



**TECHNISCHE FAKULTÄT DER  
CHRISTIAN-ALBRECHTS-UNIVERSITÄT  
ZU KIEL**

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Christian-Albrechts-Universität zu Kiel

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# 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 group worked on a new advanced implementation of the multi-paradigm language Curry and achieved new research results related to the design, semantics, implementation, and analysis of declarative programming methods. Furthermore, the research group organized the international conference event “Kiel Declarative Programming Days 2013” which unified the 20th International Conference on Applications of Declarative Programming and Knowledge Management (INAP 2013), the 22th International Workshop on Functional and (Constraint) Logic Programming (WFLP 2013), and the 27th Workshop on (Constraint) Logic Programming (WLP 2013) in Kiel.

## 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 systems. In particular, much of the research is focused towards the integration of the most important declarative programming paradigms: functional and logic programming. Due to our long-standing interest in this research area, we wrote a comprehensive survey on functional logic programming which was published during the reported period. This survey might be used as a standard reference in this area in future research and teaching activities.

In order to evaluate the concepts of declarative programming in practice, we worked on the *application and implementation* of the functional logic programming language Curry. In particular, we continued the development of our recent implementation of Curry, called KiCS2, which is based on compiling Curry programs into purely functional Haskell programs. The advantage of this implementation is the good performance of purely functional computations and the explicit representation of non-deterministic computed results in a single data structure. Due to the compilation into a purely functional target language, the implementation of typical logic programming features, like logic variables and constraints, is not immediately clear and thus, challenging. We developed a new implementation of these features and published the quite positive results.

A good implementation of high-level programming languages, like Curry, requires advanced *program analysis* techniques. For instance, the KiCS2 compiler analyzes dynamic program properties, like potential non-deterministic computations, to produce efficient target code. However, building program analyzers for realistic applications is not an easy task. In order to support developers of language tools (e.g. compiler, editor, documentation generator) in this respect, we developed a new framework and implementation for the generic and modular analysis of declarative programs. This tool, called CASS (Curry Analysis Server System), is based on a plug-in architecture to accommodate various program analyzers. Moreover, CASS provides various usage interfaces so that it can be used by various tools, such as compilers, and documentation generators as well as Eclipse plug-ins for Curry. Finally, CASS itself is implemented as a master/worker architecture in order to exploit parallel or distributed hardware environments.

During the reported period, we also worked in the area of the *design and semantics* of declarative languages. In a previous collaboration with the Portland State University (Oregon, USA), we developed a new technique to encapsulate non-deterministic computations in functional logic programs. It is based on associating to each function a set-valued function encapsulating the non-determinism caused by the function’s execution. It is the first referentially transparent approach to encapsulate non-deterministic computations and thus solves a long-standing problem in this area. Due to the

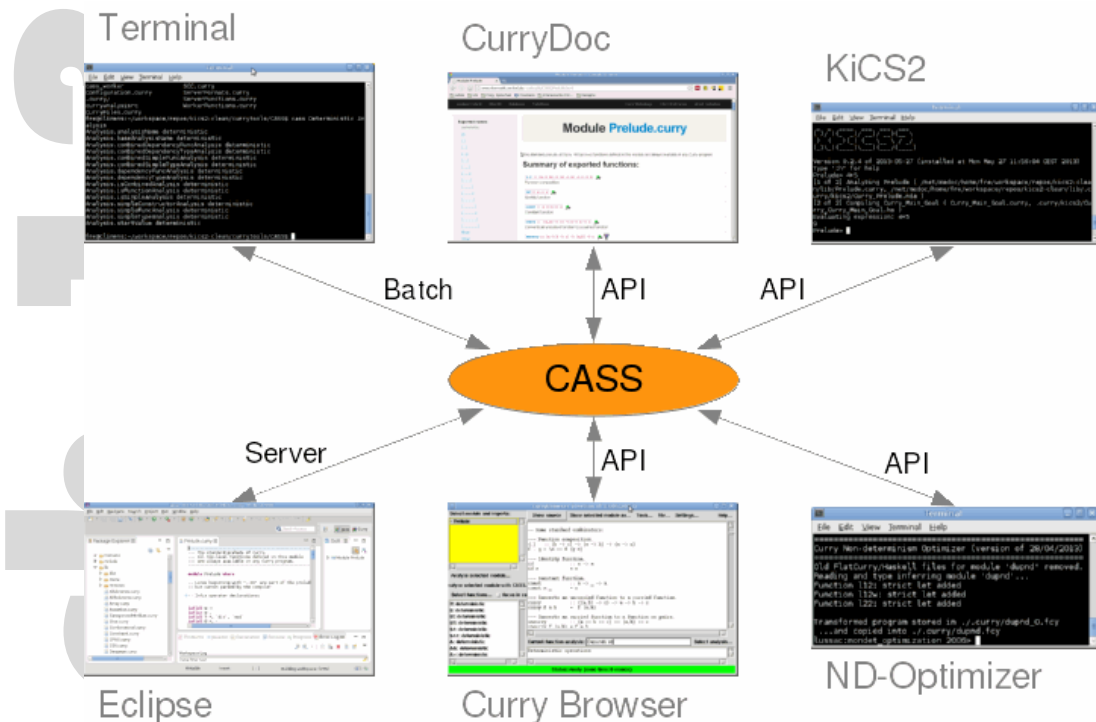


Fig. 1: The application structure of CASS

advanced implementation techniques used in KiCS2, we were also able to implement set functions in this system. During these implementation efforts, it turned out that the original proposal for set functions is underspecified so that various semantic options (empty result sets, nested set functions) are unclear. Therefore, we developed a new formal description of all these details and obtained the first denotational description of set functions. This description is not only of theoretical interest, but the basis of our new implementation of set functions. In particular, we adapted our initial implementation according to the new theoretical insights. Now, KiCS2 is the first implementation with a full support for set functions that is based on a solid theoretical foundation.

Due to the orthogonal combination of functional programming features, like lazy evaluation, and logic programming features, like non-deterministic computations, in Curry, there are different semantic options for their integration. Most researchers prefer the so-called “call-time choice” semantics since it provides an execution-independent understanding together with an efficient implementation. Recently, other researchers advocated a so-called “plural” semantics which supports, in particular cases, a more natural view on non-deterministic operations. However, the implementation of both semantic options is quite different so that it would be a huge effort to implement both in a single system. To overcome this drawback, we developed a new technique to compile the plural semantics into the call-time choice semantics. The practical implementation showed that this indirect approach is also more efficient than other approaches to implement the plural semantics in a direct manner.

Our research group also organized an international conference event, called “Kiel Declarative Programming Days 2013” (KDPD 2013). This event unified the 20th International Conference on Applications of Declarative Programming and Knowledge Management (INAP 2013), the 22th International Workshop on Functional and (Constraint) Logic Programming (WFLP 2013), and the 27th Workshop on (Constraint) Logic Programming (WLP 2013) in Kiel. This was the first time that these three events were jointly organized. It attracted researchers from many countries in Europe as well as Japan, USA, Canada, and Mexico. They presented their newest research result in the area of modern programming languages and declarative knowledge management. The post-proceedings of KDPD 2013 will appear in the Springer Lecture Notes in



Fig. 2: Participants of the Kiel Declarative Programming Days 2013

Computer Science series.

Finally, we developed a web-based distributed information system to support the master's students to plan their course of studies. It should help the students to organize their curricula as well as the faculty staff to plan their resources. This study planner is maintained by our group and currently used by our institute.

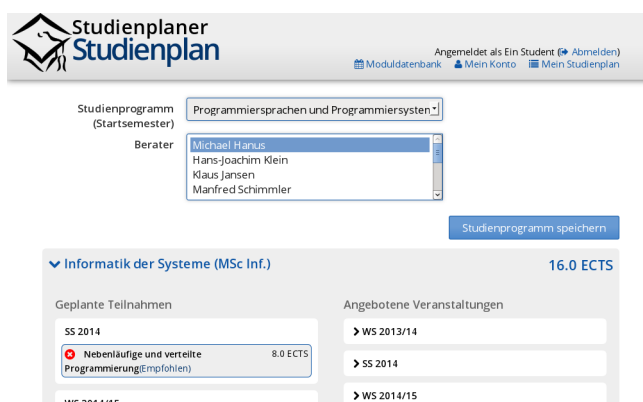


Fig. 3: The study planner developed and maintained in our group

## Personnel

Head of the group: Prof. Dr. Michael Hanus; Secretary: Jane-Maria Eitzen (50%), Linda Haberland (50%)  
 Technical Staff: Mike Gabriel (50%)

Scientific Staff:

Dr. Sebastian Fischer	01.01.-31.12.2013	Guest
PD. Dr. Frank Huch	01.01.-31.12.2013	CAU (35%)
M. SC. Björn Peemöller	01.01.-31.12.2013	CAU
Dr. Friedemann Simon	01.01.-31.12.2013	Guest
Dipl.-Inf. Fabian Skrlac	01.01.-31.12.2013	CAU
Dipl.-Inf. Jan Rasmus Tikovsky	01.04.-31.12.2013	CAU


*Winter 2012/2013*

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,  
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlusseminar - Programmiersprachen, 2 hrs Seminar/Week,  
M. Hanus

Inf-MS-Sem-PS: Programmiersprachen und Programmiersysteme, 2 hrs Seminar/Week,  
M. Hanus (+ F. Huch)

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
M. Hanus (+ F. Reck, B. Peemöller, L. Prädell, N. Danilenko, D. Ehlers, P. Munstermann)

MS0303: Deklarative Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
M. Hanus (+ B. Peemöller)

MS0306: Nebenläufige und verteilte Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
F. Huch (+ F. Reck)

Inf-Sem-PS: Programmierung und Programmiersprachen, 2 hrs Seminar/Week,  
M. Hanus

*Summer 2013*

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,  
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlusseminar - Programmiersprachen, 2 hrs Seminar/Week,  
M. Hanus

Inf-FortProg: Fortgeschrittene Programmierung, 3 (+ 2) hrs Lecture (+ Exercises)/Week,  
M. Hanus (+ B. Peemöller, Jan Rasmus Tikovsky, Nikita Danilenko)

Inf-MP-PS: Masterprojekt - Programmiersprachen und Programmiersysteme, 6 hrs Practical/Week,  
M. Hanus (+ F. Reck, Jan Rasmus Tikovsky)

MS0302: Übersetzerbau, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
Michael Hanus (+ Björn Peemöller)

*Winter 2013/2014*

Arbeitsgemeinschaft Informatik, Logik und Mathematik, 2 hrs Seminar/Week,  
M. Hanus (+ R. Berghammer)

MSS0303: Masterabschlusseminar - Programmiersprachen, 2 hrs Seminar/Week,  
M. Hanus

Inf-MS-Sem-PS: Programmiersprachen und Programmiersysteme, 2 hrs Seminar/Week,  
M. Hanus (+ F. Huch)

Inf-Prog: Programmierung, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
M. Hanus (+ Jan Rasmus Tikovsky, B. Peemöller, P. Munstermann)

MS0301: Prinzipien von Programmiersprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
M. Hanus (+ Björn Peemöller)

Inf-MP-PS: Masterprojekt - Programmiersprachen und Programmiersysteme, 6 hrs Practical/Week,  
Michael Hanus

NF-Inf-1: Informatik für Nebenfächler, 2 (+ 2) hrs Lecture (+ Exercises)/Week,  
Frank Huch (+ Fabian Skrlac, J. Piwonski)

NF-Inf-1: Informatik für Nebenfächler (vertiefend), 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
Frank Huch (+ Fabian Skrlac, J. Piwonski)

## Further Cooperation, Consulting, and Technology Transfer

During the reported period, the research group collaborated with

Sergio Antoy (Portland State University, USA)

Jan Christiansen

Sebastian Fischer

Daniel Seidel (Universität Bonn)

## Diploma, Bachelor's and Master's Theses

Torge Petersen, *Social Tagging und Folksonomies - ein Ansatz zur kollaborativen Indexierung*, 24.03.2013

Malte Hecht, *Erstellen einer Abstimmungssoftware für Vorlesungen*, 11.04.2013

Jan-Patric Baye, *Design and Implementation of Remote Function Invocation with Template Haskell*, 27.09.2013

Finn Teegen, *Implementation of a library for declarative, resolution-independent 2D graphics in Haskell*, 30.09.2013

Jan C. Gehrke, *Vergleich von Ansätzen zur Parallelisierung in Haskell*, 30.09.2013

Matthias Böhm, *Erweiterung von Curry um Typklassen*, 01.11.2013

Lukasz Rybinski, *Verteiltes Software-Transactional-Memory in Scala*, 02.09.2013

Niclas Flieger, *Uniwahlen - online*, 20.09.2013

Robert Zahnnow, *Uniwahlen - online*, 20.09.2013

## Publications

Published in 2013

Bernd Braßel, Michael Hanus, Björn Peemöller, Fabian Reck, *Implementing Equational Constraints in a Functional Language*, Proc. of the 15th International Symposium on Practical Aspects of Declarative Languages, PADL 2013, Springer LNCS 7752, 125 - 140 (2013)

Michael Hanus, *Functional Logic Programming: From Theory to Curry*, Programming Logics - Essays in Memory of Harald Ganzinger, Springer LNCS 7797, 123 - 168 (2013)

Michael Hanus, *Adding Plural Arguments to Curry Programs*, Theory and Practice of Logic Programming, 13 (4-5), (2013)

Jan Christiansen, Michael Hanus, Fabian Reck, Daniel Seidel, *A Semantics for Weakly Encapsulated Search in Functional Logic Programs*, Proc. of the 15th International Symposium on Principles and Practice of Declarative Programming, PPDP 2013, ACM Press, 49 - 60 (2013)

Michael Hanus, Fabian Reck, *A Generic Analysis Server System for Functional Logic Programs*, Proceedings of the 13th International Colloquium on Implementation of Constraint and Logic Programming Systems, CICLOPS 2013, (2013)

Michael Hanus, *Adding Plural Arguments to Curry Programs*, Ifl Research Report, 1304, (2013)

Michael Hanus, Ricardo Rocha, *Kiel Declarative Programming Days 2013*, IfI Technical Report, **1306**, (2013)

## Presentations

Fabian Reck, *Implementing Equational Constraints in a Functional Language*, 15th International Symposium on Practical Aspects of Declarative Languages, PADL 2013, Rome, Italy, 21.01.2013

Michael Hanus, *Adding Plural Arguments to Curry Programs*, 30th GI-Workshop Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2013

Fabian Reck, *Übersetzen durch Pretty Printing*, 30th GI-Workshop Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 06.05.2013

Sebastian Fischer, *“Putback” is the Essence of Bidirectional Programming*, 30th GI-Workshop Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 08.05.2013

Björn Peemöller, *Implementing Residuation in KiCS2*, 30th GI-Workshop Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 08.05.2013

Jan Rasmus Tikovsky, *Integration von FD-Constraints in KiCS2*, 30th GI-Workshop Programmiersprachen und Rechenkonzepte, Bad Honnef, Germany, 08.05.2013

Michael Hanus, *A Generic Analysis Server System for Functional Logic Programs*, 13th International Colloquium on Implementation of Constraint and Logic Programming Systems, Istanbul, Turkey, 25.08.2013

Michael Hanus, *Adding Plural Arguments to Curry Programs*, 29th International Conference on Logic Programming, Istanbul, Turkey, 27.08.2013

Fabian Reck, *A Semantics for Weakly Encapsulated Search in Functional Logic Programs*, 15th International Symposium on Principles and Practice of Declarative Programming (PPDP 2013), Madrid, Spain, 16.09.2013

## Further Activities and Events

M. Hanus: programme committee member of the Sixth Working Conference on Programming Languages (ATPS 2013), Aachen, February 2013 (part of the conference Software Engineering 2013)

M. Hanus: programme committee member of the 13th International Colloquium on Implementation of Constraint and Logic Programming Systems (CICLOPS 2013), Istanbul (Turkey), August 2013

M. Hanus: programme committee member of the 18th ACM SIGPLAN International Conference on Functional Programming (ICFP 2013), Boston (Massachusetts), September 2013

M. Hanus: programme committee chair of the 22th International Workshop on Functional and (Constraint) Logic Programming (WFLP 2013) and 27th Workshop on (Constraint) Logic Programming (WLP 2013), Kiel, September 2013

M. Hanus: organization of the Kiel Declarative Programming Days 2013, unifying the 20th International Conference on Applications of Declarative Programming and Knowledge Management (INAP 2013), the 22th International Workshop on Functional and (Constraint) Logic Programming (WFLP 2013), and the 27th Workshop on (Constraint) Logic Programming (WLP 2013), Kiel, September 2013

M. Hanus: programme committee member of the Seventh Working Conference on Programming Languages (ATPS 2014), Aachen, February 2014 (part of the conference Software Engineering 2014)

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

M. Hanus: chair of the steering committee of the ACM SIGPLAN Symposia on Principles and Practice of Declarative Programming

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: member of the executive board of the „Fakultätentag Informatik der Bundesrepublik Deutschland“

M. Hanus: chair of the selection committee of the award for the best diploma or master thesis in computer science in Germany 2013

M. Hanus: member of the selection committee of the b + m-Preis Software- und Systems-Engineering 2013

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

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

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

F. Huch: organization of the 30th Workshop of the GI-Fachgruppe Programmiersprachen und Rechenkonzepte, Bad Honnef (Germany), May 2013

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

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