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# Software Architecture

14th European Conference, ECSA 2020  
L'Aquila, Italy, September 14–18, 2020  
Proceedings

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# Preface

The European Conference on Software Architecture (ECSA) is the premier European 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 14th edition of ECSA builds upon a series of successful European workshops on software architecture held during 2004–2006, as well as a series of European software architecture conferences during 2007–2019. This edition of ECSA had a unique nature as due to the novel coronavirus, COVID-19, it was the first ECSA conference that was originally to be held in L'Aquila, Italy, but convened the participants around the globe virtually during September 14–18, 2020.

This year's technical program included a main research track, three keynote talks, and an industry track (included in this volume), as well as a doctoral symposium track with its own keynote, a gender diversity in software architecture track with its own keynote, and a tool demos track. In addition, ECSA 2020 also offered nine workshops on diverse topics related to the software architecture discipline, such as automotive architectures, quality-aware DevOps, and IoT systems. In addition, ECSA 2020 featured a journal first track partnering with the *Journal of Software and Systems*, Elsevier, and the IEEE Software Magazine. The contributions of all these other meetings are included in the companion proceedings, published in a volume by Springer CCIS.

ECSA 2020 received 103 contributions to all tracks. For the main research track, we received 60 submissions in the two main categories: full and short research papers. Based on the recommendations of the Program Committee, we accepted 12 papers as full papers and 5 additional papers as short papers. Hence the acceptance rate for full research papers was 20% for ECSA 2020. For the industrial track, we received 11 submissions and accepted 6 of them. The conference attracted papers (co-)authored by researchers, practitioners, and academia from 24 countries (Austria, Australia, Brazil, Canada, Chile, Columbia, Denmark, Ecuador, Finland, France, Germany, Italy, the Netherlands, New Zealand, Spain, Pakistan, Poland, Portugal, Romania, Sweden, Switzerland, Tunisia, the UK, and the USA).

The main ECSA program had three keynotes. Professor Ivica Crnkovic from Chalmers University, Sweden, talked about “AI engineering—new challenges in system and software architecting and managing lifecycle for AI-based systems.” Professor Diomidis Spinellis, from Athens University of Economics and Business, Greece, gave a presentation on “Fifty years of sustained progress: Form, forces, and lessons of Unix architectural evolution.” The industry keynote was delivered by Michael Keeling, an experienced software engineer and the author of the book “Design It! From Programmer to Software Architect.”

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 2020. We would like to thank the

members of the Organizing Committee of ECSA 2020 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: the University of L'Aquila, Italy, provided the technology infrastructure and the support needed, nExpecto, and Springer.

The ECSA 2020 submission and review process was supported by the EasyChair conference management system. We acknowledge the prompt and professional support from Springer who 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 2020 submissions and the attendees of the conference for their participation.

ECSA 2020 planning and execution took place during an unprecedented time in our history, globally we had to face a pandemic as well as understand and react to consequences of systematic racism and intolerance. As the ECSA community, we pledge to stand against racism and intolerance and strive to elevate the ideas and voices of black, indigenous, and people of color who have been historically excluded because of systemic racism.

We thank the support of the software architecture community, they reacted by continuing to advance the field of software architecture through their scientific submissions to ECSA, while staying flexible as the Organizing Committee had to pivot several times from an in-person, to hybrid, to an all-online conference.

July 2020

Anton Jansen  
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# Keynotes

# AI Engineering — New Challenges in System and Software Architecting and Managing Lifecycle for AI-based Systems

Ivica Crnkovic

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**Abstract.** Artificial Intelligence based on Machine Learning, and in particular Deep Learning, is today the fastest growing trend in software development, and literally used in all other research disciplines, with a very high impact on the modern society. However, a wide use of AI in many systems, in particular dependable systems, is still far away of being widely used. On the one hand there is a shortage of expertise, on the other hand the challenges for managing AI-based complex and dependable systems are enormous, though less known, and in general underestimated. Some aspects of these challenges are based on management of resources, including computational, data storage capacity, performance, and real-time constraints. Introduction of AI-based components, i.e. components that includes AI algorithms, require significant changes in system and software architecture, and its successful deployment is based on many architectural decisions and on changes of the development process.

This talk discusses some of these challenges, illustrate a case of Cyber-physical systems, and gives some ideas for new research in software engineering inducing software architecture, i.e. for AI engineering.

## Short Bio

Ivica Crnkovic is a professor of software engineering at Chalmers University, Gothenburg, Sweden. He is the director of ICT Area of Advance at Chalmers University, and the director of Chalmers AI Research Centre (CHAIR). His research interests include, software architecture, software development processes, software engineering for large complex systems, component-based software engineering, and recently Software engineering for AI. Professor Crnkovic is the author of more than 200 refereed publications on software engineering topics, and guest editor of a number of special issues in different journals and magazines, such as IEEE Software, and Elsevier JSS. He was the general chair of 40th International Conference on Software Engineering (ICSE) 2018, held in Gothenburg, 2018. Before Chalmers, Ivica Crnkovic was affiliated with Mälardalen University, Sweden, and before that he was employed at ABB company, Sweden, where he was responsible for software development environments and tools.

More information is available on <http://www.ivica-crnkovic.net>

# Fifty Years of Sustained Progress: Form, Forces, and Lessons of Unix Architectural Evolution

Diomidis Spinellis

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**Abstract.** Unix has evolved over five decades, shaping modern operating systems, key software technologies, and development practices. Studying the evolution of this remarkable system from an architectural perspective can provide insights on how to manage the growth of large, complex, and long-lived software systems. Along main Unix releases leading to the FreeBSD lineage we examine core architectural design decisions, the number of features, and code complexity, based on the analysis of source code, reference documentation, and related publications. We see that the growth in size has been uniform, with some notable outliers, while cyclomatic complexity has been religiously safeguarded. A large number of Unix-defining design decisions were implemented right from the very early beginning, with most of them still playing a major role. Unix continues to evolve from an architectural perspective, but the rate of architectural innovation has slowed down over the system's lifetime. Architectural technical debt has accrued in the forms of functionality duplication and unused facilities, but in terms of cyclomatic complexity it is systematically being paid back through what appears to be a self-correcting process. Some unsung architectural forces that shaped Unix are the emphasis on conventions over rigid enforcement, the drive for portability, a sophisticated ecosystem of other operating systems and development organizations, and the emergence of a federated architecture, often through the adoption of third-party subsystems. These findings allow us to form an initial theory on the architecture evolution of large, complex operating system software.

## Short Bio

Diomidis Spinellis is a Professor in the Department of Management Science and Technology at the Athens University of Economics and Business, Greece. His research interests include software engineering, IT security, and cloud systems engineering. He has written two award-winning, widely-translated books: "Code Reading" and "Code Quality: The Open Source Perspective". His most recent book is "Effective Debugging: 66 Specific Ways to Debug Software and Systems". Dr. Spinellis has also published more than 300 technical papers in journals and refereed conference proceedings, which have received more than 8000 citations. He served for a decade as a member of the

IEEE Software editorial board, authoring the regular “Tools of the Trade” column, and as the magazine’s Editor-in- Chief over the period 2015–2018. He has contributed code that ships with Apple’s macOS and BSD Unix and is the developer of UMLGraph, CScout, git-issue, and other open-source software packages, libraries, and tools. Dr. Spinellis is a senior member of the ACM and the IEEE.

# Mighty Methods: Four Essential Tools for Every Software Architect's Silver Toolbox

Michael Keeling

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**Abstract.** It is an oversimplification to say that we are living in extraordinary times. When my team was first asked to work from home back in February we were happy to do our part in attempting to stem the tide of an inevitable global pandemic. While we were eager to help, we were also nervous about how suddenly distributing our co-located team would affect our way of working. And yet, after several months we've settled into a "new normal" that looks surprisingly similar to our way of working from Before. Much about how we worked changed, in some cases dramatically, but a handful of design methods that were central to our team remained effective even after the shift from a co-located to fully distributed context. In particular, mob programming, example mapping, architecture decision records, and visual thinking are consistently among the most versatile and reliable tools in my silver toolbox.

In this talk we'll briefly explore these four methods and speculate about what makes them effective tools for software architects in such a broad range of contexts and situations. While this is not a talk about remote work per se, we'll attempt to use the shifting context of work we've all experienced to further isolate variables that might help us identify other potential mighty methods waiting for software architects to adopt.

## Short Bio

Michael Keeling is a software engineer at LendingHome and the author of *Design It!: From Programmer to Software Architect*. Prior to LendingHome, Keeling worked at IBM on the Watson Discovery Service, Vivisimo, BuzzHoney, and Black Knight Technology. Keeling has also served as an Adjunct Faculty member at Carnegie Mellon University in the Master of Software Engineering Distance Program since 2009. He holds a Master in Software Engineering from Carnegie Mellon University in Pittsburgh, PA and a Bachelor of Science in Computer Science from the College of William and Mary in Williamsburg, VA.

Keeling's current research interests include software architecture design methods, agile software development, and human factors of software engineering. He is a regular speaker in the architecture and agile communities, presenting papers and talks, and facilitating workshops for both national and international audiences. Keeling is a two-time winner of the SEI/IEEE Software "Architecture in Practice" Best Presentation Award for talks given at the 2012 and 2014 SATURN conferences. A full list of his talks and workshops are available on his website:

<http://www.neverletdown.net/p/speaking-and-writing.html>.



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