# 2019 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS 2019)

Madison, Wisconsin, USA 24-26 March 2019



IEEE Catalog Number: ISBN:

CFP19PER-POD 978-1-7281-0747-9

#### **Copyright © 2019 by the Institute of Electrical and Electronics Engineers, Inc. All Rights Reserved**

*Copyright and Reprint Permissions*: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

#### \*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.

IEEE Catalog Number:	CFP19PER-POD
ISBN (Print-On-Demand):	978-1-7281-0747-9
ISBN (Online):	978-1-7281-0746-2

#### Additional Copies of This Publication Are Available From:

Curran Associates, Inc 57 Morehouse Lane Red Hook, NY 12571 USA Phone: (845) 758-0400 Fax: (845) 758-2633 E-mail: curran@proceedings.com Web: www.proceedings.com



## 2019 IEEE International Symposium on Performance Analysis of Systems and Software (ISPASS) **ISPASS 2019**

### **Table of Contents**

Message from the ISPASS 2019 General Chair x
Message from the ISPASS 2019 Program Chair _xi
Committees xii
Program Committee xiii

#### **Paper Session I: Best Paper Nominees**

#### **Paper Session II: Analyis Tools**

The POP Detector: A Lightweight Online Program Phase Detection Framework .48...... Karl Taht (University of Utah), James Greensky (Intel), and Rajeev Balasubramonian (University of Utah)

Racing to Hardware-Validated Simulation .58. Almutaz Adileh (Ghent University), Cecilia González-Álvarez (Nokia Bell Labs), Juan Miguel de Haro Ruiz (Barcelona Supercomputing Center), and Lieven Eeckhout (Ghent University)
<ul> <li>Full-System Simulation of Mobile CPU/GPU Platforms .68.</li> <li>Kuba Kaszyk (The University of Edinburgh), Harry Wagstaff (The University of Edinburgh), Tom Spink (The University of Edinburgh),</li> <li>Björn Franke (The University of Edinburgh), Michael O'Boyle (The University of Edinburgh), Bruno Bodin (Yale-NUS College, National University of Singapore), and Henrik Uhrenholt (Arm Sweden)</li> </ul>
Modeling Deep Learning Accelerator Enabled GPUs .79. Md Aamir Raihan (University of British Columbia), Negar Goli (University of British Columbia), and Tor M. Aamodt (University of British Columbia)
Emulating and Evaluating Hybrid Memory for Managed Languages on NUMA Hardware .93 Shoaib Akram (Ghent University), Jennifer B. Sartor (Ghent University), Kathryn S. McKinley (Google), and Lieven Eeckhout (Ghent University)

#### Paper Session III: System Characterization

On the Impact of Instruction Address Translation Overhead .106 Yufeng Zhou (Rice University), Xiaowan Dong (University of Rochester), Alan L. Cox (Rice University), and Sandhya Dwarkadas (University of Rochester)
Quantifying Process Variations and Its Impacts on Smartphones .1.17
Guru Prasad Srinivasa (University at Buffalo), Scott Haseley
(University at Illinois), Mark Hempstead (Tufts University), and
Geoffrey Challen (University at Illinois)
Assessing the Effects of Low Voltage in Branch Prediction Units .127
Athanasios Chatzidimitriou (University of Athens), George
Papadimitriou (University of Athens), Dimitris Gizopoulos (University
of Athens), Shrikanth Ganapathy (Advanced Micro Devices, Inc.), and
John Kalamatianos (Advanced Micro Devices, Inc.)

#### **Poster Session**

Tango: A Deep Neural Network Benchmark Suite for Various Accelerators .137...... Aajna Karki (San Jose State University), Chethan Palangotu Keshava (San Jose State University), Spoorthi Mysore Shivakumar (San Jose State University), Joshua Skow (San Jose State University), Goutam Madhukeshwar Hegde (San Jose State University), and Hyeran Jeon (San Jose State University)

PARADISE - Post-Moore Architecture and Accelerator Design Space Exploration Using Device Level Simulation and Experiment .139
Dilip Vasudevan (Lawrence Berkeley National Lab), George Michelogiannakis (Lawrence Berkeley National Lab), David Donofrio (Lawrence Berkeley National Lab), and John Shalf (Lawrence Berkeley National Lab)
A Detailed Model for Contemporary GPU Memory Systems .141 Mahmoud Khairy (Purdue University), Akshay Jain (Purdue University), Tor M. Aamodt (University of British Columbia), and Tim Rogers (Purdue University)
DSMM: A Dynamic Setting for Memory Management in Apache Spark .143 Suk-Joo Chae (Ajou University) and Tae-Sun Chung (Ajou University)
Fast Modeling of the L2 Cache Reuse Distance Histograms from Software Traces .145 Jiancong Ge (National ASIC Systems Engineering Technology Research Center, Southeast University, Nanjing, China) and Ming Ling (National ASIC Systems Engineering Technology Research Center, Southeast University, Nanjing, China)
FlexCPU: A Configurable Out-of-Order CPU Abstraction .147 Bradley Wang (UC Davis), Ayaz Akram (UC Davis), and Jason Lowe-Power (UC Davis)
<ul> <li>Hierarchical Page Eviction Policy for Unified Memory in GPUs .149.</li> <li>Qi Yu (National University of Defense Technology), Bruce Childers</li> <li>(University of Pittsburgh), Libo Huang (College of Computer, National</li> <li>University of Defense Technology), Cheng Qian (National University of</li> <li>Defense Technology), and Zhiying Wang (National University of Defense</li> <li>Technology)</li> </ul>
<ul> <li>Analyzing Machine Learning Workloads Using a Detailed GPU Simulator .151</li> <li>Jonathan Lew (University of British Columbia), Deval A. Shah</li> <li>(University of British Columbia), Suchita Pati (University of</li> <li>Wisconsin-Madison), Shaylin Cattell (University of British Columbia),</li> <li>Mengchi Zhang (Purdue University), Amruth Sandhupatla (University of</li> <li>British Columbia), Christopher Ng (University of British Columbia),</li> <li>Negar Goli (University of British Columbia), Matthew D. Sinclair</li> <li>(University of Wisconsin-Madison), Timothy G. Rogers (Purdue</li> <li>University), and Tor M. Aamodt (University of British Columbia)</li> </ul>

## Paper Session IV: Workload Characterization

Empirical Investigation of Stale Value Tolerance on Parallel RNN Training 153 Joo Hwan Lee (Samsung Semiconductor, Inc.) and Hyesoon Kim (Georgia Institute of Technolog)
Characterizing Sources of Ineffectual Computations in Deep Learning Networks .165
Milos Nikolic (University of Toronto), Mostafa Mahmoud (University of
Toronto), Yiren Zhao (University of Cambridge), Robert Mullins
(University of Cambridge), and Andreas Moshovos (University of
<i>Toronto</i> )

Demystifying Bayesian Inference Workloads .1.77.
Yu Emma Wang (Harvard University), Yuhao Zhu (University of
Rochester), Glenn G. Ko (Harvard University), Brandon Reagen
(Facebook), Gu-Yeon Wei (Harvard University), and David Brooks
(Harvard University)
Workload Characterization of Nondeterministic Programs Parallelized by STATS <u>190</u> Enrico Armenio Deiana (Northwestern University) and Simone Campanoni (Northwestern University)
Parallelism Analysis of Prominent Desktop Applications: An 18-Year Perspective .202 Siying Feng (University of Michigan), Subhankar Pal (University of Michigan), Yichen Yang (University of Michigan), and Ronald G. Dreslinski (University of Michigan)

## Paper Session V: Data Centers and Cloud Computing

μqSim: Enabling Accurate and Scalable Simulation for Interactive Microservices .2.12 Yanqi Zhang (Cornell), Yu Gan (Cornell), and Christina Delimitrou (Cornell)
Distributed Software Defined Networking Controller Failure Mode and Availability Analysis .223 Paul Reeser (AT&T, Inc.), Guilhem Tesseyre (Juniper Networks, Inc.), and Marcus Callaway (AT&T, Inc.)
A Model Driven Approach Towards Improving the Performance of Apache Spark Applications .233 Kewen Wang (University of Connecticut), Mohammad Maifi Hasan Khan (University of Connecticut), Nhan Nguyen (University of Connecticut), and Swapna Gokhale (University of Connecticut)
An Improved Dynamic Vertical Partitioning Technique for Semi-Structured Data .243 Sahel Sharify (University of Toronto), Alan Lu (University of Toronto), Jin Chen (University of Toronto), Arnamoy Bhattacharyya (University of Toronto), Ali Hashemi (University of Toronto), Nick Koudas (University of Toronto), and Cristiana Amza (University of Toronto)

## Paper Session VI: Performance Modeling and Prediction

RPPM: Rapid Performance Prediction of Multithreaded Workloads on Multicore Processors .257 Sander De Pestel (Ghent University), Sam Van den Steen (Ghent
University), Shoaib Akram (Ghent University), and Lieven Eeckhout
(Ghent University)
HeteroMap: A Runtime Performance Predictor for Efficient Processing of Graph Analytics on
Heterogeneous Multi-Accelerators .268
Masab Ahmad (University of Connecticut), Halit Dogan (University of
Connecticut), Christopher J. Michael (Naval Research Laboratory
(NRL)), and Omer Khan (University of Connecticut)

mRNA: Enabling Efficient Mapping Space Exploration for a Reconfigurable Neural Accelerator .282
Zhongyuan Zhao (Shanghai Jiao Tong University), Hyoukjun Kwon (Georgia
Institute of Technology), Sachit Kuhar (Indian Institute of
Technology, Guwahati), Weiguang Sheng (Shanghai Jiao Tong University),
Zhigang Mao (Shanghai Jiao Tong University), and Tushar Krishna
(Georgia Institute of Technology)
DeLTA: GPU Performance Model for Deep Learning Applications with In-Depth Memory System Traffic Analysis .293.
Sangkug Lym (The University of Texas at Austin), Donghyuk Lee
(NVIDIA), Mike O'Connor (NVIDIA), Niladrish Chatterjee (NVIDIA), and
Mattan Erez (The University of Texas at Austin)
Timeloop: A Systematic Approach to DNN Accelerator Evaluation .304
Angshuman Parashar (NVIDIA), Priyanka Raina (Stanford University),
Yakun Sophia Shao (NVIDIA), Yu-Hsin Chen (NVIDIA), Victor A. Ying
(Massachusetts Institute of Technology), Anurag Mukkara (Massachusetts
Institute of Technology), Rangharajan Venkatesan (NVIDIA), Brucek
Khailany (NVIDIA), Stephen W. Keckler (NVIDIA, University of Texas at
Austin), and Joel Emer (NVIDIA, Massachusetts Institute of Technology)

Author Index 317.....