

Alex Orailoglu  
Marc Reichenbach  
Matthias Jung (Eds.)

LNCS 13511

# Embedded Computer Systems: Architectures, Modeling, and Simulation

22nd International Conference, SAMOS 2022  
Samos, Greece, July 3–7, 2022  
Proceedings



Springer

## Founding Editors

Gerhard Goos

*Karlsruhe Institute of Technology, Karlsruhe, Germany*

Juris Hartmanis

*Cornell University, Ithaca, NY, USA*

## Editorial Board Members

Elisa Bertino

*Purdue University, West Lafayette, IN, USA*

Wen Gao

*Peking University, Beijing, China*

Bernhard Steffen 

*TU Dortmund University, Dortmund, Germany*

Moti Yung 

*Columbia University, New York, NY, USA*

More information about this series at <https://link.springer.com/bookseries/558>

Alex Orailoglu · Marc Reichenbach ·  
Matthias Jung (Eds.)

# Embedded Computer Systems: Architectures, Modeling, and Simulation

22nd International Conference, SAMOS 2022  
Samos, Greece, July 3–7, 2022  
Proceedings

*Editors*

Alex Orailoglu  
University of California  
La Jolla, CA, USA

Marc Reichenbach  
BTU-Cottbus Senftenberg  
Cottbus, Germany

Matthias Jung  
Fraunhofer IESE  
Kaiserslautern, Germany

ISSN 0302-9743                      ISSN 1611-3349 (electronic)  
Lecture Notes in Computer Science  
ISBN 978-3-031-15073-9              ISBN 978-3-031-15074-6 (eBook)  
<https://doi.org/10.1007/978-3-031-15074-6>

© The Editor(s) (if applicable) and The Author(s), under exclusive license  
to Springer Nature Switzerland AG 2022, corrected publication 2022

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

SAMOS is a conference with a unique format. It brings together every year researchers from both academia and industry on the topic of embedded systems in the perfect setting of the island of Samos. Last year the conference was held virtually due to the COVID-19 pandemic, but this year SAMOS took place in person during July 3–7, 2022.

The SAMOS 2022 keynotes covered a wide range of embedded systems design aspects, including talks on future microprocessors by Yale Patt, University of Texas at Austin, extreme-scale virtual screening by Cristina Silvano, Polimi, and power monitors by William Fornaciari, Polimi. A specific focus was also put on machine learning and memory systems through tutorials by Michele Saad, Adobe, and Onur Mutlu, ETH Zurich.

The SAMOS 2022 proceedings comprise a selection of publications targeting either systems themselves - through their applications, architectures, and underlying processors - or methods created to automate their design. A total of 44 papers were submitted to the conference and 21 papers were selected by the Program Committee to be presented at SAMOS 2022 (48% acceptance rate). Two special sessions were included in the program to gather novel work on security and to report recent results of European projects.

The SAMOS 2022 committee would like to acknowledge the generous support of the many reviewers who contributed to the quality of these proceedings. We hope that you enjoy reading them!

July 2022

Alex Orailoglu  
Marc Reichenbach  
Matthias Jung



## Steering Committee

Shuvra Bhattacharyya	University of Maryland, College Park, USA, and IETR, France
Holger Blume	Leibniz Universität Hannover, Germany
Ed F. Deprettere	Leiden University, The Netherlands
Nikitas Dimopoulos	University of Victoria, Canada
Carlo Galuzzi	Delft University of Technology, The Netherlands
Georgi N. Gaydadjiev	Maxeler Technologies, UK
John Glossner	Optimum Semiconductor Technologies, USA
Walid Najjar	University of California, Riverside, USA
Andy D. Pimentel	University of Amsterdam, The Netherlands
Olli Silvén	University of Oulu, Finland
Dimitrios Soudris	National Technical University of Athens, Greece
Jarmo Takala	Tampere University, Finland
Stephan Wong	TU Delft, The Netherlands

## Program Committee

Giovanni Agosta	Politecnico di Milano, Italy
Shuvra Bhattacharyya	University of Maryland, College Park, USA
Holger Blume	Leibniz Universität Hannover, Germany
Luigi Carro	UFRGS, Brazil
Jeronimo Castrillon	TU Dresden, Germany
Ricardo Chaves	INESC-ID, Portugal
Francesco Conti	UniBo, Italy
Karol Desnos	INSA Rennes, France
Vassilios V. Dimakopoulos	University of Ioannina, Greece
Giorgos Dimitrakopoulos	Democritus University of Thrace, Greece
Nikitas Dimopoulos	University of Victoria, Canada
Lide Duan	University of Texas at San Antonio, USA
Holger Flatt	Fraunhofer IOSB, Germany
Carlo Galuzzi	Delft University of Technology, The Netherlands
Georgi N. Gaydadjiev	Maxeler Technologies, UK
Andreas Gerstlauer	University of Texas at Austin, USA
John Glossner	Optimum Semiconductor Technologies Inc., USA
Diana Goehringer	TU Dresden, Germany
Xinfei Guo	University of Virginia, USA
Soonhoi Ha	Seoul National University, South Korea
Frank Hannig	University of Erlangen-Nuremberg, Germany
Christian Haubelt	University of Rostock, Germany
Jasmin Jahić	University of Cambridge, UK
Pekka Jääskeläinen	Tampere University, Finland

Matthias Jung	Fraunhofer IESE, Germany
Christoforos Kachris	Athens Information Technology, Greece
Georgios Keramidas	Aristotle University of Thessaloniki, Greece
Johannes Knödtel	Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Leonidas Kosmidis	BSC, Spain
Angeliki Kritikakou	IRISA, Inria and University of Rennes 1, France
Kevin Martin	Université Bretagne Sud, France
John McAllister	Queen's University Belfast, UK
Paolo Meloni	University of Cagliari, Italy
Alexandre Mercat	Tampere University, Finland
Daniel Mueller-Gritschneider	Technical University of Munich, Germany
Chrysostomos Nicopoulos	University of Cyprus, Cyprus
Alex Orailoglu	University of California, San Diego, USA
Andrés Otero	Universidad Politécnica de Madrid, Spain
Gianluca Palermo	Politecnico di Milano, Italy
Anuj Pathania	National University of Singapore, Singapore
Guillermo Payá Vayá	Leibniz Universität Hannover, Germany
Maxime Pelcat	INSA Rennes, France
Andy Pimentel	University of Amsterdam, The Netherlands
Thilo Pionteck	Otto-von-Guericke Universität Magdeburg, Germany
Oscar Plata	University of Malaga, Spain
Dionisios Pnevmatikatos	National Technical University of Athens, Greece
Sanjay Rajopadhye	Colorado State University, USA
Francesco Regazzoni	Università della Svizzera italiana, Switzerland
Marc Reichenbach	Brandenburg University of Technology Cottbus--Senftenberg, Germany
Ruben Salvador	CentraleSupélec and IETR, France
Muhammad Shafique	NYU Abu Dhabi
Dimitrios Soudris	National Technical University of Athens, Greece
Ioannis Sourdis	Chalmers University of Technology, Sweden
Leonel Sousa	INESC-ID and IST, University of Lisbon, Portugal
Akash Sridhar	Qualcomm, USA
Todor Stefanov	Leiden University, The Netherlands
Christos Strydis	Erasmus MC, The Netherlands
Wonyong Sung	Seoul National University, South Korea
Jarmo Takala	Tampere University, Finland
Jean-Pierre Talpin	INRIA, France
George Theodoridis	University of Patras, Greece
Stavros Tripakis	University of California, Berkeley, USA

Theo Ungerer  
Carlos Valderrama  
Norbert Wehn  
Stephan Wong  
Roger Woods

University of Augsburg, Germany  
University of Mons, Belgium  
TU Kaiserslautern, Germany  
Delft University of Technology, The Netherlands  
Queen's University Belfast, UK

## **Additional Reviewers**

Muhammad Ali  
Lilas Alrahis  
J. L. F. Betting  
Viralii Burtsev  
Alessio Colucci  
Rafael Fao de Moura  
Fernando Fernandes dos Santos  
Conrad Foik  
Davide Gadioli  
Bagus Hanindhito  
Veronia Iskandar  
Mihir Kekkar  
Nesrine Khouzami  
Troya Kyl  
Christos Lamprakos

Alberto Marchisio  
Ricardo Nobre  
Elbruz Ozen  
Sotirios Panagiotou  
Daniele Passaretti  
Christodoulos Peltekis  
Patrick Plagwitz  
Bastian Schulte  
Matteo Scrugli  
Kyhong Shim  
Dennis Sprute  
Qinzhe Wu  
Hanzhi Xun  
Sicong Yuan

# Contents

## High Level Synthesis

- High-Level Synthesis of Digital Circuits from Template Haskell  
and SDF-AP ..... 3  
*H. H. Folmer, R. de Groot, and M. J. G. Bekooij*
- Implementing Synthetic Aperture Radar Backprojection in Chisel –  
A Field Report ..... 28  
*Niklas Rother, Christian Fahnemann, and Holger Blume*
- EasyHBM: Simple and Fast HBM Access for FPGAs Using  
High-Level-Synthesis ..... 43  
*Lars Schwenger, Philipp Holzinger, Dietmar Fey,  
Hector Gerardo Munoz Hernandez, and Marc Reichenbach*

## Memory Systems

- TREAM: A Tool for Evaluating Error Resilience of Tree-Based Models  
Using Approximate Memory ..... 61  
*Mikail Yayla, Zahra Valipour Dehnoo, Mojtaba Masoudinejad,  
and Jian-Jia Chen*
- Split'n'Cover: ISO 26262 Hardware Safety Analysis with SystemC ..... 74  
*Denis Uecker and Matthias Jung*
- Tagged Geometric History Length Access Interval Prediction for Tightly  
Coupled Memory Systems ..... 90  
*Viktor Razilov, Robert Wittig, Emil Matúš, and Gerhard Fettweis*

## Processor Architecture

- NanoController: A Minimal and Flexible Processor Architecture  
for Ultra-Low-Power Always-On System State Controllers ..... 103  
*Moritz Weißbrich and Guillermo Payá-Vayá*
- ControlPULP: A RISC-V Power Controller for HPC Processors  
with Parallel Control-Law Computation Acceleration ..... 120  
*Alessandro Ottaviano, Robert Balas, Giovanni Bambini,  
Corrado Bonfanti, Simone Benatti, Davide Rossi, Luca Benini,  
and Andrea Bartolini*

**Embedded Software Systems and Beyond**

CASA: An Approach for Exposing and Documenting Concurrency-Related Software Properties ..... 139  
*Jasmin Jahić, Volkan Doganci, and Hubert Gehring*

High-Level Simulation of Embedded Software Vulnerabilities to EM Side-Channel Attacks ..... 155  
*Aditya Thimmaiah, Vishnuvardhan V. Iyer, Andreas Gerstlauer, and Michael Orshansky*

**Deep Learning Optimization I**

A Design Space Exploration Methodology for Enabling Tensor Train Decomposition in Edge Devices ..... 173  
*Milad Kokhazadeh, Georgios Keramidas, Vasilios Kelefouras, and Iakovos Stamoulis*

Study of DNN-Based Ragweed Detection from Drones ..... 187  
*Martin Lechner, Lukas Steindl, and Axel Jantsch*

PULP-TrainLib: Enabling On-Device Training for RISC-V Multi-core MCUs Through Performance-Driven Autotuning ..... 200  
*Davide Nadalini, Manuele Rusci, Giuseppe Tagliavini, Leonardo Ravaglia, Luca Benini, and Francesco Conti*

**Extra-Functional Property Estimation**

The Impact of Dynamic Storage Allocation on CPython Execution Time, Memory Footprint and Energy Consumption: An Empirical Study ..... 219  
*Christos P. Lamprakos, Lazaros Papadopoulos, Francky Catthoor, and Dimitrios Soudris*

Application Runtime Estimation for AURIX Embedded MCU Using Deep Learning ..... 235  
*Florian Fricke, Stefan Scharoba, Sebastian Rachuj, Andreas Konopik, Florian Kluge, Georg Hofstetter, and Marc Reichenbach*

A Hybrid Performance Prediction Approach for Fully-Connected Artificial Neural Networks on Multi-core Platforms ..... 250  
*Quentin Dariol, Sebastien Le Nours, Sebastien Pillement, Ralf Stemmer, Domenik Helms, and Kim Grüttner*

## Deep Learning Optimization II

- A Smart HW-Accelerator for Non-uniform Linear Interpolation  
of ML-Activation Functions ..... 267  
*Sebastian Prebeck, Wafic Lawand, Mounika Vaddeboina,  
and Wolfgang Ecker*
- Hardware-Aware Evolutionary Filter Pruning ..... 283  
*Christian Heidorn, Nicolai Meyerhöfer, Christian Schinabeck,  
Frank Hannig, and Jürgen Teich*

## Innovative Architectures and Tools for Security

- Obfuscating the Hierarchy of a Digital IP ..... 303  
*Giorgi Basiashvili, Zain Ul Abideen, and Samuel Pagliarini*
- On the Effectiveness of True Random Number Generators Implemented  
on FPGAs ..... 315  
*Davide Galli, Andrea Galimberti, William Fornaciari, and Davide Zoni*

## Power and Energy

- SIDAM: A Design Space Exploration Framework for Multi-sensor  
Embedded Systems Powered by Energy Harvesting ..... 329  
*Pierre-Louis Sixdenier, Stefan Wildermann, Daniel Ziegler,  
and Jürgen Teich*
- A Data-Driven Approach to Lightweight DVFS-Aware Counter-Based  
Power Modeling for Heterogeneous Platforms ..... 346  
*Sergio Mazzola, Thomas Benz, Björn Forsberg, and Luca Benini*
- A Critical Assessment of DRAM-PIM Architectures - Trends, Challenges  
and Solutions ..... 362  
*Chirag Sudarshan, Mohammad Hassani Sadi, Lukas Steiner,  
Christian Weis, and Norbert Wehn*

## European Research Projects on Digital Systems, Services, and Platforms

- SafeDX: Standalone Modules Providing Diverse Redundancy  
for Safety-Critical Applications ..... 383  
*Ramon Canal, Francisco Bas, Sergi Alcaide, Guillem Cabo,  
Pedro Benedicte, Francisco Fuentes, Feng Chang, Ilham Lasfar,  
and Jaume Abella*

**HW/SW Acceleration of Multiple Workloads Within the SERRANO's Computing Continuum: Invited Paper** ..... 394  
*Argyris Kokkinis, Aggelos Ferikoglou, Ioannis Oroutzoglou, Dimitrios Danopoulos, Dimosthenis Masouros, and Kostas Siozios*

**LSTM Acceleration with FPGA and GPU Devices for Edge Computing Applications in B5G MEC** ..... 406  
*Dimitrios Danopoulos, Ioannis Stamoulias, George Lentaris, Dimosthenis Masouros, Ioannis Kanaropoulos, Andreas Kosmas Kakolyris, and Dimitrios Soudris*

**The TEXTAROSSA Approach to Thermal Control of Future HPC Systems** .... 420  
*William Fornaciari, Federico Terraneo, Giovanni Agosta, Zummo Giuseppe, Luca Saraceno, Giorgia Lancione, Daniele Gregori, and Massimo Celino*

**Correction to: Obfuscating the Hierarchy of a Digital IP** ..... C1  
*Giorgi Basiashvili, Zain Ul Abideen, and Samuel Pagliarini*

**Author Index** ..... 435