Introduction to the JOCN special issue on ONDM2020

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This JOCN Special Issue covers extended versions of high quality papers that were initially presented at the *24th International Conference On Optical Networks Design and Modelling* (ONDM2020) Conference. Amongst the invited and submitted contributions, four papers were selected for the S.I., based on the conference paper reviews and score, novelty, impact, and potential extensibility.

The topics covered by the papers of the Special Issue represent clear trends in current research in optical networks including filterless networks and their applicability to metropolitan scenarios; programmable, SDN-enabled sliceable bandwidth variable transceivers supporting multi-dimensionality and selected applications of Machine Learning to the cognitive reconfiguration of data-center networks in support of high-performance computing and to quality of transmission estimation for reduced margins.

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This JOCN Special Issue (S.I.) covers selected papers that were presented at the *24th International Conference On Optical Networks Design and Modelling* (ONDM2020), which took place, virtually, during May 18-21, 2020. As in previous years, ONDM addresses cutting-edge research in established areas of optical networking and its adoption in support of a wide variety of new services and applications. This includes the most recent trends such as new architectures, photonic technologies, and solutions for optical networks, 5G and beyond; data-center networking, cloud/edge computing, big data, data analytics, network telemetry or machine learning. ONDM2020 keynote speakers covered the topics of FPGAs, the evolution of optical networking and quantum cryptography. The technical sessions included 4 tutorials on machine learning, quantum networking telemetry and 5G slicing, 14 invited talks, 27 oral papers, and 11 posters.

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Filterless networks

Filterless networks are known to offer a low-cost alternative to networks encompassing typical devices such as Reconfigurable Optical Add/Drop Multiplexers (ROADMs) or Wavelength Selective Switches (WSS)s, with large potential gains regarding Capacity Expenses (CapEx) and Operational Expenses(OpEx). Filterless networks are based on a combination of passive optical devices (such as splitters or couplers), interconnectors, advanced transmission systems and efficient routing algorithms. Although the main concepts and initial works on filterless networks date of early 2000, the interest on filterless networks has been renewed in view of their use in 5G metro and x-haul networks. On the other hand, supporting bidirectional connections on a single fiber is of interest in the case of scarce fiber availability.

In this scope, in the paper *"Bidirectional single-fiber filterless optical networks: modeling and experimental assessment*", by Dimitris Uzunidis *et al.*, the design and validation of a metropolitan network using filterless technology is presented, focusing on the use of a single fiber to support bidirectional transmission, using optical circulators. The paper presents the corresponding node architectures, a methodology to study the physical layer performance and includes an experimental validation of a portion of the considered horseshoe metro network supporting bidirectional transmission.

Machine Learning

The use of Machine Learning (ML) in aspects related to optical transmission, quality of service validation, fault localization or in support of network operations is growing notably given, for example, the benefits of approaches (such as Deep Reinforcement Learning) in complex scenarios. Two papers of the special issue fit in this category.

The first application is related to High Performance Computing (HPC). There has been a significant amount of architectural and experimental research in optical switching and interconnects for DC and HPC systems, aiming at improving metrics such as the scalability and performance of large-scale cloud computing systems, reducing the cost, power consumption and operational expenses. To a large extent, such works replace (partially or completely) electronic switches, including the use of optical circuit switching where there is a clear benefit in doing so, e.g., in traffic offloading use cases.

The paper "*Machine-learning-aided cognitive reconfiguration for flexible-bandwidth HPC and data center networks"* by Xiaoliang Chen *et al.*, addresses the use of ML-aided cognitive mechanisms, with applicability in optical interconnected data-centers and high-performance computing scenarios. After a formulation of a routing scheme optimization as a mixed-integer linear programming model and the use of a classical joint optimization and two-phase heuristic, an ML-based end-to-end performance estimator proposed to assist the network control plane.

Another clear domain of applicability of Machine Learning is related to the estimation of QoT parameters. A common pattern in the design of optical networks includes the planning of links and the estimations of e.g., the Bit Error Rate (BER) on a per service basis. Despite the availability of advanced tools to compute such values, network operators often add "design margins", thus overengineering the links, to account for factors like model inaccuracies, lack of detailed data or equipment aging. Improvements on the accuracy of QoT estimations have a direct benefit on network operators. In this regard, the paper "*Associating machine-learning and analytical models for quality of transmission estimation: combining the best of both worlds*" by Emmanuel Seve *et al.* associates machine learning with the Gaussian Noise model, in order to reduce uncertainties in the output power profiles and noise figure of each amplifier. The learning process is based on a gradient-descent algorithm where all the uncertain input parameters of the analytical model are iteratively modified from their estimated values to match with the SNR of light paths, achieving design margin reductions to 0.1 dB for new traffic demands.

Sliceable Bandwidth-Variable Transceivers

In optical networking, partial disaggregation refers to the decoupling of the transceivers and of (open) line system, so the operators have the flexibility to optimize their networks, in terms of cost and efficiency. Disaggregation is a common scenario for Software-defined networking (SDN) and data model developments. With their own trade-offs, disaggregated and open networking solutions will reduce vendor lock-in, potentially achieving increased flexibility and programmability

In this context, SDN-enabled sliceable bandwidth/bitrate variable transceivers (S-BVTs) are proposed for metro networks to provide sustainable capacity growth. The last paper of this Special Issue, "*Programmable disaggregated multi-dimensional S-BVT as an enabler for high capacity optical metro networks*" by Laia Nadal *et al.* transceiver multi-dimensionality is presented exploiting spatial, polarization, and spectral information as a solution to support network capacity and bandwidth scaling for 5G requirements. In this work, multi-band transmission is assessed by exploiting the C-band and L-band. In paper analyzes and experimentally demonstrates different S-BVT advanced functionalities, including rate/distance adaptability, programmability/configurability, disaggregation, and multi-dimensionality. Different network scenarios have been considered to assess the S-BVT functionalities, enabling Tb/s optical transmission.