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# Designing Modern Embedded Systems: Software, Hardware, and Applications

Stefan Henkler, Márcio Kreutz, Marco A. Wehrmeister, Marcelo Götz, Achim  
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Stefan Henkler · Márcio Kreutz ·  
Marco A. Wehrmeister ·  
Marcelo Götz · Achim Rettberg  
Editors

# Designing Modern Embedded Systems: Software, Hardware, and Applications


7th IFIP TC 10 International  
Embedded Systems Symposium, IESS 2022  
Lippstadt, Germany, November 3–4, 2022  
Proceedings

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# Preface

This book publishes the research and technical works presented at the International Embedded Systems Symposium (IESS) 2022. After a long period of very reduced personal contact due to the worldwide measures to fight the COVID-19 pandemic, we were pleased to hold the seventh edition of IESS as a presential event. We were very happy to once again gather our community together. Deep and fruitful discussions occurred during the event covering several topical aspects of 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, engineering artificial intelligence into often-constrained embedded systems, 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 modern embedded systems, especially when it comes to including artificial intelligence algorithms and techniques in embedded systems.

The technological advances over recent years have provided a resourceful infrastructure to embedded systems in terms of an enormous amount of processing and storage capacity. Formerly external components are now integrated into a single System-on-Chip that includes various hardware accelerators such as video decoders, and artificial intelligence co-processors. This tendency results in a dramatic reduction in the size and cost of embedded systems. Such a hardware infrastructure enables an increasing number of provided services, allowing embedded systems to enter a lot of 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, by 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 keeping up with ever-increasing customer requirements. Furthermore, design complexity is steadily growing, with an increasing number of components that must cooperate properly. Novel integrated co-design approaches are deemed necessary to further improve the design flow while reducing the project's overall cost.

Embedded system designers must cope with multiple goals and constraints simultaneously, including timing, power, reliability, dependability, maintenance, packaging, and, last but not least, price. Safety, security, and privacy are mandatory requirements for modern applications that also demand different levels of intelligence and autonomy. 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, autonomous transportation systems, 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. In this initial installment, 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 (CA), USA 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 Schoß Montfort in Langenargen, Germany with 28 accepted papers and 2 tutorials ranging from efficient modeling to challenges for designers of fault-tolerant embedded systems. IESS 2013 was held in Paderborn, Germany, at the Heinz Nixdorf Museums-Forum (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. In 2019, IESS was held in Friedrichshafen, Germany, with 16 full papers and 4 short papers selected and presented at the symposium.

The seventh edition, IESS 2022, was held in Lippstadt, Germany, in the modern and newly built Innovation Quarter Lippstadt. Currently, this area is attracting a considerable amount of investment for teaching and designing modern and disruptive embedded system applications for the automotive and agricultural sectors. The articles presented in this book are the result of a rigorous review process implemented by the technical program committee. All papers were comprehensively reviewed by three or four experts in the topics covered by each paper. The selection process resulted in 10 full papers and 2 short papers.

The technical program of IESS 2022 included sessions with complementary and interdisciplinary themes, e.g., design methods, model-driven engineering, hardware architectures for embedded systems, and engineering applications of artificial intelligence targeting embedded systems. The technical program included not only remarkably interesting keynotes on actual topics, such as the safe integration of learning in embedded systems, and models for smart cyber-physical systems of systems, but also an invited talk with an industrial focus on how connectivity contributes to smart farming. A very interesting and provocative panel discussion on the future of embedded systems took place and stimulate the attendees to discuss what are the current and future problems regarding embedded systems. Last but not least, the

scientific and technical papers were presented and stimulated a deep and insightful discussion between the presenters and the attendees.

First and foremost, we thank our sponsors IFIP WG 10.2 Embedded Systems, Gesellschaft für Informatik e.V. (GI), and Hamm-Lippstadt University of Applied Sciences for their generous financial support of this conference. Without these contributions, IESS 2022 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.

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. All the editors of this volume cited below, besides their formal roles in the IESS organization, have been involved in the discussions and decisions made about the analysis of review results, the book's organization in sessions, and editing of this preface. Since we are a small group that is involved in the organization of this conference, this has been usual in all previous, as well as for the current IESS edition.

In summary, excited about our strong technical program, we had a highly successful IESS 2022 conference with fruitful and lively discussions.

November 2022

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



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