



IFIP Networking 2020
Conference and Workshops
June 22-25, 2020 - Paris, France

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IFIP Networking 2020 Welcome Message

On behalf of the Organizing Committee, we are pleased to welcome you to the IFIP Conference on Networking 2020.

Networking is the flagship conference of the IFIP Technical Committee on Communications Systems. Started as an event held every other year when launched in Paris (France) in 2000, the Networking conference became a yearly event since its 2005 edition held in Waterloo (Canada). This 19th edition of Networking is also the 20-year anniversary of the conference. We warmly welcome you all to participate and celebrate the long and successful tradition of the IFIP Networking conference.

This year's edition is also special for being the first fully online conference of the series. Our original plan was to bring the conference back to Paris and celebrate its anniversary in person but this was before the COVID-19 outbreak. Although we will not be able to enjoy the conventional conference experience and the beautiful city of Paris, we are looking forward to an exciting online conference format, where participation from all around the world is easier than ever -- thanks to Networking!

Over the years, IFIP Networking gained international recognition as one of the most prominent conferences that brings together top networking experts from academia and the industry. Cutting edge research results are presented at the conference from classical IP networking topics including routing, multimedia streaming, and performance modeling to emerging and hot topics such as those in this year's program. IFIP Networking 2020 features an impressive technical program covering a broad range of research areas including AI-empowered networking and network automation, programmable and softwarized networks, datacenter networking, the Internet of Things, Blockchain networks, 5G mobile networks, and network security among others.

IFIP Networking 2020 attracted a total of 235 submissions from all 5 continents. Each paper received at least 3 reviews with an average of 3.8 reviews per paper as well as meta reviews consolidating the reviews into recommendations to accept or reject papers. Final paper acceptance was ultimately decided based on the received reviews and passionate discussions between committee members, resulting in the selection of 55 full papers (23.4% acceptance ratio) and 25 short papers (34% acceptance ratio for both full and short papers).

In addition to technical papers, the main program of Networking 2020 includes 5 keynote talks by leaders in the industry and academia, 1 distinguished expert panel on networking challenges for the next decade, 1 industry track dedicated to the latest networking technology developments, 16 poster presentations showcasing new ideas and hot topics in networking and vibrant demo sessions featuring a total of 9 software demonstrations. Networking 2020 technical program also includes 4 co-located workshops, namely the Global Internet Symposium (GIS), the International Workshop on Time-Sensitive and Deterministic Networking (TENSOR), the International Workshop on Network Slicing, and the International Workshop on the Future of Internet Transport (FIT).

We are very pleased to offer such a rich and high-quality technical program at this year's IFIP Networking. This would not have been possible without the dedicated effort of many people in the organizing committee. Their contribution to the success of Networking 2020 is particularly appreciated this year having to make difficult decisions and switch in a short time from planning a conventional conference to something different and new. Special thanks go to Aziza Lounis and the DNAC team for their outstanding support to the organizing committee and for providing the infrastructure and the support for the virtual proceedings of the conference.

We thank the TPC members and additional reviewers for their hard work in providing high-quality reviews and participating in the online discussions. We thank the authors for presenting their work at the IFIP Networking 2020, and the numerous participants for making this virtual edition of IFIP Networking 2020 a great success. We are grateful to the keynote speakers for sharing with the conference participants their views on the future of networking: Serge Fdida (Sorbonne University, France); Marina Thottan (Nokia Bell Labs, USA); George Varghese (UCLA, USA);

Chih-Lin I (China Mobile Research Institute, People's Republic of China); and Dario Rossi (Huawei Technologies, France).

We are grateful to the IFIP Networking steering committee members for their confidence and their support throughout the conference organization. We are also grateful to our technical sponsors (IFIP TC6 and the IEEE Communications Society), our conference patrons (Nokia, Orange, gandi.net, Huawei, and Systematic), and supporting organizations (DNAC, Sorbonne Université, and the University of Waterloo).

We are looking forward to e-meeting you at Networking 2020.

General Co-Chairs

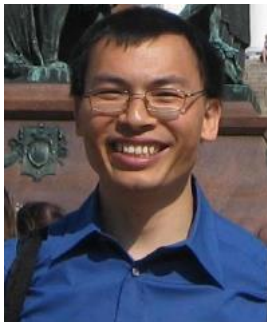


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IFIP Networking 2020 Workshops Chair Welcome Message

It is a great pleasure to present the IFIP Networking 2020 workshops. Four workshop proposals were received of which three were selected. In addition, a request was made to host another workshop, which was originally planned to take place in Asia, but was cancelled due to the covid-19 crisis. The request was accepted with the approval of the conference general co-chairs. The four workshops are within the scope of computer networks and have a special focus on emerging topics:

- Workshop on the Future of Internet Transport (FIT)
- Workshop on Time-Sensitive and Deterministic Networking (TENSOR)
- Workshop on Network Slicing (Network Slicing)
- The Global Internet Symposium (GIS)

The efforts of the workshop organisers, the TPC members, and the contributions of the authors are highly appreciated. Many thanks to Prof. Raouf Boutaba and Prof. Guy Pujolle, the general co-chairs of IFIP Networking 2020, for their support throughout the organisation of the conference. Last but not least, the continuous assistance of the local arrangements team in Paris to accommodate the special needs of the workshops has been invaluable. Sincere wishes for enjoying the IFIP Networking 2020 workshops with plenty of lively discussions on focused topics!

Workshops Chair



Marinos Charalambides,
University College London, UK

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Keynote Speakers

Keynote I

Title: New directions to Research Infrastructure in Digital Sciences

Speaker: Serge Fdida, Sorbonne Université, France

Abstract: In many other sciences thoughts experiments are an important part of the research methodology. In our domain, experimentally driven research is poorly rewarded and has developed slowly in order to equip our community with instruments that can assist the testing of various assumptions and design principles. Testbed as a Service has emerged to propose solutions to serve this need. PlanetLab, Orbit, OneLab/FIT, GENI and Fed4Fire+ are examples of such test platforms that have hosted thousands of experiments and users. In order to research and master digital infrastructures, the research community needs to address significant challenges regarding their efficiency, trust, availability, reliability, range, end-to-end latency, security and privacy. Building and deploying test platforms is complex as digital infrastructures develop rapidly, are powered by technology and driven by applications. It is therefore critical to anticipate the demand and challenging to build the next generation of test platforms. Similarly, the software-driven approach to design and deploy digital infrastructures has triggered open-source initiatives such as ONAP, OAI, OMEC and ORAN that can also inspire the framework of test platforms. A new generation of test facilities is now emerging with initiatives such as NSF/PAWR and FABRIC, Colosseum, SLICES, CENI and ICT-17 projects. On the methodology side, our community still lacks a rigorous approach to the results produced and exposed as encyclopedic knowledge. Reproducibility is addressed regularly with almost zero progress. A scientific article is considered as reproducible if the authors provide all the data and computer codes necessary to repeat the same analysis and to obtain the “same” results (depending on the deterministic characteristics of the environment under test). Reproducibility should be provided on the same but also on different platforms. As a consequence, test platforms can also play a critical role in supporting part of the experiment life cycle, open data and reproducibility. The presentation will highlight the main methodology and solutions just started being deployed and will discuss the various challenges and concerns regarding the design and usage of these platforms. The talk will be illustrated with examples taken from various projects.

Bio: *Serge Fdida* is a Professor with Sorbonne Université since 1995. He has been leading many research projects in High Performance Networking in France and Europe, notably pioneering the European activity on federated Internet testbeds. Currently, he is coordinating the French National Research Instrument FIT and the OneLab facility, two large test platforms on Future Internet technologies. He is a Distinguished ACM Member and an IEEE Senior member. He was one of the founders of the ACM Conext conference, general chair of ACM Mobicom 2015 and IEEE Infocom 2019.



Serge Fdida has also developed a strong experience related to innovation and industry transfer, - he was the co-founder of the Qosmos company, - one of the active contributors to the creation of the Cap Digital cluster in Paris, and the President of the EIT Health French community.

Keynote II

Title: Future of Network and Service Automation

Speaker: Marina Thottan, Nokia Bell Labs, USA

Abstract: Automation is becoming increasingly important, not only to support efficient network operation, but to enable the agile service creation required for Communication Service Providers (CSPs) to become the Digital Service Providers (DSPs) of the future. As the network infrastructure business is getting more commoditized, differentiation will depend on the ability of operators to efficiently and dynamically automate and optimally orchestrate networks, network slices and end-to-end services. Automation requires a new architectural framework that is designed for closed-loop control and optimized for data-driven machine learning and artificial intelligence algorithms. This talk will describe an e2e network service automation architecture and key innovations for enabling the life cycle automation of services with specific focus on dynamic end-to-end network slicing.

Bio: *Marina Thottan* leads the End-to-End Network Security and Service Automation (ENSA) Research in Nokia Bell Labs. She joined Bell Labs Research in 1999, and has contributed to a wide variety of projects, including Content Distribution, Routing protocols, Data over Optical networks, High Speed Router Design, Network Management and Anomaly Detection. Most recently she has been leading work on Network Orchestration, Network Slicing, and 5G Security. She is a Bell Labs Fellow and an IEEE Fellow (Communications Society). Marina received a Ph.D. in Electrical and Computer Engineering from Rensselaer in 2000. She has published over 60 papers in scientific journals, book chapters and conferences and holds several patents. She is co-author of the book “Communication Networks for Smart Grids: Making Smart Grids Real” and has also Co-edited a book on “Algorithms for Next Generation Networks”.



Keynote III

Title: Network Verification - When Clarke Meets Cerf

Speaker: George Varghese, UCLA, USA

Abstract: Surveys reveal that network outages are prevalent, and that many outages take hours to resolve, resulting in significant lost revenue. Many bugs are caused by errors in configuration files which are programmed using arcane, low-level languages, akin to machine code. Taking our cue from program and hardware verification, we suggest fresh approaches. I will first describe a geometric model of network forwarding called Header Space. While header space analysis is similar to finite state machine verification, we exploit domain-specific structure to scale better than off-the-shelf model checkers. Next, I show how to exploit physical symmetry to scale network verification for large data centers. While Emerson and Sistla showed how to exploit symmetry for model checking in 1996, they exploited symmetry on the logical Kripke structure. While header space models allow us to verify the forwarding tables in routers, there are also routing protocols such as BGP that build the forwarding tables. We show to go from header space verification to what we call control space verification to proactively catch latent bugs in BGP configurations. I will end with a vision for what we call Network Design Automation to build a

suite of tools for networks inspired by the Electronic Design Automation Industry. (With collaborators at CMU, Edinburgh, MSR, Stanford, and UCLA.)

Bio: **George Varghese** is a Chancellor's Professor of Computer Science at UCLA. His research interests center around network algorithmics (building fast routers) and network verification (building tools for static and dynamic verification of operational networks). He received his Ph.D. in 1992 from MIT after working at DEC designing DECNET protocols and products, including the bridge architecture and Gigaswitch. From 1993-1999, he was a professor at Washington University, and at UCSD from 1999 to 2013. He was the Distinguished Visitor in the computer science department at Stanford University from 2010-2011. From 2012-2016, he was a Principal Researcher and Partner at Microsoft Research. Together with colleagues, he has 22 patents awarded in the general field of Network Algorithmics. Several of the algorithms he helped develop appear in commercial systems including Linux (timing wheels), the Cisco GSR (DRR), and Microsoft Windows (IP lookups). He helped design the hardware lookup engine for Procket's 40 Gbps router. He has been on the advisory boards of Memoir, Jibe, Sanera, and SwitchOn, and consulted for ST MicroElectronics, AOL, and Fujitsu. In May 2004, he co-founded NetSift Inc., where he was President and CTO. NetSift was acquired by Cisco Systems in 2005. His book "Network Algorithmics" on fast router and endnode implementations was published in 2004 by Morgan-Kaufman. He has written over 100 papers, mostly on networking, but also on computer architecture, genomics, and databases. After Dijkstra's early work, he helped develop general techniques for self-stabilization, an abstraction of a strong network fault-tolerance property. His Erdos number is 2 via mathematicians Ron and Fan Graham. He was elected to the National Academy of Engineering in 2017. He won the IIT Bombay Distinguished Alumni Award in 2015, the IEEE Kobayashi Award for Computers and Communications in 2014, and the SIGCOMM Lifetime Achievement Award for networking in 2014. He has been a Fellow of the ACM since 2002 and an ONR Young Investigator.



Keynote IV

Title: The Afterthought of 5G and a Peek at 6G

Speaker: Chih-Lin I, China Mobile Research Institute, China

Abstract: ICT convergence was just an afterthought for 4G, but it's native in 5G. ICDT convergence is an afterthought for 5G, and it will be native in 6G, if there is to be a 6G. This talk will highlight the fundamental changes 5G and Beyond is ushering forth

Bio: *Chih-Lin I* received her Ph.D. degree in electrical engineering from Stanford University. She has been working at multiple world-class companies and research institutes leading the R&D, including AT&T Bell Labs; Director of AT&T HQ, Director of ITRI Taiwan, and VPGD of ASTRI Hong Kong. She received the IEEE Trans. COM Stephen Rice Best Paper Award, the IEEE ComMag Fred W. Ellersick Prize Best Paper Award, and has won the 2015 Industrial Innovation Award of IEEE Communication Society for Leadership and Innovation in Next-Generation Cellular Wireless Networks.



In 2011, she joined China Mobile as its Chief Scientist of wireless technologies, established the Green Communications Research Center, and launched the 5G Key Technologies R&D. She is spearheading major initiatives including 5G/6G, C-RAN/O-RAN, high energy efficiency system architectures, technologies and devices, green energy, and wireless big data for network embedded intelligence. She has led the launch of Wireless AI Alliance (WAIA) and O-RAN (Open RAN) Alliance. She was an Area Editor of IEEE/ACM Trans. NET, an elected Board Member of IEEE ComSoc, Chair of the ComSoc Meetings and Conferences Board, and Founding Chair of the IEEE WCNC Steering Committee. She was a Professor at NCTU, an Adjunct Professor at NTU, and an Adjunct Professor at BUPT. She is the Chair of FuTURE 5G SIG, the Chair of WAIA Executive Committee, the Chair of O-RAN TSC, an Executive Board Member of GreenTouch, a Network Operator Council Founding Member of ETSI NFV, a Steering Board Member and Vice Chair of WWRF, a Steering Committee member and the Publication Chair of IEEE 5G Initiative, a member of IEEE ComSoc SDB, SPC, and CSCN-SC, and a Scientific Advisory Board Member of Singapore NRF. Her current research interests center around ICDT Deep Convergence: “From Green & Soft to Open & Smart”.

Keynote V

Title: The Long and Winding road to Self-driving networks

Speaker: Dario Rossi, Huawei Technologies, France

Abstract: Often, advances in hardware have been at the base of success of new computing paradigm, algorithms and techniques. This is, e.g., what might happen in the future for quantum computers, and what has recently happened in the field of Artificial Intelligence (AI) and Neural Networks in particular, whose potential has been fully unleashed by commoditization of general-purpose GPUs. The success of AI in computer vision applications has led to an AI hype that extended to other fields, including the network domain, where the long term vision is to let AI fully manage, and autonomously drive, all aspects of network operation. In this keynote, we first introduce recent hardware advances, namely a new family of specialized architectures that are promising enablers for a deeper integration of AI at all network segments, particularly at the edge, and layers of the network stack. We next discuss challenges and opportunities that are specific to the networking domain, putting them in perspective with advances in other fields. Particularly, we will also discuss bumps in the road that leads to true large-scale deployment of AI technologies in networks.

Bio: **Dario Rossi** is Chief Expert on Network AI and Director of the Data Communication Network Algorithms and Measurement Technology Laboratory at Huawei Technologies. He holds an HDR from UPMC (2010), as well as a PhD (2005) and MSc (2001) degrees from Politecnico di Torino. Before joining Huawei in 2018, he occupied a Chair Professor (2016-2018), Full Professor (2012-2016) and Associate Professor (2006-2012) positions at the Computer Science and Networking department of Telecom ParisTech. He was also a Professor at the LIX department of Ecole Polytechnique (2012-2019). Prior to that, he worked with the Telecommunication Network Group of the Electrical Engineering department at Politecnico di Torino (2001-2006) and held a



Visiting Researcher position in the Computer Science division at University of California, Berkeley (2003-2004). He co-chaired the RT2, that federates the Institut Mines-Telecom researchers working on the networking domain (about 50 people from 5 schools in France), presently serves in the Steering committees of ITC and AINTEC, chaired ACM ICN (2016), the last 2 editions of ACM SIGCOMM AINTEC (2013,2014) and of the ACM SIGCOMM PhD School on Traffic Monitoring and Analysis (2014,2018) and participated in the program committees of 50+ conferences including IEEE INFOCOM, ACM CoNEXT and ACM SIGCOMM. He has coauthored 9 patents and 150+ papers in leading conferences (including IEEE INFOCOM, ACM SIGCOMM, ACM CoNEXT, ACM IMC and WWW) and journals (including IEEE JSAC, ACM/IEEE TON, ACM CCR, IEEE TMM) that attracted over 5000 citations (Google scholar) and received 7 best paper awards. He is Senior Member of IEEE (2013) and ACM (2015), received an IETF Applied Network Research Prize (2016), a Google Faculty Research Award (2015), and has been honored with Distinguished Member recognition from the INFOCOM TPC (2015, 2016, 2017, 2019). His current research interest include Machine learning, Internet traffic measurement, and high speed all-software networking, whereas previous interests included congestion control, Information-centric networks ,green networking, peer-2-peer networks and traffic engineering.

IFIP Networking 2020 – Final Program

Technical Session 1-A: IoT Networking

- Packet delay minimization in multi-hop wireless sensor networks with periodic traffic
Bartłomiej Ostrowski, Michal Pióro and Artur Tomaszewski (Warsaw University of Technology, Poland)
pp. 1-9
- Performance Comparison of Messaging Protocols and Serialization Formats
Daniel Persson Proos and Niklas Carlsson (Linköping University, Sweden)
pp. 10-18
- IoT Content Object Security with OSCoRE and NDN: A First Experimental Comparison
Cenk Gündogan (Hamburg University of Applied Sciences, Germany); Christian Amsüss (N/A, Austria); Thomas C. Schmidt (Hamburg University of Applied Sciences, Germany); Matthias Wählisch (Freie Universität Berlin, Germany)
pp. 19-27

Technical Session 1-B: User Behavior Modeling

- Revealing QoE of Web Users from Encrypted Network Traffic
Antoine Saverimoutou (Orange, France); Alexis Huet and Zied Ben Houidi (Huawei Technologies Co. Ltd, France); Hao Shi (Huawei Technologies Co., Ltd, China); Sheng-Ming Cai (Huawei Technologies Co., Ltd., China); Jinchun Xu (Huawei Technologies Co., Ltd, China); Bertrand Mathieu (Orange Labs, France); Dario Rossi (Telecom ParisTech, France)
pp. 28-36
- On the Practical Detection of Hierarchical Heavy Hitters
Jalil Moraney (Technion - Israel Institute of Technology, Israel); Danny Raz (Nokia and Technion, Israel)
pp. 37-45
- How Online Social Ties Influence the Epidemic Spreading of a Multiplex Network?
Xianzhe Tang (Fudan University, China); Yuan Zhang (University of Fudan, China); Cong Li and Xiang Li (Fudan University, China)
pp. 46-54

Technical Session 1-C: Service Function Chaining

- Virtual Network Functions Placement and Routing Problem: Path formulation
Ahlam Mouaci (University of Paris Dauphine & Orange Labs, France); Ivana Ljubic (ESSEC Business School, France); Eric Gourdin and Nancy Perrot (Orange Labs, France)
pp. 55-63

A Rank-based Mechanism for Service Placement in the Fog

Karima Velasquez, David Perez Abreu, Luis Paquete, Marilia Curado and Edmundo Monteiro (University of Coimbra, Portugal)

pp. 64-72

FlexMesh: Flexibly Chaining Network Functions on Programmable Data Planes at Runtime

Yu Zhou, Jun Bi, Cheng Zhang, Mingwei Xu and Jianping Wu (Tsinghua University, China)

pp. 73-81

Technical Session 2-A: DC Networking**Anytime Backtrack Unimodal Bandits and Applications to Cloud Computing**

Stephan Kunne (LRI, Université Paris-Sud, France); Lorenzo Maggi (Nokia Bell Labs, France); Johanne Cohen (LRI-CNRS, France); XU Xinneng (Université Paris Saclay, France)

pp. 82-90

NFV Performance Profiling on Multi-core Servers

Peng Zheng (Xi'an Jiaotong University, China); Wendi Feng (Beijing University of Posts and Telecommunications, China); Arvind Narayanan and Zhi-Li Zhang (University of Minnesota, USA)

pp. 91-99

On Max-Min Fairness of Completion Times for Multi-Task Job Scheduling

Mehrnoosh Shafiee and Javad Ghaderi (Columbia University, USA)

pp. 100-108

Achieving Optimal Edge-based Congestion-aware Load Balancing in Data Center Networks

Weifeng Zhang (Hunan University, China); Dongfang Ling (Hunan University); Yuanrong Zhang, Pengfei Li and Guo Chen (Hunan University, China)

pp. 109-117

Technical Session 2-B: Streaming Services**Measuring Decentralized Video Streaming: A Case Study of DTube**

Trinh Viet Doan, Tat Dat Pham and Markus Oberprieler (Technical University of Munich, Germany); Vaibhav Bajpai (Technische Universität München, Germany)

pp. 118-126

EnDASH - A Mobility Adapted Energy Efficient ABR Video Streaming for Cellular Networks

Abhijit Mondal (IIT Kharagpur, India); Basabdatta Palit (Indian Institute of Technology, Kharagpur, India); Somesh Khandelia (IIT Kharagpur, India); Nibir Pal (Indian Institute of Technology, Kharagpur, India); Jay Jayatheerthan (Intel Technology Pvt. Ltd., India); Krishna Paul (Intel Corporation, India); Niloy Ganguly and Sandip Chakraborty (Indian Institute of Technology Kharagpur, India)

pp. 127-135

On the Internet-scale Streaming of Holographic-type Content with Assured User Quality of Experiences

Ioannis Selinis and Ning Wang (University of Surrey, United Kingdom (Great Britain)); Bin Da (Beijing Huawei Digital Technologies Co., Ltd., China); Delei Yu (Huawei Technologies, China); Rahim Tafazolli (University of Surrey, United Kingdom (Great Britain))
pp. 136-144

Optimized Dynamic Cache Instantiation

Niklas Carlsson (Linköping University, Sweden); Derek Eager (University of Saskatchewan, Canada)
pp. 145-153

Technical Session 2-C: AI for Networks

Precise and Adaptable: Leveraging Deep Reinforcement Learning for GAP-based Multipath Scheduler

Binbin Liao (Institute of Computing Technology, Chinese Academy Sciences, China); Guangxing Zhang (Institute of Computing Technology Chinese Academy of Sciences, China); Zulong Diao (Institute of Computing Technology, Chinese Academy Sciences, China); Gaogang Xie (Institute of Computing Technology, Chinese Academy of Sciences, China)
pp. 154-162

Online Fault-tolerant VNF Chain Placement: A Deep Reinforcement Learning Approach

Weixi Mao, Lei Wang, Jin Zhao and Yuedong Xu (Fudan University, China)
pp. 163-171

Joint Coreset Construction and Quantization for Distributed Machine Learning

Hanlin Lu (Pennsylvania State University, USA); Changchang Liu (IBM Research, USA); Shiqiang Wang (IBM T. J. Watson Research Center, USA); Ting He (Penn State University, USA); Vijaykrishnan Narayanan (Pennsylvania State University, USA); Kevin S Chan (US CDC Army Research Laboratory, USA); Stephen Pasteris (University College London, United Kingdom (Great Britain))
pp. 172-180

Performance Prediction of Big Data Transfer Through Experimental Analysis and Machine Learning

Daqing Yun (Harrisburg University, USA); Wuji Liu (New Jersey Institute of Technology, USA); Chase Q. Wu (New Jersey Institute of Technology & Oak Ridge National Laboratory, USA); Nageswara Rao (Oak Ridge National Laboratory, USA); Rajkumar Kettimuthu (Argonne National Lab, USA)
pp. 181-189

Technical Session 3-A: Network Security

Characterizing the Root Landscape of Certificate Transparency Logs

Nikita Korzhitskii and Niklas Carlsson (Linköping University, Sweden)
pp. 190-198

Scaling website fingerprinting

Vincent Ghiette (Delft University of Technology, The Netherlands); Christian Doerr (Hasso Plattner Institute, Germany)
pp. 199-207

Tracking Down Sources of Spoofed IP Packets

Oswaldo Fonseca and Italo Cunha (Universidade Federal de Minas Gerais, Brazil); Elverton Fazzion (UFSJ, Brazil); Wagner Meira, Jr. (Universidade Federal de Minas Gerais, Brazil); Brivaldo A. S. Junior (Federal University of Mato Grosso do Sul, Brazil); Ronaldo Alves Ferreira (UFMS, Brazil); Ethan Katz-Bassett (Columbia University, USA)
pp. 208-216

Quantifying TCP SYN DDoS Resilience: A Longitudinal Study of Internet Services

Harm Griffioen and Christian Doerr (Hasso Plattner Institute, Germany)
pp. 217-225

Technical Session 3-B: Streaming Services**Efficient User-Cell Association for 360 Video Streaming over Wireless Networks**

Po-Han Huang and Konstantinos Psounis (University of Southern California, USA)
pp. 226-234

RTCP - Reduce Delay Variability with an End-to-end Approach

Longbo Huang and Yuxing Li (Tsinghua University, China); Jean Walrand (University of California, Berkeley, USA)
pp. 235-243

Enabling Premium Service for Streaming Video in Cellular Networks

Xing Xu (Google, USA); Ramesh Govindan (University of Southern California, USA); Ajay A Mahimkar (AT&T Labs - Research, USA); Nemmara K. Shankaranarayanan (AT&T Laboratories - Research, USA); Jia Wang (AT&T Labs - Research, USA); Minlan Yu (University of Southern California, USA)
pp. 244-252

Technical Session 3-C: AI for Networks**A Deep Deterministic Policy Gradient Based Network Scheduler For Deadline-Driven Data Transfers**

Gaurav Ghosal (University of California, Berkeley, USA); Dipak Ghosal (University of California, Davis, USA); Alex Sim (Lawrence Berkeley National Laboratory, USA); Aditya Thakur (University of California, Davis, USA); Kesheng Wu (Lawrence Berkeley National Laboratory, USA)
pp. 253-261

Approaching Fair Collision-Free Channel Access with Slotted ALOHA Using Collaborative Policy-Based Reinforcement Learning

Luca de Alfaro and Molly Zhang (University of California, Santa Cruz, USA); JJ Garcia-Luna-Aceves (University of California at Santa Cruz & Palo Alto Research Center, USA)
pp. 262-270

Fast Reinforcement Learning Algorithms for Resource Allocation in Data Centers

Yuang Jiang (Yale University, USA); Murali Kodialam (Nokia Bell Labs, USA); T. V Lakshman (Bell Labs, Nokia, USA); Sarit Mukherjee (Nokia Bell Labs, USA); Leandros Tassiulas (Yale University, USA)
pp. 271-279

Technical Session 4-A: Blockchain Networking

Privacy-Preserving Blockchain-Based Data Sharing Platform for Decentralized Storage Systems

Van Hoan Hoang (Oodrive & University of La Rochelle, France); Elyes Lehtihet (Oodrive, France); Yacine Ghamri-Doudane (University of la Rochelle, France)
pp. 280-288

Mapping the Interplanetary Filesystem

Sebastian Henningsen (Humboldt-Universität zu Berlin & Weizenbaum Institute, Germany); Martin Florian (Humboldt-Universität zu Berlin & Weizenbaum Institute for the Networked Society, Germany); Sebastian Rust (Humboldt-Universität zu Berlin, Germany); Björn Scheuermann (Humboldt University of Berlin, Germany)
pp. 289-297

How to Securely Prune Bitcoin's Blockchain

Roman Matzutt, Benedikt Kalde, Jan Pennekamp and Arthur Drichel (RWTH Aachen University, Germany); Martin Henze (Fraunhofer FKIE, Germany); Klaus Wehrle (RWTH Aachen University, Germany)
pp. 298-306

Technical Session 4-B: Network Modeling

An Analytical Model for Assessing the Performance of IEEE 802.11ad Beamforming Training

Mohammed Dahhani, André-Luc Beylot and Gentian Jakllari (University of Toulouse, France)
pp. 307-315

Implications of Routing Coherence and Consistency on Network Optimization

Yvonne-Anne Pignolet (DFINITY, Switzerland); Stefan Schmid (University of Vienna, Austria); Gilles Tredan (LAAS-CNRS, France)
pp. 316-324

Performance Analysis of VPN Gateways

Maximilian Pudelko, Paul Emmerich and Sebastian Gallenmüller (Technical University of Munich, Germany); Georg Carle (Technische Universität München, Germany)
pp. 325-333

Technical Session 4-C: Network Security

Quantifying the Influence of Regulatory Instructions over the Detection of Network Neutrality Violations

Márcio Carvalho (Federal University of Rio Grande do Sul, Brazil); Vitor A Cunha (Instituto de Telecomunicações, Portugal); Eduardo da Silva (Catarinense Federal Institute, Brazil); Daniel Corujo (Instituto de Telecomunicações Aveiro & Universidade de Aveiro, Portugal); João Paulo Barraca and Rui L Aguiar (University of Aveiro & Instituto de Telecomunicações, Portugal); Lisandro Z Granville (Federal University of Rio Grande do Sul, Brazil)

pp. 334-342

Evaluation of Centralised vs Distributed Collaborative Intrusion Detection Systems in Multi-Access Edge Computing

Rahul Sharma (University of Melbourne, Australia)

pp. 343-351

Line-Speed and Scalable Intrusion Detection at the Network Edge via Federated Learning

Qiaofeng Qin and Konstantinos Poularakis (Yale University, USA); Kin K. Leung (Imperial College, United Kingdom (Great Britain)); Leandros Tassioulas (Yale University, USA)

pp. 352-360

Technical Session 5-A: Traffic Monitoring and Analysis

A data centric computational model of IPv6 adoption

Ioana Livadariu and Ahmed Mustafa Elmokashfi (Simula Research Laboratory, Norway); Amogh Dhamdhere (CAIDA, University of California, San Diego, USA)

pp. 361-369

A Nation-Wide Wi-Fi RSSI Dataset: Statistical Analysis and Resulting Insights

Germán Capdehourat (Universidad de la República & Centro Ceibal, Uruguay); Federico Larroca and Gastón Morales (Universidad de la República, Uruguay)

pp. 370-378

Estimating Server Load Based on its Correlation with TCP SYN Response Time

Luis de Pedro (Universidad Autónoma de Madrid, Spain); Marta Martínez Redondo and Cristina Mancha (Universidad Autónoma de Madrid, Spain); Jorge E. López de Vergara (Universidad Autónoma de Madrid (UAM) & Naudit High Performance Computing and Networking, Spain)

pp. 379-385

Technical Session 5-B: Industrial and Vehicular networking

QWIN: Facilitating QoS in Wireless Industrial Networks Through Cooperation

Martin Serror, Eric Wagner, René Glebke and Klaus Wehrle (RWTH Aachen University, Germany)

pp. 386-394

MixCAN: Mixed and Backward-Compatible Data Authentication Scheme for Controller Area Networks

Teri Lenard, Roland Bolboaca, Bela Genge and Piroska Haller (University of Medicine, Pharmacy, Science and Technology of Targu Mures, Romania)
pp. 395-403

CSBR: A Cosine Similarity Based Selective Broadcast Routing Protocol for Vehicular Ad-Hoc Networks

Ankur Nahar (Indian Institute of Technology(IIT) Jodhpur, Rajasthan, India); Himani Sikarwar and Debasis Das (IIT Jodhpur, Rajasthan, India)
pp. 404-412

Technical Session 6-A: Programmable Control and Data Planes

P4rt-OVS: Programming Protocol-Independent, Runtime Extensions for Open vSwitch with P4

Tomasz Osinski (Orange Labs & Warsaw University of Technology, Poland); Halina Tarasiuk (Warsaw University of Technology, Poland); Paul Chaignon (Isovalent, The Netherlands); Mateusz Kossakowski (Orange Labs & Warsaw University of Technology, Poland)
pp. 413-421

Sequential Zeroing: Online Heavy-Hitter Detection on Programmable Hardware

Belma Turkovic (Delft University of Technology, The Netherlands); Jorik Oostenbrink (TU Delft, The Netherlands); Fernando A. Kuipers (Delft University of Technology, The Netherlands); Isaac Keslassy (Technion, VMware, Israel); Ariel Orda (Technion, Israel)
pp. 422-430

Defeating Protocol Abuse with P4: an Application to Explicit Congestion Notification

Abir Laraba (Université de Lorraine, LORIA, Inria, France); Jérôme François (INRIA Nancy Grand Est, France); Isabelle Chrisment (LORIA-TELECOM Nancy, Université de Lorraine, France); Shihabur R. Chowdhury and Raouf Boutaba (University of Waterloo, Canada)
pp. 431-439

Technical Session 6-B: Advanced Forwarding and Routing Schemes

PBC: Effective Prefix Caching for Fast Name Lookups

Chuwen Zhang and Yong Feng (Tsinghua University, China); Haoyu Song (Futurewei Technologies, USA); Beichuan Zhang (University of Arizona, USA); Yi Wang (Southern University of Science and Technology, China); Ying Wan, Wenquan Xu and Bin Liu (Tsinghua University, China)
pp. 440-448

Routing Oblivious Measurement Analytics

Ran Ben Basat (Harvard University, USA); Xiaoqi Chen (Princeton University, USA); Gil Einziger (Ben-Gurion University Of The Negev, Israel); Shir Landau Feibish (Princeton University, USA); Danny Raz (Nokia and Technion, Israel); Minlan Yu (Harvard University, USA)
pp. 449-457

Moving a step forward in the quest for Deterministic Networks (DetNet)
 Vamsi Addanki (Telecom ParisTech & Sorbonne University, France); Luigi Iannone
 (Huawei, France)
 pp. 458-466

Technical Session 7: Programmable Control and Data Planes

Decoupling of Distributed Consensus, Failure Detection and Agreement in SDN Control Plane
 Ermin Sakic (Siemens AG, Germany); Wolfgang Kellerer (Technische Universität
 München, Germany)
 pp. 467-475

Cost-Efficient Embedding of Virtual Networks With and Without Routing Flexibility
 Balázs Németh (Budapest University of Technology and Economics, Hungary); Yvonne-
 Anne Pignolet (DFINITY, Switzerland); Matthias Rost (TU Berlin, Germany); Stefan
 Schmid (University of Vienna, Austria); Balázs Vass (Budapest University of Technology
 and Economics, Hungary)
 pp. 476-484

Baking the ruleset: A heat propagation relaxation to packet classification
 Xinyi Zhang (Institute of Computing Technology, Chinese Academy of Sciences &
 University of Chinese Academy of Sciences, China); Kave Salamatian (University of
 Savoie, France); Gaogang Xie (Institute of Computing Technology, Chinese Academy of
 Sciences, China)
 pp. 485-493

Short Papers 1: Network Security

Polymorphic Encryption and Pseudonymisation of IP Network Flows
 Abraham Westerbaan (Radboud University, The Netherlands); Luuk Hendriks (University
 of Twente, The Netherlands)
 pp. 494-498

Encrypted Application Classification with Convolutional Neural Network
 Kun Yang and Lu Xu (New York University, USA); Yang Xu (Fudan University, China); H.
 Jonathan Chao (NYU Tandon School of Engineering, USA)
 pp. 499-503

Securing Route Origin Authorization with Blockchain for Inter-Domain Routing
 Guobiao He, Wei Su, Shuai Gao and Jiarui Yue (Beijing Jiaotong University, China)
 pp. 504-508

Securing Route Leaks using a Decentralized Approach
 Miquel Ferriol Galmés, Roger Coll and Albert Cabellos-Aparicio (Universitat Politècnica
 de Catalunya, Spain); Shoushou Ren (Huawei Technologies Co., Ltd., China); XinPeng Wei
 (Huawei Technologies, China); Bingyang Liu (Huawei, China)
 pp. 509-513

Short Papers 2: SFC and Cloud Networking

Multi-Cloud Chaining with Segment Routing

Francesco Spinelli (IMDEA Networks Institute & Universidad Carlos III de Madrid, Spain);
Luigi Iannone (Huawei, France); Jerome Tollet (Cisco Systems, France)
pp. 514-518

Amalgam: Distributed Network Control With Scalable Service Chaining

Subhrendu Chattopadhyay and Sukumar Nandi (Indian Institute of Technology
Guwahati, India); Sandip Chakraborty (Indian Institute of Technology Kharagpur, India);
Abhinandan Sridhara Rao Prasad (NIE Mysuru, India)
pp. 519-523

Optimizing Social Welfare for Task Offloading in Mobile Edge Computing

Hsiang-Jen Hong and Wenjun Fan (University of Colorado Colorado Springs, USA); C.
Edward Chow (University of Colorado at Colorado Springs, USA); Xiaobo Zhou
(University of Colorado, Colorado Springs, USA); Sang-Yoon Chang (University of
Colorado Colorado Springs, USA)
pp. 524-528

Toward an Efficient Real-Time Anomaly Detection System for Cloud Datacenters

Ricardo Souza Dias (Pontifícia Universidade Católica do Rio de Janeiro & Globo.com,
Brazil); Leopoldo Alexandre Freitas Mauricio (Universidade Federal do Rio de Janeiro /
GTA / UFRJ & Globo.com Company, Brazil); Marcus Poggi (PUC-Rio, Brazil)
pp. 529-533

Short Papers 3: Network Modeling

A Delicate Union of Batching and Parallelization Models in Distributed Computing and Communication

Sounak Kar (Technical University of Darmstadt, Germany); Amr Rizk (Universität Ulm,
Germany)
pp. 534-538

Modelling Edge Computing in Urban Mobility Simulation Scenarios

Katja Gilly and Salvador Alcaraz (Miguel Hernandez University, Spain); Noura Akinin
(Abdelmalek Essaadi University, Morocco); Sonja Filiposka (Faculty of Computer Science
and Engineering, Macedonia, the former Yugoslav Republic of); Anastas Mishev (Ss. Cyril
and Methodius University, Macedonia, the former Yugoslav Republic of)
pp. 539-543

A Social Spider Optimisation Algorithm for 3D Unmanned Aerial Base Stations Placement

Elhadja Chaalal and Laurent Reynaud (Orange Labs, France); Sidi-Mohammed Senouci
(University of Bourgogne - ISAT Nevers, France)
pp. 544-548

Feedback-Based Hidden-Terminal Mitigation for Distributed Scheduling in Cellular V2X

Philip Wendland (Technische Universität Ilmenau, Germany); Guenter Schaefer
(Technische Universität Ilmenau, Germany)
pp. 549-553

Virtual Cross-Flow Detouring in the Deterministic Network Calculus Analysis

Steffen Bondorf (Ruhr University Bochum, Germany); Fabien Geyer (Technical University of Munich, Germany)

pp. 554-558

Short Papers 4: AI for Networks

Zero-Day Traffic Identification Using One-Dimension Convolutional Neural Networks And Auto Encoder Machine

Dong Jin, Shuangwu Chen, Jinsen Xie and Jian Yang (University of Science and Technology of China, China); Xinmin Liu and Wei Wang (New H3C Technologies Co., China)

pp. 559-563

Human Physical Status detection related to Danger Situations based on Smartwatch and Smartphone

Andrea Tundis (Technische Universität Darmstadt, Germany); Muhammad Uzair (Incloud Engineering GmbH, Germany); Max Mühlhäuser (Technische Universität Darmstadt, Germany)

pp. 564-568

Optimizing Spectrum Use in Wireless Networks by Learning Agents

Artur Popławski (NOKIA & AGH University of Science and Technology, Poland); Szymon Szott (AGH University of Science and Technology, Poland)

pp. 569-573

Dynamic Backup Workers for Parallel Machine Learning

Chuan Xu and Giovanni Neglia (Inria, France); Nicola Sebastianelli (Inria, Italy)

pp. 574-578

Deep Neural Networks approach for Power Head-Room Predictions in 5G Networks and Beyond

Nazih Salhab (University Gustave Eiffel, France & Lebanese University, Lebanon); Rana Rahim (Lebanese University, Lebanon); Rami Langar (University Gustave Eiffel, France); Raouf Boutaba (University of Waterloo, Canada)

pp. 579-583

Short Papers 5: 5G Networking, Credential Management and AI for Networks

Multi-User collaborative scheduling in 5G massive MIMO heterogeneous networks

Marie Masson and Zwi Altman (Orange Labs, France); Eitan Altman (INRIA, France)

pp. 584-588

MHM: A Novel Collaborative Spectrum Sensing Method based on Markov-chains and Harmonic Mean for 5G Networks

Gabriel C Ferreira and Priscila Solis (Universidade de Brasilia, Brazil); Geraldo Rocha Filho and Marcos Fagundes Caetano (University of Brasilia, Brazil); Heikki Karvonen (University of Oulu, Centre for Wireless Communications, Finland); Johanna Vartiainen (Centre for Wireless Communications, Finland)

pp. 589-593

Voting Credential Management System for Electronic Voting Privacy

Arijet Sarker, SangHyun Byun, Wenjun Fan, Maria Psarakis and Sang-Yoon Chang
(University of Colorado Colorado Springs, USA)
pp. 594-598

Differentiated Transmission based on Traffic Classification with Deep Learning in DataCenter

KeKe Zhu (Tsinghua University, China); Gengbiao Shen (Tsinghua University, China);
Yong Jiang (Graduate School at Shenzhen, Tsinghua University, China); Jianhui Lv
(Northeastern University, China); Qing Li (Southern University of Science and
Technology, China); Mingwei Xu (Tsinghua University, China)
pp. 599-603

Short Papers 6: IoT Networking

An Energy-Aware SDN/NFV Architecture for the Internet of Things

Dipon Saha and Meysam Shojaee (Dalhousie University, Canada); Michael Baddeley
(Toshiba Research Europe Ltd., United Kingdom (Great Britain)); Israat Haque (Dalhousie
University, Canada)
pp. 604-608

LoRaWAN Class B Multicast Scalability

Yonatan Woldeleul Shiferaw, MSc (TNO, The Netherlands); Apoorva Arora and Fernando
A. Kuipers (Delft University of Technology, The Netherlands)
pp. 609-613

Practical evaluation of carrier sensing for a LoRa wildlife monitoring network

Morgan Roy O'Kennedy (University of Stellenbosch, South Africa); Thomas Niesler
(Stellenbosch University, South Africa); Riaan Wolhuter (University of Stellenbosch,
South Africa); Nathalie Mitton (Inria Lille - Nord Europe, France)
pp. 614-618

Poster Session 1: NFV/SDN/5G

CO2: Collaborative Packet Classification for Network Functions with Overselection

Yunhong Xu (Texas A&M University, USA); Hao Wu (Tsinghua University, China); Nick
Duffield (Texas A&M University, USA); Bin Liu (Tsinghua University, China); Minlan Yu
(Harvard University, USA)
pp. 619-621

Priority-Aware Per-flow Measurement using Cuckoo Sketch

Yibo Yan (Peking University & School of Electronics and Computer Engineering (SECE),
China); Cheng Chen, Huiping Lin, Olivier Ruas, Tengjiao Wang and Tong Yang (Peking
University, China)
pp. 622-624

Word embedding for deployment descriptors in NFV

Wassim Sellil Atoui (Télécom SudParis & Orange Labs, France); Imen Grida Ben Yahia
(Orange Labs, France); Walid Gaaloul (Telecom SudParis, Samovar, France)
pp. 625-627

Im-OFDP: An Improved OpenFlow-based Topology Discovery Protocol for Software Defined Network

Dong Li and Yongpu Gu (Huazhong University of Science and Technology, China);
Junqing Yu (Huazhong University of Science & Technology, China)
pp. 628-630

SmartSharing: A CDN with Smart Contract-based Local OTT Sharing

Jiamin Fan and Kui Wu (University of Victoria, Canada); Daming Liu (Shanghai University of Electric Power, China); Guoming Tang (National University of Defense Technology, China)
pp. 631-633

IsoRAN: Isolation and Scaling for 5G RAN via User-Level Data Plane Virtualization

Nishant Budhdev and Mun Choon Chan (National University of Singapore, Singapore);
Tulika Mitra (NUS Singapore, Singapore)
pp. 634-636

Poster Session 2: VANETs/WMNs

Poster: Seamless Client Integration for Fast Roaming in Wireless Mesh Networks

Martin Backhaus, Markus Theil and Michael Rossberg (Technische Universität Ilmenau, Germany); Guenter Schaefer (Technische Universitaet Ilmenau, Germany)
pp. 637-639

Poster: Distributed and Privacy Preserving Routing of Connected Vehicles to Minimize Congestion

Surabhi Boob (North Carolina State University, USA); Shakir Mahmood (National University of Sciences and Technology, Pakistan); Muhammad Shahzad (North Carolina State University, USA)
pp. 640-642

SafeSmart: A VANET system for efficient communication for emergency vehicles

Luis Antonio Leite Francisco da Costa and Eduardo Kochenborger Duarte (Federal University of Rio Grande do Sul, Brazil); Mikael Erneberg (H&E Solutions AB, Sweden); Edison Pignaton de Freitas (Federal University of Rio Grande do Sul, Brazil); Alexey Vinel (Halmstad University, Sweden)
pp. 643-645

TrueNets: a Topology Generator for Realistic Network Analysis

Gabriele Gemmi (University of Trento, Italy); Renato Lo Cigno (University of Brescia, Italy); Leonardo Maccari (University of Venice, Italy)
pp. 646-648

Poster Session 3: ML/Privacy

Poster: A Semi-Supervised Framework to Detect Botnets in IoT Devices

Muhammad Naveed and Hui Wu (The University of New South Wales, Australia)
pp. 649-651

Evolution of Ethereum: A Temporal Graph Perspective

Qianlan Bai, Chao Zhang and Yuedong Xu (Fudan University, China); Xiaowei Chen (The Chinese University of Hong Kong, USA); Xin Wang (Fudan University, China)
pp. 652-654

OIDPR: Optimized Insulin Dosage based on Privacy-Preserving Reinforcement Learning

Zuobin Ying, Yun Zhang and Shuanglong Cao (Anhui University, China); Shengmin Xu (Singapore Management University, Singapore); Ximeng Liu (Fuzhou University, China)
pp. 655-657

Auditable secure network overlays for multi-domain distributed applications

Reginald S Cushing, Paola Grosso, Ralph Koning and Cees de Laat (University of Amsterdam, The Netherlands)
pp. 658-660

CONtrol: Controlling Quality of Service of Container Networks in a Hyperconverged Platform

Sumitro Bhaumik (Indian Institute of Technology, Kharagpur, India); Kaustav Chanda (Manipal Institute of Technology, India); Sandip Chakraborty (Indian Institute of Technology Kharagpur, India)
pp. 661-663

Per-Hop Bridge-Local Latency Bounds with Strict Priority Transmission Selection

Alexej Grigorjew (University of Wuerzburg, Germany); Florian Metzger and Tobias Hoßfeld (University of Würzburg, Germany); Johannes Specht (University of Duisburg-Essen, Germany); Franz-Josef Goetz, Juergen Schmitt and Feng Chen (Siemens AG, Germany)
pp. 664-666

Demo Session 1: Security**A Practical Analysis on Mirai Botnet Traffic**

Getoar Gallopeni, Bruno Rodrigues and Muriel Franco (University of Zurich, Switzerland); Burkhard Stiller (University of Zürich, Switzerland)
pp. 667-668

Securing messages in C-ITS: a proof of concept

Jun Zhang (Telecom Paris, France); Houda Labiod (Telecom ParisTech, France); Ghassen Chaabane (Telecom Paris, France); Clément Ruffin and André Perpey (NeoGLS, France)
pp. 669-670

User identification by matching radio ``vision'' and computer vision through means of machine learning

Vinicius Mesquita de Pinho and Dalia Georgiana Popescu (Nokia Bell Labs, France)
pp. 671-672

Demo Session 2: Performance

Autonomous Anomaly Detector for Cloud-Radio Access Network Key Performance Indicators
Nazih Salhab (University Gustave Eiffel, France & Lebanese University, Lebanon); Rana
Rahim (Lebanese University, Lebanon); Rami Langar (University Gustave Eiffel, France)
pp. 673-674

Seamless Multimedia Streaming in Controller-Less Wireless Mesh Networks With Mobile
Stations
Markus Theil, Martin Backhaus and Michael Rossberg (Technische Universität Ilmenau,
Germany); Guenter Schaefer (Technische Universitaet Ilmenau, Germany)
pp. 675-676

Demo Session 3: Management and Configuration

FORCH: An Orchestrator for Fog Computing service deployment
Gianluca Davoli, Davide Borsatti, Daniele Tarchi and Walter Cerroni (University of
Bologna, Italy)
pp. 677-678

Demo: Crawling the IPFS Network
Sebastian Henningsen (Humboldt-Universität zu Berlin & Weizenbaum Institute,
Germany); Sebastian Rust (Humboldt-Universität zu Berlin, Germany); Martin Florian
(Humboldt-Universität zu Berlin & Weizenbaum Institute for the Networked Society,
Germany); Björn Scheuermann (Humboldt University of Berlin, Germany)
pp. 679-680

Optimum Rooted Trees for Failover in Switched Networks
Peter Willis and Nirmala Shenoy (Rochester Institute of Technology, USA)
pp. 681-682

Evaluation of Path States of Large IoT Networks Using Locally and Remotely Controlled
Measurements
Agnieszka Chodorek (Kielce University of Technology, Poland); Robert R. Chodorek (AGH
University of Science and Technology, Poland)
pp. 683-684

Industry Track - Session 1

Evolution Toward the Next Generation Radio Access Network
William Diego (Orange Labs, France)
pg. 685

Cost effective troubleshooting of NFV infrastructure
Ran Ben Basat (Harvard University, USA); Gil Einziger (Ben-Gurion University Of The
Negev, Israel); Maayan Goldstein (Nokia Bell Labs, Israel); Liat Pele (Nokia, Israel); Itai
Segall (Bell Labs Israel, Israel)
pp. 686-694

Industry Track - Session 2

A Lightweight Network-based Android Malware Detection System

Igor J. Sanz and Martin Andreoni Lopez (Samsung Research Institute, Brazil); Eduardo Viegas (Pontifical Catholic University of Parana (PUCPR), Brazil); Vinicius Sanches (Samsung Research Institute, Brazil)
pp. 695-703

Characterizing Packet Loss in City-Scale LoRaWAN Deployment: Analysis and Implications

Qian Liu, Yanyan Mu and Jin Zhao (Fudan University, China); Jingxia Feng and Bin Wang (Shanghai Oriental Full-link Technology Co., Ltd, China)
pp. 704-712

FIT - Technical Session 1: Quality of Service

A DRAM-friendly priority queue Internet packet scheduler implementation and its effects on TCP

Katsushi Kobayashi (University of Tokyo, Japan)
pp. 713-718

SRPT-ECF: challenging Round-Robin for stream-aware multipath scheduling

Baptiste Jonglez (Université Grenoble Alpes & LIG, France); Martin Heusse (Grenoble Informatics Laboratory & Grenoble INP, France); Bruno Gaujal (INRIA & LIG, France)
pp. 719-724

Transport Layer Efficiency and Security in IoT: RINA's Approach

Toktam Ramezanifarkhani and Peyman Teymoori (University of Oslo, Norway)
pp. 725-730

FIT - Technical Session 2: Transport Layer

Rethinking ACKs at the Transport Layer

Ana Custura, Tom Jones and Gorry Fairhurst (University of Aberdeen, United Kingdom (Great Britain))
pp. 731-736

A QUIC Simulation Model for INET and its Application to the Acknowledgment Ratio Issue

Ekaterina Volodina (University of Duisburg-Essen, Germany); Michael Tüxen (Münster University of Applied Sciences, Germany); Erwin P Rathgeb (University of Duisburg-Essen, Germany); Timo Völker (FH Münster University of Applied Sciences, Germany)
pp. 737-742

FIT - Technical Session 3: Measurement Studies

SABES: A Statistical approach to Available Bandwidth ESTimation from passive TCP measurements

Francesco Ciaccia (Technical University of Catalunya (UPC) & Clevernet, Spain); Ivan Romero and Oriol Arcas-Abella (Clevernet, Spain); Diego Montero (Universidad de Cuenca & Clevernet, Ecuador); René Serral-Gracià (Technical University of Catalunya (UPC) & Networking and Information Technology Lab NetIT Lab, Spain); Mario Nemirovsky (ICREA Researcher at CNS - BSC & Barcelona Supercomputing Center, Spain)
pp. 743-748

On the Incompatibility of Scalable Congestion Controls over the Internet

Ferenc Fejes and Gergo Gombos (ELTE Eötvös Loránd University, Hungary); Sándor Laki (Eötvös Loránd University, Hungary); Szilveszter Nádas (Ericsson Research, Hungary)
pp. 749-754

Evaluating QUIC's Performance Against Performance Enhancing Proxy over Satellite Link

Bhavith Shah, John Border, Chi-Jiun Su and Rob Torres (Hughes Network Systems, USA)
pp. 755-760

Network Slicing - Technical Session 1: Network Slicing for Vehicular & UAV services

Evaluation of Multi-operator dynamic 5G Network Slicing for Vehicular Emergency Scenarios

Hanif Kukkalli (Technische Universität Chemnitz & Highstreet Technologies GmbH, Germany); Sumit Maheshwari (Rutgers University, USA); Ivan Seskar (WINLAB, Rutgers University, USA); Martin Skorupski (Highstreet Technologies GmbH, Germany)
pp. 761-766

Integration of U-space and 5GS for UAV services

Lechosław Tomaszewski and Robert Kofakowski (Orange Polska, Poland); Sławomir Kuklinski (Orange Polska & Warsaw University of Technology, Poland)
pp. 767-772

Network Slicing - Technical Session 2: ITization in the support of Network Slicing

Information Exchange to Support Multi-Domain Slice Service Provision for 5G/NFV

Luis M. Contreras and Alberto Solano (Telefonica, Spain)
pp. 773-778

The case for serverless mobile networking

Marco Gramaglia, Pablo Serrano and Albert Banchs (Universidad Carlos III de Madrid, Spain); Ginés García (UC3M, Spain); Andres Garcia-Saavedra (NEC Labs Europe, Germany); Ramon Perez (Telcaría Ideas, Spain)
pp. 779-784

TENSOR - Technical Session 1: Deterministic Networking

Load Balancing for Deterministic Networks

Shuang Chen (Huawei Technologies Co. Ltd., China); Jeremie Leguay (Huawei Technologies, France Research Center, France); Sébastien Martin (Université de Lorraine, France); Paolo Medagliani (Huawei Technologies Co. Ltd., France)
pp. 785-790

P4 In-Network Source Protection for Sensor Fail-Over

Steffen Lindner, Marco Häberle and Florian Heimgaertner (University of Tuebingen, Germany); Naresh Nayak (Robert Bosch GmbH, Germany); Sebastian Schildt (Robert Bosch Corporate Research, Germany); Dennis Grewe and Hans Loehr (Robert Bosch GmbH, Germany); Michael Menth (University of Tuebingen, Germany)
pp. 791-796

TENSOR - Technical Session 2: Time-Sensitive Networking

Coupling Source Routing with Time-Sensitive Networking

Gagan Nandha Kumar (Technical University of Munich, Germany); Kostas Katsalis (HUAWEI, Germany); Panagiotis Papadimitriou (University of Macedonia, Greece)
pp. 797-802

Integrated Industrial Ethernet Networks: Time-sensitive Networking over SDN Infrastructure for mixed Applications

Mohamed Abdel Metaal (Technische Universität Darmstadt & Deutsche Telekom AG, Germany); Rene Guillaume (Robert Bosch GmbH, Germany); Ralf Steinmetz (Technische Universität Darmstadt, Germany); Amr Rizk (Universität Ulm, Germany)
pp. 803-808

GIS - Technical Session 1*The Internet in Crimea: a Case Study on Routing Interregnum*

Romain Fontugne (IIJ Research Lab), Ksenia Ermoshina (CIS CNRS / Citizen Lab), and Emile Aben (RIPE NCC)
pp. 809-814

Measuring Basic Load-Balancing and Fail-Over Setups for Email Delivery via DNS MX Records

Jukka Ruohonen (University of Turku)
pp. 815-820

GIS - Technical Session 2

General Knapsack Bounds of Web Caching Performance Regarding the Properties of each Cacheable Object

Gerhard Hasslinger (Deutsche Telekom), Konstantinos Ntougias (University of Cyprus), Frank Hasslinger (Darmstadt Univ. of Tech.), and Oliver Hohlfeld (Brandenburg Univ. of Tech.)

pp. 821-826

A Link Scheduling Algorithm for Underwater Optical Wireless Networks

Zhengxin Fan, Lei Wang, Chi Lin, Yongda Yu, Bingxian Lu, Zhongxuan Luo, Zhenquan Qin, and Ming Zhu (Dalian University of Technology)

pp. 827-832