

USENIX ATC '16
2016 USENIX Annual Technical Conference
June 22–24, 2016
Denver, CO, USA

Message from the Program Co-Chairs..... vii

Wednesday, June 22, 2016

Datacenter Networking

FLICK: Developing and Running Application-Specific Network Services	1
Abdul Alim, Richard G. Clegg, Luo Mai, Lukas Rupprecht, and Eric Seckler, <i>Imperial College London</i> ; Paolo Costa, <i>Microsoft Research and Imperial College London</i> ; Peter Pietzuch and Alexander L. Wolf, <i>Imperial College London</i> ; Nik Sultana, Jon Crowcroft, Anil Madhavapeddy, Andrew W. Moore, and Richard Mortier, <i>University of Cambridge</i> ; Masoud Koleni, Luis Oviedo, and Derek McAuley, <i>University of Nottingham</i> ; Matteo Migliavacca, <i>University of Kent</i>	
SoftFlow: A Middlebox Architecture for Open vSwitch.....	15
Ethan J. Jackson, <i>University of California, Berkeley</i> ; Melvin Walls, <i>Penn State Harrisburg and University of California, Berkeley</i> ; Aurojit Panda, <i>University of California, Berkeley</i> ; Justin Pettit, Ben Pfaff, and Jarno Rajahalme, <i>VMware, Inc.</i> ; Teemu Koponen, <i>Styra, Inc.</i> ; Scott Shenker, <i>University of California, Berkeley, and International Computer Science Institute</i>	
Fast and Cautious: Leveraging Multi-path Diversity for Transport Loss Recovery in Data Centers	29
Guo Chen, <i>Tsinghua University and Microsoft Research</i> ; Yuanwei Lu, <i>University of Science and Technology of China and Microsoft Research</i> ; Yuan Meng, <i>Tsinghua University</i> ; Bojie Li, <i>University of Science and Technology of China and Microsoft Research</i> ; Kun Tan, <i>Microsoft Research</i> ; Dan Pei, <i>Tsinghua University</i> ; Peng Cheng, Layong (Larry) Luo, and Yongqiang Xiong, <i>Microsoft Research</i> ; Xiaoliang Wang, <i>Nanjing University</i> ; Youjian Zhao, <i>Tsinghua University</i>	
StackMap: Low-Latency Networking with the OS Stack and Dedicated NICs	43
Kenichi Yasukata, <i>Keio University</i> ; Michio Honda, Douglas Santry, and Lars Eggert, <i>NetApp</i>	

File and Key-Value Systems

SLIK: Scalable Low-Latency Indexes for a Key-Value Store	57
Ankita Kejriwal, Arjun Gopalan, Ashish Gupta, Zhihao Jia, Stephen Yang, and John Ousterhout, <i>Stanford University</i>	
Understanding Manycore Scalability of File Systems.....	71
Changwoo Min, Sanidhya Kashyap, Steffen Maass, Woonhak Kang, and Taesoo Kim, <i>Georgia Institute of Technology</i>	
ParaFS: A Log-Structured File System to Exploit the Internal Parallelism of Flash Devices	87
Jiacheng Zhang, Jiwu Shu, and Youyou Lu, <i>Tsinghua University</i>	
FastCDC: a Fast and Efficient Content-Defined Chunking Approach for Data Deduplication.....	101
Wen Xia, <i>Huazhong University of Science and Technology and Sangfor Technologies Co., Ltd.</i> ; Yukun Zhou, <i>Huazhong University of Science and Technology</i> ; Hong Jiang, <i>University of Texas at Arlington</i> ; Dan Feng, Yu Hua, Yuchong Hu, Yucheng Zhang, and Qing Liu, <i>Huazhong University of Science and Technology</i>	

(Wednesday, June 22 continues on the next page)

Mobile and Apps

Unsafe Time Handling in Smartphones115
Abhilash Jindal, Prahlad Joshi, Y. Charlie Hu, and Samuel Midkiff, <i>Purdue University</i>	
Energy Discounted Computing on Multicore Smartphones.....	.129
Meng Zhu and Kai Shen, <i>University of Rochester</i>	
Beam: Ending Monolithic Applications for Connected Devices143
Chenguang Shen, <i>University of California, Los Angeles</i> ; Rayman Preet Singh, <i>Samsung Research</i> ; Amar Phanishayee, Aman Kansal, and Ratul Mahajan, <i>Microsoft Research</i>	
Caching Doesn't Improve Mobile Web Performance (Much)159
Jamshed Vesuna and Colin Scott, <i>University of California, Berkeley</i> ; Michael Buettner and Michael Piatek, <i>Google</i> ; Arvind Krishnamurthy, <i>University of Washington</i> ; Scott Shenker, <i>University of California, Berkeley</i> , and <i>International Computer Science Institute</i>	

Systems and Network Security

Secure and Efficient Application Monitoring and Replication167
Stijn Volckaert, <i>University of California, Irvine</i> , and <i>Ghent University</i> ; Bart Coppens, <i>Ghent University</i> ; Alexios Voulimeneas, <i>University of California, Irvine</i> ; Andrei Homescu, <i>Immunant, Inc.</i> ; Per Larsen, <i>University of California, Irvine</i> , and <i>Immunant, Inc.</i> ; Bjorn De Sutter, <i>Ghent University</i> ; Michael Franz, <i>University of California, Irvine</i>	
Blockstack: A Global Naming and Storage System Secured by Blockchains181
Muneeb Ali and Jude Nelson, <i>Princeton University</i> and <i>Blockstack Labs</i> ; Ryan Shea, <i>Blockstack Labs</i> ; Michael J. Freedman, <i>Princeton University</i>	
Satellite: Joint Analysis of CDNs and Network-Level Interference195
Will Scott, Thomas Anderson, Tadayoshi Kohno, and Arvind Krishnamurthy, <i>University of Washington</i>	
Subversive-C: Abusing and Protecting Dynamic Message Dispatch.....	.209
Julian Lettner, <i>University of California, Irvine</i> ; Benjamin Kollenda, <i>Ruhr-Universität Bochum</i> ; Andrei Homescu, <i>Immunant, Inc.</i> ; Per Larsen, <i>University of California, Irvine</i> , and <i>Immunant, Inc.</i> ; Felix Schuster, <i>Microsoft Research</i> ; Lucas Davi and Ahmad-Reza Sadeghi, <i>Technische Universität Darmstadt</i> ; Thorsten Holz, <i>Ruhr-Universität Bochum</i> ; Michael Franz, <i>University of California, Irvine</i>	

Thursday, June 23, 2016

Cloud, Coordination, and Consensus

Callinicos: Robust Transactional Storage for Distributed Data Structures.....	.223
Ricardo Padilha, Enrique Fynn, Robert Soulé, and Fernando Pedone, <i>Università della Svizzera Italiana (USI)</i>	
Filo: Consolidated Consensus as a Cloud Service237
Parisa Jalili Marandi, Christos Gkantsidis, Flavio Junqueira, and Dushyanth Narayanan, <i>Microsoft Research</i>	
Modular Composition of Coordination Services251
Kfir Lev-Ari, <i>Technion—Israel Institute of Technology</i> ; Edward Bortnikov, <i>Yahoo Research</i> ; Idit Keidar, <i>Technion—Israel Institute of Technology</i> and <i>Yahoo Research</i> ; Alexander Shraer, <i>Google</i>	
Cheap and Available State Machine Replication.....	.265
Rong Shi and Yang Wang, <i>The Ohio State University</i>	

Architectural Interaction

Horton Tables: Fast Hash Tables for In-Memory Data-Intensive Computing.....	.281
Alex D. Breslow, <i>AMD Research</i> and <i>University of California, San Diego</i> ; Dong Ping Zhang, Joseph L. Greathouse, and Nuwan Jayasena, <i>AMD Research</i> ; Dean M. Tullsen, <i>University of California, San Diego</i>	

Ginseng: Market-Driven LLC Allocation295
Liran Funaro, Orna Agmon Ben-Yehuda, and Assaf Schuster, <i>Technion—Israel Institute of Technology</i>	

Elfen Scheduling: Fine-Grain Principled Borrowing from Latency-Critical Workloads Using Simultaneous Multithreading309
Xi Yang and Stephen M. Blackburn, <i>Australian National University</i> ; Kathryn S. McKinley, <i>Microsoft Research</i>	

Coherence Stalls or Latency Tolerance: Informed CPU Scheduling for Socket and Core Sharing.....	.323
Sharanyan Srikanthan, Sandhya Dwarkadas, and Kai Shen, <i>University of Rochester</i>	

Caching and Indexing

Replex: A Scalable, Highly Available Multi-Index Data Store337
Amy Tai, <i>VMWare Research and Princeton University</i> ; Michael Wei, <i>VMware Research and University of California, San Diego</i> ; Michael J. Freedman, <i>Princeton University</i> ; Ittai Abraham and Dahlia Malkhi, <i>VMWare Research</i>	

Kinetic Modeling of Data Eviction in Cache351
Xiameng Hu, Xiaolin Wang, Lan Zhou, Yingwei Luo, <i>Peking University</i> ; Chen Ding, <i>University of Rochester</i> ; Zhenlin Wang, <i>Michigan Technological University</i>	

Scalable In-Memory Transaction Processing with HTM.....	.365
Yingjun Wu and Kian-Lee Tan, <i>National University of Singapore</i>	

Erasing Belady's Limitations: In Search of Flash Cache Offline Optimality379
Yue Cheng, <i>Virginia Polytechnic Institute and State University</i> ; Fred Dougis, Philip Shilane, Michael Trachtmann, and Grant Wallace, <i>EMC Corporation</i> ; Peter Desnoyers, <i>Northeastern University</i> ; Kai Li, <i>Princeton University</i>	

Energy vs. Performance

Unlocking Energy393
Babak Falsafi, Rachid Guerraoui, Javier Picorel, and Vasileios Trigonakis, <i>École Polytechnique Fédérale de Lausanne (EPFL)</i>	

Greening the Video Transcoding Service with Low-Cost Hardware Transcoders407
Peng Liu, <i>University of Wisconsin—Madison</i> ; Jongwon Yoon, <i>Hanyang University</i> ; Lance Johnson, <i>University of Minnesota</i> ; Suman Banerjee, <i>University of Wisconsin—Madison</i>	

MEANTIME: Achieving Both Minimal Energy and Timeliness with Approximate Computing421
Anne Farrell and Henry Hoffmann, <i>University of Chicago</i>	

Network Design and Usage Studies

Design Guidelines for High Performance RDMA Systems437
Anuj Kalia, <i>Carnegie Mellon University</i> ; Michael Kaminsky, <i>Intel Labs</i> ; David G. Andersen, <i>Carnegie Mellon University</i>	

Balancing CPU and Network in the Cell Distributed B-Tree Store.....	.451
Christopher Mitchell, Kate Montgomery, and Lamont Nelson, <i>New York University</i> ; Siddhartha Sen, <i>Microsoft Research</i> ; Jinyang Li, <i>New York University</i>	

An Evolutionary Study of Linux Memory Management for Fun and Profit465
Jian Huang, Moinuddin K. Qureshi, and Karsten Schwan, <i>Georgia Institute of Technology</i>	

Getting Back Up: Understanding How Enterprise Data Backups Fail479
George Amvrosiadis, <i>University of Toronto</i> ; Medha Bhadkamkar, <i>Veritas Labs</i>	

Friday, June 24, 2016

Data Is Now Big Data

SplitJoin: A Scalable, Low-latency Stream Join Architecture with Adjustable Ordering Precision 493
Mohammadreza Najafi, *Technische Universität München*; Mohammad Sadoghi, *IBM T. J. Watson Research Center*; Hans-Arno Jacobsen, *Middleware Systems Research Group*

Load the Edges You Need: A Generic I/O Optimization for Disk-based Graph Processing 507
Keval Vora, *University of California, Riverside*; Guoqing Xu, *University of California, Irvine*; Rajiv Gupta, *University of California, Riverside*

Version Traveler: Fast and Memory-Efficient Version Switching in Graph Processing Systems 523
Xiaoen Ju, *University of Michigan*; Dan Williams and Hani Jamjoom, *IBM T. J. Watson Research Center*; Kang G. Shin, *University of Michigan*

Tucana: Design and Implementation of a Fast and Efficient Scale-up Key-value Store 537
Anastasios Papagiannis, *Foundation of Research and Technology-Hellas (FORTH) and University of Crete*; Giorgos Saloustros, *Foundation of Research and Technology-Hellas (FORTH)*; Pilar González-Férez, *Foundation of Research and Technology-Hellas (FORTH) and University of Murcia*; Angelos Bilas, *Foundation of Research and Technology-Hellas (FORTH) and University of Crete*

Virtualization

Samsara: Efficient Deterministic Replay in Multiprocessor Environments with Hardware Virtualization Extensions 551
Shiru Ren, Le Tan, Chunqi Li, and Zhen Xiao, *Peking University*; Weijia Song, *Cornell University*

Hardware-Assisted On-Demand Hypervisor Activation for Efficient Security Critical Code Execution on Mobile Devices 565
Yeongpil Cho, *Seoul National University*; Junbum Shin, *Samsung Electronics*; Donghyun Kwon, *Seoul National University*; MyungJoo Ham and Yuna Kim, *Samsung Electronics*; Yunheung Paek, *Seoul National University*

gScale: Scaling up GPU Virtualization with Dynamic Sharing of Graphics Memory Space 579
Mochi Xue, *Shanghai Jiao Tong University and Intel Corporation*; Kun Tian, *Intel Corporation*; Yaozu Dong, *Shanghai Jiao Tong University and Intel Corporation*; Jiacheng Ma, Jiajun Wang, and Zhengwei Qi, *Shanghai Jiao Tong University*; Bingsheng He, *National University of Singapore*; Haibing Guan, *Shanghai Jiao Tong University*

A General Persistent Code Caching Framework for Dynamic Binary Translation (DBT) 591
Wenwen Wang, Pen-Chung Yew, Antonia Zhai, and Stephen McCamant, *University of Minnesota, Twin Cities*

Operating Systems

Instant OS Updates via Userspace Checkpoint-and-Restart 605
Sanidhya Kashyap, Changwoo Min, Byoungyoung Lee, and Taesoo Kim, *Georgia Institute of Technology*; Pavel Emelyanov, *CRIU and Odin, Inc.*

Apps with Hardware: Enabling Run-time Architectural Customization in Smart Phones 621
Michael Coughlin, Ali Ismail, and Eric Keller, *University of Colorado, Boulder*

Testing Error Handling Code in Device Drivers Using Characteristic Fault Injection 635
Jia-Ju Bai, Yu-Ping Wang, Jie Yin, and Shi-Min Hu, *Tsinghua University*

Multicore Locks: The Case Is Not Closed Yet 649
Hugo Guiroux and Renaud Lachaize, *Université Grenoble Alpes and Laboratoire d'Informatique de Grenoble*; Vivien Quéma, *Université Grenoble Alpes, Grenoble Institute of Technology, and Laboratoire d'Informatique de Grenoble*