

Conference Report

Report on the 2023 Embedded Systems Week (ESWEEK)

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■ **EMBEDDED SYSTEMS WEEK** (ESWEEK) is the premier worldwide event covering all aspects of embedded systems, encompassing software, hardware, and codesign aspects. Since its creation in 2005, it has gathered three leading conferences (International Conference on Compilers, Architecture, and Synthesis for Embedded Systems, CASES; International Conference on Hardware/Software Codesign and System Synthesis, CODES+ISSS; and International Conference on Embedded Software, EMSOFT) along with several colocated events, to offer, to the attendees, a wide range of choices unveiling state-of-the-art embedded systems design and hardware/software architectures.

In the last three years, ESWEEK was held as a virtual conference; however, the 2023 edition marked the return to a normal edition, with all attendees being present in Hamburg, Germany. The conference was hosted by the Hamburg University of Technology (TUHH), thanks to a flawless organization by the local team. Besides the three leading

conferences, ESWEEK 2023 featured two symposia [International Symposium on Formal Methods and Models for System Design (MEMOCODE) and International Symposium on Networks-on-Chip (NOCS)], three hot-topic workshops, four special sessions, six tutorials, 13 education classes, three software competitions with demos, a special program on diversity, equity, and inclusion, a special day program on the topic of semiconductor renaissance and its impact on embedded systems design, and a PhD forum and recruitment event.

The conference week was preceded by two full-day and four half-day tutorials held on Sunday, 17th September 2023. Tutorials aim to provide in-depth deliberations on new trends and hot topics. The six tutorials with speakers from both academia and industry covered a wide range of topics from high-level synthesis, model-checking, runtime monitoring and management, and hardware/software codesign. Two tutorials were sponsored by industry, respectively, by AMD on their Versal adaptable intelligent engine and its programming model, and by Siemens on an edge inference accelerator using high-level synthesis.

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A special afternoon event on diversity, equity, and inclusion in embedded systems research also took place on Sunday, 17th September 2023. We heard a report on the European Network for Gender Balance in Informatics, followed by several talks to reflect on the implications and effectiveness of activities on these topics, including personal experience. This afternoon was concluded with a mentoring session.

Furthermore, an education track containing 10 classes was held on Thursday and Friday, 14th and 15th September 2023, the week before the conference. These education classes invited top researchers in the world to teach 2-h topical lectures on emerging/newer, but well-established embedded systems concepts, tools, and methods that are not readily available in textbooks. These classes were delivered virtually in an exciting, engaging, and hands-on way to students across the globe, especially the ones that do not have access to high-quality educational content.

The main conference program itself started with the opening session on Monday, 18th September 2023 and ended on Wednesday, 20th September 2023. On each day, the program started with a 1-h keynote followed by 90-min technical sessions held in parallel tracks for the three conferences, interleaved with coffee/tea/cookies breaks to allow ample networking among the attendees. The technical and special sessions were generally well attended, with the three keynote talks being particularly popular. Many individual and small group discussions took place during the poster sessions, the coffee breaks, lunch breaks, and the social events.

Highlights of the ESWEEK program included three keynote talks by distinguished leaders in academia and industry. On Monday morning, Prof. Sarita Adve, from the University of Illinois at Urbana-Champaign, gave a talk on the era of immersive computing and how it will shape the research agenda for embedded systems. Then, on Tuesday morning, Dr. Heike Riel, an IBM fellow from IBM Research Europe in Zurich, gave a talk on how to scale quantum computing. Finally, on Wednesday morning, Prof. Lothar Thiele, from ETH Zurich, gave a talk on resilient embedded systems in the era of machine learning.

In parallel with the technical tracks dedicated to CASES, CODES+ISSS, and EMSOFT, two special half-day programs took place on Tuesday, 19th September 2023. The morning was dedicated to green Internet of Things (IoT) and green information

and communication technologies (ICTs) for the green transition, with discussions on challenges, opportunities, and recent research. The afternoon was dedicated to machine learning for embedded systems design.

ESWEEK 2023 organized two panels: 1) an industry panel on Tuesday afternoon dedicated to the links between the semiconductor industry and embedded computing and 2) an education panel on Wednesday afternoon exploring the links between computer engineering education, embedded computing, and the semiconductor renaissance.

For the second time at ESWEEK, a Test of Time Award paper was selected by each of the three main conferences, to honor the authors of articles published in previous editions of ESWEEK (resp. CASES 2008, CODES+ISSS 2007, and EMSOFT 2007), and having the highest impact. The Test of Time Award ceremony took place on Tuesday morning. Each conference also selected one best paper, with the Best Paper ceremony taking place on Wednesday morning. The best papers for the three conferences were selected from candidate papers presented during regular sessions held on Monday and Tuesday.

The three main conferences of ESWEEK 2023 (CASES, CODES+ISSS, and EMSOFT) attracted a total of 302 submissions: 238 regular papers, 36 work-in-progress papers, and 28 late-breaking (LB) papers. As in the previous years, a journal-integrated publication model was implemented, where all journal-track papers are published in the *ACM Transactions on Embedded Computing Systems* (TECS). To this end, regular papers were reviewed in a journal-style two-stage peer-review process, with the opportunity for minor/major revisions before the final decision. A total of 59 papers were accepted to appear in ACM TECS, yielding an acceptance rate of just below 25%. For their part, work-in-progress and special session papers were published in the ACM Conference Proceedings Series.

New to the 2023 edition was the possibility to submit LB result papers. LB papers provide a venue for quick dissemination of research ideas to the embedded systems community and are expected to represent complete and mature works written in a condensed form. The LB submissions were reviewed by a dedicated program subcommittee of each of the three conferences, following a journal one-stage peer-review process with the opportunity for minor revisions before the final decision. All the 18

accepted LB papers were published in *IEEE Embedded Systems Letters* (ESL).

To attract student participation and foster interest in software and hardware tools, ESWEEK 2023 hosted three student competitions: 1) the ACM SIGBED Student Research Competition (SRC), 2) the Embedded Systems Software Competition, and 3) the Tiny and Fair ML Design Contest (new in 2023). Under the supervision of Wanli Chang, the ACM SIGBED SRC attracted 20 submissions, with 10 students attending the conference to present their research. Champions of the undergraduate and graduate categories will represent SIGBED and compete against other SIGs in the ACM Grand Finals. All grand finalists, along with their supervisors, will be invited to the Annual ACM Awards Banquet, where the Turing Award is given.

Under the supervision of Weiwen Jiang and Yi Sheng, the Tiny and Fair ML Design Contest included two tracks—a segmentation track: a low-power computer vision challenge, and a classification track: a fair and intelligent embedded systems challenge. It received submissions from 83 teams worldwide, which were thoroughly evaluated, resulting in three winning team representatives attending ESWEEK.

Under the supervision of Ganapati Bhat and Biresh Kumar Joardar, the Embedded System Software Competition attracted submissions not only on embedded software, but also on embedded architecture, with VHDL- or Verilog-based solutions. It received nine complete and working solutions, with two hardware tools, six software tools, and one focusing on both hardware and software. Overall, eight of the tools presented at ESWEEK were a big success, with 20 people attending the presentations. The selected tools have been invited to submit a paper at an ACM TODAES special issue.

To attract even more students, ESWEEK 2023 organized a PhD forum for the second time, under the supervision of Shelley Lin. Twenty-five posters were submitted, with 20 being accepted for presentation. Almost all the selected posters were presented in person in Hamburg. Together with the PhD forum, ESWEEK 2023 also introduced the very first recruitment event, which provided a venue for students and professionals looking for internships or jobs to meet with representatives from companies. Six companies participated in the recruitment event this year.

On Thursday and Friday, 21st and 22nd September 2023, after the main conference, the two symposia (MEMOCODE and NOCS) and the three one-day workshops [Workshop on Compilers, Deployment, and Tooling for Edge AI (CODAI), Workshop on Agile Design and Optimization Tools for Processing-In-Memory (DOT-PIM), and International Workshop on Rapid System Prototyping (RSP)] took place. MEMOCODE featured two keynote talks from Prof. Edward Lee (UC Berkeley) and Prof. Rolf Drechsler (University of Bremen) and five technical sessions. NOCS featured two keynote talks from Prof. Axel Jantsch (TU Wien) and Prof. Diana Göhringer (TU Dresden), four technical sessions, a special session on new architectures and techniques for edge intelligence, and a closing panel. CODAI featured a keynote from Prof. Jeronimo Castrillon (TU Dresden) followed by 10 technical talks. DOT-PIM featured a keynote from Prof. Onur Mutlu (ETH and CMU) followed by 10 technical talks. Finally, RSP featured a keynote from Prof. Kenneth Kent (University of New Brunswick) followed by 11 technical talks.

We are thankful to our generous industrial sponsors (AMD, Bosch, Huawei, NXP, PiMCHIP, Siemens, and Synopsys) and our generous scientific societies (ACM Special Interest Group on Embedded Systems [SIGBED]; ACM Special Interest Group on Design Automation [SIGDA]; and IEEE Council on Electronic Design Automation [CEDA]). The organization of ESWEEK was only possible with the continuous support and help from many volunteers: The program chairs with their program committee members, the organizers of the Special Day Program, the workshops, tutorials, and symposia, all members of the organization committee, and, last but not least, the local arrangement team.

THE NEXT EDITION of ESWEEK will take place in Raleigh, NC, USA, from 29th September to 4th October 2024. On this occasion, we will celebrate the 20th edition of ESWEEK! Please visit <http://www.esweek.org> for more details. ■

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