

Editor-in-Chief

Kai Rannenber, Goethe University Frankfurt, Germany

Editorial Board Members

TC 1 – Foundations of Computer Science

Luis Soares Barbosa , University of Minho, Braga, Portugal

TC 2 – Software: Theory and Practice

Michael Goedicke, University of Duisburg-Essen, Germany

TC 3 – Education

Arthur Tatmall , Victoria University, Melbourne, Australia

TC 5 – Information Technology Applications

Erich J. Neuhold, University of Vienna, Austria

TC 6 – Communication Systems

Burkhard Stiller, University of Zurich, Zürich, Switzerland


TC 7 – System Modeling and Optimization

Fredi Tröltzsch, TU Berlin, Germany

TC 8 – Information Systems

Jan Pries-Heje, Roskilde University, Denmark


TC 9 – ICT and Society

David Kreps , National University of Ireland, Galway, Ireland

TC 10 – Computer Systems Technology

Ricardo Reis , Federal University of Rio Grande do Sul, Porto Alegre, Brazil


TC 11 – Security and Privacy Protection in Information Processing Systems

Steven Furnell , Plymouth University, UK

TC 12 – Artificial Intelligence

Eunika Mercier-Laurent , University of Reims Champagne-Ardenne, Reims, France

TC 13 – Human-Computer Interaction

Marco Winckler , University of Nice Sophia Antipolis, France

TC 14 – Entertainment Computing

Rainer Malaka, University of Bremen, Germany

IFIP – The International Federation for Information Processing

IFIP was founded in 1960 under the auspices of UNESCO, following the first World Computer Congress held in Paris the previous year. A federation for societies working in information processing, IFIP's aim is two-fold: to support information processing in the countries of its members and to encourage technology transfer to developing nations. As its mission statement clearly states:

IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.

IFIP is a non-profit-making organization, run almost solely by 2500 volunteers. It operates through a number of technical committees and working groups, which organize events and publications. IFIP's events range from large international open conferences to working conferences and local seminars.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is generally smaller and occasionally by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is also rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

IFIP distinguishes three types of institutional membership: Country Representative Members, Members at Large, and Associate Members. The type of organization that can apply for membership is a wide variety and includes national or international societies of individual computer scientists/ICT professionals, associations or federations of such societies, government institutions/government related organizations, national or international research institutes or consortia, universities, academies of sciences, companies, national or international associations or federations of companies.

More information about this series at <https://link.springer.com/bookseries/6102>

Marco A. Wehrmeister ·
Márcio Kreutz · Marcelo Götz ·
Stefan Henkler · Andy D. Pimentel ·
Achim Rettberg
Editors

Analysis, Estimations, and Applications of Embedded Systems

6th IFIP TC 10 International
Embedded Systems Symposium, IESS 2019
Friedrichshafen, Germany, September 9–11, 2019
Revised Selected Papers

Editors

Marco A. Wehrmeister 
Federal University of Technology – Parana –
UTFPR
Curitiba, Brazil

Marcelo Götz 
Federal University of Rio Grande do Sul –
UFRGS
Porto Alegre, Brazil

Andy D. Pimentel
University of Amsterdam
Amsterdam, The Netherlands

Márcio Kreutz 
Federal University of Rio Grande do Norte –
UFRN
Natal, Brazil

Stefan Henkler
University of Applied Sciences
Hamm-Lippstadt
Hamm, Germany

Achim Rettberg
University of Applied Sciences
Hamm-Lippstadt
Hamm, Germany

ISSN 1868-4238 ISSN 1868-422X (electronic)
IFIP Advances in Information and Communication Technology
ISBN 978-3-031-26499-3 ISBN 978-3-031-26500-6 (eBook)
<https://doi.org/10.1007/978-3-031-26500-6>

© IFIP International Federation for Information Processing 2023

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

This book publishes the research and technical works presented at the International Embedded Systems Symposium (IESS) 2019. Deep and fruitful discussions occurred during the event covering several aspects of modern embedded and cyber-physical systems. This book presents tendencies and solutions for problems tightly coupled to industry, ranging from new methodologies to novel hardware designs, analysis approaches, and real-world application examples.

A broad discussion on the design, analysis, and verification of embedded and cyber-physical systems is presented in a complementary view throughout the chapters of this book. The presented research and technical works cover system-level design methods, algorithms, verification and validation techniques, estimation of system properties and characteristics, performance analysis, and real-time systems design. Also, the book presents industrial and real-world application case studies that discuss the challenges and realizations of embedded systems.

Technological advances over recent years have provided a resourceful infrastructure to embedded systems through enormous processing and storage capacity. Formerly external components can now be integrated into a single System-on-Chip. This tendency results in a dramatic reduction in the size and cost of embedded systems. Such hardware infrastructures enable increasing numbers of services, allowing embedded systems to support many application areas (including cyber-physical applications). As a unique technology, the design of embedded systems is an essential element of many innovations.

Embedded systems meet their performance goals, including real-time constraints, employing a combination of special-purpose hardware and software components tailored to the system requirements. Both the development of new features and the reuse of existing intellectual property components are essential to keep up with ever-demanding customer requirements. Furthermore, design complexities are steadily growing with an increasing number of components that must cooperate properly. Embedded system designers must cope with multiple goals and constraints simultaneously, including timing, power, reliability, dependability, maintenance, packaging, and, last but not least, price.

The significance and importance of these constraints vary depending on the target application area. Typical embedded applications include consumer electronics, automotive, avionics, medical, industrial automation, robotics, communication devices, and others.

The International Embedded Systems Symposium (IESS) is a unique forum to present novel ideas, exchange timely research results, and discuss the state of the art and future trends in the field of embedded systems. Contributors and participants from both industry and academia take an active part in this symposium. The IESS conference is organized by the Computer Systems Technology committee (TC10) of the

International Federation for Information Processing (IFIP), especially the Working Group 10.2 “Embedded Systems”.

IESS is a truly interdisciplinary conference on the design of embedded systems. Computer Science and Electrical Engineering are the predominant academic disciplines concerned with the topics covered in IESS, but many applications also involve civil, mechanical, aerospace, and automotive engineering, as well as various medical disciplines.

In 2005, IESS was held for the first time in Manaus, Brazil. IESS 2005 was very successful, with 30 accepted papers ranging from specification to embedded systems applications. IESS 2007 was the second edition of the symposium held in Irvine in the US, with 35 accepted papers and 2 tutorials ranging from analysis and design methodologies to case studies from automotive and medical applications. IESS 2009 took place in the wonderful Schloß Montfort in Langenargen, Germany with 28 accepted papers and 2 tutorials ranging from efficient modeling towards challenges for designers of fault-tolerant embedded systems. IESS 2013 was held in Paderborn, Germany, at the Heinz Nixdorf MuseumsForum (HNF) with 22 full papers, and 8 short papers. IESS 2015 was held in Foz do Iguaçu, Brazil, close to the beautiful Iguaçu Falls, with 12 full papers and 6 short papers.

The sixth edition, IESS 2019, was held in Friedrichshafen, Germany, on the northern shoreline of the delightful Lake Constance (Bodensee). The articles presented in this book are the result of a rigorous review process implemented by the technical program committee. Out of 32 valid submissions, 16 full papers were accepted, yielding an acceptance rate of 50%. Also, 4 short papers are included yielding an overall acceptance rate of 62.5%. From this total, 4 full papers were published as an extended version in the International Journal of Parallel Programming, Springer. Since that journal issue was published before this proceedings volume, these were not included in this publication.

The technical program of IESS 2019 included sessions with complementary and interdisciplinary themes, e.g., embedded real-time systems, system architecture design, algorithms, embedded hardware, estimation and analysis, and applications. Remarkably interesting keynotes on diverse topics, such as computational self-awareness, a paradigm for adaptive, resilient embedded computing, were included in the technical program, along with some invited talks on evaluating soft errors in multi-core systems, digitalization in the automotive world, modern human-machine interfaces for the automotive industry, and scientific and technical presentations.

All editors of this volume cited below, besides their formal roles, were involved in the discussions and decisions made during the review phase, and during the development of this volume. We are a small group involved in the organization of this conference and previous editions, and we were pleased to organize a highly successful conference in 2019 with fruitful and lively discussions.

We thank our sponsors, ZF Friedrichshafen AG, BHTC GmbH, the IFIP WG 10.2 on Embedded Systems, the Gesellschaft für Informatik e.V. (GI), and the Hamm-Lippstadt University of Applied Sciences, for their generous financial support of this conference. Without these contributions, IESS 2019 would not have been possible in its current form. We would also like to thank IFIP as the organizational body for the promotion and support of the IESS conference. And, last but not least, we

thank the authors for their interesting research contributions and the members of the technical program committee for their valuable time and effort in reviewing the articles.

December 2022

Marco A. Wehrmeister
Márcio Kreutz
Marcelo Götz
Stefan Henkler
Andy D. Pimentel
Achim Rettberg

Organization

General Chairs

Marco A. Wehrmeister Federal University of Technology, Parana, Brazil
Andy D. Pimentel University of Amsterdam, Netherlands

Program Chairs

Stefan Henkler University of Applied Sciences Hamm-Lippstadt,
Germany
Marcio Kreutz Federal University of Rio Grande do Norte, Brazil

Steering Committee

Achim Rettberg University of Applied Sciences Hamm-Lippstadt,
Germany
Marcelo Götz Federal University of Rio Grande do Sul, Brazil
Mauro C. Zanella ZF Friedrichshafen AG, Germany
Franz J. Rammig University of Paderborn, Germany

Technical Program Committee

Samar Abdi Concordia University, Montreal, Canada
Christian Allmann Audi Electronics Venture, Germany
Michael Amann ZF Friedrichshafen, Germany
Richard Anthony University of Greenwich, UK
Jürgen Becker Karlsruher Institut für Technologie, Germany
Alecio Binotto IBM Research, Brazil
Christophe Bobda University of Arkansas, USA
Luigi Carro Federal University of Rio Grande do Sul, Brazil
Florian Dittmann Kromberg & Schubert, Germany
Rainer Doemer University of California at Irvine, USA
Cecilia Ekelin Volvo Technology Corporation, Sweden
Rolf Ernst Technical University Braunschweig, Germany
Danubia B. Espindola Federal University of Rio Grande, Brazil
Mohammad Al Faruque University of California at Irvine, USA
Masahiro Fujita University of Tokyo, Japan
Marcelo Götz Federal University of Rio Grande do Sul, Brazil
Andreas Gerstlauer University of Texas Austin, USA
Tayfun Gezgin Lufthansa Cargo, Germany
Kim Grüttner OFFIS, Germany
Andreas Hein Carl von Ossietzky University Oldenburg, Germany

Joerg Henkel	Karlsruher Institut für Technologie, Germany
Stefan Henkler	University of Applied Sciences Hamm-Lippstadt, Germany
Carsten Homburg	dSPACE, Germany
Uwe Honekamp	Vector Informatik, Germany
Michael Huebner	Ruhr-University Bochum, Germany
Marcel Jackowski	University of Sao Paulo, Brazil
Ricardo Jacobi	University of Brasilia, Brazil
Michael Keckeisen	ZF Friedrichshafen, Germany
Timo Kerstan	Vector Informatik, Germany
Amin Khajeh	Intel, USA
Doo-Hyun Kim	Konkuk University, Korea
Hermann Kopetz	Technical University Vienna, Austria
Marcio Kreutz	Federal University of Rio Grande do Norte, Brazil
Horst Krimmel	ZF Friedrichshafen, Germany
Thomas Lehmann	HAW Hamburg, Germany
Armin Lichtblau	Mentor Graphics, Germany
Patrick Lysaght	Xilinx Research Labs, USA
Roger May	Altera, UK
Adam Morawiec	ECSI, France
Wolfgang Nebel	Carl von Ossietzky University Oldenburg, Germany
Markus Oertel	Vector Informatik, Germany
Mike Olivarez	Freescale Semiconductor, USA
Carlos Eduardo Pereira	Federal University of Rio Grande do Sul, Brazil
Franz Rammig	University of Paderborn, Germany
Achim Rettberg	University of Applied Sciences Hamm-Lippstadt, Germany
Stefan Schimpf	ETAS, Germany
Juergen Schirmer	Robert Bosch, Stuttgart, Germany
Aviral Shrivastava	Arizona State University, USA
Charles Steinmetz	University of Applied Sciences Hamm-Lippstadt, Germany
Joachim Stroop	dSPACE, Germany
Hamed Tabkhi	Northeastern University Boston, USA
Hiroyuki Tomiyama	Ritsumeikan University, Japan
Flavio Rech Wagner	Federal University of Rio Grande do Sul, Brazil
Marco Wehrmeister	Federal University of Technology Parana, Brazil
Marilyn Wolf	Georgia Institute of Technology, USA
Mauro Zanella	ZF Friedrichshafen, Germany
Jianwen Zhu	University of Toronto, Canada

Co-organizing Institution

IFIP TC 10, WG 10.2 and WG 10.5

Contents

Embedded Real-Time Systems

A Real-Time Operating System for Cyber-Physical Systems Based on Physical Time and Logical Time	3
<i>Keiko Amadera, Ayumu Ichimura, Takanori Yokoyama, and Myungryun Yoo</i>	
A Proposal to Trace and Maintain Requirements Constraints of Real-time Embedded Systems	15
<i>Fabiola Gonçalves C. Ribeiro, Achim Rettberg, Carlos E. Pereira, Charles Steinmetz, and Michel S. Soares</i>	
A Comparative Analysis Between SysML and AADL When Modeling a Real-Time System	27
<i>Quelita A. D. S. Ribeiro, Achim Rettberg, Fabiola Gonçalves C. Ribeiro, and Michel S. Soares</i>	
Design, Implementation, and Evaluation of a Real Time Localization System for the Optimization of Agitation Processes.	39
<i>Andreas Heller, Ludwig Horsthemke, and Peter Glösekötter</i>	

Estimations

Improving Estimations for Latencies of Cause-Effect Chains	53
<i>Max J. Friese, Thorsten Ehlers, and Dirk Nowotka</i>	
Workload Characterization for Memory Management in Emerging Embedded Platforms	65
<i>Biswadip Maity, Bryan Donyanavard, Nalini Venkatasubramanian, and Nikil Dutt</i>	
Tool and Method for Obtaining End-to-End Reliability Parameters of Wireless Industrial Networks	77
<i>Christian Alan Krötz, Max Feldman, Gustavo Pedroso Cainelli, Gustavo Künzel, Carlos Eduardo Pereira, and Ivan Müller</i>	

Architecture and Application

Towards ASIP Architecture-Driven Algorithm Development.	91
<i>Manil Dev Gomony, Mihaela Jivanescu, and Nikolas Olaziregi</i>	

Using Data Mining and Mobile Devices to Assist the Interactive Automotive Diagnostics	101
<i>Leonardo P. de Oliveira, Marco A. Wehrmeister, and Andre S. de Oliveira</i>	
Algorithm and System C	
An Untimed SystemC Model of GoogLeNet.	117
<i>Emad Malekzadeh Arasteh and Rainer Dömer</i>	
An Efficient Lightweight Framework for Porting Vision Algorithms on Embedded SoCs.	130
<i>Apurv Ashish, Sohan Lal, and Ben Juurlink</i>	
Analysis	
IoT Assistant for People with Visual Impairment in Edge Computing	145
<i>Manoel José S. Júnior, Horácio F. Oliveira, and Raimundo S. Barreto</i>	
Analysis of Low Cost Sensors Applied to the Detection of Obstacles in High Voltage Towers.	155
<i>Guido Szekir Berger, Matheus Felype Ferraz, Álvaro Rogério Cantieri, and Marco Aurélio Wehrmeister</i>	
Monitoring of an Artificial DNA in Dynamic Environments	167
<i>Mathias Pacher and Uwe Brinkschulte</i>	
Design and Analysis of an Online Update Approach for Embedded Microprocessors	179
<i>Patrick Uven, Philipp Ittershagen, and Kim Grüttner</i>	
Author Index	189