

Real Time Systems / Embedded Systems

The research interest of the RTSYS group 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: miniaturized hearing aids, x-ray scanners, mobile 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 the outputs promptly. In other words, these are *real-time systems*. Of particular interest for us are *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:

- Pragmatics-aware model-based design of complex reactive systems,
- Automatic layout of graphical models, and
- Deterministic concurrency and synchronous languages.

The **pragmatics-aware model-based design** concentrates on the practical aspects of creating, maintaining, and visualizing graphical system models, with the goal of enhanced designer effectiveness and productivity. 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. 2013 saw major enhancements in the automatic generation of light-weight, transient views of model components, the development of technologies for web-based diagram synthesis and layout, as well as the integration of SC Charts modelling and simulation. In 2010 KIELER’s layout capabilities were integrated into UC Berkeley’s Ptolemy system and have since been used by a whole range of other projects. A user survey conducted in 2013 showed a high degree of satisfaction.

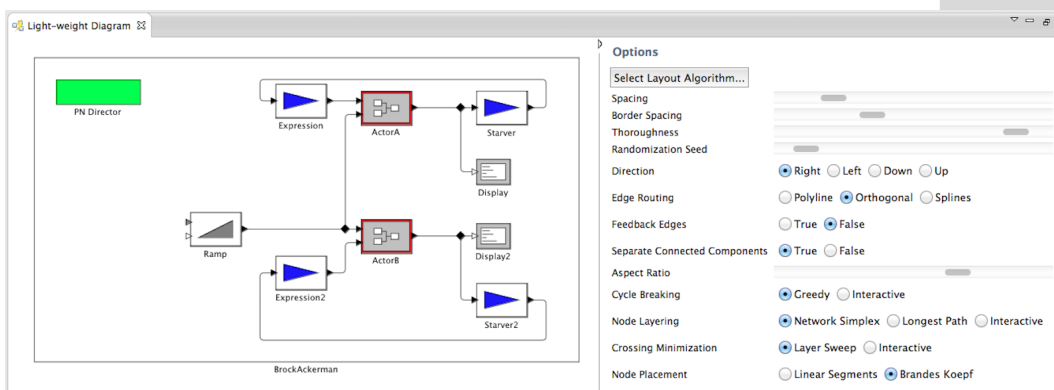
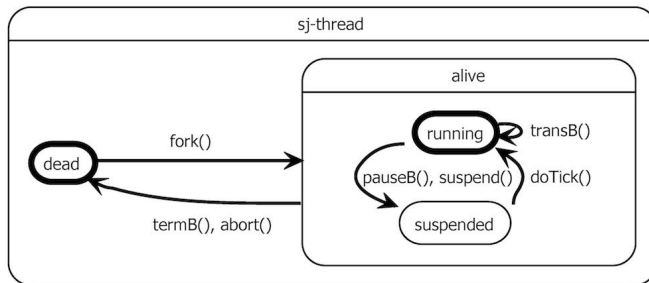


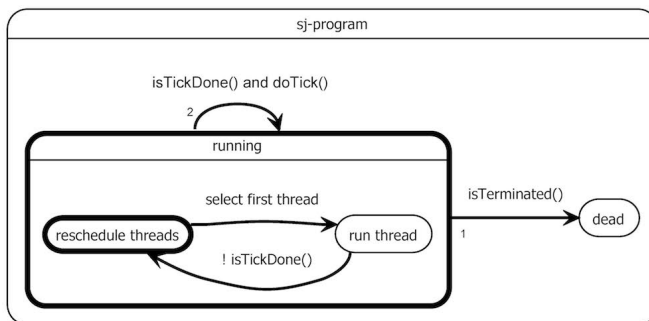
Fig. 1: A process network diagram imported from the Ptolemy project (UC Berkeley) rendered in KIELER/LighD, with sliders and buttons for direct manipulation of layout options (adapted from [Spönemann et al. 2013])

In the area of **deterministic concurrency and synchronous languages** we have concentrated on *Sequential Constructiveness* (SC). This model of computation (MoC) combines deterministic, synchronous concurrency with sequential scheduling information inherent in traditional programming languages such as C or Java. This builds on a large body of

theoretical work that has emerged from the synchronous programming community since the 1980s, but is also of practical interest for designing safety-critical systems. It has emerged from a collaboration with colleagues working in theoretical computer science, notably Prof. Michael Mendler (U Bamberg), and with industrial users, notably National Instruments. Two languages that use the SC MoC are *Synchronous Java* and the graphical *SCCharts* language, a dialect of statecharts.



(a) Life cycle of an individual SJ thread



(b) Life cycle of a complete SJ program

Fig. 2: State diagrams for the reactive life cycle of a Synchronous Java (SJ) program and its individual threads [Motika et al. 2013].

Personnel

Head of the group: Prof. Dr. R. von Hanxleden; Secretary: G. Walsdorf (50%)

Technical Staff: Dipl.-Inf. T. Grebien (50%)

Scientific Staff:

| | | |
|------------------------------------|-------------------|------|
| Dipl.-Inf. Insa Fuhrmann PRETSY | 01.01.-31.12.2013 | DFG |
| Dipl.-Inf. C. Motika | 01.01.-31.12.2013 | Land |
| Dipl.-Inf. C. D. Schulze | 01.01.-31.12.2013 | Land |
| Dipl.-Inf. M. Spönemann | 01.01.-31.12.2013 | Land |

Lectures, Seminars, and Laboratory Course Offers

Winter 2012/2013

Inf-AP-ES: Abschlussprojekt - Echtzeitsysteme/Eingebettete Systeme (Eclipse Modeling), 6 hrs Practical/Week, W. Hasselbring (+ M. Spönemann, C. D. Schulze)



Fig. 3: "Mindstorms Contest" in the class Embedded System Design (26.06.2013).

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme (Eclipse Modeling), 4 hrs Practical/Week,
W. Hasselbring (+ M. Spönemann, C. D. Schulze)

Summer 2013

Inf-EmSysDes: Embedded System Design, 2 (+ 1) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden (+ C. Motika)

Inf-EntEinSys: Entwurf eingebetteter Echtzeitsysteme, 4 (+ 2) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden (+ C. Motika)

Inf-OAR: Organisation und Architektur von Rechnern, 3 (+ 1) hrs Lecture (+ Exercises)/Week,
R. von Hanxleden (+ M. Spönemann, C. D. Schulze)

BA6.1: Projektmodul - Echtzeitsysteme/Eingebettete Systeme (Layout), 6 hrs Practical/Week,
R. von Hanxleden (+ M. Spönemann, C. D. Schulze)

MSP1101: Masterprojekt - Echtzeitsysteme/Eingebettete Systeme (Layout), 4 hrs Practical/Week,
R. von Hanxleden (+ M. Spönemann, C. D. Schulze)

Inf-Sem-Echtz: Bachelorseminar Echtzeitsysteme/Eingebettete Systeme (Layout), 2 hrs Seminar/Week,
R. von Hanxleden (+ M. Spönemann, C. D. Schulze)

MSS1101: Seminar - Echtzeitsysteme / Eingebettete Systeme (Layout), 2 hrs Seminar/Week,
R. von Hanxleden (+ M. Spönemann, C. D. Schulze)

MSS1102: Masterabschlussseminar - Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,
R. von Hanxleden

Winter 2013/2014



MS1102: Synchrone Sprachen, 4 (+ 2) hrs Lecture (+ Exercises)/Week,

R. von Hanxleden (+ C. Motika)

Inf-Sem-Echtz: Bachelorseminar Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,

R. von Hanxleden (+ I. Fuhrmann)

MSS1101: Seminar - Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,

R. von Hanxleden (+ I. Fuhrmann)

MSS1102: Masterabschlussseminar - Echtzeitsysteme / Eingebettete Systeme, 2 hrs Seminar/Week,

R. von Hanxleden

Third-Party Funds

DFG Sachbeihilfe, *Precision-Timed Synchronous Reactive Processing (PRETSY)*, 01.11.2011-30.10.2014 (251925)

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.

Cooperation with Kim Marriott, Monash University, Melbourne, Australia, on automated graph drawing.

Cooperation with John Grundy, Swinburne University of Technology, Melbourne, Australia, on modelling pragmatics.

Cooperation with ETAS/Bosch, on visual model exploration.

Cooperation with National Instruments, on Statecharts modelling and hardware synthesis.

Cooperation with Michael Mendler, Bamberg University, on sequential constructiveness.

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

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

Cooperation with Irkutsk State University, on model-based design and reactive processors (funded by DAAD, Ostpartnerschaften-Programm)

Diploma, Bachelor's and Master's Theses

W. Haribi, *A SyncChart-Editor based on Yakindu*, 14.03.2013

H. Wißmann, *Graphische Visualisierung von Java-Variablen zur Laufzeit*, 28.03.2013

S. Nasin, *Graphische Zuordnung von Elementen einer Modelltransformation*, 28.03.2013

H. Müller, *Designing Applications with the e4 Application Model*, 28.03.2013

S. Smyth, *Code Generation for Sequential Constructiveness*, 24.07.2013

G. Hoops, *Automatic Layout of UML Sequence Diagrams*, 19.04.2013

Publications

Published in 2013

S. Andalam, P. Roop, A. Girault, C. Traulsen, *A Predictable Framework for Safety-Critical Embedded Systems*, IEEE Transactions on Computers, (PrePrint), (2013)

- R. von Hanxleden, Michael Mendler, J. Aguado, B. Duderstadt, I. Fuhrmann, C. Motika, S. Mercer, O. O'Brien, *Sequentially Constructive Concurrency-A Conservative Extension of the Synchronous Model of Computation*, In Proceedings of the Design, Automation and Test in Europe Conference (DATE'13), Grenoble, France, IEEE, 581 - 586 (2013)
- C. Motika, R. von Hanxleden, M. Heinold, *Programming Deterministic Reactive Systems with Synchronous Java (Invited Paper)*, In Proceedings of the 9th Workshop on Software Technologies for Future Embedded and Ubiquitous Systems (SEUS), IEEE Proceedings, Paderborn, Germany, (2013)
- R. von Hanxleden, M. Mendler, J. Aguado, B. Duderstadt, I. Fuhrmann, C. Motika, S. Mercer, O. O'Brien, *Sequentially Constructive Concurrency-A Conservative Extension of the Synchronous Model of Computation*, Technical Report 1308, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, ISSN 2192-6247, (2013)
- M. Spönemann, C. D. Schulze, C. Motika, C. Schneider, R. von Hanxleden, *KIELER: Building on Automatic Layout for Pragmatics-Aware Modelling (Showpiece)*, In Proceedings of the IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC'13), San Jose, CA, USA, (2013)
- C. Schneider, M. Spönemann, R. von Hanxleden, *Just Model! - Putting Automatic Synthesis of Node-Link-Diagrams into Practice*, In Proceedings of the IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC'13), San Jose, CA, USA, (2013)
- C. Motika, S. Smyth, R. von Hanxleden, M. Mendler, *Sequentially Constructive Charts (SCCharts)*, Poster presented at 10th Biennial Ptolemy Miniconference (PTCONF'13), Berkeley, CA, USA, (2013)
- R. von Hanxleden, B. Duderstadt, C. Motika, S. Smyth, M. Mendler, J. Aguado, S. Mercer, O. O'Brien, *SCCharts: Sequentially Constructive Statecharts for Safety-Critical Applications*, Technical Report 1311, Christian-Albrechts-Universität zu Kiel, Department of Computer Science, ISSN 2192-6247, (2013)
- P. Axer, R. Ernst, H. Falk, A. Girault, D. Grund, N. Guan, B. Jonsson, P. Marwedel, J. Reineke, C. Rochange, M. Sebastian, R. von Hanxleden, R. Wilhelm, W. Yi, *Building Timing Predictable Embedded Systems*, ACM Transactions on Embedded Computing Systems, (2013)

Presentations

- R. von Hanxleden, *On the Pragmatics of Model-Based Design*, Seminar at Swinburne University of Technology, Melbourne, Australia, 05.02.2013
- R. von Hanxleden, *Taming Graphical Modelling*, Seminar at Monash University, Melbourne, Australia, 06.02.2013
- C. Motika, R. von Hanxleden, M. Heinold, *Programming Deterministic Reactive Systems with Synchronous Java*, 9th Workshop on Software Technologies for Future Embedded and Ubiquitous Systems (SEUS), Paderborn, Germany, 17.06.2013
- M. Spönemann, C. D. Schulze, C. Motika, C. Schneider, *KIELER: Building on Automatic Layout for Pragmatics-Aware Modelling*, IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC'13), San Jose, CA, USA, 15.-19.09.2013
- C. Schneider, M. Spönemann, R. von Hanxleden, *Just Model! - Putting Automatic Synthesis of Node-Link-Diagrams into Practice*, IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC'13), San Jose, CA, USA, 15.-19.09.2013
- U. Rüegg, C. Schneider, C. D. Schulze, M. Spönemann, C. Motika, R. von Hanxleden, *Light-Weight Synthesis of Ptolemy Diagrams with KIELER*, Tenth Biennial Ptolemy Miniconference, Berkeley, CA, USA, 07.11.2013
- R. von Hanxleden, B. Duderstadt, C. Motika, S. Smyth, M. Mendler, J. Aguado, S. Mercer, O. O'Brien, *SCCharts: Sequentially Constructive Statecharts*, Synchronous Programming (SYNCHRON'13), Schloss Dagstuhl, Germany, 19.11.2013
- R. von Hanxleden, B. Duderstadt, C. Motika, S. Smyth, M. Mendler, J. Aguado, S. Mercer, O. O'Brien, *Compiling SCCharts to Hardware and Software*, Synchronous Programming (SYNCHRON'13), Schloss Dagstuhl, Germany, 19.11.2013

Further Activities and Events

R. von Hanxleden:

Member of the *ArtistDesign European Network of Excellence on Embedded System Design*. Reviewer for the *ACM Transactions on Embedded Computing Systems (ACM TECS)*, *IEEE Computer*, *Science of Computer Programming*, *IEEE Transactions on Embedded Computing Systems*, *Transactions on Computers*, and the *Workshop on Methodical Development of Modelling Tools (MeDMoT2013)*. Reviewer of the EU-FP7 Project DESTECS (*Design Support and Tooling for Embedded Control Software*). Research visit to the University of Auckland, to NICTA, Sydney, and to Swinburne and Monash Universities, Melbourne (10.2012-03.2013).

U. Rüegg:

DAAD doctoral scholarship (FITweltweit) for a research stay at Swinburne and Monash Universities, Melbourne (11.2013-05.2014)

C. Motika, C. Schneider:

Demonstration of the Model-Railway, Girls' Day 2012 (25.04.2013) and the *Schnupperstudium* (15./16.10.2013)

B. Duderstadt:

Reviewer for *Transactions on Computers*.

I. Fuhrmann:

Reviewer for *Science of Computer Programming*.

C. Motika:

Reviewer for *IEEE Computer*.

C.-D. Schulze:

Reviewer for *Workshop Methodical Development of Modelling Tools (MeDMoT2013)*.

Further Activities

Visit from Alexei Zhukov, Irkutsk State University (04.-29.11.2013) (funded by DAAD, Ostpartnerschaften-Programm)