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TECHNISCHE FAKULTÄT DER
CHRISTIAN-ALBRECHTS-UNIVERSITÄT
ZU KIEL

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Christian-Albrechts-Universität zu Kiel

Programming Languages and Compiler Construction

The research group ''Programming Languages and Compiler Construction'' is interested in the design, implementation and application of programming languages intended to support the reliable implementation of complex systems. The research ranges from object-oriented design methods and the analysis of concurrent and distributed systems to the implementation and application of declarative programming languages, in particular, in the area of web-based systems. During the period reported below, the research has been supported by the DFG (German Research Foundation) and the DAAD (German Academic Exchange Service).

Results

The scientific work of the research group involved all areas related to declarative programming languages, e.g., design, semantics, implementation, development tools, and application of such languages. Declarative programming languages are based on clear mathematical foundations. They abstract from the underlying computer architecture and, thus, provide a higher programming level leading to more reliable programs. This also enables opportunities for improving the execution of programs. Instead of a stepwise execution oriented towards the sequential program text, a compiler may select a much more efficient demand-driven strategy oriented towards the data flow of the program. This separation of logic and control supports more efficient program development. However, in the case of programming errors, traditional debugging methods, like stepwise tracing of the program's execution, are not appropriate. Therefore, we extended our previous work on new *debugging techniques*, like debugging by observing the evaluation of distinguished expressions or functions, or declarative debugging. The latter is implemented by a two-phase execution: the first phase executes the program and collects information about program execution. This information is used as an ''oracle'' for the second phase which present the program's execution in a different order that is more comprehensible for the programmer. In order to ease the implementation of tools related to the second phase, we developed a rather generic framework to control oracle-based interpreters in a monadic manner.

In the area of the *design and semantics* of declarative languages, we collaborated with the Portland State University (Oregon, USA) and developed a new method to encapsulate nondeterministic computations in functional logic programs. This method is based on associating to each function a set-valued function encapsulating the nondeterminism caused by the function's execution. It is the first referentially transparent approach to encapsulate nondeterministic computations and, thus, solves a long-standing problem in this area. Further work in this area was the development of a new semantic foundation for declarative languages covering various degrees of nondeterministic behaviour. This research was done in cooperation with the research group ''Computer-Aided Program Development''.

We also investigated several issues related to the *implementation* of functional logic programming languages. We extended the implementation of KiCS (Kiel Curry System) that is based on a couple of new theoretical insights arising from the research of our group in previous years. We also explored a new alternative implementation of nondeterminism in a purely functional language that is based on monads. This monadic approach allows the selection of the concrete search strategy by different monad instances so that various search strategies can be selected and combined at run-time. This also provides a new basis to exploit *parallelism* since one can implement nondeterministic computations by concurrent threads that run on multicores. We experimented with various parallel search strategies in order to lay the foundations for future parallel implementations of declarative languages.

Related to the *application* of declarative languages, we developed a new framework to specify graphical and web-based user interfaces in a uniform manner so that one can generate graphical user interfaces for desktop applications as well as web-based user interfaces for web applications from the same interface specification. This approach decreases the implementation efforts for application systems. Furthermore, we designed and implemented a new framework, called Spicey, to generate complete web applications from a specification of the underlying data as an entity-relationship model. Since the generated implementation is a high-level declarative program, it is easy to adapt this program to various

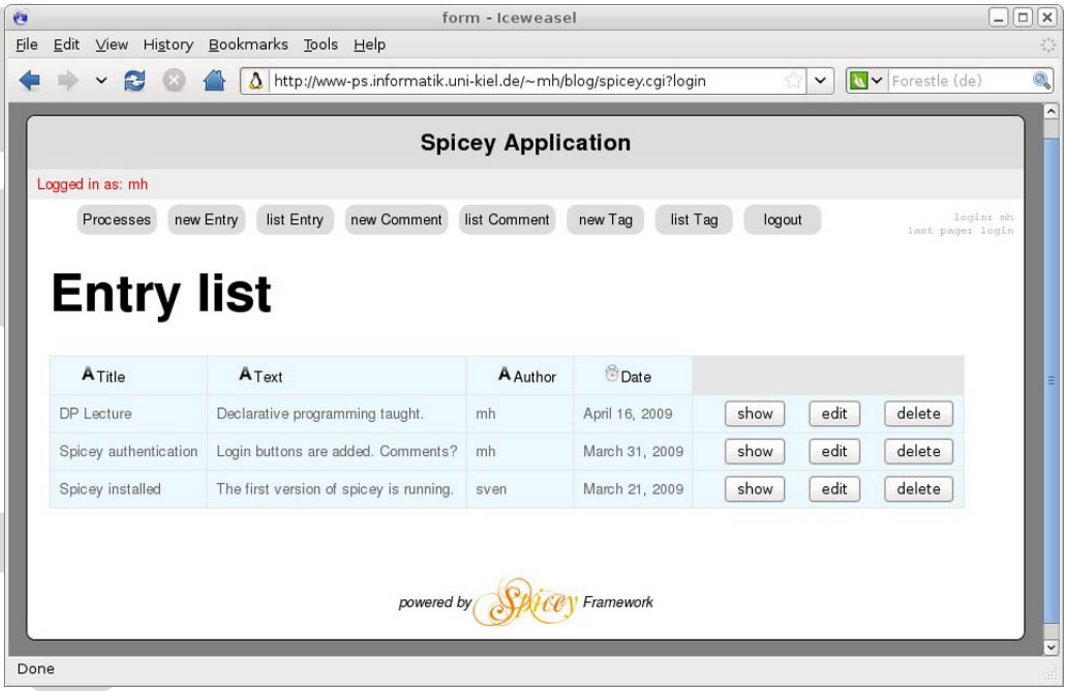

Fig. 1: A simple blog generated by the web framework Spicey

customer requirements. In contrast to other web frameworks, our framework exploits high-level declarative programming techniques so that it yields reliable implementations that avoid data inconsistencies at various levels.

Our research group was also engaged in *public relations* activities. For instance, we gave an introduction to elementary programming at the Girls' Day of the institute. The visiting students learnt basic programming techniques with the little ladybird Kara. This introduction has also been used for a one-week course on programming where the participating students developed a distributed chat program in the concurrent functional language Erlang. This course was organized by Frank Huch (in collaboration with Thomas Wilke).

Personnel

Head of the group: Prof. Dr. Michael Hanus; Secretary: Ulrike Pollakowski
Technical Staff: Dipl.-Ing. (FH) Thomas Heß

Scientific Staff:

Dr.phil. Bernd Braßel	01.04.-30.09.2009	DFG
Systematic Debugging in Declarative Programs		
Dipl.-Inf. Sebastian Fischer	01.01.-31.12.2009	CAU
Priv.-Doz. Dr. Frank Huch	01.01.-31.12.2009	CAU
Administration of study programs		
Dipl.-Inf. Fabian Reck	01.01.-31.12.2009	CAU
Dr. Friedemann Simon	01.01.-31.12.2009	CAU

Fig. 2: Participants of the "Schnupperstudium Informatik"

Lectures, Seminars, and Laboratory Course Offers

Winter 2008/2009

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

G1.1 Informatik I - Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Christina Otte)

BA6.5: Projektmodul - Werkzeuge zur Fehlersuche, 6 hrs Exercise/Week,
Michael Hanus (+ Bernd Braßel)

Informatik für Nebenfächler, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Sebastian Fischer)

MS0301: Prinzipien von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

MS0309: Softwaretechnik zum Zertifizieren von Systemen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Wolfgang Goerigk

MSP0302: Masterprojekt - Werkzeuge zur Fehlersuche, 4 hrs Exercise/Week,
Michael Hanus (+ Bernd Braßel)

Objektorientierte Programmierung für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

WI08: - Objektorientierte Programmierung, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Summer 2009

Systematisches Programmieren, 2 (+ 4) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

MS0303: - Deklarative Programmiersprachen, 4 (+ 2) hrs Seminar (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck)

MS0306: - Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch

MSS0302: Seminar - Programmiersprachen und Programmiersysteme, 2 hrs Exercise/Week,
Michael Hanus

Systematisches Programmieren für Physiker (NF-Inf-2-Phys), 2 hrs Lecture/Week,
Friedemann Simon

WI09: - Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Frank Huch, Sebastian Fischer)

Winter 2009/2010

Diplomandenseminar, 2 hrs Seminar/Week,
Michael Hanus

Inf-Prog: - Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
Michael Hanus (+ Fabian Reck, Christina Otte, Bernd Braßel, Sebastian Eggert)

MS0302: Übersetzerbau, 4 (+ 2) hrs Exercise (+ Exercises)/Week,
Michael Hanus (+ Sebastian Fischer)

NF-Inf-3: Programmiertechniken für die Künstliche Intelligenz für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

WI16: Programmiertechniken für die Künstliche Intelligenz, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Friedemann Simon

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,
Michael Hanus (+ Rudolf Berghammer)

MSS0302: Seminar - Programmiersprachen und Programmiersysteme, 2 hrs Seminar/Week,
Michael Hanus

MSS0303: Masterabschlusseminar Programmiersprachen, 2 hrs Seminar/Week,
Michael Hanus

NF-Inf-1: Informatik für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,
Frank Huch (+ Sebastian Fischer, Hauke Furhmann)

Vertiefende Übung zu: Informatik für Nebenfächler, 2 hrs Exercise/Week,
Frank Huch (+ Sebastian Fischer)

Third-Party Funds

DFG, *Systematische Fehlersuche in deklarativen Programmen*, 01.01.-26.10.2009 (31.139,41 EUR)
DAAD, *Implementation of Instrumented Semantics for Declarative Multi-Paradigm Languages*, 01.01.-31.12.2008 (7.402,00 EUR)

Further Cooperation, Consulting, and Technology Transfer

The research group cooperates with:

Portland State University (Sergio Antoy)

Technical University of Valencia (Josep Silva, German Vidal)

University of Münster (Herbert Kuchen)

Diploma, Bachelor and Master Theses

Andreas Müller, *Von der Finanzplanung zum unternehmensweiten Finanzberichtswesen - ein Berichtssystem für den BusinessPlanner .NET der Bank Austria*, 23.03.2009
Christoph Wulf, *Code-Erzeugung zur Unterstützung der Fehlersuche*, 15.04.2009
Peer Ch. Brauer, *Generierung zuverlässiger UML-Modelle von JEE-Architekturen aus Domänenmodellen*, 21.04.2009
Jan-Philip Rathje, *Entwicklung eines Java-nach-C++-Übersetzers zur Transferierung von Java-API's*, 05.05.2009
Gunnar Biederbeck, *Ein verteiltes Objektsystem zur Programmierung und synchronen Steuerung von Geräten in hochgradig multimedialen Rechnernetzen*, 17.08.2009

Dissertations / Postdoctoral Lecture Qualifications

P. Sadeghi, *Run-Time Debugging for Functional Logic Languages*, 27.01.2009
S. Fischer, *On Functional Logic Programming and its Application to Testing*, 15.12.2009

Publications

Published in 2009

C. Kluß, Michael Hanus, *Declarative Programming of User Interfaces*, Proc. of the Eleventh International Symposium on Practical Aspects of Declarative Languages, PADL 2009, **Springer LNCS 5418**, 16 - 30 (2009)
S. Antoy, Michael Hanus, *Set Functions for Functional Logic Programming*, Proc. of the 11th International ACM SIGPLAN Conference on Principles and Practice of Declarative Programming, PPDP 2009, **ACM Press**, 73 - 82 (2009)
Michael Hanus, S. Koschnicke, *An ER-based Framework for Declarative Web Programming*, Proc. 23rd Workshop on (Constraint) Logic Programming, (2009)
D. Seipel, Michael Hanus, A. Wolf, *Applications of Declarative Programming and Knowledge Management*, Springer Lecture Notes in Artificial Intelligence, **5437**, (2009)
Michael Hanus, *Logic-Based Program Synthesis and Transformation - Revised Selected Papers of the 18th International Symposium on Logic-based Program Synthesis and Transformation, LOPSTR 2008*, Springer Lecture Notes in Computer Science, **5438**, (2009)
Bernd Braßel, Michael Hanus, *Proc. 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte*, Christian-Albrechts-Universität zu Kiel, **Technical Report 0915**, (2009)
Sebastian Fischer, O. Kiselyov, C. Shan, *Purely functional lazy non-deterministic programming*, Proc. of the 14th ACM SIGPLAN International Conference on Functional programming, ICFP'09, **ACM Press**, 11 - 22 (2009)

Sebastian Fischer, *Reinventing Haskell Backtracking*, Proc. GI-Jahrestagung Informatik 2009, **Lect. Notes in Informatics P15**, 2875 - 2888 (2009)
Fabian Reck, Sebastian Fischer, *Towards a Parallel Search for Solutions of Non-deterministic Computations*, Proc. GI-Jahrestagung Informatik 2009, **Lect. Notes in Informatics P15**, 2889 - 2900 (2009)
Fabian Reck, *Ein graphischer Debugger für Haskells Software Transactional Memory*, Proc. 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, 84 (2009)
Rudolf Berghammer, Bernd Braßel, *Proposing Order-Sorted Algebra as Foundation for Declarative Programming*, Proc. 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, 114 - 123 (2009)
Sebastian Fischer, *Funktionaler fauler Nichtdeterminismus*, Proc. 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, 126 (2009)
Bernd Braßel, Frank Huch, *The Kiel Curry System KiCS*, Applications of Declarative Programming and Knowledge Management, **Springer LNAI 5437**, 195 - 205 (2009)
Rudolf Berghammer, Bernd Braßel, *Functional (logic) programs as equations over order-sorted algebras*, Proceedings of the 19th International Symposium on Logic-Based Program Synthesis and Transformation (LOPSTR 2009), 103 - 118 (2009)
Rudolf Berghammer, Bernd Braßel, *Computing and visualizing closure objects using relations and RelView*, Computer Algebra in Scientific Computing, **Springer LNCS 5743**, 29 - 44 (2009)

Patent Applications

Michael Hanus, Friedemann Simon, D. Miesling, *Wissensbasiertes Tool zur automatischen Anordnung von Bildschirmkomponenten*, Deutsches Patent- und Markenamt, 12.10.2009, DE 10 2009 043 035.0

Presentations

Michael Hanus, *Declarative Programming of User Interfaces*, International Symposium on Practical Aspects of Declarative Languages (PADL 2009), Savannah, Georgia, USA, 19.01.2009
Fabian Reck, *A Graphical Debugger for Haskell's Software Transactional Memory*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 05.05.2009
Bernd Braßel, *Proposing Order-Sorted Algebra as Foundation for Declarative Programming*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2009
Sebastian Fischer, *Purely functional lazy non-deterministic programming*, 26. Workshop der GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2009
Sebastian Fischer, *Purely functional lazy non-deterministic programming*, 14th International Conference on Functional Programming (ICFP'09), Edingburgh, Scotland, 31.08.2009
Bernd Braßel, *Functional (logic) programs as equations over order-sorted algebras*, 19th International Symposium on Logic-Based Program Synthesis and Transformation (LOPSTR'09), Coimbra, Portugal, 11.09.2009
Bernd Braßel, *Computing and visualizing closure objects using relations and RelView*, 11th International Workshop on Computer Algebra in Scientific Computing, Kobe, Japan, 14.09.2009
Michael Hanus, *An ER-based Framework for Declarative Web Programming*, 23rd Workshop on (Constraint) Logic Programming (WLP 2009), Potsdam, Germany, 15.09.2009
Sebastian Fischer, *Reinventing Haskell Backtracking*, Fourth Working Conference on Programming Languages, Lübeck, Germany, 01.10.2009
Fabian Reck, *Towards a Parallel Search for Solutions of Non-deterministic Computations*, Fourth Working Conference on Programming Languages, Lübeck, Germany, 01.10.2009
Michael Hanus, *Set Functions for Functional Logic Programming*, 15th Colloquium on Programming Languages and Foundations of Programming, Maria Taferl, Austria, 12.10.2009
Sebastian Fischer, *Reinventing Haskell Backtracking*, 15th Colloquium on Programming Languages and Foundations of

Programming, Maria Taferl, Austria, 12.10.2009

Fabian Reck, *Towards a Parallel Search for Solutions of Non-deterministic Computations*, 15th Colloquium on Programming Languages and Foundations of Programming, Maria Taferl, Austria, 12.10.2009

Bernd Braßel, *The web of proofs*, 11th International Conference on Relational Methods in Computer Science and 6th International Workshop on Applications of Kleene Algebra, Doha, Qatar, 01.11.2009

Further Activities and Events

S. Fischer: Research stay related to ''Graph-based Evaluation of Functional Logic Programs'' at Portland State University (Oregon, USA) with Prof. Sergio Antoy, September 12-26, 2009

M. Hanus: Organization of the 26th Workshop of the GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef (Germany), May 2009

M. Hanus: Program committee member of TFP 2009 (Tenth Symposium on Trends in Functional Programming), Komarno (Slovakia), June 2009

M. Hanus: Program committee member of WFLP 2009 (18th Workshop on Functional and (Constraint) Logic Programming), Brasilia (Brazil), June 2009

M. Hanus: Program committee member of WST 2009 10th International Workshop on Termination), Leipzig, June 2009

M. Hanus: Program committee member of ICLP 2009 (25th International Conference on Logic Programming), Pasadena (California, USA), July 2009

M. Hanus: Program committee member of CICLOPS 2009 (9th International Colloquium on Implementation of Constraint and Logic Programming Systems), Pasadena (California, USA), July 2009

M. Hanus: Program committee member of PPDP 2009 (11th International Symposium on Principles and Practice of Declarative Programming), Coimbra (Portugal), September 2009

M. Hanus: Program committee member of LOPSTR 2009 (19th International Symposium on Logic-based Program Synthesis and Transformation), Coimbra (Portugal), September 2009

M. Hanus: Program committee member of WLP 2009 (23rd Workshop on (Constraint) Logic Programming), Potsdam, October 2009

M. Hanus: Organization and program committee co-chair of the Fourth Working Conference on Programming Languages (ATPS'09), Lübeck, 2009 (part of the 39th annual conference of the German Gesellschaft für Informatik)

M. Hanus: Member of the Editorial Board of the Journal of Functional and Logic Programming

M. Hanus: Chair of the executive committee of the Fachgruppe ''Programmiersprachen und Rechenkonzepte'' of the Gesellschaft für Informatik e.V.

M. Hanus: Member of the steering committee of the symposia on Logic-based Program Synthesis and Transformation

M. Hanus: Member of the executive committee and vice-chair of the GLP (Gesellschaft für Logische Programmierung), German-speaking branch of the Association for Logic Programming (ALP)

M. Hanus: Member of the advisory board of the GLP (Gesellschaft für Logische Programmierung), German-speaking branch of the Association for Logic Programming (ALP)

M. Hanus: Member of the selection committee of the DAAD (German Academic Exchange Service) for the project-related support to scientific cooperation with Spain and Portugal

M. Hanus: Member of the advisory board of the „Berufsakademie an der Wirtschaftsakademie Schleswig-Holstein“

M. Hanus: Referee of the habilitation of Janis Voigtländer (title: ''Types for Programming and Reasoning''), University of Dresden, 2009

M. Hanus: Chair of the managing directorate of the Institute of Computer Science, University of Kiel

M. Hanus: Chair of the examinations board of computer science studies, University of Kiel

M. Hanus: Member of the convent of the Faculty of Engineering, University of Kiel

M. Hanus: Vice-member of the Senate Curriculum Committee, University of Kiel

M. Hanus: Vice-member of the Senate Equal Opportunities Committee, University of Kiel

F. Huch: Member of the Steering Commitee of Symposia on Implementation and Application of Functional Languages (IFL)

F. Huch: Vice-Chair of the executive committee of the Fachgruppe „Programmiersprachen und Rechenkonzepte“ of the Gesellschaft für Informatik e.V.

F. Huch: Programming course with the little ladybird Kara, Girls' Day, April 23, 2009

F. Huch: Organisation (together with Thomas Wilke) of the ''Schnupperstudium Informatik für Schülerinnen und Schüler'', April 6 - 9, 2009, Kiel, 70 participants. Course on introduction to programming: navigation of a pirates ship by means of the programming language Erlang, final project: development and implementation of a distributed chat.

F. Huch: Organisation (together with Thomas Wilke) of the ''Schnupperstudium Informatik für Schülerinnen'', October 19 - 23, 2009, Kiel, 20 participants. Course on introduction to programming: navigation of the little ladybird Kara by means of the programming language Erlang, final project: Development and implementation of a distributed chat.

F. Reck: Research stay related to „Graph-based Evaluation of Functional Logic Programs“ at Portland State University (Oregon, USA) with Prof. Sergio Antoy, September 12-26, 2009

F. Simon: Lectures related to the advanced training of teachers (IQSH)

F. Simon: Participation in seminars for students planning professional careers

F. Simon: ''Computer Museum'' representative of the Faculty of Engineering in the board of control