International Conference on Embedded Wireless Systems and Networks (EWSN) 2016

Graz, Austria
15-17 February 2016

Proceedings

Edited by

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Message from the General Chair

Kay Römer
TU Graz

Welcome to EWSN 2016, the International Conference on Embedded Wireless Systems and Networks, held during February 15-17 in Graz, Austria. Originally established as the European Conference on Wireless Sensor Networks in 2004, EWSN has been the major European outlet for sensor networks research and a yearly gathering point for the research community. Starting from sensor networks, research has expanded over the years into other related fields such as Internet of Things, where the focus is on providing Internet connectivity to embedded systems, or Cyber-Physical Systems where the focus is on inclusion of networked control aspects. Yet, all these areas share the focus on wirelessly networked embedded systems.

To reflect this broadened field, the acronym EWSN now expands to International Conference on Embedded Wireless Systems and Networks. Also new in 2016, the conference has a featured topic each year to put a focus on a hot topic, but without excluding other topics in scope of the conference. The 2016 featured topic is dependability, reflecting the trend that wirelessly networked embedded systems are increasingly used in safety-critical applications such as smart production systems that require dependable performance. To this end, EWSN 2016 features for the first time a dependability competition where international teams compete in providing the most reliable networking solution in environments with strong interference. To open EWSN also to new emerging topics, two workshops have been added to the program that explore novel wireless communication paradigms such as visible light communication and to shed light on how the next generation of wireless embedded computing platforms will look like.

Besides these changes at the naming and content levels, EWSN 2016 is also held for the first time in cooperation with ACM SIGBED. The proceedings are published electronically in the ACM Digital Library, following an open access model where the papers are available online and free of charge to everybody in order to maximize the impact of the research results published at EWSN.

Implementing all these changes in order to continue the success of EWSN also during the next decade was a major endeavour that would not have been possible without the fantastic support of the organizing team, first and foremost the program chairs Koen Langendoen and Thiemo Voigt, the workshop chairs Leo Selavo and Marco Zuniga, the competition chair Carlo Boano, as well as the poster and demo chairs Olaf Landsiedel and Luca Mottola. They brought many innovative aspects and an exciting program to EWSN 2016 as they will report on the following pages. My deepest thanks go also to the publication chair Christian Renner and Meghan Haley from Junction Publishing who were instrumental to implement the new publication model of EWSN. Christian Steger, Markus Quaritsch, Engelbert Meissl, Silvia Reiter, and Nora Zakany made EWSN happen by managing the finances, web site, and local arrangements with highest dedication. I am also grateful to the sponsors of EWSN 2016, Graz University of Technology, University of Luebeck, NXP Semiconductors, the City of Graz, and the Federal State of Styria.

I hope you enjoy the conference in its new format!

Message from the Program Chairs

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Dependability Competition Chair

Carlo Alberto Boano
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Workshop Chairs

Marco Zuniga
TU Delft

Leo Selavo
University of Latvia

To ensure the highest possible standard for the renewed EWSN conference, a number of important changes have been incorporated in the submission, review, and selection process for the papers that make up the program of the 2016 conference. First, by adopting the two-column ACM format, authors were provided with more space to present their contributions in a greater level of detail. Second, the composition of the program committee included quite a number of new faces representing expertise from adjacent and novel research fields that fit the broader scope of the conference. Third, the review process was overhauled to include a rebuttal phase, in which authors were given the opportunity to address incorrect factual statements in the reviews and provide additional information to clear away uncertainties and concerns raised by the reviewers. Many authors took this opportunity and their input was used in the first-ever live TPC meeting held on November 25th at Schiphol airport, Amsterdam, The Netherlands. The TPC meeting was attended in person by 13 members, and several others called in from home to aid the selection process. The final outcome was a total of 16 full papers and 5 short papers. Half of these selected papers were assigned a shepherd to ensure that the quality of the final version would be raised to the required level and that essential critics on the submitted version were appropriately addressed. We would like to thank both the authors and the shepherds to go the extra mile and make the renewed EWSN conference program a success.

In addition to the presentations, there are two thrilling keynotes to kick off each of the main conference days. The first keynote is given by Chenyang Lu from Washington University in St. Louis. His talk is about dependability in industrial wireless control through cyber-physical co-design. The second keynote is held by Friedemann Mattern from ETH Zürich. He covers the ongoing rise of smart objects and how humans can cooperate with them.

Posters / Demos

Complementing the oral presentations of regular papers, we have an exciting poster and demo session at EWSN with a total of 34 contributions, including 18 posters and 16 demos. Each poster and demo submission was peer-reviewed by at least 2 reviewers to ensure quality and scope. We would like to thank all TPC members of the poster and demo track for their work and for their suggestions to the authors on how to improve the abstracts. During the conference, poster and demo authors join a “one-minute madness” session to showcase their work to the entire audience. For the first time at EWSN, a “best poster/demo teaser award” is granted based on public vote.

Dependability Competition

This year’s dependability competition is an exciting premiere for EWSN that has attracted authors from 13 different countries. During the conference, 11 international teams composed of 40 authors strive to provide the most reliable and efficient networking solution in environments rich with radio interference. The idea is to bring practitioners from academia and industry together and stems from the increasing need for communication protocols that can meet the stringent dependability requirements imposed by new application domains, such as smart production, smart cities, or connected cars. Organizing the dependability competition for the first time was a major effort that would not have been possible without the exceptional support of a number of people. We would like to explicitly thank Markus Schuß, Engelbert Meissl, and Oliver Bock for their invaluable help in setting up the required infrastructure and in taking care of the local arrangements. Good luck to all contestants and happy coding!

Workshops

This year, there are two workshops in conjunction with EWSN.

MadCOM 2016 is the First International Workshop on New Wireless Communication Paradigms for the Internet of Things. We identified the need to provide a forum to discuss the new and exciting methods currently being investigated to communicate data wirelessly. We received submissions from Europe, the US and Africa; with each submission receiving at least three reviews from the TPC members. After a thorough discussion, the TPC agreed to accept 6 papers to assemble a stimulating program that brings together many different methods under one roof. The final program gives attendees the opportunity to learn and deliberate about the strengths and opportunities of areas ranging from visible light communication and ambient backscatter to novel ways to exploit active radio-frequency communication. The workshop program includes an insightful keynote by Stefan Mangold about the use of visible light communication for toys and the Internet of Things. We would like to express our gratitude to the TPC for their commitment and support.

The NextMote workshop represents "Next Generation Platforms for the Cyber-Physical Internet". It is dedicated to novel hardware, associated software paradigms, and challenges for the world of IoT and remote distributed sensing. The keynote presentation by Pat Pannuto traverses the evolution from yesterday's motes to "next" and "next-next" generation motes by touching upon the achievements and visions of the Embedded Systems Research Lab at the University of Michigan, thus setting up the tone of the workshop. The TPC has accepted 6 papers for presentation from Europe and the United States of America. Topics include dependable security for networked embedded systems with limited resources, minimizing the power consumption through energy harvesting, and new platforms that are prepared to meet the requirements of tomorrow in terms of functionality and size at the scale of few millimeters. We thank the International TPC for dedicating time and effort to this workshop to become reality. We look forward to a fruitful and interesting meeting.

We hope you enjoy all facets of the program of EWSN 2016 and appreciate the quality of the contributions presented in this conference and its workshops.

Organization

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Kay Römer
TU Graz

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Koen Langendoen
TU Delft

Thiemo Voigt
Uppsala University and SICS Swedish ICT

Poster & Demo Co-Chairs

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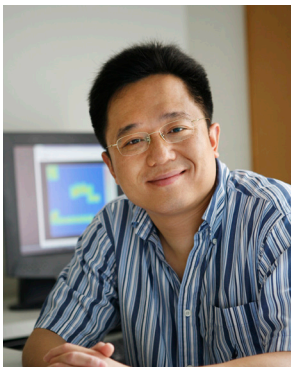
Keynote Address

Dependable Wireless Control through Cyber-Physical Co-Design

Chenyang Lu
Washington University, USA



Abstract

Industrial wireless control systems are the new frontier of cyber-physical systems. While the adoption of industrial wireless standards has demonstrated the promise of wireless sensor-actuator networks in industrial environments, there remain daunting challenges in developing control systems that are dependable over wireless networks due to communication delays, data losses and resource constraints in such networks. In contrast to traditional approaches of designing wireless and control subsystems in isolation, we need a cyber-physical co-design approach that co-joins wireless and control designs to overcome the limitations of wireless communication. This talk will present recent advances toward dependable wireless control systems: (1) real-time wireless sensor-actuator networks with delay guarantees; (2) control-aware wireless network design; (3) realistic case studies of industrial control systems through holistic wireless cyber-physical simulations. The talk will further highlight research challenges and opportunities in the exciting area of industrial wireless sensor-actuator networks.

Speaker Bio

Chenyang Lu is the Fullgraf Professor in the Department of Computer Science and Engineering at Washington University in St. Louis. His research interests include real-time systems, wireless sensor networks, cyber-physical systems and Internet of Things. He is Editor-in-Chief of ACM Transactions on *Sensor Networks*, Area Editor of IEEE *Internet of Things* Journal, and Associate Editor of the new ACM Transactions on *Cyber-Physical Systems and the Real-Time Systems* Journal. He also chaired premier conferences such as IEEE Real-Time Systems Symposium (RTSS), ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS) and ACM Conference on Embedded Networked Sensor Systems (SenSys). He is the author and co-author of over 150 research papers with over 14,000 citations and an h-index of 53. He received the Ph.D. degree from University of Virginia in 2001, the M.S. degree from Chinese Academy of Sciences in 1997, and the B.S. degree from University of Science and Technology of China in 1995. He is a Fellow of IEEE.

Keynote Address

Cooperating with smart objects: Humans in the loop!

Friedemann Mattern
ETH Zurich, Switzerland

Abstract

We embed ever smaller processors in physical objects, network them with other smart things, analyze their sensed data somewhere in a cloud, and optimize real-world processes based on the knowledge gained. The application areas and business scenarios that benefit from Internet of Things technologies are abundant: Wind farms increase their yield, logistic chains are improved, and traffic patterns in whole cities become transparent – to mention only three somewhat arbitrary examples. Many of those classical scenarios are characterized by the fact that they work almost fully automatic - humans are out of the loop. So far, so good.

But with further technical progress and cost reduction, also more and more consumer products and everyday items in our direct personal environments will become smart ("hello Barbie, can you hear me?") and connected to the Internet and its ecosystem. People will communicate - first with their devices, and later also with many of their more mundane belongings. But when people are in the loop, things get interesting and often complicated. Already the problem how and by what technical means we can communicate with our friendly personal objects is an issue - but when these objects do become really smart, communication is only a means to a higher purpose: cooperation. This gives rise to a number of interesting questions: How, in fact, do we cooperate with smart objects? Do they understand what we want? Do we always understand them? Even scenarios with such seemingly simple smart things as learning thermostats or robot vacuum cleaners are non-trivial in that respect.

There will certainly be much to explore in a future world where people are not out of the loop, but in the loop of communicating smart objects. And that future may be closer than we think.

Speaker Bio

Friedemann Mattern is a Professor of Computer Science at ETH Zurich, Switzerland. He was the founding director of the Institute for Pervasive Computing and heads the distributed systems and ubiquitous computing research group. Before being appointed by ETH Zurich in 1999, Mattern was Professor at Saarland University in Saarbrucken and at TU Darmstadt, Germany. He received his PhD from the University of Kaiserslautern, Germany, in 1989.

Mattern has written about 200 research articles and published several books. His main research fields are distributed algorithms, ubiquitous computing, and the Internet of Things, but he is also interested in the far-reaching implications of the increasing digitalization of everyday life. He is an editorial board member of a number of research journals and book series, and he also acts as a scientific and strategic advisor to several research councils. Furthermore, he has initiated and chaired a number of international conferences and is involved in various research projects, often in cooperation with industrial partners. Mattern is a member of the German National Academy of Sciences, of acatech (the German Academy of Science and Engineering), and of the Academia Europaea.

NextMote Workshop Keynote Address

From 2010 to 2030: The Recent Past and Distant Future of Embedded Systems

Pat Pannuto
University of Michigan, USA

Abstract

This talk will traverse the evolution from yesterday's motes to "next" and "next-next" generation motes. Along the way we'll face a few harsh realities that will limit and shape future evolution (a trillion devices cannot demand replacing a trillion batteries), uncover recent results already pushing boundaries (including highlights from the design and implementation of the world's smallest computer), and explore some of the possibilities that emerge when we rethink designs from the ground up (can we build useful motes that don't include CPUs?). The talk is based on recent achievements and visions of the Embedded Systems Research Lab at University of Michigan.

Speaker Bio

The keynote talk will be given by Pat Pannuto who is working with Professors Prabal Dutta and David Blaauw at University of Michigan. Pat is the Principal Systems Architect of the Michigan Micro Mote project and most recently designed MBus, a new chip-to-chip interconnect for millimeter-scale systems.

MadCom Workshop Keynote Address

Visible Light Communication for Toys and the Internet-of-Things

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Abstract

Visible Light Communication (VLC) with Light Emitting Diodes (LEDs) as transmitters and receivers enables low bitrate wireless adhoc networking, which is an interesting new approach for toys and related applications in the entertainment industry. LED-to-LED VLC adhoc networks with VLC devices communicating with each other over free-space optical links typically achieve a throughput of a few kilobit per second at distances of no more than ten meters. LED-to-LED VLC adhoc networks are useful for combining light bulbs and illumination with low-complex networking. In this talk, we present recent research achievements at Disney Research, address open challenges, and demonstrate the performance of our software-based VLC physical layer and a VLC medium access control layer that retain the simplicity of the LED-to-LED approach.

Speaker Bio

Stefan Mangold is senior research scientist at Disney Research in Zurich, Switzerland. As an Imagineer of The Walt Disney Company, Stefan has been guiding a small team that contributes to Disney Research's work on wireless communication and mobile computing. Before joining Disney in 2009, Stefan worked at Swisscom, Bern, Switzerland, and Philips Research, USA. His research covers many aspects of wireless communication, for example, protocols and system aspects for wireless LAN, visible light communication, and the Internet-of-Things. Other research interests include smart toys and play patterns, and magical experience designs for the entertainment industry. Stefan teaches a course at ETH Zurich, publishes, and generates IPR in related areas.