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Anthony Widjaja Lin (Ed.)

# Programming Languages and Systems

## 17th Asian Symposium, APLAS 2019
## Nusa Dua, Bali, Indonesia, December 1–4, 2019
## Proceedings

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# Preface

This volume contains the papers presented at the 17th Asian Symposium on Programming Languages and Systems (APLAS 2019), held in Bali, Indonesia, between December 1–4, 2019. APLAS aims to stimulate programming language research by providing a forum for the presentation of the latest results and the exchange of ideas in programming languages and systems. APLAS is based in Asia but is an international forum that serves the worldwide programming languages community.

This year we solicited contributions in the forms of regular research papers and tool papers. The conference solicts contributions in, but is not limited to, the following topics: semantics, logics, and foundational theory; design of languages, type systems, and foundational calculi; domain-specific languages compilers, interpreters, and abstract machines; program derivation, synthesis, and transformation; program analysis, verification, and model-checking; logic, constraint, probabilistic, and quantum programming; software security; concurrency and parallelism; tools and environments for programming and implementation; and applications of SAT/SMT to programming and implementation.

APLAS 2019 employed a light weight double-blind reviewing process with an author-response period. More precisely, we had a two-stage reviewing process, wherein each paper received at least three reviews before the author-response period, which was followed by a two-week Program Committee (PC) discussion taking into account initial impressions of the papers as well as the author responses.

This year APLAS received 50 submissions, out of which 22 papers (21 regular papers and 1 tool paper) were accepted after thorough reviews and discussions by the PC. After a rigorous reviewing process and PC discussion, we decided to award a Distinguished Paper Award to the paper titled "Dissecting Widening: Separating Termination from Information" by Graeme Gange, Jorge Navas, Peter Schachte, Harald Sondergaard, and Peter Stuckey. We were also honored to include three invited talks by distinguished PL researchers:

- Nate Foster (Cornell University, USA): "Network Verification: Past, Present, and Future"
- Annabelle McIver (Macquarie University, Australia): "Proving that Programs are Differentially Private"
- Philipp Rümmer (Uppsala University, Sweden): "On Strings in Software Model Checking"

I am indebted to many people who helped make APLAS 2019 possible. First and foremost, I sincerely thank the PC, who gave a lot of time and effort throughout the entire reviewing process. I am also grateful to the sub-reviewers and expert reviewers for their thorough and constructive reviews. I thank Mirna Adriani (University of Indonesia, Indonesia) who served as a general chair and worked out every detail of the conference well in advance. I thank Jens Dietrich (Victoria University of Wellington,

New Zealand) who served as a publicity chair and spent a lot of time (through posters, social media, mailing list, among others) advertising APLAS 2019. I am also grateful to the APLAS Steering Committee (especially Wei-Ngan Chin, National University of Singapore, Singapore, and Atsushi Igarashi, Kyoto University, Japan) who provided a lot of helpful advice and leadership. I thank recent APLAS PC chairs, especially Bor-Yuh Evan Chang (University of Colorado Boulder, USA) and Sukyoung Ryu (KAIST, South Korea) for their helpful advice. Finally, I thank Eelco Visser and Elmer van Chastelet for their very helpful conf.researchr.org conference management system, as well as Andrei Voronkov for the very helpful EasyChair conference management system.

Last but not least, I would like to thank the organizers of associated events that helped make APLAS 2019 a success: (1) The Poster and Student Research Competition, organized by Andreea Costea (National University of Singapore, Singapore) and (2) Workshop on New Ideas and Emerging Results (Wei-Ngan Chin and Atsushi Igarashi).

September 2019 Anthony W. Lin

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# Network Verification: Past, Present, and Future (Invited Paper)

Nate Foster

Cornell University, Ithaca, NY, USA

**Abstract.** Networks today achieve robustness not by adhering to precise formal specifications but by building implementations that tolerate modest deviations from correct behavior. This philosophy can be seen in the slogan used by the Internet Engineering Task Force, "we believe in rough consensus and running code," and by Jon Postel's famous dictum to "be conservative in what you do, be liberal in what you accept from others." But as networks have grown in scale and complexity, the frequency of faults has led to new interest in techniques for formally verifying network behavior.

This talk will discuss recent progress on practical tools for specifying and verifying formal properties of networks. In the first part of the talk, I will present p4v, a tool for verifying the low-level code that executes on individual devices such as routers and firewalls. In the second part of the talk, I will present NetKAT, a formal system for specifying and verifying network-wide behavior. In the third part of the talk, I will highlight some challenges and opportunities for future research in network verification.

# Contents

## Logic and Automata