

**18th USENIX Symposium on
Networked Systems Design and Implementation
(NSDI '21)**

April 12–14, 2021

Monday, April 12

Datacenter Networking and SDNs

Accessing Cloud with Disaggregated Software-Defined Router	1
Hua Shao, <i>Tsinghua University</i> ; Xiaoliang Wang, <i>Tencent and Nanjing University</i> ; Yuanwei Lu, Yanbo Yu, and Shengli Zheng, <i>Tencent</i> ; Youjian Zhao, <i>Tsinghua University</i>	
CodedBulk: Inter-Datacenter Bulk Transfers using Network Coding	15
Shih-Hao Tseng, Saksham Agarwal, and Rachit Agarwal, <i>Cornell University</i> ; Hitesh Ballani, <i>Microsoft Research</i> ; Ao Tang, <i>Cornell University</i>	
Twenty Years After: Hierarchical Core-Stateless Fair Queueing	29
Zhuolong Yu, Jingfeng Wu, and Vladimir Braverman, <i>Johns Hopkins University</i> ; Ion Stoica, <i>UC Berkeley</i> ; Xin Jin, <i>Peking University</i>	
Breaking the Transience-Equilibrium Nexus: A New Approach to Datacenter Packet Transport	47
Shiyu Liu and Ahmad Ghalayini, <i>Stanford University</i> ; Mohammad Alizadeh, <i>MIT</i> ; Balaji Prabhakar and Mendel Rosenblum, <i>Stanford University</i> ; Anirudh Sivaraman, <i>NYU</i>	
Running BGP in Data Centers at Scale	65
Anubhavnidhi Abhashkumar and Kausik Subramanian, <i>University of Wisconsin–Madison</i> ; Alexey Andreyev, Hyojeong Kim, Nanda Kishore Salem, Jingyi Yang, and Petr Lapukhov, <i>Facebook</i> ; Aditya Akella, <i>University of Wisconsin–Madison</i> ; Hongyi Zeng, <i>Facebook</i>	
Orion: Google’s Software-Defined Networking Control Plane	83
Andrew D. Ferguson, Steve Gribble, Chi-Yao Hong, Charles Killian, Waqar Mohsin, Henrik Muehe, Joon Ong, Leon Poutievski, Arjun Singh, Lorenzo Vicisano, Richard Alimi, Shawn Shuoshuo Chen, Mike Conley, Subhasree Mandal, Karthik Nagaraj, Kondapa Naidu Bollineni, Amr Sabaa, Shidong Zhang, Min Zhu, and Amin Vahdat, <i>Google</i>	

Verification and Formal Methods

Metha: Network Verifiers Need To Be Correct Too!.....	99
Rüdiger Birkner, Tobias Brodmann, Petar Tsankov, Laurent Vanbever, and Martin Vechev, <i>ETH Zürich</i>	
Finding Invariants of Distributed Systems: It’s a Small (Enough) World After All	115
Travis Hance, Marijn Heule, Ruben Martins, and Bryan Parno, <i>Carnegie Mellon University</i>	
Avenir: Managing Data Plane Diversity with Control Plane Synthesis	133
Eric Hayden Campbell, <i>Cornell</i> ; William T. Hallahan, <i>Yale</i> ; Priya Srikanth, <i>Cornell</i> ; Carmelo Cascone, <i>ONF</i> ; Jed Liu, <i>Intel</i> ; Vignesh Ramamurthy, <i>Infosys</i> ; Hossein Hojjat, <i>Tehran & TeIAS</i> ; Ruzica Piskac and Robert Soulé, <i>Yale</i> ; Nate Foster, <i>Cornell</i>	
Don’t Yank My Chain: Auditable NF Service Chaining.....	155
Guyue Liu and Hugo Sadok, <i>Carnegie Mellon University</i> ; Anne Kohlbrenner, <i>Princeton University</i> ; Bryan Parno, Vyas Sekar, and Justine Sherry, <i>Carnegie Mellon University</i>	

Network Management

Contracting Wide-area Network Topologies to Solve Flow Problems Quickly	175
Firas Abuzaid, <i>Microsoft Research and Stanford University</i> ; Srikanth Kandula, Behnaz Arzani, and Ishai Menache, <i>Microsoft Research</i> ; Matei Zaharia and Peter Bailis, <i>Stanford University</i>	
Cost-effective Cloud Edge Traffic Engineering with CASCARA.....	201
Rachee Singh, Sharad Agarwal, Matt Calder, and Paramvir Bahl, <i>Microsoft</i>	

A Social Network Under Social Distancing: Risk-Driven Backbone Management During COVID-19 and Beyond	217
Yiting Xia, <i>MPI-INF and Facebook</i> ; Ying Zhang, <i>Facebook</i> ; Zhizhen Zhong, <i>MIT and Facebook</i> ; Guanqing Yan, Chiun Lin Lim, Satyajeet Singh Ahuja, Soshant Bali, and Alexander Nikolaidis, <i>Facebook</i> ; Kimia Ghobadi, <i>Johns Hopkins University</i> ; Manya Ghobadi, <i>MIT</i>	
Staying Alive: Connection Path Reselection at the Edge	233
Raul Landa, Lorenzo Saino, Lennert Buytenhek, and Joao Taveira Araujo, <i>Fastly</i>	
Debugging Transient Faults in Data Centers using Synchronized Network-wide Packet Histories	253
Pravein Govindan Kannan, <i>IBM Research - India</i> ; Nishant Budhdev, Raj Joshi, and Mun Choon Chan, <i>National University of Singapore</i>	

Web and Video

Alohamora: Reviving HTTP/2 Push and Preload by Adapting Policies On the Fly	269
Nikhil Kansal, Murali Ramanujam, and Ravi Netravali, <i>UCLA</i>	
Oblique: Accelerating Page Loads Using Symbolic Execution.	289
Ronny Ko and James Mickens, <i>Harvard University</i> ; Blake Loring, <i>Royal Holloway, University of London</i> ; Ravi Netravali, <i>UCLA</i>	
SENSEI: Aligning Video Streaming Quality with Dynamic User Sensitivity	303
Xu Zhang and Yiyang Ou, <i>University of Chicago</i> ; Siddhartha Sen, <i>Microsoft Research</i> ; Junchen Jiang, <i>University of Chicago</i>	

Tuesday, April 13

Databases and Analytics

GAIA: A System for Interactive Analysis on Distributed Graphs Using a High-Level Language	321
Zhengping Qian, Chenqiang Min, Longbin Lai, Yong Fang, Gaofeng Li, Youyang Yao, Bingqing Lyu, Xiaoli Zhou, Zhimin Chen, and Jingren Zhou, <i>Alibaba Group</i>	
TEGRA: Efficient Ad-Hoc Analytics on Evolving Graphs	337
Anand Padmanabha Iyer, <i>Microsoft Research and University of California, Berkeley</i> ; Qifan Pu, <i>Google</i> ; Kishan Patel, <i>Two Sigma</i> ; Joseph E. Gonzalez and Ion Stoica, <i>University of California, Berkeley</i>	
Unifying Timestamp with Transaction Ordering for MVCC with Decentralized Scalar Timestamp	357
Xingda Wei, Rong Chen, Haibo Chen, Zhaoguo Wang, Zhenhan Gong, and Binyu Zang, <i>Shanghai Jiao Tong University</i>	
When to Hedge in Interactive Services	373
Mia Primorac, <i>Oracle Labs</i> ; Katerina Argyraki and Edouard Bugnion, <i>EPFL</i>	
Move Fast and Meet Deadlines: Fine-grained Real-time Stream Processing with Cameo	389
Le Xu, <i>University of Illinois at Urbana-Champaign</i> ; Shivaram Venkataraman, <i>UW-Madison</i> ; Indranil Gupta, <i>University of Illinois at Urbana-Champaign</i> ; Luo Mai, <i>University of Edinburgh</i> ; Rahul Potharaju, <i>Microsoft</i>	
WHIZ: Data-Driven Analytics Execution	407
Robert Grandl, <i>Google</i> ; Arjun Singhvi, <i>University of Wisconsin-Madison</i> ; Raajay Viswanathan, <i>Uber Technologies Inc.</i> ; Aditya Akella, <i>University of Wisconsin-Madison</i>	

Mobile and IoT

Pushing the Physical Limits of IoT Devices with Programmable Metasurfaces	425
Lili Chen, <i>Northwest University (China) and University of Massachusetts Amherst</i> ; Wenjun Hu, <i>Yale University</i> ; Kyle Jamieson, <i>Princeton University</i> ; Xiaojiang Chen and Dingyi Fang, <i>Northwest University (China)</i> ; Jeremy Gummesson, <i>University of Massachusetts Amherst</i>	
Bootstrapping Battery-free Wireless Networks: Efficient Neighbor Discovery and Synchronization in the Face of Intermittency	439
Kai Geissdoerfer and Marco Zimmerling, <i>TU Dresden</i>	
AIRCODE: Hidden Screen-Camera Communication on an Invisible and Inaudible Dual Channel	457
Kun Qian, <i>Tsinghua University and University of California San Diego</i> ; Yumeng Lu, Zheng Yang, Kai Zhang, Kehong Huang, and Xinjun Cai, <i>Tsinghua University</i> ; Chenshu Wu, <i>University of Maryland College Park</i> ; Yunhao Liu, <i>Tsinghua University and Michigan State University</i>	

Device-Based LTE Latency Reduction at the Application Layer	471
Zhaowei Tan and Jinghao Zhao, <i>UCLA</i> ; Yuanjie Li, <i>Tsinghua University</i> ; Yifei Xu, <i>Peking University</i> ; Songwu Lu, <i>UCLA</i>	

System Performance and Programmability

BMC: Accelerating Memcached using Safe In-kernel Caching and Pre-stack Processing.....	487
Yoann Ghigoff, <i>Orange Labs, Sorbonne Université, Inria, LIP6</i> ; Julien Sopena, <i>Sorbonne Université, LIP6</i> ; Kahina Lazri, <i>Orange Labs</i> ; Antoine Blin, <i>Gandi</i> ; Gilles Muller, <i>Inria</i>	
Segcache: a memory-efficient and scalable in-memory key-value cache for small objects	503
Juncheng Yang, <i>Carnegie Mellon University</i> ; Yao Yue, <i>Twitter</i> ; Rashmi Vinayak, <i>Carnegie Mellon University</i>	
When Cloud Storage Meets RDMA	519
Yixiao Gao, <i>Nanjing University and Alibaba Group</i> ; Qiang Li, Lingbo Tang, Yongqing Xi, Pengcheng Zhang, Wenwen Peng, Bo Li, Yaohui Wu, Shaozong Liu, Lei Yan, Fei Feng, Yan Zhuang, Fan Liu, Pan Liu, Xingkui Liu, Zhongjie Wu, Junping Wu, and Zheng Cao, <i>Alibaba Group</i> ; Chen Tian, <i>Nanjing University</i> ; Jinbo Wu, Jiaji Zhu, Haiyong Wang, Dennis Cai, and Jiesheng Wu, <i>Alibaba Group</i>	
Prism: Proxies without the Pain	535
Yutaro Hayakawa, <i>LINE Corporation</i> ; Michio Honda, <i>University of Edinburgh</i> ; Douglas Santry, <i>Apple Inc.</i> ; Lars Eggert, <i>NetApp</i>	
Programming Network Stack for Middleboxes with Rubik.....	551
Hao Li, <i>Xi'an Jiaotong University</i> ; Changhao Wu, <i>Xi'an Jiaotong University and Brown University</i> ; Guangda Sun, Peng Zhang, and Danfeng Shan, <i>Xi'an Jiaotong University</i> ; Tian Pan, <i>Beijing University of Posts and Telecommunications</i> ; Chengchen Hu, <i>Xilinx Labs Asia Pacific</i>	
Flightplan: Dataplane Disaggregation and Placement for P4 Programs	571
Nik Sultana, John Sonchack, Hans Giesen, Isaac Pedisich, Zhaoyang Han, Nishanth Shyamkumar, Shivani Burad, André DeHon, and Boon Thau Loo, <i>University of Pennsylvania</i>	

Distributed Systems

MilliSort and MilliQuery: Large-Scale Data-Intensive Computing in Milliseconds	593
Yilong Li, <i>Stanford University</i> ; Seo Jin Park, <i>MIT CSAIL</i> ; John Ousterhout, <i>Stanford University</i>	
EPaxos Revisited.....	613
Sarah Tollman, <i>Stanford University</i> ; Seo Jin Park, <i>MIT CSAIL</i> ; John Ousterhout, <i>Stanford University</i>	
Ship Compute or Ship Data? Why Not Both?	633
Jie You, <i>University of Michigan</i> ; Jingfeng Wu, <i>Johns Hopkins University</i> ; Xin Jin, <i>Peking University</i> ; Mosharaf Chowdhury, <i>University of Michigan</i>	
Caerus: NIMBLE Task Scheduling for Serverless Analytics.....	653
Hong Zhang, <i>UC Berkeley</i> ; Yupeng Tang and Anurag Khandelwal, <i>Yale University</i> ; Jingrong Chen, <i>Duke University</i> ; Ion Stoica, <i>UC Berkeley</i>	
Ownership: A Distributed Futures System for Fine-Grained Tasks.....	671
Stephanie Wang, Eric Liang, and Edward Oakes, <i>UC Berkeley and Anyscale</i> ; Ben Hindman, Frank Sifei Luan, Audrey Cheng, and Ion Stoica, <i>UC Berkeley</i>	
Fault-Tolerant Replication with Pull-Based Consensus in MongoDB	687
Siyuan Zhou, <i>MongoDB Inc.</i> ; Shuai Mu, <i>Stony Brook University</i>	

Wednesday, April 14

Machine Learning in a Systems Context

Mistify: Automating DNN Model Porting for On-Device Inference at the Edge	705
Peizhen Guo, Bo Hu, and Wenjun Hu, <i>Yale University</i>	
Elastic Resource Sharing for Distributed Deep Learning	721
Changho Hwang and Taehyun Kim, <i>KAIST</i> ; Sunghyun Kim, <i>MIT</i> ; Jinwoo Shin and KyoungSoo Park, <i>KAIST</i>	

ATP: In-network Aggregation for Multi-tenant Learning	741
ChonLam Lao, <i>Tsinghua University</i> ; Yanfang Le and Kshiteej Mahajan, <i>University of Wisconsin-Madison</i> ; Yixi Chen and Wenfei Wu, <i>Tsinghua University</i> ; Aditya Akella and Michael Swift, <i>University of Wisconsin-Madison</i>	
On the Use of ML for Blackbox System Performance Prediction	763
Silvery Fu, <i>UC Berkeley</i> ; Saurabh Gupta and Radhika Mittal, <i>UIUC</i> ; Sylvia Ratnasamy, <i>UC Berkeley</i>	
Scaling Distributed Machine Learning with In-Network Aggregation.....	785
Amedeo Sapienza, Marco Canini, and Chen-Yu Ho, <i>KAUST</i> ; Jacob Nelson, <i>Microsoft</i> ; Panos Kalnis, <i>KAUST</i> ; Changhoon Kim, <i>Barefoot Networks</i> ; Arvind Krishnamurthy, <i>University of Washington</i> ; Masoud Moshref, <i>Barefoot Networks</i> ; Dan Ports, <i>Microsoft</i> ; Peter Richtarik, <i>KAUST</i>	

Wireless Sensing

Efficient Wideband Spectrum Sensing Using MEMS Acoustic Resonators.....	809
Junfeng Guan, Jitian Zhang, Ruochen Lu, Hyungjoo Seo, Jin Zhou, Songbin Gong, and Haitham Hassanieh, <i>University of Illinois at Urbana-Champaign</i>	
WiForce: Wireless Sensing and Localization of Contact Forces on a Space Continuum	827
Agrim Gupta, Cédric Girerd, Manideep Dunna, Qiming Zhang, Raghav Subbaraman, Tania Morimoto, and Dinesh Bharadia, <i>University of California, San Diego</i>	
MAVL: Multiresolution Analysis of Voice Localization	845
Mei Wang, Wei Sun, and Lili Qiu, <i>The University of Texas at Austin</i>	
From Conception to Retirement: a Lifetime Story of a 3-Year-Old Wireless Beacon System in the Wild	859
Yi Ding, <i>Alibaba Group</i> , <i>University of Minnesota</i> ; Ling Liu, <i>Shanghai Jiao Tong University</i> ; Yu Yang, <i>Rutgers University</i> ; Yunhuai Liu, <i>Peking University</i> ; Desheng Zhang, <i>Rutgers University</i> ; Tian He, <i>Alibaba Group</i> , <i>University of Minnesota</i>	
EarFisher: Detecting Wireless Eavesdroppers by Stimulating and Sensing Memory EMR	873
Cheng Shen, <i>Peking University</i> ; Jun Huang, <i>Massachusetts Institute of Technology</i>	

Wireless

Adapting Wireless Mesh Network Configuration from Simulation to Reality via Deep Learning based Domain Adaptation.....	887
Junyang Shi and Mo Sha, <i>State University of New York at Binghamton</i> ; Xi Peng, <i>University of Delaware</i>	
Practical Null Steering in Millimeter Wave Networks	903
Sohrab Madani and Suraj Jog, <i>University of Illinois Urbana Champaign</i> ; Jesus O. Lacruz and Joerg Widmer, <i>IMDEA Networks</i> ; Haitham Hassanieh, <i>University of Illinois Urbana Champaign</i>	
SyncScatter: Enabling WiFi like synchronization and range for WiFi backscatter Communication	923
Manideep Dunna, Miao Meng, Po-Han Wang, Chi Zhang, Patrick Mercier, and Dinesh Bharadia, <i>University of California, San Diego</i>	
Verification and Redesign of OFDM Backscatter	939
Xin Liu, <i>University of Maryland, Baltimore County</i> ; Zicheng Chi, <i>Cleveland State University</i> ; Wei Wang, Yao Yao, Pei Hao, and Ting Zhu, <i>University of Maryland, Baltimore County</i>	
Simplifying Backscatter Deployment: Full-Duplex LoRa Backscatter	955
Mohamad Katanbaf, <i>Jeeva Wireless and University of Washington</i> ; Anthony Weinand and Vamsi Talla, <i>Jeeva Wireless</i>	
One Protocol to Rule Them All: Wireless Network-on-Chip using Deep Reinforcement Learning	973
Suraj Jog, Zikun Liu, Antonio Franques, and Vimuth Fernando, <i>University of Illinois at Urbana Champaign</i> ; Sergi Abadal, <i>Polytechnic University of Catalonia</i> ; Josep Torrellas and Haitham Hassanieh, <i>University of Illinois at Urbana Champaign</i>	

Measurement

LightGuardian: A Full-Visibility, Lightweight, In-band Telemetry System Using Sketchlets	991
Yikai Zhao, Kaicheng Yang, and Zirui Liu, <i>Peking University</i> ; Tong Yang, <i>Peking University and Peng Cheng Laboratory</i> ; Li Chen, <i>Huawei Theory Lab</i> ; Shiyi Liu, Naiqian Zheng, Ruixin Wang, and Hanbo Wu, <i>Peking University</i> ; Yi Wang, <i>Southern University of Science and Technology and Peng Cheng Laboratory</i> ; Nicholas Zhang, <i>Huawei Theory Lab</i>	

Fast and Light Bandwidth Testing for Internet Users	1011
Xinlei Yang, Xianlong Wang, Zhenhua Li, and Yunhao Liu, <i>Tsinghua University</i> ; Feng Qian, <i>University of Minnesota</i> ; Liangyi Gong, <i>Tsinghua University</i> ; Rui Miao, <i>Alibaba Group</i> ; Tianyin Xu, <i>University of Illinois Urbana-Champaign</i>	
Toward Nearly-Zero-Error Sketching via Compressive Sensing.....	1027
Qun Huang, <i>Peking University and Pengcheng Lab</i> ; Siyuan Sheng, <i>Institute of Computing Technology, CAS</i> ; Xiang Chen, <i>Peking University and Pengcheng Lab and Fuzhou University</i> ; Yungang Bao, <i>Institute of Computing Technology, CAS</i> ; Rui Zhang, Yanwei Xu, and Gong Zhang, <i>Huawei Theory Department</i>	