



**Proceedings of the**

**18th International Workshop on  
Software and Compilers for Embedded Systems**

**SCOPES 2015**

[www.scopesconf.org](http://www.scopesconf.org)

Copyright © 2015 by the Association for Computing Machinery, Inc (ACM). Permission to make digital or hard copies of portions of this work for personal or classroom use is granted without fee provided that the copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted.

To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permission to republish from: Publications Dept. ACM, Inc. Fax +1-212-869-0481 or E-mail [permissions@acm.org](mailto:permissions@acm.org).

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

Proceedings of the

**18th International Workshop on  
Software and Compilers for Embedded Systems**

SCOPEs 2015

June 1-3, 2015  
Schloss Rheinfels  
St. Goar, Germany

*Sponsors*

EDAA

*In cooperation with*

ACM SIGBED

*Editor*

Sander Stuijk, Eindhoven University of Technology, The Netherlands





## Table of Contents

• Preface .....	iii
• Committee .....	v
• Sponsors .....	vii
• <b>Keynotes</b>	
• Computation in Memory for Data-Intensive Applications: Beyond CMOS and beyond Von-Neumann <i>Said Hamdioui</i> .....	1
• Adaptive Isolation for Predictable MPSoC Stream Processing <i>Jürgen Teich</i> .....	2
• <b>Full Papers</b>	
• Programming Strategies for Contextual Runtime Specialization <i>Tiago Carvalho, Pedro Pinto and João Cardoso</i> .....	3
• Static analysis of energy consumption for LLVM IR programs <i>Neville Grech, Kyriakos Georgiou, James Pallister, Steve Kerrison, Jeremy Morse and Kerstin Eder</i> .....	12
• Byte-wise Register Allocation <i>Philipp Klaus Krause</i> .....	22
• Utilization Improvement by Enforcing Mutual Exclusive Task Execution in Modal Stream Processing Applications <i>Guus Kuiper, Stefan J. Geuns and Marco J.G. Bekooij</i> .....	28
• Efficient Compilation of Stream Programs for Heterogeneous Architectures: A Model-Checking based approach <i>Rajesh Thakur and Y.N. Srikant</i> .....	38
• Plasmon-based Virus Detection on Heterogeneous Embedded Systems <i>Olaf Neugebauer, Pascal Libuschewski, Michael Engel, Heinrich Mueller and Peter Marwedel</i> .....	48
• Use of Previously Acquired Positioning of Optimizations for Phase Ordering Exploration <i>Ricardo Nobre, Luiz Martins and João Cardoso</i> .....	58
• Throughput-optimizing Compilation of Dataflow Applications for Multi-Cores using Quasi-Static Scheduling <i>Tobias Schwarzer, Joachim Falk, Michael Glaß, Jürgen Teich, Christian Zebelein and Christian Haubelt</i> .....	68
• <b>Research Presentations</b>	
• A Toolflow for Parallelization of Embedded Software in Multicore DSP Platforms <i>Miguel Angel Aguilar, Rainer Leupers, Gerd Ascheid and Nikolaos Kavvadias</i> .....	76
• Is dynamic compilation possible for embedded systems ? <i>Henri-Pierre Charles and Victor Lomüller</i> .....	80
• Application-Specific Architecture Exploration Based on Processor-Agnostic Performance Estimation <i>Juan Fernando Eusse, Luis Gabriel Murillo, Christopher McGirr, Rainer Leupers and Gerd Ascheid</i> .....	84
• A model-based, single-source approach to design-space exploration and synthesis of mixed-criticality systems (Extended Abstract) <i>F. Herrera, P. Peñil and E. Villar</i> .....	88
• A Concept of Vector Clock Utilization in an Iterative Tracing Approach for Distributed Embedded Systems <i>Robert Hoettger and Burkhard Igel</i> .....	92
• High-level software-pipelining in LLVM <i>Roel Jordans and Henk Corporaal</i> .....	97
• Schedulability Aware WCET-Optimization of Periodic Preemptive Hard Real-Time Multitasking Systems <i>Arno Luppold and Heiko Falk</i> .....	101
• Fast Crown Scheduling Heuristics for Energy-Efficient Mapping and Scaling of Moldable Streaming Tasks on Many-Core Systems – extended abstract <i>Nicolas Melot, Christoph Kessler, Jörg Keller and Patrick Eitschberger</i> .....	105
• Modular translation validation of a full-sized synchronous compiler using off-the-shelf verification tools (abstract) <i>Van-Chan Ngo, Jean-Pierre Talpin, Thierry Gautier, Loïc Besnard and Paul Le Guernic</i> .....	109
• An Energy Efficient Message Passing Synchronization Algorithm for Concurrent Data Structures in Embedded Systems <i>Lazaros Papadopoulos and Dimitrios Soudris</i> .....	113

- 
- VLIW Code Generation for a Convolutional Network Accelerator ..... 117  
*Maurice Peemen, Wisnu Pramadi, Bart Mesman and Henk Corporaal*
  - Runtime Adaptation of Application Execution under Thermal and Power Constraints in Massively Parallel Processor Arrays ..... 121  
*Éricles Sousa, Frank Hannig, Jürgen Teich, Qingqing Chen and Ulf Schlichtmann*
  - A framework for optimizing OpenVX applications performance on embedded manycore accelerators ..... 125  
*Giuseppe Tagliavini, Germain Haugou, Andrea Marongiu and Luca Benini*
  - Modeling Exclusive Memory Access for a Time-Decoupled Parallel SystemC Simulator ..... 129  
*Jan Henrik Weinstock, Rainer Leupers and Gerd Ascheid*
  - Synchronous Reactive Nano-Kernels: Exploring the Limits of Power and Energy Efficiency in Embedded Systems ..... 133  
*Bartosz Ziótek, Mariusz Ryndzionek, Zbigniew Chamski and Piotr Romaniuk*

## Preface

Dear Colleague,

Welcome to Sankt Goar and the SCOPES workshop. This year we are presenting a workshop program that features many interesting talks on all aspects related to the design of modern embedded systems. I hope that you will find our program interesting, stimulating and exciting.

The influence of embedded systems is constantly growing. Increasingly powerful and versatile devices are developed and put on the market at a fast pace. Their functionality and number of features is increasing, and so are the constraints on the systems concerning size, performance, energy dissipation and timing predictability. To meet all these constraints, multi-processor systems on a chip (MPSoCs) are becoming popular in embedded systems. In order to meet the performance and energy constraints of embedded applications, heterogeneous architectures incorporating functional units optimized for specific functions are commonly employed. This technological trend has dramatic consequences on the parallelization, mapping, compiler and design technology used to develop these systems. The SCOPES workshop focuses on the software generation process for these modern embedded systems. Topics of interest include all aspects of the compilation and mapping process of embedded single and multi-processor systems.

SCOPES received a total of 18 research papers coming from many different countries in Europe, North-America, Asia, Middle-East, Africa, and Australia. Each paper has been reviewed by at least three independent reviewers to ensure the quality of the workshop. Each reviewer provided a score together with detailed comments and suggestions on how to improve the overall quality of each paper. After an on-line meeting, the program committee has decided to accept 8 papers out of these 18 submissions. This gives an acceptance rate of 44% which is similar to earlier editions of the SCOPES workshop. It also reflects our commitment to only select high quality papers for presentation at our workshop.

In addition to the research papers, the workshop features also 18 research presentations. The idea of research presentations was previously used at the Map2MPSoC workshop. After the merger of SCOPES and Map2MPSoC this idea has been continued in the SCOPES workshop program. Research presentations show research results relevant to the topics addressed by the workshop. These presentations may be based on on-going work or research results that have previously been presented in other forums. Research presentations may include a short publication in the SCOPES proceedings. Therefore all submitted presentations have undergone a light review.

In conclusion, I would like to thank the members of the program committee and the external reviewers for their contribution to the quality of this workshop. I would also like to thank all authors for choosing SCOPES as the workshop where to report your research and your contributions to the scientific community. Finally, I would like to thank our sponsors for their support to SCOPES 2015. I wish all of you a fruitful conference and a pleasant stay in Sankt Goar.

Sander Stuijk  
SCOPES 2015 Program Chair  
Eindhoven University of Technology, NL  
s.stuijk@tue.nl





## Committee

- **General Chair**  
Henk Corporaal  
Eindhoven University of Technology, NL
- **Program Chair**  
Sander Stuijk  
Eindhoven University of Technology, NL
- **Publicity Chair**  
Peter Marwedel  
Dortmund University of Technology, DE
- **Program Committee**
  - Marco Bekooij  
NXP Semiconductors, NL
  - Nikil Dutt  
University of Irvine, USA
  - Michael Engel  
Leeds-Beckett, UK
  - Heiko Falk  
TU Hamburg-Harburg, DE
  - Carlo Galuzzi  
TU Delft, NL
  - Soheil Ghiasi  
UC Davis, USA
  - Armin Größlinger  
University of Passau, DE
  - Jan Haase  
Helmut-Schmidt-Universität, AT
  - Frank Hannig  
University of Erlangen, DE
  - Jörg Henkel  
University of Karlsruhe, DE
  - Timothy Jones  
University of Cambridge, UK
  - Ben Juurlink  
TU Berlin, DE
  - Andreas Krall  
TU Vienna, AT
  - Akash Kumar  
National University of Singapore, SG
  - Rainer Leupers  
RWTH Aachen, DE
  - Andrea Marongiu  
University of Bologna, IT
  - Luis Miguel Pinho  
Polytechnic Institute of Porto, PO
  - Anca Molnos  
CEA LETI, FR
  - Yunheung Paek  
Seoul National University, KR
  - Andy Pimentel  
University of Amsterdam, NL
  - Dimitrios Soudris  
NTUA, GR
  - Todor Stefanov  
Leiden University, NL
  - Sander Stuijk  
TU Eindhoven, NL
  - Jean-Pierre Talpin  
INRIA, FR
  - Jürgen Teich  
University of Erlangen, DE
  - Eugenio Villar  
University of Cantabria, ES

**• External Reviewers**

- Corinne Ancourt
- Biagio Cosenza
- Tamer Dallou
- Anup Das
- Juan Eusse
- Florian Gouin
- Philipp Habermann
- Ang Li
- Arno Luppold
- Gereon Onnebrink
- Santiago Pagani
- Lazaros Papadopoulos
- Hiren Patel
- Anuj Pathania
- Nam Khanh Pham
- Projjol Ray
- Semeen Rehman
- Oliver Reiche
- Rafael Rosales
- Moritz Schmid
- Stefan Wildermann

## Sponsors

SCOPES 2015 is kindly supported and sponsored by the following institutions:

- ACM SIGBED

<http://www.acm.org/sigbed>

- European Design and Automation Association, EDAA

<http://www.edaa.com>

