JOURNAL OF
Optical Communications
and Networking

# Introduction to the ONDM 2022 special issue

Jarosław Piotr Turkiewicz,[1,*] Teresa Gomes,[2] Mirosław Klinkowski,[3] Jacek Rak,[4] and Massimo Tornatore[5]

[1]Warsaw University of Technology, Poland
[2]University of Coimbra, INESC Coimbra, DEEC, Portugal
[3]National Institute of Telecommunications, Warsaw, Poland
[4]Gdańsk University of Technology, Poland
[5]Politecnico di Milano, Italy
*jaroslaw.turkiewicz@pw.edu.pl

Received 13 April 2023; published 27 April 2023

**This JOCN special issue contains extended versions of selected papers presented at the 26th International Conference on Optical Network Design and Modeling (ONDM 2022), which took place 16–19 May 2022 at Warsaw University of Technology, Warsaw, Poland. The topics covered by the papers represent trends in optical networking research: application of machine learning to network management, cross-layer network performance optimization, visible light communication as well as coherent metro networks.** 

https://doi.org/10.1364/JOCN.493228

This special issue features the extended versions of selected papers presented at the 26th International Conference on Optical Network Design and Modeling (ONDM 2022), which took place on 16–19 May 2022. The conference was organized in the hybrid form at Warsaw University of Technology, Warsaw, Poland. Traditionally, the conference addresses cutting-edge research in established areas of optical networking and their adoption in support of a wide variety of new services and applications. This includes the most recent trends such as 5G/6G, data-center networking, the Internet of Things, cloud/edge computing, network real-time monitoring, artificial intelligence/machine learning (ML) based network design and management, visible light networks, and quantum communication. The program featured 21 contributed papers and 6 posters, as well as 3 keynotes, 16 invited talks, and 3 tutorials. With over 230 guest all over the world, ONDM 2022 was a very successful conference. The papers included in this special issue outline the current trends in optical networking research, ranging from the influence of network topology on network performance as well as optical wireless communication through the application of ML techniques to network management to coherent transmission networks.

**Key Physical Topology Features for Optical Backbone Networks via a Multilayer Correlation Analysis**

Modern communication networks are formed by layered technologies. The paper "Key physical topology features for optical backbone networks via a multilayer correlation analysis" by Katsuaki Higashimori *et al.* investigates the impact of the physical topology on the network performance. The authors developed the correlation analysis framework between the physical topology and layer 1 that allows quantitative comparison of topology features. The proposed framework is applied to investigate the relationship between physical topology features and the total communication capacity, cost, and robustness of optical communication networks. It is found that two nonspectral quantities, the average path length and the cluster coefficient, and two spectral quantities, the Laplacian spectral radius and the geodesic distance Laplacian spectral radius, are the key topological features affecting the overall system performance.

**Machine Learning Aided Optimization for Balanced Resource Allocations in SDM-EONs**

Elastic optical networks (EONs) allow more efficient use of the optical bandwidth. Parallel multicarrier distance adaptive transmissions on different cores of the same fiber can be achieved using multicore fiber based space division multiplexed (SDM) EONs (SDM-EONS). However, the quality of transmission (QoT) is affected by the intercore crosstalk (XT) of parallel transmissions on the same fiber. The establishment of end-to-end lightpaths, with adequate bandwidth, ensuring the required QoT, in SDM-EON networks requires solving the routing, modulation, core, and spectrum assignment (RMCSA) problem. The interdependence between the selected cores, the spectrum choices in each core, and the selected modulation format have an impact on the XT (which impacts the QoT) and makes the RMCSA problem difficult to solve. The paper "Machine learning aided optimization for balanced resource allocations in SDM-EONs" by S. Petale and S. Subramaniam presents a ML aided optimization strategy for the selection of optimal thresholds on the number of adjacent cores that can be occupied that improves the performance of any RMCSA algorithm for any network model. The authors also propose the spectrum wastage avoidance based resource

allocation (SWARM) algorithm and show it has better performance than other RMCSA algorithms. Moreover, they verified the ML-optimized version of SWARM had better performance than the ML-optimized version of other RMCSA algorithms.

**Scalable Filterless Coherent Point-to-Multipoint Metro Network Architecture**

The increase in the data traffic of service providers results in higher bandwidth capacity demands in optical networks and requires new optical technological solutions. In the case of metro access networks, this creates pressure for low-cost, low-power, interoperable, and standardized solutions due to the large number of devices to deploy. To overcome the data rate limitations of legacy 10G/25G intensity modulation direct detection (IM-DD), which is still the predominant equipment, new solutions have been proposed. Castro *et al.*, in "Scalable filterless coherent point-to-multipoint metro network architecture," consider the utilization of digital subcarrier (DSC) based optical networks based on coherent point-to-point (P2P) and point-to-multipoint (P2MP) connections in access metro networks. The two solutions are evaluated through a cost analysis for different network topologies and traffic matrices. Results show the greater flexibility of DSC-based coherent modules leads to significant cost savings over three considered phases that represent the growth of traffic with time: short-, mid-, and long-term. Namely, results confirm the use of coherent P2MP leads to significant savings when compared with P2P, assuming the matching transmission performance of both solutions. Additionally, data obtained from a real-world experimental scenario is presented.

**Exploring the Relationship among Traffic, Topology, and Throughput: Towards a Traffic-Optimal Optical Network Topology Design**

One of the principal constraints in optical networks is the physical topology, which impacts the performance and the costs of building and managing the network. In the network topology design, maximizing network throughput is a key optimization target. The challenge of designing networks with maximum throughput comes from the complexity of the involved computational problems. For this reason, developing computationally efficient methods for the topology design problem is of high importance. The paper "Exploring the relationship among traffic, topology, and throughput: towards a traffic-optimal optical network topology design" by R. Luo *et al.* focuses on the classical, NP-hard problem of physical topology design for optical networks, in which the optimization goal is to maximize the network throughput. The authors propose a novel objective function of the polynomial complexity, namely, the demand weighted cost (DWC) metric, which parameterizes the relationship between network topology and traffic demand. The DWC metric has advantageous features such as high correlation to network throughput and fast evaluation time. The performance of the metric is analyzed within three different topology optimization algorithms, showing significant throughout enhancements for both small-scale and large-scale topology designs.

**Techno-Economic Study of Very Dense Optical Wireless Access Using Visible or Infrared Light**

The cost of deployment of optical wireless access providing high-quality services to a high density of end-user devices is one of the major issues in the design of future wireless architectures. In "Techno-economic study of very dense optical wireless access using visible or infrared light," C. Mas-Machuca *et al.* present the respective cost analysis for a scenario of optical wireless communications in a large production hall. Two selected topologies of light fidelity networks are compared, and the results for a rich set of characteristics (referring to the fronthaul cabling layout, equipment investments, installation, and operational costs for energy and maintenance) are provided for greenfield and brownfield scenarios. The techno-economic analysis concerning the total cost of ownership is presented and extended by a discussion of the contribution of each cost category to the final cost. In conclusion, two factors, the delivered capacity and the power consumption, have been underlined by the authors as the two most crucial parameters in the cost analysis of optical wireless access.

**Link Load Prediction in an Optical Network with Restoration Mechanisms**

Applications of ML for traffic load prediction have been intensively investigated in the past decade in different network segments and network technologies. The paper "Link load prediction in an optical network with restoration mechanisms" by Knapińska *et al.* successfully approaches this classical problem from a new angle, by investigating how to gain accurate link load prediction in a situation of a link failure followed by restoration in optical core networks. The proposed methodologies are based on multistep moving-window forecasts that target link-load prediction in terms of overall bitrate allocated on a link and number of frequency slots occupied. The proposed prediction methods are evaluated on a representative European network topology with realistic traffic, and extensive numerical evaluations confirm the high forecast accuracy of the proposed methodology.

We are convinced that the presented papers will inspire the readers to conduct new groundbreaking research. We would like to thank the authors for extending their work and preparing the papers as well as the reviewers for their inspiring feedback. We are very grateful to the Editor-in-Chief Andrew Lord and the JOCN staff for their continuous help and support.

Guest editors:
Jarosław Turkiewicz, Warsaw University of Technology, Poland,
Lead Guest Editor
Teresa Gomes, University of Coimbra, INESC Coimbra, DEEC, Portugal
Mirosław Klinkowski, National Institute of Telecommunications, Poland
Jacek Rak, Gdańsk University of Technology, Poland
Massimo Tornatore, Politecnico di Milano, Italy