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Proceedings

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Preface

This volume contains the proceedings of the 13th European Conference on Software Engineering (ECSA 2019), held in Paris, France, during September 9–13, 2019. ECSA is the premier European software engineering conference that provides researchers and practitioners with a platform to present and discuss the most recent, innovative, and significant findings and experiences in the field of software architecture research and practice. This edition of ECSA builds upon a series of successful European workshops on software architecture held during 2004–2006, as well a series of European software architecture conferences during 2007–2018. This year was special, as we shared the venue and part of the program with the Systems and Software Product Lines Conference (SPLC) in Paris, France. Some keynotes and tracks were common to both events.

This year's technical program included a main research track, five keynote talks, an industry track, a doctoral symposium track with its own keynote, a Women in Software Engineering (WSE) track focusing on diversity, and a tools and demonstrations track. In addition, we also offered several workshops on diverse topics related to the software architecture discipline. The contributions of all these meetings are included in the companion proceedings, published in the ACM Digital Library.

This volume, assembling just the papers from the main conference, is published by Springer, following a tradition which dates back to its origin in 2004. For this reason, Springer provided 1,000 Euros in funding for the 2019 event. This was used to bestow the ECSA 2019 Best Paper Award, which was announced during the Gala Dinner. Also, for this reason, Springer itself was recognized as a bronze sponsor for the ECSA 2019 edition.

For the main research track, we received 63 submissions in the two main categories: full and short research papers. Based on the recommendations of the Program Committee, we accepted 11 papers as full papers, and 4 additional papers as short papers. Hence the acceptance rate for full research papers was 17,4% for ECSA 2019. For the industrial track, we received 6 submissions and accepted 3 of them. The conference attracted papers (co-)authored by researchers, practitioners, and academia from 28 countries (Algeria, Argentina, Austria, Australia, Belgium, Brazil, Canada, Chile, Columbia, Czech Republic, Equator, Finland, France, Germany, India, Ireland, Italy, the Netherlands, New Zealand, Spain, Poland, Portugal, Romania, Sweden, Switzerland, Turkey, the United Kingdom, and the United States).

It was a great pleasure to have prominent keynote speakers at ECSA 2019. The opening day keynote was delivered by Christian Kästner from Carnegie Mellon University on "Performance Analysis for Highly-Configurable Systems". Professor Carlo Ghezzi from Politecnico di Milano was pleased to accept our invitation to present a keynote for young researchers at the Doctoral Symposium on "Becoming and Being a Researcher: What I Wish Someone Would Have Told Me When I Started Doing Research". The third keynote was presented by Professor Lidia Fuentes from the

University of Malaga on "Variability Variations in Cyber-Physical Systems". These three keynotes were shared with the SPLC program. Rainer Grau from Juropera, Switzerland, delivered the industrial keynote. He spoke about "Good Practices to Identify Bounded Context to Build Agile Organizations in Sync with a Smart System Architecture". The last Keynote was presented by Professor Awais Rashid from University of Bristol. He presented his work on "Secure Software Architectures for a Hyperconnected World: Game Changer or Pipe Dream?".

The role of women in computing has gained more and more attention. To this end, the fourth special track on Women in Software Engineering (WSE) co-located with ECSA 2019 and SPLC 2019 brought together students, junior and senior researchers, as well as practitioners, to present, share, and celebrate their accomplishments and experiences in achieving more diversity in SE/STEM. A large panel was dedicated to this important track. The five panelists, specialized in the field of gender and diversity, were Serge Abiteboul, researcher at Inria and Ecole Normale Supérieure Paris; Isabelle Collet, Professor from University of Geneva; Chiara Condi, activist for women's empowerment and the founder of Led By HER; Elisabeth Kohler, director of the CNRS Mission for Women's Integration; and Florence Sedes, Professor from the University of Toulouse. 33% of ECSA 2019 registered participants were women, which shows the importance of organizing such a track to encourage them to find their place in the community.

We are grateful to the members of the Program Committee for helping us to seek submissions and provide valuable and timely reviews. Their efforts enabled us to put together a high-quality technical program for ECSA 2019. We would like to thank the members of the Organizing Committee of ECSA 2019 for playing an enormously important role in successfully organizing the event with several tracks and collocated events, as well as the workshop organizers, who made significant contributions to this year's successful event.

We also thank our sponsors who provided financial support for the event: Université de Lille, I-Site ULNE, Inria, Missions pour les femmes-CNRS, GDR CNRS Génie de la Programmation et de Logiciel, the Computer Science Lab CRIStAL-UMR CNRS, and the Spirals research group.

The ECSA 2019 submission and review process was extensively supported by the EasyChair conference management system. We acknowledge the prompt and professional support from Springer, that published these proceedings in electronic volumes as part of the *Lecture Notes in Computer Science* series. Finally, we would like to thank the authors of all the ECSA 2019 submissions and the attendees of the conference for their participation, and we look forward to seeing you in L'Aquila, Italy for ECSA 2020.

July 2019

Tomas Bures
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Abstracts of Keynotes

Performance Analysis for Highly-Configurable Systems

Christian Kästner

Carnegie Mellon University

Abstract. Almost every modern software system is highly configurable with dozens or more options to customize behavior for different use cases. Beyond enabling or disabling optional functionality, configuration options often adjust tradeoffs among accuracy, performance, security, and other qualities. However, with possible interactions among options and an exponentially exploding configuration space, reasoning about the impact of configurations is challenging. Which options affect performance or accuracy? Which options interact? What's the optimal configuration for a given workload? In this talk, I will give an overview of different strategies and challenges to learn performance models from highly-configurable systems by observing their behavior in different configurations, looking at sampling and learning strategies, transfer learning strategies, and strategies that analyze the internals or architecture of the system.

Short Bio

Christian Kästner is an associate professor in the School of Computer Science at Carnegie Mellon University. He received his PhD in 2010 from the University of Magdeburg, Germany, for his work on virtual separation of concerns. For his dissertation he received the prestigious GI Dissertation Award. Kästner develops mechanisms, languages, and tools to implement variability in a disciplined way despite imperfect modularity, to understand feature interactions and inter-operability issues, to detect errors, to help with non-modular changes, and to improve program comprehension in software systems, typically systems with a high amount of variability. Among others, Kästner has developed approaches to parse and type check all compile-time configurations of the Linux kernel in the TypeChef project.

Becoming and Being a Researcher: What I Wish Someone Would Have Told Me When I Started Doing Research

Carlo Ghezzi

Politecnico di Milano

Abstract. Why should one wish to become a researcher? What is the role of research and researchers in society? What does one need to do to become a researcher as a PhD student (but also before and after)? What can be the progress of a researcher in his or her career? How to survive and be successful? These are some of the questions I will try to answer in my presentation, based on what I learnt from others and from my own experience.

Very often, young researchers are too busy doing their own research and don't care about the global picture, ignoring these questions. Often, their academic supervisors only focus on the technical side of their supervision, and don't open the eyes of their young research collaborators. But then, sooner or later, these questions emerge and an answer must be given. In particular, I will focus on three issues:

1. *Diffusion of research, through publications and other means*. What does a beginning researcher need to know and what is a good personal strategy?
2. *Evaluation of research and researcher*. Researchers need to understand that they will be subject to continuous evaluation. Why? How? And, most importantly, how should they prepare to live through continuous evaluations?
3. *Ethics*. Researchers need to be aware of the ethical issues involved in doing research. On the one side, integrity is needed in the everyday practice of research. On the other, research is changing the world in which we live. The products of research lead to innovations that can have profound influence on society, and because of the increasingly fast transition from research to practice, they affect the world even before we understand the potential risks. What researchers might see as purely technical problems may have ethical implications, and this requires ethics awareness while doing research.

Short Bio

Carlo Ghezzi is an ACM Fellow (1999), an IEEE Fellow (2005), as well as a member of the European Academy of Sciences and of the Italian Academy of Sciences. He

received the ACM SIGSOFT Outstanding Research Award (2015) and the Distinguished Service Award (2006). He has been President of Informatics Europe. He has been a member of the Program Committee of flagship conferences in the software engineering field, such as the ICSE and ESEC/FSE, for which he also served as program and general chair. He has been the editor in chief of the ACM Transactions on Software Engineering and Methodology and an associate editor of IEEE Transactions on Software Engineering, Communications of the ACM and Science of Computer Programming, and Computing. Ghezzi's research has predominately focused on different aspects of software engineering. He co-authored over 200 papers and 8 books. He coordinated several national and international research projects. He has been the recipient of an ERC Advanced Grant.

Variability Variations in Cyber-Physical Systems

Lidia Fuentes

University of Malaga

Abstract. With the increasing size and heterogeneity of systems (e.g., IoT, cyber-physical systems) and enhanced power and versatility of IoT devices (e.g., smart watches, home intelligence sensors), the complexity of managing different kinds of variability for a given vertical domain becomes more difficult to handle. The structural variability of cyber-physical systems becomes more complex, comprising not only the inherent hardware variability of IoT devices and their network access protocols, but also the infrastructure variability derived from modern virtualization technologies, such as microcontainers or unikernels. Variability of software frameworks used to develop domain specific applications and/or services for Cloud/Edge computing environments should not be intermingled with hardware and infrastructure variability modeling. In addition, to exploit the full potential of flexibility in processing, data storage, and networking resource management, experts should define dynamic configuration processes that optimize QoS such as energy efficiency or latency respecting application-specific requirements. In this keynote talk, I will present how QoS assurance in cyber-physical systems implies modeling and configuring different kinds of variability during design, but also at runtime (e.g., user demands, usage context variability), enabling the late binding of dynamic variation points, distributed in IoT/Edge/Cloud devices, and how this can be materialized using current SPL artefacts.

Short Bio

Lidia Fuentes is a professor at the School of Informatics at the University of Malaga, Spain since 2011, with more than 25 years of experience teaching, leading research projects, and supervising thesis. She leads a cross-disciplinary research group CAOSD, focused on applying advanced software engineering technologies to network and distributed systems. Her current research interests include modeling different kinds of variability of Internet of Things (IoT), and cypher-physical systems to support dynamic reconfiguration and green computing. Her scientific production has been very prolific so far, with more than two hundred scientific publications in international forums. Her work has received several best-paper awards at conferences such as ICSR or SPLC-Tools track. She chaired several conferences as general chair (Modularity 2016), program chair (SPLC industry track, VaMoS), served on numerous program committees, and also participated as a panelist at ICSR 2017. She is member of the Steering

Committee of AOSA (Aspect-Oriented Software Association) and VaMoS. She is currently concerned in promoting the STEM careers in girls, participating as a mentor of the Technovation Challenge initiative.

Good Practices to Identify Bounded Context to Build Agile Organizations in Sync with a Smart System Architecture

Rainer Grau

Juropera GmbH

Abstract. The term bounded context describes a (ideal world) technical AND organizational autonomous area of the business model of a company. A bounded context combines three orthogonal aspects: the technology of microservices and DevOps; a functional context with its very specific terminology; an as autonomous as possible organizational unit (a team or a set of teams). The challenge of a company transforming towards the idea of bounded context is the smart design of the orthogonal aspect into a well-balanced overall system. The goal of the well-balanced system to minimize the management overhead required to govern the given complexity of the system.

This talk presents a set of good practices for companies to design a well-balanced overall system addressing the three orthogonal aspects of bounded context. Influencing factors in these good practices are size of the company; complexity and number of different business models; level of organizational complexity such as an international business group with different legal entities; ratio of in-house development versus X-shoring; or existing IT infrastructure dependencies.

Although bounded context are very popular especially in agile environments, this talk will silently communicate that classical methods such as business process modeling or business analysis still are first class citizens in the method toolbox of modern companies.

Short Bio

For over 20 years, Rainer Grau engages with or within companies around the topics of agility, lean leadership, enterprise architecture, and lean organization, or to say it differently, he engages in continuous improvement to integrate modern ideas and new approaches in technology, architecture, and organizational design with the goal to succeed in the market as company and to work with fun as human being.

Steps in his professional life are distinguished consultant and partner at Zühlke Engineering; head of business development at Digitec Galaxus; founder of the Suisse Agile Leader Circle SALC; lecturer at universities in topics around innovation, agility, and digital readiness; founding member and reviewer of the International Requirements Engineering Board (IREB);and speaker at many conferences and venues. Rainer is engaged in the agile community in Switzerland with a long-time passion. Discover more information about Rainer Grau on www.juropera.com.

Secure Software Architectures for a Hyperconnected World: Game Changer or Pipe Dream?

Awais Rashid

University of Bristol

Abstract. The world is experiencing a massive growth in connected cyber-physical systems. Innovations such as smart cities, Internet of Things (IoT), body-area networks, smart grids, and wearable sensors mean that future environments will be hyper-connected, highly open, and regularly collect, process, or disseminate massive amounts of data. It is not difficult to envisage large-scale deployments with hundreds of thousands of nodes that are, in turn, used by a large number of stakeholders to provide a multitude of services. Such shared cyber-physical infrastructures will remain in operation for a long time (potentially decades) and the physical composition, the services provided, and the stakeholders involved will change with time. Software is at the heart of these critical systems that will underpin our society for the foreseeable future. What is the role of software architecture in these emerging hyperconnected environments? In this talk, I will discuss this very question and the challenges of architecting secure software systems when faced with this scale, longevity, and dynamicity.

Short Bio

Awais Rashid is Professor of Cyber Security at the University of Bristol, a Fellow of the Alan Turing Institute, and Director of the EPSRC Centre for Doctoral Training in Trust, Identity, Privacy and Security in Large-scale Infrastructures. His research spans software engineering and cyber security - in particular novel techniques to improve the security and resilience of infrastructures underpinning society. He leads projects as part of the UK Research Institute on Trustworthy, Interconnected, Cyber-Physical Systems (RITICS) and the UK Research Institute on Science of Cyber Security (RISCS). He co-leads the Security and Safety theme within the UK Hub on Cyber Security of Internet of Things (PETRAS) and heads a major international effort on developing a Cyber Security Body of Knowledge (CyBOK) to provide interdisciplinary foundations for education and training programs.

Contents

Research Track

Services and Micro-services

Guiding Architectural Decision Making on Service Mesh Based Microservice Architectures 3
Amine El Malki and Uwe Zdun

Supporting Architectural Decision Making on Data Management in Microservice Architectures 20
Evangelos Ntentos, Uwe Zdun, Konstantinos Plakidas, Daniel Schall, Fei Li, and Sebastian Meixner

From a Monolith to a Microservices Architecture: An Approach Based on Transactional Contexts 37
Luís Nunes, Nuno Santos, and António Rito Silva

Software Architecture in Development Process

An Exploratory Study of Naturalistic Decision Making in Complex Software Architecture Environments 55
Ken Power and Rebecca Wirfs-Brock

Evaluating the Effectiveness of Multi-level Greedy Modularity Clustering for Software Architecture Recovery 71
Hasan Sözer

What Quality Attributes Can We Find in Product Backlogs? A Machine Learning Perspective 88
Matthias Galster, Fabian Gilson, and François Georis

Architecturing Elastic Edge Storage Services for Data-Driven Decision Making 97
Ivan Lujic and Hong-Linh Truong

Adaptation and Design Space Exploration

Continuous Adaptation Management in Collective Intelligence Systems 109
Angelika Musil, Juergen Musil, Danny Weyns, and Stefan Biffl

ADOOPLA - Combining Product-Line- and Product-Level Criteria in Multi-objective Optimization of Product Line Architectures 126
Tobias Wägemann, Ramin Tavakoli Kolagari, and Klaus Schmid

Assessing Adaptability of Software Architectures for Cyber Physical Production Systems 143
Michael Mayrhofer, Christoph Mayr-Dorn, Alois Zoitl, Ouijdane Guiza, Georg Weichhart, and Alexander Egyed

Quality Attributes

Optimising Architectures for Performance, Cost, and Security 161
Rajitha Yasaweerasinghelage, Mark Staples, Hye-Young Paik, and Ingo Weber

QoS-Based Formation of Software Architectures in the Internet of Things . . . 178
Martina De Sanctis, Romina Spalazzese, and Catia Trubiani

A Survey on Big Data Analytics Solutions Deployment 195
Camilo Castellanos, Boris Pérez, Carlos A. Varela, María del Pilar Villamil, and Dario Correal

Assessing the Quality Impact of Features in Component-Based Software Architectures 211
Axel Busch, Dominik Fuchß, Maximilian Eckert, and Anne Koziolek

Components and Design Alternatives in E-Assessment Systems 220
Michael Striewe

Industry Track

A Four-Layer Architecture Pattern for Constructing and Managing Digital Twins 231
Somayeh Malakuti, Johannes Schmitt, Marie Platenius-Mohr, Sten Grüner, Ralf Gitzel, and Prerna Bihani

Tool Support for the Migration to Microservice Architecture: An Industrial Case Study 247
Ilaria Pigazzini, Francesca Arcelli Fontana, and Andrea Maggioni

ACE: Easy Deployment of Field Optimization Experiments 264
David Issa Mattos, Jan Bosch, and Helena Holmström Olsson

Author Index 281