

**USENIX ATC '18:**  
**2018 USENIX Annual Technical Conference**  
**July 11–13, 2018**  
**Boston, MA, USA**

## Performance

|  |           |
|--|-----------|
| <b>Tributary: spot-dancing for elastic services with latency SLOs .....</b>  | <b>1</b>  |
| Aaron Harlap and Andrew Chung, <i>Carnegie Mellon University</i> ; Alexey Tumanov, <i>UC Berkeley</i> ; Gregory R. Ganger and Phillip B. Gibbons, <i>Carnegie Mellon University</i>  |           |
| <b>FastTrack: Foreground App-Aware I/O Management for Improving User Experience of Android Smartphones .....</b>   | <b>15</b> |
| Sangwook Shane Hahn, <i>Seoul National University</i> ; Sungjin Lee, <i>DGIST</i> ; Inhyuk Yee, <i>AIBrain Asia</i> ; Donguk Ryu, <i>Samsung Electronics</i> ; Jihong Kim, <i>Seoul National University</i>  |           |
| <b>Mainstream: Dynamic Stem-Sharing for Multi-Tenant Video Processing.....</b>   | <b>29</b> |
| Angela H. Jiang, Daniel L.K. Wong, Christopher Canel, Lilia Tang, and Ishan Misra, <i>Carnegie Mellon University</i> ; Michael Kaminsky, Michael A. Kozuch, and Padmanabhan Pillai, <i>Intel Labs</i> ; David G. Andersen and Gregory R. Ganger, <i>Carnegie Mellon University</i> |           |
| <b>VIDEOCHEF: Efficient Approximation for Streaming Video Processing Pipelines .....</b>   | <b>43</b> |
| Ran Xu, Jinkyu Koo, Rakesh Kumar, and Peter Bai, <i>Purdue University</i> ; Subrata Mitra, <i>Adobe Research</i> ; Sasa Misailovic, <i>University of Illinois Urbana-Champaign</i> ; Saurabh Bagchi, <i>Purdue University</i>  |           |

## Kernel

|   |           |
|---|-----------|
| <b>SOCK: Rapid Task Provisioning with Serverless-Optimized Containers .....</b>   | <b>57</b> |
| Edward Oakes, Leon Yang, Dennis Zhou, and Kevin Houck, <i>University of Wisconsin-Madison</i> ; Tyler Harter, <i>Microsoft, GSL</i> ; Andrea C. Arpacı-Dusseau and Remzi H. Arpacı-Dusseau, <i>University of Wisconsin-Madison</i>    |           |
| <b>DynaMix: Dynamic Mobile Device Integration for Efficient Cross-device Resource Sharing.....</b>  | <b>71</b> |
| Dongju Chae, <i>POSTECH</i> ; Joonsung Kim and Gwangmu Lee, <i>Seoul National University</i> ; Hanjun Kim, <i>POSTECH</i> ; Kyung-Ah Chang and Hyogun Lee, <i>Samsung Electronics</i> ; Jangwoo Kim, <i>Seoul National University</i> |           |
| <b>The Battle of the Schedulers: FreeBSD ULE vs. Linux CFS .....</b>  | <b>85</b> |
| Justinien Bouron, Sébastien Chevalley, Baptiste Lepers, and Willy Zwaenepoel, <i>EPFL</i> ; Redha Gouicem, Julia Lawall, Gilles Muller, and Julien Sopena, <i>Sorbonne University/Inria/LIP6</i>                                      |           |
| <b>The Design and Implementation of Hyperupcalls.....</b>   | <b>97</b> |
| Nadav Amit and Michael Wei, <i>VMware Research</i>  |           |

## Security 1

|  |            |
|--|------------|
| <b>AIQL: Enabling Efficient Attack Investigation from System Monitoring Data .....</b>   | <b>113</b> |
| Peng Gao, <i>Princeton University</i> ; Xusheng Xiao, <i>Case Western Reserve University</i> ; Zhichun Li and Kangkook Jee, <i>NEC Laboratories America, Inc.</i> ; Fengyuan Xu, <i>National Key Lab for Novel Software Technology, Nanjing University</i> ; Sanjeev R. Kulkarni and Prateek Mittal, <i>Princeton University</i> |            |
| <b>Application Memory Isolation on Ultra-Low-Power MCUs.....</b>   | <b>127</b> |
| Taylor Hardin, <i>Dartmouth College</i> ; Ryan Scott, <i>Clemson University</i> ; Patrick Proctor, <i>Dartmouth College</i> ; Josiah Hester, <i>Northwestern University</i> ; Jacob Sorber, <i>Clemson University</i> ; David Kotz, <i>Dartmouth College</i>   |            |
| <b>Peeking Behind the Curtains of Serverless Platforms .....</b>   | <b>133</b> |
| Liang Wang, <i>UW-Madison</i> ; Mengyuan Li and Yinqian Zhang, <i>The Ohio State University</i> ; Thomas Ristenpart, <i>Cornell Tech</i> ; Michael Swift, <i>UW-Madison</i>  |            |
| <b>SOTERIA: Automated IoT Safety and Security Analysis.....</b>  | <b>147</b> |
| Z. Berkay Celik, Patrick McDaniel, and Gang Tan, <i>The Pennsylvania State University</i>  |            |

## **Virtualization**

- Scaling Guest OS Critical Sections with eCS** ..... 159  
Sanidhya Kashyap, *Georgia Institute of Technology*; Changwoo Min, *Virginia Tech*; Taesoo Kim, *Georgia Institute of Technology*

- KylinX: A Dynamic Library Operating System for Simplified and Efficient Cloud Virtualization** ..... 173  
Yiming Zhang, *NiceX Lab, NUDT*; Jon Crowcroft, *University of Cambridge*; Dongsheng Li and Chengfen Zhang, *NUDT*; Huiba Li, *Alibaba*; Yaozheng Wang and Kai Yu, *NUDT*; Yongqiang Xiong, *Microsoft*; Guihai Chen, *SJTU*

- Virtualizing Energy Storage Management Using RAIBA** ..... 187  
Tzi-cker Chiueh, Mao-Cheng Huang, Kai-Cheung Juang, Shih-Hao Liang, and Welkin Ling, *Industrial Technology Research Institute*

- CNTR: Lightweight OS Containers** ..... 199  
Jörg Thalheim and Pramod Bhatotia, *University of Edinburgh*; Pedro Fonseca, *University of Washington*; Baris Kasikci, *University of Michigan*

## **Security 2**

- Throwhammer: Rowhammer Attacks over the Network and Defenses** ..... 213  
Andrei Tatar and Radhesh Krishnan Konoth, *Vrije Universiteit Amsterdam*; Elias Athanasopoulos, *University of Cyprus*; Cristiano Giuffrida, Herbert Bos, and Kaveh Razavi, *Vrije Universiteit Amsterdam*

- Varys: Protecting SGX Enclaves from Practical Side-Channel Attacks** ..... 227  
Oleksii Oleksenko, Bohdan Trach, Robert Krahn, and André Martin, *TU Dresden*; Mark Silberstein, *Technion*; Christof Fetzer, *TU Dresden*

- Kernel-Supported Cost-Effective Audit Logging for Causality Tracking** ..... 241  
Shiqing Ma, *Purdue University*; Juan Zhai, *Nanjing University*; Yonghui Kwon, *Purdue University*; Kyu Hyung Lee, *University of Georgia*; Xiangyu Zhang, *Purdue University*; Gabriela Ciocarlie, Ashish Gehani, and Vinod Yegneswaran, *SRI International*; Dongyan Xu, *Purdue University*; Somesh Jha, *University of Wisconsin-Madison*

- EPTI: Efficient Defence against Meltdown Attack for Unpatched VMs** ..... 255  
Zhichao Hua, Dong Du, Yubin Xia, Haibo Chen, and Binyu Zang, *Institute of Parallel and Distributed Systems, Shanghai Jiao Tong University*

## **Multicore**

- Effectively Mitigating I/O Inactivity in vCPU Scheduling** ..... 267  
Weiwei Jia, *The University of Hong Kong, New Jersey Institute of Technology*; Cheng Wang and Xusheng Chen, *The University of Hong Kong*; Jianchen Shan and Xiaowei Shang, *New Jersey Institute of Technology*; Heming Cui, *The University of Hong Kong*; Xiaoning Ding, *New Jersey Institute of Technology*; Luwei Cheng, *Facebook*; Francis C. M. Lau and Yuexuan Wang, *The University of Hong Kong*; Yuangang Wang, *Huawei*

- Placement of Virtual Containers on NUMA systems: A Practical and Comprehensive Model** ..... 281  
Justin Funston, Maxime Lorrillere, and Alexandra Fedorova, *University of British Columbia*; Baptiste Lepers, *EPFL*; David Vengerov and Jean-Pierre Lozi, *Oracle Labs*; Vivien Quémé, *IMAG*

- Getting to the Root of Concurrent Binary Search Tree Performance** ..... 295  
Maya Arbel-Raviv, *Technion*; Trevor Brown, *IST Austria*; Adam Morrison, *Tel Aviv University*

- TerseCades: Efficient Data Compression in Stream Processing** ..... 307  
Gennady Pekhimenko, *University of Toronto*; Chuanxiong Guo, *Bytedance Inc.*; Myeongjae Jeon, *Microsoft Research*; Peng Huang, *Johns Hopkins University*; Lidong Zhou, *Microsoft Research*

(continued on next page)

## Problem Determination

|   |             |
|---|-------------|
| <b>Troubleshooting Transiently-Recurring Errors in Production Systems with Blame-Proportional Logging</b> .....   | <b>321</b>  |
| Liang Luo, <i>University of Washington</i> ; Suman Nath, Lenin Ravindranath Sivalingam, and Madan Musuvathi, <i>Microsoft Research</i> ; Luis Ceze, <i>University of Washington</i> |             |
| <b>NanoLog: A Nanosecond Scale Logging System</b> .....   | <b>.335</b> |
| Stephen Yang, Seo Jin Park, and John Ousterhout, <i>Stanford University</i>   |             |
| <b>Model Governance: Reducing the Anarchy of Production ML</b> .....  | <b>.351</b> |
| Vinay Sridhar, Sriram Subramanian, Dulcardo Arteaga, Swaminathan Sundararaman, Drew Roselli, and Nisha Talagala, <i>ParallelM</i>   |             |

## Consistency

|   |             |
|---|-------------|
| <b>Fine-grained consistency for geo-replicated systems</b> .....  | <b>.359</b> |
| Cheng Li, <i>University of Science and Technology of China</i> ; Nuno Preguica, <i>NOVA LINCS &amp; FCT, Univ. NOVA de Lisboa</i> ; Rodrigo Rodrigues, <i>INESC-ID &amp; Instituto Superior Técnico, Universidade de Lisboa</i> |             |
| <b>Log-Free Concurrent Data Structures</b> .....  | <b>.373</b> |
| Tudor David, <i>IBM Research, Zurich</i> ; Aleksandar Dragojevic, <i>MSR Cambridge</i> ; Rachid Guerraoui and Igor Zablotchi, <i>EPFL</i>   |             |
| <b>Stable and Consistent Membership at Scale with Rapid</b> .....   | <b>.387</b> |
| Lalith Suresh, Dahlia Malkhi, and Parikshit Gopalan, <i>VMware Research</i> ; Ivan Porto Carreiro, <i>One Concern</i> ; Zeeshan Lokhandwala, <i>VMware</i>  |             |

## Big Data Faster

|  |             |
|--|-------------|
| <b>On Smart Query Routing: For Distributed Graph Querying with Decoupled Storage</b> .....   | <b>.401</b> |
| Arijit Khan, <i>Nanyang Technological University, Singapore</i> ; Gustavo Segovia, <i>ETH Zurich, Switzerland</i> ; Donald Kossmann, <i>Microsoft Research, Redmond, USA</i>   |             |
| <b>Locality-Aware Software Throttling for Sparse Matrix Operation on GPUs</b> .....  | <b>.413</b> |
| Yanhao Chen and Ari B. Hayes, <i>Rutgers University</i> ; Chi Zhang, <i>University of Pittsburgh</i> ; Timothy Salmon and Eddy Z. Zhang, <i>Rutgers University</i>   |             |
| <b>Accelerating PageRank using Partition-Centric Processing</b> .....  | <b>.427</b> |
| Kartik Lakhotia, <i>University of Southern California</i> ; Rajgopal Kannan, <i>US Army Research Lab</i> ; Viktor Prasanna, <i>University of Southern California</i>   |             |
| <b>CGraph: A Correlations-aware Approach for Efficient Concurrent Iterative Graph Processing</b> .....   | <b>.441</b> |
| Yu Zhang, Xiaofei Liao, Hai Jin, and Lin Gu, <i>Huazhong University of Science and Technology</i> ; Ligang He, <i>University of Warwick</i> ; Bingsheng He, <i>National University of Singapore</i> ; Haikun Liu, <i>Huazhong University of Science and Technology</i> |             |

## Availability

|  |             |
|--|-------------|
| <b>Don't share, Don't lock: Large-scale Software Connection Tracking with Krononat</b> .....   | <b>.453</b> |
| Fabien André, Stéphane Gouache, Nicolas Le Scouarnec, and Antoine Monsifrot, <i>Technicolor</i>  |             |
| <b>Accurate Timeout Detection Despite Arbitrary Processing Delays</b> .....  | <b>.467</b> |
| Sixiang Ma and Yang Wang, <i>The Ohio State University</i>   |             |
| <b>Improving Service Availability of Cloud Systems by Predicting Disk Error</b> .....  | <b>.481</b> |
| Yong Xu and Kaixin Sui, <i>Microsoft Research, China</i> ; Randolph Yao, <i>Microsoft Azure, USA</i> ; Hongyu Zhang, <i>The University of Newcastle, Australia</i> ; Qingwei Lin, <i>Microsoft Research, China</i> ; Yingnong Dang, <i>Microsoft Azure, USA</i> ; Peng Li, <i>Nankai University, China</i> ; Keceng Jiang, WENCHI Zhang, and Jian-Guang Lou, <i>Microsoft Research, China</i> ; Murali Chintalapati, <i>Microsoft Azure, USA</i> ; Dongmei Zhang, <i>Microsoft Research, China</i> |             |

|   |            |
|---|------------|
| <b>RAFI: Risk-Aware Failure Identification to Improve the RAS in Erasure-coded Data Centers.....</b>      | <b>495</b> |
| Juntao Fang, <i>Wuhan National Laboratory for Optoelectronics, Huazhong University of Sci. and Tech.;</i> |            |
| Shenggang Wan, <i>School of Computer Science and Technology, Huazhong University of Sci. and Tech.;</i>   |            |
| Xubin He, <i>Department of Computer and Information Sciences, Temple University</i>                       |            |

## Big Data 1

|  |            |
|--|------------|
| <b>Siphon: Expediting Inter-Datacenter Coflows in Wide-Area Data Analytics .....</b>   | <b>507</b> |
| Shuhao Liu, Li Chen, and Baochun Li, <i>University of Toronto</i>  |            |
| <b>PerfIso: Performance Isolation for Commercial Latency-Sensitive Services .....</b>  | <b>519</b> |
| Călin Iorgulescu, <i>EPFL</i> ; Reza Azimi, <i>Brown University</i> ; Youngjin Kwon, <i>U. Texas at Austin</i> ; Sameh Elnikety, Manoj Syamala, and Vivek Narasayya, <i>Microsoft Research</i> ; Herodotos Herodotou, <i>Cyprus University of Technology</i> ; Paulo Tomita, Alex Chen, Jack Zhang, and Junhua Wang, <i>Microsoft Bing</i> |            |
| <b>On the diversity of cluster workloads and its impact on research results.....</b>   | <b>533</b> |
| George Amvrosiadis, Jun Woo Park, Gregory R. Ganger, and Garth A. Gibson, <i>Carnegie Mellon University</i> ; Elisabeth Baseman and Nathan DeBardeleben, <i>Los Alamos National Laboratory</i>   |            |
| <b>SLAOrchestrator: Reducing the Cost of Performance SLAs for Cloud Data Analytics .....</b>   | <b>547</b> |
| Jennifer Ortiz, Brendan Lee, and Magdalena Balazinska, <i>University of Washington</i> ; Johannes Gehrke, <i>Microsoft</i> ; Joseph L. Hellerstein, <i>eScience Institute</i>  |            |

## Analyzing Code

|  |            |
|--|------------|
| <b>Spindle: Informed Memory Access Monitoring .....</b>  | <b>561</b> |
| Haojie Wang, <i>Tsinghua University</i> , <i>Qatar Computing Research Institute</i> ; Jidong Zhai, <i>Tsinghua University</i> ; Xiongchao Tang, <i>Tsinghua University</i> , <i>Qatar Computing Research Institute</i> ; Bowen Yu, <i>Tsinghua University</i> ; Xiaosong Ma, <i>Qatar Computing Research Institute</i> ; Wenguang Chen, <i>Tsinghua University</i> |            |
| <b>Touchstone: Generating Enormous Query-Aware Test Databases .....</b>  | <b>575</b> |
| Yuming Li and Rong Zhang, <i>East China Normal University</i> ; Xiaoyan Yang and Zhenjie Zhang, <i>Singapore R&amp;D, Yitu Technology Ltd.</i> ; Aoying Zhou, <i>East China Normal University</i>  |            |
| <b>DSAC: Effective Static Analysis of Sleep-in-Atomic-Context Bugs in Kernel Modules .....</b>   | <b>587</b> |
| Jia-Ju Bai and Yu-Ping Wang, <i>Tsinghua University</i> ; Julia Lawall, <i>Sorbonne Université/Inria/LIP6</i> ; Shi-Min Hu, <i>Tsinghua University</i>   |            |
| <b>Coccinelle: 10 Years of Automated Evolution in the Linux Kernel .....</b>   | <b>601</b> |
| Julia Lawall and Gilles Muller, <i>Sorbonne University/Inria/LIP6</i>  |            |

## Big Data 2

|  |            |
|--|------------|
| <b>Albis: High-Performance File Format for Big Data Systems.....</b>   | <b>615</b> |
| Animesh Trivedi, Patrick Stuedi, Jonas Pfefferle, Adrian Schuepbach, and Bernard Metzler, <i>IBM Research, Zurich</i>  |            |
| <b>Litz: Elastic Framework for High-Performance Distributed Machine Learning .....</b>   | <b>631</b> |
| Aurick Qiao, <i>Petuum, Inc. and Carnegie Mellon University</i> ; Abutalib Aghayev, <i>Carnegie Mellon University</i> ; Weiren Yu, <i>Petuum, Inc. and Beihang University</i> ; Haoyang Chen and Qirong Ho, <i>Petuum, Inc.</i> ; Garth A. Gibson, <i>Carnegie Mellon University and Vector Institute</i> ; Eric P. Xing, <i>Petuum, Inc. and Carnegie Mellon University</i> |            |
| <b>Putting the “Micro” Back in Microservice .....</b>  | <b>645</b> |
| Sol Boucher, Anuj Kalia, and David G. Andersen, <i>Carnegie Mellon University</i> ; Michael Kaminsky, <i>Intel Labs</i>  |            |
| <b>Fast and Concurrent RDF Queries using RDMA-assisted GPU Graph Exploration .....</b>   | <b>651</b> |
| Siyuan Wang, Chang Lou, Rong Chen, and Haibo Chen, <i>Shanghai Jiao Tong University</i>  |            |

(continued on next page)

## SSDs

|  |            |
|--|------------|
| <b>MDev-NVMe: A NVMe Storage Virtualization Solution with Mediated Pass-Through .....</b>  | <b>665</b> |
| Bo Peng, <i>Shanghai Jiao Tong University, Intel</i> ; Haohong Zhang, <i>Intel</i> ; Jianguo Yao, <i>Shanghai Jiao Tong University</i> ; Yaozu Dong, <i>Intel</i> ; Yu Xu and Haibing Guan, <i>Shanghai Jiao Tong University</i> |            |
| <b>AutoSSD: an Autonomic SSD Architecture.....</b>   | <b>677</b> |
| Bryan S. Kim, <i>Seoul National University</i> ; Hyun Suk Yang, <i>Hongik University</i> ; Sang Lyul Min, <i>Seoul National University</i>   |            |
| <b>Geriatrix: Aging what you see and what you don't see. A file system aging approach for modern storage systems .....</b>   | <b>691</b> |
| Saurabh Kadekodi, Vaishnav Nagarajan, and Gregory R. Ganger, <i>Carnegie Mellon University</i> ; Garth A. Gibson, <i>Carnegie Mellon University, Vector Institute</i>  |            |
| <b>Can't We All Get Along? Redesigning Protection Storage for Modern Workloads .....</b>   | <b>705</b> |
| Yamini Allu, Fred Douglis, Mahesh Kamat, Ramya Prabhakar, Philip Shilane, and Rahul Ugale, <i>Dell EMC</i>   |            |

## The Network

|   |            |
|---|------------|
| <b>STMS: Improving MPTCP Throughput Under Heterogeneous Networks.....</b>   | <b>719</b> |
| Hang Shi and Yong Cui, <i>Tsinghua University</i> ; Xin Wang, <i>Stony Brook University</i> ; Yuming Hu and Minglong Dai, <i>Tsinghua University</i> ; Fanzhao Wang and Kai Zheng, <i>Huawei Technologies</i>         |            |
| <b>Pantheon: the training ground for Internet congestion-control research.....</b>  | <b>731</b> |
| Francis Y. Yan, Jestin Ma, and Greg D. Hill, <i>Stanford University</i> ; Deepti Raghavan, <i>Massachusetts Institute of Technology</i> ; Riad S. Wahby, Philip Levis, and Keith Winstein, <i>Stanford University</i> |            |
| <b>ClickNF: a Modular Stack for Custom Network Functions.....</b>   | <b>745</b> |
| Massimo Gallo and Rafael Laufer, <i>Nokia Bell Labs</i>   |            |

## Storage 1

|   |            |
|---|------------|
| <b>Selecta: Heterogeneous Cloud Storage Configuration for Data Analytics .....</b>  | <b>759</b> |
| Ana Klimovic, <i>Stanford University</i> ; Heiner Litz, <i>UC Santa Cruz</i> ; Christos Kozyrakis, <i>Stanford University</i>   |            |
| <b>Remote regions: a simple abstraction for remote memory.....</b>  | <b>775</b> |
| Marcos K. Aguilera, Nadav Amit, Irina Calciu, Xavier Deguillard, Jayneel Gandhi, Stanko Novakovic, Arun Ramanathan, Pratap Subrahmanyam, Lalith Suresh, Kiran Tati, Rajesh Venkatasubramanian, and Michael Wei, <i>VMware</i> |            |
| <b>Understanding Ephemeral Storage for Serverless Analytics .....</b>   | <b>789</b> |
| Ana Klimovic, Yawen Wang, and Christos Kozyrakis, <i>Stanford University</i> ; Patrick Stuedi, Jonas Pfefferle, and Animesh Trivedi, <i>IBM Research</i>  |            |

## Transactions

|   |            |
|---|------------|
| <b>Solar: Towards a Shared-Everything Database on Distributed Log-Structured Storage.....</b>   | <b>795</b> |
| Tao Zhu, <i>East China Normal University</i> ; Zhuoyue Zhao and Feifei Li, <i>University of Utah</i> ; Weinig Qian and Aoying Zhou, <i>East China Normal University</i> ; Dong Xie and Ryan Stutsman, <i>University of Utah</i> ; Haining Li, <i>Bank of Communications</i> ; Huiqi Hu, <i>East China Normal University</i> ; <i>Bank of Communications</i> |            |
| <b>Toward Coordination-free and Reconfigurable Mixed Concurrency Control.....</b>   | <b>809</b> |
| Dixin Tang and Aaron J. Elmore, <i>University of Chicago</i>  |            |
| <b>Scaling Hardware Accelerated Network Monitoring to Concurrent and Dynamic Queries With *Flow .....</b>   | <b>823</b> |
| John Sonchack, <i>University of Pennsylvania</i> ; Oliver Michel, <i>University of Colorado Boulder</i> ; Adam J. Aviv, <i>United States Naval Academy</i> ; Eric Keller, <i>University of Colorado Boulder</i> ; Jonathan M. Smith, <i>University of Pennsylvania</i>  |            |
| <b>Applying Hardware Transactional Memory for Concurrency-Bug Failure Recovery in Production Runs ...</b>   | <b>837</b> |
| Yuxi Chen, Shu Wang, and Shan Lu, <i>University of Chicago</i> ; Karthikeyan Sankaralingam, <i>University of Wisconsin – Madison</i>  |            |

## Storage 2

- Tailwind: Fast and Atomic RDMA-based Replication** ..... 851  
Yacine Taleb, *Univ Rennes, Inria, CNRS, IRISA*; Ryan Stutsman, *University of Utah*; Gabriel Antoniu, *Univ Rennes, Inria, CNRS, IRISA*; Toni Cortes, *BSC, UPC*

- On Fault Tolerance, Locality, and Optimality in Locally Repairable Codes** ..... 865  
Oleg Kolosov, *School of Electrical Engineering, Tel Aviv University*; Gala Yadgar, *Computer Science Department, Technion, and School of Electrical Engineering, Tel Aviv University*; Matan Liram, *Computer Science Department, Technion*; Itzhak Tamo, *School of Electrical Engineering, Tel Aviv University*; Alexander Barg, *Department of ECE/ISR, University of Maryland*

- TxFS: Leveraging File-System Crash Consistency to Provide ACID Transactions** ..... 879  
Yige Hu, Zhiting Zhu, Ian Neal, Youngjin Kwon, and Tianyu Cheng, *The University of Texas at Austin*; Vijay Chidambaram, *The University of Texas at Austin and VMware Research*; Emmett Witchel, *The University of Texas at Austin*

- Towards Better Understanding of Black-box Auto-Tuning: A Comparative Analysis for Storage Systems** ... 893  
Zhen Cao, *Stony Brook University*; Vasily Tarasov, *IBM Research-Almaden*; Sachin Tiwari and Erez Zadok, *Stony Brook University*

## Data Center/Machine Learning

- HeavyKeeper: An Accurate Algorithm for Finding Top- $k$  Elephant Flows** ..... 909  
Junzhi Gong, Tong Yang, Huawei Zhang, and Hao Li, *Peking University*; Steve Uhlig, *Queen Mary, University of London*; Shigang Chen, *University of Florida*; Lorna Uden, *Staffordshire University*; Xiaoming Li, *Peking University*

- SAND: Towards High-Performance Serverless Computing** ..... 923  
Istemci Ekin Akkus, Ruichuan Chen, Ivica Rimac, Manuel Stein, Klaus Satzke, Andre Beck, Paarijaat Aditya, and Volker Hilt, *Nokia Bell Labs*

- Cavs: An Efficient Runtime System for Dynamic Neural Networks** ..... 937  
Shizhen Xu, *Carnegie Mellon University, Tsinghua University*; Hao Zhang, Graham Neubig, and Wei Dai, *Carnegie Mellon University, Petuum Inc.*; Jin Kyu Kim, *Carnegie Mellon University*; Zhijie Deng, *Tsinghua University*; Qirong Ho, *Petuum Inc.*; Guangwen Yang, *Tsinghua University*; Eric P. Xing, *Petuum Inc.*

- DeepCPU: Serving RNN-based Deep Learning Models 10x Faster** ..... 951  
Minjia Zhang, Samyam Rajbhandari, Wenhan Wang, and Yuxiong He, *Microsoft AI and Research*

## Key/Value Storage

- Closing the Performance Gap Between Volatile and Persistent Key-Value Stores Using Cross-Referencing Logs** ..... 967  
Yihe Huang, *Harvard University*; Matej Pavlovic, *EPFL*; Virendra Marathe, Margo Seltzer, Tim Harris, and Steve Byan, *Oracle Labs*

- Metis: Robustly Tuning Tail Latencies of Cloud Systems** ..... 981  
Zhao Lucis Li, *USTC*; Chieh-Jan Mike Liang, *Microsoft Research*; Wenjia He, *USTC*; Lianjie Zhu, Wenjun Dai, and Jin Jiang, *Microsoft Bing Ads*; Guangzhong Sun, *USTC*

- Redesigning LSMs for Nonvolatile Memory with NoveLSM** ..... 993  
Sudarsun Kannan, *University of Wisconsin-Madison*; Nitish Bhat and Ada Gavrilovska, *Georgia Tech*; Andrea Arpaci-Dusseau and Remzi Arpaci-Dusseau, *University of Wisconsin-Madison*

- HashKV: Enabling Efficient Updates in KV Storage via Hashing** ..... 1007  
Helen H. W. Chan, *The Chinese University of Hong Kong*; Yongkun Li, *University of Science and Technology of China*; Patrick P. C. Lee, *The Chinese University of Hong Kong*; Yinlong Xu, *University of Science and Technology of China*