

Volume 46, Number 1
January 2011

*A Monthly Publication of the ACM Special Interest Group
on Programming Languages*



SIGPLAN *notices*

Proceedings of the
38th Annual SIGPLAN-SIGACT Symposium on
Principles of Programming Languages (POPL'11)



Association for
Computing Machinery

Advancing Computing as a Science & Profession

January 26–28, 2011
Austin, Texas, USA



Association for
Computing Machinery

Advancing Computing as a Science & Profession



POPL'11

Proceedings of the 38th Annual ACM SIGPLAN-SIGACT Symposium on
Principles of Programming Languages

Sponsored by:

ACM SIGPLAN

In cooperation with:

ACM SIGACT

Supported by:

**Google, IBM Research, Intel, Microsoft Research, Mozilla, NEC,
NSF, & Computer Science Dept., University of Texas at Austin**

Table of Contents

POPL'11 Symposium Organization	xi
POPL'11 Additional Reviewers	xii
POPL'11 Sponsor & Supporters	xiv

Invited Talk

Session Chair: Mooly Sagiv (*Tel Aviv University*)

- **Verified Squared: Does Critical Software Deserve Verified Tools?**..... 1
Xavier Leroy (*INRIA Paris-Rocquencourt*)

Session 1.1: Pointer Analysis

Session Chair: Ganesan Ramalingam (*Microsoft Research*)

- **Points-To Analysis with Efficient Strong Updates**..... 3
Ondřej Lhoták, Kwok-Chiang Andrew Chung (*University of Waterloo*)
- **Pick Your Contexts Well: Understanding Object-Sensitivity — The Making of a Precise and Scalable Pointer Analysis** 17
Yannis Smaragdakis (*University of Massachusetts*), Martin Bravenboer (*LogicBlox Inc.*), Ondřej Lhoták (*University of Waterloo*)
- **Learning Minimal Abstractions**..... 31
Percy Liang (*University of California, Berkeley*), Omer Tripp (*Tel-Aviv University*), Mayur Naik (*Intel Labs Berkeley*)

Session 1.2: Semi-Automated Verification

Session Chair: David Naumann (*Stevens Institute of Technology*)

- **Relaxed-Memory Concurrency and Verified Compilation**..... 43
Jaroslav Ševčík (*University of Cambridge*), Viktor Vafeiadis (*University of Cambridge & MPI-SWS*), Francesco Zappa Nardelli (*INRIA*), Suresh Jagannathan (*Purdue University*), Peter Sewell (*University of Cambridge*)
- **Mathematizing C++ Concurrency**..... 55
Mark Batty, Scott Owens, Susmit Sarkar, Peter Sewell, Tjark Weber (*University of Cambridge*)
- **Formal Verification of Object Layout for C++ Multiple Inheritance**..... 67
Tahina Ramananandro (*INRIA Paris-Rocquencourt*), Gabriel Dos Reis (*Texas A&M University*), Xavier Leroy (*INRIA Paris-Rocquencourt*)

Session 2.1: Static Analysis

Session Chair: Eran Yahav (*IBM Research*)

- **Static Analysis of Multi-Staged Programs Via Unstaging Translation**..... 81
Wontae Choi (*Seoul National University*), Baris Aktemur (*University of Illinois at Urbana Champaign, USA & Ozyegin University, Turkey*), Kwangkeun Yi (*Seoul National University*), Makoto Tatsuta (*National Institute of Informatics, Japan*)
- **Static Analysis of Interrupt-Driven Programs Synchronized Via the Priority Ceiling Protocol**..... 93
Martin D. Schwarz, Helmut Seidl, Vesal Vojdani (*Technische Universität München*), Peter Lammich, Markus Müller-Olm (*Westfälische Wilhelms-Universität Münster*)
- **A Parametric Segmentation Functor for Fully Automatic and Scalable Array Content Analysis** 105
Patrick Cousot (*Ecole Normale Supérieure & New York University*), Radhia Cousot (*Ecole Normale Supérieure & Microsoft Research, Redmond*), Francesco Logozzo (*Microsoft Research, Redmond*)

Session 2.2: Semantic Models and Translations

Session Chair: Philippa Gardner (*Imperial College*)

- **Step-Indexed Kripke Models Over Recursive Worlds** 119
Lars Birkedal (*IT University of Copenhagen*), Bernhard Reus (*University of Sussex*),
Jan Schwinghammer (*Saarland University*),
Kristian Støvring, Jacob Thamsborg (*IT University of Copenhagen*),
Hongseok Yang (*Queen Mary University London*)
- **A Kripke Logical Relation Between ML and Assembly** 133
Chung-Kil Hur, Derek Dreyer (*Max Planck Institute for Software Systems*)
- **A Typed Store-Passing Translation for General References** 147
François Pottier (*INRIA*)

Session 3.1: Shape Analysis

Session Chair: Radhia Cousot (*École Normale Supérieure*)

- **A Shape Analysis for Optimizing Parallel Graph Programs** 159
Dimitrios Prountzos, Roman Manevich, Keshav Pingali, Kathryn S. McKinley
(*The University of Texas at Austin*)
- **Calling Context Abstraction with Shapes** 173
Xavier Rival (*INRIA Paris-Rocquencourt*), Bor-Yuh Evan Chang (*University of Colorado at Boulder*)
- **Precise Reasoning for Programs Using Containers** 187
Isil Dillig, Thomas Dillig, Alex Aiken (*Stanford University*)

Session 3.2: Type Abstractions

Session Chair: Derek Dreyer (*MPI-SWS*)

- **Blame for All** 201
Amal Ahmed (*Indiana University*), Robert Bruce Findler (*Northwestern University*),
Jeremy G. Siek (*University of Colorado at Boulder*), Philip Wadler (*University of Edinburgh*)
- **Correct Blame for Contracts: No More Scapegoating** 215
Christos Dimoulas, Robert Bruce Findler (*Northwestern University*),
Cormac Flanagan (*University of California*), Matthias Felleisen (*Northeastern University*)
- **Generative Type Abstraction and Type-Level Computation** 227
Stephanie Weirich (*University of Pennsylvania*),
Dimitrios Vytiniotis, Simon Peyton Jones (*Microsoft Research*),
Steve Zdancewic (*University of Pennsylvania*)

Invited Talk

Session Chair: Steve Zdancewic (*University of Pennsylvania*)

- **The Design of Kodu:
A Tiny Visual Programming Language for Children on the Xbox 360** 241
Matthew B. MacLaurin (*Microsoft Research*)

Session 4.1: Separation Logic

Session Chair: Hongseok Yang (*Queen Mary*)

- **A Separation Logic for Refining Concurrent Objects** 247
Aaron J. Turon, Mitchell Wand (*Northeastern University*)
- **Modular Reasoning for Deterministic Parallelism** 259
Mike Dodds (*University of Cambridge*), Suresh Jagannathan (*Purdue University*),
Matthew J. Parkinson (*Microsoft Research Cambridge*)
- **Expressive Modular Fine-Grained Concurrency Specification** 271
Bart Jacobs, Frank Piessens (*Katholieke Universiteit Leuven*)

Session 4.2: Automata

Session Chair: Kathleen Fisher (*AT&T Laboratoire*)

- **The Tree Width of Auxiliary Storage**.....283
P. Madhusudan (*University of Illinois at Urbana-Champaign*),
Gennaro Parlato (*LIAFA, CNRS and University of Paris, Diderot*)
- **Fresh-Register Automata**.....295
Nikos Tzevelekos (*Oxford University*)
- **Vector Addition System Reachability Problem: A Short Self-Contained Proof**.....307
Jérôme Leroux (*Université de Bordeaux, CNRS*)

Session 5.1: Synthesis

Session Chair: Viktor Kuncak (*EPFL*)

- **Automating String Processing in Spreadsheets Using Input-Output Examples**.....317
Sumit Gulwani (*Microsoft Corporation*)
- **Predicate Abstraction and Refinement for Verifying Multi-Threaded Programs**.....331
Ashutosh Gupta, Corneliu Popeea, Andrey Rybalchenko (*Technische Universität München*)
- **Geometry of Synthesis III: Resource Management Through Type Inference**.....345
Dan R. Ghica, Alex Smith (*University of Birmingham*)

Session 5.2: Algebra

Session Chair: Jeff Foster (*University of Maryland*)

- **Multivariate Amortized Resource Analysis**.....357
Jan Hoffmann, Klaus Aehlig, Martin Hofmann (*Ludwig-Maximilians-Universität*)
- **Symmetric Lenses**371
Martin Hofmann (*Ludwig-Maximilians-Universität München*),
Benjamin Pierce, Daniel Wagner (*University of Pennsylvania*)
- **Regular Expression Containment:
Coinductive Axiomatization and Computational Interpretation**385
Fritz Henglein, Lasse Nielsen (*University of Copenhagen*)

Session 6.1: Model Checking

Session Chair: Azadeh Farzan (*University of Toronto*)

- **Making Prophecies with Decision Predicates**.....399
Byron Cook (*Microsoft Research & Queen Mary, University of London*),
Eric Koskinen (*University of Cambridge*)
- **Delay-Bounded Scheduling**.....411
Michael Emmi (*Université Paris Diderot*), Shaz Qadeer (*Microsoft Research*),
Zvonimir Rakamarić (*University of British Columbia*)
- **On Interference Abstractions**.....423
Nishant Sinha, Chao Wang (*NEC Laboratories America*)

Session 6.2: Types

Session Chair: Stephen Freund (*Williams College*)

- **Dynamic Multirole Session Types**.....435
Pierre-Malo Deniérou, Nobuko Yoshida (*Imperial College London*)
- **Practical Affine Types**447
Jesse A. Tov, Riccardo Pucella (*Northeastern University*)
- **Dynamic Inference of Static Types for Ruby**459
Jong-hoon (David) An (*Epic Systems Corporation*),
Avik Chaudhuri (*Advanced Technology Labs, Adobe Systems*),
Jeffrey S. Foster, Michael Hicks (*University of Maryland, College Park*)

Invited Talk

Session Chair: Thomas Ball (*Microsoft Research*)

- **Robin Milner 1934–2010: Verification, Languages, and Concurrency**473
Andrew D. Gordon (*Microsoft Research*), Robert Harper (*Carnegie Mellon University*), John Harrison (*Intel*),
Alan Jeffrey (*Bell Labs*), Peter Sewell (*University of Cambridge*)

Session 7.1: Complexity

Session Chair: Madhusudan Parthasarathy (*University of Illinois*)

- **Space Overhead Bounds for Dynamic Memory Management with Partial Compaction**475
Anna Bendersky, Erez Petrank (*Technion*)
- **Laws of Order:**
Expensive Synchronization in Concurrent Algorithms Cannot be Eliminated487
Hagit Attiya (*Technion*), Rachid Guerraoui (*EPFL*) Danny Hendler (*Ben-Gurion University*),
Petr Kuznetsov (*TU Berlin/Deutsche Telekom Labs*),
Maged M. Michael, Martin Vechev (*IBM T. J. Watson Research Center*)
- **Complexity of Pattern-Based Verification for Multithreaded Programs**499
Javier Esparza (*Technische Universität München*), Pierre Ganty (*The IMDEA Software Institute*)

Session 7.2: Medley

Session Chair: Jan Vitek (*Purdue University*)

- **EigenCFA: Accelerating Flow Analysis with GPUs**511
Tarun Prabhu, Shreyas Ramalingam, Matthew Might, Mary Hall (*University of Utah*)
- **Bisimulation for Quantum Processes**523
Yuan Feng, Runyao Duan, Mingsheng Ying (*University of Technology Sydney and Tsinghua University*)
- **Safe Nondeterminism in a Deterministic-by-Default Parallel Language**535
Robert L. Bocchino, Jr. (*Carnegie Mellon University*), Stephen Heumann, Nima Honarmand, Sarita V. Adve,
Vikram S. Adve (*University of Illinois at Urbana-Champaign*), Adam Welc (*Adobe Systems*),
Tatiana Shpeisman (*Intel Labs*)

Session 8.1: Compilation

Session Chair: Dan Grossman (*University of Washington*)

- **Loop Transformations: Convexity, Pruning and Optimization**549
Louis-Noël Pouchet (*The Ohio State University*), Uday Bondhugula (*IBM T.J. Watson Research Center*),
Cédric Bastoul (*University of Paris-sud 11*), Albert Cohen (*INRIA*),
J. Ramanujam (*Louisiana State University*), P. Sadayappan (*The Ohio State University*),
Nicolas Vasilache (*Reservoir Labs, Inc.*)
- **The Essence of Compiling with Traces**563
Shu-yu Guo, Jens Palsberg (*University of California, Los Angeles*)
- **Resourceable, Retargetable, Modular Instruction Selection Using a Machine-Independent, Type-Based Tiling of Low-Level Intermediate Code**575
Norman Ramsey, João Dias (*Tufts University*)

Session 8.2: Verification

Session Chair: Sumit Gulwani (*Microsoft Research*)

- **Verifying Higher-Order Functional Programs with Pattern-Matching Algebraic Data Types**587
C.-H. Luke Ong, Steven J. Ramsay (*Oxford University*)
- **Streaming Transducers for Algorithmic Verification of Single-Pass List-Processing Programs**599
Rajeev Alur (*University of Pennsylvania*), Pavol Černý (*IST Austria*)
- **Decidable Logics Combining Heap Structures and Data**611
P. Madhusudan (*University of Illinois at Urbana-Champaign*),
Gennaro Parlato (*LIAFA, CNRS and University of Paris*),
Xiaokang Qiu (*University of Illinois at Urbana-Champaign*)

Sessions 8.1 + 8.2

Session Chair: Michael Hicks (*University of Maryland*)

- **A Technique for the Effective and Automatic Reuse of Classical Compiler Optimizations on Multithreaded Code**623
Pramod G. Joisha, Robert S. Schreiber, Prithviraj Banerjee, Hans J. Boehm,
Dhruba R. Chakrabarti (*Hewlett-Packard Laboratories*)

Author Index637