Einar Broch Johnsen
Manuel Wimmer (Eds.)

Fundamental Approaches to Software Engineering

25th International Conference, FASE 2022
Held as Part of the European Joint Conferences
on Theory and Practice of Software, ETAPS 2022
Munich, Germany, April 2–7, 2022
Proceedings

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ETAPS Foreword

Welcome to the 25th ETAPS! ETAPS 2022 took place in Munich, the beautiful capital of Bavaria, in Germany.

ETAPS 2022 is the 25th instance of the European Joint Conferences on Theory and Practice of Software. ETAPS is an annual federated conference established in 1998, and consists of four conferences: ESOP, FASE, FoSSaCS, and TACAS. Each conference has its own Program Committee (PC) and its own Steering Committee (SC). The conferences cover various aspects of software systems, ranging from theoretical computer science to foundations of programming languages, analysis tools, and formal approaches to software engineering. Organizing these conferences in a coherent, highly synchronized conference program enables researchers to participate in an exciting event, having the possibility to meet many colleagues working in different directions in the field, and to easily attend talks of different conferences. On the weekend before the main conference, numerous satellite workshops took place that attract many researchers from all over the globe.

ETAPS 2022 received 362 submissions in total, 111 of which were accepted, yielding an overall acceptance rate of 30.7%. I thank all the authors for their interest in ETAPS, all the reviewers for their reviewing efforts, the PC members for their contributions, and in particular the PC (co-)chairs for their hard work in running this entire intensive process. Last but not least, my congratulations to all authors of the accepted papers!

ETAPS 2022 featured the unifying invited speakers Alexandra Silva (University College London, UK, and Cornell University, USA) and Tomáš Vojnar (Brno University of Technology, Czech Republic) and the conference-specific invited speakers Nathalie Bertrand (Inria Rennes, France) for FoSSaCS and Lenore Zuck (University of Illinois at Chicago, USA) for TACAS. Invited tutorials were provided by Stacey Jeffery (CWI and QuSoft, The Netherlands) on quantum computing and Nicholas Lane (University of Cambridge and Samsung AI Lab, UK) on federated learning.

As this event was the 25th edition of ETAPS, part of the program was a special celebration where we looked back on the achievements of ETAPS and its constituting conferences in the past, but we also looked into the future, and discussed the challenges ahead for research in software science. This edition also reinstated the ETAPS mentoring workshop for PhD students.

ETAPS 2022 took place in Munich, Germany, and was organized jointly by the Technical University of Munich (TUM) and the LMU Munich. The former was founded in 1868, and the latter in 1472 as the 6th oldest German university still running today. Together, they have 100,000 enrolled students, regularly rank among the top 100 universities worldwide (with TUM's computer-science department ranked #1 in the European Union), and their researchers and alumni include 60 Nobel laureates.

The local organization team consisted of Jan Křetínský (general chair), Dirk Beyer (general, financial, and workshop chair), Julia Eisentraut (organization chair), and Alexandros Evangelidis (local proceedings chair).

ETAPS 2022 was further supported by the following associations and societies: ETAPS e.V., EATCS (European Association for Theoretical Computer Science), EAPLS (European Association for Programming Languages and Systems), and EASST (European Association of Software Science and Technology).

The ETAPS Steering Committee consists of an Executive Board, and representatives of the individual ETAPS conferences, as well as representatives of EATCS, EAPLS, and EASST. The Executive Board consists of Holger Hermanns (Saarbrücken), Marieke Huisman (Twente, chair), Jan Kofroň (Prague), Barbara König (Duisburg), Thomas Noll (Aachen), Caterina Urban (Paris), Tarmo Uustalu (Reykjavik and Tallinn), and Lenore Zuck (Chicago).

Other members of the Steering Committee are Patricia Bouyer (Paris), Einar Broch Johnsen (Oslo), Dana Fisman (Be'er Sheva), Reiko Heckel (Leicester), Joost-Pieter Katoen (Aachen and Twente), Fabrice Kordon (Paris), Jan Křetínský (Munich), Orna Kupferman (Jerusalem), Leen Lambers (Cottbus), Tiziana Margaria (Limerick), Andrew M. Pitts (Cambridge), Elizabeth Polgreen (Edinburgh), Grigore Roşu (Illinois), Peter Ryan (Luxembourg), Sriram Sankaranarayanan (Boulder), Don Sannella (Edinburgh), Lutz Schröder (Erlangen), Ilya Sergey (Singapore), Natasha Sharygina (Lugano), Pawel Sobocinski (Tallinn), Peter Thiemann (Freiburg), Sebastián Uchitel (London and Buenos Aires), Jan Vitek (Prague), Andrzej Wasowski (Copenhagen), Thomas Wies (New York), Anton Wijs (Eindhoven), and Manuel Wimmer (Linz).

I'd like to take this opportunity to thank all authors, attendees, organizers of the satellite workshops, and Springer-Verlag GmbH for their support. I hope you all enjoyed ETAPS 2022.

Finally, a big thanks to Jan, Julia, Dirk, and their local organization team for all their enormous efforts to make ETAPS a fantastic event.

February 2022
Marieke Huisman
ETAPS SC Chair
ETAPS e.V. President

Preface

This volume contains the papers presented at FASE 2022, the 25th International Conference on Fundamental Approaches to Software Engineering. FASE 2022 was organized as part of the annual European Joint Conferences on Theory and Practice of Software (ETAPS 2022).

FASE is concerned with the foundations on which software engineering is built, including topics like software engineering as an engineering discipline, requirements engineering, software architectures, software quality, model-driven development, software processes, software evolution, AI-based software engineering, and the specification, design, and implementation of particular classes of systems, such as (self-) adaptive, collaborative, AI, embedded, distributed, mobile, pervasive, cyber-physical, or service-oriented applications.

FASE 2022 received 61 submissions and used a double-anonymous reviewing process. Each submission was reviewed by three Program Committee members. After an online discussion period, the Program Committee accepted 17 papers as part of the conference program (28% acceptance rate).

FASE 2022 hosted the 4th International Competition on Software Testing (Test-Comp 2022). Test-Comp is an annual comparative evaluation of testing tools. This edition contained 12 participating tools, from academia and industry. These proceedings contain the competition report and two system descriptions of participating tools. The system-description papers were reviewed and selected by a separate Program Committee: the Test-Comp jury. Each paper was assessed by at least three reviewers. Two sessions in the FASE program were reserved for the presentation of the results: the summary by the Test-Comp chair and of the participating tools by the developer teams in the first session, and the community meeting in the second session.

Many people contributed to the success of FASE 2022. We are grateful to the Program Committee members and reviewers for their thorough reviews and constructive discussions. We thank the ETAPS 2022 organizers, in particular, Jan Křetínský and Dirk Beyer (General Chairs), Julia Eisentraut (Organization Chair), Maximilian Weininger (Web Chair), and Alexandros Evangelidis (Proceedings Chair). We thank Marieke Huisman (ETAPS Steering Committee Chair) and Tarmo Uustalu (ETAPS Publicity Chair) for managing the process, and Andrzej Wasowski (FASE Steering Committee Chair) for his feedback and support. We are especially grateful to our Artefact Evaluation Committee Chairs Marie-Christine Jakobs and Eduard Kamburjan. Last but not least, we would like to thank the authors for their excellent work.

February 2022

Einar Broch Johnsen
Manuel Wimmer

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