13th European Conference on Software Architecture

Proceedings - Volume 2

Edited by:

Laurence Duchien, Anne Koziolek, Raffaela Mirandola, Elena Maria Navarro Martinez, Clément Quinton, Ricardo Scandariato, Patrizia Scandurra, Catia Trubiani, Danny Weyns

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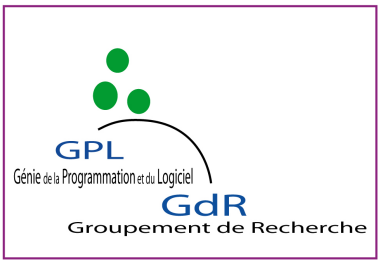
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Laurence Duchien
University of Lille
France
laurence.duchien@univ-lille.fr

Catia Trubiani
Gran Sasso Science Institute (GSSI)
Italy
catia.trubiani@gssi.it

Riccardo Scandariato
Chalmers | University of Gothenburg
Sweden
riccardo.scandariato@cse.gu.se

Raffaela Mirandola
Polytecnico di Milano
Italy
raffaela.mirandola@polimi.it

Elena Maria Navarro Martinez
Universidad de Castilla-La Mancha
Spain
elena.navarro@uclm.es

Danny Weyns
Katholieke Universiteit Leuven
Belgium
danny.weyns@kuleuven.be

Anne Koziolek
Karlsruhe Institute of Technology
Germany
koziolek@kit.edu

Patrizia Scandurra
University of Bergamo
Italy
patrizia.scandurra@unibg.it

Clément Quinton
University of Lille
France
clement.quinton@univ-lille.fr

1 INTRODUCTION

The European Conference on Software Architecture (ECSA), held this year from September 9th to 13th at the FIAP, in Paris, France, is a premier European software architecture conference providing researchers, practitioners, and educators 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 year was special, as we shared the venue and part of the program with the Systems & Software Product Lines Conference (SPLC). Some keynotes and tracks were common to both events. In addition to the main track, the conference featured various events and tracks including the Track on Women in Software Engineering (WSE), a Doctoral symposium, a Tool, demos and poster session, and six workshops. All these events were held with the aim to explore new trends and to support researchers in the early stages of their careers.

2 POSTERS, TOOLS, DEMOS

The Posters, Tools, and Demos Track provides an opportunity for both practitioners and researchers to present and discuss the most recent advances, ideas, experiences, and challenges in the field of software architecture by means of posters and live tool/demo presentations. Specifically,

- Posters intend to stimulate discussions among conference participants: reflections on the past, descriptions of current initiatives, visions of the future, and new results in software architecture research and practice are very welcome.
- Tools and Demos aim to address any aspect of tool support for software architects and can belong to two distinct categories:
  - Tools used in practice, either from commercial vendors, industry or open source projects. These demonstrations focus on practical applications within the different activities of software architecture and should show how they advance the current state of the practice.
  - Research tools from academic or industrial research environments. These demonstrations highlight underlying scientific contributions and show how scientific approaches have been transferred into a working tool.

3 DOCTORAL SYMPOSIUM

The goal of the Doctoral Symposium is to encourage PhD students in the field of software architecture to actively participate in a contribution to ECSA 2019. Students are able to present their research goals, methods and (preliminary) results. They can interact closely with established researchers in their fields, receive feedback on their work and get advice on managing their research. The symposium also helps participants establish new research projects and to network with their peers in the field of software architecture. This year, Professor Carlo Ghezzi 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".

4 WOMEN IN SOFTWARE ENGINEERING

ECSA 2019 includes the fourth Track for Women in Software Engineering co-located with SPLC 2019, in order to support gender diversity in the field. This special track aims at bringing together students, industry professionals, academics, and other leaders in computing to present, share, and celebrate their accomplishments and experiences in achieving more diversity in SE / STEM. The track presents a mix of technical presentations and a panel to discuss current and future issues in the field by leading experts from industry and academia. In addition to the technical content, the intertwining theme is diversity, which plays a key role in being successful, competitive and innovative in software development. Diversity presents itself in many ways: gender, culture, religion,

race, country of origin, etc. Both women and men were invited to collaborate and attend this track. 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 womenâĂŹs empowerment and the founder of Led By HER, Elisabeth Kohler, Director of the CNRS Mission for WomenâĂŹs 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.

5 WORKSHOPS

ECSA invited researchers and practitioners to submit proposals for workshops to be affiliated with the main conference. The main goal of the workshops is to serve as collaborative forums for researchers to exchange and explore innovative software architecture (scientific or engineering) ideas and challenges at an early stage. Suggested topics of interest included software architecture issues for AI- and ML-based systems, for self-adaptive systems, for Cyber-physical systems, in big data and cloud computing, in IoT-based systems, in blockchain engineering as well as in terms of Quality-of-service (QoS) measurements, privacy and security properties, context-aware, autonomous, and smart architecture, sustainable software architecture, software architecture erosion and architectural consistency. ECSA 2019 received nine proposals and accepted the following six workshops:

- 1st workshop dealing with Designing and Measuring Cyber-Security in Software Architectures (DeMeSSA)
- 3rd Formal Approaches for Advanced Computing Systems (FAACS)
- 2nd International Workshop on Software Architecture Challenges in Big Data (SACBD)
- 6th Workshop on Software Architecture Erosion and Architectural Consistency (SAEroCon)
- 1st International Workshop on Software Architectures and Human Values (SAHVA)
- 1st Workshop on Systems, Architectures, and Solutions for Industry 4.0 (SASI4)

Workshops ran as "mini tracks" during the two days before the ECSA main conference. Each workshop had its own organizing committee, program committee, and paper solicitation, review and selection process. Participation in workshops was open but papers for proceedings were selected following a peer-review process organized by each workshop separately.

Introduction to the Posters, Tools, and Demos Track

Elena Navarro
Universidad de Castilla-La Mancha
Spain
elena.navarro@uclm.es

Danny Weyns
KU Leuven, Linnaeus University
Belgium
danny.weyns@kuleuven.be

The 13th European Conference on Software Architecture (ECSA 2019) Posters, Tools, and Demos Track offers researchers and practitioners a forum to discuss novel and emerging topics and demonstrate results in the area of software architecture in an interactive manner. The track solicited two types of submissions:

- Posters are intended to stimulate discussions among conference participants and included: reflections on the past, descriptions of current initiatives, visions for the future, and new results in software architecture research and practice. Authors had to submit a four page paper for review. During the conference, posters will be presented in the poster session.
- Demos are intended to demonstrate practical results obtained in the area of software architecture. Tools are intended to demonstrate reusable artifacts that can support researchers or practitioners with architectural tasks. Demos and tools papers are also four pages and show how scientific approaches have been transferred into a working artifact.

Each submission was reviewed by at least three members of the Program Committee. From 15 submissions, four demos and six posters were accepted. The topics addressed by the accepted papers are quite diverse. Demo and tool papers focus on topics as diverse as: automation of architectural adaptations, support for trace-ability from code to architecture, and support for encoding architectural knowledge in collaborative environments. On the other side, poster papers focus on initial proposals including the following topics: assessing the quality of software architecture linked to patterns and recommendation systems, the reconstruction of the software architecture, and a novel approach for introducing self-adaptation in software architecture.

To engage the broader ECSA audience in the track, a teaser session will be organized, where authors of posters, tools and demos, will be able to briefly showcase their work. After that, an open and interactive session is planned for the presentation of the artifacts. A best paper for the track will be awarded during the conference.

We thank all the authors for submitting papers to this track. We express our sincere appreciation to the following people of the Program Committee of this track:

- Ilias Gerostathopoulos, Technical University of Munich
- Claudia Raibulet, University of Milano-Bicocca
- Silverio Martinez-Fernandez, Fraunhofer
- Thomas Vogel, Humboldt University Berlin
- Elisa Yumi Nakagawa, University of SÃčo Paulo
- Rodrigo Santos, UNIRIO
- Rami Bahsoon, School of Computer Science, University of Birmingham
- Henry Muccini, University of L'Aquila
- Diego Perez-Palacin, Linnaeus University
- Jennifer Perez, Universidad Politecnica de Madrid
- Pablo Oliveira Antonino, Fraunhofer
- Ingrid Nunes, Universidade Federal do Rio Grande do Sul (UFRGS)

Last but not least, thanks go to the Organizing Committee, in particular, to the General Chair and Workshops Co-Chairs for their time and effort in organizing ECSA 2019.

Introduction to the Doctoral Symposium

Raffaela Mirandola
Politecnico di Milano
Milan, Italy
raffaela.mirandola@polimi.it

As in previous editions of the European Conference on Software Architecture, the Doctoral Symposium has been envisaged as an opportunity to encourage PhD students in the field of software architecture to actively participate in and contribute to the 13th European Conference on Software Architecture (ECSA 2019). Students were encouraged to present their research goals, methods and (preliminary) results, interacting closely with established researchers in their fields, receiving feedback on their work and getting advice on managing their research. Both Ph.D. students at early and advanced stages of their research were welcome. Every submitted paper was reviewed by at least three Doctoral Symposium Committee members. The review process was based on technical quality of the submission (e.g., clarity, precision, and adequacy of the problem statement, related work, self-contained solution description, expected results and their evaluation plan), and overall quality, including originality of the submission, the novelty of the research approach, and relevance to ECSA 2019. We received 11 submissions and after this thorough review process, 7 contributions were accepted for presentation during the conference.

This year the Doctoral Symposium featured also an inspiring keynote from Professor Carlo Ghezzi, about the challenges of the academic career, that afforded questions like: *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?*. During the talk, he presented answers based on what he learnt from others and on his own experience.

Our gratitude to Professor Carlo Ghezzi who accepted to share his experience with the students, and to the Doctoral Symposium Committee members for all their support. Thanks also to the PhD students who actively discussed and argued about their work and debating during the sessions. They all enabled us to have an interesting symposium.

1 DOCTORAL SYMPOSIUM COMMITTEE

Introduction to the track Women in Software Engineering

WSE@ECSA&SPLC 2019

Anne Koziolek
Karlsruhe Institute of Technology
Germany
koziolek@kit.edu

Patrizia Scandurra
Università degli Studi di Bergamo,
Bergamo, Italy
patrizia.scandurra@unibg.it

OVERVIEW

It has been widely demonstrated that diversity in gender, culture, religion, country, etc. is a key factor to have success and be competitive and innovative in software development. In the case of gender diversity, the role of women in the Computing area has gained more and more importance with the emerging information age. However, setting up gender-balanced teams in ICT companies and in STEM universities and research centers is still hard to realize in practice, even if all recognize the importance of achieving gender diversity for the success of projects.

In this scenario, the special track on "Women in Software Engineering" is part of the two co-located conferences: the 13th premier European Conference on Software Architecture (ECSA 2019) and the 23rd Systems and Software Product Line Conference (SPLC 2019). As the fourth consecutive year, following the success of the past editions of the "Women in Software Architecture" track of previous ECSA editions, WSE will provide a forum for discussions about how to achieve more diversity in SE / STEM. Both women and men are invited to collaborate and attend to this track. Students, industry professionals, academics, and other leaders in computing are welcome to promote networking and technical discussion to motivate the participation and visibility of women in STEM degree and industry.

There will be a mix of presentations and a panel to discuss about current and future issues in the field by leading experts from industry and academia.

The topics of WSE include, but are not limited to, preliminary results from work-in-progress, discussion of challenges, position papers, experience reports, or studies; all regarding gender diversity in Software Engineering, and more generally in STEM, both in industry and academia. The evaluation criteria for submissions were whether they contribute ideas or results to the challenge of achieving more diversity in SE/STEM and whether the argumentation and/or study are sound.

This year, WSE received a total of eight submissions. All papers were reviewed by three members of the Program Committee. Five contributions have been accepted for inclusion in the technical program. Colomo-Palacios and Casado-Lumbreras analyzed whether a set of socioeconomic and cultural factors can explain the observed percentage of women in ICT in different European countries. Marzolla and Mirandola provide descriptive analysis of the gender balance in Computer Science and Computer Engineering in Italian Universities. Buhnova et al. present their experience with the Czechitas project which assists women in their 20s and 30s in changing career towards tech. Singh discussed resulst of a study about experience of women in open source software projects. Finally, Schindler and Müller present a study on gender differences and self ratings among first semester university CS students.

A panel about current and future practices to mitigate gender stereotypes and sexism in IT recruitment and workplaces will follow these presentations. The following five high-profile panelists accepted our invitation:

- *Isabelle Collet*, professor at University of Genève, Switzerland
- *Chiara Condi*, activist for women's empowerment and founder of Led By HER, France
- *Elisabeth Kohler*, director of the CNRS Mission for Women's Integration, France
- *Florence Sedes*, professor at University of Toulouse, France
- *Serge Abiteboul*, senior researcher at Inria and affiliated professor at ENS Paris-Saclay, France

ACKNOWLEDGMENTS

We would like to thank all the program committee members for their reviewing job. We want to thank the organization of ECSA 2019 for their impressive responsiveness and help. Last, but not least, we also extend our gratitude to all authors for the received submissions.

PROGRAM COMMITTEE

- Alberto Avritzer – eSulabSolutions, USA
- Carlos E. Cuesta – Universidad Rey Juan Carlos, Spain
- Javier Javier Cámara – University of York, England
- Letizia Jaccheri – NTNU, Norway
- Patricia Lago – VU Amsterdam, The Netherlands
- Seonah Lee – Gyeongsang National University, Jinju, Korea
- Grace Lewis – Carnegie Mellon SEI, USA
- Bashar Nuseibeh – Open University (UK) & Lero (Ireland)
- Flavio Oquendo – IRISA, University of South Brittany, France
- Jennifer Perez – Universidad Politécnica de Madrid, Spain
- Diego Perez Palacin – Linnaeus University, Sweden
- Rafael Prikladnicki – PUCRS, Brazil
- ClÃĺment Quinton – University of Lille, France
- Ralf Reussner – Karlsruhe Institute of Technology, Germany
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- David Shepherd – ABB Inc, USA
- Marjan Sirjani – Mälardalen University, Sweden
- Catia Trubiani – Gran Sasso Science Institute, Italy

WSE 2019 webpages

https://ecsa2019.univ-lille.fr/tracks/women-software-engineering
https://ecsa2019.univ-lille.fr/program/women-software-engineering-panel

Editorial Message for the International Workshop on Designing and Measuring CyberSecurity in Software Architectures (DeMeSSA)

Flavio Oquendo & Vanea Chiprianov
IRISA – UMR CNRS / Univ. of South Brittany, France

Reijo Savola
VTT Technical Research Centre of Finland, Oulu, Finland

Axel Legay
UCLouvain – Catholic Univ. of Louvain, Belgium

Habtamu Abie
Norwegian Computing Center, Oslo, Norway

Jamal El Hachem
LIUPPA – University of Pau and Adour, France

Pekka Savolainen
VTT Technical Research Centre of Finland, Oulu, Finland

ABSTRACT

With the growing complexity of software and in particular of software-reliant systems and systems-of-systems, the focus of cybersecurity on network and code has been increasingly shifted to design and more recently to "cybersecurity by design" or "design for cybersecurity", where the software architecture is the keystone for enforcing cybersecurity. Early evidence of cyber risks, attacks and vulnerabilities enables efficient and effective cybersecurity solutions. Security measurement of software architectures is needed to produce sufficient evidence of cybersecurity level in the design phase. Moreover, software architectures have to support runtime security measurement to obtain up-to-date cybersecurity information. This is essential for self-protecting systems and self-adaptive cybersecurity solutions.

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1 INTRODUCTION

With the growing complexity of software and in particular of software-reliant systems and systems-of-systems, the focus of cybersecurity on "network" and "code" has been increasingly shifted to "design" and more recently to "security by design", where the software architecture is the keystone for enforcing cybersecurity. Indeed, as consensually admitted, software architecture is the fundamental artifact for addressing extra-functional requirements in software-reliant systems and systems-of-systems, especially in the case of cybersecurity issues.

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Therefore, the endeavor of addressing threats, vulnerabilities, and security controls (safeguards or countermeasures) evolved from the operational phase, where the focus was mainly on network security, in the last decades, to architect software-reliant systems and systems-of-systems in recent years. De facto, cybersecurity has intrinsic characteristics that are hard to address, in particular related to the unpredictability and uncertainty of threats and attacks, which call for novel approaches in Software Architecture as part of the effort to achieve cybersecurity by design.

This International Workshop on Designing and Measuring CyberSecurity in Software Architecture (DeMeSSA 2019) at ECSA 2019, has provided researchers and practitioners with a forum to exchange ideas and experiences, analyze research and development issues, discuss promising solutions, and propose inspiring visions for the future in complementary fields of Cybersecurity from the perspective of the Software Architecture: Designing CyberSecurity in Software Architecture and Measuring CyberSecurity in Software Architecture Design.

2 MOTIVATION FOR DESIGNING AND MEASURING SECURE SOFTWARE ARCHITECTURES

From the software architecture perspective, cybersecurity is a built-in quality attribute affecting the whole software lifecycle. Indeed, the keystone to "security by design" is to prevent security flaws by introducing security controls (safeguards or countermeasures) in the early phases of a secure software development lifecycle [4]. Also, early security considerations during software architecture design promotes economic and social benefits as shown in recent empirical studies [2]. In fact, addressing security at the architectural design time contributes to minimize cybersecurity risks as well as efforts/costs of security controls [3] [6] [11]. Actually, security vulnerabilities discovered later in the software development cycle are much more expensive to fix than those discovered early at architectural design [1] [7]. Moreover, fixing vulnerabilities after implementation requires work around which often increase the attack surface [10].

In addition, poor design practices and unmethodical design of security functionalities may lead to security troubles causing serious financial loss or even loss of lives [3] [8].

Moreover, the upcoming generation of software-reliant systems and systems-of-systems will operate in environments that are open in the sense of that they are only partially known at design-time. These bring new challenges to address cybersecurity at the software architecture level, in terms of initial design and subsequent adaptations, self-adaptations or self-organizations at operational time.

Security modeling and analysis at the design stage helps preventing the damage that can occur as a consequence of such security problems. The main advantages of security modeling is the delivery of reusable, extendable and refinable security artifacts [9] [5]. For that reason, there is need of methods, processes and tools to design more secure systems.

3 STATISTICS

The Program Committee selected 3 full papers out of 6 submissions, giving an acceptance rate of 50%. These papers were selected based on originality, quality, soundness, and relevance to this workshop and conference. Submissions were reviewed in average by three members of the Program Committee.

4 TOPICS

DeMeSSA 2019 fosters (but is not limited to) submissions in the following topics:

- Metrics and measurement approaches
  - Security, trust and privacy metrics
  - Measurement systems and associated data gathering
  - Measurability-increasing mechanisms for software architectures
  - Security trade-off analysis
  - Assurance and re-assurance methods
  - Runtime security measurements
  - Evolutionary techniques
- Metrics applications
  - Adaptive and cognitive security
  - Artificial Intelligence security
  - Cloud security solutions
  - Internet of Things security
  - Situational awareness and threat intelligence
  - Architecture-based self-protecting systems
  - 5G and Software Defined Networks
  - Forensics and data analytics
  - Visualization approaches for security measurements
  - Empirical case studies and experimental results from security measurements
- Security architecture techniques
  - Architecture Risk Management
  - Security-Driven Architecture
  - Design Patterns Driven Security
  - Enforcing Security from Architectural Designs to Implementation Artefacts
- Model-based techniques for secure software architectures
  - Secure Architecture Modeling
  - Attack and Intrusion Modeling
  - Defense Modeling
  - Vulnerability Modeling
  - Adaptive Security Modeling
  - Model-based Security Frameworks
- Relation of Security with other Extra-Functional Properties
  - Safety & Security by Architectural Design
  - Dependability & Security by Architectural Design
  - Reliability & Security by Architectural Design
  - Interdependencies and Trade-offs at Architectural Design
- Security by Architectural Design in Different Kinds of Systems: Critical Systems, Cyber-Physical Systems, Systems of Systems, Cloud Computing, Internet of Things
- Future Perspectives, Challenges and Roadmaps on Security by Architectural Design

5 PROGRAM COMMITTEE

We would like to thank the members of the Program Committee for providing thoughtful and knowledgeable reviews and for their substantial effort in making DeMeSSA a successful workshop.

Name	Surname	Affiliation	Country
Muhammad	Ali Babar	The Uni. of Adelaide	Australia
Amel	Bennaceur	The Open Uni.	UK
Lorenzo	Blasi	Hewlett Packard	Italy
Svetlana	Boudko	Norwegian Computing Center	Norway
Barbora	Buhnova	Masaryk Uni.	Czech Republic
Nora	Cuppens-Boulahia	IMT Atlantique	France
Antti	Evesti	KPMG	Finland
Eduardo B.	Fernandez	Florida Atlantic Uni.	USA
Tapio	Frantti	Uni. of Oulu	Finland
Lothar	Fritsch	Karlstad Uni.	Sweden
Volker	Gruhn	Universität Duisburg-Essen	Germany
Pontus	Johnson	KTH Royal Institute of Technology	Sweden
Jan	Jürjens	Fraunhofer Inst. for Soft. & Syst. Eng. ISST and Uni. of Koblenz-Landau	Germany
Basel	Katt	Uni. of Science and Technology (NTNU)	Norway
Rick	Kazman	SEI, Carnegie-Mellon Uni., and Uni. of Hawaii	USA
Nuno	Laranjeiro	Uni. of Coimbra	Portugal
Yves	Le Traon	Uni. of Luxembourg	Luxembourg
Wolfgang	Leister	Norwegian Computing Center	Norway
Fabio	Martinelli	IIT-CNR	Italy

Name	Surname	Affiliation	Country
Antonio	Maña	Uni. of Malaga	Spain
Mohammad	Mozumdar	CSU Long Beach	USA
Phu H.	Nguyen	SINTEF	Norway
Ebenezer	Paintsil	Telenor ASA	Norway
Juha	Röning	Uni. of Oulu	Finland
Riccardo	Scandariato	Uni. of Gothenburg	Sweden
Einar	Snekkenes	Uni. of Science and Technology (NTNU)	Norway
Claudia	Szabo	The Uni. of Adelaide	Australia
Denis	Trcek	Uni. of Ljubljana	Slovenia
Koen	Yskout	Katholieke Universiteit Leuven	Belgium

6 WORKSHOP PROGRAM

DeMeSSA was a 1-Day Workshop:

- In the morning, in the first session, there was the keynote by Riccardo Scandariato (University of Gothenburg and Chalmers, Sweden), entitled "Security and privacy in software architecture: build 'em, break 'em, fix 'em", followed by a second session with the presentation of the 3 accepted papers.
- In the afternoon, two working sessions were organized, on key challenges for cybersecurity related to software architecture. In the first working session we split in groups, in the second we merged, with one presentation per group and the panel/final discussion.

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3rd workshop on Formal Approaches for Advanced Computing Systems (FAACS)

Alessandro Bianchi
Dept. of Information Technology,
Università degli Studi di Bari,
Bari, Italy
alessandro.bianchi@uniba.it

Matteo Camilli
Dept. of Computer Science,
Università degli Studi di Milano,
Milan, Italy
matteo.camilli@unimi.it

Patrizia Scandurra
Dept. of Management, Information,
and Production Engineering,
Università degli Studi di Bergamo,
Bergamo, Italy
patrizia.scandurra@unibg.it

OVERVIEW

The Third edition of the International Workshop series on Formal Approaches for Advanced Computing Systems (FAACS 2019) will be held in Paris, France, on September 10th, 2019. The workshop is co-located with the 13th European Conference on Software Architecture (ECSA 2019). The history of FAACS is briefly described in the following. In 2017, the 1st Workshop on Formal Approaches for Advanced Computing Systems (FAACS2017) took place in Trento, Italy, on September 4th, 2017, as a satellite workshop of the 15th International Conference on Software Engineering and Formal Methods (SEFM2017). The 2nd edition (FAACS2018) was held in Madrid, Spain, on September 25th, 2018, as a satellite workshop of the 12th European Conference on Software Architecture (ECSA2018).

The main mission of the workshop is to foster integration between the formal methods and the software architecture communities with the purpose of improving their connection in the field of Advanced Computing Systems. This is an emerging class of software systems that expose complex computational models (such as mobile, cloud, autonomic, and adaptive computing) and exploit new technologies and infrastructures (such as IoT connectivity and smart devices) to deliver services and information to a multitude of end-users. The development of these Advanced Computing Systems requires advanced architectural design exploiting the integration of heterogeneous architecture description languages, architectural patterns, qualitative and quantitative assessment of architectures, and solutions already individually tested in specific contexts. Although significant advancement has been achieved during decades of research activity, formal methods are still not widely adopted by the software industry. Thus, delivered products often behave unexpectedly, sometimes exposing users to highly undesired consequences, such as threats to confidentiality and even financial or health danger. Ensuring the reliability, safety, availability, and so on, of such systems, is a very challenging problem, requiring advanced software architecture design that can be devised by the software architecture community, on one hand, and rigorous modeling and analysis techniques that can be devised by the formal methods community, on the other hand.

Specific topics of FAACS include, but are not limited to:

- Application of formal/semi-formal methods in:
  - Linking requirements engineering and software architectures
  - Architecture design, validation and verification, quality analysis and evaluation
  - Architecture description languages and meta-models
  - Architecture-centric model driven engineering
  - Architecture-centric process models and frameworks
  - Architectural patterns, styles and tactics, viewpoints and views
  - Architecture transformation and refinement, architecture-based synthesis
  - Architecture-based evolution
- Integrating formal/semi-formal methods and architecture-centric software engineering for:
  - Service-Oriented Architectures (SOA), Web services, and Microservices reconfigurable and self-adaptive systems
  - mobile applications
  - cloud applications
  - mobile cloud applications
  - IoT applications
  - smart systems
  - ultra-large scale, long-lived systems and systems-of-systems
  - cyber-Physical Systems
- Formal/semi-formal analysis and architecture-centric software engineering provided as a service on the Cloud or in an IoT infrastructure.
- Case studies and experience reports in using formal approaches in software architecture design and analysis.

Authors of accepted contributions will present their own current work/results and they will discuss their findings in relation with the motivation and scope of the workshop. Namely, significant research questions that will be addressed include: (*i*) are formal methods, at the current stage of the state-of-the-art, suitable for the specification and analysis of such systems in co-operation with software architecture design and assessment methodologies and techniques? (*ii*) do they require some kind of renewal? (*iii*) what are the upcoming challenges for both formal methods and software architecture communities in devising formal techniques and tools for such systems?

This year, FAACS received a total of seven submissions. Five contributions have been accepted for inclusion in the technical program, after review and discussion by at least three members of the Program Committee.

Consistently with the previous FAACS editions, a major objective of the workshop is to establish a forum for researchers and practitioners to discuss about effectiveness of formal (and semi-formal) methods for architectural design and behavioral specification of advanced computing systems, and about the upcoming challenges for the formal methods community in devising rigorous approaches able to deal with characteristics of the emerging technologies and

computational models of this class of systems. Fostering integration between formal methods and software architecture communities would help to strengthen links between them, and to stimulate researchers to share novel ideas, techniques, and lessons learned, from both industrial and academic experts, from a variety of application domains and software disciplines.

KEYNOTE SPEAKER

The workshop program will include an invited keynote speech by Javier Cámara. Javier graduated from the University of Granada (Spain). After receiving his Ph.D. in Computer Science from the University of Málaga (Spain), he worked as a postdoctoral researcher at INRIA Rhône-Alpes (France), and the University of Coimbra (Portugal). He has been a Senior Research Scientist at Carnegie Mellon University (USA). He is currently a Lecturer in the Department of Computer Science at the University of York (UK). Javier have been holding technical leadership responsibilities in projects that explored the construction and formal analysis of self-managing systems by combining quantitative verification, game-theoretical models, and formal descriptions of software architectures. He has applied these techniques in projects that span the mobile robotics, Cyber Security, and Systems-of-Systems domains.

Title. Model Integration and Decision-Making for Self-Adaptation in Mobile Robotics

Abstract. Cyber Physical Systems (CPS) often need to self-adapt their structure and behavior at run time to respond to changes in their operating environment. Existing approaches to engineering self-adaptation have at their core a set of models used to support reasoning about when and how to best adapt the system at run time. Combining information from such models to feed run-time analysis and planning processes for self-adaptation in pure software systems is relatively straightforward because all the models describe software. However, models in a CPS are much more heterogeneous in terms of representation, semantics, and facet of the domain that they capture (e.g., energy consumption, software architecture, physical space, safety). This heterogeneity poses a fundamental challenge in bringing together the information represented in these models to support self-adaptation in CPS. This challenge is complicated by the inherent uncertainty that arises both from the imprecision of the models, as well as the variability and lack of predictability of the environment.

This talk introduces a model-based synthesis and quantitative verification approach to decision-making for self-adaptation that has been applied to the domain of mobile service robots. The approach: (*i*) abstracts relevant information into views from heterogeneous models, and integrates them into high-level probabilistic models, and (*ii*) incorporates planning that has at its core a probabilistic model checker (PRISM) that is used to reason quantitatively about the outcome of adaptation decisions in a rich trade-off space. The key benefits of this approach are extensibility (new types of models can be added), generality (the planning mechanism allows an arbitrary number of quantifiable quality dimensions), assurance (the probabilistic planner provides quantitative guarantees about behavior), and automation (system reconfiguration actions and task planning can be directly synthesized from models).

ACKNOWLEDGMENTS

We would like to thank our keynote speaker, Javier Cámara for accepting the invitation, and all the program committee members for their reviewing job. We want to thank the organization of ECSA 2019 for their impressive responsiveness and help, and in particular the workshop chairs Catia Trubiani and Riccardo Scandariato. Furthermore, we want to tank the steering committee members for their valuable support. Last, but not least, we also extend our gratitude to all authors for the received submissions. The program co-chairs Alessandro, Matteo, and Patrizia appreciate their effort and help in making FAACS 2019 a great event.

PROGRAM COMMITTEE

- Yamine Ait Ameur, IRIT/INPT-ENSEEIHT, France
- Paolo Arcaini, National Institute of Informatics, Japan
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- Paolo Arcaini, National Institute of Informatics, Japan
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- Patrizia Scandurra, UniversitÃă degli Studi di Bergamo, Italy

FAACS 2019 webpage

http://faacs.di.unimi.it

FAACS 2019 social media

Twitter @faacs2019

2nd International Workshop on Software Architecture Challenges in Big Data (SACBD)

Zoltán Ádám Mann
paluno – The Ruhr Institute for Software Technology
University of Duisburg-Essen
Essen, Germany
zoltan.mann@paluno.uni-due.de

Michele Guerriero
Politecnico di Milano
Milano, Italy
michele.guerriero@polimi.it

Daniel Alonso Román
Instituto Tecnológico de Informática
Valencia, Spain
dalonso@iti.es

Alessandra Bagnato
SOFTEAM R&D Department
Guyancourt, France
alessandra.bagnato@softeam.fr

Software systems managing big data have very challenging architectural requirements, e.g., in terms of performance, flexibility, and reliability. Big data systems often embody a number of technologies, such as cloud computing, the Internet of Things (IoT), fog computing, high-performance computing (HPC), artificial intelligence (AI), and in particular machine learning (ML). These technologies come with their own technical limitations and constraints that also impact the architecture of big data systems. Enforcing security, privacy, transparency, and ethics are also concerns of increasing importance, with potential architectural implications.

The Big Data Value Association (BDVA, http://www.bdva.eu/) initiated the Workshop on Software Architecture Challenges in Big Data (SACBD) workshop series to provide a forum for discussing all aspects of the software architecture challenges of big data systems. The workshop is open to all, both BDVA members and non-members.

The main discussion topics of the workshop are:

- Software architectures in genuine big data scenarios
- Architectural patterns for big data
- Architectures of big data systems (e.g., Spark, Flink, Hadoop)
- Integration of Big Data systems with other business systems
- Non-functional requirements (e.g., performance, security, privacy, reliability)
- Combining big data with IoT, HPC, cloud computing, fog computing
- Applying machine learning to big data scenarios, big data integration with artificial intelligence
- Fostering business with big data and analytics

Every submitted paper was reviewed by at least three members of the Program Committee. Finally, three papers were accepted for publication and oral presentation to this workshop. All selected papers are of high quality and able to convey fruitful discussions and exchanges during the workshop, thanks to the professionalism of the authors, reviewers and program committee members.

Program committee:

- Ali Serdar Atalay, BitNet, Turkey
- Peter Baumann, Jacobs University Bremen, Germany
- Arne Berre, SINTEF, Norway
- David Bowden, DELL, Ireland
- Sergio Campos, Tecnalia Research & Innovation, Spain
- Alexandru Costan, IRISA / INSA Rennes, France
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- Ana Isabel Torre, Tecnalia, Spain
- Anwar Vahed, Meraka Institute, South Africa
- Juan Manuel Vara, Universidad Rey Juan Carlos, Spain

We would like to take this opportunity to thank the people who have contributed to the SACBD 2019 workshop. We wish to thank all authors and reviewers for their valuable contributions, and we

wish them a successful continuation of their work in this area. Finally, we thank the organization of the 13th European Conference on Software Architecture (ECSA) conference in which this workshop has been embedded.

July 2019

The Organizational Committee

- Zoltán Ádám Mann, University of Duisburg-Essen, Germany
- Daniel Alonso Román, Technology Institute of Valencia, Spain
- Michele Guerriero, Politecnico di Milano, Italy
- Alessandra Bagnato, Softeam, France

The 6th Workshop on Software Architecture Erosion and Architectural Consistency (SAEroCon)

Jim Buckley
Lero / CSIS
University of Limerick
Limerick, Ireland
+353 (0)61 213531
jim.buckley@ul.ie

Sebastian Herold
Department of Mathematics and
Computer Science, Karlstad University
651 88 Karlstad, Sweden
+ 46 (0)54 7002104
sebastian.herold@kau.se

Jan Martijn van der Werf
Department of ICS
Utrecht University
3584 CC, Utrecht, Netherlands
+31 (30)253 1807
J.M.E.M.vanderWerf@uu.nl

Categories and Subject Descriptors
D.2.11 [**Software Engineering**]: Software Architectures

Keywords
Software architecture, architecture consistency, architecture erosion

INTRODUCTION
As software systems evolve over time to increased complexity and scale, it is difficult to avoid effects like software architecture erosion/drift, where the architecture of the implemented system moves away from the originally envisaged architecture for the system [1]. In the case of erosion, the resultant divergence is associated with negative impacts on the quality attributes associated with the intended architecture. Drift is not as immediately problematic, in that it does not impact on the quality attributes, but it does lead to a situation where there is decreased understanding of the architectural status of the system across the team. As studies have shown, untreated divergence can lead to systems which are impossible to maintain in the long run. Expensive redevelopments and replacements are too often the consequences [2].

Studies suggest that software architecture erosion/drift, and the inconsistencies resulting from these effects, are prevalent, yet under-researched problems in industrial practice. Technical challenges related to these problems are the recovery of intended architectures, particularly for legacy systems without a documented intended architecture; stalling the introduction of divergences between the planned and implemented architecture [3]; detection of erosion/drift; avoiding or resolving the results of drift/erosion efficiently [4]; and evolving the architecture so that consistency is preserved. However, organizational challenges like estimating the benefit of putting effort into pro-actively avoiding or resolving erosion also play an important role in practice [5].

In recent years, researchers from different communities like software maintenance, model-driven development, and software architecture have all investigated aspects of software architecture erosion and drift from different perspectives. This interest from such different communities points to the prevalence of the concern for the software engineering community.

The goal of the SAEroCon workshop is to intensify the exchange of ideas regarding the current state-of-the-art/the state-of-the-practice in this field, and to guide future research directions regarding architecture consistency, architecture recovery and erosion-result mitigation. The workshop targets all software engineering researchers and practitioners interested in discussing ideas regarding these topics and shaping future research related to them.

Two core organizational characteristics serve to distinguish this workshop from others. Firstly, authors are pre-invited to present each other's work to the group and pose a set of initial questions back to the original author. Then, the original author is invited to respond: to address any misunderstandings or inaccuracies in the presentation and to answer the original set of questions posed by the presenter. This format prompts immersive discussion and debate of the papers, insuring that (at least) two of the participants are very familiar with the material contained within each paper in advance of the workshop. Additionally, this serves to draw other participants into the discussion of the paper, as the questions are discussed. The ultimate goal here is to prompt interaction with the work presented at a level that facilitates community-building and collaboration.

The second distinguishing feature of the workshop is that a developer with architectural knowledge of an Open Source system is invited to present and discuss the architecture of that system with the group. This takes the form of an initial, general presentation of the architecture and subsequent discussion where the architect is directed towards providing architectural ground-truths about the system that can be used to evaluate architectural consistency approaches. The goal here is to provide benchmark material that facilitates empirical evaluation going forward. Material from these sessions is typically recorded in an openly-available repository of Open Source ground-truth architectures, for evaluation purposes, and is available to researchers at [6].

The architect may also describe any efforts the Open Source community have made to address architectural violations. Finally, time will be set aside for the architect to try out different prototype tools developed by the participants to provide feedback on their workings.

This year Eric Verbeek from the development team of ProM has kindly agreed to participate in the workshop, and he will have two sessions, dedicated to the tool's architecture.

ORGANIZING COMMITTEE

- Jim Buckley, University of Limerick, Ireland
- Sebastian Herold, Karlstad University, Sweden
- Jan Martijn van der Werf, Utrecht University, the Netherlands

PROGRAM COMMITTEE

- Nour Ali, Brunel University, The United Kingdom
- * Martin Blom, Karlstad University, Sweden
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- Andrew LeGear, Horizon Globex
- Tobias Olsson, Linnaeus University
- Martijn van der Werf., Utrecht University, The Netherlands

Acknowledgements

We would like to thank everyone that supports this year's SAEroCon. We would particularly like to thank the authors who submit and present work and all those participants who engage in fruitful constructive discussions over the 2 days of the workshop itself. We would also like to acknowledge the diligent work of the program committee in reviewing the submissions thoroughly, in a timely fashion, and with integrity.

We are extremely grateful to Eric Verbeek from ProM for being with us, and presenting and discussing the tool's architecture with the workshop participants. His insights will allow the research community to gain a deeper perspective on the system, obtaining a "real-world ground-truth architecture" – which is crucial for the evaluation and comparison of approaches in our field going forward.

Finally, this work was supported, in part, by Science Foundation Ireland Grant 13/RC/2094 to Lero, the Irish Software Engineering Research Centre (http://www.lero.ie)

Jim Buckley
Sebastian Herold
Jan Martijn van der Werf

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1st International Workshop on Software Architectures and Human Values (SAHVA)

Elisa Yumi Nakagawa
University of São Paulo-USP
São Carlos, SP, Brazil
elisa@icmc.usp.br

Maria Angela Ferrario
Lancaster University
Lancaster, United Kingdom
m.ferrario@lancaster.ac.uk

Colin C. Venters
University of Huddersfield
Huddersfield, United Kingdom
c.venters@hud.ac.uk

Milena Guessi
University of São Paulo-USP and University of Toronto
São Carlos, SP, Brazil
milena@icmc.usp.br

ABSTRACT

Sustainable software systems require an in-depth understanding about the role that software systems play in our society at a scale and along time frames that are often difficult to grasp and envisage. We argue that a values 'first' software engineering (SE) perspective can offer new insights not only about the human and social aspects that shape SE decision-making processes, but also the potential uses, misuses, and vulnerabilities of complex socio-technical systems afforded by high-level design decisions. While the area of values-based SE has explored means for identifying and making sense of values in the analysis of software production, more effort is required to investigate how values are ultimately instantiated in the architectural structuring of software systems, and the long-term implications of such design decisions. This workshop provides a unique forum where students, researchers, and practitioners working on requirements engineering, software processes, societal aspects of SE, and software sustainability can come together to advance the field of value-based software architectures.

CCS CONCEPTS

• **Software and its engineering → Software architectures**; **Extra-functional properties**; • **Human-centered computing**;

KEYWORDS

software architecture, human value

1 INTRODUCTION

Software architectures have had a determinant role in successful software systems, encompassing the fundamental organization of a system that is embodied in its components, their relationships to each other and to the environment, and the principles governing its design and evolution over time [1]. While software architects tend to focus on the technical elements that make up a software system, the far reaching effects of software systems to society are rarely visible in the engineering process. Moreover, the individual and organizational principles that drive software decision-making processes, such as prestige, financial success, and social good, can have long-term implications to software systems design.

For over a decade, the values-based Software Engineering (SE) has explored means for identifying and making sense of values in the analysis of software production [3, 5]. Values represent our guiding principles influencing our decision-making processes as groups, individuals, and organizations [2]. Nonetheless, more research is required to better understand how values are ultimately instantiated in the architectural design of software systems, and the long-term implications of such design decisions [4]. A values 'first' SE perspective can offer new insights not only about the human and social aspects that shape SE decision-making processes, but also the potential uses, misuses, and vulnerabilities of complex socio-technical systems that have been afforded by high-level design decisions [6].

Since software architects are ultimately the ones responsible for shaping software systems design, the ECSA offers the perfect setting for outlining the present and future of the value-based software architecture research field.

2 WORKSHOP GOALS

In this workshop, we aim to understand the impact of values in software architectures, discuss the relationship of values to high-level decisions, identify potential tensions that require methods for value negotiation, and offer practical advice for value management within software processes. We also look for contributions that demonstrate how software architectures have been designed to meet a specific set of values or where values tensions may have led to systems failures or to mechanisms that have addressed or mitigated such tensions. The aim is to distil practice-based experiences, methods, and theory that will support the community working in this new and emerging research field.

This workshop will provide a forum where students, researchers, and practitioners working on requirements engineering, software processes, societal aspects of SE, and software sustainability will be able to share their latest research results, challenges, and future directions for addressing human values in software architectures.

3 PROGRAM COMMITTEE

In addition to the workshop organizers, the Program Committee consisted of practitioners and researchers:

- Pauline Anthonysamy, Lancaster University and Google Switzerland, UK
- Stefanie Betz, Furtwangen University, Germany
- Coral Calero, Universidad de Castilla-La Mancha, Spain
- Jeffrey Carver, University of Alabama, USA
- Ruzanna Chitchyan, University of Bristol, UK

- Leticia Duboc, University Ramon Llull, Spain
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- Shihong Huang, Florida Atlantic University and Carnegie Mellow University, USA
- Lucy Hunt, Lancaster University, UK
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- Rick Kazman, Software Engineering Institute, Carnegie-Mellon University, and University of Hawaii, USA
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- Grace Lewis, Carnegie Mellon Software Engineering Institute, USA
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- Pablo Oliveira Antonino, Fraunhofer IESE, Germany
- Birgit Penzenstadler, California State University Long Beach, USA
- Emily Winter, Lancaster University, UK

4 ACCEPTED PAPERS

The first edition of this workshop received six papers that were peer-reviewed by the Program Committee members.

- Ogunyemi, A.; Plank, M.; and Vanbuel, M. *Placing Human Values at the Core of Socio-Technical Systems.* The authors reported a case where usability, inclusiveness, and intuitiveness played a key role for the design of a media player service targeting researchers and educators as well as the general public.
- Müller, M.; Vorraber, W.; Herold, M.; Schindler, C.; Slany, W. and Tanaka, K. *Streamlining Value in a FOSS Project.* The authors discussed the challenges for supporting an open source repository over the years and how they plan to sustain its growth in the future.
- Gennari, S. and Goya, D. *A Systems-of-Systems Security Framework for Requirements Definition in Cloud Environment*: This paper proposed a framework to guide the planning and definition phases of security requirements for systems-of-systems in the context of agile development and DevSecOps.
- Kassab, M.; Graciano Neto, V. V. and Allian, A.P.; *Investigating Quality Requirements from a Human Perspective in IoT-Based Software Architectures for Education.* Based on results of a systematic literature review, the authors discussed on the benefits and challenges of incorporating Internet of Things technologies in the teaching and learning activities, in particular, on three domain-related quality requirements in IoTs for education; namely, security, scalability and humanization.
- Volpato, T.; Allian, A.; Nakagawa, E.Y. *Has social sustainability been addressed in software architectures?* This paper discussed the social sustainability as a concern in software architectures design, in particular, some issues in the design of software systems that generate social values and have a positive impact on communities.

ACKNOWLEDGMENTS

We are grateful to all authors who submitted their works to SAHVA 2019 and to all Program Committee members. We are indebted to the ECSA organization for its hard work to the success of the conference. Last, but not least, we would like to thank the workshop chairs Catia Trubiani and Riccardo Scandariato for their assistance, dedication, and great work.

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1st Workshop on Systems, Architectures, and Solutions for Industry 4.0 (SASI4)

Rafael Capilla
Department of Informatics
Rey Juan Carlos University
Madrid, Spain
rafael.capilla@urjc.es

Klaus Schmid
Institute of Computer Science
University of Hildesheim
Hildesheim, Germany
schmid@sse.uni-hildesheim.de

Patrizio Pelliccione
Chalmers | University of Gothenburg, Sweden
University of L'Aquila, L'Aquila, Italy
patrizio.pelliccione@univaq.it

Andreas Burger
ABB Corporate Research
Ladenburg, Germany
andreas.burger@de.abb.com

ABSTRACT

Industry 4.0 (I4) is the next software revolution from computerized systems to digitalization of industry solutions. This fourth generation of the industrial revolution attempts to automate as much as possible all industry processes and manage an unprecedented amount of data where cyber-physical systems (CPSs) interact with humans to produce software-intensive systems more efficiently. From a software engineering perspective such complex systems must be produced in many cases using continuous software engineering approaches and multiple releases demanding continuous integration and delivery. From the software architecture point of view, flexible and open architectures are required to integrate the diversity of platforms and technology in support of I4 processes and manage the vast amount of data required by complex engineering processes. Consequently, this workshop aims to increase the awareness combining software architecture and complex systems engineering processes to understand how modern systems under the industry 4.0 umbrella must be designed and efficiently built at lower costs.

CCS CONCEPTS

Software and its engineering → Software creation and management → Designing software → Software design engineering

KEYWORDS

Industry 4.0, software architectures, automation, manufacturing, continuous software engineering, continuous integration, continuous deployment, software platforms.

1 Motivation

Future software and complex systems production require more and more open and flexible software architectures able to handle the diversity of systems deployment and configuration and integrate new software technologies (e.g., Big Data, 3D Printing, machine learning) to support the production process of modern factories. The current trend where smart factories demand high digitalization of each phase of the production process and the shift where workers and users are skilled workers and customers in favor of the efficiency and optimization of heavy tasks currently performed by robots, are new challenges the systems engineering discipline and the software architecture field must address in the upcoming years. Nowadays, many companies are replacing or upgrading old rigid architecture approaches in favor of the greater flexibility supported by platforms (e.g., Micro-service architectures) to provide higher scalability, but also domain-specific architectures (e.g., Robotics and automotive domains) demand new technologies and software solutions to produce more efficient and versatile systems.

This workshop is relevant for the software architecture field to understand how to design and maintain complex software architectures in different application domains where multiple stakeholder's concerns and multiple quality attributes must coexist to produce complex systems as the result of an integration of different software technologies embedded in many cases with hardware or electronic control units (ECUs). Future software and complex systems production require more and more open architectures.

Also, the current views on requirements and quality are significantly impacted by the push towards I4. Along with the needs to create more open systems, the requirements will evolve often during the lifetime of the systems, either because new functionality is required that was not anticipated during creation of the systems or because new needs are identified based on requirements monitoring []. Intertwined with this dynamicity of requirements is the need to perform continuous quality analysis to understand issues based on requirements monitoring, but also as an extension to upfront quality assurance. In addition, this focus on continuous data collection and quality assurance enables new business models like predictive maintenance services.

2 Objectives and Topics

The main goal of this workshop is to:

(i) discuss research challenges relevant for software engineering and software architecture, and in particular for the development of complex Systems-of-Systems (SoS) where engineers from different background, companies, development processes, business goals, and disciplines must interact,

(ii) provide innovative solutions and ways to integrate platforms, software technologies, and hardware around a software architecture,
(iii) manage large set of data and describe the interactions in I4.0 systems,
(iv) describe how current software architectures can support post-deployment configurations and the dynamic parts of CPS systems, and
(v) provide means to support the continuous monitoring of quality properties to avoid architecture and systems erosion.

As the diversity of topics is broad, we solicited papers around four main research areas covering a wide range of research topics, such as we describe below.

Software architecture and Ecosystems for I4

- Software architectures for complex systems in smart factories
- Integration of multiple stakeholders' concerns in the software architecting process
- Architectures for CPS systems
- Domain-specific architectures (e.g. automotive, safety critical systems, smart cities and IoT systems)
- Case studies of software architectures supporting I4 processes
- Evolution and migration of software architectures to integrate I4 solutions
- Architecting out complexity and multiple views
- Design principles: Interconnection, Information transparency, decentralized decisions, etc.

Systems engineering development and integration

- Collaborative aspects in I4 ecosystems
- Continuous integration, deployment and delivery of systems
- DevOps tools and solutions for I4
- Variability for accelerating the deployment and configuration of multiple releases (especially at run-time)
- Architectures for dynamic ecosystems

Quality aspects

- Monitoring the quality of I4 processes
- Estimating technical debt and architecture erosion
- Continuous monitoring solutions of systems quality in architecture and code
- Tools for monitoring the quality of systems
- Technical and environmental sustainability for I4

I4.0 in practice

- Case studies and experiences adapting software architectures to smart factories
- M2M and human-to-machine communication to improve the productivity in smart factories
- Human factors training highly qualified workers and skilled customers
- Architecture evolution and migration case studies
- Adoption of new technologies supporting smart factory production (e.g. BigData analytics, ML, Blockchain)
- Case studies and experiences in automating I4 processes

3 Selected Papers

In this first edition we had ten abstracts and eight papers submitted and after the review process we decided to accept three full papers and two short papers. The summary of the papers accepted is as follows:

In "*Architecture Trace Diagrams for Cyber-Physical Systems*" by Börsting and his colleagues, the authors present an approach to model architecture trace diagrams (ATDs) for modeling the architecture of cyber-physical systems (CPS) as an alternative solution to UML diagrams in terms of correctness and efficacy. As CPS systems are very relevant for I4.0 solutions, the design of new software architectures can benefit of the ATD technique depicting better the interactions between the different parts of the target system and increasing learnability.

In "*Blueprints for Architecture Drivers and Architecture Solutions for Industry 4.0 Shopfloor Applications"* by Oliveira and his colleagues describe a quality quality-centered architecture derived from industrial cases and architecture solutions based on the concepts of Digital Twins, Service-Oriented Architecture, and Virtual Automation Bus. The proposed solution aims to provide a better understanding of current industrial processes connecting shopfloor machines to systems from different layers that can be automated. The presented architecture and solution has been instantiated in different Industry 4.0 contexts, such as BaSys 4.0 (the German national reference project for Industry 4.0).

In "*An Empirical Study of CPS and IoT Firmware Update Systems*" by Villegas and her colleagues the authors outline an analysis of update mechanisms in 26 existing open-source IoT/CPS software projects. They report 9 of the 26 projects have a specific update system and 5 describe the structure and use regarding its Over-the-Air (OTA) firmware updates.

In the paper "*Towards Creation of a Reference Architecture for Trust-based Digital Ecosystems*", Cioroaica and her colleagues present the notion of trust-based digital ecosystems, which are built upon the concept of a digital twin of this ecosystem. The authors introduce a reference architecture for trust-based digital ecosystems as a basis for analyzing competitive forces that influence the health of an ecosystem.

Finally, in "*Dynamic Security Rules for Legacy Systems*" by Al-Ali and her colleagues, the authors suggest an approach to integrate

dynamic access control to legacy systems that take into account inter-systems situations, and using self-adaptive architectures. They introduce a security adaptation mechanism to adapt static security rules of existing legacy systems in order to adjust them to the current inter-system situation in hand.

4 Outlook

In this first edition of the workshop, we received a number of interesting contributions from diverse directions. In this first iteration, it will be the goal to further structure the area with its numerous challenges and to identify further open issues like quality impact and opportunities in Industry 4.0 for the continuous monitoring of the quality of products aimed to achieve operational excellence in the development process. Also, the integration of new technologies (e.g. machine learning, Big Data, Connected Devices, etc.) under continuous software engineering processes and the DevOps strategy is another important goal worth to be discussed.

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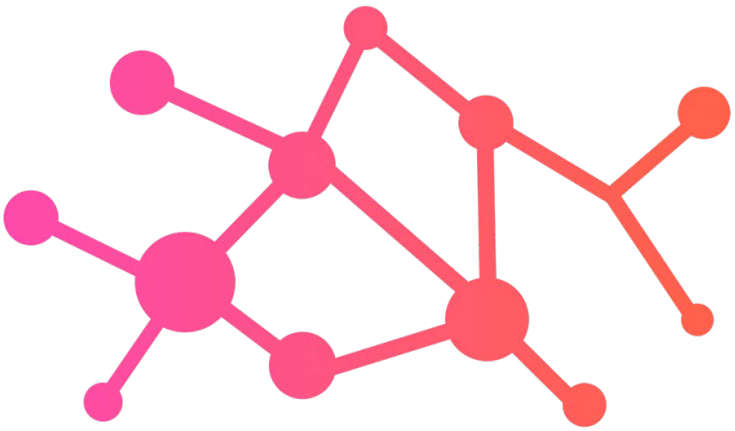

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