PREFACE

This was a year of continued expansion and stabilization of the work in the laboratory after the new professors were appointed in 1996 and 1997. The personnel grew from 25 to 30. Our international contacts in research and education strengthened. An indication of this process is that during the year we had a number of visitors. Attila Vidács, a Ph.D. student from the Technical University of Budapest joined the Laboratory to do research for his thesis. In September, we welcomed professor Vinod Sharma, from the Indian Institute of Science, Bangalore, for a visit. Three exchange students from Valencia Technical University were working on their final projects in the laboratory. In the Spring we visited the Telecommunications Laboratory at the Tallinn Technical University and hosted a return visit of professors Ots, Schults and Meister to our Laboratory.

A staff member of the Laboratory, Samuli Aalto, and a Dr.Tech. student, Marko Silventoinen, successfully defended their dissertations. The number of publications by the research staff of the laboratory experienced a substantial growth reflecting the maturation of our research groups.

Telecommunications Forum, the Studia Generalia on hot topics in Telecommunications, was organised for the second time. Although not compulsory for any of the subjects taught by the University, the course gathered audiences of up to more than 200 people and was sent over the network to half a dozen sites in Finland. The Forum has established itself as an important means of continuing the dialogue between the University and the Telecommunications service, software and equipment industries.

We continued to develop our own activities by organising development days where we discussed working atmosphere in general, teaching and reviewed our own results. During the year the renovation of the student laboratory infrastructure was also completed.

We also continued our cooperation with the Communications Laboratory within the framework of the Telecommunications Institute. The Laboratory of Acoustics and Audio Signal Processing joined the Institute. In terms of our department and university wide activities we were active in the discussions on the new study structure for the Basic and Option studies at the ECE Department. We continued to take part in the preparation of the Master's Programme in Telecommunications – the first degree programme at HUT specifically set up for English-speaking students.

I want to take the opportunity and thank all the staff of laboratory and our partners in the Industry, particularly those who gave talks and lessons in our courses, for their contributions in research and education.

Raimo Kantola

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1. INTRODUCTION

1.1 General

Due to the growth, there were times during the past year when we were short of office space. At the time of writing this problem has been solved. The gradual remodelling of our office space has continued and in 1998 we completed the renovation of the infrastructure in our teaching laboratory.

Old laboratory hall which was based on a normal office room was modified to a modern research and education environment. The laboratory has now an independent air conditioning and power supply which brings the operation and the reliability of education equipment to a very high level. Also actual student exercises were modified extensively to contain modern telecom networking concepts from the PSTN related SS7 to the ATM and Internet. Substantial investments related to these topics were made.

1.2 Research

The research has been growing in three main directions: ATM networks and their traffic theory, signal processing for mobile communications, and Internet-based switching and speech transmission. Research contacts have been active both with Finnish and foreign colleagues. Three visiting professors and six visiting researcher scientists spent several months with us in co-operative projects.

1.3 Teaching

During the year a lot of effort was put on reshaping the option courses provided by the Laboratory. Kirsi Voipio and Seppo Uusitupa completed the main body of work on their book “Tietoliikenneaapinen” the pre-prints of which were used in the course “Introduction to Telecommunications”. Two new courses were produced: “Simulation of telecommunications networks” and “Introduction to teletraffic theory”. The latter course is being proposed for inclusion in the telecommunications option studies at the Department of Electrical and Communications Engineering (ECE).

Eight of our staff of lecturers and teaching assistants were rewarded for the quality of teaching during 1997 based on the Quality system at the Department.

1.4 Departmental Activities

We participated vigorously in the efforts to renew the structure of Basic and Option studies at the ECE department. From the telecommunications technology point of view the key problem is that necessary methodological courses on event-based systems are not available to students of ECE, majoring in telecommunications. To solve the problem we provided input and participated in a working group on the study structure arguing for more flexibility (http://www.tct.hut.fi/u/kantola).

We participated in the preparation of the new Master's Programme in Telecommunications (http://www.tct.hut.fi/masters) which will start in the fall 1999. The programme is the first degree programme at Helsinki University of Technology for English speaking foreign students with the clear objective of increasing the number of DI (MSc) degrees awarded to foreign students. In the beginning the programme will provide majors in Telecommunications Software and in Radio Communications.

1.5 Key facts 1998

Masters degrees	40
Dr.Tech. degrees	1
International journal publications	9
Conference presentations	29
Other publications	7

2. PERSONNEL

2.1 Laboratory staff

Kantola, Raimo	Dr.Tech., acting professor, head of laboratory
Kilkki, Kalevi	Dr.Tech., docent
Laakso, Timo	Dr.Tech., professor
Pirinen, Aulis	Dr.Phil., docent
Rahko, Kauko	Dr.Tech., professor emeritus
Virtamo, Jorma	Dr.Tech., professor
Aalto, Samuli	Ph.D., research scientist
Baghaie, Ramin	Lic.Sc. (Tech.), senior assistant
Brax, Veikko	M.Sc., research scientist
Erke, Tapio	Laboratory engineer, on leave of absence
Hyytiä, Esa	M.Sc., research scientist
Hänninen, Arja	Department secretary
Ilvesmäki, Mika	M.Sc., research scientist
Karttunen, Petri	M.Sc., research scientist
Kosonen, Vesa	M.Sc., research scientist
Kyläkoski, Kaisa	M.Sc., research scientist
Lakkakorpi, Jani	Research assistant
Lassila, Pasi	M.Sc., research scientist
Lindfors, Anna-Kaisa	Research assistant
Liu, Yaohui	M.Sc., research scientist
Luoma, Marko	M.Sc., research scientist
Manninen, Kaisa	Secretary
Marjamäki, Harri	Research assistant
Mäntylä, Harri	Research assistant
Nupponen, Esko	Senior laboratory supervisor
Peräläinen, Ilkka	M.Sc., research scientist
Peuhkuri, Markus	M.Sc., research scientist
Pitkäniemi, Kimmo	Research assistant
Syväsalmi, Sari	Secretary
Uusitupa, Seppo	Lic.Sc. (Tech.), senior engineer
Voipio, Kirsi	Student adviser
Vidács, Attila	M.Sc., research scientist
Werner, Stefan	M.Sc., research scientist
Xie, Dazhao	M.Sc., research scientist

Figure 1: The personnel of the Laboratory of Telecommunications Technology

2.2 Part-time teachers & assistants

Kari Kalliojärvi	S-38.211	Signal Processing in Telecommunications I
Atte Karvinen	S-38.166	Programming of Telecommunication Switching Systems
Hannu Koukkula	S-38.191	Corporate Networks
Tiina Mikkola	S-38.166	Programming of Telecommunication Switching Systems
Pauli Mertanen	S-38.124	Telecommunications Technology, laboratory course II
Aarne Nurminen	S-38.166	Programming of Telecommunication Switching Systems
Tomi Nummi	S-38.202	Telecommunications Engineering Project Work
Jukka Nurmi	S-38.123	Telecommunications Technology, laboratory course I
Sampo Sainio	S-38.147	Simulation of Telecommunication Networks
Tuukka Tihula	S-38.166	Programming of Telecommunication Switching Systems
Eero Tarjanne	S-38.105	Principles of Communication Engineering
Janne Väänänen	S-38.211	Signal Processing in Telecommunication I

2.3 Guest lecturers

S-38.001 Telecommunications Forum

Heikki Ahava	Vice President	Nokia Mobile Phones
Sari Baldauf	President	Nokia Telecommunications
Hannu H. Kari	Director	TSE-Institute/HUT
Jari Karpakka	Sales Director	Kolumbus
Heimo Laamanen	Researcher	Sonera
Kari Marttinen	Director	Sonera
Veli-Matti Mattila	President	L M Ericsson
Vesa Palonen	Chief Director	Finnish Ministry of Transport and Communications
Lauri Pesonen	Division Manager	Setec
Petri Pöyhönen	Vice President	Nokia Telecommunications
Jukka Riivari	Vice President	TeamWARE group
Timo Rinne	Development Manager	Helsinki Telephone Company
Ari Saapunki	Special Advisor	Population Register Centre

3. RESEARCH PROJECTS

3.1 Models for Integrated Telecommunication Network Traffic and Architecture (MITTA)

Project leader: Kauko Rahko
Researchers: Marko Luoma, Markus Peuhkuri, Anna-Kaisa Lindfors

Project was funded by Academy of Finland for years 1996-1998. Project focused on the traffic management in ATM networks.The aim was to find out which are the key factors in the effective traffic management and how they should be adjusted in order to minimise the load of the traffic management. During these years, several people worked in this project. The main results are summarised below:

- In the area of buffer management, we tried to solve problems by using real time measurements. We made predictions about the traffic distribution by using an estimation from the measured traffic stream. This research was done through the simulations using commercial and self made tools.
- Connection admission control was studied by adopting genetic algorithms. The goal was to optimise required admission algorithms so that they suit to the real time calculations.
- ATM traffic management was reorganised to be more suitable for Internet type networking, which seems to be leading the way of broadband networking. A simplified model for traffic management was studied with the goal of adopting measurement based approaches in buffer allocation and CAC.
- End system and application influence to the measured traffic was studied through the instrumentation of the operating system.
- Traffic measurements were carried out on the local area networks and on the FUNET backbone. Models of self-similarity were adopted in analysing these traffic streams. Also estimation methods developed for the buffer management were extended to the prediction of the network and the application traffic profile.

3.2 Radio Interface and Network Design Techniques in 3rd-generation radio systems (RAVE)

Project leader Timo Laakso
Researchers: Ramin Baghaie, Petri Karttunen, Kimmo Kettunen, Stefan Werner

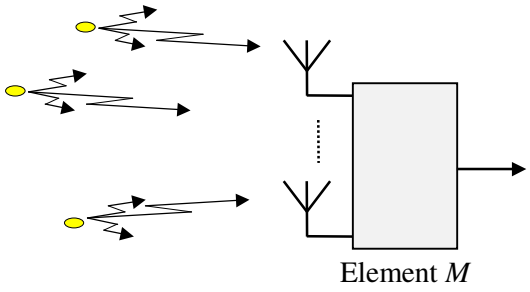

Fig 2: Multiple antenna-element receiver enables the increase in the system capacity of the future WCDMA telecommunication systems by employing clever adaptive array processing algorithms.

This is a two-year project of the Institute of Radio Communications (IRC). The IRC was established in 1993 to coordinate research on radio communications by several laboratories of the department. The research is funded by TEKES and industry partners including Nokia, Sonera, and Helsinki Telephone Company. The RAVE project focuses on new mobile communcations systems and it divides into several subprojects. Our subproject is Region B: Radio interface and algorithms, which further divides into the following projects of our laboratory:

3.2.1 Channel modeling and estimation for Wideband CDMA

Researcher: Petri Karttunen

This project focuses on two issues. The first is the analysis of temporal and spatial correlations of wideband radio channels in multiple-antenna arrays, based on the measurement results provided by the Radio Laboratory. The initial results show strong correlation between adjacent antenna elements and low correlation between different spatial locations of mobile user. This has important implications for the multiple-antenna receiver algorithm design if the correlation effects are discarded [20]. The second part of the research project focuses on the development of fast and robust user tracking algorithms for a base station in the wideband code division multiple access (CDMA) receivers with multiple antenna elements. A system has been developed, which can track several users simultaneously using either conventional gradient based least mean squared (LMS) error adaptive algorithms with the adaptive step size or more advanced conjugate gradient and the high resolution subspace techniques.

3.2.2 Adaptive detection for multiple-antenna CDMA systems

Researchers: Stefan Werner, Paulo Diniz, Jose Apolinario, Marcello de Campos

The main objective of this work is to develop efficient receiver algorithms for the wideband CDMA mobile receiver. The assumption is that the receiver only knows the own user's spreading code, so that the other-user interference has to be reduced without this information. Previous work concentrated on blind interference cancellation which, however, requires short codes, i.e., that the spreading codes overlap one symbol interval exactly [39-41]. In recent work the compatibility with long codes has been guaranteed in a channel decorrelation approach. Both schemes provide clearly superior performance in terms of signal-to-noise ratio (and bit error rate) to the conventional correlator, and also excellent robustness to the so-called near-far problem (on strong interfering user). This project includes cooperation with Prof. Paulo Diniz's group at the Federal University of Rio de Janeiro whose expertise is in the field of adaptive algorithms. Prof. Diniz himself as well as his colleagues Jose Apolinario and Marcello de Campos have contributed in the project during their visits to our laboratory in 1998.

3.2.3 Implementation of fast algorithms for multiple-antenna CDMA systems

Researcher: Ramin Baghaie

This project addresses the methodologies needed to design VLSI circuits for systems that require higher throughput or lower power consumption. This is of great importance when implementing mobile communication systems. Some of the techniques that are presented in this project are applied to the DSP algorithms needed in the previous subprojects [7-10]. The first part of this project considers high-level algorithm transformation techniques such as the look-ahead (LA), relaxed look-ahead (RLA), and strength reduction (SR). In [8-10], for the pipelined implementation of adaptive mobile receiver the LA and RLA techniques were utilized. As a result, higher throughputs or lower power consumption were achieved. On the other hand, the strength reduction transformation is applied to reduce the number of multiplications. This will result in remarkable savings in consumed power and silicon area. In [7], low-power RAKE receivers were proposed that utilize the Strength Reduction transformation technique. The second part of this project addresses several high-level architectural transformations that can be used to design families of architectures for a given algorithm. These transformations include pipelining, retiming, unfolding, and array processor design. Pipelined DSP algorithms allow us to tradeoff speed, power and area during the course of VLSI implementation.

3.2.4 Multiuser receivers and channel coding

Researcher: Kimmo Kettunen

The classical multiuser receiver algorithms of Verdu, Varanasi and Aazhang, et al. have been implemented completely without error-correction coding which is assumed to be separate. However, it is known that better results in terms of bit error rate can be obtained by considering them in the same process. This project addresses the problem of joint detection and decoding in a multiuser wideband CDMA receiver. Iterative techniques have been investigated which implement interference cancellation type detection and iterative channel decoding in an alternating manner. Both soft and hard tentative decisions have been employed. The proposed technique has been shown to provide several decibels' improvement over traditional techniques, particularly when soft tentative decisions and variance re-estimation after each iteration step is employed.

3.3 Fast Digital Subscriber Line (DSL) technologies in broadband transmission

Project leader: Timo Laakso
Researchers: Amoakoh Gyasi-Agyei, Yaohui Liu, Harri Mäntylä

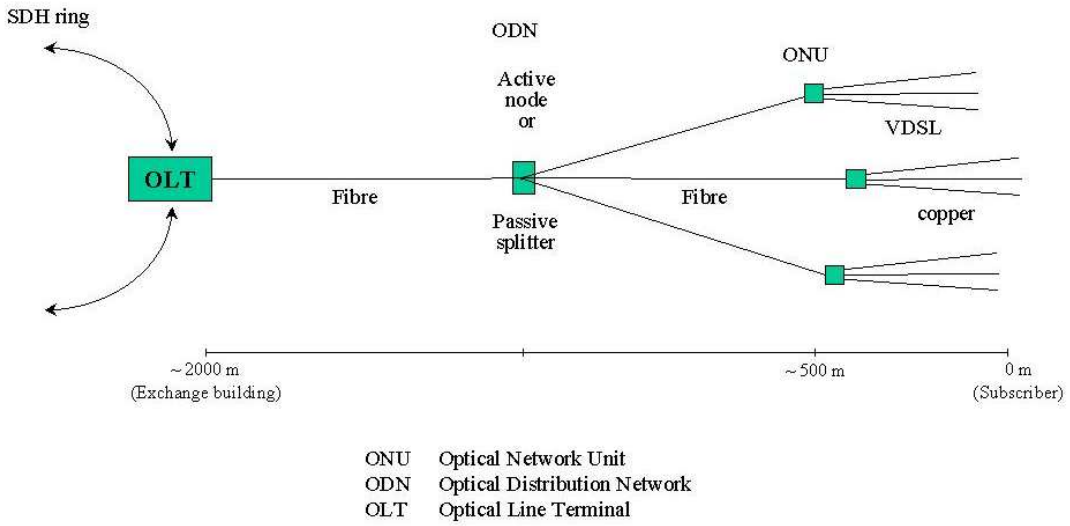

Fig. 3: VDSL network structure

This 3-year project started in 1998 and is carried out together with prof. Markku Renfors' group in the Telecommunications laboratory of Tampere University of Technology. It is funded by TEKES and industrial partners (Nokia Telecommunications, Tellabs, Helsinki Telephone Company and Tampere Telephone Company). The main objective of the research is to develop technology for the reuse of old copper telephone wiring for multi-megabit transmission using advanced signal processing techniques.

3.3.1 Channel measurements and modelling

Researcher: Yaohui Liu

In this project, the telephone line measurements carried out in Tampere are analysed. The focus is on interference measurements and modelling and in capacity analysis of connections.

3.3.2 Design of pulse shaping filters

Researcher: Amoakoh Gyasi-Agyei

This subproject focuses on pulse shaping filter design for CAP/QAM type line code. Efficient FIR filter design techniques employing symmetric coefficients were studied in [28]. Special attention is paid on suppression of radio amateur interference.

3.3.3 Design of VDSL networks

Researcher: Harri Mäntylä

Different schemes for implementing the subscriber networks are studied. The basic issue is how close to the subscribers the optical fiber should be brought.

3.4 COST 257

Project leader: Jorma Virtamo
Researchers: Samuli Aalto, Pasi Lassila, Esa Hyytiä, Kaisa Kyläkoski, Jani Lakkakorpi

COST 257 is a joint project between the Laboratory of Telecommunications Technology at HUT and VTT Information Technology. It represents the Finnish contribution to the European COST 257 Action, in which laboratories and research institutes from 18 countries participate. The research is mainly funded by TEKES with the support of Nokia Telecommunications and Sonera. The research focuses on developing models and methods for the performance analysis of telecommunication systems. The following problem areas have been addressed:

- Effective simulation of multiservice loss systems (such as an ATM network considered at the call level). Two new variance reduction methods have been developed and applied to the estimation of blocking probabilities in multiservice loss systems. In the conditional expectation method, analytically calculated blocking probabilities within one-dimensioned subsets are used as observed variables of the simulation. For the variance reduction by importance sampling an efficient composite form sampling distribution has been developed (see Figure 4). The methods have been tested for a benchmark problem and show a significant variance reduction.

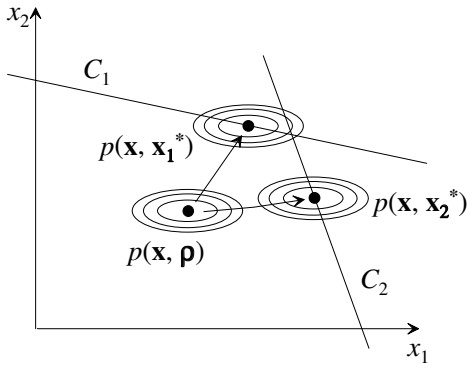

Figure 4: An example of using composite distributions for a two-traffic class and two-link example

- Optimal routing and wavelength assignment in all optical WDM backbone networks. Optimal wavelength assignment is equivalent to the so called graph colouring problem. Several heuristic techniques for finding "good" solutions for the problem have been implemented and refined. TABU search and simulated annealing appear as the most promising methods. The wavelength assignment has been extended to the multifiber case. The search for the optimal routing on top of the wavelength assignment has also been studied and tested with hypothetical WDM networks.
- Proxy cache algorithms. Caching is an important means for reducing latency times and network costs of www requests. Different models for analysing the cache behaviour have been studied. A simulation model based on a renewal type arrival process has been implemented. The cache management by using different keys for the document ordering has been studied.
- SIMA. A simulation model for studying the performance of the SIMA (Simple Integrated Media Access) concept has been built using the BONeS simulation tool. The model includes a coarse-grained handling of the TCP flow control. Also, the behaviour of the users has been modelled in the simulation. A number of traffic scenarios have been studied.
- Multicast traffic. The generalised Engset model developed in the previous year for calculating blocking probabilities in a single link has been extended to the network case by using the reduced load approximation. Also the traffic load due to signalling of the multicast connection has been modelled. This work has been done jointly with the Laboratory of Telecommunication Software and Multimedia.
- Traffic Measurements. The traffic arriving at the modem pool of HUT has been analysed based on the log files. An extensive set of graphs has been prepared.

3.5 Computational Methods for the Performance Analysis of Broadband Communication Networks, Com^2

Project leader: Jorma Virtamo
Researchers: Attila Vidács, Jani Lakkakorpi

This is a three years project funded by the Academy of Finland and started in September 1998. An efficient method for estimating the three parameters of the fractional Brownian motion from measured traffic is being developed. The key idea is to sample the traffic at geometrically separated points in order to see the scaling behaviour with fewer sample points. Maximum likelihood method is applied for the estimation.

In the project also Mathematica and C libraries of algorithms for the solution of basic queuing systems is developed and maintained. Several new algorithms have been implemented.

3.6 Studies in queuing theory

Project leader: Samuli Aalto,Vinod Sharma

Optimal control problems of various batch service queuing systems have been considered, focusing on the case of finite service capacity. The models of this kind have natural applications in the area of transportation systems. Also the output process of some fluid flow storage models used in the teletraffic theory as burst scale models of multiplexers have been characterised. This work has resulted in a Ph.D. thesis.

A new queuing model for systems with a finite buffer capacity (in bits rather than in buffer places) has been developed. The input processes considered include Poisson arrivals, MMPP process and two traffic classes with priorities.

3.7 IP/Voice

Project leader: Raimo Kantola
Researcher: Vesa Kosonen, Harri Marjamäki, Nicklas Beijar

Voice over IP studies the transmission, switching and routing of voice in IP networks and service interoperability of such networks with PSTN/ISDN. The project was initiated in April 1997 and is planned to continue for three years. The project is mainly funded by a TEKES grant, and it has five industrial partners (Nokia Research Center, Nokia Telecommunications, Sonera Oy, Omnitele/Helsinki Telephone Research and Miratel).

Results for the second year include Harri Marjamäki's M.Sc thesis on Delay Characteristics of IP Voice Terminals, a conference paper at ITS98 on Voice Packet Interarrival jitter over IP switching, invited talks by professor Kantola at the Teleware seminar and in the NTC Research & Developing day. In addition, internal reports and student papers were produced.

3.8 IP / Switch

Project leader: Raimo Kantola
Researchers: Mika Ilvesmäki, Ilkka Peräläinen, Veikko Brax, Anna-Kaisa Lindfors

The project was initiated in April 1997 and is planned to continue for 3 years. The project is mainly funded by a TEKES grant, it has five industrial partners (Nokia Telecommunications, Sonera Oy, Omnitele/Helsinki Telephone Research and Tellabs).

Although viewed as the prototype of the future Information Superhighway, the current Internet technology has a number of drawbacks, including: limited transmission and routing capacity and limited speed, long and variable transmission delays and no support for quality of service. The project is aimed at helping to solve some of these problems by focusing on issues of deployment of ATM to increase the performance of the Internet and to improve the quality of service available to the user.

Besides technology evaluation the most important results in the project are based on using neural algorithms for Internet traffic classification and applying the classification results for boosting the network performance and perceived quality of service.

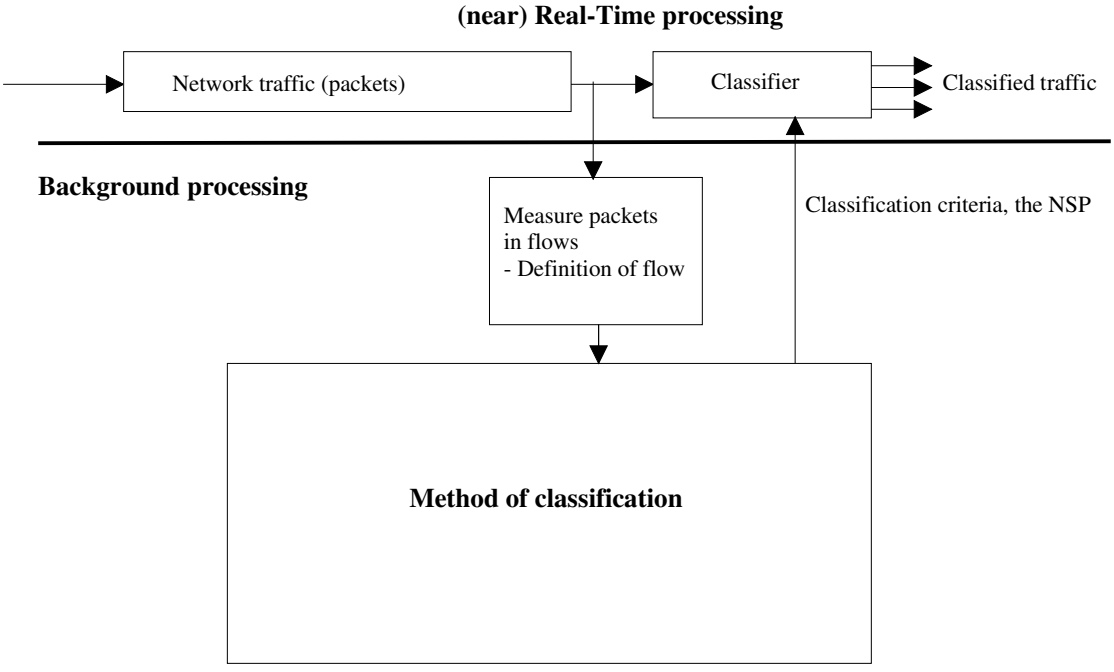

Figure 5: Procedure for measurement based Internet traffic classification

Results during the year include Ilkka Peräläinen's M.Sc thesis, a journal paper, three conference papers, internal reports and reports of special assignments by the students. More results are in the pipeline.

4. TEACHING

4.1 Development of teaching

The course "Introduction to teletraffic theory" (S-38.145) was given for the first time in spring 1998. The course is planned to give a broad view of teletraffic issues in communications networks and familiarise the students with the basic tools for the dimensioning and analysis of the networks. Most of the material of the course is available in electronic form.

The course "Simulation of telecommunications networks" (S-38.147), was given for the first time in fall 1999. The course consists of three parts. In the first part general aspects of simulation are addressed and different methods for the generation of random variables and statistical analysis of the results are introduced. The second part deals with the construction of an event based simulation program. The third part gives an introduction to the available commercial simulation tools and a more detailed look at a specific tool.

The contents of the optional course "Principles in communication engineering" (S-38.105) was largely renewed. The course is now an overview of telecommunications and its purpose is to provide guidelines and pointers for further studies. The main body of work for the course book "Tietoliikenneaapinen" was completed during the year by Kirsi Voipio and Seppo Uusitupa.

The contents of the course Telecommunications Technology II was partially renewed. The course is now totally devoted to routing in packet and circuit switched networks.

4.2 Courses

The laboratory has given education in 25 courses. The courses can be divided into 7 groups:

4.2.1 Basic courses for all students studying telecommunications

S-38.105 Principles in Communication Engineering (Tietoliikennetekniikan perusteet)
S-38.118 Principles in Telecommunications Technology (Teletekniikan perusteet)

4.2.2 Courses concerning communications and networks

S-38.117 Seminar on Telecommunications Technology (Teletekniikan seminaari)
S-38.188 Telecommunication Networks (Tietoliikenneverkot)
S-38.191 Corporate Networks (Televerkot yrityksissä)

4.2.3 Courses on switching and ATM

S-38.110 Telecommunication Switching Technology I (Tiedonvälitystekniikka I)
S-38.122 Telecommunication Switching Technology II (Tiedonvälitystekniikka II)
S-38.164 Broadband Switching Technology (Laajakaistainen välitystekniikka)
S-38.166 Programming of Telecommunication Switching Systems
(Televälitysjärjestelmien ohjelmointi)

4.2.4 Courses on signal processing

S-38.211 Signal Processing in Telecommunications I
(Signaalinkäsittely tietoliikenteessä I)
S-38.212 Signal Processing in Telecommunications II
(Signaalinkäsittely tietoliikenteessä II)

4.2.5 Postgraduate courses

S-38.001 Telecommunications Forum (Telecommunications Forum)
S-38.130 Postgraduate Course in Telecommunications (Teletekniikan lisensiaattikurssi)
S-38.141 Teletraffic Theory (Teleliikenneteoria)
S-38.143 Queueing Theory (Jonoteoria)
S-38.149 Postgraduate Course in Teletraffic Theory (Teleliikenneteorian lisensiaattikurssi)
S-38.200 Individual Course in Telecommunications (Teletekniikan yksilöllinen opintojakso)
S-38.220 Licentiate Course in Signal Processing in Communications
(Tietoliikenteen signaalinkäsittelyn lisensiaattikurssi)
S-38.350 Research Seminar on Telecommunications Technology
(Teletekniikan tutkijaseminaari)

4.2.6 Courses on teletraffic theory

S-38.145 Introduction to Teletraffic Theory (Liikenneteorian perusteet)
S-38.147 Simulation of Telecommunication networks (Televerkkojen simulointi)

4.2.7 Other courses

S-38.123 Telecommunications Technology, laboratory course I
(Teletekniikan laboratoriotyöt I)
S-38.124 Telecommunications Technology, laboratory course II (Teletekniikan laboratoriotyöt II)
S-38.128 Telecommunications Technology, special assignment
(Teletekniikan erikoistyö)
S-38.300 Thesis Seminar on Telecommunications Technology
(Teletekniikan diplomityöseminaari)

4.3 Degrees

4.3.1 Doctor of Technology

Marko Silventoinen: Indoor GSM base station systems

The thesis of Marko Silventoinen studies indoor GSM base station systems. The indoor environment can be divided into two parts, home and office.

At home the subscriber can be given the possibility to invest in his or her own infrastructure by offering a low-cost Home Base Station (HBS). This will allow the GSM operator to apply lower rates at calls made from home, thus challenging the fixed line operator. An MS based hardware architecture will be used to achieve the low costs required from a consumer product. This leads to modifications on the air interface. In this thesis Silventoinen has studied two aspects of the HBS air interface: a frequency hopping scheme that allows HBSs to share the spectrum with the overlaying GSM network, and a fast power control scheme that helps HBSs to increase their performance without frequency hopping capability.

In the near future the shortage of carrier frequencies at the GSM band will force the operators to look for possibilities to enhance GSM's spectral efficiency, especially in already congested urban areas. The studies performed on the office BTS address this problem and propose new ways to improve the spectral efficiency while maintaining the air interface compatibility with the existing handsets.

The proposed indoor GSM base station concepts can serve also in other environments: HBS in small offices, and office BTS in shopping malls, stadiums, or even as a generic hot-spot solution.

4.3.2 Doctor of Philosophy (Helsinki University)

Samuli Aalto: Studies in queueing theory

The thesis of Samuli Aalto consists of two parts. In Part I, the optimal control problem of batch service queueing systems is studied. A natural control problem involves the determination of the epochs at which the service is initiated as well as the sizes of the batches served. The case of finite service capacity with general holding costs is considered with two types of arrival processes (Poisson and compound Poisson). In each case a new class of operating policies is introduced and it is proven that, under some additional assumptions, there is an optimal operating policy belonging to this new class. Models of this kind have applications, for example, in the area of transportation systems

In Part II the output process of some fluid flow storage models are characterized. First, assuming that the input rate is modulated by a certain type of a Markov jump process, it is proven that there exists another Markov jump process that modulates the output rate. The modulating process is explicitly constructed. Second, a fluid model of a multiplexer loaded by a finite number of heterogenerous on-off sources is considered.

The main result here is a generalization of an earlier result characterizing the active periods on the output line by means of Laplace transforms.

4.3.3 Masters of Science in Telecommunication technology

1. Aaltonen S.	The optimization of the creation of management applications for the intelligent networks, in Finnish (Hallintasovellusten luonnin optimointi älyverkon palvelun-hallinnassa)	NTC
2. Aromaa A.	Mid-sized company's network and the evolution of it, in Finnish (Keskikokoisen yrityksen lähiverkko ja sen kehittäminen)	TIE
3. Bäckström M.	Interworking concepts for computer supported corperative work applications in a heterogeneous network, in Finnish (Ryhmätyösovellusten yhteiskäyttö heterogeenisessä verkkoympäristössä)	HPY
4. Eronen H.	Mobile and secure access to corporate intranet	TWG
5. Haaksiala A.	A descriptive method of interoperability for distributed information systems, in Finnish (Menetelmä hajautettujen tietojärjestelmien yhteistoiminnallisuuden kuvaamiseksi)	NTC
6. Heikkinen T.	Information flow in internal trade, in Finnish (Tiedonsiirto yrityksen sisäisessä kaupankäynnissä)	F-ICLC
7. Helsingius M.	Service level management and application response time measurement in a client/server environment	HP
8. Huopaniemi J.	The use of GSM-based protocols in intelligent network, in Finnish (GSM-protokollien käyttö älyverkon palvelukehityksessä)	SON
9. Huostila T.	The requirements on and advantages of the optimal routing of GSM calls from the point of view of a teleoperator, in Finnish (GSM-puheluiden optimaalisen reitityksen vaatimukset ja hyödyt teleoperaattorin kannalta)	SON
10. Hänninen M.	The short message transfer capacity optimization using TCP/IP protocol, in Finnish (Lyhytsanomavälityksen optimointi TCP/IP-protokollan avulla)	NTC
11. Iisakkila K.	Air interface interoperability of network layer services in TETRA mobile radio networks, in Finnish (Verkkokerrospalvelujen yhteensopivuus TETRA-erillisradioverkon ilmatierajapinnassa)	NTC
12. Iraji S.	Preprocessor software platform design for Nokia DX200 system	NTC
13. Jaatinen A.	Charging in the permanent and switched ATM networks, in Finnish (Veloitus kiinteässä ja kytkentäisessä ATM-verkossa)	DAT

14. Kahanpää H.	The implementation of CTI functions to subscribers of an EWSD exchange, in Finnish (Tietokoneen ja puhelimen yhteiskäyttötoiminteiden toteuttaminen EWSD-keskuksen tilaajille)	SIE
15. Kanerva J.	The development and the commercializing of one digital announcer, in Finnish (Digitaalisen tiedotuslaitteen kehitys ja tuotteistus)	MUUT
16. Kaseva M.	Implementing network supplementary services into intelligent networks, in Finnish (Älyverkon käyttö tilaajatoiminteiden toteuttamisessa)	SON
17. Kehä M.	Improving network performance for a workstation cluster	NRC
18. Koivisto E.	Feasibility of data communications services on the ISDN D-channel	NTC
19. Koski J.	GSM service evolution towards universal mobile telecommunications system	SON
20. Kuusivaara J.	Production testing of broadband interface modules, in Finnish (Laajakaistaisten tietoliikennemoduulien tuotantotestaus)	TE
21. Laamanen M.	Extranet application in telecom customer services	LME
22. Laamanen P.	The use of unifield modeling language in intranet project, in Finnish (UML-kuvauskielen käyttö Intranet-projektissa)	SPY
23. Laitala K.	Subscriber segmentation in mobile networks	NTC
24. Lehtonen J.	Energy company's customer reporting system, in Finnish (Energiayhtiön asiakasraportointijärjestelmä)	TUE
25. Lehtovirta V.	Internet protocol switching in cellular access networks	LME
26. Leinonen M.	Applying OCTOPUS-method to DX 200 -systems hardware configuration management, in Finnish (Octopus-menetelmän soveltaminen DX200-järjestelmän laitteisto-konfiguraation hallintaan)	NTC
27. Liu J.	China's telecommunications market and Technomen's operation - a case study	TM
28. Mensola S.	Communication management in IP-based networks, in Finnish (IP-verkon kommunikaatiopalveluiden hallinta)	HPY
29. Merikoski M.	Distance education through the world wide web	CERN
30. Miikkulainen J.	Automation of the hardware configuration management of a distributed system	NTC
31. Peltonen L.	Software process measurement and improvement: a case study in telecommunications	NTC

32. Peräläinen I.	Labelbased multilayer routing, in Finnish (Leimapohjainen monikerrosreititys)	HUT
33. Rosqvist T.	Modernisation of an automatic fire alarm system, in Finnish (Erään automaattisen paloilmoitinjärjestelmän uudistaminen)	NES
34. Rostas P.	Architecture for web based Information services in GSM networks	SON
35. Räsänen P.	Screening as a part of security of common channel signalling, in Finnish (STP-liikenteen käyttörajoitukset osana yhteiskanavamerkinannon turvallisuutta)	NTC
36. Saukko T.	Simulator testing of ISDN user part in mobile networks, in Finnish (ISDN-käyttäjäosan simulaattoritestaus matkapuhelinverkoissa)	SIE
37. Sipilä J.	Application of external intelligent peripherals to mobile networks	SIE
38. Teppo I.	Future development of the short message service	TM
39. Timonen P.	The co-operation of the short message service with other services of GSM network, in Finnish (Lyhytsanomapalvelun yhteistoiminta GSM-verkon muiden palveluiden kanssa)	SON
40. Xie D.	Design of optimal digital FIR pulse shaping filters for digital subscriber lines	HUT
41. Yletyinen T.	The quality of voice over IP	HUT

CERN	European Laboratory for Particle Physics
DAT	Datatie Oy
F-ICLC	Fujitsu-ICL Computers
HP	Hewlett-Packard Oy
HPY	Helsinki Telephone Company
HUT	Helsinki Univ. of Technology/ Lab. of Telecom. Technology
LME	Oy L M Ericsson Ab
MUUT	Independetn research
NES	Neste Oy
NRC	Nokia Research Center
NTC	Nokia Telecommunications
SIE	Siemens Finland
SON	Sonera
SPY	Savonlinnan puhelinyhdistys
TE	Tellabs Oy
TIE	Tieturi
TM	Tecnomen Oy
TUE	Turku Energia
TWG	Team WARE Group

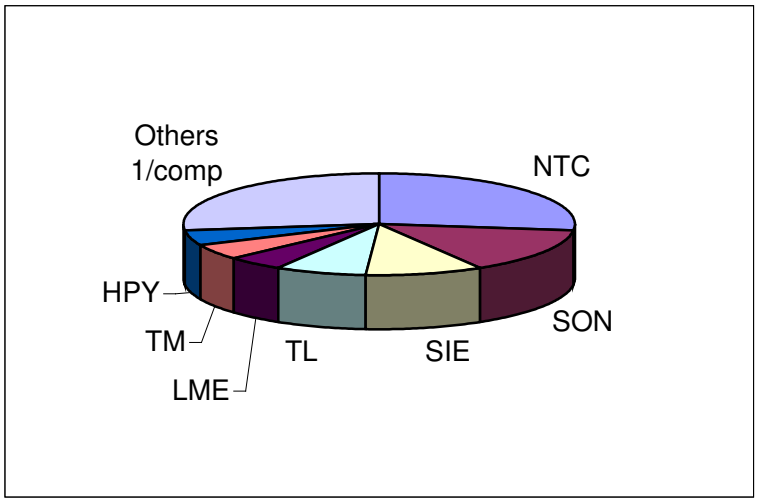

Figure 6: Employers of Masters students

5. ACTIVITIES

5.1 International conferences and meetings

- COST 257 Management Committee meeting January 15-16, 1998, Rome, Italy (Virtamo)
- 6th International conference on telecommunication Systems Modelling and Analysis, March 5 - 8, Nashville, USA (Aalto)
- 4th INFORMS Telecommunications Conference, 8-11 March 1998 Boca Raton, Florida (Aalto)
- Tallinn University of Technology, March 10-11, (laboratory staff)
- "The Dagstuhl Seminar on Advanced Stochastic Modelling Applied to Telecommunication Networks and Distributed Systems", March 30 - April 3, Schloss Dagstuhl, Wadern, Germany (Virtamo)
- Voice on the Net '98 Spring conference, March 28 - April 4, San José, USA (Kantola)
- IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP'98, May 12-15, 1998, Seattle, Washington (Baghaie)
- COST 257 Management Committee meeting May 25-26, 1998, Ronneby, Sweden (Virtamo)
- IFIP TC6/WG6.3 Seventh International Conference on Performance of Information and Communication Systems (PICS'98), 25-28 May 1998, Lund, Sweden (Lassila, Virtamo)
- The International Conference on Communications (ICC'98), June 6-13, Atlanta, USA (Kantola, Werner)
- IEEE Nordic Signal Processing Symposium, June 8-11, Vigsjoe, Denmark (Baghaie)
- The ITC Sponsored Reginal International Teletraffic Seminar "Teletraffic Theory as a base for QoS", June 2-5, St. Petersburg, Russia (Kantola, Virtamo)
- 16th European Conference on Operational Research (EURO XVI) 12-15 July, 1998, Brussels, Belgium (Aalto)
- SBT/IEEE International Telecommunications Symposium, August 9-13, Sao Paulo, Brazil (Werner)
- Fourteenth Nordic Tele-traffic Seminar, NTS-14 August 18 - 20, 1998, Technical University of Denmark, Copenhagen, Denmark (Hyytiä, Virtamo)
- IX European Signal Processing Conference EUSIPCO'98, September 8-11, 1998, Island of Rhodes, Greece (Baghaie)
- COST 257 Management Committee meeting September 23-24, 1998, Granada, Spain (Lassila)

- International Conference on Universal Personal Communications (ICUPC'98), October 5-9, 1998, Florence, Italy (Karttunen)
- 8th International Telecommunication Network planning Symposium, October 18-23, Sorrento, Italy (Mäntylä)
- International Conference on Voice, Video and Data Communications, November 2-4, Boston, USA (Luoma, Peuhkuri)
- IEEE Global Telecommunications Conference GLOBECOM, November 8-12, Sydney, Australia (Ilvesmäki)

5.2 Foreign visitors in 1998

The following persons have visited the Laboratory of Telecommunications Technology during the year 1998:

- Mr. David Vasquez Cortizo from Universidad de la Corunna (January-February 1998)
- Mr. Genis Sanchez Gomez from Universitat Politècnica de Catalunya (June-August 1998)
- Professor Dieter Baum from University of Trier (August 1998)
- Dr. José Apolinario from Universidade Federal do Rio de Janeiro, Brazil (September 1998)
- Professor Paulo Diniz from Universidade Federal do Rio de Janeiro, Brazil (September-October 1998)
- Professor Marcello de Campos from Universidade Federal do Rio de Janeiro, Brazil (September-December 1998)
- Ms Inmaculada Espigares from Universidad Politecnica de Valencia (October-December 1998)
- Mr. Ricardo Insa Hernandez from Universidad Politecnica de Valencia (October-December 1998)
- Professor Andreas Polydoros from University of Athens (December 1998)
- Mr. Attila Vidács from Technical University of Budapest (September–December 1998)
- Professor Vinod Sharma from Indian Institute of Science, Bangalore (Septeber-December 1998)

6. PARTICIPATION IN BOARDS AND COMMITTEES

6.1 University boards and committees

- **Timo Laakso**
  - Chairman of the Library Committee of the Department of Electrical and Communications Engineering
- **Jorma Virtamo**
  - Vice chairman of the Committee for the International Affairs
- **Raimo Kantola**
  - Chairman of the Telecommunications Institute (YVA)
  - Member of the Committee of Public relations of the Department of Electrical and Communications Engineering
  - Chairman of the Fitness for Work Committee at the Department of Electrical and Communications Engineering
  - Director of the Master's Programme in Telecommunications
  - Member of Board of Otaverkko Oy, subsidiary of HUT
  - Member of the working group on the new structure of basic and option studies.

6.2 Other boards and committees

- **Timo Laakso**
  - Member of the Digital Signal Processing Technical Committee of the IEEE Circuits and Systems Society
  - Member of the editorial board of Applied Signal Processing (Journal by Springer Verlag)
  - Vice chairman of the International Conference on Communications, to be held in Finland in 2001
  - Treasurer of the IEEE Finland Section
- **Jorma Virtamo**
  - Vice Chairman of the Management Committee of the Action COST 257 "Impacts of new services on the architecture and performance of broadband networks"
  - Member of the IFIP/WG 6.3 on Performance of Communication Systems
  - Member of the Technical Program Committee of the 16th International Teletraffic Congress ITC-16, to be held in Edinburgh, 7-11 June, 1999

- Member of the Program Committee of the International Conference "Performance of information and communications systems", PICS'98 Lund, May 25-28, 1998
- Member of the Technical Program Committee of the ITC sponsored seminar, "Teletraffic Theory as a Base for QoS: Monitoring, Evaluation, Decisions", St. Petersburg, June 1-7, 1998
- Member of the Program Committee of the "Workshop on Modelling, Measuring and Quality of Service" in the 7th Summer School on Telecommunications, Lappeenranta, August 7, 1998

- **Raimo Kantola**
  - Member of the Broad-band Core Networks Group of the TEKES Telecommunications Technology Programme
  - Member of the Supervisory Council in Sonera Oyj

6.3 Referee activities

- **Timo Laakso**
  - Reviewer for the following scientific journals: IEEE Transactions on Signal Processing, IEEE Trans. on Circuits and Systems, IEEE Trans. on Communications, Signal Processing, Applied Signal Processing, IEE Electronic Letters
  - External evaluator of the Dr.Tech. dissertation of Z. Hang, Tampere University of Technology
  - Opponent in the Dr.Tech. dissertation of M. Latva-aho, Oulu University
- **Jorma Virtamo**
  - Viewer for the Journal Performance Evaluation and the conferences: ITC-16, Pics´98 and the workshop on Modelling, Measuring and Quality of Service
  - External evaluator of the Ph.D. dissertation of Mr. J.M. Barcelò, Universidad Politechnica de Cataluna
  - Opponent in the Ph.D. dissertation of J.M. Barcelò, Universidad Politechnica de Cataluna
  - External evaluator of the Dr.Tech. dissertation of H. Tang, Helsinki University of Technology
  - Opponent in the Dr.Tech. dissertation of Haitao Tang, Helsinki University of Technology
  - Opponent in the Dr.Tech. dissertation of M. Grundström, Tampere University of Technology
  - External evaluator of the Ph.D. dissertation of S. Shankar, Indian Institute of Science

- **Raimo Kantola**
  - Reviewer of the conference on Distributed Applications and Interoperable Systems (DAIS´99).

7. Publications

1. Aalto, S. Characterization of the output rate process for a Markovian storage model. Journal of Applied Probability, 1998. Vol. 35, pp. 184-199.

2. Aalto, S. Optimal control of batch service queues with compound Poisson arrivals and finite service capacity. Mathematical Methods of Operations Research, 1998. Vol. 48, No. 3, pp. 317-335.

3. Aalto, S. Output of a multiplexer loaded by heterogeneous on-off sources. Communications in Statistics-Stochastic Models, 1998. Vol. 14, No. 4, pp. 993-1005.

4. Aalto, S. Studies in Queueing Theory. (1. p.). Espoo 1998, Helsinki University of Technology, Laboratory of Telecommunications Technology, Report 1/98, 100 p.

5. Apolinario, J.A., Diniz, P.S.R., Laakso, T.I. & de Campos, M.L.R. Step-size optimization of the BNDR-LMS algorithm. IX European Signal Processing Conference (EUSIPCO'98), 8.-11.9.1998. Rhodes, Greece 1998, pp. 1249-1252.

6. Apolinario, J., Werner, S., Laakso, T.I. & Diniz, P.S.R. Constrained normalized adaptive filtering for CDMA mobile communications. IX European Signal Processing Conference (EUSIPCO'98), 8.-11.9.1998. Rhodes, Greece 1998, pp. 2053-2056.

7. Baghaie, R. & Laakso, T. Implementation of low-power CDMA rake receivers using strength reduction transformation. IEEE Nordic Signal Processing Symposium, Vigsjoe, Denmark, 8.-11.6.1998. Aalborg, Denmark 1998, Aalborg University, pp. 169-172.

8. Baghaie, R. & Werner, S. Pipelined adaptive CDMA mobile receivers. IEEE Nordic Signal Processing Symposium, Vigsoe, Denmark, 8.-11.6.1998. Aalborg, Denmanrk 1998, Aalborg University, Denmark, pp. 69-72.

9. Baghaie, R., Werner, S. & Laakso, T. Pipelined implementation of adaptive multiple-antenna CDMA receivers. IEEE International Conference on Acoustics, Speech and Signal Processing, ICASSP'98. Washington 1998, pp. 3229-3232.

10. Baghaie, R., Werner, S. & Laakso, T. Relaxed look-ahead techniques for pipelined implementation of adaptive multiple-antenna CDMA mobile receivers. Proceedings IX European Signal Processing Conference EUSIPCO'98. Greece 1998, pp. 877-880.

11. Cortizo, D. V. & Garcia, J. A collision resolution algorithm for ad-hoc wireless LANs. IFIP TC6/WG6.2 Fourth International Conference on Broadband communications (BC98). University of Stuttgart, Germany 1998, Chapman & Hall, pp. 119-130.

12. de Campos, M., Werner, S., Apolinario, J. & Laakso, T. Constrained quasi-Newton algorithm for CDMA mobile communications. SBT/IEEE International Telecommunications Symposium ITS'98. Sao Paulo, Brazil 1998, pp. 371-376.

13. Diniz, S. R. P. Nonlinear adaptive filtering. (1.p.). Espoo 1998, Helsinki University of Technology, Laboratory of Telecommunications Technology, Report 4/98, 61 p.

14. Hyytiä, E. Optimaalinen reititys ja aallonpituuksien jako täysoptisessa DM-järjestelmässä. Espoo 1998, Helsinki University of Technology, Laboratory of Telecommunications Technology, Report 2/98, 70 p.

15. Hyytiä, E. & Virtamo, J. Wavelength assignment and routing in WDM networks. Proceedings of the Fourteenth Nordic Teletraffic Seminar NTS-14. Copenhagen 1998, pp. 31-40.

16. Annual report 1997. Espoo 1998, Helsinki University of Technology, Laboratory of Telecommunications Technology, 26 p.

17. Ilvesmäki, M., Kantola, R. & Luoma, M. Adaptive flow classification in IP switching: The measurement based approach. Internet Routing and Quality of Service. USA 1998, SPIE, pp. 277-286.

18. Ilvesmäki, M., Kantola, R. & Luoma M. Learning vector quantization in flow classification of IP switched networks. IEEE 1998 Global Telecommunications Conference. USA 1998, IEEE, pp. 3017-3022.

19. Ilvesmäki, M., Luoma, M., & Kantola, R. Flow classification schemes in traffic-based multilayer IP switching-comparison between conventional and neural

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20. Karttunen, P. T., Kalliola, K., Laakso, T. & Vainikainen, P. Measurement analysis of spatial and temporal correlation in wideband radio channels with adaptive antenna array. International Conference on Universal Personal Communications (ICUPC'98). Italy 1998, pp. 671-675.

21. Karvo, J. & Ilvesmäki, M. Nondeterministic classifier performance evaluation for flow based IP switching. High Performance Networking '98, Vienna, September 21 - 15, 1998. Vienna 1998, IFIP TC-6, Kluwer Academic Publishers, pp. 598-609.

22. Karvo, J., Virtamo, J., Aalto, S. & Martikainen, O. Blocking of dynamic multicast connections in a single link. Broadband '98, Stuttgart, Germany, 1.3.4.1998. London 1998, IFIP, pp. 473-483.

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28. Laakso, T. & Välimäki, V. Energy-based effective length of the impulse response of a recursive filter. IEEE Int. Conference on Acoustics, Speech and Signal Processing. Seattle, Washington 1998, pp. 1253-1256.

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30. Lassila, P. & Virtamo, J. Using Gibbs Sampler in Simulating Multiservice Loss Systems. Rome 1998, COST 257 TD (98)19.

31. Lassila, P. & Virtamo, J. Using gibbs sampler in simulating multiservice loss systems. IFIP TC6/WG6.3 Seventh International Conference on Performance of Information and Communications Systems. Lund, Sweden 1998, Chapman & Hall, pp. 261-272.

32. Lassila, P. & Virtamo, J. Efficient Monte Carlo simulation of product form systems. Proceedings of the Fourteenth Nordic Teletraffic Seminar NTS-14. Copenhagen, Denmark 1998, pp. 355-366.

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35. Merikallio, M. & Virtamo J. Adaptive detection algorithms in DS-CDMA. International Conference on Universal Personal Communications, ICUPC'98. Florence, Italy 1998, pp. 39-44.

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