia, Electronic Commerce, and Transactional Services for Mobile Computing (Multimeetmobile), Prof Henry Tirri, 1.8.1999-31.5.2001
8. Optimizing TCP for Wireless Links (IWTCP), Prof Kimmo Raatikainen, 1.8.1999-31.7.2000.
9. Performance and Usability of the CORBA Architecture in Telecommunications Technology (CORBA-FORTE), Prof Martti Tienari, Prof Kimmo Raatikainen (Pekka Kähkipuro), 1.1.1998-31.12.1999.
10. Real-Time Object-Based Database Architecture for Intelligent Networks (RODAIN), Prof Kimmo Raatikainen, (Tiina Niklander), 1.1.1996-31.12.1999.

European Commission

1. Neural Computational Learning II (NeuroCOLT), Esko Ukkonen, 1.1.1998-31.12.2000
2. Knowledge Extraction for Statistical Offices (KESO), Heikki Mannila (A. Inkeri Verkamo), 1.1.1996-31.3.1999
3. Mobile Intelligent Agents in Accounting, Charging and Personal Mobility Support (MONTAGE), Kimmo Raatikainen, 1.4.1998-29.2.2000
4. High Performance Gigabit I_2O Networking Software (HPGIN), Martti Tienari, Kimmo Raatikainen (Auvo Häkkinen), 1.12.1998-31.5.2000
5. Promoting Interoperability for Multimedia services in Europe (Prime), Kimmo Raatikainen, 1.10.1998-29.2.2000

C Visits and Visitors

Longer visits abroad

1. Ahonen-Myka, Helena, Eberhard-Karl-Universität Tübingen, Wilhelm-Schickard-Institut, Germany, 1.1.-31.7.1999
2. Kaivola, Roope, Intel, Portland, Oregon, United States, 1.2.1999-
3. Kivinen, Jyrki, University of California, Santa Cruz, United States, 22.6.-15.7.1999
4. Mannila, Heikki, Microsoft Research, Seattle, United States, 1.1-31.7.1999
5. Tienari, Martti, Universität Paderborn, Germany, 1.1.-31.3.1999; ETH Zürich, Switzerland, 1.4.-30.9.1999; CERN, Switzerland, 1.10.-30.11.1999

In addition, about 40 researchers of the Department have participated in international conferences and visited foreign research institutions in 1999.

Foreign Visitors

1. Bogoiavlenski, Iouri, Professor, Petroskoy State University, Russia, 12.4.-10.5.1999
2. Cantler, Florian, Researcher, Universität Münster, Germany, 15.2.-15.4.1999,
3. Dawid, Phil, Dr. Professor, University College London, United Kingdom, 10.-20.8.1999
4. Dehaspe, Luc, PhD, Researcher, Katholieke Universiteit Leuven, Department of Computer Science, Belgium, 15.-23.1.1999
5. Erdmann, Andreas, Universität Köln, Germany, 3.-19.6.1999
6. Langley, Pat, PhD, Head of Adaptive Systems Group, DaimlerChrysler Research and Technology, United States, 10.8.1999
7. Mittasch, Christian, PhD, Assistant, TU Bergakademie Freiberg, Germany, 25.-26.10.1999
8. Mohan, C., PhD., Research Fellow, IBM Research, United States, 10.-15.3.1999
9. Murakami, Yoshikazu, Master of Education, Professor, Director, Ehime University, Center for Education and Research, Japan, 22.6.1999,
10. Navarro, Gonzalo, PhD, Researcher, University of Chile, Santiago, Chile, 1.8.-30.11.1999
11. Rissanen, Jorma, IBM Almaden Research Center, United States, 14.5.1999 and 5.11.1999
12. Tompa, Frank, Professor, University of Waterloo, Department of Computer Science, Canada, 20.4.1999
13. Zhang, Ming, Associate Professor, University of Beijing, China, 1.9.-31.12.1999

D Publications

Algorithms

Journal articles

1. T. Elomaa and J. Rousu: General and efficient multisplitting of numerical attributes. *Machine Learning* **36**, *3* (Sept. 1999), 201-244.
2. K. Fredriksson and E. Ukkonen: Combinatorial methods for approximate image matching under translations and rotations. *Pattern Recognition Letters* **20**, *11/13* (1999), 1249-1258.
3. G. Grahne, M. Nykänen, and E. Ukkonen: Reasoning about strings in databases. *Journal of Computer and System Sciences* **59**, *1* (1999), 116-162
4. D. P. Helmbold, J. Kivinen and M. K. Warmuth: Relative loss bounds for single neurons. *IEEE Transactions on Neural Networks* **10**, *6* (Nov. 1999), 1291-1304.
5. Y. Huhtala, J. Kärkkäinen, P. Porkka and H. Toivonen: TANE: An Efficient Algorithm for Discovering Functional and Approximate Dependencies. *The Computer Journal* **42**, *2* (1999), 100-111.

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6. T. Elomaa: The biases of decision tree pruning strategies. *Proc. 3rd International Symposium on Advances in Intelligent Data Analysis, IDA '99* (eds. D. Hand, J. Kok and M. Berthold), Lecture Notes in Computer Science, Vol. 1642, Springer, 1999, 63-74.
7. T. Elomaa, and J. Rousu: Speeding up the search for optimal partitions. *Proc. 3rd European Symposium on Principles of Data Mining and Knowledge Discovery, PKDD '99*, (eds. J. Zytkow and J. Rauch) Lecture Notes in Artificial Intelligence, Vol. 1704, Springer, 1999, 89-97.
8. R. Hakli, M. Nykänen, and H. Tamm: A declarative programming system for manipulating strings. *Proc. Fenno-Ugric Symposium on Software Technology, FUSST '99*, (ed. J. Penjam), Technical Report 104/99, Institute of Cybernetics, Tallinn Technical University, 29-40.
9. R. Hakli, and M. Nykänen, H. Tamm, and E. Ukkonen: Implementing a declarative string query language with string restructuring. *Proc. 1st International Workshop on Practical Aspects of Declarative Languages, PADL '99* (ed. G. Gupta), Lecture Notes in Computer Science, Vol. 1551, Springer, 1999, 179-195.
10. J. Kivinen, and M. K. Warmuth: Averaging expert predictions. *Proc. 4th European Conference on Computational Learning Theory, EuroCOLT '99* (eds. P. Fischer and H. U. Simon), Lecture Notes on Artificial Intelligence, Vol. 1572, Springer, 1999, 153-167.
11. J. Kivinen, and M. K. Warmuth: Boosting as entropy projection. *Proc. 12th Annual Conference on Computational Learning Theory, COLT '99*, ACM, 1999, 134-144.

12. K. Lemström, P. Laine, and S. Perttu: Using relative interval slope in music information retrieval. *Proc. International Computer Music Conference, ICMC '99*, 1999, 317-320.

13. K. Lemström, O. Yli-Harja, and I. Shmulevich: Graph-based smoothing of class data with applications in musical key finding. *Proc. 1999 IEEE-EURASIP Workshop on Nonlinear Signal and Image Processing, NSIP '99*, 1999, 311-315.

14. M. Nykänen: Using acceptors as transducers. *Proc. 3rd International Workshop on Implementing Automata — Automata Implementation, WIA '98* (eds. J.-M. Champarnaud, D. Maurel, D. Ziadi), revised papers, Lecture Notes in Computer Science, Vol. 1660, Springer, 1999, 133-148.

15. M. Nykänen and E. Ukkonen: Finding paths with the right cost. *Proc. 16th Annual Symposium on Theoretical Aspects of Computer Science, STACS '99* (eds. C. Meinel and S. Tison), Lecture Notes in Computer Science, Vol. 1563, Springer, 1999, 345-355.

16. J. Rousu, T. Elomaa, and R. Aarts: Predicting the speed of beer fermentation in laboratory and industrial scale. *Proc. International Work-Conference on Artificial and Natural Neural Networks, IWANN '99, Vol. 2: Engineering applications of bio-inspired artificial neural networks* (eds. J. Mira and J. Sanchez-Andrez), Lecture Notes in Computer Science, Vol. 1607, Springer, 1999, 893-901.

17. I. Shmulevich, O. Yli-Harja, E. Cole, D.-J. Povel, and K. Lemström: Perceptual issues in music pattern recognition: complexity of rhythm and key finding. *Proc. Symposium on Musical Creativity, AISB '99*, Edinburgh College of Art and Division of Informatics, University of Edinburgh, 1999, 64-69.

18. O. Yli-Harja, J. A. Bangham, and R. Harvey: Static reduction of recursive median filters. *Proc. Nonlinear image processing X, EI '99*, 1999, 67-77.

Other articles

19. T. Elomaa: Darwin ja tekoäly. (Review of: How the mind works by Steven Pinker. New York, 1997.) *Kanava* **27**, *1* (Jan. 1999), 34-37.

20. M. Mäki-Uuro: Limits to the brute force intelligence in computer chess. *Proc. 1999 HeCSE Winter School*, (ed. T. Elomaa), Report No. C-1999-1, Department of Computer Science, University of Helsinki, 1999, 29-38.

21. E. Ukkonen: International co-operation in computer science: the NeuroCOLT Working Group. *Proc. Information Society Technologies Conference and Exhibition, IST 99 Helsinki*, summary proceedings, Information Society Directorate General of the European Commission & Finnish National Technology Agency (TEKES), 1999, 153-154.

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22. J. Kärkkäinen: Repetition-based text indexes. PhD Thesis, Report No. A-1999-4, Department of Computer Science, University of Helsinki 1999.

23. K. Lemström and L. Hella: Approximate pattern matching and transitive closure logics. Report No. C-1999-51, Department of Computer Science, University of Helsinki 1999.

24. K. Lemström and J. Tarhio: Detecting monophonic patterns within polyphonic sources. Report No. C-1999-37, Department of Computer Science, University of Helsinki 1999.

Intelligent Systems

Books

25. P. Ruohotie, P. Nokelainen, H. Tirri, and T. Silander (eds.): *Modern modeling of professional growth*, Vol. 1, Center for Vocational Education, Saarijärven Offset 1999.

Journal articles

26. E. Hyvönen, and S. De Pascale: Scientific spreadsheet computing. *Scientific data management* **3**, *4* (1999), 26-30.

27. P. Myllymäki: Massively parallel probabilistic reasoning with Boltzmann machines. *Applied Intelligence* **11** (1999), 31-44.

Peer reviewed conference and collection articles

28. E. Hyvönen, and S. De Pascale: A new basis for spreadsheet computing: Interval Solver for Microsoft Excel. *Proc. 16th National Conference on Artificial Intelligence, AAAI-99, Proc. 11th Conference on Innovative Applications of Artificial Intelligence, IAAI-99*, AAAI, 1999, 799-806.

29. P. Kontkanen, J. Lahtinen, P. Myllymäki, T. Silander, and H. Tirri: Using Bayesian networks for visualizing high-dimensional data. *Pre- and post-processing in machine learning and data mining: theoretical aspects and applications, a workshop within Machine learning and applications, Advanced Course on Artificial Intelligence 1999, ACAI '99* (ed. I. Bruha), 1999, 38-47.

30. P. Kontkanen, P. Myllymäki, T. Silander, and H. Tirri: Density estimation by minimum encoding mixtures of histograms. *Proc. 2nd European Conference on Highly Structured Stochastic Systems, HSSS '99*, book of abstracts, 1999, 162-164.

31. P. Kontkanen, P. Myllymäki, T. Silander, and H. Tirri: On the accuracy of stochastic complexity approximations. *Causal Models and Intelligent Data Management* (ed. A. Gammerman), Springer, 1999, 120-136.

32. P. Kontkanen, P. Myllymäki, T. Silander, H. Tirri and K. Valtonen: Exploring the robustness of Bayesian and information-theoretic methods for predictive inference. *Proc. Uncertainty 99: 7th International Workshop on Artificial Intelligence and Statistics* (eds. D. Heckerman and J. Whittaker), Morgan Kaufmann 1999, 231-236.

33. P. Kontkanen, T. Silander, P. Myllymäki, and H. Tirri: On supervised selection of Bayesian networks. *Proc. 15th Conference on Uncertainty in Artificial*

Intelligence, UAI '99 (ed. K. Laskey and H. Prade), Morgan Kaufmann, 1999, 334-342.

34. J. Lahtinen, P. Myllymäki, T. Silander, H. Tirri, and H. Wettig: An empirical evaluation of stochastic search methods in real-world telecommunication domains. *Proc. 3rd World Multiconference on Systemics, Cybernetics and Informatics, SCI '99*, and *5th International Conference on Information Systems Analysis and Synthesis, ISAS '99* (eds. M. Torres, B. Sanchez, S. Radhakrishan and R. Osers), Vol. 4, International Institute of Information and Systemics 1999, 181-187.
35. P. Nokelainen, H. Tirri, and P. Ruohotie: Professional growth determinants: comparing Bayesian and linear approaches to classification. *Modern modeling of professional growth*, Vol. 1, (eds. P. Ruohotie, H. Tirri, P. Nokelainen and T. Silander), Center for Vocational Education, Saarijärven Offset 1999, 85-120.
36. P. Ruohotie, and H. Tirri: Introduction. *Modern modeling of professional growth*, Vol. 1, (eds. P. Ruohotie, H. Tirri, P. Nokelainen and T. Silander), Center for Vocational Education, Saarijärven Offset 1999, 1-3.
37. T. Silander, and H. Tirri: Bayesian classification. *Modern modeling of professional growth*, Vol. 1, (eds. P. Ruohotie, H. Tirri, P. Nokelainen and T. Silander), Center for Vocational Education, Saarijärven Offset 1999, 61-83.
38. H. Tirri: What the heritage of Thomas Bayes has to offer for modern educational research? *Modern modeling of professional growth*, Vol. 1, (eds. P. Ruohotie, H. Tirri, P. Nokelainen and T. Silander), Center for Vocational Education, Saarijärven Offset 1999, 37-59.
39. H. Tirri and T. Silander, Tomi: Stochastic complexity based estimation of missing elements in questionnaire data. ERIC [distr.] 1999, 1 microcard.

Other articles

40. P. Kontkanen, P. Myllymäki, T. Silander, and H. Tirri: Urban Legends in Bayesian Network Research I: Model Selection for Supervised Problems. *Arpakannus* 1/1999, 8-14.
41. P. Nokelainen and H. Tirri: Tietoyhteiskunnan modernit mallinnusmenetelmät. *Tiedosta ja tiedon tutkimuksesta*, 273-276.

Software Engineering

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42. M. Hakala, J. Hautamäki, J. Tuomi, A. Viljamaa, J. Viljamaa, K. Koskimies, and J. Paakki: Managing Object-Oriented Frameworks with Specialization Templates. *Proc. International Workshop on Object Technology for Product-Line Architectures, ECOOP '99*. European Software Institute, 1999, 87-97.
43. M. Hakala, J. Hautamäki, J. Tuomi, A. Viljamaa, J. Viljamaa, K. Koskimies, and J. Paakki: Task-driven framework specialization. *Proc. Fenno-Ugric Symposium on Software Technology, FUSST '99* (ed. J. Penjam), Technical Report 104/99, Institute of Cybernetics, Tallinn Technical University, 1999, 65-74.

44. A.-P. Tuovinen: Vilpert — visual language expert. *Proc. Fenno-Ugric Symposium on Software technology, FUSST '99*, (ed. J. Penjam), Technical Report 104/99, Institute of Cybernetics, Tallinn Technical University, 1999, 127-138.

Other articles

45. L. Nenonen: Ohjelmistoprojektit. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 4.
46. J. Paakki: Transferring technology between academia and industry: a Nokia case. *Advance: Information from Nokia Research Center* **15** (Sept. 1999), 30-33.
47. J. Paakki: Tietokoneviruksiin osattava varautua. *Helsingin Sanomat* 10.4.1999, A2.
48. J. Paakki and P. Kutvonen: Mullistaako Linux ohjelmistoalan? *Helsingin Sanomat* 12.3.1999, D2.

PhD Theses and technical reports

49. J. Gustafsson and L. Nenonen: Olioperustaisen ohjelmistomittauksen nykytila. Report No. C-1999-52, Department of Computer Science, University of Helsinki 1999.
50. J. Koskinen, A. Salminen, and J. Paakki: Hypertext support for information needs of software maintainers. Working Paper WP-37, Department of Computer Science and Information Systems, University of Jyväskylä, 1999.

Distributed Systems and Data Communication

Books

51. L. Kutvonen, H. König, and M. Tienari (eds.): *Proc. 2nd International Working Conference on Distributed Applications and Interoperable Systems Distributed applications and interoperable systems II: IFIP TC6 WG6.1 S, DAIS '99*, Kluwer Academic Publishers, 1999.

Journal articles

52. T. Alanko, M. Kojo, M. Liljeberg, and K. Raatikainen: *Internet Research: Electronic Networking Applications and Policy* **9**, *1* (1999), 58-65.

Peer reviewed conference and collection articles

53. H. Helin, H. Laamanen, and K. Raatikainen: Mobile Agent Communication in Wireless Networks. *Proc. European Wireless '99/ITG '99*, VDE-Verlag, 1999, 211-216.
54. L. Kutvonen: Sovereign systems and dynamic federations. Distributed applications and interoperable systems. *Proc. 2nd International Working Conference on Distributed Applications and Interoperable Systems, DAIS '99* (eds. L. Kutvonen, H. Koenig, M. Tienari), Kluwer Academic Publishers, 1999, 77-90.

55. P. Kähkipuro: The method of decomposition for analyzing queuing networks with simultaneous resource possessions. *Proc. Communication Networks and Distributed Systems Modeling and Simulation Conference, CNDS '99*, 1999 Western MultiConference, 1999, 165-172.

56. P. Kähkipuro: UML based performance modeling framework for object-oriented distributed systems. *Proc. 2nd International Conference on the Unified Modeling Language: beyond the standard, UML '99*, 1999, 356-371.

57. H. Laamanen, T. Alanko, and K. Raatikainen: Dependability issues in mobile distributed system. *1999 Pacific Rim International Symposium on Dependable Computing, PRDC '99*, IEEE 1999, 7-14.

58. J. Lindström and K. Raatikainen, Dynamic adjustment of serialization order Uuing timestamp intervals in real-time databases. *Proc. 6th International Conference on Real-Time Computing Systems and Applications, RTCSA '99*, IEEE, 1999, 13-20.

59. K. Raatikainen, L. Hippeläinen, H. Laamanen and M. Turunen: Monads - Adaptation Agents for Nomadic Users. *Proc. World Telecom '99*, 1999.

60. K. Raatikainen, J. Lindström, T. Niklander, and P. Porkka: A distributed real-time main-memory database for telecommunication. *Proc. Workshop on Databases in Telecommunications*, co-located with VLDB '99, 1999, 11.

61. J. Taina, and K. Raatikainen: Requirements analysis of distribution in databases for telecommunications. *Proc. Workshop on Databases in Telecommunications*, co-located with VLDB '99, 1999, 16.

Other articles

62. P. Kähkipuro: UML based performance modeling of object-oriented distributed systems. *Proc. Software Performance Prediction Workshop*, Heriot-Watt University, Edinburgh, UK, November 1999.

63. L. Kutvonen: Tutkimus suuntaamassa suomalaista tietoliikennekehitystä: tietojenkäsittelyopin historiaa. *Tietojenkäsittelytiede*, June 1999, 10-14.

64. P. Kutvonen: Todellinen eetteriverkko. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 5.

65. K.-P. Laakso: Linux by Linus. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 4.

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Journal articles

66. P. Kilpeläinen: SGML and XML content models. *Markup Languages: Theory and Practice* **1**, *2* (1999), 53-76.

67. M. Klemettinen, H. Mannila, and H. Toivonen: Interactive exploration of interesting findings in the Telecommunication Network Alarm Sequence Analyzer TASA. *Information and Software Technology* **41**, *9* (1999), 557-567.

68. M. Klemettinen, H. Mannila, and H. Toivonen: Rule Discovery in Telecommunication Alarm Data. *Journal of Network and Systems Management* **7**, *4* (December 1999), Plenum Press.

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69. H. Ahonen: Knowledge discovery in documents by extracting frequent word sequences. *Library Trends on Knowledge discovery in bibliographic databases* (eds. J. Qin and M. J. Norton), University of Illinois at Urbana-Champaign, 160-181.

70. H. Ahonen-Myka: Finding all maximal frequent sequences in text. *Proc. 16th International Conference on Machine Learning: Workshop on Machine Learning in Text Data Analysis* (eds. D. Mladenic and M. Grobelnik), J. Stefan Institute, Ljubljana, 11-17.

71. H. Ahonen-Myka, O. Heinonen, M. Klemettinen, and A. I. Verkamo: Finding co-occurring text phrases by combining sequence and frequent set discovery. *Proc. 16th International Joint Conference on Artificial Intelligence, IJCAI '99: Workshop on Text Mining: Foundations, Techniques and Applications*, (ed. R. Feldman), 1999, 1-9.

72. J.-F. Boulicaut, M. Klemettinen, and H. Mannila: Modeling KDD processes within the inductive database framework. *Proc. 1st International Conference on Data Warehousing and Knowledge Discovery, DaWaK '99* (eds. M. K. Mohania and A. M. Tjoa), Lecture Notes in Computer Science, Vol. 1676, Springer 1999, 293-302.

73. Y. Huhtala, J. Kärkkäinen, and H. Toivonen: Mining similarities in aligned time series using wavelets. *Data Mining and Knowledge Discovery: Theory, Tools, and Technology* (ed. B. V. Dasarathy), Proceedings of the International Society for Optical Engineering (SPIE), Vol. 3695, SPIE 1999, 150-160.

74. M. Klemettinen, H. Mannila, and A. I. Verkamo: Association rule selection in a data mining environment. *Proc. 3rd European Symposium on Principles of Data Mining and Knowledge Discovery, PKDD '99*, (eds. J. Zytkow and J. Rauch) Lecture Notes in Artificial Intelligence, Vol. 1704, Springer, 1999, 372-377.

75. H. Mannila, and P. Moen: Similarity between event types in sequences. *Proc. 1st International Conference on Data Warehousing and knowledge discovery, DaWaK '99*, (eds. M. K. Mohania and A. M. Tjoa), Lecture Notes in Computer Science, Vol. 1676, Springer, 1999, 271-280.

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77. J.-F. Boulicaut, M. Klemettinen, and H. Mannila: Querying inductive databases: a case study on the MINE RULE operator. *Proc. 1999 HeCSE Winter School* (ed. T. Elomaa), Report No. C-1999-1, Department of Computer Science, University of Helsinki, 1999, 11-19.

78. B. Heikkinen, O. Heinonen, and M. Klemettinen. Rakenteisten dokumenttien koostamisen älykkäät apuvälineet. *Proc. of the RAJU Seminar*, Helsinki University of Technology, 1999.

79. H. Toivonen: Challenges for knowledge discovery in databases. *Proc. of the 1999 HeCSE Winter School*, (ed. T. Elomaa), Report No. C-1999-1, Department of Computer Science, University of Helsinki, 1999, 1.

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81. P. Kilpeläinen, and J. Jaakkola: Nested text-region algebra. Report No. C-1999-2, Department of Computer Science, University of Helsinki 1999.

82. M. Klemettinen: A knowledge discovery methodology for telecommunication network alarm databases. PhD Thesis, Report No. A-1999-1, Department of Computer Science, University of Helsinki 1999.

83. J. Puustjärvi: Transactional workflows. PhD Thesis, Report No. A-1999-2, Department of Computer Science, University of Helsinki 1999.

84. H. Toivonen, H. Mannila, J. Seppänen, and K. Vasko: Bassist user's guide: for version 0.8.3. Report No. C-1999-36, Department of Computer Science, University of Helsinki 1999.

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85. K. Järvinen, T. Pienimäki, J. Kyaruzi, E. Sutinen, T. Teräsvirta: Between Tanzania and Finland: learning Java over the Web. *Proc. 13th SIGCSE Technical Symposium on Computer Science Education, SIGCSE '99*, ACM, 1999, 217-221.

86. J. Kurhila, E. Sutinen, J. Tarhio: Towards meaningful computer uses in education. *Proc. Information Technology Shaping European Universities, EUNIS '99* (ed. K. Sarlin), Espoo, Finland, 1999, 261-264.

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87. P. Iso-Markku, J. Kurhila: *Sosiaalialan tietotekniikkakartoitus* (Survey of information technology in social and human services in Finland, in Finnish). Publications of the National Network of Excellence Centres 1, Helsinki 1999.

General

Books

88. A. Wikla: *Ohjelmoinnin perusteet Java-kielellä.* OtaDATA 1999.

Other articles

89. R. Hakola, and J. Paakki: Opiskelijapako jo hälyttävää. *Helsingin Sanomat* 18.6.1999, D2-D3.
90. T. Kerola, and P. Kutvonen: Transmetan salaisuus. *Helsingin Sanomat* 17.12.1999, D2.
91. M. Klemettinen: TKT-päivät '99 20.-21.5.1999 Tampereella. *Tietojenkäsittelytiede*, June 1999, 28-30.
92. M. Klemettinen: Väitöskirjapalkinto: Juha-Pekka Tolvanen. *Tietojenkäsittelytiede*, June 1999, 23.
93. M. Klemettinen: FuksiPower, fuksivoimaa. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 7.
94. M. Klemettinen: Tietoyhteiskunnan tulevaisuus. *Tietojenkäsittelytiede*, December 1999, 10-14.
95. M. Klemettinen: Sääntömääräinen syyskokous 1.12.1999: seuran toimintaa. *Tietojenkäsittelytiede*, December 1999, 30.
96. J. Paakki: Ansiokkaat ja ansiottomat väitöskirjat. *Tietojenkäsittelytiede*, June 1999, 4-5.
97. J. Paakki: Tatu Ylönen — tiedon turvaaja. *Tietojenkäsittelytiede*, June 1999, 7-9.
98. J. Paakki: Pääkirjoitus. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 2.
99. J. Paakki: Mistä on pienet tutkijat tehty? *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 12-14.
100. J. Paakki: Vuonna siis 2025: pääkirjoitus. *Tietojenkäsittelytiede*, December 1999, 4-6.
101. J. Paakki: Tietotekniikka '99: teknistä osaamista ja bisneslähtöistä oivaltamista. Tietojenkäsittelytiede, December 1999, 26-30.
102. J. Paakki: Linus Torvalds: internet-sukupolven supertähti. *Alumni 1999*, 14-15.
103. J. Paakki and M. Klemettinen: Pikku-uutisia. *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 11.
104. A. Saura: TKO-äly — ystäviä ja vaikutusvaltaa jo opiskeluaikana! *dATAbITTI — elämää tietojenkäsittelytieteen laitoksella 1999-2000*, 6.
105. E. Ukkonen: Tietojenkäsittelytieteen saavutusten kymmenen kärjessä. *Tietojenkäsittelytiede*, December 1999, 20-22.
106. V. Yläjääski and H. Lokki: Lokki korpin pesällä. *Yliopistolainen: Helsingin yliopiston henkilöstölehti 1999* **5**, 16.

Other reports

107. T. Elomaa (ed.): Proceedings of the 1999 HeCSE Winter School. Report No. C-1999-1, Department of Computer Science, University of Helsinki, 1999.

108. G. Lindén and E. Ukkonen (eds.): Department of Computer Science: annual report 1998. Report No. A-1999-3, Department of Computer Science, University of Helsinki 1999.

109. M. Tienari: Research and development in computing at CERN. CERN 1999.

E Accepted Theses

PhD Theses

The theses have been published in Series A at the Department of Computer Science at the University of Helsinki.

1. Klemettinen, Mika: A knowledge discovery methodology for telecommunication network alarm databases. (A-1999-1).
2. Kärkkäinen, Juha: Repetition-based text indexes. (A-1999-4).
3. Puustjärvi, Juha: Transactional workflows. (A-1999-2).

Master's Theses

The Master's Theses have been written either in Finnish, Swedish or English. They are grouped according to the specialisation areas General Computer Science, Software, Information Systems, Applied Computer Science, or Teacher in Computer Science. The areas General Computer Science and Software have since been divided each into two areas (see Section 1). The theses have been published in Series C at the Department of Computer Science at the University of Helsinki.

General Computer Science

1. Haapaniemi, Atso: MIDI-musiikin automaattinen haku sisällön perusteella. (C-1999-028).
2. Mäkinen, Veli: Likimääräisen hahmonetsinnän tehostaminen indeksirakenteiden avulla. (C-1999-065).
3. Ruotsalainen, Laura: Molekyylibiologisten sekvenssien tilastollinen analyysi. (C-1999-014).
4. Sihvo, Satu: Kolmiulotteisten molekyylikompleksien tallennus tietokantaan. (C-1999-062).
5. Tenni, Jarno: Methods and a tool for controlled language specification. (C-1999-029).
6. Uronen, Pekka: Bayes-verkkojen visualisointi. (C-1999-059).
7. Vasko, Kari: Automatisoitu bayesilaisten hierarkkisten mallien soveltaminen ympäristömuuttujan rekonstruoinnissa. (C-1999-041).

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8. Ahonen, Mikko: CORBA Mowgli-ympäristössä. (C-1999-046).
9. Haajanen, Jyrki: Uudelleenkäyttävä ohjelmistoprosessi tutkimusorganisaatiossa. (C-1999-060).
10. Halme, Petteri: Yrityksen suljetut virtuaaliverkot. (C-1999-034).
11. Hu, Rui: Performance-oriented software engineering for E-commerce. (C-1999-063).
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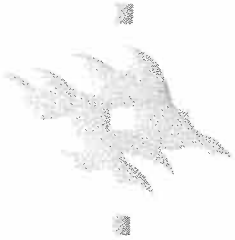

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