Introduction to the Special Section on Coexisting Radio and Optical Wireless Deployments (CROWD)

WE ARE delighted to introduce the readers to this special section of the IEEE TRANSACTIONS ON COGNITIVE COMMUNICATIONS AND NETWORKING (TCCN), which has the purpose of addressing the current state-of-the-art for research and new efficient schemes, techniques, and protocols to address fundamental and practical challenges in cognitive radio-optical networks and Coexisting Radio and Optical Wireless Deployments (CROWD) networks. We received a total of 13 submissions, and after a rigorous review process, 6 articles have been selected for publication, which are briefly discussed next.

The first article is entitled "Green RF/FSO Communications in Cognitive Relay-Based Space Information Networks for Maritime Surveillance," authored by Arienzo *et al*. This article proposes a cognitive relay-based architecture for the satellite communication through a spectrum sensing operating on both free-space optical (FSO) and radio frequency (RF) bands. The low timing jitter and the high directivity of the optical beam allow a high data rate. On the other hand, various unpredictable environmental factors like clouds, snow, fog and rain cause strong attenuation of the optical power. The author proves that hybrid radio-optical communication enhances link availability as well as data transmission. Especially, it increases the throughput and the real-time reception capacity and reduces the network energy consumption. Previous works have shown that a Gamma distribution models the spectrum sensing energy for RF signals. The author extends the energy model to FSO signals and for including the Gamma-Gamma fading and the strong attenuation. Further, the author derives the formula of the minimum network energy consumption in the presence of multipath fading and considering both amplify-and-forward and decode-and-forward data relay schemes. The performance evaluation shows that the novel architecture enhances the coverage, the throughput and the real-time reception capacity of the existing maritime surveillance systems reducing the network energy consumption by jointly optimizing communication functionalities.

The second article is entitled "Impact of Atmospheric Turbulence, Pointing Error and Traffic Pattern on the Performance of Cognitive Hybrid FSO/RF System," authored by Sengar *et al*. The article present a co-existing optical and RF architecture that aims to utilize the precious and scarce RF resource more efficiently by sharing it with multiple FSOs. A solitary FSO link is transformed into a Hybrid FSO/RF system on a Cognitive basis by tapping into the RF temporal holes of a nearby conventional Hybrid FSO/RF system. The article highlights the influence of the optical channel conditions along with the nature of traffic patterns on the utilization of this shared RF resource and the performance of the two Hybrid FSO/RF links. The traffic on the RF is modeled by the alternate renewal process. Integration of the traffic pattern, atmospheric turbulence and pointing error in the analysis, revealed the presence of RF temporal holes which were dependent on the data traffic pattern as well as the optical channel conditions. The outage of the transformed FSO link, now, a Cognitive Hybrid FSO/RF link shows significant improvement without any loss in the performance of the Hybrid FSO/RF link. Thus, such a coexisting optical and RF system allows the RF resource to be used more efficiently while improving the performance of the system as a whole.

The third article is entitled "On the Effect of Incorrect Channel Condition Information on Modified Switching Scheme of Hybrid FSO/RF System," authored by Singh *et al*. In hybrid FSO/RF communication, the optical link, as well as the RF link, is switched ON and/or OFF based on the feedback of the channel state information (CSI). However, feedback of full CSI is computationally complex and bandwidth inefficient. A bandwidth-efficient form of CSI which is referred to as Channel Condition Information (CCI) is used as feedback to decide the modes of transmission/operation in accordance with the switching scheme that is used. In this article, the impact of incorrect reception of CCI on the performance of the hybrid FSO/RF system under strong turbulence and fading conditions is studied. Additive white Gaussian noise (AWGN) and Rayleigh fading feedback RF channel are considered. The closed-form expressions for outage probability and bit-error rate (BER) are derived.

The fourth article is entitled "Efficient Hybrid Multi-Faults Location Based on Hopfield Neural Network in 5G Coexisting Radio and Optical Wireless Networks," authored by Wang *et al*. Rapid evolution of 5G/6G network has prompted the design of more reliable service assurance mechanism for radio and optical wireless networks. Once multiple failures occur simultaneously, more users will be affected and the transmission of real-time services cannot be guaranteed. Rapid locating of faults is the premise for the network to recover quickly. This article proposes an efficient hybrid multi-faults location algorithm based on Hopfield Neural Network (HNN). The authors use HNN as an optimization method to

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analyze the uncertainty of faults and alarms and to find where the faults most likely occur by constructing a proper energy function.

The fifth article is entitled "Performance of Location-Based Equalization for OFDM Indoor Visible Light Communications," authored by You *et al*. In indoor visible light communication (VLC) systems, multiple optical transmitters and reflections will result in a dispersive multipath channel. Conventionally, to compensate for multi-path interference, adaptive algorithms with intermittent training sequences can be adopted. However, the convergence procedure of adaptive calculation is challenging and will limit terminal mobility. On the other hand, indoor VLC is based on intensity modulation with direct detection (IM/DD). There is no random coherent superposition as in RF systems. Instead, a VLC channel takes on a simple and static property. As long as the location of the receiver terminal is measured, the linear distortion of the multipath channel is theoretically estimable and will not change. Based on this, the authors propose a novel location-based equalization (LBE) method for the first time. With indoor positioning, the location information of a VLC receiver, particularly in terms of coordinates, is utilized for channel estimation. The estimated channel parameters can be further used in a variety of ways for real-time channel equalization, where a location-based compensator only needs to be updated when receiver location changes. As a result, VLC becomes a smart location-based value-added service. Extensive numerical experiments are carried out to verify the feasibility of LBE. Results show that LBE can effectively improve system BER performance at different indoor locations. Even in the presence of location error, link shadowing, or receiver tilt, the LBE design, especially based on only a line-of-sight channel, still shows good robustness to achieve reliable transmission quality with BER $<10^{-3}$ at various locations.

The sixth article is entitled "Energy Efficient *M*-Ary Frequency-Shift Keying Based Modulation Techniques for Visible Light Communication," authored by Azim *et al*. The article presents two energy efficient modulation schemes for Internet-of-Things (IoT) based on VLC. The classical orthogonal frequency-shift keying (FSK) modulation from RF communications is tailored to comply with the constraints of VLC. Both modulation techniques are energy efficient compared to the classical linear modulations (On-Off-Keying, Pulse-Amplitude-Modulation).

Our Guest Editor team is pleased with the technical depth and span of this Special Section in IEEE TCCN, and also recognizes that it cannot cover all Coexisting Radio and Optical Wireless Deployments (CROWD) issues. We sincerely thank all the authors and reviewers for the tremendous efforts, and of course the Editor-in-Chief and Staff Members for their great guidance. We hope that the readers will enjoy this special section.

HANY ELGALA
Electrical and Computer Engineering Department
University at Albany–State University of New York
Albany, NY 12222 USA

MOHAMED-SLIM ALOUINI
Communication Theory Lab
King Abdullah University of Science and Technology
Thuwal 23955, Saudi Arabia

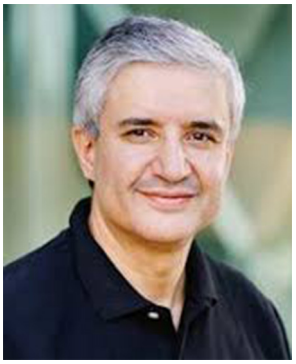
HARALD HAAS
Chair of Mobile Communications
University of Edinburgh
Edinburgh EH8 9YL, U.K.

MICHAEL RAHAIM
Engineering Department
University of Massachusetts
Boston, MA 02125 USA

HINA TABASSUM
Lassonde School of Engineering
York University
Toronto, ON M3J 1P3, Canada

TAKASHI WATANABE
Graduate School of Information Science and Technology
Osaka University
Osaka 565-0871, Japan

Hany Elgala (S'02–M'10) received the Ph.D. degree from Jacobs University, Germany, in 2010. He was a Research Professor with Boston University, MA, USA. He is an Assistant Professor with the Electrical and Computer Engineering Department, University at Albany—State University of New York. He works in the area of wireless networks, digital signal processing, and embedded systems. He has been active in visible light communications research for more than 12 years, including OFDM modulation, MIMO transmission, coexistence with RF technologies and nonlinearity. He was a Faculty Member and a Communications Testbed Leader with the Light Enabled Systems & Applications, Engineering Research Center. He has authored or coauthored over 80 journal and conference publications, several patents, and a book chapter entitled *Dimming and Modulation for VLC-Enabled Lighting*. He is currently serving as an Editor for the IEEE TRANSACTIONS ON COMMUNICATIONS for Optical Wireless Systems and Networks. He was a Guest Editor of the IEEE ACCESS Special Section: Optical Wireless Technologies for 5G Communications and Beyond and the TPC member for conferences and symposia, including the IEEE Optical Networks and Systems Symposium and the Optical Wireless Communications Workshop on at GLOBECOM from 2012 to 2015.



Mohamed-Slim Alouini (M'98–SM'03–F'09) was born in Tunis, Tunisia. He received the Ph.D. degree in electrical engineering from the California Institute of Technology, Pasadena, CA, USA, in 1998. He served as a Faculty Member with the University of Minnesota, Minneapolis, MN, USA, and Texas A&M University at Qatar, Education City, Doha, Qatar. In 2009, he joined the King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, as a Professor of electrical engineering, where he leads the Communication Theory Lab. His current research interests include the modeling, design, and performance analysis of wireless communication systems. He has coauthored the textbook entitled *Digital Communication Over Fading Channels* (Wiley Interscience). His current research interests include design and performance analysis of diversity combining techniques, MIMO techniques, multihop/cooperative communications systems, optical wireless communication systems, cognitive radio systems, and multiresolution, hierarchical and adaptive modulation schemes. He has published several papers on the above subjects. He has also won several awards in his career: For instance, he recently received the 2016 Recognition Award of the IEEE Communication Society Wireless Technical Committee, the 2016 Abdul Hameed Shoman Award for Arab Researchers in Engineering Sciences, and the Inaugural Organization of Islamic Cooperation Science and Technology Achievement Award in Engineering Sciences in 2017. Other recognitions include his selection as an IEEE Distinguished Lecturer for the IEEE Communication Society, a member for several times in the annual Thomson ISI Web of Knowledge list of Highly Cited Researchers as well as the Shanghai Ranking/Elsevier list of Most Cited Researchers, and a co-recipient of best paper awards in 11 IEEE conferences, including ICC, GLOBECOM, VTC, PIMRC, ISWCS, and DySPAN.

Harald Haas is a Full Professor with the University of Edinburgh. He is a Co-Founder of pureLiFi, Ltd. He is also the Director of the LiFi Research and Development Center, University of Edinburgh. He holds 47 patents and has more than 30 pending patent applications. He has published more than 500 conference and journal papers including a paper in Science. He has delivered 50 invited keynotes talks at international conferences and workshops. He delivered two TED Global talks which together have been watched online more than 5 million times. His research interests are in optical wireless communications and spatial modulation. He has been on the Thomson Reuters list of Highly Cited Scientists in 2017, 2018, and 2019. He is a co-recipient of several best paper awards at IEEE conferences, such as ICC, VTC, and PIMRC. He was the recipient of the prestigious Established Career Fellowship from the EPSRC in 2012, the outstanding achievement award from the International Solid State Lighting Alliance in 2016, the Royal Society Wolfson Research Merit Award in 2017, the three-year EPSRC Established Career Fellowship Extension in 2018, and the James Evans Avant Garde Award in 2019 awarded by the IEEE Vehicular Technology Society. He was selected by EPSRC as one of ten Recognizing Inspirational Scientists and Engineers Leaders, U.K., in 2014. He was elected a fellow of the Royal Society of Edinburgh in 2017 and also the Royal Academy of Engineering in 2019.

Michael Rahaim is an Assistant Professor with the Engineering Department, University of Massachusetts, Boston, where he leads the Ubiquitous Communications and Networking Lab. His current research focuses on dynamic and adaptive wireless networks; optical wireless communications; and software-defined radio. During his Ph.D. and Post-Doctoral tenure with Boston University, he was part of the NSF funded Engineering Research Center for Lighting Enabled Systems and Applications where his research focused primarily on heterogeneous network integration of RF and optical wireless networks. He is the Co-Founder of the SDR-Boston User Group and the Co-Organizer of the associated New England Workshop for Software Defined Radio. He is a member of the IEEE Communications Society.

Hina Tabassum (SM'17) received the Ph.D. degree from the King Abdullah University of Science and Technology, Saudi Arabia, in 2013. She was a Research Fellow in the area of wireless communications with the Department of Electrical and Computer Engineering, University of Manitoba, Canada. She is an Assistant Professor with the Lassonde School of Engineering, York University, Canada, since July 2018. She has published over 50 technical articles in well-reputed IEEE journals, magazines, and conferences. Her research interests include wireless communications with a focus on interference modeling, spectrum allocation, and power control in heterogeneous networks. She has been serving as a lead guest editor and the technical program committee member in various IEEE venues. She has been recognized as an Exemplary Reviewer by the IEEE TRANSACTIONS ON COMMUNICATIONS in 2015, 2016, and 2017. She received various awards and honors throughout her career. She is a Registered Professional Engineer in Canada.

Takashi Watanabe received B.E., M.E., and Ph.D. degrees from Osaka University, Osaka, Japan, in 1982, 1984, and 1987, respectively. In 1987, he joined the Faculty of Engineering, Tokushima University as an Assistant Professor and moved to the Faculty of Engineering, Shizuoka University, in 1990. He was a Visiting Researcher with the University of California, Irvine, from 1995 to 1996. He is currently a Professor with the Graduate School of Information Science and Technology, Osaka University. His research interests include wireless networking, mobile networking, ad hoc networks, sensor networks, ubiquitous networks, and intelligent transport systems, especially, MAC and routing. He has served on many program committees for networking conferences, such as IEEE, the Association for Computing Machinery, the Information Processing Society of Japan (IPSJ), and the Information and Communication Engineers (IEICE). He is a member of the IEEE Communications Society, the IEEE Computer Society, IPSJ, and the Institute of Electronics, IEICE, Japan.