

**Proceedings**

**2018 ACM/IEEE 6th International  
Workshop on  
Green and Sustainable Software**

**— GREENS 2018 —**

**27 May 2018  
Gothenburg, Sweden**



Association for  
Computing Machinery



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# 2018 ACM/IEEE 6th International Workshop on Green And Sustainable Software **GREENS 2018**

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## Message from the ICSE 2018 General Chair



It is my great pleasure to welcome you to the 40th International Conference on Software Engineering in Gothenburg, Sweden. Science and research, as well as the openness to new ideas and new people, are an important part of the Scandinavian culture. Sweden hosts many high technology companies in which software plays an essential role. The Town of Gothenburg, with its two internationally renowned universities, variety of ICT and related companies, with many cultural attractions, and beautiful natural surroundings, welcomes you!

This year's ICSE is unique in at least two respects. **ICSE 2018 celebrates its 40<sup>th</sup> anniversary.** During its journey, ICSE has developed to the premier conference in Software Engineering, known for its quality, excellence, attractiveness, and inspirational atmosphere. We pay tribute to the 40<sup>th</sup> anniversary with a collection of memories of previous conferences printed in a booklet, and with a celebration session gathering all previous chairs to thank them for their devoted and highly successful work. The second unique event of this conference is **the celebration of the 50 years of Software Engineering**, that is considered to be born at the NATO Software Engineering Conference 1968, held in Garmisch, where the term Software Engineering was established. We honor this event with keynotes which have direct impact of the Software Engineering development and a panel with some of the participants of the 1968 conference.

ICSE 2018 is, however, not only about the past. It is much about the present and the future - and in particular, about the essence of Software Engineering - collaboration between industry and academia, practitioners and researchers. ICSE 2018 hosts a one-day **Industry Forum** event gathering researchers and practitioners and offering talks of prominent researchers and experts from leading software and software-intensive systems companies.

As a part of the program and the celebration, we are happy to have outstanding conference keynote speakers from industry and academia. **Magnus Frodigh**, acting Head of Research at Ericsson, will talk about new challenges in building *Communication systems and networks as enablers or digitizing industry and society*. **Frederick P. Brooks, Jr.**, the Kenan Professor of Computer Science, known for his legendary book "The Mythical Man-Month: Essays on Software Engineering", will talk about the beginnings of Software Engineering *Learning the Hard Way: A History of Software Engineering 1948-1980*. **Margaret Hamilton**, CEO of Hamilton Technologies, famous for building Apollo's on-board flight software and inventing the term "Software Engineering" to establish it as a form of engineering in its own right, will reflect on being a software engineer with a talk *The Language as a Software Engineer*. **Brian Randell** from Newcastle University, also a participant of the famous NATO conference 1968, and one of the most prominent researchers in Software Engineering, will introduce the panel discussion *50 years of Software Engineering*, with several participants of the 1968 conference. **Ivar Jacobson**, the inventor of "use case" and one of the co-authors of UML, will conclude the celebration with a talk *50 years of software engineering, so now what?* on Friday. The same day, the plenary keynotes, **Andrew J. Ko** and **Brad A. Myers**, the authors of the most influential paper, will present their paper *Debugging reinvented: asking and answering why and why not questions about program behavior*. **Andreas Zeller**, the holder of Outstanding Research Award for 2018, will conclude the award session with his inspiring talk *Relevance, Simplicity, and Innovation: Stories and Takeaways from Software Engineering Research*.

The ICSE 2018 week starts on Sunday May 27, with three days of workshops, co-located events, special events and symposia. It then continues on Wednesday May 30 with three days of the main conference, and concludes with more workshops and co-located events for the last two days, Saturday June 2, and Sunday, June 3. We have **29 workshops** with the total 280 papers accepted for the presentation and publication, **seven co-located events**, and the conference pre-events: **Technical Briefings** with 12 short tutorials, and

**New Faculty Symposium** with inspirational talks from leading researchers in Software Engineering giving advice to young researchers. A side track, but exceptionally attractive one, is the **2001: A Space Odyssey Symposium** - 50 years celebration of the movie that includes a talk about the HAL computer given by **David Stork**, followed by the panel and finishing by showing the movie. In addition, ICSE 2018 is emphasizing the industrial relevance by exchanging a live video stream with the local event **Lindholmen Software Development Day**, that each year attracts 500-600 software developers from the region.

The heart of ICSE 2018 is the main conference. The special event this year is the celebration of 40<sup>th</sup> anniversary of ICSE, with more than 40 program and general chairs from the previous conferences showing on the stage, and with a book *40 editions of ICSE: the ruby anniversary celebration*, specially printed for this occasion.

The main conference will include several tracks. The **Technical Papers** track, with 105 accepted papers (of 502 submitted), and 49 Journal First Papers (JFP), is the largest technical papers track in the history of ICSE. To make it possible to present all papers for three days, four parallel tracks during the first two days, and six tracks on the third day are organized. In parallel with the Technical Track, we will have four other special tracks. As a part of the main conference, the **Industry Forum** (IF) track offers two keynotes, **Jan Bosch** from Chalmers University of Technology, and **Danica Kragic** from Royal University of Technology, Stockholm, with several invited speakers and a panel from industry and academia. The **Software Engineering in Practice** (SEIP) track, with 36 accepted papers out of 131 submitted (the record number of submissions), and three keynote speakers (**Linda Northrop** from SEI, **Frank Buschmann** from Siemens, and **Ödgård Andersson** from Volvo Cars), will talk about current challenges and opportunities in software industry. The **Software Engineering and Training** (SEET) track accepted 21 papers for presentation, out of 74 submitted. The track offers a keynote (**Gregor Kiczales** from UBC) and a panel composed of distinguished researchers and lecturers. The **Software Engineering in Society** (SEIS) track received 31 submissions of which 11 were selected for the presentation, combined with a keynote presentation (**Roberto di Cosmo**, Paris Diderot University) and a panel discussion. ICSE 2018 is continuing a tradition established earlier with **New Ideas and Emerging Results** (NIER) track, which received 101 submissions and accepted 28 papers for the presentation. In addition, 30 tools will be demonstrated, selected out of 72 submissions. All in all, 280 papers have been accepted for presentations on the main conference tracks, which is the same as the number of papers accepted for the workshops. During the lunches and coffee breaks, the participants can enjoy the poster exhibition; during the three days, 175 posters, about 60 each day, will be presented in the exhibition area. Of these, 160 posters were accepted for publication as extended abstracts in a separate volume.

ICSE 2018 includes three events dedicated to PhD and Master students. In the **Doctoral Symposium** (DS), 17 PhD students were accepted to present and discuss their research. The **Student Contest on Software Engineering** (SCORE) invited three student teams to compete in the final, and **ACM Student Research Competition** (SRC) selected 10 students for the final competition.

Finally, ICSE 2018 has 8 co-located events: **ICGSE 2018** - 13th IEEE International Conference on Global Software Engineering, **ICPC 2018** - 26th IEEE International Conference on Program Comprehension, **MSR 2018** - 15th International Conference on Mining Software Repositories, **MobileSoft 2018** - 5th IEEE/ACM International Conference on Mobile Software Engineering and Systems, **SEAMS 2018** - 13th International Symposium on Software Engineering for Adaptive and Self-Managing Systems, **TechDebt 2018** - International Conference on Technical Debt, **SEiA 2018** - Symposium on Software Engineering in Africa, and **FormalISE 2018** - 6th Conference on Formal Methods in Software Engineering. The last two started as new conferences, and SEiA was the first co-located event at ICSE organized from Africa. ICSE is also hosting more than 20 community meetings run during lunches or after the sessions.

ICSE 2018 will most probably be the largest conference in ICSE history. By the early registration due date, ICSE 2018 has more than 1600 registrations, and 1250 registrations for the main conferences which is already the record, two months before the conference start.

All of these events required significant organizational and logistical effort, communication, flexibility and dedication that was only possible as a result of a work of a great **Team**. The organizing committee, the dedicated 53 members, spent days and days in designing, organizing, managing, analyzing, improving, administrating, inventing, reminding, repeating, and putting their personal career ambitions on hold. How can I thank them all for this intensive, hard, but so inspirational time? First of all, I would like to thank the Technical Track chairs, **Marsha Chechik** and **Mark Harman**. We three started from the very beginning and worked hard for many hours. During this time, I learned a lot from them. I was deeply impressed and inspired by their analytical capabilities, sharpness, precision, creativity, enormous energy, and dedication to the work. But they were not alone. How many times did I ask the Web chairs, **Josip Maras** and **Hugo Andrade**, to *immediately* update the web pages, or how many times have the Publication chairs, **Bara Buhnova** and **Patrizio Pelliccione**, sent mails to the track chairs explaining the publication process, and process hundreds of papers and a few thousands of authors? But they were not alone. We had highly motivated and efficient track chairs: **Frances Paulisch** and **Jan Bosch** (SEIP), **Valerie Issarny** and **Schahram Dustdar** (SEIS), **Patricia Lago** and **Michal Young** (SEET), **Andrea Zisman** and **Sven Apel** (NIER), **Tien Nguyen** and **Anne Koziol** (Demos), and **Gerardo Canfora** (JFP). We had chairs of special tracks full of new and innovative ideas: **Judith Bishop** and **Pekka Abrahamsson** (IF), **Jaana NyFjord** (Local Industry), **Olga Baysal** and **Jun Sun** (SRC), **Lars Grunske**, **Betty Cheng** and **Xiaoying Bai** (NFS), **Jane Cleland-Huang** and **Per Runeson** (TB), **Tracy Hall** and **Julia Rubin** (DS), **Christine Julien** and **Rafael Prikladnicki** (SCORE). **David Rosenblum** and **Neno Medvidović** (50 years of SE) did real detective- and data mining work to find all sorts of details from the last 50 years in Software Engineering, and prepared the celebration

including the anniversary booklet. But they were not alone. **Dimitra Dianakopoulou** and **Paul Grünbacher** (Workshop chairs) managed and inspired numerous workshops, and **Tom Zimmermann** (co-located events chair) handled all events co-located with ICSE, in every detail. How many messages, announcements, tweets and results have been sent, how many flyers, brochures have been designed and distributed by the publicity and communication chairs **Henry Muccini**, **Tao Xie**, **Federico Ciccozzi**, **Ivano Malavolta**, **Malin Ulfarson** and **David Issa Mattos**? And how many contributed posters from our many tracks did the Posters chairs, **Raffaella Mirandola** and **Yuriy Brun**, process, taking care of all possible details. And they were not alone. The Registration chair **Carlo Furia** spent many days designing, monitoring and analyzing the registration process, **Yue Jia** prepared Easychair. **Matt Dwyer** and **Volker Gruhn**, the most influential paper chairs organized the selection process of the most influential paper presented at ICSE 10 years ago. And when I asked **Sandeep Kuttal** for help in processing NSF scholarships on Dec. 30, she replied that she will try to manage whatever is possible before the New Year! When I asked **Will Tracz** about taking on the responsibility in processing awards, he knew exactly what needed to be done. And what an amazing job did **Birgit Penzenstadler** and **Christian Berger** (Student Volunteers chairs) do to prepare 52 students volunteers for a support? And finally, how many discussions did I have with **Michel Chaudron** (the Conference chair) about the banquet place, reception, lunch organization, music, child care? The magnificent 53! But we were not alone. We had numerous people helping us in the preparation and during the conference: 52 student volunteers from 22 countries, “local” PhD students and researchers, financial and administration officers at Chalmers University. We had also a fantastic help from conference organization company MEETX with **Jorge Gómez** leading the local organization on the venue side, from CPS IEEE working on the 46 proceedings volumes, and from ACM Sigsoft and IEEE TCSE, the conference sponsors. And we had numerous supporters, who helped in making all this happen. Finally, here we have 500+ researchers who served on different program committees, and 300+ members of the workshops committees, and 300+ members from co-located events. To all of them a big thanks, for the enormous work and enthusiasm to make this event memorable. And even all these people are not alone. Here are you, all participants. I wish you all to have a great time here in Gothenburg at ICSE 2018.

*Enjoy this unique event and keep being inspired for the next 50 years!*



**Ivica Crnkovic**

Chalmers University of Technology | University of Gothenburg  
Sweden



## Message from the GREENS 2018 Chairs

Welcome to GREENS 2018, the 6th International Workshop on Green and Sustainable Software, May 27, 2018, in Gothenburg, Sweden. GREENS 2018 is co-located with the 40th International Conference on Software Engineering (ICSE 2018).

The GREENS workshop provides a forum for practitioners and academics to share knowledge, ideas, practices, and current results related to green and sustainable software engineering. Engineering green software-intensive systems is critical in our drive towards a sustainable, smarter planet. The goal of green software engineering is to apply green principles to the design and operation of software-intensive systems. Green and self-greening software systems have tremendous potential to decrease energy consumption. Moreover, enterprise software can and should be re-thought to address sustainability issues using innovative business models, processes, and incentives. Monitoring and measuring the greenness of software is critical towards the notion of sustainable and green software. Demonstrating improvement is paramount for users to achieve and affect change. The GREENS 2018 theme is design patterns and reference architecture for green and sustainable software. Analysis of the sustainability of a specific software system requires software developers to weigh four major dimensions of sustainability – economic, social, environmental, and technical – which affects their trade-offs. The software engineering community must assume leadership in this important challenge.

The GREENS 2018 workshop is the sixth instance of the workshop, all organized in conjunction with the International Conference on Software Engineering (ICSE), and brings together researchers and practitioners to discuss both the state-of-the-art and state-of-the-practice in green software, including novel ideas, research challenges, methods, experiences, and tools to support the engineering of sustainable and energy efficient software systems.

To ensure high quality papers and presentations, all submissions were reviewed by at least three program committee members whose identity was not revealed to any of the authors. The reviewers did not review papers for which they had a conflict of interest. The organizers were excluded by the reviewer selection process when in direct or indirect conflict of interest. Out of the 8 full paper submissions, 6 full papers were accepted to be included in the workshops proceedings.

The workshop dedicates most of its program to discussion among the attendees. After a keynote and short presentations and discussions of each paper, facilitated working sessions will focus on the most interesting topics, as identified by the attendees. Last, but not least, we are most grateful to all the authors for their submissions to GREENS 2018, and to the invited Program Committee members for their valuable time and effort in reviewing the submitted papers. We also want to extend our gratitude to the organizers of ICSE 2018 for the facilities regarding the logistics of the workshop and the publication of the proceedings.

Ivano Malavolta, Rick Kazman, and João Saraiva  
*GREENS 2018 Program Committee Chairs*

## Organizing Committee for GREENS 2018



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