

# Realtime Systems / Embedded Systems

Our research interest is the systematic design and analysis of “computers, that are not perceived as such” - which is one definition of *embedded systems*. These systems appear in all contexts of daily life, from miniaturized hearing aids to x-ray scanners, cell phones, airbag controllers, anti-lock brakes to fly-by-wire aircrafts. Such systems not only have to provide the correct outputs to the environment, they also have to provide these in time. In other words, these are *real-time systems*. Of particular interest are for us the *reactive systems*, which continuously react to (mainly discrete) input events of the environment with corresponding output events.

The number of embedded real-time systems today exceeds by far the number of “classical” computers. However, this area is still a comparatively new field within computer science. In the past, such systems have been primarily developed by application experts without a specific computer science background. However, because of the ever-increasing complexity of today’s applications, this becomes less and less practical.

## Results

Current research activities concentrate on the development of reactive embedded real-time systems. Key areas are

- The model-based design of complex embedded real-time systems
- Reactive processors.

The activities on the **model-based design of complex embedded real-time systems** concentrate on the *modeling pragmatics*, that is, the practical aspects of creating, maintaining and visualizing graphical system models. The Kiel Integrated Environment for Layout (KIEL) is a prototypical modeling environment that serves as a test bed to explore and validate novel modeling approaches. A key enabler is the ability to automatically compute the layout of graphical models. This frees the user from the tedious task of manually drawing diagrams, and allows novel techniques such as customized views during simulation. KIEL has been in development since about 2004, and has demonstrated a number of approaches for creating Statecharts. In 2008, developments have begun on a successor project, KIEL for the Eclipse Rich Client Platform (KIELER). KIELER aims to extend KIEL in several ways regarding modeling languages and modeling paradigms.

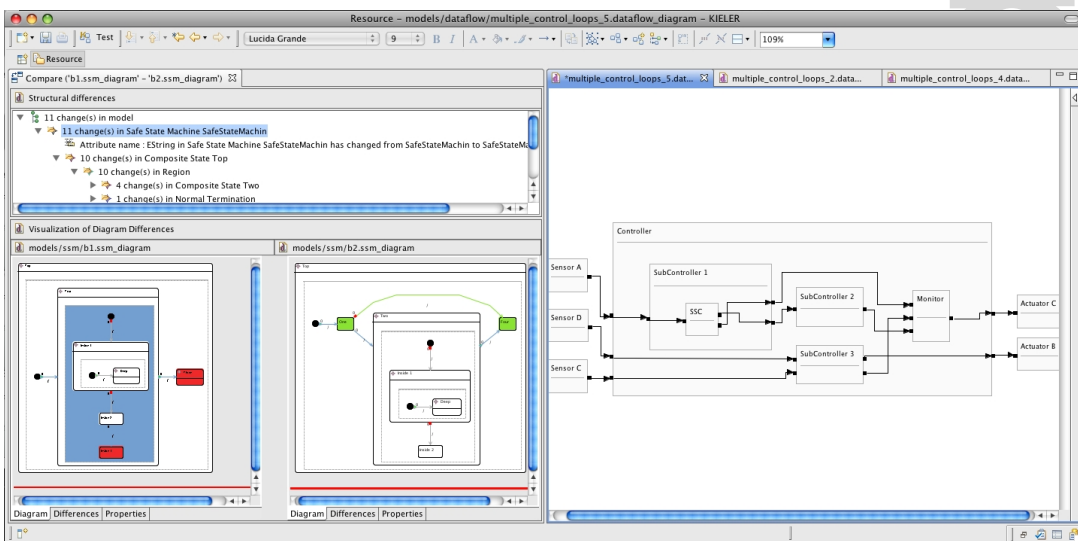


Fig. 1: KIELER showing a graphical modell diff (left) and an auto-layout dataflow diagram (right).

**Reactive Processors** aim to implement reactive behavior with deterministic behavior and minimal resource usage. The Kiel Esterel Processor (KEP) is a reactive processor that supports concurrency through multithreading and offers highly predictable timing at minimal power consumption. In 2008, we have completed an Esterel implementation of the KEP and presented a framework for the analysis of the Worst Case Reaction Time. Furthermore, the reactive processing family has been extended by the Kiel Lustre Processor (KLEP) and the Kiel Reactive Processor (KREP).



Fig. 2: Excursions to b+m Informatik AG, Melsdorf, and Funkwerk Information Technologies GmbH, Kiel Wellsee.

## Personnel

Head of the group: Prof. Dr. Reinhard von Hanxleden; Secretary: Maren Lutz (50%), Gesa Walsdorf (50%)

Technical Staff: Tim Grebien (50%)

Scientific Staff:

Dipl.-Inf. Hauke Fuhrmann	01.01.-31.12.2008	Landesmittel
Dr. rer nat. Jan Lukoschus ELBASYS	01.01.-31.12.2008	Drittmittel
Dipl.-Inf. Steffen Prochnow	01.01.-31.07.2008	Landesmittel
Dipl.-Inf. Claus Traulsen	01.01.-31.12.2008	Landesmittel

## Lectures, Seminars, and Laboratory Course Offers

*Winter 2007/2008*

Softwarepraktikum, 3 hrs Lab/Week,  
R. von Hanxleden (+ C. Traulsen, K. Haase)

Vertiefende Übung UML Modellierung für graphische Modelle, 4 hrs Lab/Week,  
R. von Hanxleden (+ H. Fuhrmann)

Vertiefende Übung UML Modellierung für graphische Modelle, 8 hrs Lab/Week,  
R. von Hanxleden (+ H. Fuhrmann)

Vertiefende Übung Anwendung reaktiver Prozessoren Fortgeschrittenenpraktikum, 4 hrs Lab/Week,  
R. von Hanxleden (+ C. Traulsen)

Seminar Empirische Forschungsmethoden in der Softwaretechnik, 2 hrs Seminar/Week,  
R. von Hanxleden (+ S. Prochnow)

Oberseminar Echtzeitsysteme/Eingebettete Systeme, 2 hrs Seminar/Week,  
R. von Hanxleden

### Summer 2008

Systemorientierte Informatik II - Organisation und Architektur von Rechnern, 3 (+ 2) hrs Lecture (+ Exercises)/Week,  
R. von Hanxleden (+ H. Fuhrmann)

Softwarepraktikum, 3 hrs Lab/Week,  
R. von Hanxleden (+ C. Traulsen, H. Peters)

Synchrone Sprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
R. von Hanxleden (+ C. Traulsen)

Seminar Synchrone Sprachen, 2 hrs Seminar/Week,  
R. von Hanxleden (+ C. Traulsen)

Oberseminar Echtzeitsysteme/Eingebettete Systeme, 2 hrs Seminar/Week,  
R. von Hanxleden (+ S. Prochnow)

### Winter 2008/2009

Entwurf eingebetteter Echtzeitsysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,  
R. von Hanxleden (+ H. Fuhrmann)

Vertiefende Übung Synchrone Sprachen, 4 hrs Exercise/Week,  
R. von Hanxleden (+ C. Traulsen)

Vertiefende Übung Synchrone Sprachen, 8 hrs Exercise/Week,  
R. von Hanxleden (+ C. Traulsen)

Seminar Eclipse Technologien, 2 hrs Seminar/Week,  
R. von Hanxleden (+ H. Fuhrmann)

Oberseminar Echtzeitsysteme/Eingebettete Systeme, 2 hrs Seminar/Week,  
R. von Hanxleden

### Third-Party Funds

Airbus Deutschland GmbH, *Elektrische Basissysteme in einem CFK-Rumpf (ELBASYS)*, 16.09.2007-30.09.2008  
(153000)

### Further Cooperation, Consulting, and Technology Transfer

Cooperation with EADS Airbus, Hamburg, on the model-based design of distributed, time-triggered architectures.

Cooperation with Philips Medical Systems GmbH, Hamburg, on the model-based design of medical applications.

### Diploma, Bachelor and Master Theses

Steffen Jacobs, *Automatisierte Validierung von IMA-Konfigurationen*, 24.01.2008

Malte Tiedje, *Beschreibung des Kiel Esterel Prozessors in Esterel*, 29.01.2008

Jonas Voelcker, *Kognitive Aspekte bei der Erstellung von Statecharts*, 04.05.2008

Arne Schipper, *Layout and Visual Comparison of Statecharts*, 18.12.2008

Steffen Prochnow, *Efficient Development of Complex Statecharts*, 08.05.2008


**Publications**

Published in 2008

- M. Boldt, C. Traulsen, R. von Hanxleden, *Worst Case Reaction Time Analysis of Concurrent Reactive Programs*, Electronic Notes in Theoretical Computer Science, **203(4)**, 65 - 79 (2008)
- C. Brooks, T. Huining Feng, E. Lee, R. von Hanxleden, *Multimodeling: A Preliminary Case Study*, UCB/Eecs-2008-7, EECS Department, University of California, Berkeley, (2008)
- C. Brooks, P. Chih-Hong, T. Huining Feng, E. Lee, R. von Hanxleden, *Model Engineering using Multimodeling*, UCB/Eecs-2008-39, EECS Department, University of California, Berkeley, (2008)
- C. Brooks, P. Chih-Hong, T. Huining Feng, E. Lee, R. von Hanxleden, *Model Engineering using Multimodeling*, Proceedings of the 1st International Workshop on Model Co-Evolution and Consistency Management (MCCM'08), a workshop at MODELS'08, Toulouse, (2008)
- R. von Hanxleden, *On the Pragmatics of Model-Based Design - Position Statement*, Pre-Proceedings of the 15th International Monterey Workshop on Foundations of Computer Software, Future Trends and Techniques for Development, (2008)
- F. Maraninchi, M. Moy, J. Cornet, L. Mailet-Contoz, C. Helmstetter, C. Traulsen, *SystemC/TLM Semantics for Heterogeneous System-on-Chip Validation*, Joint IEEE-NEWCAS and TAISA Conference, (2008)
- M. Tiedje, C. Traulsen, R. von Hanxleden, *Designing a Reactive Processor with Esterel v7*, Proceedings of the Workshop on Model-Driven High-Level Programming of Embedded Systems (SLA+ + P'08), (2008)


**Presentations**

- R. von Hanxleden, *A Multi-Threaded Reactive Processor*, Colloquium of the Department of Computer Science, Kaiserslautern University, Kaiserslautern, 21.01.2008
- R. von Hanxleden, *A Multi-Threaded Reactive Processor*, Colloquium of VERIMAG Grenoble, Grenoble, France, 25.04.2008
- C. Traulsen, M. Tiedje, *Designing a Reactive Processor with Esterel v7*, Workshop on Model-Driven High-Level Programming of Embedded Systems (SLA+ + P'08), Budapest, Hungary, 05.04.2008
- F. Maraninchi, M. Moy, J. Cornet, L. Mailet-Contoz, C. Helmstetter, C. Traulsen, *SystemC/TLM Semantics for Heterogeneous System-on-Chip Validation*, 2008 Joint IEEE-NEWCAS and TAISA Conference, Montreal, Canada, 22.-25.06.2008
- H. Fuhrmann, *Visual Modeling of Complex Systems - The KIELER Approach*, Ptolemy group presentation, Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, Berkeley, USA, 24.09.2008
- R. von Hanxleden, *On the Pragmatics of Model-Based Design - Position Statement*, 15th International Monterey Workshop on Foundations of Computer Software, Future Trends and Techniques for Development, Budapest, Hungary, 22.-26.09.2008
- R. von Hanxleden, *The Kiel Esterel Processor - Predictable, Light-Weight Execution of Esterel*, Esterel Consortium Meeting, Juan les Pins, France, 20.11.2008
- C. Traulsen, M. Mendler, R. von Hanxleden, *The Kiel Lustre Processor*, 15th International Open Workshop on Synchronous Programming (SYNCHRON'08), Aussois, France, 01.-05.12.2008
- R. von Hanxleden, *Mehr als Null und Eins - wie kommen Zahlen in den Computer?*, Saturday Morning Physics, CAU, 29.11.2008

 Further Activities and Events

Excursion to b+ m Informatik AG, Melsdorf (14.03.2008).

Presentation of the model railway at the Girls' Day (C. Traulsen, 24.04.2008).

Excursion to Funkwerk Information Technologies GmbH, Kiel Wellsee (15.07.2008).

Presentation of Lego Mindstorms rover at the CinemaxX for the opening of the Pixar movie Wall-E (T. Grebien and J. Lukoschus, 27.09.2008).

Presentation of the automatic pinball machine at the Schleswig Holstein Tag, Neumünster (M. Tiedje and most other members of the group, 11.07. - 14.07.2008).

Presentation on embedded real-time systems at the *Schnupperstudium* (C. Traulsen, 21.10.2008).

Invited speaker to departmental colloquium: Prof. Edward A. Lee, University of California at Berkeley, *Model Engineering* (14.11.08).

**H. Fuhrmann:**

Research visit to the Department of Electrical Engineering and Computer Sciences, University of California at Berkeley (13.09. - 22.10.2008).

**R. von Hanxleden, C. Traulsen:**

Members of the *IEEE Esterel v7 Standardization Working Group*.

Reviewers for *Science of Computer Programming*, the *EURASIP Journal on Embedded Systems*, and the *ACM Transactions on Design Automation of Electronic Systems*.