Lecture Notes in Computer Science 13511

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

Springer

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

Organization

General Chair

Alex Orailoglu	University of California, San Diego, USA

Program Chairs

Marc Reichenbach	Brandenburg University of Technology Cottbus-Senftenberg, Germany
Matthias Jung	Fraunhofer IESE, Germany

Special Session Chairs

Innovative Architectures and Tools for Security

Francesco Regazzoni	Università della Svizzera italiana, Switzerland, and University of Amsterdam, The Netherlands

European Research Projects on Digital Systems, Services, and Platforms

Giovanni Agosta	Politecnico di Milano, Italy
Jasmin Jahic	University of Cambridge, UK
Dimitrios Soudris	National Technical University of Athens, Greece

Tutorial Chairs

Michele Saad	Adobe, USA
Onur Mutlu	ETH Zurich, Switzerland

Web Chair

Jasmin Jahic	University of Cambridge, UK

Proceedings and Finance Chair

Carlo Galuzzi	Delft University of Technology, The Netherlands

Submission and Publicity Chair

Andy D. Pimentel	University of Amsterdam, The Netherlands

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-Gritschneder	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	University of Augsburg, Germany
Carlos Valderrama	University of Mons, Belgium
Norbert Wehn	TU Kaiserslautern, Germany
Stephan Wong	Delft University of Technology, The Netherlands
Roger Woods	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
Kyuhong 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 Groote, 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