2023 IEEE 24th International Conference on High Performance Switching and Routing (HPSR 2023)

Albuquerque, New Mexico, USA
5 – 7 June 2023

IEEE Catalog Number: CFP23HPS-POD
ISBN: 978-1-6654-7641-6

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IEEE Catalog Number:	CFP23HPS-POD
ISBN (Print-On-Demand):	978-1-6654-7641-6
ISBN (Online):	978-1-6654-7640-9
ISSN:	2325-5595

Additional Copies of This Publication Are Available From:

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Monday, June 5

Monday, June 5 9:30 - 12:00

Tutorial 1: An Overview of a Distributed Post-5G Network Architecture within the EU SLICES-RI Research Infrastructure

Prof. Raymond Knopp, Prof. Adlen Ksentini, Dr. Damien Saucez, and Dr. Nikos Makris
We provide an overview of a blueprint for a disaggregated real-time post-5G network architecture that can be deployed on commodity networking and computing equipment. This activity is part of the European SLICES-RI research infrastructure and constitutes a distributed experimental post-5G playground for academic research purposes to be deployed across several EU countries. The blueprint is meant to be reproducible and to evolve in a collaborative manner. It makes use of open-source solutions such as SD-Fabric, Aether, OpenAirInterface, Nephio and others. The tutorial focuses on key networking components such as software-defined edge fabric, P4-based switching implementing the 5G user-plane function (UPF), cloud-native 5G radio-access (RAN) and core network functions (5GC), O-RAN near real-time RAN intelligent controllers (nRT-RIC), O-RAN Open-fronthaul interfaces and multi-cluster orchestration solutions. The tutorial will demonstrate live deployment and operation of a radio-edge site in Sophia Antipolis, France making use of some of the above technologies.

Monday, June 5 9:30 - 11:30

WS: Online Workshops

Monday, June 5 13:00 - 15:30

Tutorial 2: The Role Of Data Engineering In Network Automation

Dr. Engin Zeydan and Dr. Josep Mangues-Bafalluy

To address the complex issues that larger and highly integrated networks face in the design, analysis, deployment and management phases, recent advances in data science and engineering technologies in both academia and industry have spurred the adoption of various Artificial Intelligence (AI)/Machine Learning (ML) platforms and frameworks in telecommunication network infrastructures. In this tutorial, we aim to provide a comprehensive and thorough overview of the recent advances in data engineering frameworks and link the capabilities of the data engineering ecosystem with a possible connection to future telecommunication systems in the context of network management and orchestration. Some special features of this tutorial are: a clear link between the data engineering ecosystem (including data connection, data ingestion, data processing & analysis, data storage, data monitoring & visualization and data management & orchestration frameworks) and recent developments in networking, an overview of standardization efforts in network management and orchestration and how these can be related to data engineering frameworks, the relationship to data science frameworks, ML platforms used in the industry, and related data engineering use cases for telecommunications networks will be discussed. Two examples on log management in NFV service orchestration and AI/ML-driven scaling of digital service will also be demonstrated.

Monday, June 5 15:45 - 18:15

Tutorial 3: Introduction to Networking Technologies for High-Performance Computing

Prof. Dhabaleswar K. (DK) Panda and Prof. Hari Subramoni
InfiniBand (IB), High-speed Ethernet (HSE), RoCE, Omni-Path, EFA, Tofu, Slingshot, and Aquila technologies are generating a lot of excitement towards building next generation High-End Computing (HEC) systems including clusters, data- centers, file systems, storage, cloud computing and Big Data (Hadoop, Spark, HBase and Memcached) environments. This tutorial will provide an overview of these emerging technologies, their offered architectural features, their current market standing, and their suitability for designing HEC systems. It will start with a brief overview of IB, HSE, RoCE, Omni- Path, EFA, Tofu, Slingshot, and Aquila. In-depth overview of the architectural features of IB, HSE (including iWARP and RoCE), and Omni-Path, their similarities and differences, and the associated protocols will be presented. An overview of the emerging NVLink, NVLink2, NVSwitch, Slingshot, Tofu, Aquila architectures will also be given. Next, an overview of the OpenFabrics stack which encapsulates IB, HSE, and RoCE (v1/v2) in a unified manner will be presented. An overview of libfabrics stack will also be provided. Hardware/software solutions and the market trends behind these networking technologies will be highlighted. Sample performance numbers of these technologies and protocols for different environments will be presented. Finally, hands-on exercises will be carried out for the attendees to gain first-hand experience of running experiments with high-performance networks.

Monday, June 5 19:00 - 20:30

PD: Poster and demo session

Spain); Farhad Rezazadeh (UPC & CTTC, Spain); Josep Mangues-Bafalluy (Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain)

19:45 ***Droppable Wireless Mesh Network for Intelligent Mine Rescue System.....49***
Patrick Duane, Sihua Shao, Mostafa Hassanalian, Vasileios Androulakis, Hassan Khaniani and Pedram Roghanchi (New Mexico Tech, USA)

20:07 ***Split Learning for Image Classification in Internet of Drones Networks.....52***
Jingjing Yao (Texas Tech University, USA)

Tuesday, June 6

Tuesday, June 6 9:00 - 10:00

Keynote 1: Latency is the new Bandwidth

Dr. Shivendra Panwar

The data rates of both wired and wireline links have increased relentlessly over the last several decades. Wireless access rates used to trail those for wireline access rates, but of late have started catching up, so much so that they can be viewed as essentially equal. For most applications, including mobile applications, bandwidth availability is not viewed as a serious constraint anymore. 5G is delivering tens of megabits per second to users, and will soon provide more. The next driver of advances in networking is expected to be the need for reliable low latency connectivity, rather than bandwidth alone. These applications include XR (Augmented Reality, Virtual Reality and Mixed Reality), wirelessly controlled robots and haptic communications. The latency requirements for such applications vary from tens of milliseconds down to the sub-millisecond range. While the latency requirements for these applications can be met by carefully engineered wired and wireless communications, typically in controlled indoor environments, it is still a challenge to provide them over cellular networks. This talk will focus on the emerging challenge of providing reliable low latency broadband communications over cellular networks.

Tuesday, June 6 10:30 - 12:00

TS1: Programmable Control and Data Plane

10:30 ***ADMBIFA: Accurate Detection and Mitigation of Blended Interest Flooding Attacks in NDN Networks.....56***

Yanan Zhang (Tianjin University of Science & Technology, China); XinXin Guo (Tianjin University of Science and Technology, China); Maode Ma (Qatar University, Qatar); Yiying Zhang (Tianjin University of Science and Technology, China)

Tuesday, June 6 13:00 - 14:30

TS2: Switching and Routing

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Umakant Kulkarni and Yufeng Chen (Purdue University, USA); Patrick Melampy (Juniper Networks, USA); Sonia Fahmy (Purdue University, USA)

Tuesday, June 6 14:45 - 16:15

TS3: Wireless Networks

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Jin Zhang, Daoye Wang, Kai Liu and Jianhua Lu (Tsinghua University, China)

15:03 *CTGAN-Assisted CNN for High-Resolution Wireless Channel Delay Estimation.....126*

Liyan Xu, Lei Feng, Li Wenjing (Beijing University of Posts and Telecommunications, China)

15:21 *Experiment-Driven Platform for Link Quality Estimation in IEEE 802.11 WLANs.....134*

Thierry Arrabal (INSA Lyon, France); Marija Stojanova (ENS Paris, France); Isabelle Guérin Lassous (Université Claude Bernard Lyon 1 - LIP, France); Joris Picot (École Normale Supérieure de Lyon LIP Université de Lyon France, France)

15:39 *Modelling the Performance of High Capacity Access Networks for the Benefit of End-Users and Public Policies.....140*

Antonio Capone and Maurizio Dècina (Politecnico di Milano, Italy); Aldo Milan and Marco Petracca (AGCOM, Italy)

15:57 *TSOA: Two-State Offloading Algorithm from Users to Co-Located Vehicular Microclouds.....146*

Bo-Jun Qiu and Jyh-Cheng Chen (National Yang Ming Chiao Tung University, Taiwan); Falko Dressler (TU Berlin, Germany)

Tuesday, June 6 16:30 - 18:00

Tutorial 4: Network Softwarization at the Edge With SD-WAN

Prof. Sebastian Troia and Prof. Guido Maier

This tutorial addresses the Software-Defined Wide Area Network (SD-WAN) technology, which has recently conquered the enterprise-networking market all over the world. SD-WAN is regarded as very promising for the next-generation WANs, especially by the Communication Service Providers (CSPs) as a new highly effective solution they can offer to their customers. SD-WAN brings the advantages of SDN to the WAN, applying the concept of separation among data and control plane. The main goal is to provide dynamic, fast and reliable interconnections between the sites of an organization, such as headquarters, data-centers, branch offices, that are geographically distributed over a wide area. A

communication infrastructure with a national or international or even global extension can thus be provided to the tenants as an overlay network over heterogeneous public WANs. SD-WAN reduces the costs, but has to preserve the same quality of service of alternative, more expensive technologies, such as MPLS. We will present a detailed overview of SD-WAN by addressing the most important use cases, such as enterprise branch-to-headquarter and headquarter-to-data-center switching interconnection. In particular, we will focus on the network architecture requirements in order to obtain an agile and efficient control plane. Afterwards, we will describe the decision techniques that can be implemented inside the SD-WAN controller, making a comparison between traditional and Machine-Learning solutions. During the tutorial we will display some testbeds and present a live demo.

Wednesday, June 7

Wednesday, June 7 9:00 - 10:00

Keynote 2: A New CubeSat Design with Reconfigurable Multi-band Radios for Dynamic Spectrum Access in Internet of Space Things

Dr. Ian F. Akyildiz

Small satellites, or CubeSats, are envisioned as a promising solution for future satellite communication networks because of their low costs and short deployment cycle. Currently, CubeSats communicate at conventionally allocated satellite communication frequencies. However, with the increase in the number of CubeSats, CubeSat-enabled communication systems, and many new use cases, new spectrum bands and a more efficient spectrum usage are needed. In this talk, a novel CubeSat design with reconfigurable multi-band radios for communication in dynamic frequencies is proposed. The multi-band radio design is realized by two complementary approaches, namely, an electronics-based and a photonics-based approach. The multi-band communication covers a wide range from radio frequencies (2-30 GHz), millimeter wave (30-300 GHz), Terahertz band (up to 10 THz), and optical frequencies (with typical bands of 850 nm/350 THz, 1300 nm/230 THz, and 1550 nm/193 THz). A thorough link budget analysis is conducted to demonstrate the potential of the proposed multi-band architecture for space information networks. Key parameters in the satellite constellation design are investigated to explore the feasibility of deployment at different altitudes in the exosphere orbit (500 km and above). Furthermore, software-defined networking (SDN), and network function virtualization (NFV) have been incorporated to effectively separate the abstraction of functionalities from the hardware by decoupling the data forwarding plane from the control plane, such separation is of prime importance given the limited onboard processing on CubeSats. Additionally, key parameters in the constellation design including the coverage footprint and number of CubeSats as well as orbital planes, etc. are investigated for feasibility and deployment studies at different altitudes in the exosphere orbit.

Wednesday, June 7 10:30 - 12:00

TS4: Machine Learning & Networks

10:30 ***Network Traffic Prediction with Attention-Based Spatial-Temporal Graph Network.....153***

Yufei Peng, Yingya Guo, Hao Run and Junda Lin (Fuzhou University, China)

10:48 ***LOBIN: In-Network Machine Learning for Limit Order Books.....159***

Xinpeng Hong, Changgang Zheng, Stefan Zohren and Noa Zilberman (University of Oxford, United Kingdom (Great Britain))

11:06 ***D3T: Double Deep Q-Network Decision Transformer for Service Function Chain Placement.....167***

Binghui Wu and Dongbo Chen (National University of Singapore, Singapore); Venkata Abhishek Nalam (Singapore Institute of Technology, Singapore); Mohan Gurusamy (National University of Singapore, Singapore)

11:24 ***FTG-Net: Hierarchical Flow-To-Traffic Graph Neural Network for DDoS Attack Detection.....173***

Luca Barsellotti (University of Modena and Reggio Emilia (UNIMORE), Italy); Lorenzo De Marinis (Scuola Superiore Sant'Anna, Italy); Filippo Cugini and Francesco Paolucci (CNIT, Italy)

11:42 ***A Two-Stage Cooperative Reinforcement Learning Scheme for Energy-Aware Computational Offloading.....179***

Marios Avgeris (Carleton University, Canada); Meriem Mechennef and Aris Leivadeas (École de Technologie Supérieure, Canada); Ioannis Lambadaris (Carleton University, Canada)

Wednesday, June 7 13:00 - 14:30

TS5: Terrestrial and Aerial Mobile Networks

13:00 ***Energy-Efficient Federated Learning in Internet of Drones Networks.....185***

Jingjing Yao (Texas Tech University, USA); Xiang Sun (University of New Mexico, USA)

13:18 ***Self-Sovereign Identity Management for Hierarchical Federated Learning in Vehicular Networks.....191***

Engin Zeydan and Josep Mangues-Bafalluy (Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain); Suayb S. Arslan (Massachusetts

Wednesday, June 7 14:45 - 17:15

Tutorial 5: 6G Network Slicing Technics: Recent Advances, Standards, and Challenges

Prof. Jiadai Wang and Prof. Jiajia Liu

6G is designed to achieve breakthroughs in mobile networks, and is expected to have features such as seamless global coverage, full virtualization, and ubiquitous intelligence. More application scenarios with specific capabilities will emerge, which urgently require customized end-to-end service provisioning. Network slicing is widely recognized as a key enabling technology for 6G, which can divide the physical network into multiple logical networks as needed, changing the network form from "one-size-fits-all" to "one-size-per-service" to meet differentiated performance metrics and service requirements. Although the network slicing concept has been explored to some extent in 5G, it will be fully extended and perfected in 6G with the combination of ubiquitous intelligence and various innovative application scenarios. This tutorial comprehensively reviews the research work on 6G network slicing technics from three aspects: recent advances, standards, and challenges. Slicing technics are the basis of end-to-end logical isolation and service provisioning, which involves many technical domains such as access network, transport network, core network, and slicing management system. We first introduce key recent advances in slicing technics according to these different domains. In particular, we emphasize the great potential of artificial intelligence techniques for network slicing. In addition, cross-domain and cross-vendor standards can provide guidance for slicing technics, which is necessary for the wide application and commercialization of 6G network slicing. Finally, we highlight the challenges faced by network slicing and envision its future development.