



**Association for
Computing Machinery**

Advancing Computing as a Science & Profession

July 12, 2021
Virtual, Denmark



COP '21

Proceedings of the 13th ACM International Workshop on

Context-Oriented Programming and Advanced Modularity

Edited by:

**Yu David Liu, Harumi Watanabe, Robert Hirschfeld, Atsushi Igarashi, and
Hidehiko Masuhara**

Sponsored by:

ACM SIGPLAN

Co-located with:

ECOOP/ISSTA '21

Association for Computing Machinery, Inc.
1601 Broadway, 10th Floor
New York, NY 10019-7434
USA

Copyright © 2021 by the Association for Computing Machinery, Inc (ACM). Permission to make digital or hard copies of portions of this work for personal or classroom use is granted without fee provided that the copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted.

To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permission to republish from: Publications Dept. ACM, Inc.
Fax +1-212-869-0481 or E-mail permissions@acm.org.

For other copying of articles that carry a code at the bottom of the first or last page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, USA.

ACM ISBN: 978-1-4503-8542-8

Cover photo “Aarhus Universitets Aula”, © 2014, by Mikkel Houmøller, licensed as CC BY-SA 4.0, cropped version, original available at https://commons.wikimedia.org/wiki/File:Aarhus_Universitet_Aula.jpg

Production: Conference Publishing Consulting
D-94034 Passau, Germany, info@conference-publishing.com

Message from the Chairs

Welcome to COP 2021, the 13th International Workshop on Context-Oriented Programming and Advanced Modularity, co-located with the 35th European Conference on Object-Oriented Programming (ECOOP 2021) and the 30th ACM SIGSOFT International Symposium on Software Testing and Analysis (ISSTA 2021).

Context-Oriented Programming (COP) is a programming paradigm that directly supports variability of contexts at the programming level. It enables run-time behavior to be dispatched directly on any varied properties of the execution or user context. COP addresses a crucial need of modern software systems, where continuous adaptation to the ever-changing execution and usage contexts is the norm not the exception of computing.

In the 2021 addition, we further expand the scope of this workshop to include advanced forms of software modularity. It is our belief that developing adaptive and dynamic software should further promote modular software development, instead of being at the expense of the latter. Topics of interest to the workshop include, but are not limited to:

- COP and contextual modeling in modern computer systems (mobile systems, IoTs, cloud/edge computing, autonomous systems, etc.)
- Programming language abstractions for COP (e.g., dynamic scoping, roles, traits, prototype-based extensions)
- Implementation issues for COP (e.g., optimization, VM support, JIT compilation)
- COP applications in computer systems (e.g., mobile systems, IoTs, cloud/edge computing, security)
- COP applications in autonomous systems (e.g., unmanned aerial vehicles, autonomous vehicles)
- Configuration languages (e.g., feature description interpreters, transformational approaches)
- Programming language abstractions for composition and modularization (e.g., modules, aspects, features, layers, plugins, libraries, components)
- Theoretical foundations and reasoning support for COP and modular systems (e.g., semantics, type systems, mechanized proofs)
- Software lifecycle support for modularization (e.g., requirements; architecture; synthesis; metrics; software product lines; economics; testing; patterns)
- Tool support for modular software development (e.g., platform; refactoring; static and dynamic analysis; evolution; reverse engineering; mining)
- Modular applications (e.g., data-intensive applications, micro-services, serverless computing)

COP 2021 attracted three submissions. Each submission was reviewed by at least four program committee members. The committee decided to accept all three papers for presentation and publication. The workshop was held on July 12th, 2021. It is the second virtual workshop of the COP series. Participants met online through live Zoom sessions.

We would like to thank our program committee members, all authors, and the workshop attendees for their contributions.

Best Regards,

Harumi Watanabe

Yu David Liu

Robert Hirschfeld

Atsushi Igarashi

Hidehiko Masuhara

Program Committee

- Mehdi Bagherzadeh, Oakland University
- Nicolás Cardozo, Universidad de los Andes
- Cynthia Disenfeld, Foretellix and Open University of Israel
- Robert Hirschfeld, HPI, University of Potsdam
- Kenji Hisazumi, Kyushu University
- Atsushi Igarashi, Kyoto University
- Yu David Liu, SUNY Binghamton
- Hidehiko Masuhara, Tokyo Institute of Technology
- Natsuko Noda, Sibaura Institute of Technology
- Patrick Rein, Hasso Plattner Institute
- Harumi Watanabe, Tokai University

Organizers

- Harumi Watanabe, Tokai University
- Yu David Liu, SUNY Binghamton
- Robert Hirschfeld, HPI, University of Potsdam
- Atsushi Igarashi, Kyoto University
- Hidehiko Masuhara, Tokyo Institute of Technology

Contents

Frontmatter

Message from the Chairs	iii
-----------------------------------	-----

Papers

Resolving Synchronization Conflicts in Role-Based Multimodel-Synchronization Environments Sebastian Ebert, Tim Kluge, and Sebastian Götz – <i>TU Dresden, Germany</i>	1
First-Class Concepts: Reifying Architectural Knowledge beyond the Dominant Decomposition Toni Mattis, Tom Beckmann, Patrick Rein, and Robert Hirschfeld – <i>HPI, Germany; University of Potsdam, Germany</i>	9
Towards a Framework for Analyzing Context-Oriented Programming Languages Achiya Elyasaf and Arnon Sturm – <i>Ben-Gurion University of the Negev, Israel</i>	16
Author Index	24