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**UNIVERSITÄT
BERN**

Institut für Informatik und
angewandte Mathematik
Universität Bern

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IAM Annual Report 07/08



IAM Annual Report
Academic Year 2007/2008

July, 2008

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1 Institute of Computer Science and Applied Mathematics (IAM)

1.1 Address

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www: <http://www.iam.unibe.ch>

1.2 Personnel

Board of directors

Prof. Dr. Hanspeter Bieri; Prof. Dr. Torsten Braun; Prof. Dr. Horst Bunke;
Prof. Dr. Gerhard Jäger; Prof. Dr. Oscar Nierstrasz.

Teaching staff

Prof. Dr. Hanspeter Bieri; Prof. Dr. Torsten Braun; Prof. Dr. Horst Bunke;
Dr. Orla Greevy; Prof. Dr. Rolf Haenni; Prof. Dr. Gerhard Jäger; Dr. Urs-
Viktor Marti; Prof. Dr. Oscar Nierstrasz; Prof. Dr. Kilian Stoffel; Prof. Dr.
Thomas Strahm; Dr. Thomas Studer.

Director

Prof. Dr. Torsten Braun.

Administration

Ruth Bestgen; Bettina Choffat; Sabine Gerber; Iris Keller; Therese
Schmid; Susanne Thüler.

Library

Gudrun Heim.

Technical staff

Peppo Brambilla; Dragan Milic.

Scientific staff

Dr. L. Alberucci; M. Anwander; R. Bertolami; P. Brambilla; M. Brogle; Dr. K. Brännler; Th. Buchberger; S. Bucheli; M. Denker; V. Frinken; Dr. T. Gîrba; R. Goetschi; Dr. O. Greevy; Dr. T. Ha-Minh; Prof. Dr. R. Haenni; M. Hugli; E. Indermühle; J. Jonczy; R. Kohlas; J. Krähenbühl; A. Kuhn; Dr. U.-M. Künzi; Dr. R. Kuznets; P. Lauer; A. Lienhard; M. Liwicki; Dr. R. McKinley; D. Milic; Dr. G. Ostrin; Dr. D. Probst; L. Renggli; K. Riesen; Ph. Robert; D. Röthlisberger; S. Schär; A. Schlapbach; D. Spescha; T. Staub; D. Steiner; Ph. Stouppa; Prof. Dr. Th. Strahm; Dr. Th. Studer; T. Verwaest; M. Wachter; G. Wagenknecht; M. Wälchli; R. Wehbe; Dr. M. Wulff.

2 Teaching Activities

2.1 Courses for Major and Minor in Computer Science

Autumn Semester 2007

- Bachelor 1st Semester

Einführung in die Informatik (H. Bieri, 5 ECTS)

Programmierung 1 (Th. Strahm, 5 ECTS)

Grundlagen der technischen Informatik (Th. Studer, 5 ECTS)

- Bachelor 3rd Semester

Information und Logik (G. Jäger, 5 ECTS)

Einführung in Software Engineering (O. Nierstrasz, 5 ECTS)

Computernetze (T. Braun, 5 ECTS)

- Bachelor 5th Semester

Computergrafik (H. Bieri, 5 ECTS)

Künstliche Intelligenz (H. Bunke, 5 ECTS)

Mensch Maschine Schnittstelle (Th. Strahm, 5 ECTS)

- Master Courses

Dynamic Object-Oriented Programming with Smalltalk (O. Nierstrasz, 5 ECTS)

Graduate Seminar Logik und Information (J. Kohlas, J. Schmid, K. Stoffel, G. Jäger, 5 ECTS)

Grundlagen der Mustererkennung (H. Bunke, 5 ECTS)

Highlights in Logic I (G. Jäger, J. Schmid, 10 ECTS)

Mobilkommunikation (T. Braun, 5 ECTS)

Seminar: Algebra und Logik (G. Jäger, J. Schmid, 5 ECTS)
Seminar: Computergeometrie und Grafik (H. Bieri, 5 ECTS)
Seminar: Künstliche Intelligenz (H. Bunke, 5 ECTS)
Seminar: Rechnernetze und Verteilte Systeme (T. Braun, 5 ECTS)
Seminar: Software Composition (O. Nierstrasz, 5 ECTS)
Seminar: Theoretische Information und Logik (G. Jäger, 5 ECTS)

- Service Course

Anwendungssoftware (Th. Studer, 3 ECTS)

Spring Semester 2007

- Bachelor 2nd Semester

Datenstrukturen und Algorithmen (H. Bieri, 5 ECTS)
Datenbanken (K. Stoffel, 5 ECTS)
Programmierung 2 (O. Greevy, 5 ECTS)
Rechnerarchitektur (Th. Studer, 5 ECTS)

- Bachelor 4th Semester

Automaten und formale Sprachen (H. Bunke, 5 ECTS)
Betriebssysteme (T. Braun, 5 ECTS)
Berechenbarkeit und Komplexität (Th. Strahm, 5 ECTS)
Praktikum in Software Engineering (Th. Studer, 5 ECTS)

- Bachelor 6th Semester

Proseminare

- Master Courses

- Automatische Sprachdienste (U. V. Marti, 5 ECTS)
- Computer Vision (H. Bieri, 5 ECTS)
- Graduate Seminar Logik und Information (J. Kohlas, J. Schmid, K. Stoffel, G. Jäger, 5 ECTS)
- Highlights in Logic II (G. Jäger, J. Schmid, 5 ECTS)
- Komplexitätstheorie (Th. Strahm, 5 ECTS)
- Mustererkennung 2 (H. Bunke, 5 ECTS)
- Programming Languages (O. Nierstrasz, 5 ECTS)
- Seminar: Computergeometrie und Grafik (H. Bieri, 5 ECTS)
- Seminar: Künstliche Intelligenz (H. Bunke, 5 ECTS)
- Seminar: Logic of Proofs (G. Jäger, 5 ECTS)
- Seminar: Metamodeling and Mataprogramming (O. Nierstrasz, 5 ECTS)
- Seminar: Rechnernetze und Verteilte Systeme (T. Braun, 5 ECTS)
- Seminar: Software Composition (O. Nierstrasz, 5 ECTS)
- Seminar: Theoretische Information und Logik (G. Jäger, 5 ECTS)
- Sensornetze (T. Braun, 5 ECTS)

- Service Course

Anwendungssoftware (Th. Strahm, 3 ECTS)

2.2 Students

- Major Subject Students: HS 2007: 193, FS 2008: 171
- Minor Subject Students: HS 2007: 177, FS 2008: 153
- Ph.D. Candidates: HS 2007: 30, FS 2008: 26

2.3 Degrees and Examinations

- Ph.D.: 6
- Diploma: 2
- Master: 15
- Bachelor: 14
- Propädeutische Hauptfachprüfung: 2
- Completion of Minor Studies: 36 (90E: 1, 60E: 7, 30E: 11, 25E: 7, 15E: 10 (1165 ECTS))
- Semester Examinations Autumn Semester 2007: 400 (1902 ECTS)
- Bachelor/Diploma/Master Theses and Computer Science Projects Autumn Semester 2007: 11 (351 ECTS)
- Semester Examinations Spring Semester 2008: 359 (1591 ECTS)
- Bachelor/Diploma/Master Theses and Computer Science Projects Spring Semester 2008: 19 (518 ECTS)

2.4 Activities

- Offering a full day program for the “Tochterttag”, Bern, November 8, 2007
- Hosting and organizing the “GST-Mitgliederversammlung” including a presentation about the IAM by T. Braun, November 23, 2007
- Hosting and organizing the “Informatik Camp” for the participants of the Swiss Science Olympiads, Bern, January 25–26, 2008
- Contributing to the “Fit in IT - Roadshow” at the Gymnase de la Broye, Payerne, May 29–30, 2008
- Contributing to the “Fit in IT - Roadshow” at the Neue Kantonsschule Aarau, Aarau, June 9, 2008

2.5 Awards

- Award from Faculty of Science at University of Bern in Computer Science / Mathematics in the year 2007 for the Master thesis of Philipp Hurni: “Unsynchronized Energy-Efficient Medium Access Control and Routing in Wireless Sensor Networks”
- IAM Alumni award for the Ph.D. thesis of Marcus Liwicki: “Recognition of Whiteboard Notes - On-Line, Off-Line and Combination”
- IAM Alumni award for the Master thesis of Michael Meyer: “Scripting Interactive Visualizations”

3 Research Group on Computational Geometry and Graphics

3.1 Personnel

Head:	Prof. Dr. H. Bieri	Tel.: +41 31 631 8670 email: bieri@iam.unibe.ch
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	M. Hugli	Tel.: +41 31 631 3321 email: hugli@iam.unibe.ch
	Ph. Robert	Tel.: +41 31 631 4679 email: robert@iam.unibe.ch
	S. Schär	Tel.: +41 31 631 8955 email: schaer@iam.unibe.ch

3.2 Overview

The research group CGG (computational geometry and graphics) focuses on geometry on the computer and its applications to computer graphics, image processing and computer vision. The group is mainly interested in applications that require techniques from several of those fields and are of practical relevance, for instance in history, art history and archaeology. Its three main areas of interest are the following:

Polyhedra in d dimensions

Since approx. 1975, a promising new kind of polyhedra - the so-called Nef polyhedra - have been developed at this institute. Nef polyhedra are dimension independent and therefore especially interesting for applications where the dimension of the underlying space is higher than 3. A typical example are configuration spaces. Ongoing work extends the theory and implements the kernel of a modeling system based on Nef polyhedra.

Reconstruction of geometric objects

Museums, exhibitions and research projects in history, archaeology, etc. need virtual reconstructions of many kinds of 2D and 3D objects. The existing data are extremely varied, and so have to be the corresponding reconstruction techniques. Several projects deal with such reconstructions and try to combine some of the most promising techniques in order to generalize them and to base them on sound theoretical fundamentals.

Frameworks for graphics applications

A number of independent frameworks are developed, e.g. for interactive ray tracing, 3D games, 3D city models and scene graphs for generic 3D applications. Each such framework is extended with implementations of different techniques for similar purposes, and one main goal consists in building “intelligent” dispatchers capable to select the most promising technique in view of the requirements and characteristics of a given application.

3.3 Research Projects

d-dimensional General Polyhedra

These polyhedra, now called “Nef polyhedra”, are those subsets of the d-dimensional Euclidean space that can be obtained by applying a finite number of Boolean set operations to a finite number of linear halfspaces. The project extends the theory of Nef polyhedra, develops and analyses convenient data structures and lays the foundation of an object-oriented implementation of the kernel of a solid modeler for working with Nef polyhedra.

Research staff: H. Bieri, W. Nef, J. Tammik, T. Jakob

Anatomy of Real-Time 3D Game Engines

This research project investigates various aspects of 3D game engines for next generation platforms. We provide the design and implementation of a reference game engine with all major features to build a state of the art computer game:

- Multi resolution geometry (subdivision surfaces)

- GPU shader techniques (per pixel lighting, parallax mapping, and dynamic shadows)
- Character animation
- High level scripting language integration
- Content pipeline (authoring, data export and preprocessing)
- Middleware integration

The main goal of this research project is to analyse the architectures and designs of game engines.

Research staff: Ch. Ammann

Collaboration on scene graph based 3D models

Professional 3D modeling applications like Autodesk Maya or 3ds max offer only limited support for a team of artists to work on a 3D model collaboratively. There is even less support for efficiently managing revisions and variants or different representations of designs. Commercial group authoring tools and revision control systems cannot provide a solution as most of them are specialized on text documents and don't know how to handle the scenes of 3d modeling applications, because those applications usually store 3D models in a proprietary binary format by assembling thousands of objects in a complex structure called the scene graph (DAG).

This project provides support for collaboration on scene graph based 3D models by means of a specialized scene graph repository that implements version control for DAG structured 3D data, avoiding pitfalls like version proliferation. The versioning implemented by the repository is based on change sets and allows for intensional and extensional versioning of scene graphs. Collaboration is based on an optimistic locking scheme combining a check-in/-out mechanism with automatic merging of consistent changes to a 3D model. A revision history keeps track of who made when what changes to a model and also provides information about a models alternatives and different representations.

The scene graph repository stores 3D models in an attributed scene graph that has been designed to hold scene graphs of different 3D applications without loss of information. Attributed scene graphs also reflect dependencies between nodes in order to track the effects of changes to nodes

through the scene graph. This allows modelers to reliably detect inconsistent collaborative changes and identify unexpected side effects possibly not taken into account before. In addition, a GUI helps to track down such unwanted side effects of collaborative changes visually by directing modelers to the critical points in a scene and by isolating changes and their side effects.

An XML schema defines the attributed scene graph model formally and allows to export/import such scene graphs to/from XML files. Typically, check-out/-in and export/import operations are implemented in plug-ins for 3D applications.

Research staff: L. Ammon, A. Rüttimann

Creating Hierarchical 3D City Models

This project deals with various aspects of 3D city modelling. Its goal is the development of a generic framework supporting the creation, management, analysis and visualization of 3D city models. A main problem is the acquisition of the underlying geometric data. Today several methods are known, but most of them are time-consuming and expensive. Thus methods that support semi-automatic generation of the model from various easy accessible data sources as e.g. city maps or cadastral data are being developed. Due to the different accuracies of the input data, a data model supporting multiple levels of detail as well as its refinement and abstraction is being worked out. Another problem is the automation of modelling geometric details of house fronts such as windows and doors. Here a rule-based approach for generating house fronts depending on various parameters is pursued. As an example application the development of the city of Bern as a function of time shall be visualized and animated.

Research staff: Th. Buchberger

Reconstruction of Classical City Models

The principal practical goal of this project is to digitize a famous classical city model in the Historical Museum of Bern which shows Bern at about 1800. The intended result is a representation with little loss of information and close to a CAD model. More generally, we try to establish a generic pipeline for the digital reconstruction of city and similar models, offering a fairly automatic conversion from an initial point cloud to the final CAD

representation. At the moment, our scan data consists of approximately 80 million points. A number of established and new techniques relating to point cloud editing and 3D reconstruction are being combined and enhanced, in particular registration methods, point cloud filtering (local and global), automatic noise and error correction, terrain recognition, mesh repair, 3D edge detection, pattern recognition methods, and large data handling.

Research staff: M. Hugli, H. Bieri

Interactive Ray Tracing

This project investigates algorithms, data structures and rendering techniques which have to be adopted in order to design and implement a scalable and interactive ray tracing system. Our main focus lies on aspects which are of particular importance to single system image (SSI) architectures consisting of multiple GPUs and CPUs. Among these are

- general purpose computations on graphics hardware (GPGPU)
- image-space based rendering optimisations
- scalable rendering techniques
- efficient memory management and cache usage
- algorithmic optimisations
- point-based ray tracing techniques

Part of this project is the development of a ray tracing based graphics library and a prototype application, which enables us to research various aspects of interactive ray tracing systems.

Research staff: Ph. Robert, R. Künzli

JMesh: A Mesh Library in Java

Polygonal meshes are very popular in 3D graphics and thus the topic of many ongoing research projects all over the world. Many standalone tools and mesh libraries with a specialized focus are available today. But currently there exists no comprehensive software basis in Java that supports and integrates the different research approaches to meshes.

This project intends to build JMesh, a uniform but flexible framework to experiment with different kinds of mesh data structures (e.g halfedge, corner table, etc.) and algorithms.

A basic mesh abstraction layer is defined that unifies several mesh representations. Different implementation techniques and new language features and extensions to Java (e.g. generic classes, aspect oriented programming) are analyzed and evaluated for their benefit in this context.

The most important basic and state-of-the-art algorithms on meshes have been implemented as mesh operations, in the area of mesh reconstruction, mesh generation, mesh simplification, mesh subdivision, and signal processing with meshes.

These mesh data structures and algorithms offer specific extensions targeting at didactic use cases, like e.g. visualization and documentation. Several typical JMesh based prototype applications investigate the extensibility, efficiency, and reliability of the framework. The novel application called "JMesh Workbench" allows the interactive exploration of 3D meshes and analysis of the attained results of the various mesh operations.

Although typical target application areas for JMesh come from research and didactics in computer graphics, JMesh will be useful to application developers too.

Research staff: Th. Wenger, Ch. Aymon, A. Kobel, M. Ryter

Digital Terrain Visualization

This project was initiated by the Institute of Archaeology at the University of Berne (Prof M. Heinzemann) which was looking for an application to visualize their archeological excavation sites and ancient buildings. The gathered data from the sites is stored in a geographic information system (GIS), i. e. Manifold System, which is widely used and well known at the institute. The aim of this project is to create a real-time 3D application to visualize terrains and additional data, e.g. labels and vegetation, from the GIS. The application will contain a number of specialized features:

- Interface to the GIS for easily importing data
- Import of modeled 3D objects from the excavation sites
- Intuitive 6 degrees of freedom navigation (using 3Dconnexion 3D navigation devices)
- Viewshed analysis

- Automatically generated vegetation and structures based on maps
- Comfortable terrain switching
- Geographical and general functions (isolines, distance measurement, ...)
- Configurable time system (day/night, ...)

The challenge lies in the amount of data that has to be visualized. Therefore, intelligent, highly optimized algorithms are needed to reach the goal of real-time. Furthermore, the acquisition of the terrain data is complicated and expensive because it is obtained by satellites. As an example terrain, the province of L'Aquila in the territory of Abruzzo, Italy, will be visualized.

Research staff: R. Hauck, R. Witschi

Implant Deformation

The reposition of bone fractures in trauma and cranio-maxillofacial surgery is followed by fixation using implants and fixation devices. Some of the trauma implants have been designed to fit most of human anatomy. In this case, the challenge is to select the best fitting implant. Sometimes, e.g. when fractures are located around the joints, the implants need to be bent to fit the individual anatomy of the patient. Inadequate bending might lead to loosening of the implant or failure. Surgeons bend the implants with the trial-and-error method throughout surgery. The repetitive deformation may cause fatigue problems of the metal. Moreover, corrections after improper bending are difficult. Therefore, we want to provide surgeons with a computer assisted planning system. With it, a 3D model of the patient morphology is generated out of various formats of images, e.g. CT scans. Then, an implant is selected out of the virtual implant database and deformed until it fits the individual patient's bone structure. With this system it should be possible to create the desired form within the first attempt and to reduce the time required to perform the surgery. Until now, the difficult and expensive task to bend the implants patient-specifically can be only achieved in the virtual model. In order to practically use implant bending in a surgical navigation system, the bending needs to be improved in such a way that it becomes physically realistic.

Research staff: S. Schmutz, in collaboration with the MEM Research Center at the University of Bern

Introducing Stereo Effects into Cel Animations

Animated cartoons are an imaginative movie genre, often, but not only, made for children. Stereo effects could improve the visual impact of such movies, especially since children are an audience amenable to different visual experiences. New, 3D computer generated imagery (CGI) animations can directly be rendered in stereo, but old, classical cartoons cannot be converted that easily. The goal of our work is to introduce stereo effects into such cartoon animations. The necessary conversion should be easy to perform by an unexperienced user and should not require much user interaction.

In this project, we analyze the characteristics of cel animations and the differences between them and live action movies. As 3D reconstruction from single images or videos is a broad field of research, we mainly study the prominent methods to estimate depth information for a monocular video input (e.g. shape from shading, structure from motion, shape from texture, etc.) and their applicability to cel animations. We implement a conversion framework, define test cases and perform quality ratings of the visual 3D effect.

Research staff: S. Schär, X. Jiang, H. Bieri, T. Killer, S. Willi, A. E. Moddaberi

3.4 Ph.D. Theses

- Philippe C. D. Robert: Streaming Ray Tracing on a Non-Uniform Graphics Architecture

3.5 Master and Diploma Theses

- Christoph Aymon: Algorithmen zur Approximation von Oberflächen mit Dreiecksmeshes
- Rolf Künzli: Punkt-basiertes Ray Tracing
- Michael Ryter: Signalverarbeitung auf Meshes
- Silvia Schmutz: Investigation of Deformation Based Methods for Medical Implant Planning

3.6 Bachelor Theses and Computer Science Projects

- Thomas Killer: Video Region Growing – Räumliche Segmentierung von Comic-Videosequenzen
- Amir Ehsan Moddaberi: Color Optical Flow
- Michael Pfeuti: Stochastic Ray Tracing

3.7 Further Activities

- Member of the Kuratorium of “Repertorium Academicum Germanicum (RAG) – Die graduierten Gelehrten des alten Reichs bis 1550” (H. Bieri)
- Farewell Lecture “Originale und Kopien”, May 21, 2008 (H. Bieri)

3.8 Publications

- Ammon, L., Bieri, H.: Collaboration on Scene Graph Based 3D Data. In Braz, J., Ranchordas, A., Arajo, H., Jorge, J. (Eds.): *Advances in Computer Graphics and Computer Vision*, 78 – 90. Springer 2007.
- Bieri, H., Zwahlen, S. (Eds.): “Trinkt, o Augen, was die Wimper hält,...” *Farbe und Farben in Wissenschaft und Kunst*. Haupt 2008.
- Schär, S., Bieri, H., Jiang, X., Killer, T.: Introducing stereo effects into cel animations. In *Proceedings of 3DTV Conference 2008*, Istanbul, May 28 – 30, 2008.

4 Research Group on Computer Networks and Distributed Systems

4.1 Personnel

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Office Manager:	R. Bestgen	Tel.: +41 31 511 2630 email: bestgen@iam.unibe.ch
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	M. Brogle*	Tel.: +41 31 511 2632 email: brogle@iam.unibe.ch
	P. Lauer*	Tel.: +41 31 511 2639 email: lauer@iam.unibe.ch
	D. Milic*	Tel.: +41 31 511 2633 email: milic@iam.unibe.ch
	T. Staub*	Tel.: +41 31 511 2637 email: staub@iam.unibe.ch
	G. Wagenknecht*	Tel.: +41 31 511 2636 email: wagen@iam.unibe.ch
	M. Wälchli*	Tel.: +41 31 511 2638 email: waelchli@iam.unibe.ch
	Dr. M. Wulff*	Tel.: +41 31 511 2635 email: mwulff@iam.unibe.ch
Guests:	Saurabh Bhargava	Indian Institute of Technology, (IIT), Roorkee, India May 2008 – July 2008

* with financial support from a third party

4.2 Overview

The research group for Computer Networks and Distributed Systems (Rechnernetze und Verteilte Systeme, RVS) is active in several areas of computer communications and distributed systems.

Multimedia Communications The Internet is increasingly being used for multimedia data transfer (audio, video, data). We are investigating

how services with high demands on the quality and reliability of communication systems and networks can be supported. Overlay networks and peer-to-peer systems are becoming more important for new Internet services, in particular to support communication within user groups. We are focusing on the design, development, and evaluation of methods to construct overlay networks supporting the quality-of-service requirements of distributed applications and using network resources efficiently.

Wireless and Mobile Communication Decentralized system architectures and self-organization are fundamental concepts of future wireless and mobile communication systems. These concepts are particularly important in application scenarios such as sensor networks, mobile ad hoc networks and wireless mesh networks. There is an urgent need for research on routing and transport protocols as well as on security and management mechanisms. In sensor networks, limited energy, computing and memory resources as well as limited reliability require special forms of distributed data processing and management.

Security in Distributed Systems The Internet simplifies access to distributed resources and services such as web services, e-learning contents, computer grids or sensor nodes. Traditional techniques for authentication and authorization are not very user-friendly and barely scalable. We investigate, design, implement, and evaluate novel schemes for efficient and secure authentication and authorization.

Distance Learning In all our lectures, we are using distance learning elements that are based on standard components but also on developments resulting from recent research projects. We are developing new methods and tools to support learners and teachers in e-learning environments. In particular, we aim to support practical experiments.

4.3 Research Projects

National Competence Center in Research for Mobile Information and Communication Systems (NCCR-MICS)

The NCCR-MICS (<http://www.mics.ch>) project was launched in 2001. Its goal is to study fundamental and applied research questions raised by new generation mobile communication and information services, based on self-organization. Such systems have become very topical with the advent of mobile ad-hoc, peer-to-peer, and sensor networks. NCCR-MICS is composed of more than twenty research projects distributed over four clusters. The research project of the RVS group on “Distributed event detection and localization architecture for wireless sensor networks” (IP4) aims at designing and implementing a distributed event detection, event localization, and event classification framework. It includes efficient and reliable signaling protocols as well as mechanisms to dynamically reconfigure its specific sensor network applications.

Based on previous work, the distributed event detection and localization architecture (DELTA) has been refined. The DELTA implementation already provided algorithms to efficiently detect environmental events and dynamically establish tracking groups to monitor them. Furthermore, DELTA has already been able, based on data collected at designated group leaders, to accurately localize events and estimate their emitted signal power(s). Localization procedures have been investigated in more detail and classification procedures have been added. The proposed classifier is tuned by unsupervised learning mechanisms and supports the filtering of false alarms, i.e., the filtering of event reports which do not satisfy a given quality criteria. The classifier modeling includes soft computing mechanisms, i.e., fuzzy logic concepts. Learning the classifier parameters from training data eases the application and distribution of the classifier as no expert knowledge is required. Preventing false alarms saves costs in terms of energy, time, and money. Once the training has been done, the computed parameters are downloaded onto the sensor nodes, where all subsequent classification can be performed based on locally collected data provided by DELTA.

So far, the classifier has been successfully applied in an application classifying varying light sources. To support DELTA with a routing topology and to provide an energy saving mechanism, a virtual backbone has been developed and implemented. The virtual backbone mechanism allows the temporary disconnection of redundant nodes, which are not part of the backbone, from the network. It is periodically (re)established to distribute

the backbone load and it provides link repair mechanisms. This backbone is also used to distribute the classifier parameters learned in the classifier tuning phase.

Research staff: Markus Wälchli, Reto Zurbuchen, Samuel Bissig, Torsten Braun

Financial support: Swiss National Science Foundation Project No. 5005-067322 and University of Bern

Mobile IP Telephony (MIPTel)

Wireless mesh networks (WMN) are evolving to an important access technology for wireless broadband services. They provide a cost efficient way to interconnect isolated networks as well as to enhance wireless network coverage. WMNs usually consist of static mesh routers and mobile or static mesh clients. Both support multi-hop communication and may act as routers. The mesh nodes might support multiple heterogeneous radio interfaces. WMNs offer a more robust and redundant communication infrastructure than many wireless networks deployed today. They provide communication facilities even in special situations where certain systems such as GSM are overloaded.

Our project aims at exploiting WMNs as an infrastructure for Mobile IP telephony. IP telephony requires short delays and moderate packet loss. In WMNs the quality of the routes may vary unpredictably because of the unreliable and erroneous wireless medium. Routes may break, if the network topology changes due to node or link failures. Links and nodes may become congested, which leads to larger delays or packet loss. This makes the deployment of a real time application such as IP telephony a challenging task.

We see two important approaches to improve the speech quality and to reduce outages in a Mobile IP telephony application in WMNs: path diversity and multi-stream coding. The characteristics of multiple paths are usually uncorrelated, i.e. the delay, jitter, and loss rate of the paths differ a lot from each other. Therefore, the transmission over multiple paths can be used to compensate for the dynamic and unpredictable nature of WMNs. In order to exploit this path diversity for improving the quality of the audio transmission, a robust multi-path routing protocol and a mechanism for selecting appropriate coding and path allocation for the given network conditions are needed.

We have designed ATOM (Adaptive Transport over Multipaths), which is an architecture to enable real-time communications in Wireless Mesh Networks. ATOM reduces the problems of real-time transmissions over WMNs by using path diversity and multi-stream coding. At session establishment, ATOM decides on the used parameter set (encodings, paths etc.) considering current network conditions and collected historic data. After session establishment, the effect of this decision is continuously monitored and if necessary adapted.

We ported an existing framework for multi-channel communication to latest Linux kernels and integrated it into our Linux image for the wireless mesh nodes. In order to use small MIPS-based mesh nodes in our testbed, we customized and further reduced the size of our Linux image. Furthermore, we have set up a cross-compile toolchain that can build images for x86 and MIPS-based nodes. The toolchain runs on most Linux distributions and does not require a special Linux system anymore.

To make experiments with Linux based nodes in larger topologies, we have designed VirtualMesh, which provides a virtualization of a wireless mesh network. Several mesh nodes are running on top of one computer using host virtualization (XEN). They communicate over an emulated wireless medium provided by a network simulator. Our architecture can provide networks consisting of real and virtualized mesh nodes using an adapted wireless interface driver.

In addition, we have designed a temporary WMN based system to support video communication in large construction sites, which faces the problem of missing communication facilities at the time of electric installation. By providing video communication over an “easy-to-install” temporary WMN, the requirement of costly on-site visits by an electrical engineer is reduced.

Research staff: Thomas Staub, Stefan Ott, Daniel Balsiger, Reto Ganzenbein, Christine Müller, Saurabh Bhargava, Mona Farsad, Torsten Braun

Financial support: Swiss National Foundation Project No. 200020-113677/1

Efficient and Robust Overlay Networks (ERON)

The ERON projects aims at developing an efficient and robust overlay network. An overlay network is a virtual communication network built on top of an existing communication network such as the Internet. Overlay networks

are used for different tasks such as routing of multicast messages. Since the full-mesh overlay network, in which every pair of participants is communicating directly with each other, is not scalable, overlay networks usually have other structures. One of the most important criteria for deciding, which overlay network participants get “connected” is the communication delay, since it is the limiting factor on the maximum effective bandwidth for the TCP connections. Similar to a full-mesh overlay network, measuring the communication delay between all overlay participants does not scale. To exploit the communication delay information, numerous communication delay prediction systems such as IDMaps, GNP, ICS, Vivaldi, S-Vivaldi etc. were developed. Most promising communication delay prediction systems are coordinates-based. In coordinates-based systems, communication partners are represented as points in an n -dimensional Euclidean space such that the distance function in that space predicts the communication delay.

Moreover, we are developing a protocol for building an overlay networks based on round-trip time (RTT) as a distance metric. The goal of this protocol is to provide a fisheye view of the overlay network for each end system that is a part of this network. Having a fisheye view of the overlay network means that each end system has a quite good knowledge about hosts located near itself, but at the same time it should have knowledge of distant hosts to be able to achieve efficient routing. The distinguishing feature of our approach compared to others is that we do not rely on a priori embedding into a virtual space. We only use measured RTTs as a distance to calculate the fisheye views of the end systems in a distributed manner.

Combined with the PIM-DM like routing protocol we developed earlier, this overlay network should provide a very efficient Application Layer Multicast (ALM) infrastructure. Our preliminary simulation results show that such an ALM is far more efficient in terms of RTT optimization of the multicast tree compared with Scribe/Pastry. We started to investigate a distributed method for assigning positions in a virtual space to hosts. The approach for determining coordinates we are pursuing, bases on assigning positions as a part of a crystallization process. The assumes that the end-systems are already interconnected in a fisheye-view based overlay network. The crystallization itself starts at one point in the overlay network and spreads like a shock wave trough the overlay network leaving a crystal structure behind.

Research staff: Dragan Milic, Roger Strähl, Torsten Braun

Financial support: Swiss National Foundation Project No. 200021-109270/1

End-to-end Quality of service support over heterogeneous networks (EuQoS)

The *EuQoS* project (<http://www.euqos.eu>) aimed to resolve outstanding design issues presently associated with the delivery of end to end Quality of Service across heterogeneous networks. With the help of EuQoS the network infrastructure should be upgraded so that new applications can be supported by the Internet and new service packages can be offered by operators, ISPs and other service providers. Our research group was involved in the work packages 1, 3, 5 and 6.

WP1 (Business Model and System Design) defined an architecture for different aspects of the EuQoS system. We finalized the support for QoS regarding IP Multicast. Our research focused on providing an efficient and transparent support for ALM on end systems but still offering the IP Multicast API. Mechanisms for setting up a QoS-aware P2P overlay network have been investigated and resulted in an architectural adaptation of Scribe / Pastry. The Multicast Middleware framework was extended with the ability to perform QoS reservations for IP Multicast groups by the end-user through a web-service enabled interface. The Multicast Middleware maps the reservations for the multicast groups to the respective unicast connections of the ALM and performs the corresponding QoS reservations in the EuQoS system.

WP3 (Implementation of the EuQoS System) delivers the proposed applications and services according to the architectures defined in *WP1*. We developed a transparent multicast facility known as "Multicast Middleware," which is based on a virtual network interface (TAP) and has been implemented mostly using Java (version 5.0) to support different operating systems (Win32, Linux and Mac OS X). The Multicast Middleware is independent from the underlying QoS mechanisms. It uses the EuQoS QoS signaling to reserve the required QoS in underlying network. The overlay network is constructed using a Scribe/Pastry implementation called Freepastry. This implementation has been extended to support QoS-aware construction of multicast trees by Scribe through modifying the basic node distribution mechanisms of Pastry. Another focus has been the performance. Therefore, the Multicast Middleware has been optimized to support high bandwidth data dissemination with 100 Mbps and more on end-systems with recent hardware. The Multicast Middleware has been successfully

demonstrated at the final review of the EuQoS project.

WP5 (EuQoS Pan European trials) built a testbed environment in which the developed prototypes and applications can be tested and evaluated. Different heterogeneous networks (WLAN, UMTS, LAN, xDSL, etc.) are interconnected in a full mesh among the partners. Our testbed represents a high speed gigabit-LAN-based network interconnected by GRE tunnels to twelve other testbeds belonging to other EuQoS consortium partners. Different prototypes of the EuQoS system and some of its applications have been successfully tested in this environment. The testbed located in Bern was also used for evaluating and testing the Multicast Middleware. Furthermore, a seminar held in Poland has been broadcasted to several other partners through the testbed using Video Lan Client (VLC) in combination with the Multicast Middleware.

WP6 (Dissemination, Standards and Training) focused on delivering the project results to the public. In addition to leading and managing the whole work package, our main contributions addressed the training activities. Within this context, a course focusing on QoS related topics has been developed for students and industrial learners. The goal of the course is to raise the familiarity with QoS technologies for next generation networks and applications. The course is based on distance learning technologies and consists of seven QoS related modules. We have developed the didactical concept of the e-learning course and coordinated its implementation. In particular, we have developed the course modules "Applications' QoS demands", "Implementing protocols on network simulators" including a tool for the visualization and animation of simulator trace files (VAT4Net), "Multicast in EuQoS system", and an overview animation for the "EuQoS overview" module.

Besides the e-learning activities, the EuQoS partners have written the learning book "End-to-End Quality of Service Over Heterogeneous Networks" published by Springer. It covers QoS mechanisms in heterogeneous networks, the EuQoS system as a case study for a comprehensive end-to-end QoS architecture, and development methodologies. It fosters awareness of QoS mechanisms and presents the EuQoS approach as a comprehensive architecture offering end-to-end QoS over heterogeneous networks. The book provides the basis for different network lectures at universities and shows the latest QoS developments and standards for industrial researchers and engineers. Members of our research group coordinated the publication and editing process of the book.

Research staff: Marc Brogle, Dragan Milic, Matthias Scheidegger, Thomas Staub, Patrick Lauer, Gerald Wagenknecht, Markus Wulff, Jana

Krähenbühl, Daniel Frey, Milan Nikolic, Luca Bettosini, Sonia Schär, Torsten Braun

Financial support: EU project IST-2003-004503

Virtual Internet and Telecommunications Laboratory of Switzerland (VITELS)

VITELS, a first series Swiss Virtual Campus (SVC) project has been funded within the SVC consolidation program. The goal of VITELS has been to develop an e-learning course in English language that provides theory and practical hands-on exercises in the area of telecommunications and computer networks with real network hardware for computer science students. VITELS consists of eight modules, six designed and maintained by University of Bern, one by University of Neuchâtel, and one by University of Fribourg. The course is fully operational and has been productively used in different regular courses on the Bachelor level at the Universities of Bern (in the “Computer Networks” lecture), Fribourg, and Neuchâtel. Updates in the theory parts of the modules have been integrated. Recently, the main focus was on the hands-on experiments. Three of these experiments, namely “IP Security”, “Sockets & RPC”, and “Security and Privacy in the Internet”, have been improved or reimplemented to ensure a better usability and reliability. For maintenance of the VITELS modules the comments and suggestions from students have been taken into account. Security certificates for the lab exercise and portal servers has been changed to ensure better compatibility with common Web browsers.

Research staff: Markus Anwander, Torsten Braun, Patrick Lauer, Thomas Staub, Markus Wulff

Financial support: Staatssekretariat für Bildung und Forschung (SBF), Virtual Campus Switzerland Project No. 991043

Operating Systems Laboratory (OSLab)

The Operating System Laboratory, OSLab, is an online course to teach students about the principles of computer operating systems using a progressive approach and problem-oriented learning. OSLab focuses on the

hands-on training experience of the students and will complement existing lectures. The course is modularly structured, each module covers a topic and is self-contained. A teacher can select modules according to his needs and easily add new modules to the course.

Three new modules have been created, namely, "Memory Management", "Distributed File Systems", and "Inter-Process Communication & Synchronization". This includes the theory section as well as the hands-on exercises. In the hands-on part the students have to solve programming and/or configuration tasks in order to deepen the theoretical knowledge.

Additionally, the OSLab tools framework has been improved. The framework basically consists of two Java applets and aims to present a common user interface for the hands-on exercises. The learners applet can be adapted to the special needs of the respective exercise and provides a graphical user interface in the Web browser for the remote hands-on exercises. If the learner solved the exercise he/she gets an encrypted passcode to be sent to the course tutor. The second applet is for the course tutor and allows to decrypt the solution sent by the learners and helps to organise the received solutions. Furthermore, the tutor can review the exercise solutions (e.g. programme source code) and is provided with a basic plagiarism finder.

The e-learning infrastructure used for OSLab and VITELS has been revised. By using virtualisation techniques, less hardware is needed and at the same time the maintainability and reliability of the e-learning laboratory could be improved. Furthermore, a monitoring software has been installed to receive detailed information about server and network usage. Finally, a new backup system now provides a faster recovery of the e-learning services after a system failure or data loss.

Another central component of the e-learning infrastructure is the reservation system which manages the access to the laboratory resources. It has been reimplemented and provides some new features and a higher reliability.

Research staff: Torsten Braun, Gerald Wagenknecht, Markus Wulff, Daniel Frey

Financial support: Staatssekretariat für Bildung und Forschung (SBF), Programm Virtueller Campus Schweiz, Project No. P-4-019, and University of Bern

E-learning in Distributed Data Network Laboratory (Edinet)

Edinet (<http://www.svc-edinet.eu>) is a multilateral cooperation project in the 'Lifelong Learning Programme' of the European Commission. Its objectives are to a) analyse common pedagogical principles for blended learning (blended learning include several forms of learning tools) based on common understanding as a ground for curriculum development and implementation; b) promote virtual mobility by implementation of semi-virtual campus (a virtual campus where actually studies will be done with real equipment via network connections); c) enhance open education resources by sharing, integrating, and mutually improving local resources (including knowledge) and best practices by establishing a semi-virtual campus; and d) to promote the usage of expensive laboratory environment through an innovative blended eLearning system in the field of data network technology.

Our research group is mainly involved in two work packages. For the Edinet infrastructure we are developing the Authentication and Authorization Infrastructure (AAI). The goal is to export the available knowledge to establish a AAI federation with the European partners. Furthermore, a TCP congestion control learning module is being developed and several contributions to other work packages like for the pedagogical framework of the Edinet virtual campus have been provided.

Research staff: Torsten Braun, Patrick Lauer, Markus Wulff, Markus Anwander, Thomas Staub

Financial support: Staatssekretariat für Bildung und Forschung SBF, LLP/Erasmus, Edinet, SBF-No. LLP/07/06-E

Energy-efficient Management of Heterogeneous Wireless Sensor Networks

This project investigates efficient and reliable communication mechanisms for the operation of a wireless sensor network (WSN) management framework. Reliable and robust transport protocols are needed to distribute operating system / application level code and node parameters efficiently as well as to solicit specific node information.

ESB, tmote SKY, BTnodes and micaZ nodes have been chosen to build a heterogeneous sensor network. For the backbone a Wireless Router

Application Platform Board (WRAP) has been selected. The mesh network allows to interconnect WSNs with sensor nodes of different types.

In order to realize such interconnection between the WSN and an external network without any proxies or middle-boxes, we propose to use TCP/IP as the standard protocol for all network entities, e.g., for configuration and uploading application code to the sensor nodes. We developed TSS (TCP Support for Sensor Nodes) a protocol which enables using TCP in wireless sensor networks. TCP/IP allows to connect a WSN to other networks such as the Internet. Thus, a user can monitor, control and manage WSNs remotely. The TSS protocol is located between IP and TCP. It contains a number of mechanisms, such as caching packets, local retransmission, aggressive acknowledgment regeneration and recovery. Packets are cached on intermediate nodes on the path from the sender to the receiver. In case of a lost packet a end-to-end retransmission is avoided. This reduces the number of transmitted packets and thus energy consumption. In case of lost acknowledgment packets the intermediate node can regenerate the acknowledgment to avoid unnecessary retransmissions.

We developed a MAC protocol called BEEM (Burst-enabled Energy-Efficient MAC) implementing the MAC layer of nonbeacon-enabled personal area networks (PANs) defined in the IEEE 802.15.4 standard for peer-to-peer topologies. It provides multihop communication and is the first implementation in this way. The MAC protocol holds a buffer of configurable size to store the incoming frames from the lower layer (radio transceiver) and the upper layers (TCP-TSS- μ IP). To ensure a reliable hop-to-hop transmission we use explicit acknowledgments and implicit acknowledgments

To optimize the performance of the protocols interchanging cross layer information is necessary. Thus, we designed a cross layer interface. Every protocol can subscribe for information from another protocol. Thus protocols on different layers can better collaborate. For example, the physical layer can provide additional information about the transmissions. The radio transceiver provides information about the channel and the signal to the MAC protocol, which decides whether a frame can be transmitted to a neighbor node. The MAC protocol and the TSS protocol exchange information about retransmission state of a frame, about the traffic between the nodes and the TSS buffer size. This information is important for the reliability and congestion control mechanisms.

The protocols have been implemented in the OMNeT++ simulator and evaluated with several scenarios. We compared a pure TCP implementation and a TCP implementation with TSS. The simulations showed that the performance can be increased by the factor of 10. Further, we

compared both acknowledgment mechanisms. Explicit acknowledgments cause faster transmission times as using implicit acknowledgments. We showed that up to 90% of consumed energy can be saved using these mechanisms.

Research staff: Markus Anwander, Gerald Wagenknecht, James Matheka, Simon Morgenthaler

Financial support: Hasler Foundation under grant number ManCom 2060 and the Swiss National Science Foundation under grant number 200020-113677/1

Wireless Sensor Network Testbeds (WISEBED)

The *WISEBED* project (<http://www.wisebed.eu>) started in June 2008. It aims to provide a multi-level infrastructure of interconnected testbeds of large-scale wireless sensor networks for research purposes, pursuing an interdisciplinary approach that integrates the aspects of hardware, software, algorithms, and data. This will demonstrate how heterogeneous small-scale devices and testbeds can be brought together to form well-organized, large-scale structures. The *WISEBED* project will implement recent theoretical results on algorithms, mechanisms and protocols and transform them into software. The project intends to make these distributed laboratories available to the European scientific community, so that other research groups will take advantage of the federated infrastructure. Our research group is involved as task leaders in several work packages.

Within WP1 (*Hardware Installation*), we plan to deploy a wireless sensor network testbed in the Engehalde area. The construction of a testbed or a WSN deployment has many crucial steps. To ease the installation of hardware for such a testbed or the deployment of large WSN, we will work on an automatic neighborhood and transmission-power configuration solution. In long-term experiments huge series of data will have to be collected, which a sensor node may not be able to transmit. We therefore plan to co-deploy a mesh network backbone to the WSN research testbed in order to gather data and simplify remote configuration and management.

Within WP2 (*Testbed operation, access, and management*) we will develop a workflow management system that will enable the execution of plans for verification, testing and performance evaluation of algorithms and applications. Workflow management systems provide a clean interface for the definition of the execution logic, by means of sequences of operations.

A webservice-based solution would be most useful, since it allows for very flexible dynamic reconfiguration, for convenient access for software development, deployment and experiment. We intend to integrate the workflow system with the rest of the software infrastructure. The operation of the testbed will remain secure and confidential to the user of the testbed.

Real-world environmental data is of major importance for significant simulation results. The idea of WP4 (*Producing traces for hardware*) is to feed recorded data back into the simulator. We will define a common data representation language in order to create a trace model that can be employed at all sites. This includes various parameters of network topology, but also communication parameters and received signal strength indicators. Most testbeds break down regularly because some nodes fail to operate. Integrating the data back into simulators will be an invaluable source for fault analysis when trying to find out why certain algorithms failed.

Research staff: Philipp Hurni, Torsten Braun

Financial support: EU project ICT-2008-224460

Power Saving in Wireless Ad Hoc Networks

Today's energy saving wireless MAC protocols periodically switch the radio transceiver hardware between the costly operation modes receive and transmit and an energy-saving sleep mode. The majority of the existing power saving MAC approaches tries to synchronize the state changes of the nodes in the network and introduces mechanisms to let the nodes synchronously wake up at designated points of time, which however requires costly synchronization. With low traffic, the energetic overhead may exceed the energy spent for the actual data traffic.

We investigated on modifications and optimizations on recently proposed fully unsynchronized power saving MAC protocols for wireless sensor networks based on asynchronous wake-up patterns, and intended for sensor networks with low traffic requirements. We carried out investigations on the following aspects:

A performance optimization scheme considering the broadcast operation mode achieves a higher energy-efficiency both at the sender and the receiver. Experimental results approve the energy-efficiency of the scheme called *best-instants broadcast* when a limited amount of neighbors has to be reached.

An alternative allocation and arrangement scheme of sensor node's wake intervals averts performance degrading systematic overhearing and fairness effects of existing power saving MAC protocols with a fixed static wake-up pattern. A cross-layer solution to exploit the properties of the unsynchronized MAC and the alternative arrangement scheme of the wake-up intervals has been designed, which achieves to find paths with the least-possible delay.

We developed a mechanism to improve the traffic-adaptivity of wireless sensor MAC protocols in cases with multiple nodes aiming to forward data over certain receivers, which are likely to occur in wireless sensor network topologies. It succeeds in increasing the throughput in comparison with existing approaches in both simulation and sensor testbed implementation.

We tested the proposed mechanisms and improvements in a network simulator environment and on a prototype implementation on a sensor hardware testbed. Some of the developed mechanisms delivered motivating results in simulation and real-world experiments.

Research staff: Philipp Hurni, Torsten Braun

E-learning module “Sensor Networks”

The e-learning module “Sensor Networks” addresses key characteristics of wireless sensor networks. The module is designed to deepen the understanding of students concerning contributions and challenges of wireless sensor network technologies. The course is guided, self-explaining and in a closed form.

The course essentially consists of a theoretical part introducing the course subject in detail, and of a practical part, in which the learned theoretical concepts are applied. The theoretical part contains references to continuative literature and self-tests to improve the learning process of the students. In the subsequent hands-on sessions some of the acquired concepts are investigated from the practical point of view. Thus, the students get an impression of implementation details and challenges. The theoretical concepts have been implemented in the Contiki OS, a well-known operating system for tiny embedded systems. The solution can be tested and evaluated in the COOJA simulator, which is provided by the Contiki OS. The course provides web-based applications for both development and evaluation.

The scientific focus of the course is on medium access control and localization in wireless sensor networks. Both are basic challenges of wireless sensor networks research and development. The e-learning course provides a medium to address these two aspects in more detail than it would be possible in a lecture only.

Research staff: Markus Wälchli, Torsten Braun

Financial support: University of Bern, VC-Kleinprojekt

Testbed for Mobile and Internet Communications

Our research group maintains its own testbed network for various purposes. The testbed is used to build networks of experimental routers and end systems in order to be able to evaluate the behavior of new networking procedures and architectures in a realistic environment. The testbed also forms a productive network of Linux PCs and provides the storage capacity and CPU power for many of the RVS group's projects. The ERON project for example uses the available CPU power to compute embeddings of network distances into Euclidean space. Furthermore, a significant part of EuQoS project's testbed is still located within the RVS testbed. It is a Gigabit LAN environment of 10 machines for pan-european trials, and it is connected via IP tunnels to 11 partners' sites. The available CPU power is used by three network traffic measuring points. An educational laboratory network for students' training is also connected and being extended by the OSLab project. The RVS group also takes part in PlanetLab (<http://planet-lab.org>), an open platform for developing, deploying, and accessing planetary-scale services. For this purpose we are hosting four PlanetLab nodes in our testbed network. The RVS group owns a number of sensor nodes: Embedded Sensor Board (ESB), tmote SKY nodes, BTnodes, MSB nodes and micaZ nodes. A testbed consisting of multiple mesh nodes has been deployed throughout the building and work environment of the research group. In this testbed, reliable secure communication and software distribution/updates are being performed and evaluated.

Research staff: All members of the RVS research group

4.4 Master and Diploma Theses

- Philipp Hurni: Unsynchronized Energy-Efficient Medium Access Control and Routing in Wireless Sensor Networks, November, 2007
- Jana Krähenbühl: Theory and Hands-on Exercises with Network Simulators for E-Learning on Distributed Systems, September, 2007

4.5 Bachelor Theses and Computer Science Projects

- Luca Bettosini: Performance Comparison of Native Multicast versus Overlay Multicast, April, 2008
- Milan Nikolic: WinJTAP Interface for Multicast Middleware on the Win32 Platform, March, 2008
- Daniel Balsiger, Michael Lustenberger: Secure Remote Management and Software Distribution for Wireless Mesh Networks, September, 2007
- Dave Wick: Delay Tolerant Networks in a Nutshell, August, 2007

4.6 Further Activities

Memberships

- Chair of ERCIM working group on eMobility (Torsten Braun)
- Secretary General of ERCIM working group on eMobility (Markus Wulff)
- Erweitertes Leitungsgremium Fachgruppe "Kommunikation und Verteilte Systeme", Gesellschaft für Informatik (Torsten Braun)
- Management Board of EU IST project EuQoS (Torsten Braun)
- Integration Coordination Board and Steering Committee of EU IST project Wisebed (Torsten Braun)
- Swiss Representative, Management Committee Member, and Working Group Chair of COST 290 Action "Traffic and QoS Management in Wireless Multimedia Networks" (Torsten Braun)

- SWITCH Stiftungsrat (Torsten Braun)
- SWITCH Stiftungsratsausschuss (Torsten Braun)
- Kuratorium Fritz-Kutter-Fonds (Torsten Braun)
- Expert for Diploma Exams at Fachhochschule Bern (Torsten Braun)

Editorial Boards

Torsten Braun

- Editorial Board of Elsevier's Computer Communications Journal
- Editorial Board of Elsevier's Computer Networks Journal
- Editorial Board of Informatik Spektrum / Springer-Verlag
- Editorial Board of Journal of Internet Engineering (Editor in Chief)

Conference Chairs

- Co-Chair of the Fourth ACM SIGACT-SIGOPS International Workshop on Foundations of Mobile Computing (DIAL M-POMC 2007), August 16, 2007, Portland, Oregon, USA (Torsten Braun)
- General Chair of 2nd ERCIM Workshop on eMobility, May 30, 2008, Tampere, Finland (Torsten Braun)
- TPC Co-Chair of 2nd ERCIM Workshop on eMobility, May 30, 2008, Tampere, Finland (Markus Wulff)

Conference Program Committees

Torsten Braun

- 33rd EUROMICRO Conference 2007, Lübeck, Germany, August 28–31, 2007
- 7th International Conference on Next Generation Teletraffic and Wired/Wireless Advanced Networking (NEW2AN), St.Petersburg, Russia, September 10–14, 2007

- 1st IEEE International Workshop on Enabling Technologies and Standards for Wireless Mesh Networking, Pisa, Italy, October 8, 2007
- 32nd Annual IEEE Conference on Local Computer Networks (LCN), Dublin, Ireland, October 15, 2007
- IEEE Workshop on “Monitoring, Attack Detection and Mitigation”, Toulouse, France, November 5–6, 2007
- IEEE Globecom, Washington, USA, November 26–30, 2007
- 3rd International Conference on Wireless Communication and Sensor Networks (WCSN), Allahabad, India, December 13–15, 2007
- 2nd IEEE Broadband Wireless Access (BWA) Workshop, Las Vegas, USA, January 12, 2008
- 5th IEEE/IFIP WONS Annual Conference on Wireless On demand Network Systems and Services, Garmisch-Partenkirchen, Germany, January 23–25, 2008
- 5th European conference on Wireless Sensor Networks, Bologna, Italy, January 30–31, 2008
- IEEE Wireless Communications and Networking Conference (WCNC), Las Vegas, USA, March 31 – April 3, 2008
- Workshop on Real-World Wireless Sensor Networks (RealWSN), Glasgow, UK, April 1, 2008
- 11th IEEE/IFIP Network Operations and Management Symposium (NOMS), Salvador da Bahia, Brazil, April 7–11, 2008
- 2nd IEEE International Workshop on Bandwidth on Demand (BoD 2008), Salvador da Bahia, Brazil, April 11, 2008
- IEEE INFOCOM High-Speed Networks Workshop (HSN), Phoenix, USA, April 13, 2008
- IFIP Networking, Singapore, May 5–9, 2008
- 3rd IEEE Broadband Wireless Access (BWA) Workshop, May 19, 2008, Beijing, China
- IEEE International Conference on Communications, Beijing, China, May 19–23, 2008

- 6th International Conference on Wired/Wireless Internet Communications (WWIC), Tampere, Finland, May 28–30, 2008
- 15th IEEE Workshop on Local and Metropolitan Area Networks, Princeton, USA, June 10–13, 2007
- Fachgespräch Future Internet der GI/ITG-Fachgruppe “Kommunikation und Verteilte Systeme”, Heidelberg, Germany, June 17, 2008
- 3rd IEEE Workshop on advanced EXPerimental activities ON WIRELESS networks & systems (EXPONWIRELESS08), Newport Beach, USA, June 23, 2008
- IFIP Conference on Wireless Sensor and Actor Networks, Ottawa, Canada, July 14–15, 2008

Ph.D. Jury Memberships

Torsten Braun

- Mark Doll: Management qualitätsbasierter Gruppenkommunikation im Internet, Universität Karlsruhe, December 14, 2007
- Dominik Jungo: VeriNeC - Secure Network Configuration Through Verification, Université de Fribourg, July 29, 2008

Reviewing Activities

Torsten Braun

- Swiss National Science Foundation (SNSF)
- nano-tera.ch
- Research Council of Norway (RCN)
- Agence Nationale de la Recherche (French National Research Agency, ANR)
- COST office of Swiss State Secretariat for Education and Research
- IEEE Network Magazine
- IEEE Transactions on Parallel and Distributed Systems

- Journal of Medical Systems, Springer-Verlag
- Security and Communication Networks, Wiley

Invited Talks and Tutorials

- Torsten Braun: Telematiknetze, Kaderkurs Telematik, Bundesamt für Bevölkerungsschutz, November 27, 2007, May 6, 2008, May 27, 2008, Schwarzenburg, Switzerland
- Thomas Staub: Réseaux de communications, cours de cadres pour chefs de la télématique, Office fédéral de la protection de la population, May 6, 2008, May 27, 2008, Schwarzenburg, Switzerland
- Torsten Braun: Sensor Networks, 15th TF-Mobility Meeting, September 28, 2007, Zürich
- Torsten Braun: Sensor Networks, 16th SWITCH Mobile Working Group Meeting, December 7, 2007, Zürich
- Torsten Braun: Power Saving in Wireless Multi-hop Networks, 10th COST 290 Meeting, October 1, 2007, Vienna, Austria
- Torsten Braun: Energy-efficient Management of Heterogeneous Wireless Sensor Networks, Haslerstiftung ManCom Workshop, April 25, 2008, Bern

Organized Events

- Organizing a Computer Science Summer School seminar together with the TNS group of University Fribourg and the IIUN of University Neuchâtel, at Quarten, Switzerland, June 23–26, 2008

Awards

- Winner of the competition “Wer hat die beste e-Schule” (who has the best e-school) conducted by IBM. The course “Computernetze” (Computernetworks) won the first price in the academic category.

4.7 Publications

Publications submitted in the academic year 2007/2008 and appearing in 2008/2009 or later are not listed.

Books and Book Chapters

- Arunabha Sen, Torsten Braun: Dial-M-POMC 2007, The Fourth ACM SIGACT-SIGOPS International Workshop on Foundations of Mobile Computing, Portland, Oregon, USA, August 16, 2007, ACM, ISBN 978-1-59593-874-9, CD-ROM
- Torsten Braun, Geert Heijenk, Dimitri Konstantas, Markus Wulff: Second ERCIM Workshop on eMobility, Tampere, Finland, May 30, 2008, ISBN 978-952-15-1972-7
- Torsten Braun: Entstehung und Funktionsweise des Internets, Virtuelle Welten? Die Realität des Internets, Vol. Kul. Vorl., Nr. Band 106, April, 2008, pp. 15-28, Peter Lang Publishing Group, ISBN ISBN 978-3-03911-310, Book chapter

Reviewed Journal and Conference Papers

- Torsten Braun, Jana Krähenbühl, Thomas Staub: VAT4Net - a Visualization and Animation Tool for Network Simulations, 6th Symposium on Design, Analysis, and Simulation of Distributed Systems 2008, Edinburgh, UK, June 16 - 18, 2008, pp. 244-251, Summer Computer Simulation Conference (SCSC'08), ISBN 1-56555-320-9, CD-ROM
- Markus Anwander, Gerald Wagenknecht, Torsten Braun: Management of Wireless Sensor Networks using TCP/IP, International Workshop on Sensor Network Engineering (IWSNE) at the 4th IEEE/ACM International Conference on Distributed Computing in Sensor Systems, Santorini Island, Greece, June 11, 2008, pp. II.1-II.8, ISBN 978-90-9023209-6
- Markus Wälchli, Samuel Bissig, Michael Meer, Torsten Braun: Distributed Event Tracking and Classification in Wireless Sensor Networks, Journal of Internet Engineering, Vol. 2, Nr. 1, June, 2008, pp. 117-126, Klidarithmos Press, ISSN 1791-177X

- Thomas Staub, Torsten Braun: ATOM: Adaptive Transport over Multipaths in Wireless Mesh Networks, 2nd ERCIM Workshop on eMobility, Tampere, Finland, May 30, 2008, ISBN 978-952-15-1972-7
- Gerald Wagenknecht, Markus Anwander, Torsten Braun, Thomas Staub, James Matheka, Simon Morgenthaler: MARWIS: A Management Architecture for Heterogeneous Wireless Sensor Networks, 6th International Conference on Wired/Wireless Internet Communications (WWIC'08), Tampere, Finland, Springer LCNS, Nr. 5031, May 28 - 30, 2008, pp. 177-188, ISBN 978-3-540-68805-1
- Markus Wulff, Patrick Lauer, Torsten Braun: Content management and architectural issues of a remote learning laboratory, 2nd International Workshop on e-learning and Virtual and Remote Laboratories 2008, Hasso-Plattner-Institute Potsdam, Germany, February 14 - 15, 2008, ISBN 978-3-940793-17-1
- Philipp Hurni, Torsten Braun: Increasing Throughput for WiseMAC, IEEE/IFIP WONS 2008, Garmisch-Partenkirchen, Germany, January 23 - 25, 2008, ISBN 978-1-4244-1958-6
- Torsten Braun, Marc Brogle, Patrick Lauer: Peer-to-Peer-Netze: Informationen effizient im Internet verbreiten, Bulletin SEV/VSE, Vol. 07, Nr. 21, December, 2007, pp. 9-12, Electrosuisse, ISSN 1660-6738
- Markus Wulff, Torsten Braun: OSLab: An Interactive Operating System Laboratory, Nr. 71, October, 2007, pp. 46-47, ERCIM EEIG, ISSN 0926-4981
- Matthias Scheidegger, Torsten Braun: Meridian-based Grouping in Overlay Networks, *it - Information Technology*, Vol. 49, Nr. 5, September 17, 2007, pp. 289-297, Oldenbourg Wissenschaftsverlag GmbH, ISSN 1611-2776
- Dragan Milic, Torsten Braun: Optimizing Dimensionality and Accelerating Landmark Positioning for Coordinates Based RTT Predictions, IEEE BroadNets 2007: Fourth Annual Conference on Broadband Communications, Networks, and Systems, Raleigh, North Carolina, USA, September 10 - 14, 2007, ISBN 978-1-4244-1432-1
- Marc Brogle, Dragan Milic, Torsten Braun: Supporting IP Multicast Streaming Using Overlay Networks, QShine: International Conference on Heterogeneous Networking for Quality, Reliability, Security

and Robustness, Vancouver, British Columbia, Canada, August 14 - 17, 2007, ICST, ISBN 978-1-59593-756-8, CD-ROM

Technical Reports

- Lothar Braun, Torsten Braun, Georg Carle, Falko Dressler, Anja Feldmann, Dirk Haage, Tobias Limmer, Tanja Zseby: 5. 08102 Working Group – Measurement Requirements, Perspectives Workshop: Network Attack Detection and Defense, Dagstuhl, Germany, Nr. 08102, March 2 - 6, 2008, Schloss Dagstuhl - Leibniz-Zentrum für Informatik, Germany, ISSN 1862-4405
- Wojciech Burakowski, Jordi Mongay Batalla, Marc Brogle, et al: Report on scalability evaluation of EuQoS system, EuQoS Report, January 25, 2008
- José Enríquez, María Ángeles Callejo, Marc Brogle, Dragan Milic, et al: Annex to D1.2.2: EuQoS Architecture update for, Annex to EuQoS Deliverable D51.2.2, CEC Deliverable Number 004503/TID/DS/D1.2.2/A2 - ANNEX, December 28, 2007 José Enríquez, María Ángeles Callejo, Marc Brogle, Dragan Milic, et al:
- EuQoS Architecture update for Phase 2, EuQoS Deliverable D51.2.2, CEC Deliverable Number 004503/TID/DS/D1.2.2/A2, December 28, 2007
- Donal Morris, Marc Brogle, Dragan Milic, et al: Annex to D1.2.3: Exploitation Cookbook, Final, EuQoS Deliverable D1.2.3, CEC Deliverable Number 004503/TID/DS/D1.2.3/A1 - ANNEX, December 28, 2007
- Halina Tarasiuk and Wojciech Burakowski, Marc Brogle, Dragan Milic, et al: Methodology for testing EuQoS system, EuQoS Deliverable D2.2.5, CEC Deliverable Number 004503/WUT/DS/D2.2.5/A2, December 28, 2007
- María Ángeles Callejo, José Enríquez, Marc Brogle, Dragan Milic, et al: Annex 1 to D3.2.5: Implementation Final Report Detailed design, EuQoS Deliverable D3.2.5, CEC Deliverable Number 004503/ED/DS/D3.2.5/A1 Annex 1, December 28, 2007
- María Ángeles Callejo, José Enríquez, Marc Brogle, Dragan Milic, et al: Annex 2 to D3.2.5: Implementation Final Report EuQoS

users manual, EuQoS Deliverable D3.2.5, CEC Deliverable Number 004503/ED/DS/D3.2.5/A1 Annex 2, December 28, 2007

- Olivier Dugeon, Marc Brogle, Dragan Milic, et al: Prototype P#4 tests report , EuQoS Deliverable D5.2.3, CEC Deliverable Number 004503/FTRD/DS/D5.2.3/A1, December 28, 2007
- Olivier Dugeon, Marc Brogle, et al: EuQoS System Demonstrations Report for Phase II, EuQoS Deliverable D5.2.4, CEC Deliverable Number 004503/FTRD/DS/D5.2.4/A1, December 28, 2007
- Thomas Staub, Marc Brogle, et al: Report on teaching experiences of the e-learning course, the improvements to be done and the improvements achieved, EuQoS Deliverable D6.2.4, CEC Deliverable Number 004503/UBern/DS/D6.2.4/A1, December 28, 2007
- Michel Diaz, Donal Morris, Thomas Staub, et al: Third Standardization Report, EuQoS Deliverable D6.2.5, CEC Deliverable Number 004503/CNRS/DS/D6.2.5/A1, December 28, 2007
- Martin Potts, Mark Günter, Thomas Staub, et al: Third report on dissemination activities (demonstrations, publications, participations...), EuQoS Deliverable D6.2.6, CEC Deliverable Number 004503/Martel/DS/6.2.6/A1, December 28, 2007
- Torsten Braun, Ulrich Ultes-Nitsche, Marc Brogle, Dragan Milic, Patrick Lauer, Thomas Staub, Gerald Wagenknecht, Markus Anwander, Markus Waelchli, Markus Wulff, Carolin Latze, Michael Hayoz, Christoph Ehret, Thierry Nicola: RVS Retreat 2007 at Quarten, December, 2007, IAM-07-004

5 Research Group on Computer Vision and Artificial Intelligence

5.1 Personnel

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	Dr. T. Ha-Minh	Tel: +41 31 631 33 23 email: ha-minh@iam.unibe.ch
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	K. Riesen*	Tel: +41 31 631 86 99 email: riesen@iam.unibe.ch
	A. Schlapbach	Tel: +41 31 631 49 02 email: schlpbch@iam.unibe.ch (until 31.12.07)
Guests:	Dr. A. Toselli	Universidad Politécnica de Valencia October 2007 – December 2007
	A. Fornés	Universitat Autònoma de Barcelona March 2008 – Mai 2008
	Prof. A. Kandel	University of South Florida, Tampa, USA May 2008

* with financial support from a third party

5.2 Overview

Since 1984, the FKI group has been working on various topics in pattern recognition, machine vision, and computational intelligence. One of the current subject areas is document image analysis and handwriting recognition, where we have recently extended our activities from pure off-line to both on-line and off-line data. Furthermore, we are working in the field of structural pattern recognition, where we aim at developing methods to extend and improve current algorithms for clustering and classification using non-vectorial object representations.

5.3 Research Projects

Document Image Analysis and Understanding

A variety of problems occurring in the context of document image analysis are being investigated. These include the processing and analysis of both machine printed and handwritten documents. Current focus is on handwriting recognition, particularly on general text recognition and the use of natural language processing techniques for both on-line and off-line handwriting data. Recently, also the problem of writer identification has been studied. Furthermore, multiple classifier systems and their application to handwriting recognition are under investigation. Some of these activities are carried out as part of the Swiss NCCR project “Interactive Multimodal Information Management Systems”.

Research staff: R. Bertolami, V. Frinken, Dr. T. Ha-Minh, E. Indermühle, M. Liwicki, A. Schlapbach

Structural Pattern Recognition

Feature vectors are the predominant representation formalism in pattern recognition. Recently, however, non-vectorial representations, such as strings, trees and graphs, are becoming more and more popular for a number of reasons. But in contrast to vector spaces, the domain of symbolic data structures does not have a rich mathematical structure. Therefore, there is a severe lack of mathematical tools and algorithms for graph clustering and classification. In this project, we study a variety of issues, including efficient algorithms for graph matching, graph kernels, embedding

of symbolic data structures in vector spaces, and the adaptation of concepts from vector representations to the domains of strings, trees, and graphs.

Research Staff: K. Riesen

5.4 Ph.D. Theses

- Liwicki, M.: Recognition of whiteboard notes – on-line, off-line, and combination (November 2007)
- Schlapbach, A.: Writer identification and verification (November 2007)
- Bertolami, R.: Ensemble Methods for Offline Handwritten Text Line Recognition (May 2008)

5.5 Master and Diploma Theses

- Gerber, S.: Clustering of vector space embedded strings (October 2007)
- Gutmann, Ch.: Reduktion des Lexikons bei der Handschrifterkennung mit Hilfe von HMMs (October 2007)
- Fischer, V.: Erkennung handgeschriebener Textzeilen mit Graphen (November 2007)
- Wittwer, D.: Kern-Methoden für die Analyse von Graphen und Graphsequenzen (March 2008)
- Brügger, A.: Implementation eines Information Retrieval Systems auf der Basis von Graph Matching (April 2008)
- Indermühle, E.: Erkennung historischer Schriften des Schweizerischen Literaturarchivs in Bern (May 2008)
- Wüthrich, T.: Schreibererkennung durch Vergleich individueller Schriftzeichen (July 2008)
- Fischer, A.: Classification of dissimilarity space embedded graphs (July 2008)

5.6 Bachelor Theses and Computer Science Projects

- Cabrera, J.: On-Line Handwriting Recognition for the UNIPEN database (July 2007)
- Nyffenegger, B.: Extraktion von Zahlen aus einer Tabellenstruktur (October 2007)
- Schürch, S.: Unterscheidung von Personen in Telefongesprächen zur Emotionsdetektion (September 2007)
- Fankhauser S.: Exaktes Graphmatching mit einer bipartiten Heuristic (October 2007)
- Eggel, J.: Detektion fehlender Wrter in der Handschrifterkennung (February 2008)

5.7 Further Activities

Editorial Boards

H. Bunke

- Editor-in-Chief of *Electronic Letters on Computer Vision and Image Analysis*
- Member of the editorial board of the *International Journal of Pattern Recognition and Artificial Intelligence*
- Member of the editorial board of *Acta Cybernetica*
- Member of the editorial board of *Frontiers of Computer Science in China*
- Member of the advisory board of *Pattern Recognition*
- Editor-in-chief of the book series *Machine Perception and Artificial Intelligence* by World Scientific Publ., Singapore

Membership in Committees

H. Bunke

- Program Committee Member “9th Int. Conf. on Document Analysis and Recognition”, Curitiba, Brazil, September 23 – 26, 2007
- Program Committee Member “13th Conf. of the Int. Graphonomics Society”, Melbourne, November 11 – 13, 2007
- Program Committee Member “12th Iberoamerican Congress on Pattern Recognition”, Vina del Mar, Chile, November 13 – 16, 2007
- Program Committee Member “30th Annual Symposium of the German Pattern Recognition Association”, Munich, June 10 – 13, 2008
- Program Committee Member “8th Int. Workshop on Pattern Recognition in Information Systems”, Barcelona, June 12 – 13, 2008
- Program Committee Member “3rd Int. Workshop on Neural Networks in Pattern Recognition”, Paris, July 2 – 4, 2008

Activities in National NCCR

H. Bunke

- Member of the individual project “Video Processing” of the NCCR Project IM2 (Interactive Multimodal Information Management Systems)
- Member of the Steering Committee of the NCCR Project IM2

Additional Activities

H. Bunke

- Member Scientific Advisory Board of the German Research Center for Artificial Intelligence

5.8 Publications

Books

- H. Bunke, A. Kandel, and M. Last, editors. *Applied Pattern Recognition*. Springer, 2008.
- M. Neuhaus and H. Bunke. *Bridging the Gap between Graph Edit Distance and Kernel Machines*, Volume 68 of *Machine Perception and Artificial Intelligence*. World Scientific, 2007.

Journal Publications

- A. Schlapbach, M. Liwicki, and H. Bunke. A writer identification system for on-line white-board data. *Pattern Recognition*, 41:2381–2397, 2008.

Papers in Refereed Conference Proceedings and Chapters in Edited Books

- A. Brügger, H. Bunke, P. Dickinson, and K. Riesen. Generalized graph matching for data mining and information retrieval. In P. Perner, editor, *Advances in Data Mining. Medical Applications, E-Commerce, Marketing, and Theoretical Aspects*, LNCS 5077, pages 298–312. Springer, July 2008.
- K. Riesen and H. Bunke. Kernel k -means clustering applied to vector space embeddings of graphs. In L. Prevost, S. Marinai, and F. Schwenker, editors, *Proc. 3rd IAPR Workshop Artificial Neural Networks in Pattern Recognition*, LNAI 5064, pages 24–35. Springer, 2008.
- H. Bunke and K. Riesen. Recent developments in graph classification and clustering using graph embedding kernels. In A. Juan-Ciscar and G. Sanchez-Albaladejo, editors, *Proc. 8th Int. Workshop Pattern Recognition in Information Systems*, pages 3–13, 2008.
- K. Riesen and H. Bunke. Non-linear transformations of vector space embedded graphs. In A. Juan-Ciscar and G. Sanchez-Albaladejo, editors, *Proc. 8th Int. Workshop Pattern Recognition in Information Systems*, pages 173–183, 2008.

- R. Bertolami and H. Bunke. Ensemble methods to improve the performance of an English handwritten text line recognizer. In D. Doerman and S. Jaeger, editors, *Arabic and Chinese Handwriting Recognition*, LNCS 4768, pages 265–277. Springer, 2008.
- H. Bunke, P. Dickinson, M. Neuhaus, and M. Stettler. Matching of hypergraphs – algorithms, applications, and experiments. In H. Bunke, A. Kandel, and M. Last, editors, *Applied Pattern Recognition*, pages 131–154. Springer, 2008.
- A. Schlapbach and H. Bunke. Off-line writer identification and verification using Gaussian mixture models. In S. Marinai and H. Fujisawa, editor, *Machine Learning in Document Analysis and Recognition*, pages 409–428. Springer, 2008.
- T. Varga and H. Bunke. Perturbation models for generating synthetic training data in handwriting recognition. In S. Marinai and H. Fujisawa, editors, *Machine Learning in Document Analysis and Recognition*, pages 333–360. Springer, 2008.
- X. Jiang and H. Bunke. Graph matching. In P. Perner, editor, *Case-Based Reasoning on Images and Signals*, pages 149–173. Springer, 2007.
- H. Bunke and K. Riesen. A family of novel kernel graphs for structural pattern recognition. In L. Rueda, D. Mery, and J. Kittler, editors, *Proc. 12th Iberoamerican Congress on Pattern Recognition*, number 4756 in *Lecture Notes in Computer Science*, pages 20–31. Springer, 2007.
- M. Liwicki and H. Bunke. Feature selection for on-line handwriting recognition of whiteboard notes. In *Proc. 13th Conf. of the Graphonomics Society*, pages 101–105, 2007.
- M. Liwicki, A. Schlapbach, P. Loretan, and H. Bunke. Automatic detection of gender and handedness from on-line handwriting. In *Proc. 13th Conf. of the Graphonomics Society*, pages 179–183, 2007.
- F. Lüthy, T. Varga, and H. Bunke. Using hidden Markov models as a tool for handwritten text line segmentation. In *Proc. 9th Int. Conf. on Document Analysis and Recognition*, pages 8–12, 2007.
- R. Bertolami, S. Uchida, M. Zimmermann, and H. Bunke. Non-uniform slant correction for handwritten text line recognition. In *Proc.*

9th Int. Conf. on Document Analysis and Recognition, pages 18–22, 2007.

- A. Schlapbach and H. Bunke. Fusing asynchronous feature streams for on-line writer identification. In Proc. 9th Int. Conf. on Document Analysis and Recognition, pages 103–107, 2007.
- M. Liwicki, A. Graves, H. Bunke, and J. Schmidhuber. A novel approach to on-line handwriting recognition based on bidirectional long short-term memory networks. In Proc. 9th Int. Conf. on Document Analysis and Recognition, pages 367–371, 2007.
- A. Graves, M. Liwicki, and H. Bunke. Unconstrained on-line handwriting recognition with recurrent neural networks. In Advances in Neural Information Processing, NIPS, Vancouver, 2007.
- M. Liwicki and H. Bunke. Combining on-line and off-line systems for handwriting recognition. In Proc. 9th Int. Conf. on Document Analysis and Recognition, pages 372–376, 2007.
- M. Liwicki, E. Indermühle, and H. Bunke. On-line handwritten text line detection using dynamic programming. In Proc. 9th Int. Conf. on Document Analysis and Recognition, pages 447–451, 2007.

6 Research Group on Theoretical Computer Science and Logic

6.1 Personnel

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6.2 Overview

The TIL research group (theoretical computer science and logic) focuses on theoretical computer science and mathematical logic, especially proof theory, computational logics and theory of computation. We have been dealing for many years with formal methods, analysis of deductions, general computations and, in particular, applications of mathematical logic to computer science. The three main subject areas are the following:

Computational Logic: Logical formalisms are perfectly suited to the specification of complex systems, the representation of knowledge and information, the description of processes (e.g. in distributed multi-agent systems) and for providing formal proofs of important system properties such as, for example, correctness and fairness. The research group has long been interested in the deductive, procedural and dynamic aspects of the corresponding formalisms and in the design of modern deductive systems. New approaches are being developed for information update purposes. In addition, the way in which simple, logical formalisms can be extended to become genuine multi-user systems taking into account the dynamic aspects of ontologies in the data mining context and in connection with the semantic web is being investigated.

Proof Theory: This research topic focuses on the development and analysis of formal systems of first and second order arithmetic, set theory and of what are known as logical frameworks (type and set theoretical, explicit, constructive, extensional, intentional). Our interests range from feasible subsystems of arithmetic to highly impredicative set and type theories and

deals with the interplay between constructive, recursive and operational approaches. In addition, abstract computations and computable knowledge are being investigated.

Reasoning under Uncertainty: This area covers researches on reasoning and decision under uncertainty both on the methodological and on the applicative sides. Reasoning is the process of deriving conclusions from given evidence, and these conclusions are then used as a basis for possible decisions. One of the main difficulties in this reasoning and decision-making process is the uncertainty often included in the available evidence. The goal in this research area is to define and implement formal methods to describe and represent all possible aspects of uncertainty. Most of the techniques rely on logical and probabilistic methods.

6.3 Research Projects

A Proof Theory for Modal Fixed Point Logics

Temporal logics are widely used to specify and verify the correctness of information systems when system reliability is crucial. Epistemic logics with common knowledge are important for reasoning about knowledge. Both types of logics are examples of modal fixed point logics. While these logics are well-understood semantically, our syntactic understanding of them is lacking. The state of proof theory for modal logics in general is widely recognised as unsatisfactory. For modal fixed point logics in particular there are no satisfactory cut-free sequent systems. Such systems generally are suitable for automated proof search and, together with their cut elimination procedures, can serve as a basis for declarative programming languages. We intend to address the problem of designing cut-free sequent systems for modal fixed point logics on two levels:

1. Whenever possible we plan to develop such systems together with syntactic cut elimination procedures. If possible, we aim for traditional sequent systems in Gentzen style, but if needed we will also employ ideas from richer proof theoretic formalisms such as the display calculus or deep inference.
2. On the other hand, if no cut-free systems exist for modal fixed point logics, we hope to gain a better understanding of why they do not exist. In this case we are interested in good syntactic approximations.

The development of a proof theory for modal fixed point logics is an important theoretical contribution to the understanding of inference and deduction in these logics, and thus in particular a relevant underpinning of specification and verification of information systems. It is central ground work concerning the procedural aspects of frameworks dealing with information.

Research staff: L. Alberucci, K. Brännler, G. Jäger, R. Wehbe

Financial support: Hasler Foundation

Algebraic and Logical Aspects of Knowledge Processing

In this project, we employ and set up conceptual frameworks, in particular, theories relating classical mathematics with constructive mathematics and feasible mathematics. Thereby we always emphasize the computational properties and complexities of our formalisms. We use proof theory as our main tool for analyzing the constructive and computational content of various formalisms and aim at further exploiting the proofs as computations paradigm. Besides the traditional subsystems of first- and second-order arithmetic and (admissible) set theory, we will focus on theories of explicit mathematics, operational set theories, and theories of partial truth.

Research staff: G. Jäger, J. Krähenbühl, R. McKinley, D. Probst, D. Spescha, Th. Strahm

Financial support: Swiss National Science Foundation

Structural Proof Theory and the Logic of Proofs

The Logic of Proofs was developed by S. Artemov in the nineties in order to solve a problem posed by K. Gödel in the thirties. It is based on the notion of a so-called "proof polynomial", which allows to talk about proofs inside of the logical language. Because of that it has found numerous applications in the areas of epistemic logic, verification systems and foundations of functional programming languages. Epistemic logic is the study of knowledge. Here the Logic of Proofs allows to reason not only about knowledge, but also about the evidence from which we obtain the knowledge. Verification is used ensure the correctness of computational

systems. Here the Logic of Proofs allows to reason about the correctness of the verifier itself. The Logic of Proofs also led to foundations of functional programming languages in which the execution itself can be part of the program, in a certain sense.

Even though the field has been growing rapidly, there still are areas which are not well understood. In particular, it is not known how to design proof polynomials for logics with so-called "fixed points". This is unfortunate, because this includes important logics such as epistemic logics with common knowledge and various temporal logics. Common knowledge is a central concept in epistemic logic. It describes the fact that not only everybody knows a fact, but also everybody knows that everybody knows this fact, and everybody knows that everybody knows that... and so on. That we should go at a green light and stop at a red light, for example, is common knowledge among car drivers. Temporal logics, on the other hand, can reason about time and are central in the verification of the correctness of computational systems.

The lack of proof polynomials for fixed points in particular means that there is no formal setting in which evidence-based knowledge and common knowledge can be studied together. Also, there is no evidence-based formal setting for reasoning about time. This is the first problem we want to attack.

Also, the relationship between proof polynomials and the so-called cut elimination is not well understood. Cut elimination is arguably the most important operation on proofs. Crudely speaking it transforms a short creative proof into one that is long and not creative. Among many other things this ensures that a proofs can be found even without creativity, such as by a computer. The study of cut elimination in the presence of proof polynomials is the second problem we want to attack.

Research staff: K. Brännler, S. Bucheli, R. Goetschi, G. Jäger, R. Kuznets

Financial support: Swiss National Science Foundation

Dynamic Ontologies

In collaboration with: Prof. Dr. K. Stoffel, University of Neuchâtel

Over the last decade, ontologies have moved beyond academic domains such as knowledge representation, philosophy, or library science. They

became a cornerstone in support of interoperability for facilitation of knowledge management and configuration. This development triggered a lot of interesting research questions. One of the fundamental questions is how to extend the simple logical inference system into real multi-user systems that are able to deal with the dynamic aspects of ontologies in such an environment. The goal of the dynamic ontologies project is to formally analyze, specify and implement a prototype of a complex ontology management system that will be able to meet the requirements imposed by modern information management systems.

Research staff: Ph. Stouppa, Th. Studer

Financial support: Swiss National Science Foundation

Inference and Deduction

In collaboration with: Prof. Dr. J. Kohlas, University of Fribourg

Information and knowledge are concepts which are mostly used in computer science in an intuitive understanding, although there exist some fragments of a formal theory of information: information theory in the sense of Shannon, algorithmic information theory, logic of information or information flow, logic of knowledge. Each of these fragments addresses a particular aspect of the concept of information and knowledge.

We study in this project further aspects of information and knowledge. These include:

1. Algebraic aspects of information arising from the operations of aggregation (combination) and focusing of information.
2. Modeling of structures of compatible questions or domains and the relation of information and its measures relative to particular questions or domains.
3. Uncertain nature of information, the corresponding inference problems, with particular attention to statistical information.
4. Dynamic nature of information and knowledge, including the passage from information to knowledge and reasoning about knowledge.
5. Proof theory of modal μ -calculus.

These issues will be studied in their own right, but also with the goal to establish links between the fragments and existing fragments of a theory of information. This should be a step towards an integrated theory of information.

The relative nature of information and its measure with respect to particular questions is emphasized. The algebraic aspects of information are studied in the perspective of important practical systems such as relational databases, constraint systems and probability networks. Information and its algebraic structure is also considered in relation to general abstract structures such as contexts, classifications or Chu spaces. The combinatorial nature of information arising from their algebraic structure will be carried over to uncertain information. Frameworks for knowledge representation (including common knowledge) and knowledge accumulation, updates and belief revision will be developed. The dynamical aspects of information and knowledge and their explicit logical treatment will play an important role.

This is a common project of the theoretical computer science groups of the Universities of Fribourg and Berne. Both groups have a specific background: Fribourg in the domain of the algebraic structure of information (valuation and information algebras), and additionally in probabilistic modeling, in particular probabilistic argumentation systems, Berne in the field of mathematical and computational logic. The alternative, but complementary backgrounds have proven fruitful in the past and will be profitable for the project proposed here.

Research staff: P. Brambilla, G. Jäger, D. Steiner

Financial support: Swiss National Science Foundation

Logic and Computation

This very general project deals with the close connections between mathematical logic and certain parts of computer science, and emphasis is put on a proof-theoretic approach to some of the central questions in this area of research. These include the development of perspicuous and feasible logical frameworks for studying typical questions in computer science like termination and correctness of functional programs, properties of distributed systems and the like.

We study applicative theories as well as strongly typed formalisms and are interested in the connections to constructive and explicit mathemat-

ics. Furthermore, we are interested in analyzing the close connections between the complexities of computations and proofs in suitable formalizations, ranging from propositional calculi up to abstract frameworks for computations (in higher types).

Research staff: All members of the research group

Logic and Information

In collaboration with: Prof. Dr. J. Schmid, University of Bern; Prof. Dr. J. Kohlas, Prof. Dr. U. Ultes-Nitsche, Prof. Dr. G. Sommaruga, University of Fribourg; Prof. Dr. K. Stoffel, University of Neuchâtel

A collaboration project within the so-called "Réseau BeNeFri" in order to enhance and support research on logic and information and the many connections between both. Focus is on

- good models for the representation and processing of information and knowledge,
- powerful deduction and inference procedures, including the relevant complexity considerations,
- concrete applications.

Research staff: G. Jäger, G. Ostrin, D. Probst, Th. Strahm, Th. Studer

Financial support: Swiss University Conference (CUS)

Probabilistic Logic and Probabilistic Networks

Logic and probability theory have both a long history in science. They are mainly rooted in philosophy and mathematics, but are nowadays important tools in many other fields such as computer science and, in particular, artificial intelligence. Some philosophers studied the connection between logical and probabilistic reasoning, and some attempts to combine these disciplines have been made in computer science, but logic and probability theory are still widely considered to be separate theories that are only loosely connected.

This project investigates a new perspective which shows that logical and probabilistic reasoning are no more and no less than two opposite extreme

cases of one and the same universal theory of reasoning called probabilistic argumentation. The goal of the project is to further study this theory and its wide range of possible applications in different areas of uncertain reasoning.

Research staff: R. Haenni, J. Jonczy, R. Kohlas, M. Wachter

Financial support: Leverhulme Trust, Proginet project

Resource-Bounded Reasoning and Anytime Algorithms

Anytime algorithms are computational procedures for which the quality of the result improves gradually as computation time increases. They give the user the possibility to trade off computational resources against accuracy of the results. Anytime algorithms provide thus a flexible solution to the widespread problem of limited computational resources and are nowadays an emerging research topic in various areas. Of particular importance for this project is the field of real-time reasoning in intelligent knowledge-based systems.

The goal of the project is to analyze the foundations and properties of resource-bounded reasoning and anytime algorithms in intelligent systems more deeply. The project will study generic resource-bounded procedures in the framework of valuation algebras and develop corresponding methods in various specific formalisms such as Bayesian networks, Dempster-Shafer theory, or constraint satisfaction. The expected results will then be implemented and tested with respect to existing techniques, and their relevance to specific application domains will be evaluated.

Research staff: R. Haenni, J. Jonczy, R. Kohlas, M. Wachter

Financial support: Swiss National Science Foundation

ViLoLa - a Virtual Logic Laboratory (maintenance)

In collaboration with: Prof. Dr. J. Schmid and Dr. M. Sprenger, University of Bern; Prof. Dr. J. Rolim, University of Geneva; Dr. U.-M. Künzi, Fachhochschule Rapperswil

ViLoLa provides a modular learning environment for many aspects of logic: Philosophical, mathematical and applications to computer science.

The original aims of the ViLoLa package are met, partially even surpassed. All modules have been field tested, some are in regular use at this time or will be in the academic year 2004/05. Tools (LWB, Logic Work Bench; AWB, Algebraic Work Bench) are continually expanded and even used in courses outside the original ViLoLa framework. Evaluation procedures are integrated into the project (project partner A. Hollenstein). It has become apparent that a module “Introduction to Set Theory” should complement the package to make it fully self-contained and independent.

Research staff: G. Jäger, U.-M. Künzi

Financial support: Swiss Virtual Campus

6.4 Ph.D. Theses

- R. Kohlas: Decentralized Trust Evaluation and Public-Key Authentication

6.5 Master and Diploma Theses

- S. Bucheli: Explicit mathematics with positive existential stratified comprehension, join and uniform monotone inductive definitions
- O. Spycher: BABE: Eine Sprache zur Spezifikation Bayesianischer Netzwerke
- R. Goetschi: Polytime functions in two-sorted bounded arithmetic

6.6 Bachelor Theses and Computer Science Projects

- D. Fabian: Polynomial time computable arithmetic and conservative extensions

6.7 Further Activities

Editorial Boards

- Member of the editorial board of Archive of Mathematical Logic (G. Jäger)
- Member of the editorial board of Logica Universalis (G. Jäger)
- Member of the consulting board of Dialectica (Th. Strahm)
- Member of the editorial board of International Journal of Approximate Reasoning (R. Haenni)
- Member of the editorial board of The Reasoner (R. Haenni)
- Member of the editorial board of Journal of Applied Logic, Special Issue on Probabilistic Logic and Probabilistic Networks (R. Haenni)

Technical and Research Committees

- Research Council Member of the Swiss National Science Foundation (G. Jäger)
- Member of the Steering Committee of the Platform Mathematics, Astronomy and Physics (MAP) of the Swiss Academy of Sciences (G. Jäger)
- Secretary of the Swiss Society for Logic and Philosophy of Science (Th. Strahm)
- Member of the Scientific Council of the European Association for Computer Science Logic (G. Jäger)
- Expert for Maturitätsprüfungen Mathematik (G. Jäger, G. Ostrin, D. Probst, Th. Strahm, Th. Studer)
- Program Committee Member and Chair of the Organizing Committee of the Logic Colloquium 2008 (G. Jäger)
- Organizing Committee member of the Logic Colloquium 2008 (L. Alberucci, K. Brännler, B. Choffat, J. Krähenbühl, R. McKinley, D. Probst, D. Spescha, Th. Strahm, Th. Studer)

- Program and Organizing Committee of the Workshop on Proof Theory 2008 (G. Jäger, Th. Strahm)
- PC Member, ABCD on μ -calculus (L. Alberucci)
- PC Member, Digitale Informationen: Zwischen Flüchtigkeit und Bewahrung, Collegium generale (Th. Studer)
- Organizing Committee member of the 3rd Workshop on Combining Probability and Logic 2007 (R. Haenni)
- Program Committee member of the 4th European Workshop on Probabilistic Graphical Models 2008 (R. Haenni)
- Program Committee member of the International Workshop on Interval/Probabilistic Uncertainty and Non-Classical Logics 2008 (R. Haenni)

6.8 Publications

- L. Alberucci, Sequent calculi for the modal μ -calculus over S5, submitted
- L. Alberucci, A syntactical treatment of simultaneous fixpoints in the modal μ -calculus, submitted
- L. Alberucci and A. Facchini, On modal μ -calculus and Gödel-Löb logic, submitted
- L. Alberucci and A. Facchini, The modal μ -calculus hierarchy over restricted classes of transition systems, submitted
- K. Brännler and M. Lange, Cut-free sequent systems for temporal logic, *Journal of Logic and Algebraic Programming*, 2008
- K. Brännler, D. Probst and Th. Studer, On contraction and the modal fragment, *Mathematical Logic Quarterly*, 2008
- K. Brännler and Th. Studer, Syntactic cut-elimination for common knowledge, *Proceedings of Methods for Modalities 5*, to appear
- R. Hänni, Probabilistic Argumentation, *Journal of Applied Logic*, 2008

- R. Hänni, Non-Additive Degrees of Belief, *Degrees of Belief*, 2008
- R. Hänni, Aggregating Referee Scores: an Algebraic Approach, *COMSOC'08, 2nd International Workshop on Computational Social Choice*, 2008
- R. Hänni, Editorial, *The Reasoner*, 2008
- R. Hänni, Interview with Jürg Kohlas, *The Reasoner*, 2008
- R. Hänni, A Trust Evaluation Method Based on Logic and Probability Theory, *FIPTM'08, 2nd Joint iTrust and PST Conferences on Privacy Trust Management and Security*, 2008
- R. Hänni, Climbing the Hills of Compiled Credal Networks, *ISIPTA'07, 5th International Symposium on Imprecise Probabilities and Their Applications*, 2007
- R. Hänni, F. Cozman, J. W. Romeijn, F. Russo, G. Wheeler and J. Williamson, Special Issue on Combining Probability and Logic, *Journal of Applied Logic*, 2008
- R. Hänni and J. Jonczy, Network Reliability Evaluation with Propositional Directed Acyclic Graphs, *Advances in Mathematical Modeling for Reliability*, 2008
- R. Hänni and J. Jonczy, A New Approach to Network Reliability, *5th International Conference on Mathematical Methods In Reliability*, 2007
- R. Hänni and J. Jonczy, A New Approach to PGP's Web of Trust, *European e-Identity Conference*, 2007
- R. Hänni, M. Pouly and M. Wachter, Optimizing Inference in Bayesian Networks and Semiring Valuation Algebras, *6th Mexican International Conference on Artificial Intelligence*, 2007
- R. Hänni, M. Pouly and M. Wachter, Compiling Solution Configurations in Semiring Valuation Systems, *6th Mexican International Conference on Artificial Intelligence*, 2007
- R. Hänni, J. W. Romeijn, G. Wheeler and J. Williamson, Logical Relations in a Statistical Problem, *Foundation of the formal Sciences VI, Reasoning about Probabilities and Probabilistic Reasoning, Studies in Logic*, 2008

- R. Hänni, J. W. Romeijn, G. Wheeler and J. Williamson, Possible Semantics for a Common Framework of Probabilistic Logics, *UncLog'08, International Workshop on Interval/Probabilistic Uncertainty and Non-Classical Logics*, 2008
- R. Hänni and M. Wachter, Logical Compilation of Bayesian Networks with Discrete Variables, *9th European Conference on Symbolic and Quantitative Approaches to Reasoning under Uncertainty*, 2007
- G. Jäger, On Feferman's operational set theory OST, *Annals of Pure and Applied Logic*, 2007
- G. Jäger, Operations, sets and classes, submitted
- G. Jäger, Full operational set theory with unbounded existential quantification and power set, submitted
- G. Jäger, M. Kretz and Th. Studer, Cut-free common knowledge, *Journal of Applied Logic*, 2007
- G. Jäger, M. Kretz and Th. Studer, Canonical completeness of infinitary μ , *Journal of Logic and Algebraic Programming*, 2008
- J. Jonczyk and R. Kohlas, Trust and Authenticity Networks, *EEMA'07, European e-Identity Conference*, 2007
- N. Kottmann and Th. Studer, Improving semantic query answering, *Proceedings of Database and Expert Systems Applications*, 2007
- R. McKinley, Soft linear set theory, *Journal of Logic and Algebraic Programming*, 2008
- R. McKinley, Herbrand Expansion proofs and proof identity, *Classical logic and computation 08*, 2008
- D. Spescha and Th. Strahm, Elementary explicit types and polynomial time operations, *Mathematical Logic Quarterly*, to appear
- Th. Strahm and J.I. Zucker, Primitive recursive selection functions for existential assertions over abstract algebras, *Journal of Logic and Algebraic Programming*, 2008
- Th. Studer, On the proof theory of the modal μ -calculus, *Studia Logica*, to appear

- R. Wehbe, Computing with common knowledge, *Proceedings of Artificial Intelligence and Soft Computing*, 2007

7 Research Group on Software Composition

7.1 Personnel

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*with financial support from a third party

7.2 Overview

Complex software systems must continuously change if they are to remain useful. The Software Composition Group carries out research in (1) programming language design, and (2) software reengineering with the goal of facilitating the development of flexible, open software systems. In both cases we are investigating mechanisms and techniques that enable the graceful evolution of software systems by putting change at the center of the software process.

7.3 Research Projects

Analyzing, Capturing and Taming Software Change

Complex software systems must change in order to keep pace with changing needs and requirements. Nevertheless, modern programming languages and environments place more emphasis on mechanisms to enforce consistency and to limit the effects of change than on enabling change.

In this project we put change in the center of attention and we tackle it from several perspectives: (1) how to encapsulate change, (2) how to manage the scope of change in a running system, (3) how to assess the impact of change in a complex system, and (4) how to exploit change to reveal implicit trends and emergent software artifacts.

Recent progress includes the introduction of the notion of sub-method reflection as an approach to offer access to fine grained reflection. We used this mechanism to add support for pluggable types in a dynamic system by means of annotating the source code. Furthermore, we also introduced an approach to control the scope of reflective changes.

We matured our approach for tracing how objects flow through the system at runtime. This work led to the development of a virtual machine that supports back-in-time debugging in a practical way. The paper describing this approach received the distinguished paper award at ECOOP 2008.

Research staff: All members of the research group.

Duration: October 2006 – September 2008

Financial support: Swiss National Science Foundation,
Project #200020-113342

For further details, please consult:

<http://scg.iam.unibe.ch/Research/SNF06>

Enabling the evolution of J2EE applications through reverse engineering and quality assurance

Enterprise applications are complex software products that manipulate much persistent data and interacts with the user through a vast and complex user interface. Modern technologies that address this field consist of mechanisms requiring implementations in several languages. Java 2 Platform, Enterprise Edition (J2EE) is one of the most prominent such

technologies. It was first introduced in 1999, and since then it has become one of the standard technologies in enterprise application development. To address the complexity of enterprise applications, J2EE offers a conglomerate of several technologies, (e.g. Enterprise Java Beans — EJB or Java Server Pages — JSP) using several languages, (e.g. Java, XML or SQL).

In this context, simply applying existing reverse engineering and quality assurance techniques developed for object-oriented systems fails because these techniques focus only on the Java source code. As such, they overlook the information written in other languages such as the XML configurations, the JSP files, the database structure or the SQL statements. Furthermore, even for the Java code, these techniques also do not take into account the specifics of the framework.

This project aims to conduct a systematic study in reverse engineering and quality assurance of J2EE applications. During the first year we started to work on meta-modeling issues to support J2EE analysis. We also started to apply some J2EE specific analyses on industrial case studies.

Research staff: All members of the research group.

Duration: October 2007 – September 2010

Financial support: Hasler Foundation (project no. 2234).

For further details, please consult:

<http://scg.iam.unibe.ch/Research/Hasler07>

7.4 Ph.D. Theses

- Marcus Denker. *Sub-method Structural and Behavioral Reflection*. phd thesis, University of Bern, May 2008.

7.5 Master's Theses

- Andrea Brühlmann. *Enriching reverse engineering with annotations*. Master's thesis, University of Bern, April 2008.

7.6 Bachelor's Theses and Computer Science Projects

- Lea Haensenberger. JExample. Bachelor's project, University of Bern, March 2008.
- Lucas Streit. Basil — scripting Flash from Smalltalk. Bachelor's thesis, University of Bern, October 2007.

7.7 Further Activities

Editorial Boards

Oscar Nierstrasz

- Springer LNCS – SL2 – Programming Techniques and Software Engineering (Series Editor)
- ACM TOSEM – Transactions on Software Engineering and Methodology (Associate Editor)

Memberships

Oscar Nierstrasz

- SARIT – Swiss Association for Research in Information Technology (Board Member)
- AITO – Association Internationale pour les Technologies Objets (Vice President)
- CHOOSE – Swiss Group for Object-Oriented Systems and Environments (Board Member)
- ESEC – European Software Engineering Conference (Steering Committee Member)
- MoDELS – International Conference on Model Driven Engineering Languages and Systems (Steering Committee Member)
- SC – Software Composition Symposium (Steering Committee Member)

- Moose Association (Board Member)

Tudor Girba

- CHOOSE – Swiss Group for Object-Oriented Systems and Environments (Treasurer)
- Moose Association (President)

Adrian Kuhn

- Moose Association (Founding President)

Orla Greevy

- Moose Association (Treasurer)

Program Committees

Oscar Nierstrasz

- PC Member of DLS 2008 (Dynamic Languages Symposium — Paphos, Cyprus, July 8, 2008)
- PC Member of WASDeTT 2008 (International Workshop on Advanced Software Development Tools and Techniques — Paphos, Cyprus, July 8, 2008)
- PC Member of TOOLS Europe 2008 (International Conference on Objects, Models, Components, Patterns — Zurich, Switzerland, June 30 - July 4, 2008)
- PC Member of ICPC 2008 (International Conference on Program Comprehension — Amsterdam, The Netherlands, 10-13 June, 2008)
- PC Member of FASE 2008 (Fundamental Approaches to Software Engineering — Budapest, Hungary, 29 March - 6 April, 2008)
- Co-organizer of the CHOOSE Forum 2007 (Languages for the Web — FHNW Brugg, November 9, 2007)
- PC Member of DLS 07 (Dynamic Languages Symposium 2007 — collocated with OOPSLA 07, Montreal, October 22, 2007)

Tudor Gîrba

- Workshop Committee Member of TOOLS 2008 (International Conference Objects, Models, Components, Patterns — Zurich, June 30 - July 4, 2008)
- PC Member of ICPC 2008 (International Conference on Program Comprehension — Amsterdam, The Netherlands, June 10-13, 2008)
- Program Co-chair of QTAPC 2008 (Query Technologies and Applications for Program Comprehension — collocated with ICPC 2008, Amsterdam, The Netherlands, June 10, 2008)
- PC Member of MSR 2008 (Working Conference on Mining Software Repositories — collocated with ICSE 2008, Leipzig, Germany, May 10-11, 2008)
- PC member of ENASE 2008 (International Conference on Evaluation of Novel Approaches to Software Engineering — Milan, Italy, May 6-10, 2008)
- PC Member of PCODA 2007 (International Workshop on Program Analysis through Dynamic Analysis — collocated with WCRE 2007, October 29, 2007)
- PC Member of ICSM 2007 (International Conference on Software Maintenance — Paris, France, October 2-5, 2007)
- PC Member of IWPSE 2007 (International Workshop on Principles of Software Evolution — collocated with ESEC/FSE, Dubrovnik, Croatia, Sept, 3-4, 2007)

Orla Greevy

- Program Co-chair of PCODA 2007 (International Workshop on Program Analysis through Dynamic Analysis – collocated WCRE 2007, October 29, 2007).

Adrian Kuhn

- Co-organizer of WASDeTT 2008 (International Workshop on Advanced Software Development Tools and Techniques – collocated with ECOOP 2008, Paphos, Cyprus, July 8, 2008)

Reviewing Activities

Oscar Nierstrasz

- Swiss National Science Foundation
- Hasler Foundation
- Australian Research Council
- INRIA
- Information and Software Technology Journal (IST)
- Science of Computer Programming Journal (SciCo)
- Journal of Universal Computer Science (J.UCS)

Tudor Gîrba

- Transactions on Software Engineering (TSE)
- IEEE Software
- Journal of Software Maintenance and Evolution (JSME)
- Journal of Empirical Software Engineering

7.8 Publications

Books

- Andrew Black, Stéphane Ducasse, Oscar Nierstrasz, Damien Pollet, Damien Cassou, and Marcus Denker. *Squeak by Example*. Square Bracket Associates, 2007. <http://SqueakByExample.org/>.

Journal Papers

- Alexandre Bergel, Stéphane Ducasse, Oscar Nierstrasz, and Roel Wuyts. Stateful traits and their formalization. *Journal of Computer Languages, Systems and Structures*, 34(2-3):83–108, 2007.
- Alexandre Bergel, Stéphane Ducasse, and Lukas Renggli. Seaside – advanced composition and control flow for dynamic web applications. *ERCIM News*, 72, January 2008.

- Stéphane Ducasse, Adrian Lienhard, and Lukas Renggli. Seaside: A flexible environment for building dynamic web applications. *IEEE Software*, 24(5):56–63, 2007.
- Niklaus Haldimann, Marcus Denker, and Oscar Nierstrasz. Practical, pluggable types for a dynamic language. *Journal of Computer Languages, Systems and Structures*, 2008. To appear.
- Robert Hirschfeld, Pascal Costanza, and Oscar Nierstrasz. Context-oriented programming. *Journal of Object Technology*, 7(3), March 2008.
- David Röthlisberger, Marcus Denker, and Éric Tanter. Unanticipated partial behavioral reflection: Adapting applications at runtime. *Journal of Computer Languages, Systems and Structures*, 34(2-3):46–65, July 2008.

Conference Papers

- Mihai Balint, Petru Florin Mihancea, Tudor Gîrba, and Radu Marinescu. Norex: A distributed reengineering environment. In *Proceedings of International Conference on Software Maintenance (ICSM 2007)*, pages 523–524. IEEE Computer Society, September 2007. Tool demo.
- Alexandre Bergel, Wolfgang De Meuter, Stéphane Ducasse, Oscar Nierstrasz, and Roel Wuyts. Dynamic languages and applications, report on the workshop Dyla'07 at ECOOP 2007. In *Object-Oriented Technology. ECOOP 2007 Workshop Reader*, volume 4906 of *LNCS*, pages 7–12. Springer-Verlag, 2008.
- Marcus Denker, Stéphane Ducasse, Adrian Lienhard, and Philippe Marschall. Sub-method reflection. In *Journal of Object Technology, Special Issue. Proceedings of TOOLS Europe 2007*, volume 6/9, pages 231–251. ETH, October 2007.
- Marcus Denker, Tudor Gîrba, Adrian Lienhard, Oscar Nierstrasz, Lukas Renggli, and Pascal Zumkehr. Encapsulating and exploiting change with Changeboxes. In *Proceedings of the 2007 International Conference on Dynamic Languages (ICDL 2007)*, pages 25–49. ACM Digital Library, 2007.

- Marcus Denker, Mathieu Suen, and Stéphane Ducasse. The meta in meta-object architectures. In *Proceedings of TOOLS EUROPE 2008*, volume 11 of *LNBIP*, pages 218–237, 2008.
- Adrian Dozsa, Tudor Gîrba, and Radu Marinescu. How Lisp systems look different. In *European Conference on Software Maintenance and Re-Engineering (CSMR 2008)*, pages 223–232. IEEE Computer Society Press, 2008.
- Stéphane Ducasse, Roel Wuyts, Alexandre Bergel, and Oscar Nierstrasz. User-changeable visibility: Resolving unanticipated name clashes in traits. In *Proceedings of 22nd International Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA'07)*, pages 171–190, New York, NY, USA, October 2007. ACM Press.
- Markus Gaelli, Rafael Wampfler, and Oscar Nierstrasz. Composing tests from examples. In *Journal of Object Technology, Special Issue. Proceedings of TOOLS Europe 2007*, volume 6/9, pages 71–86, October 2007.
- Niklaus Haldimann, Marcus Denker, and Oscar Nierstrasz. Practical, pluggable types. In *Proceedings of the 2007 International Conference on Dynamic Languages (ICDL 2007)*, pages 183–204. ACM Digital Library, 2007.
- Abdelwahab Hamou-Lhadj, Andy Zaidman, and Orla Greevy. Workshop on program comprehension through dynamic analysis (PCODA). In *Proceedings of IEEE 14th Working Conference on Software Maintenance and Reengineering (WCRE)*, pages 298–298, October 2007.
- Adrian Kuhn, Bart Van Rompaey Lea, Haensenberger, Oscar Nierstrasz, Serge Demeyer, Markus Gaelli, and Koenraad Van Leemput. JExample: Exploiting dependencies between tests to improve defect localization. In P. Abrahamsson, editor, *Extreme Programming and Agile Processes in Software Engineering, 9th International Conference, XP 2008*, Lecture Notes in Computer Science, pages 73–82. Springer, 2008.
- Adrian Lienhard, Stéphane Ducasse, and Tudor Gîrba. Object flow analysis — taking an object-centric view on dynamic analysis. In

Proceedings of the 2007 International Conference on Dynamic Languages (ICDL'07), pages 121–140, New York, NY, USA, 2007. ACM Digital Library.

- Adrian Lienhard, Tudor Gîrba, Orla Greevy, and Oscar Nierstrasz. Test blueprints – exposing side effects in execution traces to support writing unit tests. In *12th European Conference on Software Maintenance and Reengineering (CSMR'08)*, pages 83–92. IEEE Computer Society Press, 2008.
- Adrian Lienhard, Tudor Gîrba, and Oscar Nierstrasz. Practical object-oriented back-in-time debugging. In *22nd European Conference on Object-Oriented Programming (ECOOP'08)*, volume 5142 of *LNCS*, pages 592–615. Springer, 2008. ECOOP distinguished paper award.
- Mircea Lungu, Michele Lanza, Tudor Gîrba, and Reinout Heeck. Reverse engineering super-repositories. In *Proceedings of WCRE 2007 (14th Working Conference on Reverse Engineering)*, pages 120–129, Los Alamitos CA, 2007. IEEE Computer Society Press.
- Stefan Reichhart, Tudor Gîrba, and Stéphane Ducasse. Rule-based assessment of test quality. In *Journal of Object Technology, Special Issue. Proceedings of TOOLS Europe 2007*, volume 6/9, pages 231–251, October 2007. Special Issue. Proceedings of TOOLS Europe 2007.
- Lukas Renggli and Oscar Nierstrasz. Transactional memory for Smalltalk. In *Proceedings of the 2007 International Conference on Dynamic Languages (ICDL 2007)*, pages 207–221. ACM Digital Library, 2007.
- David Röthlisberger, Orla Greevy, and Oscar Nierstrasz. Feature driven browsing. In *Proceedings of the 2007 International Conference on Dynamic Languages (ICDL 2007)*, pages 79–100. ACM Digital Library, 2007.
- David Röthlisberger, Orla Greevy, and Oscar Nierstrasz. Exploiting runtime information in the ide. In *Proceedings of the 16th International Conference on Program Comprehension (ICPC 2008)*, volume 0, pages 63–72, Los Alamitos, CA, USA, 2008. IEEE Computer Society.

- Rajesh Vasa, Jean-Guy Schneider, and Oscar Nierstrasz. The inevitable stability of software change. In *Proceedings of 23rd IEEE International Conference on Software Maintenance (ICSM '07)*, pages 4–13, Los Alamitos CA, 2007. IEEE Computer Society.
- Rajesh Vasa, Jean-Guy Schneider, Oscar Nierstrasz, and Clint Woodward. On the resilience of classes to change. In Tom Mens, Maja D'Hondt, and Kim Mens, editors, *Proceedings of 3d International ERCIM Symposium on Software Evolution (Software Evolution 2007)*, volume 8. Electronic Communications of the EASST, 2008.
- Mathieu Verbaere, Michael W. Godfrey, and Tudor Gîrba. Query technologies and applications for program comprehension. In *Proceedings of International Conference on Program Comprehension (ICPC 2008)*, pages 285–288, 2008.
- Martin von Löwis, Marcus Denker, and Oscar Nierstrasz. Context-oriented programming: Beyond layers. In *Proceedings of the 2007 International Conference on Dynamic Languages (ICDL 2007)*, pages 143–156. ACM Digital Library, 2007.

Technical Reports

- Oscar Nierstrasz, Marcus Denker, Tudor Gîrba, Adrian Kuhn, Adrian Lienhard, and David Röthlisberger. Self-aware, evolving eternal systems. Technical Report IAM-08-001, University of Bern, Institute of Applied Mathematics and Computer Sciences, 2008.

Workshop Papers

- Marcus Denker, Orla Greevy, and Oscar Nierstrasz. Supporting feature analysis with runtime annotations. In *Proceedings of the 3rd International Workshop on Program Comprehension through Dynamic Analysis (PCODA 2007)*, pages 29–33. Technische Universiteit Delft, 2007.
- Mariangiola Dezani-Ciancaglini, Paola Giannini, and Oscar Nierstrasz. A calculus of evolving objects. In *Proceedings of the 6th International Workshop on Multiparadigm Programming with Object-Oriented Languages (MPOOL 2008)*, 2008.

- Tudor Gîrba, Stéphane Ducasse, Adrian Kuhn, Radu Marinescu, and Daniel Rațiu. Using concept analysis to detect co-change patterns. In *Proceedings of International Workshop on Principles of Software Evolution (IWPSE 2007)*, pages 83–89. ACM Press, 2007.
- Michael Haupt, Robert Hirschfeld, and Marcus Denker. Type feedback for bytecode interpreters. In *Proceedings of the Second Workshop on Implementation, Compilation, Optimization of Object-Oriented Languages, Programs and Systems (ICOOOLPS'2007)*, pages 17–22. TU Berlin, July 2007.
- Adrian Kuhn. Collective behavior. In *Proceedings of 3rd ECOOP Workshop on Dynamic Languages and Applications (DYLA 2007)*, August 2007.
- Adrian Lienhard, Tudor Gîrba, Orla Greevy, and Oscar Nierstrasz. Exposing side effects in execution traces. In Andy Zaidman, Abdelwahab Hamou-Lhadj, and Orla Greevy, editors, *Proceedings of the 3rd International Workshop on Program Comprehension through Dynamic Analysis (PCODA'07)*, pages 11–17. Technische Universiteit Delft, 2007.
- Mircea Lungu and Tudor Gîrba. A small observatory for super-repositories. In *Proceedings of International Workshop on Principles of Software Evolution (IWPSE 2007)*, pages 106–109. ACM Press, 2007.
- David Röthlisberger. Querying runtime information in the IDE. In *Proceedings of the 2008 workshop on Query Technologies and Applications for Program Comprehension (QTAPC 2008)*, 2008.

Miscellaneous

- Adrian Kuhn. Rbcrawler — a visual navigation system for Smalltalk's Refactoring Browser. European Smalltalk User Group Innovation Technology Award, August 2007.
- Mircea Lungu, Michele Lanza, and Tudor Gîrba. The small project observatory. European Smalltalk User Group 2007 Technology Innovation Awards, August 2007. It received the 1st prize.

- Lukas Renggli. Pier — the meta-described content management system. European Smalltalk User Group Innovation Technology Award, August 2007. Won the 3rd prize.
- David Röthlisberger. Hermion — exploiting the dynamics of software. European Smalltalk User Group Innovation Technology Award, August 2008.

8 Administration

University:

- H. Bieri: Member of Collegium generale
- T. Braun: Member of the Committee for Computing Services (Kommission für Informatikdienste)
Delegate of the University of Bern at SWITCH Stiftungsrat
- H. Bunke: Member of the Senat
- G. Jäger: Member of the Committee for Qualitätssicherung und Qualitätsentwicklung

Faculty:

- H. Bunke: Faculty Delegate for Mathematics / Computer Science
- T. Braun: Member of Evaluation Commission
- G. Jäger: Member of the Planning Board
Qualitätsbeauftragter

Institute:

- T. Braun: Director of IAM
- H. Bunke: Member of Hauskommission Engehalde
- G. Jäger: Director of Studies
- O. Nierstrasz: Deputy Director of IAM
- T. Strahm: Member of Library Committee Exakte Wissenschaften
Member of Hauskommission Exakte Wissenschaften