Next-Generation Optical Access Networks to Support Super-Broadband Services and 5G/6G Mobile Networks

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We are pleased to introduce to our readers the following Special Issue (SI) on Next-Generation Optical Access Networks to support Super-Broadband Services and 5G/6G Mobile Networks in *IEEE Network*. In recent years, optical access networks have been playing a growing role in mobile networks and will become even more prominent with 5G/6G due to the demand for extreme bandwidth, coverage, synchronization, and low latency. The success of future mobile networks will not just be about new radio access technologies. The deployment of future wireless technologies will be dependent on the ability of optical access networks to seamlessly connect to radio access networks (RANs) and edge/cloud computing resources. Many technologies are currently being developed for optical networks for convergence and access to increase throughput, improve energy efficiency, and simplify network design, deployment, and operation. This SI is intended to provide recent advances in optical networking technologies, concentrating on optical access networks and the convergence of integrated fiber and wireless access technologies.

This SI features one invited and seven contributed articles. The invited article, "TDM-PON-Based Optical Access Network for Tactile Internet, 5G, and Beyond" was derived from the invited talk of the latest Optical Fiber Communications Conference. This article sets the stage for this topic, reviewing TDM-PON-based optical access technologies for bandwidth-intensive as well as low-latency services, and introducing recent feasibility demonstration of a Tactile Internet testbed. A rigorous review process, led by the Guest Editors, has resulted in an excellent collection of contributed articles covering many aspects of optical access networks research for mobile services. The article "Architectural Design and Life Cycle Management of Network Slicing for Software-Defined Optical Access Networks," by Zhang *et al.* provides practical use cases of network slicing in the context of software-defined optical access network. "A Software-Defined Programmable Testbed for Beyond-5G Optical-Wireless Experimentation at City Scale" by Chen *et al.* demonstrates a beyond-5G optical-wireless testbed at city scale with dynamic wavelength allocations. "Self-Optimizing Data Offloading in Mobile Heterogeneous Radio-Optical Networks: A Deep Reinforcement Learning Approach" by Shao *et al.* presents the concept of mobile heterogeneous networks (HetNets) with deep reinforcement learning. "Low-Latency PON PHY Implementation on GPUs for Fully Software-Defined Access Networks" by Suzuki *et al.* demonstrates 10G-PON PHY softwarization with reduced latency. "Coherent Passive Optical Networks for 100G/λ-and-Beyond Fiber Access: Recent Progress and Outlook" by Zhang *et al.* reviews the use cases, challenges, recent progress, and future directions of coherent PON for 100G/λ- and -beyond fiber access networks. "Global-Local AI Coordinated Learning over Optical Access Networks for Scalable H2M/R Collaborations" by Mondal *et al.* propose a coordinated learning framework that harnesses learning at the local edge, and sharing of this local knowledge globally to improve human-to-machine/robot scalability and reach, as well as realize rapid onboarding of new machines/robots. "Optimal Slicing of Virtualized Passive Optical Networks to Support Dense Deployment of Cloud-RAN and Multi-Access Edge Computing" by Das *et al.* provides a mechanism for PONs to provide direct low-latency mesh connectivity between endpoints, thus supporting fronthaul Open-RAN across edge computing nodes.

The COVID-19 pandemic had a tremendous impact on people's lives and societies around the globe. We all learned that networking and connectivity are essential to our well being and happiness. After years of working from home, remote learning, and social distancing, the quality of both optical and radio access networks has never been more important, and high-speed Internet and ubiquitous cellular coverage are now regarded as necessities of our daily life. As a prestigious magazine focusing on global networking systems and technologies, *IEEE Network* is a perfect venue for publishing such a timely SI on optical access networks and their convergence with new radio access networks. We truly believe that our SI covers a number of emerging topics which are of interest of the readers of *IEEE Network*. We trust that this SI will provide you with insight and stimulate your interest and further research in this exciting field.

Acknowledgments

Biographies

Zhensheng Jia [SM'19] (s.jia@cablelabs.com) is a Distinguished Technologist on the wired technology team at CableLabs. He serves as a Technical Lead for multiple broadband access innovation projects for optical communication systems. He has published more than 180 peer-reviewed journal and conference papers, one book, and 10 book chapters. He also holds 110 U.S. and international patents. He has been the Technical Lead for Point-to-Point Coherent Optics specifications development, and he is now the Working Group Chair of the coherent passive optical network (CPON) project for next generation 100G access networks at

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ELAINE WONG [S'99, M'03, SM'14] (ewon@unimelb.edu.au) is Associate Dean and professor at the Faculty of Engineering and Information Technology, University of Melbourne, Australia. She has made numerous significant intellectual contributions in the field of optical fiber communications and optical networking, particularly in the areas of optical access network architectures and subsystem technologies, converged/hybrid fiber-wireless networks and subsystem technologies, and more recently in low-latency human-to-machine communications for 5G and beyond networks. She is the OFC 2023 Program Chair and currently serves on the IEEE Photonics Society Board of Governors, the Australian Research Council College of Experts, the Optica Fellow Selection Committee, the *Journal of Lightwave Technology* Steering Committee (Secretary), IEEE Technical Activities Board Diversity and Inclusion Committee, and the IEEE Communications Society Optical Networking Technical Committee (Vice-Chair). She is a Fellow of Optica (formerly Optical Society of America).

MARCO RUFFINI (Marco.Ruffini@tcd.ie) is an associate professor and Fellow of Trinity College Dublin (TCD), Ireland, and Principal Investigator of both the IPIC Photonics Integration Centre and the CONNECT Telecommunications Research Centre. He is involved in several Science Foundation Ireland and European projects, including OpenIreland, a new research infrastructure to build a beyond 5G testbed in Dublin. He leads the Optical Network Architecture Group, TCD, and has authored over 160 international publications and over 10 patents, and contributed to standards in the Broadband Forum. He has raised research funding in excess of €8 million. His main research is in the area of 5G optical networks, where he carries out pioneering work on the convergence of fixed-mobile and access-metro networks, and on the virtualization of next generation networks, and has been invited to share his vision through several keynote addresses and talks at major international conferences across the world.

JUN-ICHI KANI [M'98, SM'18] (junichi.kani.wb@hco.ntt.co.jp) received his M.E. and Ph.D. degrees in applied physics from Waseda University, Tokyo, Japan, in 1996 and 2005, respectively. In 1996, he joined NTT Optical Network Systems Laboratories, where he was engaged in research on optical multiplexing and transmission technologies. Since 2003, he has been with NTT Access Network Service Systems Laboratories, where he has been engaged in R&D and standardization of optical communication systems for access and metro applications. He is currently a Senior Distinguished Researcher and heads the Access Systems Technologies Group in NTT Access Network Service Systems Laboratories, Yokosuka, Japan. He i is Associate Rapporteur of Question 2 (optical systems for fiber access networks) in ITU-T Study Group 15, Chair of the Full Service Access Network (FSAN) initiative, an Associate Editor of the *IEEE/OSA Journal Optical Communications and Networking*, and General Co-Chair of Optical Fiber Communications Conference 2021.

JUNWEN ZHANG (junwenzhang@fudan.edu.cn) received a Ph.D. in the field of optical communication from Fudan University, Shanghai, China, in 2014. He studied and worked at Georgia Tech from 2015 to 2016. He joined ZTE(Tx) in 2016, and he was at CableLabs from 2018 to 2020, focusing on optical and wireless access technologies. He joined Fudan University as a full professor in 2021. He has published more than 200 journal and conference papers, edited one book, and written two book chapters on high-speed optical transmission, access, and signal processing. He was a TPC member of OFC 2018–2021 in N4 (Access Network) and SPIE Photonics West 2018–2021, and also served as the Subcommittee Chair of N4 in OFC 2022 and Co-Chair of IEEE Summer Topical Meeting 2019. He is an Associate Editor of the *IEEE Photonics Journal* and *Frontiers in Communications and Networks*. He received Marconi Society Paul Baran Young Scholar Award in 2016, IEEE Photonics Society Graduate Student Fellowship and Wang Daheng Optics Award in 2013.