

## Real Time Systems / Embedded Systems

The research interest of the RTSYS group is the systematic design and analysis of „computers, which are not perceived as such“ , which is one definition of *embedded systems*. These systems appear in all contexts of daily life: miniaturized hearing aids, x-ray scanners, cell phones, airbag controllers, anti-lock brakes, fly-by-wire aircraft. 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 for us are the *reactive systems*, which continuously react to (mainly discrete) input events of the environment with corresponding output events.

### Results

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

- The model-based design of complex reactive systems,
- Reactive processors, and
- Deterministic concurrency and synchronous languages.

The activities on the **model-based design of complex reactive systems** concentrate on the *modelling pragmatics*, that is, the practical aspects of creating, maintaining and visualizing graphical system models. The Kiel Integrated Environment for Layout Eclipse Rich Client (KIELER) is a prototypical modelling environment that serves as a test bed to explore and validate novel modelling 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. Novel developments in 2010 include capabilities for the automatic layout of UML class diagrams, and a new graph editor with a graph analysis framework for assistance of algorithm engineering. KIELER's layout capabilities have also been added to UC Berkeley's Ptolemy system. KIELER is also an integral part of the MENGES project, which aims to develop a model-driven software toolchain for a new type of electronic railway control centre. The project started in January 2010 and will last to December 2012. MENGES is funded by the ZPW (*Zukunftsprogramm Wirtschaft*), a program to support research and development in Schleswig-Holstein. Project partners are Funkwerk Information Technologies GmbH, Kiel, b + m Informatik AG, Melsdorf and the groups for Software Engineering (Prof. Hasselbring) and for Real-Time and Embedded Systems of Christian Albrechts University Kiel. MENGES is one of the initial projects associated with the Competence Federation Software Systems Engineering (*Kompetenzverbund Software Systems Engineering, KoSSE*).

**Reactive Processors** aim to implement reactive behaviour with deterministic behaviour 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 2010, developments focused on compilation for the Kiel Lustre Processor, a reactive processor for the synchronous data-flow language Lustre.

The major result in the area **deterministic concurrency and synchronous languages** is the development of *Synchronous C (SC)* and *Synchronous Java (SJ)*, which are light-weight mechanisms to embed deterministic concurrency in C and Java. SC and SJ are inspired by the reactive processing paradigm, but are implemented as macros/classes expressed in standard C/Java, available as open-source code. In 2010, the main developments were a first working prototype for SJ, and an improved, more structured syntax for SC (developed in cooperation with UC Berkeley).

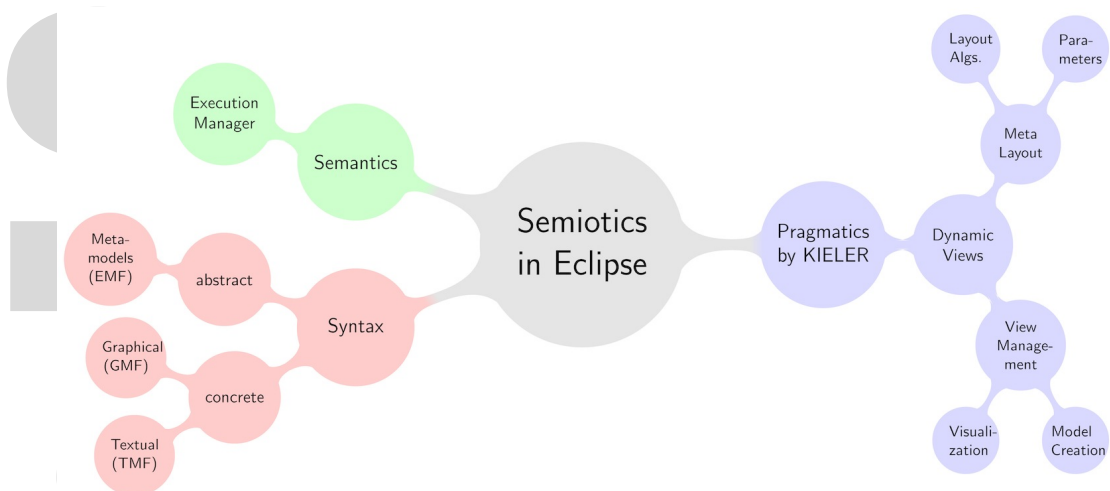


Fig. 1: A mind map illustrating how the KIELER modelling environment is positioned in the Eclipse context [from Fuhrmann/v. Hanxleden, MODELS'10]. KIELER focuses on pragmatics, which together with syntax and semantics constitutes the field of semiotics.

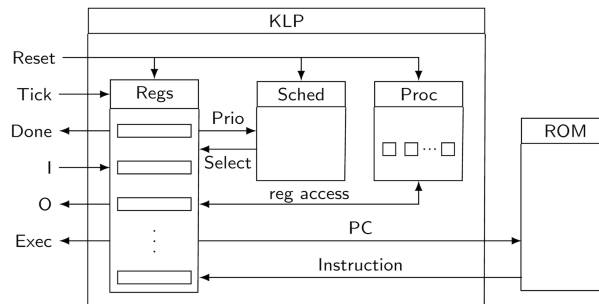


Fig. 2: Architectural overview of the Kiel Lustre Processor [from Traulsen/v. Hanxleden, SAC'10]. A priority-based scheduler interacts with a set of processors, to exploit maximal parallelism while still respecting data dependencies.

## Personnel

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

Technical Staff: Tim Grebien (50%)

Scientific Staff:

Dipl.-Inf. Hauke Fuhrmann	01.01.-30.09.2010	Landesmittel
Dipl.-Inf. Hauke Fuhrmann MENGES	01.10.-31.12.2010	Drittmittel
Dipl.-Inf. Christian Motika MENGES	01.01.-31.03.2010	Drittmittel
Dipl.-Inf. Christian Motika	01.04.-31.12.2010	Landesmittel
Dipl.-Inf. Jens Schönborn	01.-31.12.2010	Landesmittel
Dipl.-Inf. Miro Spönemann	01.01.-31.12.2010	Landesmittel



Fig. 3: Final Mindstorms Contest, in the class *Design of Embedded Real-Time Systems* held in the summer semester 2010 (07.07).

Dipl.-Inf. Claus Traulsen

01.01.-31.03.2010

Landesmittel

## Lectures, Seminars, and Laboratory Course Offers

### *Winter 2009/2010*

MS1102: - Synchrone Sprachen, 4 hrs Vorlesung/Week,  
Reinhard von Hanxleden

Übung zu: Synchrone Sprachen, 2 hrs Übung/Week,  
Reinhard von Hanxleden (+ Claus Traulsen)

A5.3.3: Fortgeschrittenenpraktikum - Echtzeitsysteme/Eingebettete Systeme (Modellierung in Eclipse), 4 hrs Exercise/Week,  
Reinhard von Hanxleden (+ Miro Spönemann, Hauke Fuhrmann)

MSS1101: Seminar - Echtzeitsysteme/Eingebettete Systeme (Modellierung und Ausführung Nebenläufiger Systeme), 2 hrs Seminar/Week,  
Reinhard von Hanxleden (+ Miro Spönemann, Hauke Fuhrmann)

Oberseminar, 2 hrs Seminar/Week,  
Reinhard von Hanxleden

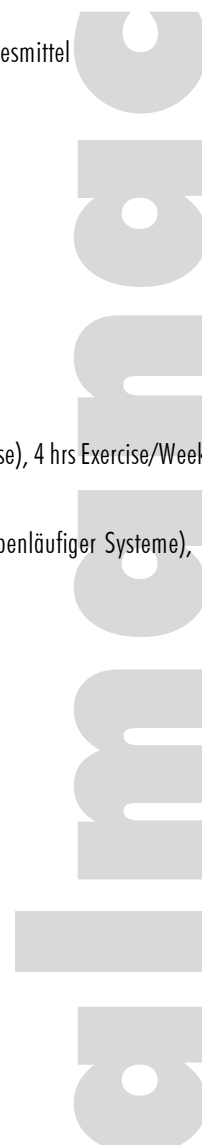
### *Summer 2010*

Inf-OAR: Organisation und Architektur von Rechnern, 3 hrs Vorlesung/Week,  
Reinhard von Hanxleden (+ Hauke Fuhrmann)

Übung zu: Organisation und Architektur von Rechnern, 2 hrs Übung/Week,  
Hauke Fuhrmann (+ Miro Spönemann)

WI20: Entwurf eingebetteter Echtzeitsysteme, 4 hrs Vorlesung/Week,  
Reinhard von Hanxleden

Übung zu: Entwurf eingebetteter Echtzeitsysteme, 2 hrs Übung/Week,  
Christian Motika



Fortgeschrittenenpraktikum - Echtzeitsysteme/Eingebettete Systeme (Layout-Algorithmen), 4 hrs Praktikum/Week,  
Reinhard von Hanxleden (+ Hauke Fuhrmann, Miro Spönemann)

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme (Layout-Algorithmen), 4 hrs Masterprojekt/Week,  
Reinhard von Hanxleden (+ Miro Spönemann, Hauke Fuhrmann)

WI24: Wahlpflichtmodul Informatik - Modellbasierter Entwurf (Layout-Algorithmen), 2 hrs Seminar/Week,  
Reinhard von Hanxleden (+ Miro Spönemann, Hauke Fuhrmann)

MSS1101: Seminar - Echtzeitsysteme/Eingebettete Systeme (Synchrone Sprachen), 2 hrs Seminar/Week,  
Reinhard von Hanxleden (+ Christian Motika)

Oberseminar, 2 hrs Seminar/Week,  
Reinhard von Hanxleden

### Winter 2010/2011

Inf-BS: Betriebssysteme, 3 hrs Vorlesung/Week,  
Reinhard von Hanxleden

Übung zu: Betriebssysteme, 2 hrs Übung/Week,  
Reinhard von Hanxleden (+ Hagen Peters, Christian Motika)

MS1101: Modellierung nebenläufiger Systeme, 4 hrs Vorlesung/Week,  
Reinhard von Hanxleden (+ Rudolf Berghammer)

Übung zu: Modellierung nebenläufiger Systeme, 2 hrs Übung/Week,  
Reinhard von Hanxleden (+ Miro Spönemann)

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme, 4 hrs Übung/Week,  
Reinhard von Hanxleden (+ Miro Spönemann, Christian Motika)

MSS1101: Seminar - Echtzeitsysteme/Eingebettete Systeme, 2 hrs Seminar/Week,  
Reinhard von Hanxleden (+ Christian Motika)

Oberseminar - Echtzeitsysteme und Eingebettete Systeme, 2 hrs Seminar/Week,  
Reinhard von Hanxleden

### Third-Party Funds

Zukunftsprogramm Wirtschaft (ZPW), *Modellbasierte Entwurfsmethoden für eine neue Generation elektronischer  
Stellwerke (MENGENS)*, 01.08.2009-31.07.2012 (217.560 EUR)

DAAD Programm des Projektbezogenen Personenaustauschs (PPP) USA, *Model Engineering and Predictable Processing*,  
01.01.2010-31.12.2011 (15.318 EUR)

### Further Cooperation, Consulting, and Technology Transfer

Cooperation with Edward A. Lee, University of California, Berkeley, on the automatic layout of Ptolemy II diagrams and simulation of SyncCharts (funded by DAAD PPP).

Cooperation with the Software Engineering group (Prof. Hasselbring), b+m Informatik AG and Funkwerk Information Technologies GmbH on the model-based design of railway signalling applications (project MENGENS).

Cooperation with ETAS/Bosch, on visual model exploration. Advisorship (R. v. Hanxleden) of a doctoral researcher (Matthias Schmeling, graduate of the CAU) at ETAS.

Cooperation with Michael Mandler, Bamberg University, on worst case reaction time analysis.

Cooperation with Petra Mutzel, University of Dortmund, on layout algorithms with port constraints.

Cooperation with Partha Roop and Sidharta Andalarn, University of Auckland, New Zealand, on reactive processors and timing analysis.

Cooperation with CEA List (Saclay, Paris), on pragmatics of UML2 modelling.

Cooperation with the Daimler Center for Automotive IT Innovations (Berlin), on the automatic layout of Simulink diagrams.

## Diploma, Bachelor and Master Theses

Sören Hansen, (*Bachelor Thesis*) *Configurations and Automated Execution in the KIELER Execution Manager*, 24.03.2010

Michael Matzen, (*Diploma Thesis*) *A Generic Framework for Structure-Based Editing of Graphical Models in Eclipse*, 26.03.2010

Adriana Lukaschewitz, (*Bachelor Thesis*) *Transformation von Esterel nach SyncCharts in KIELER*, 30.03.2010

Matthias Schmeling, (*Diploma Thesis*) *A Graphical Editor for IEC 61499 Function Blocks*, 17.04.2010

Torsten Amende, (*Diploma Thesis*) *Synthese von SC-Code aus SyncCharts*, 22.05.2010

Joachim Bleidiessel, (*Diploma Thesis*) *A Domain Specific Language for Railway Control*, 20.09.2010

Ole Claußen, (*Bachelor Thesis*) *Implementing an Algorithm for Orthogonal Graph Layout*, 29.09.2010

Philipp Döhring, (*Bachelor Thesis*) *Algorithmen zur Layerzuweisung*, 29.09.2010

Christian Kutschmar, (*Bachelor Thesis*) *Planarisierung von Hypergraphen*, 29.09.2010

John Carstens, (*Bachelor Thesis*) *Datenvisualisierung in grafischen Modellen*, 30.09.2010

Mirko Heinold, (*Bachelor Thesis*) *Synchronous Java*, 30.09.2010

Paul Klose, (*Bachelor Thesis*) *Beispiel Management in KIELER*, 30.09.2010

Martin Rieß, (*Bachelor Thesis*) *A Graph Editor for Algorithm Engineering*, 30.09.2010

Niclas Köser, (*Diploma Thesis*) *SyncCharts in C auf Multicore*, 20.10.2010

## Dissertations / Postdoctoral Lecture Qualifications

Claus Traulsen, *Reactive Processing for Synchronous Languages and its Worst Case Reaction Time Analysis*, 26.02.2010

## Publications

Published in 2010

H. Fuhrmann, M. Spönemann, M. Matzen, R. von Hanxleden, *Automatic Layout and Structure-Based Editing of UML Diagrams*, Proceedings of the 1st Workshop on Model Based Engineering for Embedded Systems Design, (2010)

C. Traulsen, R. von Hanxleden, *Reactive Parallel Processing for Synchronous Dataflow*, Proceedings of the 25th Symposium On Applied Computing (SAC'10), Special Track Embedded Systems: Applications, Solutions, and Techniques. Sierre, Switzerland, (2010)

C. Traulsen, T. Amende, R. von Hanxleden, *Compiling SyncCharts to Synchronous C*, Technical Report 1006, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, Kiel, Germany, (2010)

C. Motika, H. Fuhrmann, R. von Hanxleden, *Semantics and Execution of Domain Specific Models*, 2nd Workshop Methodische Entwicklung von Modellierungswerkzeugen (MEMWe 2010) at conference INFORMATIK 2010, GI-Edition - Lecture Notes in Informatics (LNI), Bonner Köllen Verlag. Leipzig, Germany, (2010)

M. Spönemann, H. Fuhrmann, R. von Hanxleden, P. Mutzel, *Port Constraints in Hierarchical Layout of Data Flow Diagrams*, Proceedings of the 17th International Symposium on Graph Drawing (GD'09), volume 5849 of LNCS, Springer, 135 - 146 (2010)

X. Li, R. von Hanxleden, *Multi-Threaded Reactive Programming - The Kiel Esterel Processor*, IEEE Transactions on

Computers, preprint, (2010)

- H. Fuhrmann, R. von Hanxleden, *Taming Graphical Modeling*, Proceedings of the ACM/IEEE 13th International Conference on Model Driven Engineering Languages and Systems (MoDELS'10), LNCS, Oslo, Norway, Springer, (2010)
- H. Fuhrmann, R. von Hanxleden, *Taming Graphical Modeling*, Technical Report 1003, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, (2010)
- H. Fuhrmann, R. von Hanxleden, *On the Pragmatics of Model-Based Design*, Foundations of Computer Software. Future Trends and Techniques for Development - 15th Monterey Workshop 2008, Budapest, Hungary, September 24-26, 2008, Revised Selected Papers, volume 6028 of LNCS, (2010)
- M. Chimani, C. Gutwenger, P. Mutzel, M. Spönemann, H. Wong, *Crossing Minimization and Layouts of Directed Hypergraphs with Port Constraints*, Proceedings of the 18th International Symposium on Graph Drawing (GD'10), LNCS, Springer, (2010)

## Presentations

- C. Motika, *KlePto - KIELER Leveraging Ptolemy Semantics - Executing SyncCharts with Ptolemy*, Presentation at the Ptolemy group, Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, Berkeley, USA, 09.03.2010
- H. Fuhrmann, M. Spönemann, M. Matzen, R. von Hanxleden, *Automatic Layout and Structure-Based Editing of UML Diagrams*, Proceedings of the 1st Workshop on Model Based Engineering for Embedded Systems Design (M-BED 2010), Dresden, Dresden, Germany, 12.03.2010
- H. Fuhrmann, C. Motika, *Metamodeling, Transformation and Code Generation in Eclipse*, Presentation and interactive demo at the Ptolemy group, Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, Berkeley, USA, 16.03.2010
- C. Traulsen, R. von Hanxleden, *Reactive Parallel Processing for Synchronous Dataflow*, Proceedings of the 25th Symposium On Applied Computing (SAC'10), Special Track Embedded Systems: Applications, Solutions, and Techniques, Sierre, Switzerland, 22.-26.03.2010
- R. von Hanxleden, *Modellieren statt Malen - Ein pragmatischer Ansatz*, Computer Science and Transport Symposium Kiel, Kiel, Germany, 05.05.2010
- J. Bleidiessel, *On the Pragmatics of Model-Based Design— The KIELER Approach*, Invited presentation at the Irkutsk State University, Irkutsk, Russia, 26.05.2010
- M. Spönemann, *Pragmatik modellgetriebener Systementwicklung*, Modellierung@CAU, Kiel, Germany, 20.07.2010
- R. von Hanxleden, *Lightweight and Deterministic Concurrency and Preemption in C and Java*, Robotics and Embedded Systems Seminar, UC Berkeley, Berkeley, USA, 15.09.2010
- C. Motika, *Simulating SyncCharts and Actor-Oriented Modeling in KIELER*, Presentation and interactive demo at the Ptolemy group, Department of Electrical Engineering and Computer Sciences, University of California at Berkeley, Berkeley, USA, 21.09.2010
- C. Motika, H. Fuhrmann, R. von Hanxleden, *Semantics and Execution of Domain Specific Models*, 2nd Workshop Methodische Entwicklung von Modellierungswerkzeugen (MEMWe 2010) at conference INFORMATIK 2010, GI-Edition - Lecture Notes in Informatics (LNI), Bonner Köllen Verlag, Leipzig, Germany, 29.09.2010
- H. Fuhrmann, R. von Hanxleden, *Taming Graphical Modeling*, Proceedings of the ACM/IEEE 13th International Conference on Model Driven Engineering Languages and Systems (MoDELS'10), LNCS, Oslo, Norway, Springer, Oslo, Norway, 03.-08.10.2010
- C. Schneider, G. Hoops, W. Goerigk, *Integration von textueller und grafischer Modellierung - Pragmatik in MENGES*, KoSSE-Workshop, Lübeck, Germany, 10.11.2010
- R. von Hanxleden, H. Fuhrmann, *Taming Graphical Modeling*, Presentation at the 17th International Open Workshop on Synchronous Programming (SYNCHRON'10), Frejus, France, 29.11.-03.12.2010
- C. Motika, *Executing SyncCharts with Ptolemy*, 17th International Open Workshop on Synchronous Programming

(SYNCHRON'10), Frejus, France, 29.11.-03.12.2010

## Further Activities and Events

**H. Fuhrmann, C. Motika, C. Schneider, M. Spönemann:**

reviewer for the *International Conference on Embedded Software* (EMSOFT).

**R. von Hanxleden:**

member of the *ArtistDesign European Network of Excellence on Embedded System Design*. Program Committee member for the *International Conference on Embedded Software* (EMSOFT) and for the workshop *Methodische Entwicklung von Modellierungswerkzeugen*. Reviewer for the *ACM Transactions on Embedded Computing Systems*, the *Design Automation for Embedded Systems Journal*, and the *European Symposium on Programming* (ESOP).

**C. Motika, C. Schneider:**

demonstration of the model-railway, Girls' Day 2010 (22.04.) and the Schnupperstudium (20.10.)

**J. Schönborn, M. Spönemann:** reviewer for the ACM SIGPLAN/SIGBED Conference on Languages, Compilers and Tools for Embedded Systems (LCTES).

**C. Traulsen:**

reviewer for the *Design Automation for Embedded Systems Journal* and for the *Microprocessors and Microsystems Journal*.

**Atin Ruia (Jadavpur University, India):**

DAAD-WISE scholarship, for summer internship at the RTSYS group 01.06. - 31.07.