RWTH Aachen

Department of Computer Science
Technical Report

An Offensive Approach to Teaching Information Security: "Aachen Summer School Applied IT Security"

Maximillian Dornseif and Felix C. Gärtner and Thorsten Holz and Martin Mink

ISSN 0935–3232 · Aachener Informatik Berichte · AIB-2005-02

RWTH Aachen · Department of Computer Science · January 2005

The publications of the Department of Computer Science of *RWTH Aachen University* are in general accessible through the World Wide Web.

`http://aib.informatik.rwth-aachen.de/`

An Offensive Approach to Teaching Information Security: "Aachen Summer School Applied IT Security"

Maximillian Dornseif and Felix C. Gärtner and Thorsten Holz* and Martin Mink

Laboratory for Dependable Distributed Systems
RWTH Aachen University, Department of Computer Science
52056 Aachen, Germany
Email: {dornseif, gaertner, holz, mink}@i4.informatik.rwth-aachen.de

Abstract. There is a general consensus that courses on data security at university degree level should be research-oriented and teach fundamentals of the field, i.e., items of long-term knowledge in contrast to technology-oriented system knowledge. Unfortunately, this consensus often results in courses that are either too theoretical or are outdated with respect to current developments in security technology. To understand the importance of information security, students should have the possibility to gain practical experience how security systems fail, using offensive techniques.
In this article, we give an overview over a three-week intensive course on applied computer security we held at RWTH Aachen university. It brought together students from various countries and with different previous knowledge. We describe in detail the course outline, course contents and the lessons learned.

1 Introduction

The ACM Curricula Recommendations [ACM] have had profound influences on academic computer science curricula in use at educational institutions throughout the world. These recommendations also mention the term *Security* as a part of academic education but unfortunately do not specify in what way this topic should be taught. Reviewing the standard courses in IT security given at major US and European universities, we observe that the courses focus on either theoretical aspects of information security (e.g. encryption) or defensive approaches like intrusion detection systems and firewalls. In our view, this leaves computer science graduates ill-prepared for their professional career because they lack both hands-on knowledge on how to deal with security technology or they always trail active adversaries in their efforts to master them.

In summer term 2004 the Laboratory for Dependable Distributed Systems at RWTH Aachen University offered a novel course in the area of information security: The Summer School "Applied IT security" gave graduate and Ph.D. students a deep understanding of issues in computer security. The distinguishing feature of this course was its "offensive" approach. Offensive can mean two things: it either refers to items which are "designed for attack" or items which "give painful or unpleasant sensations" [Lon95]. The first meaning is the primary one for this course and often implies the second: We took an approach with explicit

* Work by Thorsten Holz was supported by the Deutsche Forschungsgemeinschaft (DFG) as part of the Graduiertenkolleg "Software for mobile communication systems"

intentions of attacking systems. This approach, also advocated for example by Arce and McGraw [AM04], is uncommon for an academic curriculum, in which theoretical foundations are often preferred over practical aspects. But due to the fast development in the area of information technology and especially information security, we think that it is of eminent importance to train future computer science professionals in the ways of thinking of their adversaries. Furthermore, we aim at bringing a solid foundation to research in this area and contribute some ideas to enhance the field and the associated curriculum.

During the three week period, we gave the students the possibility to learn on the one hand theoretical basics and on the other hand practical implications of security problems. We focused on offensive techniques and procedures, e.g. we gave lectures on exploitation of programming errors, wireless (in)securities, and sniffing and spoofing. In this paper, we give an overview over the course and present in detail the lectures and exercises we offered. This may inspire others and leads to a tighter integration of security in university curricula.

Some words on "hacker" courses: Our method of teaching information security is an aggressive one. We teach students how to find "interesting" systems, how to exploit systems, how to hide traces, and more. This seems to offer the students knowledge which they can abuse later for malicious purposes. But we think the opposite is true: One has to understand how an attacker proceeds in order to develop new methods for defense. To quote White and Nordstrom [WN98], who taught a similar course at the United States Air Force Academy in 1998:

> There are scores of hackers operating throughout the Internet today. We believe that hiding their techniques from our students only leads to a generation of system administrators who are "sitting ducks" for the hackers that are out there. We use a knowledge of security holes to teach our students what must be done in order to secure their own systems.

Furthermore, our selection process (based on prior experience, expected willingness to work hard, and interest in scientific work) aimed to ensure that participants were in a position of being able to judge their actions and apply their knowledge in a responsible way.

The rest of this paper is structured as follows: Section 2 describes related projects in the area of teaching information security. Section 3 describes the concept and organization of the Summer School, whereas Section 4 presents the lectures and exercises in detail. In Section 5 we analyze the lessons we learned during the Summer School. Finally, we conclude our work and experience in Section 6.

2 Related Projects

Although we are not aware of any efforts along the lines of the Summer School, several other projects pioneered some teaching concepts we used in the Summer School.

There have been some good attempts to incorporate practical elements of information security into university degree courses. The computer science department of Darmstadt University of Technology, Germany, regularly runs a so-called

Hacker Contest for several years [SMR00]. The Hacker Contest is a lab course in which students form teams that have to set up systems and then use common exploitation techniques to attack the systems of the other teams. The attendees also have to analyze attacks against their own systems and increasingly deploy stronger defense measures. The University of Magdeburg, Germany, also offers a similar lab course and has joined efforts with Darmstadt in that students from Darmstadt perform penetration tests of systems deployed in Magdeburg and vice versa.

There are some universities that offer courses in which the students learn the underlying concepts of offensive IT security and can also apply their knowledge. As an example, the Distributed Systems Group of the Technical University of Vienna offers courses on Internet security: Practical aspects of IT security like race conditions, viruses and reverse engineering are covered and exercises in which the students have to implement the attacks must be solved. In the military education, one can find similar examples of offensive lectures, for example [WN98].

Several projects have pioneered the use of offensive techniques as teaching concepts, but none of them has treated offensive techniques in a research-oriented way, as it is done in the Summer School. So called *Wargames* and *Capture the Flag* (*CTF*) contests have a long tradition among security enthusiasts. In Wargames, the organizer creates a set of challenging scenarios of increasing difficulty which have to be solved by the participants. Challenges usually are modeled somewhat after the problems an attacker faces when attempting a system penetration. Typical Wargames can be found at [Dig,Hac]. Slightly more competitive than Wargames are CTF or so called *Deathmatch* contests where teams compete against each other over the control of a network. Most famous are probably the annual *Root-Fu* contest [Ghe] and the CTF contest of the UCSB, in which several educational institutions spread across the United States battle against each other [Vig03,UCS].

The Information Technology and Operations Center (ITOC) at the U.S. Military Academy West Point has a curriculum which also teaches offensive information security techniques. ITOC also organizes a yearly *Cyber Defense Exercise* which has similarities to the Capture the Flag contests. U.S. authorities with an information security education branch like the United States Military Academy, the United States Air Force Academy, and the Naval Postgraduate School, participate in these exercises. Machines maintained by the participants are attacked by the NSA 92nd Aggressor Squadron – Land Information Warfare Activity over the course of several days and participants have to counter these attacks [DRR03,SJ98].

3 Concept and Organization

3.1 Goals

At university degree level, it is a rule of good academic practice to teach long-term methodological knowledge instead of short-term system knowledge. In the area of information security, this has resulted in university curricula which either tend towards theoretical topics (like cryptographic protocols or formal modeling of security) or towards practical topics highlighting defensive strategies (e.g., access

control techniques, firewalls and VPNs). Information security, however, is a field which is rapidly changing. The new developments like the security threats in Web-based systems (e.g., cross-site scripting) or the dangers of so-called botnets are often neglected because professors tend to cherish their own specialized and theoretical research areas in their courses. This leaves university graduates with only faint ideas of the security threats they will face in their professional career. Moreover, a typical computer science graduate, even if she has specialized in information security, usually has very little practical experience with the way *real* systems react in the presence of malice. With the Summer School not only future researchers, but especially future software designers or project managers should experience how hardware and software fails and learn how to improve things. So we wanted to give them an impression how easily things can break.

We wanted to give the students the possibility to learn offensive techniques in information security, but also treat this topic in a research-oriented way. In addition, we want to create a network in the community of researchers interested in offensive information security techniques.

Another goal was to get participants of different skill levels to cooperate and thus foster knowledge transfer. We especially wanted to have more experienced researchers like Ph.D. students to team up with less experienced students. We hoped that this would help to introduce students to the scientific approach and possibly interest them in information security as a science.

3.2 Implementation

The staff organizing the Summer School consisted of two research assistants of the Laboratory and two students of whom one is a research student of the laboratory and the other a regular student at another university. While the three organizers from our university could – at least partly – do their preparation during their regular paid working hours, the forth organizer had to do all of his contributions in his spare time.

The intended audience were students and young scientists from Europe with a profound interest not only in information security but also in offensive techniques in relation to security. We also expected a high level degree of technical skills: Participants were expected to work hard during the Summer School and to use a wide array of tools and techniques during the lab sessions.

Since these traits could not be checked like simple requirements in an application form, we decided to use some kind of scare tactics to deter less determined students and give others the opportunity to show creativity. For example, we requested a list of publications in the application form. While some participants could offer a long list of scientific publications, we were more interested in the approach used by others. So some applicants put advisories or even newsgroup postings in their applications – we generally preferred that over "None".

We did only low profile advertisement for the Summer School. Besides announcing it during the lectures given by the members of the laboratory and at our webpage, we mentioned it to friends and colleagues. In addition, we did an announcement on a mailing-list dedicated to penetration testing. Since this already resulted in more than 50 applications, we refrained from doing further advertisement.

We selected 16 students on the base of prior experience, expected willingness to work hard, and interest in scientific work. Of those 16 students selected, one was from Turkey, one from The Netherlands, four from Great Britain (three of them members of Professor Ross Anderson's security group), and 10 from Germany (Aachen, Berlin, Cologne and Gelsenkirchen). Unfortunately, two of the selected students informed us only a short time before the beginning of the Summer School that they would be unable to attend. So the final number of participants was fourteen.

The Summer School took partially place in the lecture halls of our university, which were unused during the summer break. Additionally we provided a room for the lab sessions where the students could use their own laptop computers and which held a lot of obscure hardware and complex network infrastructure to experiment with.

To foster informal communication between students, we converted an office to a coffee hall with sofas, an overall relaxed ambiance, and a choice of snacks and refreshments. Finally, there was a plain room for temporary use by students which had the feeling they need concentration for specific tasks. The housing was left to the students themselves and their choices showed a very wide variety of solutions ranging from the universities' guest-house to the local camping ground.

The schedule during the Summer School was demanding: Lectures started at a quarter to nine in the morning and covered two topics until noon. After lunch, the lab session started, during which students applied the techniques learned in the lectures and developed them further. While some of the lab sessions took a very guided approach asking students to solve specific tasks, others were more general up to the point where students were just asked to apply the knowledge gathered in the morning. For an outline of the Summer School see table 3.2.

The lab session was interrupted by a so called "coffee table talk": We invited external contributors to give a short statement related to a topic of their interest or a short introduction one some project they work on. The coffee table talks were intended to broaden the view of the participants. We aimed at showing the students problems being worked on in the real world and to teach them looking at problems not only from the security perspective. Speakers were sent by corporations ranging from Microsoft and Pixelpark up to German Postbank and the TÜV Rheinland. But we had also participants from other groups like the Chaos Computer Club (CCC) or the "Verein digitale Kultur", which covers artistic expression via digital means, and various academic research groups. Topics covered in the coffee table talk ranged from computer-ethics, civil liberties in relation to the Internet, phishing attacks from a banks perspective, up to highly technical subjects like attacks on memory management and XML security.

A typical day ended with a meeting: usually around six in the evening everybody presented his work of the day. But students often stayed through large parts of the night to develop their projects further.

4 Running the School

4.1 First week

On the first day (September 20) we started with a brief overview over the whole Summer School and gave the people the possibility to introduce themselves. We

Day	Lecture 1	Lecture 2	Lab
	8:45-10:15	10:45 - 12:15	at least until 18:30
Week 1			
1	Introduction	Hardware Security	Hardware / Wargames
2	Web Applications	Web Applications	Web Applications
3	Buffer Overflows	Other Programming Errors	Exploiting Overflows
4	Advanced Exploitation	Networking	Network Programming
5	Sniffing: Layer 1 & 2	Spoofing, DoS & DDoS	Sniffing & Spoofing
Week 2			
1	Network Topology	Application Fingerprinting	Network mapping
2	Bluetooth	Wireless Attacks	Wardriving
3	Hidden Data	Honeynets	Wardriving
4	Introspection	Projects	Projects
5	Projects	Projects	Projects
Week 3			
1	Misc. Forensics	Disk Forensics	Forensics
2	Disk Forensics	Disk Forensics	Forensics
3	Malware Unix	Unix infection	Honeynets
4	Excursion	Excursion	Excursion
5	Wargame	Wargame	Wargame

Fig. 1. Schedule of the Summer School

tried to give them an insight into our expectations for the upcoming three weeks and also wanted to know their wishes. After this introductory lecture the first "real" lecture took place: "Hardware Hacking" was the topic and the students got an insight into limitations and vulnerabilities of hardware devices. During the lab session, the students opened some devices (e.g. cable modems, router, switches) to inspect the insides. They also played some wargames like `www.hackthispage.tk` and averaged at about five levels.

The topic of the second day was "Attacks Against Web Applications": One lecture concentrated on general problems in web applications (e.g. SQL injection and cross site scripting), while the other had the special focus on programming errors on web-applications written in PHP, a scripting language that is quite popular among developers. The corresponding lab session had no very tight focus. The students should find bugs in real web applications. They did not like this exercise, probably they were missing some guidelines. During the afternoon George Danezis, one of the participants and research assistant from the university of Cambridge, gave a talk on "Anonymous Communication".

On Wednesday, the lectures concentrated on buffer overflows and other programming errors. This is a very broad topic and probably two lectures are not enough to cover the whole field. Therefore, these two lectures concentrated on the basics and two other coffee table talks deepened the knowledge of the participants. The lecture "Buffer Overflows" gave an overview of some techniques to exploit buffer overflows and the second lecture concentrated on other common programming errors. The lab session was quite popular at this day: The students should exploit various programs and they apparently had much fun doing this. For many people, this was their first exploit and they were quite proud to be able to write one. One student also found some bugs in real applications (e.g. a format-string vulnerability in Tor, an anonymizing overlay network for TCP) and further examined them. In cooperation with the authors of the software,

these holes were fixed. “Phishing” was the topic of the coffee table talk and an IT-security specialist of a large German bank explained the threat.

“Advanced / Automatic Exploitation” was the topic of the first lecture on Thursday. This talk dealt with some tools that aggressors can use for attacks, e.g. the Metasploit Framework, search engines like Google to collect information, etc. In addition, the art of fuzzing, a technique to find errors in a given program in a semi-automated fashion, was presented. The second lecture repeated necessary knowledge on communication networks and gave an introduction to network programming and the important libraries (e.g. libnet, libpcap). Implementation of covert channels, ARP-spoofing and various other tools were the focuses of the lab session. The students could choose which technique they wanted to implement and it worked out well. Jens Ohlig from the Chaos Computer Club gave a historical overview about political activism and hackers during the coffee table talk.

On Friday, sniffing & spoofing and (distributed) denial-of-service (DDoS) attacks were covered. The lectures gave an overview of tools and techniques used to sniff passwords and other sensitive information on networks. The lectures also explained how to spoof packets in order to receive interesting packets and gave a background on (distributed) denial-of-service attacks. During the lab session, the student experimented with the available tools and also implemented some small programs for ARP-spoofing and similar techniques. Many attendees were surprised how easy it is to sniff passwords even in switched networks and got an insight in why encryption should be used whenever possible. The coffee-table talk entitled “XML Security” was given by Christian Geuer-Pollman from the European Microsoft Innovation Center (EMIC), Aachen.

4.2 Second week

The next week started with a lecture on network reconnaissance. This lecture covered techniques to find useful information about targets and first steps of an attacker after a successful compromise. It also introduced some common fingerprinting techniques for OSI layers 2-4. The second lecture focused on further steps after an intrusion and covered application fingerprinting in depth. During the lab session, we tested something new: We gave the not that dedicated students a mandatory exercise. They should parse the data structures of some fingerprinting tools and use these in self-written applications. The students did not like this exercise, they were forced to do something boring and somehow lost the motivation. This was the only day we had a mandatory exercise. Beside this, the students were encouraged to do portscans of the network of our university. The center for computing and communication explicitly allowed us to do this and we found some security holes during these tests: One student found several routers with default passwords and another tracked down some printers that could be managed remotely via a web-interface. In cooperation with the responsible persons from the center for computing and communication these security holes are now fixed. Penetration-testing for phone-systems was the topic of the coffee-table talk on this day. Rolf von Stein from TÜV Secure IT explained the motivation behind this and gave some background information.

Wireless Security was the focus on Tuesday: The first lecture with the title “Bluetooth Security” introduced the attendees to the basics of the Bluetooth

standard and pointed out some attacks. The focus of the second lecture was on WLAN (mainly 802.11b) and also a small introduction to RFID and its concerns was given. During the afternoon, the students were able to gain experience in so called "wardriving", the challenge of finding wireless LANs. They drove through the city and found more than 100 wireless LANs in total. The collected data were handed over to researchers at our university who are involved with wireless networks for further analysis. The question "Where is information security today and what in the future?" was answered during the coffee-table talk by Dogan Kesdogan, a research member of the Chair of Computer Science 4 from RWTH Aachen University.

On Wednesday we demonstrated some of the current research topics of the Laboratory for Dependable Systems: The first lecture covered "Hidden Data In Documents" and explained that there are many interesting data in proprietary formats that can be misused. The second lecture gave an introduction to honeynets and related security research. It also covered an attack on the monitoring software commonly used on honeypots – a result of the honeynet research at our laboratory. Like the day before, interested students had the possibility to search for wireless LANs in the city. Some participants stayed at the lab and developed their projects further. One project was especially interesting: One attendee wrote a crawler which automatically searches for images with an included thumbnail in the Exif header. At the end of the Summer School, he had downloaded about 3.000.000 images, from which about one percent had a significant difference between the image and the included thumbnail. This showed that a significant amount of images has interesting data hidden inside the document itself. At this day, one of the students prepared the coffee-table talks: Ilja van Sprundel filled with his talk on heap-based overflows a gap that was left by the lectures on programming errors.

The rest of the week gave the students the possibility to do some research on their own and implement novel techniques. To prepare this, we collected ideas for further research on Thursday morning. From Thursday noon until Friday evening, the participants had time to implement their projects. The resulting projects covered tools for covert channels and fingerprinting applications. Furthermore, a fuzzing framework and low level network libraries were implemented and an embedded device was introspected. The coffee-table talk on Friday gave an insight into the relation between project management and security. Rainer Lingmann from Pixelpark gave a talk entitled "IT-Security: Das Gretchenprojekt aus Projektmanagment Sicht".

4.3 Third week

The last week started with two lectures about computer forensics. These lectures covered the basic of disc forensics and gave an introduction on computer forensics in general. During the lab session the students had to solve a game: We gave them a Compact Flash card which we pretended to have retrieved from a suspected terrorist. They had the task to reconstruct the corrupted files and retrieve as much information as possible, especially the place and time for the next "terrorist meeting". The attendees had much fun with this challenging exercise and many were able to recover the damaged files. The second task for this afternoon was forensic imaging of used hard discs that we had previously bought at

ebay. With this exercise we wanted to verify some results which were published by Garfinkel and Shelat in [GS03]. The students found some hard discs which contained information that is both confidential and recoverable: One disc was obviously the former hard disc of a cashier terminal or cashier computer because we found bills and accounting information on it. Another hard disc was used in a bookstore before and contained many hundreds of e-mails with partially sensitive information. And a third hard disc was obviously used in a mailbox and the students were able to reconstruct the user database. How to realize "Software Detection of Currency" was presented by Steven Murdoch, a participant of the Summer School and Ph.D. student from Cambridge. He presented ongoing research he is currently doing in the security group at his university [Mur04].

An external guest gave two lectures on Tuesday: Knut Eckstein from the NATO C3 Agency talked about "Advanced Filesystem Forensics – Journaling Filesystems". More forensics of disk images was the topic of the lab session. This was too much forensics, and the students got bored. During the coffee table talk, a member from the Chaos Computer Club Cologne presented *grsecurity*, a suite of patches for the Linux kernel that are an attempt to improve the security of a Linux system.

The lectures on Wednesday concentrated on malware for Linux. The first talk gave a general introduction to the topic and presented rootkits and backdoors. In contrast to that, the second lecture concentrated on code infection for ELF binaries. During the lab session, the students deepend the knowledge gained during the lectures and some wrote ELF modification code. One of the students provided a small challenge for the lab session: Lisa Thalheim prepared an ELF binary and posed some questions. These tasks were demanding for the students, but most of them were able to solve them. Interestingly, at least three different approaches were used and this again showed the creative nature of the participants. In addition, the coffee table talk was prepared by Ilja van Sprundel. He talked about format-string attacks and filled another gap that was not covered during the lectures on exploitation of programming errors.

An excursion to some abandoned industrial sites was arranged for Thursday. We wanted to have an alternation to the usual schedule and therefore organized a trip to a coking plant in Essen, a gasholder in Oberhausen and some geocaching locations in Wuppertal. The main goal for this tour was fun and getting to know each other better.

We used the last day of the Summer School to get feedback on the three weeks, we will present these results in the next section. The highlight of this day was the Wargame with several levels and increasing difficulty, which Christian N. Klein had prepared beforehand. It offered the students the possibility to apply all techniques they had learned in the previous days. Fun prevailed during this game, with some minor exceptions due to missing tools. We noticed that it is very hard to get the difficulty of the levels right, we had to tweak some levels while the game was running.

4.4 After the Summer School

After the three weeks, some further noteworthy things happened. The participants of the Summer School had submitted six talks to the Chaos Communication Congress, an annual meeting of hackers organized by the Chaos Computer Club.

All six submission were accepted for presentation. The participants of the Summer School also agreed to meet at the Congress again. Furthermore, the students created an "alumni" mailinglist to stay in contact with each other and exchange further ideas. They use the mailinglist on a regular basis now.

During the lab session we found several vulnerabilities and flaws. All of these weak points were reported to the authors of the software or the operators of the systems. In cooperation with these persons, the holes were fixed.

5 Lessons Learned

It turned out during the course of the Summer School that people had extremely different skill levels, but this is difficult to asses ex ante. Nonetheless cooperation between the differently skilled people worked well. Everybody explained concepts they knew about to each other and exchanged new ideas. So one of the goals – to foster knowledge transfer – was achieved. We hope that this introduced some students to the scientific approach of information security.

While the lab sessions with less guidance lead to some very impressive results, especially the less experienced students felt that they had a better learning experience in the lab sessions with more instructions. On the other hand, when during one lab session we had given a concrete and mandatory task, people felt bored and didn't like doing it. So we refrained from repeating that.

The biggest lesson we learned: Practical aspects of security and exploitation of real systems are fun for students. When the students exploited their first buffer overflow, they were very enthusiastic and worked hard to learn more. Especially the Ph.D.-students liked the knowledge about insecurities.

At the end of the Summer School participants were asked to fill out a questionnaire to give use some pointers for improvements. In summary, the feedback was mostly positive. The main criticisms were:

- Three weeks are too long, especially if the students have to work so hard and spend so much time at the courses as they did.
- Some lectures need improvements, on one hand the depth of the talks and on the other hand the understandability.

Even so they rated the Summer School as as good a concept, that they asked for a sequel.

All in all the event was a huge success but also an immense drainage on everybody's power. With more personal resources we would have had more opportunities to better prepare. Especially some of the lab sessions would have profited from a better preparation.

6 Conclusions

The Summer School was a successful experiment in approaching offensive techniques in information security from an academic angle. All three primary goals where archived: We managed to give hands-on experience in offensive techniques to participant who until then had only theoretical knowledge of threats and risks. We fostered academic research on offensive techniques – several papers are being

written by participants as a result of the Summer School and the collaborative research from the Summer School led already to five successful conference submissions in October. Finally, the Summer School succeeded in promoting networking in the community of researchers interested in offensive information security techniques.

Also our secondary goal of getting undergraduate students to work close together with more experienced researchers to induct a knowledge transfer in scientific methodology worked to a certain extent. Although teams formed mostly among participants with the same level of experience, the more experienced teams acted as a role model for the others. But since we had extreme diversity in our participants – from the research assistant with Ph.D. in Cambridge to second semester students from our university and from very experienced penetration-testers to researchers which had attacked security up to then mainly from a theoretical point of view – there was still a great amount of informal knowledge transfer happening at the Summer School.

The concept of lectures in the morning followed by immediate application of the techniques learned and the challenge to further develop these techniques in the lab sessions in the afternoon was a success although it was universally acknowledged by participants and staff that there needs to be more time available in the lab sessions.

The concept of the coffee-table talks worked as we hoped: most of the talks where an inspiration for attendees and often laid the basis for prolonged discussion among participants. Also, most of the invited speakers enjoyed their visit and meeting the participants of the Summer School a lot.

But also we had to learn that three weeks of Summer School with a tight schedule put a considerable strain on both the staff and the students. In the third week we had to slow down the pace considerable. It also turned out that fulfilling other duties in the last preparation phase and during the Summer School itself puts high pressure on staff. Future events like the Summer School should be limited to two weeks and it should be ensured that the staff can dedicate its full time to the effort.

In conclusion, the concept of the Summer School was very sound and it's already planned to repeat that event in 2005.

Acknowledgement We owe many thanks to Christian N. Klein for helping before and during the Summer School.

Furthermore, we wish to thank the responsible people from the universities' computing center, the secretaries and all participants and guests of the Summer School.

References

[ACM] ACM. Homepage "'acm curricula recommendations"'. `http://www.acm.org/education/curricula.html`. Accessed 2004-10-15.

[AM04] Iváan Arce and Gary McGraw. Guest Editors' introduction: Why attacking systems is a good idea. *IEEE Security & Privacy*, 2(4):17–19, July/August 2004.

[Dig] Digital Evolution. Homepage "'digital evolution"'. `http://www.dievo.org/`. Accessed 2004-10-15.

[DRR03] R. Dodge, D. J. Ragsdale, and C. Reynolds. Organization and training of a cyber security team. In *Proceedings of the 2003 IEEE International Conference on Systems, Man & Cybernetics*, 2003.

[Ghe] Ghetto Hackers. Homepage "'root-fu"'. `http://www.ghettohackers.net/rootfu/`. Accessed 2004-10-15.

[GS03] Simson L. Garfinkel and Abhi Shelat. Remembrance of data passed: A study of disk sanitization practices. *IEEE Security & Privacy*, 1(1), 2003.

[Hac] Hack this page. Homepage "'hack this page"'. `http://www.hackthispage.tk/`. Accessed 2004-10-15.

[Lon95] *Longman Dictionary of Contemporary English.* Longman, Harlow, Essex, UK, third edition, 1995.

[Mur04] Steven J. Murdoch. Software detection of currency. In *6th Information Hiding Workshop, Toronto*, 2004.

[SJ98] W.J. Schepens and J. James. Architecture of a cyber defense competition. In *Proceedings of the 2003 IEEE International Conference on Systems, Man & Cybernetics*, 1998.

[SMR00] Markus Schumacher, Marie-Luise Moschgath, and Utz Roedig. Angewandte Informationssicherheit: Ein Hacker-Praktikum an Universit"aten. *Informatik Spektrum*, 6(23), June 2000.

[UCS] UCSB. Homepage "'ucsb capture the flag"'. `http://www.cs.ucsb.edu/~vigna/CTF/`. Accessed 2004-11-05.

[Vig03] Giovanni Vigna. Teaching network security through live exercises. In Cynthia E. Irvine and Helen L. Armstrong, editors, *World Conference on Information Security Education*, volume 253 of *IFIP Conference Proceedings*, pages 3–18. Kluwer, 2003.

[WN98] Gregory White and Gregory Nordstrom. Security across the curriculum: using computer security to teach computer science principles. In *Proceedings of the 19th International Information Systems Security Conference*, pages 519–525, 1998.

Aachener Informatik-Berichte

This is a list of recent technical reports. To obtain copies of technical reports please consult `http://aib.informatik.rwth-aachen.de/` or send your request to: Informatik-Bibliothek, RWTH Aachen, Ahornstr. 55, 52056 Aachen, Email: `biblio@informatik.rwth-aachen.de`

1987-01 * Fachgruppe Informatik: Jahresbericht 1986

1987-02 * David de Frutos Escrig, Klaus Indermark: Equivalence Relations of Non-Deterministic Ianov-Schemes

1987-03 * Manfred Nagl: A Software Development Environment based on Graph Technology

1987-04 * Claus Lewerentz, Manfred Nagl, Bernhard Westfechtel: On Integration Mechanisms within a Graph-Based Software Development Environment

1987-05 * Reinhard Rinn: Über Eingabeanomalien bei verschiedenen Inferenzmodellen

1987-06 * Werner Damm, Gert Döhmen: Specifying Distributed Computer Architectures in AADL*

1987-07 * Gregor Engels, Claus Lewerentz, Wilhelm Schäfer: Graph Grammar Engineering: A Software Specification Method

1987-08 * Manfred Nagl: Set Theoretic Approaches to Graph Grammars

1987-09 * Claus Lewerentz, Andreas Schürr: Experiences with a Database System for Software Documents

1987-10 * Herbert Klaeren, Klaus Indermark: A New Implementation Technique for Recursive Function Definitions

1987-11 * Rita Loogen: Design of a Parallel Programmable Graph Reduction Machine with Distributed Memory

1987-12 J. Börstler, U. Möncke, R. Wilhelm: Table compression for tree automata

1988-01 * Gabriele Esser, Johannes Rückert, Frank Wagner: Gesellschaftliche Aspekte der Informatik

1988-02 * Peter Martini, Otto Spaniol: Token-Passing in High-Speed Backbone Networks for Campus-Wide Environments

1988-03 * Thomas Welzel: Simulation of a Multiple Token Ring Backbone

1988-04 * Peter Martini: Performance Comparison for HSLAN Media Access Protocols

1988-05 * Peter Martini: Performance Analysis of Multiple Token Rings

1988-06 * Andreas Mann, Johannes Rückert, Otto Spaniol: Datenfunknetze

1988-07 * Andreas Mann, Johannes Rückert: Packet Radio Networks for Data Exchange

1988-08 * Andreas Mann, Johannes Rückert: Concurrent Slot Assignment Protocol for Packet Radio Networks

1988-09 * W. Kremer, F. Reichert, J. Rückert, A. Mann: Entwurf einer Netzwerktopologie für ein Mobilfunknetz zur Unterstützung des öffentlichen Straßenverkehrs

1988-10 * Kai Jakobs: Towards User-Friendly Networking

1988-11 * Kai Jakobs: The Directory - Evolution of a Standard

1988-12 * Kai Jakobs: Directory Services in Distributed Systems - A Survey

1988-13 * Martine Schümmer: RS-511, a Protocol for the Plant Floor

1988-14 * U. Quernheim: Satellite Communication Protocols - A Performance Comparison Considering On-Board Processing

1988-15 * Peter Martini, Otto Spaniol, Thomas Welzel: File Transfer in High Speed Token Ring Networks: Performance Evaluation by Approximate Analysis and Simulation

1988-16 * Fachgruppe Informatik: Jahresbericht 1987

1988-17 * Wolfgang Thomas: Automata on Infinite Objects

1988-18 * Michael Sonnenschein: On Petri Nets and Data Flow Graphs

1988-19 * Heiko Vogler: Functional Distribution of the Contextual Analysis in Block-Structured Programming Languages: A Case Study of Tree Transducers

1988-20 * Thomas Welzel: Einsatz des Simulationswerkzeuges QNAP2 zur Leistungsbewertung von Kommunikationsprotokollen

1988-21 * Th. Janning, C. Lewerentz: Integrated Project Team Management in a Software Development Environment

1988-22 * Joost Engelfriet, Heiko Vogler: Modular Tree Transducers

1988-23 * Wolfgang Thomas: Automata and Quantifier Hierarchies

1988-24 * Uschi Heuter: Generalized Definite Tree Languages

1989-01 * Fachgruppe Informatik: Jahresbericht 1988

1989-02 * G. Esser, J. Rückert, F. Wagner (Hrsg.): Gesellschaftliche Aspekte der Informatik

1989-03 * Heiko Vogler: Bottom-Up Computation of Primitive Recursive Tree Functions

1989-04 * Andy Schürr: Introduction to PROGRESS, an Attribute Graph Grammar Based Specification Language

1989-05 J. Börstler: Reuse and Software Development - Problems, Solutions, and Bibliography (in German)

1989-06 * Kai Jakobs: OSI - An Appropriate Basis for Group Communication?

1989-07 * Kai Jakobs: ISO's Directory Proposal - Evolution, Current Status and Future Problems

1989-08 * Bernhard Westfechtel: Extension of a Graph Storage for Software Documents with Primitives for Undo/Redo and Revision Control

1989-09 * Peter Martini: High Speed Local Area Networks - A Tutorial

1989-10 * P. Davids, Th. Welzel: Performance Analysis of DQDB Based on Simulation

1989-11 * Manfred Nagl (Ed.): Abstracts of Talks presented at the WG '89 15th International Workshop on Graphtheoretic Concepts in Computer Science

1989-12 * Peter Martini: The DQDB Protocol - Is it Playing the Game?

1989-13 * Martine Schümmer: CNC/DNC Communication with MAP

1989-14 * Martine Schümmer: Local Area Networks for Manufactoring Environments with hard Real-Time Requirements

1989-15 * M. Schümmer, Th. Welzel, P. Martini: Integration of Field Bus and MAP Networks - Hierarchical Communication Systems in Production Environments

1989-16 * G. Vossen, K.-U. Witt: SUXESS: Towards a Sound Unification of Extensions of the Relational Data Model

1989-17 * J. Derissen, P. Hruschka, M.v.d. Beeck, Th. Janning, M. Nagl: Integrating Structured Analysis and Information Modelling

1989-18 A. Maassen: Programming with Higher Order Functions

1989-19 * Mario Rodriguez-Artalejo, Heiko Vogler: A Narrowing Machine for Syntax Directed BABEL

1989-20 H. Kuchen, R. Loogen, J.J. Moreno Navarro, M. Rodriguez Artalejo: Graph-based Implementation of a Functional Logic Language

1990-01 * Fachgruppe Informatik: Jahresbericht 1989

1990-02 * Vera Jansen, Andreas Potthoff, Wolfgang Thomas, Udo Wermuth: A Short Guide to the AMORE System (Computing Automata, MOnoids and Regular Expressions)

1990-03 * Jerzy Skurczynski: On Three Hierarchies of Weak SkS Formulas

1990-04 R. Loogen: Stack-based Implementation of Narrowing

1990-05 H. Kuchen, A. Wagener: Comparison of Dynamic Load Balancing Strategies

1990-06 * Kai Jakobs, Frank Reichert: Directory Services for Mobile Communication

1990-07 * Kai Jakobs: What's Beyond the Interface - OSI Networks to Support Cooperative Work

1990-08 * Kai Jakobs: Directory Names and Schema - An Evaluation

1990-09 * Ulrich Quernheim, Dieter Kreuer: Das CCITT - Signalisierungssystem Nr. 7 auf Satellitenstrecken; Simulation der Zeichengabestrecke

1990-11 H. Kuchen, R. Loogen, J.J. Moreno Navarro, M. Rodriguez Artalejo: Lazy Narrowing in a Graph Machine

1990-12 * Kai Jakobs, Josef Kaltwasser, Frank Reichert, Otto Spaniol: Der Computer fährt mit

1990-13 * Rudolf Mathar, Andreas Mann: Analyzing a Distributed Slot Assignment Protocol by Markov Chains

1990-14 A. Maassen: Compilerentwicklung in Miranda - ein Praktikum in funktionaler Programmierung (written in german)

1990-15 * Manfred Nagl, Andreas Schürr: A Specification Environment for Graph Grammars

1990-16 A. Schürr: PROGRESS: A VHL-Language Based on Graph Grammars

1990-17 * Marita Möller: Ein Ebenenmodell wissensbasierter Konsultationen - Unterstützung für Wissensakquisition und Erklärungsfähigkeit

1990-18 * Eric Kowalewski: Entwurf und Interpretation einer Sprache zur Beschreibung von Konsultationsphasen in Expertensystemen

1990-20 Y. Ortega Mallen, D. de Frutos Escrig: A Complete Proof System for Timed Observations

1990-21 * Manfred Nagl: Modelling of Software Architectures: Importance, Notions, Experiences

1990-22 H. Fassbender, H. Vogler: A Call-by-need Implementation of Syntax Directed Functional Programming

1991-01 Guenther Geiler (ed.), Fachgruppe Informatik: Jahresbericht 1990

1991-03 B. Steffen, A. Ingolfsdottir: Characteristic Formulae for Processes with Divergence

1991-04 M. Portz: A new class of cryptosystems based on interconnection networks

1991-05 H. Kuchen, G. Geiler: Distributed Applicative Arrays

1991-06 * Ludwig Staiger: Kolmogorov Complexity and Hausdorff Dimension

1991-07 * Ludwig Staiger: Syntactic Congruences for w-languages

1991-09 * Eila Kuikka: A Proposal for a Syntax-Directed Text Processing System

1991-10 K. Gladitz, H. Fassbender, H. Vogler: Compiler-based Implementation of Syntax-Directed Functional Programming

1991-11 R. Loogen, St. Winkler: Dynamic Detection of Determinism in Functional Logic Languages

1991-12 * K. Indermark, M. Rodriguez Artalejo (Eds.): Granada Workshop on the Integration of Functional and Logic Programming

1991-13 * Rolf Hager, Wolfgang Kremer: The Adaptive Priority Scheduler: A More Fair Priority Service Discipline

1991-14 * Andreas Fasbender, Wolfgang Kremer: A New Approximation Algorithm for Tandem Networks with Priority Nodes

1991-15 J. Börstler, A. Zündorf: Revisiting extensions to Modula-2 to support reusability

1991-16 J. Börstler, Th. Janning: Bridging the gap between Requirements Analysis and Design

1991-17 A. Zündorf, A. Schürr: Nondeterministic Control Structures for Graph Rewriting Systems

1991-18 * Matthias Jarke, John Mylopoulos, Joachim W. Schmidt, Yannis Vassiliou: DAIDA: An Environment for Evolving Information Systems

1991-19 M. Jeusfeld, M. Jarke: From Relational to Object-Oriented Integrity Simplification

1991-20 G. Hogen, A. Kindler, R. Loogen: Automatic Parallelization of Lazy Functional Programs

1991-21 * Prof. Dr. rer. nat. Otto Spaniol: ODP (Open Distributed Processing): Yet another Viewpoint

1991-22 H. Kuchen, F. Lücking, H. Stoltze: The Topology Description Language TDL

1991-23 S. Graf, B. Steffen: Compositional Minimization of Finite State Systems

1991-24 R. Cleaveland, J. Parrow, B. Steffen: The Concurrency Workbench: A Semantics Based Tool for the Verification of Concurrent Systems

1991-25 * Rudolf Mathar, Jürgen Mattfeldt: Optimal Transmission Ranges for Mobile Communication in Linear Multihop Packet Radio Networks

1991-26 M. Jeusfeld, M. Staudt: Query Optimization in Deductive Object Bases

1991-27 J. Knoop, B. Steffen: The Interprocedural Coincidence Theorem

1991-28 J. Knoop, B. Steffen: Unifying Strength Reduction and Semantic Code Motion

1991-30 T. Margaria: First-Order theories for the verification of complex FSMs

1991-31 B. Steffen: Generating Data Flow Analysis Algorithms from Modal Specifications

1992-01 Stefan Eherer (ed.), Fachgruppe Informatik: Jahresbericht 1991

1992-02 * Bernhard Westfechtel: Basismechanismen zur Datenverwaltung in strukturbezogenen Hypertextsystemen

1992-04 S. A. Smolka, B. Steffen: Priority as Extremal Probability

1992-05 * Matthias Jarke, Carlos Maltzahn, Thomas Rose: Sharing Processes: Team Coordination in Design Repositories

1992-06 O. Burkart, B. Steffen: Model Checking for Context-Free Processes

1992-07 * Matthias Jarke, Klaus Pohl: Information Systems Quality and Quality Information Systems

1992-08 * Rudolf Mathar, Jürgen Mattfeldt: Analyzing Routing Strategy NFP in Multihop Packet Radio Networks on a Line

1992-09 * Alfons Kemper, Guido Moerkotte: Grundlagen objektorientierter Datenbanksysteme

1992-10 Matthias Jarke, Manfred Jeusfeld, Andreas Miethsam, Michael Gocek: Towards a logic-based reconstruction of software configuration management

1992-11 Werner Hans: A Complete Indexing Scheme for WAM-based Abstract Machines

1992-12 W. Hans, R. Loogen, St. Winkler: On the Interaction of Lazy Evaluation and Backtracking

1992-13 * Matthias Jarke, Thomas Rose: Specification Management with CAD

1992-14 Th. Noll, H. Vogler: Top-down Parsing with Simultaneous Evaluation on Noncircular Attribute Grammars

1992-15 A. Schuerr, B. Westfechtel: Graphgrammatiken und Graphersetzungssysteme(written in german)

1992-16 * Graduiertenkolleg Informatik und Technik (Hrsg.): Forschungsprojekte des Graduiertenkollegs Informatik und Technik

1992-17 M. Jarke (ed.): ConceptBase V3.1 User Manual

1992-18 * Clarence A. Ellis, Matthias Jarke (Eds.): Distributed Cooperation in Integrated Information Systems - Proceedings of the Third International Workshop on Intelligent and Cooperative Information Systems

1992-19-00 H. Kuchen, R. Loogen (eds.): Proceedings of the 4th Int. Workshop on the Parallel Implementation of Functional Languages

1992-19-01 G. Hogen, R. Loogen: PASTEL - A Parallel Stack-Based Implementation of Eager Functional Programs with Lazy Data Structures (Extended Abstract)

1992-19-02 H. Kuchen, K. Gladitz: Implementing Bags on a Shared Memory MIMD-Machine

1992-19-03 C. Rathsack, S.B. Scholz: LISA - A Lazy Interpreter for a Full-Fledged Lambda-Calculus

1992-19-04 T.A. Bratvold: Determining Useful Parallelism in Higher Order Functions

1992-19-05 S. Kahrs: Polymorphic Type Checking by Interpretation of Code

1992-19-06 M. Chakravarty, M. Köhler: Equational Constraints, Residuation, and the Parallel JUMP-Machine

1992-19-07 J. Seward: Polymorphic Strictness Analysis using Frontiers (Draft Version)

1992-19-08 D. Gärtner, A. Kimms, W. Kluge: pi-Redˆ+ - A Compiling Graph-Reduction System for a Full Fledged Lambda-Calculus

1992-19-09 D. Howe, G. Burn: Experiments with strict STG code

1992-19-10 J. Glauert: Parallel Implementation of Functional Languages Using Small Processes

1992-19-11 M. Joy, T. Axford: A Parallel Graph Reduction Machine

1992-19-12 A. Bennett, P. Kelly: Simulation of Multicache Parallel Reduction

1992-19-13 K. Langendoen, D.J. Agterkamp: Cache Behaviour of Lazy Functional Programs (Working Paper)

1992-19-14 K. Hammond, S. Peyton Jones: Profiling scheduling strategies on the GRIP parallel reducer

1992-19-15 S. Mintchev: Using Strictness Information in the STG-machine

1992-19-16 D. Rushall: An Attribute Grammar Evaluator in Haskell

1992-19-17 J. Wild, H. Glaser, P. Hartel: Statistics on storage management in a lazy functional language implementation

1992-19-18 W.S. Martins: Parallel Implementations of Functional Languages

1992-19-19 D. Lester: Distributed Garbage Collection of Cyclic Structures (Draft version)

1992-19-20 J.C. Glas, R.F.H. Hofman, W.G. Vree: Parallelization of Branch-and-Bound Algorithms in a Functional Programming Environment

1992-19-21 S. Hwang, D. Rushall: The nu-STG machine: a parallelized Spineless Tagless Graph Reduction Machine in a distributed memory architecture (Draft version)

1992-19-22 G. Burn, D. Le Metayer: Cps-Translation and the Correctness of Optimising Compilers

1992-19-23 S.L. Peyton Jones, P. Wadler: Imperative functional programming (Brief summary)

1992-19-24 W. Damm, F. Liu, Th. Peikenkamp: Evaluation and Parallelization of Functions in Functional + Logic Languages (abstract)

1992-19-25 M. Kesseler: Communication Issues Regarding Parallel Functional Graph Rewriting

1992-19-26 Th. Peikenkamp: Charakterizing and representing neededness in functional loginc languages (abstract)

1992-19-27 H. Doerr: Monitoring with Graph-Grammars as formal operational Models

1992-19-28 J. van Groningen: Some implementation aspects of Concurrent Clean on distributed memory architectures

1992-19-29 G. Ostheimer: Load Bounding for Implicit Parallelism (abstract)

1992-20 H. Kuchen, F.J. Lopez Fraguas, J.J. Moreno Navarro, M. Rodriguez Artalejo: Implementing Disequality in a Lazy Functional Logic Language

1992-21 H. Kuchen, F.J. Lopez Fraguas: Result Directed Computing in a Functional Logic Language

1992-22 H. Kuchen, J.J. Moreno Navarro, M.V. Hermenegildo: Independent AND-Parallel Narrowing

1992-23 T. Margaria, B. Steffen: Distinguishing Formulas for Free

1992-24 K. Pohl: The Three Dimensions of Requirements Engineering

1992-25 * R. Stainov: A Dynamic Configuration Facility for Multimedia Communications

1992-26 * Michael von der Beeck: Integration of Structured Analysis and Timed Statecharts for Real-Time and Concurrency Specification

1992-27 W. Hans, St. Winkler: Aliasing and Groundness Analysis of Logic Programs through Abstract Interpretation and its Safety

1992-28 * Gerhard Steinke, Matthias Jarke: Support for Security Modeling in Information Systems Design

1992-29 B. Schinzel: Warum Frauenforschung in Naturwissenschaft und Technik

1992-30 A. Kemper, G. Moerkotte, K. Peithner: Object-Orientation Axiomatised by Dynamic Logic

1992-32 * Bernd Heinrichs, Kai Jakobs: Timer Handling in High-Performance Transport Systems

1992-33 * B. Heinrichs, K. Jakobs, K. Lenßen, W. Reinhardt, A. Spinner: EuroBridge: Communication Services for Multimedia Applications

1992-34 C. Gerlhof, A. Kemper, Ch. Kilger, G. Moerkotte: Partition-Based Clustering in Object Bases: From Theory to Practice

1992-35 J. Börstler: Feature-Oriented Classification and Reuse in IPSEN

1992-36 M. Jarke, J. Bubenko, C. Rolland, A. Sutcliffe, Y. Vassiliou: Theories Underlying Requirements Engineering: An Overview of NATURE at Genesis

1992-37 * K. Pohl, M. Jarke: Quality Information Systems: Repository Support for Evolving Process Models

1992-38 A. Zuendorf: Implementation of the imperative / rule based language PROGRES

1992-39 P. Koch: Intelligentes Backtracking bei der Auswertung funktional-logischer Programme

1992-40 * Rudolf Mathar, Jürgen Mattfeldt: Channel Assignment in Cellular Radio Networks

1992-41 * Gerhard Friedrich, Wolfgang Neidl: Constructive Utility in Model-Based Diagnosis Repair Systems

1992-42 * P. S. Chen, R. Hennicker, M. Jarke: On the Retrieval of Reusable Software Components

1992-43 W. Hans, St.Winkler: Abstract Interpretation of Functional Logic Languages

1992-44 N. Kiesel, A. Schuerr, B. Westfechtel: Design and Evaluation of GRAS, a Graph-Oriented Database System for Engineering Applications

1993-01 * Fachgruppe Informatik: Jahresbericht 1992

1993-02 * Patrick Shicheng Chen: On Inference Rules of Logic-Based Information Retrieval Systems

1993-03 G. Hogen, R. Loogen: A New Stack Technique for the Management of Runtime Structures in Distributed Environments

1993-05 A. Zuendorf: A Heuristic for the Subgraph Isomorphism Problem in Executing PROGRES

1993-06 A. Kemper, D. Kossmann: Adaptable Pointer Swizzling Strategies in Object Bases: Design, Realization, and Quantitative Analysis

1993-07 * Graduiertenkolleg Informatik und Technik (Hrsg.): Graduiertenkolleg Informatik und Technik

1993-08 * Matthias Berger: k-Coloring Vertices using a Neural Network with Convergence to Valid Solutions

1993-09 M. Buchheit, M. Jeusfeld, W. Nutt, M. Staudt: Subsumption between Queries to Object-Oriented Databases

1993-10 O. Burkart, B. Steffen: Pushdown Processes: Parallel Composition and Model Checking

1993-11 * R. Große-Wienker, O. Hermanns, D. Menzenbach, A. Pollacks, S. Repetzki, J. Schwartz, K. Sonnenschein, B. Westfechtel: Das SUKITS-Projekt: A-posteriori-Integration heterogener CIM-Anwendungssysteme

1993-12 * Rudolf Mathar, Jürgen Mattfeldt: On the Distribution of Cumulated Interference Power in Rayleigh Fading Channels

1993-13 O. Maler, L. Staiger: On Syntactic Congruences for omega-languages

1993-14 M. Jarke, St. Eherer, R. Gallersdoerfer, M. Jeusfeld, M. Staudt: ConceptBase - A Deductive Object Base Manager

1993-15 M. Staudt, H.W. Nissen, M.A. Jeusfeld: Query by Class, Rule and Concept

1993-16 * M. Jarke, K. Pohl, St. Jacobs et al.: Requirements Engineering: An Integrated View of Representation Process and Domain

1993-17 * M. Jarke, K. Pohl: Establishing Vision in Context: Towards a Model of Requirements Processes

1993-18 W. Hans, H. Kuchen, St. Winkler: Full Indexing for Lazy Narrowing

1993-19 W. Hans, J.J. Ruz, F. Saenz, St. Winkler: A VHDL Specification of a Shared Memory Parallel Machine for Babel

1993-20 * K. Finke, M. Jarke, P. Szczurko, R. Soltysiak: Quality Management for Expert Systems in Process Control

1993-21 M. Jarke, M.A. Jeusfeld, P. Szczurko: Three Aspects of Intelligent Cooperation in the Quality Cycle

1994-01 Margit Generet, Sven Martin (eds.), Fachgruppe Informatik: Jahresbericht 1993

1994-02 M. Lefering: Development of Incremental Integration Tools Using Formal Specifications

1994-03 * P. Constantopoulos, M. Jarke, J. Mylopoulos, Y. Vassiliou: The Software Information Base: A Server for Reuse

1994-04 * Rolf Hager, Rudolf Mathar, Jürgen Mattfeldt: Intelligent Cruise Control and Reliable Communication of Mobile Stations

1994-05 * Rolf Hager, Peter Hermesmann, Michael Portz: Feasibility of Authentication Procedures within Advanced Transport Telematics

1994-06 * Claudia Popien, Bernd Meyer, Axel Kuepper: A Formal Approach to Service Import in ODP Trader Federations

1994-07 P. Peters, P. Szczurko: Integrating Models of Quality Management Methods by an Object-Oriented Repository

1994-08 * Manfred Nagl, Bernhard Westfechtel: A Universal Component for the Administration in Distributed and Integrated Development Environments

1994-09 * Patrick Horster, Holger Petersen: Signatur- und Authentifikationsverfahren auf der Basis des diskreten Logarithmusproblems

1994-11 A. Schürr: PROGRES, A Visual Language and Environment for PROgramming with Graph REwrite Systems

1994-12 A. Schürr: Specification of Graph Translators with Triple Graph Grammars

1994-13 A. Schürr: Logic Based Programmed Structure Rewriting Systems

1994-14 L. Staiger: Codes, Simplifying Words, and Open Set Condition

1994-15 * Bernhard Westfechtel: A Graph-Based System for Managing Configurations of Engineering Design Documents

1994-16 P. Klein: Designing Software with Modula-3

1994-17 I. Litovsky, L. Staiger: Finite acceptance of infinite words

1994-18 G. Hogen, R. Loogen: Parallel Functional Implementations: Graphbased vs. Stackbased Reduction

1994-19 M. Jeusfeld, U. Johnen: An Executable Meta Model for Re-Engineering of Database Schemas

1994-20 * R. Gallersdörfer, M. Jarke, K. Klabunde: Intelligent Networks as a Data Intensive Application (INDIA)

1994-21 M. Mohnen: Proving the Correctness of the Static Link Technique Using Evolving Algebras

1994-22 H. Fernau, L. Staiger: Valuations and Unambiguity of Languages, with Applications to Fractal Geometry

1994-24 * M. Jarke, K. Pohl, R. Dömges, St. Jacobs, H. W. Nissen: Requirements Information Management: The NATURE Approach

1994-25 * M. Jarke, K. Pohl, C. Rolland, J.-R. Schmitt: Experience-Based Method Evaluation and Improvement: A Process Modeling Approach

1994-26 * St. Jacobs, St. Kethers: Improving Communication and Decision Making within Quality Function Deployment

1994-27 * M. Jarke, H. W. Nissen, K. Pohl: Tool Integration in Evolving Information Systems Environments

1994-28 O. Burkart, D. Caucal, B. Steffen: An Elementary Bisimulation Decision Procedure for Arbitrary Context-Free Processes

1995-01 * Fachgruppe Informatik: Jahresbericht 1994

1995-02 Andy Schürr, Andreas J. Winter, Albert Zündorf: Graph Grammar Engineering with PROGRES

1995-03 Ludwig Staiger: A Tight Upper Bound on Kolmogorov Complexity by Hausdorff Dimension and Uniformly Optimal Prediction

1995-04 Birgitta König-Ries, Sven Helmer, Guido Moerkotte: An experimental study on the complexity of left-deep join ordering problems for cyclic queries

1995-05 Sophie Cluet, Guido Moerkotte: Efficient Evaluation of Aggregates on Bulk Types

1995-06 Sophie Cluet, Guido Moerkotte: Nested Queries in Object Bases

1995-07 Sophie Cluet, Guido Moerkotte: Query Optimization Techniques Exploiting Class Hierarchies

1995-08 Markus Mohnen: Efficient Compile-Time Garbage Collection for Arbitrary Data Structures

1995-09 Markus Mohnen: Functional Specification of Imperative Programs: An Alternative Point of View of Functional Languages

1995-10 Rainer Gallersdörfer, Matthias Nicola: Improving Performance in Replicated Databases through Relaxed Coherency

1995-11 * M.Staudt, K.von Thadden: Subsumption Checking in Knowledge Bases

1995-12 * G.V.Zemanek, H.W.Nissen, H.Hubert, M.Jarke: Requirements Analysis from Multiple Perspectives: Experiences with Conceptual Modeling Technology

1995-13 * M.Staudt, M.Jarke: Incremental Maintenance of Externally Materialized Views

1995-14 * P.Peters, P.Szczurko, M.Jeusfeld: Oriented Information Management: Conceptual Models at Work

1995-15 * Matthias Jarke, Sudha Ram (Hrsg.): WITS 95 Proceedings of the 5th Annual Workshop on Information Technologies and Systems

1995-16 * W.Hans, St.Winkler, F.Saenz: Distributed Execution in Functional Logic Programming

1996-01 * Jahresbericht 1995

1996-02 Michael Hanus, Christian Prehofer: Higher-Order Narrowing with Definitional Trees

1996-03 * W.Scheufele, G.Moerkotte: Optimal Ordering of Selections and Joins in Acyclic Queries with Expensive Predicates

1996-04 Klaus Pohl: PRO-ART: Enabling Requirements Pre-Traceability

1996-05 Klaus Pohl: Requirements Engineering: An Overview

1996-06 * M.Jarke, W.Marquardt: Design and Evaluation of Computer–Aided Process Modelling Tools

1996-07 Olaf Chitil: The Sigma-Semantics: A Comprehensive Semantics for Functional Programs

1996-08 * S.Sripada: On Entropy and the Limitations of the Second Law of Thermodynamics

1996-09 Michael Hanus (Ed.): Proceedings of the Poster Session of ALP96 - Fifth International Conference on Algebraic and Logic Programming

1996-09-0 Michael Hanus (Ed.): Proceedings of the Poster Session of ALP 96 - Fifth International Conference on Algebraic and Logic Programming: Introduction and table of contents

1996-09-1 Ilies Alouini: An Implementation of Conditional Concurrent Rewriting on Distributed Memory Machines

1996-09-2 Olivier Danvy, Karoline Malmkjær: On the Idempotence of the CPS Transformation

1996-09-3 Víctor M. Gulías, José L. Freire: Concurrent Programming in Haskell

1996-09-4 Sébastien Limet, Pierre Réty: On Decidability of Unifiability Modulo Rewrite Systems

1996-09-5 Alexandre Tessier: Declarative Debugging in Constraint Logic Programming

1996-10 Reidar Conradi, Bernhard Westfechtel: Version Models for Software Configuration Management

1996-11 * C.Weise, D.Lenzkes: A Fast Decision Algorithm for Timed Refinement

1996-12 * R.Dömges, K.Pohl, M.Jarke, B.Lohmann, W.Marquardt: PRO-ART/CE* — An Environment for Managing the Evolution of Chemical Process Simulation Models

1996-13 * K.Pohl, R.Klamma, K.Weidenhaupt, R.Dömges, P.Haumer, M.Jarke: A Framework for Process-Integrated Tools

1996-14 * R.Gallersdörfer, K.Klabunde, A.Stolz, M.Eßmajor: INDIA — Intelligent Networks as a Data Intensive Application, Final Project Report, June 1996

1996-15 * H.Schimpe, M.Staudt: VAREX: An Environment for Validating and Refining Rule Bases

1996-16 * M.Jarke, M.Gebhardt, S.Jacobs, H.Nissen: Conflict Analysis Across Heterogeneous Viewpoints: Formalization and Visualization

1996-17 Manfred A. Jeusfeld, Tung X. Bui: Decision Support Components on the Internet

1996-18 Manfred A. Jeusfeld, Mike Papazoglou: Information Brokering: Design, Search and Transformation

1996-19 * P.Peters, M.Jarke: Simulating the impact of information flows in networked organizations

1996-20 Matthias Jarke, Peter Peters, Manfred A. Jeusfeld: Model-driven planning and design of cooperative information systems

1996-21 * G.de Michelis, E.Dubois, M.Jarke, F.Matthes, J.Mylopoulos, K.Pohl, J.Schmidt, C.Woo, E.Yu: Cooperative information systems: a manifesto

1996-22 * S.Jacobs, M.Gebhardt, S.Kethers, W.Rzasa: Filling HTML forms simultaneously: CoWeb architecture and functionality

1996-23 * M.Gebhardt, S.Jacobs: Conflict Management in Design

1997-01 Michael Hanus, Frank Zartmann (eds.): Jahresbericht 1996

1997-02 Johannes Faassen: Using full parallel Boltzmann Machines for Optimization

1997-03 Andreas Winter, Andy Schürr: Modules and Updatable Graph Views for PROgrammed Graph REwriting Systems

1997-04 Markus Mohnen, Stefan Tobies: Implementing Context Patterns in the Glasgow Haskell Compiler

1997-05 * S.Gruner: Schemakorrespondenzaxiome unterstützen die paargrammatische Spezifikation inkrementeller Integrationswerkzeuge

1997-06 Matthias Nicola, Matthias Jarke: Design and Evaluation of Wireless Health Care Information Systems in Developing Countries

1997-07 Petra Hofstedt: Taskparallele Skelette für irregulär strukturierte Probleme in deklarativen Sprachen

1997-08 Dorothea Blostein, Andy Schürr: Computing with Graphs and Graph Rewriting

1997-09 Carl-Arndt Krapp, Bernhard Westfechtel: Feedback Handling in Dynamic Task Nets

1997-10 Matthias Nicola, Matthias Jarke: Integrating Replication and Communication in Performance Models of Distributed Databases

1997-11 * R. Klamma, P. Peters, M. Jarke: Workflow Support for Failure Management in Federated Organizations

1997-13 Markus Mohnen: Optimising the Memory Management of Higher-Order Functional Programs

1997-14 Roland Baumann: Client/Server Distribution in a Structure-Oriented Database Management System

1997-15 George Botorog: High-Level Parallel Programming and the Efficient Implementation of Numerical Algorithms

1998-01 * Fachgruppe Informatik: Jahresbericht 1997

1998-02 Stefan Gruner, Manfred Nagel, Andy Schürr: Fine-grained and Structure-Oriented Document Integration Tools are Needed for Development Processes

1998-03 Stefan Gruner: Einige Anmerkungen zur graphgrammatischen Spezifikation von Integrationswerkzeugen nach Westfechtel, Janning, Lefering und Schürr

1998-04 * O. Kubitz: Mobile Robots in Dynamic Environments

1998-05 Martin Leucker, Stephan Tobies: Truth - A Verification Platform for Distributed Systems

1998-06 * Matthias Oliver Berger: DECT in the Factory of the Future

1998-07 M. Arnold, M. Erdmann, M. Glinz, P. Haumer, R. Knoll, B. Paech, K. Pohl, J. Ryser, R. Studer, K. Weidenhaupt: Survey on the Scenario Use in Twelve Selected Industrial Projects

1998-08 * H. Aust: Sprachverstehen und Dialogmodellierung in natürlichsprachlichen Informationssystemen

1998-09 * Th. Lehmann: Geometrische Ausrichtung medizinischer Bilder am Beispiel intraoraler Radiographien

1998-10 * M. Nicola, M. Jarke: Performance Modeling of Distributed and Replicated Databases

1998-11 * Ansgar Schleicher, Bernhard Westfechtel, Dirk Jäger: Modeling Dynamic Software Processes in UML

1998-12 * W. Appelt, M. Jarke: Interoperable Tools for Cooperation Support using the World Wide Web

1998-13 Klaus Indermark: Semantik rekursiver Funktionsdefinitionen mit Striktheitsinformation

1999-01 * Jahresbericht 1998

1999-02 * F. Huch: Verifcation of Erlang Programs using Abstract Interpretation and Model Checking — Extended Version

1999-03 * R. Gallersdörfer, M. Jarke, M. Nicola: The ADR Replication Manager

1999-04 María Alpuente, Michael Hanus, Salvador Lucas, Germán Vidal: Specialization of Functional Logic Programs Based on Needed Narrowing

1999-05 * W. Thomas (Ed.): DLT 99 - Developments in Language Theory Fourth International Conference

1999-06 * Kai Jakobs, Klaus-Dieter Kleefeld: Informationssysteme für die angewandte historische Geographie

1999-07 Thomas Wilke: CTL+ is exponentially more succinct than CTL

1999-08 Oliver Matz: Dot-Depth and Monadic Quantifier Alternation over Pictures

2000-01 * Jahresbericht 1999

2000-02 Jens Vöge, Marcin Jurdzinski: A Discrete Strategy Improvement Algorithm for Solving Parity Games

2000-04 Andreas Becks, Stefan Sklorz, Matthias Jarke: Exploring the Semantic Structure of Technical Document Collections: A Cooperative Systems Approach

2000-05 Mareike Schoop: Cooperative Document Management

2000-06 Mareike Schoop, Christoph Quix (eds.): Proceedings of the Fifth International Workshop on the Language-Action Perspective on Communication Modelling

2000-07 * Markus Mohnen, Pieter Koopman (Eds.): Proceedings of the 12th International Workshop of Functional Languages

2000-08 Thomas Arts, Thomas Noll: Verifying Generic Erlang Client-Server Implementations

2001-01 * Jahresbericht 2000

2001-02 Benedikt Bollig, Martin Leucker: Deciding LTL over Mazurkiewicz Traces

2001-03 Thierry Cachat: The power of one-letter rational languages

2001-04 Benedikt Bollig, Martin Leucker, Michael Weber: Local Parallel Model Checking for the Alternation Free mu-Calculus

2001-05 Benedikt Bollig, Martin Leucker, Thomas Noll: Regular MSC Languages

2001-06 Achim Blumensath: Prefix-Recognisable Graphs and Monadic Second-Order Logic

2001-07 Martin Grohe, Stefan Wöhrle: An Existential Locality Theorem

2001-08 Mareike Schoop, James Taylor (eds.): Proceedings of the Sixth International Workshop on the Language-Action Perspective on Communication Modelling

2001-09 Thomas Arts, Jürgen Giesl: A collection of examples for termination of term rewriting using dependency pairs

2001-10 Achim Blumensath: Axiomatising Tree-interpretable Structures

2001-11 Klaus Indermark, Thomas Noll (eds.): Kolloquium Programmiersprachen und Grundlagen der Programmierung

2002-01 * Jahresbericht 2001

2002-02 Jürgen Giesl, Aart Middeldorp: Transformation Techniques for Context-Sensitive Rewrite Systems

2002-03 Benedikt Bollig, Martin Leucker, Thomas Noll: Generalised Regular MSC Languages

2002-04 Jürgen Giesl, Aart Middeldorp: Innermost Termination of Context-Sensitive Rewriting

2002-05 Horst Lichter, Thomas von der Maßen, Thomas Weiler: Modelling Requirements and Architectures for Software Product Lines

2002-06 Henry N. Adorna: 3-Party Message Complexity is Better than 2-Party Ones for Proving Lower Bounds on the Size of Minimal Nondeterministic Finite Automata

2002-07 Jörg Dahmen: Invariant Image Object Recognition using Gaussian Mixture Densities

2002-08 Markus Mohnen: An Open Framework for Data-Flow Analysis in Java

2002-09 Markus Mohnen: Interfaces with Default Implementations in Java

2002-10 Martin Leucker: Logics for Mazurkiewicz traces

2002-11 Jürgen Giesl, Hans Zantema: Liveness in Rewriting

2003-01 * Jahresbericht 2002

2003-02 Jürgen Giesl, René Thiemann: Size-Change Termination for Term Rewriting

2003-03 Jürgen Giesl, Deepak Kapur: Deciding Inductive Validity of Equations

2003-04 Jürgen Giesl, René Thiemann, Peter Schneider-Kamp, Stephan Falke: Improving Dependency Pairs

2003-05 Christof Löding, Philipp Rohde: Solving the Sabotage Game is PSPACE-hard

2003-06 Franz Josef Och: Statistical Machine Translation: From Single-Word Models to Alignment Templates

2003-07 Horst Lichter, Thomas von der Maßen, Alexander Nyßen, Thomas Weiler: Vergleich von Ansätzen zur Feature Modellierung bei der Softwareproduktlinienentwicklung

2003-08 Jürgen Giesl, René Thiemann, Peter Schneider-Kamp, Stephan Falke: Mechanizing Dependency Pairs

2004-01 * Fachgruppe Informatik: Jahresbericht 2004

2004-02 Benedikt Bollig, Martin Leucker: Message-Passing Automata are expressively equivalent to EMSO logic

2004-03 Delia Kesner, Femke van Raamsdonk, Joe Wells (eds.): HOR 2004 – 2nd International Workshop on Higher-Order Rewriting

2004-04 Slim Abdennadher, Christophe Ringeissen (eds.): RULE 04 – Fifth International Workshop on Rule-Based Programming

2004-05 Herbert Kuchen (ed.): WFLP 04 – 13th International Workshop on Functional and (Constraint) Logic Programming

2004-06 Sergio Antoy, Yoshihito Toyama (eds.): WRS 04 – 4th International Workshop on Reduction Strategies in Rewriting and Programming

2004-07 Michael Codish, Aart Middeldorp (eds.): WST 04 – 7th International Workshop on Termination

2004-08 Klaus Indermark, Thomas Noll: Algebraic Correctness Proofs for Compiling Recursive Function Definitions with Strictness Information

2004-09 Joachim Kneis, Daniel Mölle, Stefan Richter, Peter Rossmanith: Parameterized Power Domination Complexity

2004-10 Zinaida Benenson, Felix C. Gärtner, Dogan Kesdogan: Secure Multi-Party Computation with Security Modules

* These reports are only available as a printed version.

Please contact `biblio@informatik.rwth-aachen.de` to obtain copies.