USENIX Association

Proceedings of the 2020 USENIX Annual Technical Conference

July 15–17, 2020

© 2020 by The USENIX Association

All Rights Reserved

This volume is published as a collective work. Rights to individual papers remain with the author or the author's employer. Permission is granted for the noncommercial reproduction of the complete work for educational or research purposes. Permission is granted to print, primarily for one person's exclusive use, a single copy of these Proceedings. USENIX acknowledges all trademarks herein.

ISBN 978-1-939133-14-4

Cover Image created by freevector.com and distributed under the Creative Commons Attribution-ShareAlike 4.0 license (https://creativecommons.org/licenses/by-sa/4.0/).

Conference Organizers

Program Co-Chairs Ada Gavrilovska, Georgia Institute of Technology Erez Zadok, Stony Brook University **Program Committee Leaders** Aruna Balasubramanian, Stony Brook University Donald Porter, The University of North Carolina at Chapel Hill Liuba Shrira, Brandeis University Swaminathan Sundararaman, Pyxeda AI Vasily Tarasov, IBM Research-Almaden **Program Committee** Sangeetha Abdu Jyothi, VMware Research and University of California, Irvine Rachit Agarwal, Cornell University Nitin Agrawal, ThoughtSpot Irfan Ahmad, CachePhysics Gustavo Alonso, ETH Zurich Deniz Altinbuken, Google George Amvrosiadis, Carnegie Mellon University Andrea Arpaci-Dusseau, University of Wisconsin-Madison Behnaz Arzani, Microsoft Research Mona Attariyan, Google Anirudh Badam, Microsoft Research Saurabh Bagchi, Purdue University Antonio Barbalace, Stevens Institute of Technology Ran Ben Basat, Harvard University Orna Agmon Ben-Yehuda, Technion-Israel Institute of Technology Pramod Bhatotia, University of Edinburgh Ken Birman, Cornell University Sergey Blagodurov, AMD Research Herbert Bos, Vrije Universiteit Amsterdam James Bottomley, IBM Research Kevin Butler, University of Florida Yinzhi Cao, Johns Hopkins University Zhen Cao, Google Feng Chen, Louisiana State University Ming Chen, Google Young-ri Choi, Ulsan National Institute of Science and Technology (UNIST) Guilherme Cox, Nvidia Heming Cui, The University of Hong Kong (HKU) Dilma Da Silva, Texas A&M University Alex Daglis, Georgia Institute of Technology David Devescery, Georgia Institute of Technology Abhinav Duggal, Dell EMC Michael Ferdman, Stony Brook University Pedro Fonseca, Purdue University Moshe Gabel, University of Toronto Manya Ghobadi, Massachusetts Institute of Technology Jana Giceva, Imperial College London Ashvin Goel, University of Toronto Xiaohui (Helen) Gu, North Carolina State University Vishakha Gupta-Cledat, ApertureData Andreas Haeberlen, University of Pennsylvania

Dongsu Han, Korea Advanced Institute of Science and Technology (KAIST) Danny Harnik, IBM Research-Haifa Tim Harris, Amazon Eshcar Hillel, Yahoo Research Michio Honda, University of Edinburgh Yu Hua, Huazhong University of Science and Technology Jian Huang, The University of Illinois at Urbana-Champaign Trent Jaeger, The Pennsylvania State University Bill Jannen, Williams College Junchen Jiang, University of Chicago Changhee Jung, Purdue University Sudarsun Kannan, Rutgers University Baris Kasikci, University of Michigan Idit Keidar, Technion-Israel Institute of Technology Ana Klimovic, Google Brain Michael Kozuch, Intel Labs Orran Krieger, Boston University Mohan Kumar Kumar, Facebook Youngjin Kwon, Korea Advanced Institute of Science and Technology (KAIST) Julia Lawall, Inria/LIP6 Philip Levis, Stanford University Felix Lin, Purdue University Heiner Litz, University of California, Santa Cruz, Vincent Liu, University of Pennsylvania Brandon Lucia, Carnegie Mellon University Xiaosong Ma, Qatar Computing Research Institute (QCRI), HBKU, Qatar Peter Macko, NetApp Harsha V. Madhyastha, University of Michigan Carlos Maltzahn, University of California, Santa Cruz Alexander Merritt, Intel Michael Mesnier. Intel Labs Changwoo Min, Virginia Polytechnic Institute and State University Shuai Mu, Stony Brook University Gilles Muller, Inria Kiran-Kumar Muniswamy-Reddy, Oracle Srinivasan Narayanamurthy, NetApp Ravi Netravali, University of California, Los Angeles Radhika Niranjan Mysore, VMware Research Roberto Palmieri, Lehigh University Aurojit Panda, New York University Gabriel Parmer, George Washington University Raju Rangaswami, Florida International University Oriana Riva, Microsoft Research Amitabha Roy, Google Larry Rudolph, Two Sigma Jack Sampson, The Pennsylvania State University Mahadev Satyanarayanan, Carnegie Mellon University Jiri Schindler, Tranquil Data Malte Schwarzkopf, Brown University Russell Sears, Apple Siddhartha Sen, Microsoft Research

Philip Shilane, Dell EMC Mark Silberstein, Technion-Israel Institute of Technology Richard Spillane, VMware Research Scott Stoller, Stony Brook University Patrick Stuedi, LinkedIn Lalith Suresh, VMware Research Amy Tai, VMware Research Eno Thereska, Amazon Theodore Ts'o, Google Alexey Tumanov, Georgia Institute of Technology Keval Vora, Simon Fraser University Ric Wheeler, Facebook Avani Wildani, Emory University Emmett Witchel, The University of Texas at Austin Yue Yang, Micron Technology Ming Zhao, Arizona State University Lin Zhong, *Rice University* Noa Zilberman, University of Oxford

External Review Committee

Raja Appuswamy, EURECOM, Sophia Antipolis
Muli Ben-Yehuda, LightBits Labs
Angela Demke Brown, University of Toronto
Sindhu Ghanta, Pyxeda Inc.
Gernot Heiser, UNSW Sydney
Paul E. McKenney, IBM Linux Technology Center
Ethan Miller, University of California, Santa Cruz, and Pure Storage
Dalit Naor, IBM Research—Haifa
Youjip Won, Korea Advanced Institute of Science and Technology (KAIST)
Gala Yadgar, Technion—Israel Institute of Technology
Submissions Co-Chairs
Ketan Bhardwaj, Georgia Institute of Technology
Dongyoon Lee, Stony Brook University

External Reviewers

Amogh Akshintala Ali Anwar Avi Asayag Gal Assa Jia-Ju Bai Lauren Bindschaedler Yuval Cassuto Joanna Che Yitao Chen Peter Chubb Shir Cohen Dave Dice Babak Esmaeili Sungho Hong Trammell Hudson Kasra Jamshidi Runyu Jin Geoff Kuenning Eugene Kuznetsov Yubo Liu Mugilan Mariappan Matthew Morrison Oded Naor Arik Rinberg Donour Sizemore Weijia Song Lynus Vaz Tianzheng Wang David Yakira Qirui Yang Yiting Yao Ding Yuan Kaiqi Zhao