

Editorial

Special Issue on Optical Communication Networks: Advancements and Future Directions

Shu-Hao Chang 

Science and Technology Policy Research and Information Center, National Institutes of Applied Research,
Taipei 10636, Taiwan; shchang@niar.org.tw

In the field of photonics, research on optical communication networks has long been one of the most dynamic and rapidly advancing topics. When Dr. Shu-Hao Chang was invited to edit a Special Issue of *Photonics* titled “Optical Communication Networks: Advancements and Future Directions” (https://www.mdpi.com/journal/photonics/special_issues/H14EBF6SQC), he gladly accepted the challenge. Later, Dr. Chang proposed inviting Dr. Chin-Yuan Fan as Co-Editor, forming the editorial team for this Special Issue. Building on this foundation, we invited distinguished experts and scholars in the field to share their insights and collectively explore the current status and future development of optical communication networks.

In recent years, optical communication networks have experienced rapid development, with technologically advanced countries investing significant resources and labor to build the infrastructure required for these networks. This has led to an explosive growth in data traffic, highlighting both the critical role of optical communication networks and the increasing demand for this technology. Consequently, we have focused on compiling and presenting forward-looking technologies and guidelines in this field.

In this Special Issue, we emphasize recent advancements in photonic integrated circuits, elastic optical networks, and a fiber assignment algorithm, as well as the optimized planning of survivable optical 5G XHaul access networks. The details are given below. Pandey et al. present an extended version of in-PIC temperature monitoring. This approach can be applied to any photonic integrated circuit platform, enabling simplified temperature monitoring and improved independence from the interrogating laser wavelength. Their work provides concrete experimental evidence demonstrating the feasibility of detecting relative temperature using differential mode, also extending the previous work [1] on temperature monitoring at the chip surface.

In addition, Bouchmal et al. propose an innovative quantum-based approach to address the routing and spectrum assignment (RSA) problem in elastic optical networks (EONs), aiming to minimize end-to-end delay while respecting the continuity and contiguity constraints of the selected frequency slots. The inherent capability of EONs to reconfigure the network in real time enhances resilience and scalability, making them particularly suitable for next-generation networks, including 5G and beyond [2], and ensuring seamless connectivity and optimized performance across diverse network scenarios [3]. Xhaul, which comprises the fronthaul, midhaul, and backhaul segments, is already deployed in fifth-generation mobile networks (5G) [4,5] and is expected to be integral to future sixth-generation (6G) networks [6]. Building on this context, Klinkowski present a novel dedicated path protection scheme with flexible switching for passive optical 5G Xhaul access networks, aiming to improve network survivability while optimizing cost efficiency.

In recent years, telecommunications traffic has grown tremendously due to the rise of applications and services that demand high bandwidth and generate massive amounts



Received: 7 November 2025

Accepted: 10 November 2025

Published: 11 November 2025

Citation: Chang, S.-H. Special Issue on Optical Communication Networks: Advancements and Future Directions. *Photonics* **2025**, *12*, 1111. <https://doi.org/10.3390/photonics12111111>

Copyright: © 2025 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

of data, including video streaming platforms, social media, cloud computing, and the adoption of emerging technologies such as 5G and artificial intelligence [7]. This rapidly evolving landscape calls for the deployment of ultra-high-speed networks, such as optical networks. Since network capacity is a critical factor affecting optical network performance [8–10], Freitas and Pires propose a method to evaluate network capacity that considers the optical reach to account for physical layer constraints, in combination with constrained routing techniques for traffic management. Because this type of routing can result in traffic blocking—particularly due to limitations on the number of wavelengths per fiber—they also introduce a fiber assignment algorithm that is specifically designed to address this issue.

The contributions included herein demonstrate significant advancements in network design, optimization, and photonic integration, offering valuable guidance for both academic researchers and industry practitioners aiming to address the challenges and opportunities in next-generation communication infrastructures. Through these combined efforts, the Special Issue underscores the critical role of optical communication networks in supporting the exponential growth of data traffic and the development of future technologies.

In summary, clarifying the current development trends and key directions of optical communication networks remains one of the most active research areas for both industry and academia. In particular, in the era of AI, the optical communications industry is emerging as a critical sector enabling us to meet the enormous data exchange demands of generative AI models. It is our hope that this Special Issue not only summarizes the various research directions but also encourages further investigation and innovation by researchers in this vibrant and rapidly evolving field.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Pandey, S.; Abejide, A.E.; Rodrigues, F.; Lima, M.; Teixeira, A. Grating-Based Structure for in-PIC Temperature Monitoring. In Proceedings of the 2023 23rd International Conference on Transparent Optical Networks (ICTON), Bucharest, Romania, 2–6 July 2023; pp. 1–4.
2. Jinno, M. Elastic Optical Networking: Roles and Benefits in Beyond 100-Gb/s Era. *J. Light. Technol.* **2017**, *35*, 1116–1124. [\[CrossRef\]](#)
3. Chatterjee, B.; Oki, E. *Elastic Optical Networks: Fundamentals, Design, Control, and Management*; CRC Press: Boca Raton, FL, USA, 2020.
4. Chih-Lin, I.; Korhonen, J.; Huang, J.; Han, L. RAN Revolution with NGFI (xhaul) for 5G. *IEEE J. Lightw. Technol.* **2018**, *36*, 541–550.
5. O-RAN Alliance. Xhaul Transport Requirements Tech. Spec. v1.0. 2021. Available online: <https://www.o-ran.org/> (accessed on 9 November 2025).
6. Sizer, T.; Samardzija, D.; Viswanathan, H.; Le, S.T.; Bidkar, S.; Dom, P.; Harstead, E.; Pfeiffer, T. Integrated Solutions for Deployment of 6G Mobile Networks. *IEEE J. Lightw. Technol.* **2022**, *40*, 346–357. [\[CrossRef\]](#)
7. Winzer, P.J.; Neilson, D.T. From scaling disparities to integrated parallelism: A decathlon for a decade. *J. Lightw. Technol.* **2017**, *35*, 1099–1115. [\[CrossRef\]](#)
8. Essiambre, R.-J.; Kramer, G.; Winzer, P.J.; Foschini, G.J.; Goebel, B. Capacity limits of optical fiber networks. *J. Lightw. Technol.* **2010**, *28*, 662–701. [\[CrossRef\]](#)
9. Ives, D.J.; Bayvel, P.; Savory, S.J. Routing, modulation, spectrum and launch power assignment to maximize the traffic throughput of a nonlinear optical mesh network. *Photon. Netw. Commun.* **2015**, *29*, 244–256. [\[CrossRef\]](#)
10. Vincent, R.J.; Ives, D.J.; Savory, S.J. Scalable capacity estimation for nonlinear elastic all-optical core networks. *J. Lightw. Technol.* **2019**, *37*, 5380–5391. [\[CrossRef\]](#)

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.