

# Guest Editorial: Special Issue on Machine Learning and Artificial Intelligence for Managing Networks, Systems, and Services—Part I

## I. INTRODUCTION

**M**ACHINE learning and artificial intelligence can harness the immense stream of operational data from clouds, to services, to social and communication networks. In the era of big data and connected devices of all varieties, machine learning and artificial intelligence have found ways to improve operations and management of information technology and communications.

Further research is therefore needed to understand and improve the potential and suitability of machine learning and artificial intelligence in the context of network, system and service management. This will provide deeper understanding and better decision making based on largely collected and available operational and management data. It will also present opportunities for improving machine learning and artificial intelligence algorithms on aspects such as reliability, dependability, and scalability, as well as demonstrate the benefits of these methods in control and management systems. Moreover, there is an opportunity to define novel platforms that can harness the vast operational data and advance machine learning and artificial intelligence algorithms to drive management decisions in open and highly programmable networks, clouds, and data centers.

This special issue of IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT presents novel research tackling the above challenges. It is the sixth special issue in this area to appear in this series, after issues published in [1], [2], [3], [4], [5], [6]. The collection of works we present illustrates recent trends, novel solutions and approaches to leverage machine learning and artificial intelligence in network and service management, as well as to extract insights from data that can guide system operators and network managers in their daily activities.

The special issues consists of two parts. In Part I, presented here, we have accepted 23 papers out of 138 papers submitted to the open call for novel contributions addressing the underlying challenges of Machine Learning and Artificial Intelligence for Managing Networks, Systems and Services. Part II will be published in a later issue.

## II. SPECIAL ISSUE OVERVIEW

The special issue papers span four central areas of Machine Learning (ML) and Artificial Intelligence (AI) for

Management of Networks, Systems and Services: (i) ML/AI for managing quality of service, (ii) ML/AI for managing resources, (iii) ML/AI for managing networks in general, and (iv) ML/AI for managing privacy and security.

### A. ML/AI for Quality of Service Management

Seven papers in this special issue focus on ML/AI for managing quality service related issues on networks, systems, and services.

In [A1], Xu et al. investigate the trade-offs between scaling techniques to address quality of service requirements in microservice-based cloud computing environments.

In [A2], Hameed et al. propose a temporal transformer model and a unified system to predict several quality of service metrics for heterogeneous IoT applications for communicating with the edge of the network.

In [A3], Yao et al. present a framework that collects, infers, and supplies networking state information with low processing latency in a scalable buffer layout for data driven quality of service management in the cloud.

In [A4], Dai et al. introduce an architecture that encodes syntactic as well as semantic information and graph structure information of source code to recommend developers a set of variables to log.

In [A5], Xia et al. explore a quality of service optimization method for software-defined factory heterogeneous networks based on deep learning.

In [A6], Lu et al. focus on an explicit intelligent software defined networking that aims to manage the bandwidth and computing resources across the network to enable quality of service.

In [A7], Kang et al. propose to cluster Web services by utilizing both description documents and the structural information from the service relationship network to manage quality of services.

### B. ML/AI for Resource Management

Five papers in this special issue focus on ML/AI for resource management and task analysis related issues on networks, systems, and services.

In [A8], Joda et al. focus on minimizing the end-to-end delay of users and the cost of open radio access networks. The aim is to propose strategies for the placement of central and distributed units while jointly associating the users to radio units.

In [A9], Zhang et al. investigate to design efficient scheduling approaches for multi-dimension network resources. They propose a reinforcement learning assisted bandwidth aware virtual network resource allocation algorithm to address the problem.

In [A10], Aouedi et al. introduce on integrating ensemble based deep learning to analyze encrypted and non-encrypted network traffic for task analysis.

In [A11], Sun et al. present a conditional deep generative model for synthesizing high-fidelity multi-service network traffic data of mobile networks that need only publicly available context information of targeted regions.

In [A12], Li et al. propose task offloading policies to maximize long-term offloading benefits on delay and energy consumption of emerging 5G applications.

### C. ML/AI for General Network Management

Five papers in this special issue focus on ML/AI for general management related issues on networks, systems, and services.

In [A13], Rui et al. explore a model compression algorithm based on model pruning and model clustering in smart network maintenance. The clustering model aims to be adaptive in an edge cloud computing environment.

In [A14], Xavier et al. introduce a framework that explores the feasibility of mapping machine learning models in programmable network devices. They validate the framework for the task analysis of network traffic classification.

In [A15], Zhao et al. propose an intelligent multi-attribute routing scheme for two-layered software-defined vehicle networks. The proposed scheme includes the routing path calculation and the multi-attribute vehicle autonomous routing decision-making.

In [A16], Cao et al. focus on a deep learning method, integrating fractional integral with fractal dimension, for crack detection in transportation service management.

In [A17], Stergiou and Psannis investigate a federated learning approach decoupling clients from training a local model and the communication with the server. They aim to identify an optimal distributed architecture, to meet the demand, and optimize the key parameters of the algorithms.

### D. ML/AI for Privacy and Security Management

Six papers in this special issue focus on ML/AI for managing privacy and security related issues on networks, systems, and services.

In [A18], Zhang et al. propose a grouped verifiable chain federated learning scheme to reduce the number of visible users of the aggregation server, the use of complex cryptographic primitives, and to minimize the number of aggregations for model requirements.

In [A19], Yue et al. focus on challenges brought by intra-class diversity and inter-class similarity, and explore a contrastive learning based approach to enhance intrusion detection while disentangling samples from different classes.

In [A20], Chai et al. present a multichannel malware image generation method based on multiview. In doing so, they aim to solve the problem of classifying new or unknown malware.

In [A21], Mei et al. investigate a particle swarm optimization multiclass support vector machine based approach to automatically identify the organization behind complex advanced persistent threat attack defence.

In [A22], Illy et al. introduce a hybrid multistage deep learning based intrusion detection and prevention system for critical industrial control systems where they aim for better accuracy and lower latency.

In [A23], Yang et al. explore a metapath-aware clustering recommendation method for location based social networks. The aim is to discover the complex community structure and make accurate recommendations while respecting privacy.

### ACKNOWLEDGMENT

We sincerely thank the authors for contributing their papers and the reviewers for their thorough assessment and their work to improve the quality and presentation of each paper. We are very grateful to the Editor-in-Chief Hanan Lutfiyya for her continuous support throughout the process and to Janine Bruttin and Catherine Van Sciver for their help with the administrative tasks associated to this special issue.

### APPENDIX: RELATED ARTICLES

- [A1] M. Xu et al., "CoScal: Multi-faceted scaling of microservices with reinforcement learning," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 3995–4009, Dec. 2022.
- [A2] A. Hameed, J. Violos, A. Leivadreas, N. Santi, R. Grünblatt, and N. Mitton, "Towards QoS prediction based on temporal transformers for IoT applications," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4010–4027, Dec. 2022.
- [A3] Z. Yao, Y. Desmouceaux, J.-A. Cordero-Fuertes, M. Townsley, and T. Clausen, "Aquarius -enable fast, scalable, data-driven service management in the cloud," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4028–4044, Dec. 2022.
- [A4] S. Dai et al., "REVAL: REcommend which VArables to log with pre-trained model and graph neural network," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4045–4057, Dec. 2022.
- [A5] D. Xia, J. Wan, P. Xu, and J. Tan, "Deep reinforcement learning-based QoS optimization for software-defined factory heterogeneous networks," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4058–4068, Dec. 2022.
- [A6] K. Lu, Z. Du, J. Li, K. Zhang, and G. Min, "Resource-efficient distributed deep neural networks empowered by intelligent software defined networking," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4069–4081, Dec. 2022.
- [A7] G. Kang, J. Liu, Y. Xiao, Y. Cao, B. Cao, and M. Shi, "Web services clustering via exploring unified content and structural semantic representation," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4082–4096, Dec. 2022.
- [A8] R. Joda, T. Pamuklu, P. E. Iturria-Rivera, and M. Erol-Kantarci, "Deep reinforcement learning-based joint user association and CU-DU placement in O-RAN," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4097–4110, Dec. 2022.
- [A9] P. Zhang, Y. Su, J. Wang, C. Jiang, C.-H. Hsu, and S. Shen, "Reinforcement learning assisted bandwidth aware virtual network resource allocation," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4111–4123, Dec. 2022.
- [A10] O. Aouedi, K. Piamrat, and B. Parrein, "Ensemble-based deep learning model for network traffic classification," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4124–4135, Dec. 2022.

- [A11] C. Sun, K. Xu, M. Fiore, M. K. Marina, Y. Wang, and C. Ziemlicki, "AppShot: A conditional deep generative model for synthesizing service-level mobile traffic snapshots at city scale," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4136–4150, Dec. 2022.
- [A12] H. Li, K. D. R. Assis, S. Yan, and D. Simeonidou, "DRL-based long-term resource planning for task offloading policies in multi-server edge computing networks," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4151–4164, Dec. 2022.
- [A13] L. Rui, S. Yang, S. Chen, Y. Yang, and Z. Gao, "Smart network maintenance in an edge cloud computing environment: An adaptive model compression algorithm based on model pruning and model clustering," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4165–4175, Dec. 2022.
- [A14] B. M. Xavier, R. S. Guimarães, G. Comarela, and M. Martinello, "MAP4: A pragmatic framework for in-network machine learning traffic classification," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4176–4188, Dec. 2022.
- [A15] L. Zhao et al., "A fuzzy logic based intelligent multi-attribute routing scheme for two-layered SDNs," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4189–4200, Dec. 2022.
- [A16] T. Cao, L. Liu, K. Wang, and J. Li, "A fractional integral and fractal dimension-based deep learning approach for pavement crack detection in transportation service management," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4201–4212, Dec. 2022.
- [A17] K. D. Stergiou and K. E. Psannis, "Federated learning approach decouples clients from training a local model and with the communication with the server," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4213–4218, Dec. 2022.
- [A18] Z. Zhang et al., "G-VCFL: Grouped verifiable chained privacy-preserving federated learning," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4219–4231, Dec. 2022.
- [A19] Y. Yue, X. Chen, Z. Han, X. Zeng, and Y. Zhu, "Contrastive learning enhanced intrusion detection," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4232–4247, Dec. 2022.
- [A20] Y. Chai, J. Qiu, L. Yin, L. Zhang, B. B. Gupta, and Z. Tian, "From data and model levels: Improve the performance of few-shot malware classification," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4248–4261, Dec. 2022.
- [A21] Y. Mei, W. Han, S. Li, and K. Lin, "A hybrid intelligent approach to attribute advanced persistent threat organization using PSO-MSVM algorithm," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4262–4272, Dec. 2022.
- [A22] P. Illy, G. Kaddoum, P. F. de Araujo-Filho, K. Kaur, and S. Garg, "A hybrid multistage DNN-based collaborative IDPS for high-risk smart factory networks," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4273–4283, Dec. 2022.
- [A23] Z. Yang, Z. Wang, L. Guo, W. Liu, and S. Sun, "Meta path-aware recommendation method based on non-negative matrix factorization in LBSN," *IEEE Trans. Netw. Service Manag.*, vol. 19, no. 4, pp. 4284–4297, Dec. 2022.

## REFERENCES

- [1] G. Casale, Y. Diao, H. Lutfiyya, P. Owezarski, and D. Raz, "Guest editors' introduction: Special issue on big data analytics for management," *IEEE Trans. Netw. Service Manag.*, vol. 13, no. 3, pp. 578–580, Sep. 2016.
- [2] G. Casale, Y. Diao, M. Mellia, R. Ranjan, and N. Zincir-Heywood, "Guest editorial: Special section on advances in big data analytics for management," *IEEE Trans. Netw. Service Manag.*, vol. 15, no. 1, pp. 10–12, Mar. 2018.
- [3] D. Carrera, G. Casale, T. Inoue, H. Lutfiyya, J. Wang, and N. Zincir-Heywood, "Guest editorial: special issue on novel techniques in big data analytics for management," *IEEE Trans. Netw. Service Manag.*, vol. 16, no. 3, pp. 797–799, Sep. 2019.
- [4] N. Zincir-Heywood et al., "Guest editorial: Special section on data Analytics and machine learning for network and service management—Part I," *IEEE Trans. Netw. Service Manag.*, vol. 17, no. 4, pp. 1971–1974, Dec. 2020.
- [5] N. Zincir-Heywood et al., "Guest editorial: Special issue on data Analytics and machine learning for network and service management—Part II," *IEEE Trans. Netw. Service Manag.*, vol. 18, no. 1, pp. 775–779, Mar. 2021.
- [6] H. Lutfiyya et al., "Guest editorial: Special section on embracing artificial intelligence for network and service management," *IEEE Trans. Netw. Service Manag.*, vol. 18, no. 4, pp. 3936–3941, Dec. 2021.

NUR ZINCIR-HEYWOOD  
Faculty of Computer Science  
Dalhousie University  
Halifax, NS B3H 4R2, Canada

ROBERT BIRKE  
Department of Computer Science  
University of Turin  
10124 Turin, Italy

ELIAS BOU-HARB  
College of Business  
University of Texas at San Antonio  
San Antonio, TX 78249 USA

GIULIANO CASALE  
Department of Computing  
Imperial College London  
London SW7 2BX, U.K.

KHALIL EL-KHATIB  
Faculty of Business and Information Technology  
University of Ontario Institute of Technology  
Oshawa, ON L1G 0C5, Canada

TAKERU INOUE  
NTT Network Innovation Laboratories  
NTT Corporation  
Yokosuka, Japan

NEERAJ KUMAR  
Department of Computer Science and Engineering  
Thapar Institute of Engineering and Technology  
Patiala 147004, India

HANAN LUTFIYYA  
Department of Computer Science  
Western University  
London, ON N6A 3K7, Canada

DEEPAK PUTHAL  
School of Computing  
Newcastle University  
NE1 7RU Newcastle upon Tyne, U.K.

ABDALLAH SHAMI  
Electrical and Computer Engineering  
Western University  
London, ON N6A 3K7, Canada

NATALIA STAKHANOVA  
Department of Computer Science  
University of Saskatchewan  
Saskatoon, SK S7N 5C9, Canada

FARHANA ZULKERNINE  
School of Computing  
Queen's University  
Kingston, ON K7L 3N6, Canada



**Nur Zincir-Heywood** (Member, IEEE) is a Dalhousie Distinguished Research Professor and an Associate Dean Research of Computer Science with Dalhousie University, Canada. Her research interests include machine learning and artificial intelligence for cyber security, network, systems, and information analysis, topics on which she has published over 200 fully reviewed papers. She is the Co-Editor of the books *Communication Networks and Service Management in the Era of Artificial Intelligence and Machine Learning* (Wiley/IEEE), and *Recent Advances in Computational Intelligence in Defense and Security* (Springer) as well as the coauthor of the book *Nature-Inspired Cyber Security and Resiliency: Fundamentals, Techniques, and Applications* (IET). She is a recipient of several best paper awards as well as the Supervisor for the recipient of the IFIP/IEEE IM 2013 Best Ph.D. Dissertation Award in Network Management. She is an Associate Editor of the IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT and *International Journal of Network Management* (Wiley), and a Guest Editor of *Journal of Network and Systems Management* (Springer).



**Robert Birke** (Senior Member, IEEE) received the Ph.D. degree in electronics and communications engineering from the Politecnico di Torino, Italy, in 2009. He is a Tenured Assistant Professor with the University of Turin, Italy. He has been a Visiting Researcher with IBM Research Zurich, Switzerland, and a Principal Scientist with ABB Corporate Research, Switzerland. He has published more than 90 papers at venues related to communication, system performance, and machine learning, e.g., SIGCOMM, SIGMETRICS, FAST, INFOCOM, ACML, and JSAC. His research interests are in the broad area of virtual resource management, including network design, workload characterization, and AI and big-data application optimization.



**Elias Bou-Harb** (Senior Member, IEEE) received the Ph.D. degree in computer science from Concordia University, Montreal, Canada, which was executed in collaboration with Public Safety Canada, Industry Canada, and NCFTA Canada. He is currently the Director of the Cyber Center For Security and Analytics, UTSA, where he leads, directs, and organizes university-wide innovative cyber security research, development, and training initiatives. He is also a Tenured Associate Professor with the Department of Information Systems and Cyber Security specializing in operational cyber security and data science as applicable to national security challenges. Previously, he was a Senior Research Scientist with Carnegie Mellon University, where he contributed to federally funded projects related to critical infrastructure security and worked closely with the Software Engineering Institute. His research and development activities and interests focus on operational cyber security, attacks' detection and characterization, malware investigation, cyber security for critical infrastructure, and big data analytics. He has authored more than 130 refereed publications in leading security and data science venues, has acquired significant state and federal

cyber security research grants, and is the recipient of five best research paper awards, including the prestigious ACM's best digital forensics research paper.



**Giuliano Casale** (Member, IEEE) joined the Department of Computing, Imperial College London in 2010, where he is currently a Senior Lecturer of Modeling and Simulation. Previously, he worked as a Scientist with SAP Research, U.K., and as a Consultant in the capacity planning industry. He teaches and does research in performance engineering and cloud computing, topics on which he has published more than 130 refereed papers. He has served as the Program Co-Chair for several conferences in the area of performance engineering, such as ACM SIGMETRICS/Performance and IEEE MASCOTS. His research is recipient of multiple awards, recently the Best Paper Award at ACM SIGMETRICS 2017. He serves on the editorial boards of IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT and *ACM Transactions on Modeling and Performance Evaluation of Computing Systems* and as the Current Chair of ACM SIGMETRICS.





**Khalil El-Khatib** (Member, IEEE) received the bachelor's degree in computer science from the American University of Beirut, the Master of Computer Science degree from McGill University, Montreal, Canada, and the Ph.D. degree from the University of Ottawa, Canada. He is currently working as a Professor of Information Security and the Director of the Faculty of Business and Information Technology, Institute for Cybersecurity and Resilient Systems, Ontario Tech. Before joining Ontario Tech, he worked as an Assistant Professor with the University of Western Ontario. His research interests include big data and security analytics, security and privacy issues in wireless sensor networks, smart cities and communities, mobile wireless ad hoc networks and vehicular networks, smart grid security, biometrics, and ubiquitous computing.



**Takeru Inoue** (Member, IEEE) received the B.E. and M.E. degrees in engineering science and the Ph.D. degree in information science from Kyoto University, Japan, in 1998, 2000, and 2006, respectively. He joined Nippon Telegraph and Telephone Corporation Laboratories in 2000, where he is currently a Distinguished Researcher. He was an ERATO Researcher with the Japan Science and Technology Agency from 2011 to 2013, where his research focused on algorithms and data structures. His research interests widely cover algorithmic approaches in communication networks. He is an Associate Editor of the IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT. He is a member of the Institute of Electronics, Information, and Communication Engineers.



**Neeraj Kumar** (Member, IEEE) is working as a Full Professor with the Department of Computer Science and Engineering, Thapar Institute of Engineering and Technology (Deemed to be University), Patiala, India. He is also an Adjunct Professor at various organizations in India and abroad. He has published more than 400 technical research papers in top-cited journals and conferences which are cited more than 31 500 times from well-known researchers across the globe with current H-index of 97. He is a Highly Cited Researcher in 2019–2021 in the list released by Web of Science. He has guided many research scholars leading to Ph.D. (14) and M.E./M.Tech. (24). His research is supported by funding from various competitive agencies across the globe. His broad research areas are green computing and network management, IoT, big data analytics, deep learning, and cyber security. He has also edited/authored ten books with international/national publishers, such as *Security and Privacy of Electronic Healthcare Records: Concepts, Paradigms and Solutions* (IET), *Machine Learning in Cognitive IoT* (CRC Press), *Blockchain, Big Data and Machine Learning* (CRC Press), *Blockchain Technologies Across*

*Industrial Vertical* (Elsevier), *Multimedia Big Data Computing for IoT Applications: Concepts, Paradigms and Solutions* (Springer), *Proceedings of First International Conference on Computing, Communications, and Cyber-Security (IC4S 2019)* (Springer), and *Probabilistic Data Structures for Blockchain Based IoT Applications* (CRC Press). One of the edited textbooks titled *Multimedia Big Data Computing for IoT Applications: Concepts, Paradigms, and Solutions* (Springer, 2019) has had 3.5 million downloads as of 6 June 2020. It attracts attention of the researchers across the globe. He has won the Best Paper Award from IEEE SYSTEMS JOURNAL and IEEE ICC 2018, Kansas City, in 2018. He won the Best Researcher Award from TIET, Patiala, India, every year from last eight consecutive years. He is serving as an Editor for *ACM Computing Survey*, IEEE TRANSACTIONS ON SUSTAINABLE COMPUTING, IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT, *IEEE Network Magazine*, *IEEE Communication Magazine*, *Journal of Networks and Computer Applications* (Elsevier), *Computer Communication* (Elsevier), and *International Journal of Communication Systems* (Wiley). Also, he has organized various special issues of journals of repute from IEEE, Elsevier, and Springer. He has been the Workshop Chair at IEEE Globecom 2018, IEEE Infocom 2020, and IEEE ICC 2020 and the Track Chair of Security and Privacy of IEEE MSN 2020. He is also the TPC Chair and a member for various international conferences, such as IEEE MASS 2020 and IEEE MSN 2020.



**Hanan Lutfiyya** (Senior Member, IEEE) is a Professor with the Department of Computer Science, Western University, Canada. Her research interests include Internet of Things, software engineering, self-adaptive and self-managing systems, autonomic computing, monitoring and diagnostics, mobile systems, policies, and clouds. She was a recipient of the UWO Faculty Scholar Award in 2006. She is a past member of the Natural Science and Engineering Research Council of Canada (NSERC) Discovery Grant Committee, and a past member and the Chair of an NSERC Strategic Grants Committee. She was a member of the Computer Science Accreditation Council. She is currently an Associate Editor of the IEEE TRANSACTIONS ON NETWORK AND SERVICE MANAGEMENT, and has recently served as the General Co-Chair for the IEEE International Conference on Network and Service Management. She is currently on the board of directors for CS-Can—Info-Can.



**Deepak Puthal** (Member, IEEE) is a Lecturer (Assistant Professor) with the School of Computing, Newcastle University, U.K. Prior to this position, he was a Lecturer with the University of Technology Sydney, Australia, an Associate Researcher with Commonwealth Scientific and Industrial Research Organization (CSIRO Data61), Australia, and a Research Associate with Qatar Mobility Innovations Center, Qatar. His research spans several areas in cyber security, blockchain, Internet of Things, and edge/fog computing. He has received several recognitions and best paper awards from IEEE. He serves on the editorial boards of top quality international journals, including IEEE TRANSACTIONS ON BIG DATA, *IEEE Consumer Electronics Magazine*, *Computers and Electrical Engineering* (Elsevier), *International Journal of Communication Systems* (Wiley), and *Internet Technology Letters* (Wiley).



**Abdallah Shami** (Senior Member, IEEE) received the B.E. degree in electrical and computer engineering from Lebanese University, Beirut, Lebanon, in 1997, and the Ph.D. degree in electrical engineering from the Graduate School and University Center, The City University of New York, New York, NY, USA, in 2003. He is currently a Professor with the Electrical and Computer Engineering Department and the Acting Associate Dean (Research) of the Faculty of Engineering, Western University, London, ON, Canada, where he is also the Director of the Optimized Computing and Communications Laboratory. He has chaired key symposia for the IEEE GLOBECOM, IEEE International Conference on Communications, and IEEE International Conference on Computing, Networking and Communications. He was the Elected Chair for the IEEE Communications Society Technical Committee on Communications Software from 2016 to 2017 and the IEEE London Ontario Section Chair from 2016 to 2018. He is currently an Associate Editor of the IEEE TRANSACTIONS ON MOBILE COMPUTING, IEEE NETWORK, and IEEE COMMUNICATIONS SURVEYS AND TUTORIALS.



**Natalia Stakhanova** is the Canada Research Chair of Security and Privacy and an Associate Professor with the University of Saskatchewan, Canada. She is a former NB Innovation Research Chair of Cybersecurity with the University of New Brunswick. Her work focuses on software security. She has published over 60 publications in the areas of mobile security, software protection, and code attribution. Working closely with the industry on a variety of research and development projects, she developed a number of technologies that resulted in four patents in the field of computer security and have been adopted by high-tech companies. She is the recipient of numerous recognitions and awards, including the Top 20 Women in Cybersecurity, the CyberNB Recognition Award, the McCain Young Scholar Award, and the Anita Borg Institute Faculty Award.



**Farhana Zulkernine** received the Ph.D. degree from the School of Computing, Queen's University, where she is currently an Assistant Professor and the Coordinator of the Cognitive Science Program. She has more than 15 years of international work experience in three continents in software design, analysis, and research. Her current research interests include big data analytics and management, and cognitive and cloud computing. She is a member of the Professional Engineers of Ontario.