Guest Editors' Introduction: Special Section on Robust and Reliable Networks of the Future

I. Introduction

THIS Special Section features research contributions in the area of robust and reliable networks of the future. Modern network infrastructures must support a growing demand for intensive data processing and high-speed communication, that has led, in the last decade, to a constant evolution towards convergence of networking and computing infrastructures. This convergence was made possible by the introduction of network function virtualization and by the emergence of the Software-Defined Networking (SDN) paradigm, and has enabled new forms of cloud and edge computing to cope with the strict requirements of new services and applications, as those in the realm of the Internet of Things (IoT).

Network virtualization, in particular, by allowing to create independent virtual networks (or "slices") over a set of shared physical resources, leads to more effective use of network resources, but also poses new challenges when it comes to guarantee high level of isolation across slices, and, in general, robustness and reliability of the communication infrastructure. The on-going deployment of 5G networks requires to support Ultra-Reliable Low-Latency Communication (URLLC) services with availabilities of up to 6 nines, to be provided with very low latencies. Such requirements are poised to become even more strict in the next 6th generation of mobile communications, hence new and improved solutions need to be investigated.

As complexity of communications networks increases, network providers are increasingly leveraging the monitoring data coming from the network, adopting new strategies for network automation and fault self-diagnosis. Novel technological trends, as network disaggregation and network programmability, are emerging both in wireless and wired network domains. Concomitantly, providers are becoming increasingly aware of the need to ensure the privacy of data while offering higher levels of security to their services. Moreover, disaster resilience, especially related to new threats coming from climate change and political instability, is also an increasing concern for government and industry. Hence, new technical developments are being pursued to attain the robust and reliable networks of the future. Some of those developments are presented in this Special Section.

II. Overview of Special Section

The Special Section received sixty six submissions. After a thorough and timely review process, 24 papers were accepted for publication in this Special Section. The 24 accepted papers have been classified into five categories: (i) reliable network virtualization; (ii) data-driven robust network management; (iii) transport and datacenter network resilience; (iv) wireless and IoT network resilience, and (v) privacy and quality-of-service.

A. Reliable Network Virtualization

One of the main enablers for network virtualization is the deployment software-based network functions, which are typically distributed in the network infrastructure in the form of a sequence of functions, known as a service function chain (SFC). Achieving high level of availability for SFC is an active research topic, especially considering the importance of availability guarantees in the context of URLLC services.

Zheng et al. [A1] investigated the problem of fault-tolerant SFC deployment. The challenge is how to perform SFC embedding while considering multiple concurrent physical/virtual network failures and hardware/software failures, and while minimizing bandwidth resources consumption. The authors propose a fault-tolerant service function graph embedding (FT-SFGE) algorithm, which outperforms state-of-the-art solutions in terms of cost efficiency.

A similar fault-tolerant function placement problem in edge clouds, to jointly optimize latency and reliability, is studied in [A2]. The authors consider single chains, multiple chains (with and without order on functions), disjoint clusters (every function is implemented only once), and non-disjoint clusters. The authors prove that in some cases an optimal solution exists, but in other cases (e.g., for the case of multi chains in non-disjoint clusters) the problem needs to be tackled as a bi-objective problem. Moreover, the authors discuss the trade-off between the optimal solutions for each of the metrics and give an algorithm for the disjoint clusters case that allows tuning assignments according to specific system requirements (increasing reliability at the expense of latency or vice-versa).

In [A3], the authors investigate the network slicing problem taking into account reliability, considering the protection of each virtual path against any single link failures by a dedicated backup disjoint virtual path. Applied to 5Gnetworks, the authors propose a nested decomposition mathematical modeling and a column generation algorithm to solve it. Furthermore, the paper devises new acceleration schemes to reduce the computational time as well as the computation of dual bounds with Lagrangian relaxation to assess the solutions' accuracy.

The problem of sharing resources of different virtualized Cloud-RAN function (namely, virtualized BaseBand Units,

Digital Object Identifier 10.1109/TNSM.2023.3315095

or vBBUs) with co-located applications on the same Mobile Edge Computing (MEC) server is addressed in [A4]. The authors propose a run-time/dynamic CPU sharing mechanism for containerized virtualization in MEC servers hosting real-time applications. The proposed solution shows significant reduction in the execution time with respect to the default host RT-Kernel approach.

Taghavian et al. [A5] also model a SFC placement problem, and propose approaches for exact resolution using integer linear programming and column generation. The authors introduce their deterministic placement solution, which can obtain optimal results with the scalability of a heuristic-grade approach. Their method employs a branch and bound structure, applying artificial intelligence strategies to address the network service placement problem.

B. Data-Driven Robust Network Management

The increasing deployment of 5G networks in vertical industries makes accurate estimation of service resilience of paramount importance. As today's network infrastructure generates, more than ever, a large amount of monitoring data, new data-driven strategies for network resilience are being developed.

For example, traditionally, historical traffic and QoS measurements have been used to predict long-timescale variation of service quality. However, short timescale abnormal traffic is much more challenging to forecast and can cause service degradation. A model to estimate service resilience in a short timescale is presented in [A6]. A hierarchical Petri Net-based model is used to estimate 5G network service resilience performance. The model can capture the virtualized network characteristics and dynamic behaviors, and the authors show it can be applied to quantify network resilience.

Another traffic-monitoring technique is presented in [A7]. Despite years of research on traffic monitoring, most network operators, even today, are not able to reconstruct a complete view of their traffic matrix state, as they can only rely on partial measurements. In this study, author propose a new matrix completion and prediction algorithm based on a combination of generative autoencoders and Hidden Markov Models. Using extensive experimental evaluation based on both real-world datasets and on a testbed, the authors demonstrate that their algorithm can accurately reconstruct missing values while also predicting short-term traffic evolution.

Also for virtual-function placement, new data-driven approaches can be leveraged. Azadiabad et al. [A8] address the problem of joint placement Virtual Network Functions (VNFs) and virtual links (VLs) in a dynamic scenario. The authors propose a framework for the runtime adaptation of VNFs and VLs that reacts to changes and adapts the NS configuration so that it can fulfill their availability and continuity requirements. Machine learning models are proposed and evaluated in a testbed. Results show, for some case studies, how service availability and continuity requirements are guaranteed.

Recently, due to its successful application in other fields, Reinforcement Learning (RL) has been investigated for several applications in network management and routing. However, the need for frequent retraining and, more generically, its sample inefficiency, have hindered the actual deployment of RL-based routing in real environments. Bhavanasi et al. [A9], explore how to construct a RL policy capable of routing in dynamic network conditions without retraining. The proposed approach is compared to other routing protocols using various Quality-of-Service metrics.

Finally, as detecting abnormal network events is an important activity of Internet Service Providers, (particularly when running critical applications), the authors in [A10] present a comprehensive evaluation of eight unsupervised ML models selected from different classes of ML algorithms and applied to anomaly detection in the context of cloud-gaming applications. The authors further extended their study to apply a novel Window Anomaly Decision approach that overcomes drawbacks with existing approaches. They leveraged experimental results to provide insights about the most relevant models for detecting QoE degradation and offer recommendations on their suitability for different application requirements.

C. Transport and Datacenter Network Resilience

Resilience is a traditional research topic in transport networks, yet novel directions are always emerging, stimulated by new emerging technologies as time deterministic networking, network programmability, and optical network disagreggation.

In [A11], insights are provided into the importance of service protection in time-deterministic networks. The authors examine the per-packet-based replication/elimination service protection mechanisms, ongoing standardization efforts, and potential areas for further development. They also provide insights on the practical implementation of this service protection technique in real network scenarios, including its impact on operation and maintenance, and evaluate its effectiveness on a real 5G testbed.

Regarding emerging programmable networks, a mechanism, designated as In-network Fast ReRouting (InFaRR), for fast rerouting in case of link failures is proposed in [A12], exploiting programmable switches and P4. InFaRR presents four features that are not jointly found in other recovery mechanisms: loop prevention, pushback, recognition and restoration, and return to the main route. The performance of InFarr was evaluated for single and up to three simultaneous failures on various Fat-Tree topologies. Results show it performs better than three other approaches (adapted to work in P4).

As for optical networks, three papers, [A13], [A14] and [A15], highlight recent directions emerging in this area. [A13] deals with problem of the planning a survivable optical network equipped with the latest generation of point-to-multipoint coherent optical transceivers. The authors address single-link failures with shared backup path protection (SBPP), and formulate both an Integer Linear Programming (ILP) model and a more time-efficient heuristic to solve the problem. Simulation results show heuristic approach approximates well the optimal results from the ILP and presents better performance than two other greedy-based benchmarks.

Borraccini et al. [A14] demonstrate the advantages of disaggragation in terms of efficiency and cost reduction. Disaggregation contributes to augment network reliability, allowing also to trade-off between robustness and maximum capacity exploitation. The work presents an optical network architecture leveraging a physical-layer digital twin within a multi-layer hierarchical control. An experimental proof of concept is described using open re-configurable optical add & drop multiplexers and white-box transponders. The reliability of the proposed architecture is experimentally demonstrated mimicking the use case of an automatic failure recovery from a fiber cut.

Liu et al. [A15] address the disaster-resilient SFC provisioning problem in elastic optical inter-datacenter networks, seeking to minimize power and spectrum usage, under disaster resilience constraints. Given the dependence of today's society on network communications, protection methods that will guarantee SFC-based connections survive a disaster failure in EO-DCNs are most relevant. An ILP model is formulated to solve the problem, but given its large execution time, a heuristic is also proposed. Numerical simulation results show that the proposed disaster protection schemes reduce significantly power consumption.

In [A16] the author concentrates on an emerging architecture for datacenter networks, and studies fundamental survivability properties of HyperX, a recent and relevant proposal in this area. The study examines the availability of disjoint paths connecting a pair of input nodes in HyperX and explores the trade-off between allowing longer paths and extending available sets of disjoint paths. Simulative and analytical evaluations illustrate properties of path availability and the potential impact of failures in HyperX.

D. Wireless and IoT Network Resilience

Resilience is a primary concern also for future wireless and IoT networks.

Miranda et al. [A17] argue that Time-Sensitive Networking (TSN) is a vital technology to enable time-critical deterministic communication for many applications with industrial-grade requirements. Achieving multi-domain end-to-end TSN communication, however, requires addressing challenges on end-to-end time synchronization, multi-domain control-plane interoperability, run-time end-to-end scheduling, and fine-grained monitoring. Accordingly, the authors present a novel, fully-programmable controller for end-to-end TSN-enabled networks; their controller is based on a modular architecture. They deployed a proof-of-concept testbed to evaluate key performance indicators and demonstrated the effectiveness of the controller in performing seamless fine-grained traffic control.

Yacheur et al. [A18] propose a scalable hybrid vehicular-communication architecture that leverages the performance of multiple Radio Access Technologies (RATs). The authors present a novel station protocol stack for Intelligent Transportation Systems, and a decentralized RAT selection strategy that uses Deep Reinforcement Learning (DRL). The proposed approach employs a double deep Q-learning algorithm which allows each vehicle to determine the optimal RAT combination to meet the specific needs of the V2X application while limiting resource consumption. The ability of the proposed architecture to offer reliable and high throughput communication in two different scenarios with varying traffic flow densities is studied and validated.

Azari et al. [A19] investigate the energy-reliability trade-off of IoT communications in coexisting scenarios, i.e., scenario where multiple competing radio-access technologies share spectrum resources. The focus is on solutions exploiting grant-free communications, which have been adopted in recent IoT technologies, like SigFox and LoRa, due to their potential for lower the energy consumption. The authors show how proper adjustment of communications parameters at the device side and proper provisioning resources at the network side allow to minimize energy consumption in coexisting scenarios. Analytical results and simulative numerical evaluations are provided in some representative network setups.

Rosa et al. [A20] develop a lightweight secure access enhancement (Light-SAE) key distribution scheme for multi-hop IoT networks. They propose a modular solution capitalizing on the strengths of lightweight cryptography to offer an approach that can be easily adapted to meet the needs of private wireless sensor networks. The solution is designed to work in multi-hop communication networks.

E. Privacy and Quality-of-Service

The studies published in this Special Section cover also research topics related to privacy and quality of service.

Zainudin et al. [A21] propose a low-complexity intrusion detection and classification method for SDN-enabled industrial cyber-physical systems. The proposed framework is based on Federated Learning and utilizes Chi-square and Pearson correlation coefficient for feature selection, in order to reduce model complexity and boost performance. The proposed model is evaluated realistic SDN and IoT datasets, and achieves higher accuracy, lower computational cost, and lower complexity compared to state-of-the-art approaches.

Consumer privacy is a major concern also in Content-Centric Networking (CCN). A new approach to increase privacy for the end-user on CCN is introduced in [A22]. The performance of the proposed approach is evaluated using a prototype implemented on a P4 switch that provides Tbps forwarding speed.

Carofiglio et al. [A23] address the problem to guarantee high-quality, reliable, in-time delivery over the Internet and at a global worldwide scale for real-time communications services. They propose ROBUST, a Reliable and Flexible Media Transport based on pub/sub-information-centric networking principles. ROBUST enhances reliability and flexibility to real-time applications over varying network environments and conditions.

Finally, Bolla et al. [A24] address the challenging case of reliable cooperation between humans and robots in a factory automation context. The authors propose an optimization problem to select redundant radio bearers for each user equipment in a beyond-5G network. Additionally, they propose and evaluate heuristics to effectively solve the problem.

Acknowledgment

The editors would like to sincerely thank all authors who submitted papers to this special section and all reviewers for their relevant comments, constructive suggestions, and timely submission of their reviews. Finally, we appreciate the support of the Editor-in-Chief, Hanan Lutfiyya, and Janine Bruttin, IEEE TNSM Administrative Assistant, for their precious help in the preparation of this special section. Teresa Gomes, was partially funded by FCT – Fundação para a Ciência e a Tecnologia, I.P. under the project UIDB/00308/2020. Massimo Tornatore acknowledges the support of U.S.-Japan JUNO3 project, NSF Grant no. 2210384.

APPENDIX: RELATED ARTICLES

[A1] D. Zheng, G. Shen, Y. Li, X. Cao, and B. Mukherjee, "Service function chaining and embedding with heterogeneous faults tolerance in edge networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2157–2171, Sep. 2023, doi: 10.1109/TNSM.2022.3220667.

[A2] R. B. Haim and O. Rottenstreich, "Low-latency and reliable virtual network function placement in edge clouds," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2172–2185, Sep. 2023, doi: 10.1109/TNSM.2023.3298089.

[A3] B. Jaumard and Q. H. Duong, "A nested decomposition model for reliable NFV 5G network slicing," *IEEE Trans. Netw. Service Manag.*, vol. 20, no. 3, pp. 2186–2200, Sep. 2023, doi: 10.1109/TNSM.2023.3298090.

[A4] A. F. Ocampo, M.-R. Fida, J. F. Botero, A. Elmokashfi, and H. Bryhni, "Opportunistic CPU sharing in mobile edge computing deploying the cloud-RAN," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2201–2217, Sep. 2023, doi: 10.1109/TNSM.2023.3304067.

[A5] M. Taghavian, Y. Hadjadj-Aoul, G. Texier, N. Huin, and P. Bertin, "An approach to network service placement reconciling optimality and scalability," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2218–2229, Sep. 2023, doi: 10.1109/TNSM.2023.3284602.

[A6] R. Li, B. Decocq, A. Barros, Y.-P. Fang, and Z. Zeng, "Estimating 5G network service resilience against short timescale traffic variation," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2230–2243, Sep. 2023, doi: 10.1109/TNSM.2023.3269673.

[A7] A. Sacco, F. Esposito, and G. Marchetto, "Completing and predicting Internet traffic matrices using adversarial autoencoders and hidden Markov models," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2244–2258, Sep. 2023, doi: 10.1109/TNSM.2023.3270166.

[A8] S. Azadiabad, F. Khendek, and M. Toeroe, "Runtime adaptation framework for fulfilling availability and continuity requirements of network services," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2259–2282, Sep. 2023, doi: 10.1109/TNSM.2023.3280944.

[A9] S. S. Bhavanasi, L. Pappone, and F. Esposito, "Dealing with changes: Resilient routing via graph neural networks and multi-agent deep reinforcement learning," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2283–2294, Sep. 2023, doi: 10.1109/TNSM.2023.3287936.

[A10] J. R. Ky, B. Mathieu, A. Lahmadi, and R. Boutaba, "ML models for detecting QoE degradation in low-latency applications: A cloud-gaming case study," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2295–2308, Sep. 2023, doi: 10.1109/TNSM.2023.3293806.

[A11] B. Varga, J. Farkas, F. Fejes, J. Ansari, I. Moldován; M. Mátè, "Robustness and reliability provided by deterministic packet networks (TSN and DetNet)," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2309–2318, Sep. 2023, doi: 10.1109/TNSM.2023.3284590.

[A12] F. L. Verdi and G. V. Luz, "InFaRR: In-network fast rerouting," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2319–2330, Sep. 2023, doi: 10.1109/TNSM.2023.3283459.

[A13] Y. Zhang, Q. Lv, R. Li, X. Tian, and Z. Zhu, "Planning of survivable wavelength-switched optical networks based on P2MP transceivers," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2331–2342, Sep. 2023, doi: 10.1109/TNSM.2023.3287302.

[A14] G. Borraccini et al., "Experimental demonstration of partially disaggregated optical network control using the physical layer digital twin," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2343–2355, Sep. 2023, doi: 10.1109/TNSM.2023.3288823.

[A15] Y. Liu, F. Zhou, T. Shang, and J.-M. Torres-Moreno, "Disaster protection for service function chain provisioning in EO-DCNs," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2356–2369, Sep. 2023, doi: 10.1109/TNSM.2023.3293815.

[A16] O. Rottenstreich, "Path diversity and survivability for the HyperX datacenter topology," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2370–2385, Sep. 2023, doi: 10.1109/TNSM.2023.3285914.

[A17] G. Miranda, E. Municio, J. Haxhibeqiri, J. Hoebeke, I. Moerman, and J. M. Marquez-Barja, "Enabling time-sensitive network management over multi-domain wired/Wi-Fi networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2386–2399, Sep. 2023, doi: 10.1109/TNSM.2023.3274590.

[A18] B. Y. Yacheur, T. Ahmed, and M. Mosbah, "Efficient DRL-based selection strategy in hybrid vehicular networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2400–2411, Sep. 2023, doi: 10.1109/TNSM.2023.3300653.

[A19] A. Azari, M. Masoudi, V. Stefanović, and C. Cavdar, "Reliable and energy-efficient IoT systems: Design considerations in coexistence deployments," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2412–2427, Sep. 2023, doi: 10.1109/TNSM.2023.3296059.

[A20] P. Rosa, A. Souto, and J. Cecílio, "Light-SAE: A lightweight authentication protocol for large-scale IoT environments made with constrained devices," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2428–2441, Sep. 2023, doi: 10.1109/TNSM.2023.3275011.

[A21] A. Zainudin, R. Akter, D.-S. Kim, and J.-M. Lee, "Federated learning inspired low-complexity intrusion detection and classification technique for SDN-based industrial CPS," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2442–2459, Sep. 2023, doi: 10.1109/TNSM.2023.3299606.

[A22] Y. Yoshinaka, K. Kita, J. Takemasa, Y. Koizumi, and T. Hasegawa, "Programmable name obfuscation framework for controlling privacy and performance on CCN," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2460–2474, Sep. 2023, doi: 10.1109/TNSM.2023.3275250.

[A23] G. Carofiglio, G. Grassi, L. Muscariello, M. Papalini, and J. Samain, "ROBUST: A reliable and flexible media transport for real-time services," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2475–2488, Sep. 2023, doi: 10.1109/TNSM.2023.3293871.

[A24] R. Bolla et al., "Adaptive reliability for the automated control of human-robot collaboration in beyond-5G networks," *IEEE Trans. Netw. Service Manag.*, vol. 20, no 3, pp. 2489–2503, Sep. 2023, doi: 10.1109/TNSM.2023.3298171.

MASSIMO TORNATORE
Department of Electronics, Information and Bioengineering
Politecnico di Milano
20133 Milan, Italy

TERESA GOMES
Department of Electrical and Computer Engineering
University of Coimbra
3030-290 Coimbra, Portugal
INESC Coimbra
DEEC
3030-290 Coimbra, Portugal

CARMEN MAS-MACHUCA
University of the Bundeswehr Munich
85579 Neubiberg, Germany

EIJI OKI
Graduate School of Informatics
Kyoto University
Kyoto 606-8501, Japan

CHADI ASSI
Concordia University
Montreal, QC H3G 1M8, Canada

DOMINIC SCHUPKE
Central Research and Technology
Airbus
81663 Munich, Germany

Massimo Tornatore (Fellow, IEEE) received the Ph.D. degree from the Politecnico di Milano in 2016, where he is currently a Professor. He has also held appointments as an Adjunct Professor with the University of California at Davis, Davis, USA, and as a Visiting Professor with the University of Waterloo, Canada. His research interests include performance evaluation and optimization of communication networks (with an emphasis on optical networking), cloud computing, and machine learning application for network management. In these areas, he coauthored more than 400 peer-reviewed conference and journal papers (with 19 best paper awards), two books, and one patent. He is an Editorial Board Member of IEEE COMMUNICATION SURVEYS AND TUTORIALS, IEEE/ACM TRANSACTIONS ON NETWORKING, IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT, and IEEE COMMUNICATION LETTERS.

Teresa Gomes (Member, IEEE) received the M.Sc. degree in computer science and the Ph.D. degree in electrical engineering (telecommunications and electronics) from the University of Coimbra, Portugal, in 1989 and 1998, respectively, where she is currently an Assistant Professor. She is also a Researcher with the Institute for Systems Engineering and Computers, Coimbra. From April 2013 to July 2013, she was a Visiting Researcher with the School of Information Sciences, University of Pittsburgh, USA. She is the author/coauthor of over 100 technical publications in international journals, conference proceedings, and book chapters, including one European patent. She has been responsible for several national projects, mainly with industry. Her main interests are routing, protection, and reliability analysis models and algorithms for communication networks. She served as a TPC member of numerous international conferences. She was the General Chair of ONDM 2023, the TPC Co-Chair of ONDM 2022, and the Co-Chair of DRCN 2019. She is an Associate Editor of *Journal of Network and Systems Management* (Springer), and IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT.

Carmen Mas-Machuca (Senior Member, IEEE) is Currently a Professor with the Communication Networks Chair, University of the Bundeswehr Munich (UniBW). Since 2005, and prior to her appointment with UniBW, she had been working with the Chair of Communication Networks, Technical University of Munich. The planning problems are applied to single and multiple domains or technologies as well as to new solutions (e.g., QKD). She has published more than 150 peer-reviewed articles. Her research interests cover several topics related to optimal network planning taking reliability, resources, service requirements, and security and/or cost into account. She is a Guest Editor of IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT, IEEE/OSA JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING, and *IEEE Communications Magazine* and also active in international conferences as the chair, the TPC co-chair, and a TPC member.

Eiji Oki (Fellow, IEEE) received the B.E. and M.E. degrees in instrumentation engineering and the Ph.D. degree in electrical engineering from Keio University, Yokohama, Japan, in 1991, 1993, and 1999, respectively. He is a Professor with Kyoto University, Kyoto, Japan. From 1993 to 2008, he was with Nippon Telegraph and Telephone Corporation Laboratories, Tokyo, Japan. From 2000 to 2001, he was a Visiting Scholar with Polytechnic University, Brooklyn, NY, USA. He was with The University of Electro-Communications, Tokyo, from 2008 to 2017. He joined Kyoto University in 2017. He has been active in standardization of path computation element in IETF. He has authored/contributed to 12 IETF RFCs. His research interests include routing, switching, protocols, optimization, and traffic engineering in communication and information networks. He is an IEICE Fellow.

Chadi Assi (Fellow, IEEE) received the Ph.D. degree from the City University of New York (CUNY). During his Ph.D., he worked on optical networks, and namely on lightpath provisioning and survivability. He spent a year as a Visiting Researcher with Nokia Research Center, Boston. where he worked on quality of service in passive optical access networks. He joined Concordia University as an Assistant Professor in 2003, where he is currently a Full Professor. He was a Concordia Research Chair (Tier 2) from 2012 to 2017, then since 2017, he has been holding the Research Chair, Tier 1. His research interests are in the general area of networks and telecommunications (both wired and wireless), (IoT) cyber security, and smart grids. He was the recipient of the Prestigious Mina Rees Dissertation Award from CUNY in 2002, for his research on wavelength division multiplexing in optical networks. He serves or served on the editorial board of several flagship journals of the IEEE. He was elevated to an IEEE Fellow by the Communications Society for "contributions to resource allocation for optical and wireless networks."

Dominic Schupke (Senior Member, IEEE) received the Dr.-Ing. degree (summa cum laude) in electrical engineering and information technology from RWTH Aachen, Imperial College London, and the Technical University of Munich (TUM). He is a Research Leader of Reliable Communication Networks, currently focusing on Wireless Communications with Airbus, Munich, Germany. He is also a Lecturer of Network Planning with TUM. Prior to Airbus, he was with Nokia, Siemens, and TUM. He is a author or a coauthor of more than 150 journal and conference papers (Google Scholar H-index 32). His recent research addresses aerospace networks.