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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: COMMUNICATION AND FOG/EDGE COMPUTING TOWARD INTELLIGENT CONNECTED VEHICLES (ICVS)

Intelligent connected vehicles (ICVs) are usually expected to run a huge number of emerging smart applications (e.g., autonomous driving, safety early warning, natural language processing, etc.) for assisting both the drivers and passengers in vehicular environments. These kinds of applications typically require significant computing power to perform computation-intensive and latency-sensitive tasks generated by the vehicle sensors for low-latency response. However, the limited computation capacity of on-board computers makes it difficult to satisfy the computation requirements of quality-of-experience (QoE)-demanding applications. To tackle the challenge, fog/edge computing is proposed as innovative computing paradigms to extend computing capacity to the network edge to meet the requirements. This Special Section in IEEE ACCESS focuses on innovative technologies and solutions enabled communication and edge computing toward ICVs.

In the article ''Deep learning-based channel prediction for edge computing networks toward intelligent connected vehicles,'' by Liu *et al.*, a novel channel prediction model based on deep learning approach is proposed for improving the performance of forecasting the CSI in the field of edge computing networks. The prediction of wireless channel parameters is helpful for scheduling system resource management and the optimization of system performance.

In the article ''A methodology for the design of safety-compliant and secure communication of autonomous vehicles,'' by Passerone *et al.*, a novel design methodology is proposed using a contract-based approach for specifying safety and combining it in the design flow with the use of the arrowhead framework to support security. Safety and security is very important for ICVs.

In the article ''ASTSMAC: Application suitable time-slot sharing MAC protocol for vehicular *ad hoc* networks,'' by Li *et al.*, an application suitable time-slot sharing MAC protocol, called ASTSMAC, is proposed for VANET. The application layer should adjust the packet generation frequency dynamically according to the need to reduce unnecessary spectrum access, so as to improve performance in vehicular networks.

The article by Xu *et al.*, ''A computation offloading method for edge computing with vehicle-to-everything,'' proposes a computation offloading method named V2X-COM which employs V2X technology for data transmission in edge computing. The vehicle-to-everything (V2X) communication is a promising technology to support edge computing transmitting tasks across vehicles.

In the article ''Secure energy-efficient transmission for SWIPT intelligent connected vehicles with imperfect CSI,'' by Meng *et al.*, the secure energy-efficient transmission problem for an artificial-noise (AN)-aided simultaneous wireless information and power transfer (SWIPT) and vehicle-to-infrastructure (V2I) communication system with the imperfect channel state information (CSI) is studied. In the case of incomplete CSI, a safe energy efficiency problem is established, and it has an effect on the safety of the Internet of vehicles.

In the article ''Contention-based opportunistic spectrum access in one-way highway vehicular networks,'' by Song and Yuan, a spectrum sharing problem is studied under the scenario of a one-way highway vehicular network. This article effectively solves the resource allocation and management problem of one-way highway vehicle networks.

In the article ''Constrained optimization and distributed model predictive control-based merging strategies for adjacent connected autonomous vehicle platoons,'' by Min *et al.*, a merging strategy is proposed by jointly considering safe space and acceleration limitations for two adjacent platoons comprising connected autonomous vehicles (CAVs). The proposed strategy is more feasible and efficient, and less time-consuming than the existing state-of-the-art methods and has the advantages of taking safety distance and control input constraints into account.

The article by Chao *et al.*, ''Multi-lane detection based on deep convolutional neural network,'' proposes a multi-lane detection algorithm based on deep convolutional neural network. Machine learning and deep learning are used to realize intelligent management and control.

In the article ''BNNC: Improving performance of multipath transmission in heterogeneous vehicular networks,'' by Zhang *et al.*, a BigNum network coding (BNNC) scheme for vehicle-to-ground multipath communication is proposed. The purpose of this article is to achieve the reliability of wireless networks.

The article by Nguyen *et al*., ''Distributed deep deterministic policy gradient for power allocation control in D2D-based V2V communications,'' presents two novel approaches based on deep deterministic policy gradient algorithm. With the rapid increase of user devices and sensors, more efficient resource allocation algorithms are needed to improve the network performance and guarantee quality of service.

In the article ''Joint beamforming design for energy efficient wireless communications in heterogeneous intelligent connected vehicles networks,'' by Zhao *et al*., an iterative algorithm is developed for jointly optimizing all the beamforming vectors to maximize the energy efficiency of the whole system. In this article, the wireless communication problem of intelligent connected vehicle (ICV) networks is studied.

In the article ''Enhancing the user experience in vehicular edge computing networks: An adaptive resource allocation approach,'' by Sun *et al*., an adaptive resource allocation approach is investigated to enhance the user experience in vehicular edge computing networks. Specifically, leveraging the idea of task scalability, a model for balancing computing quality and resource consumption is introduced to exploit the computational resources fully.

The article by Zhang *et al*., ''Group-signature and group session key combined safety message authentication protocol for VANETs,'' deals with an efficient safety message authentication protocol for VANETs by combining batch group signature verification and the proposed group session key (GSK). The proposed protocol has better performance in terms of message loss rate.

In the article ''An ameliorative hybrid algorithm for solving the capacitated vehicle routing problem,'' by Hosseinabadi *et al*., a novel hybrid algorithm is proposed based on gravitational emulation local search (GELS) and genetic algorithm (GA).

The article by Li *et al*., ''Intelligent vehicle-to-vehicle charging navigation for mobile electric vehicles via VANET-based communication,'' proposes an intelligent V2V charging navigation strategy for a large number of mobile EVs.

In the article ''Collaborative vehicular edge computing networks: Architecture design and research challenges,'' by Xie *et al*., the novel collaborative vehicular edge computing network (CVECN) architecture is proposed. Based on the proposed architecture, the computing and storage capacity of vehicular networks can be further improved.

In the article ''A novel QoS-awared grid routing protocol in the sensing layer of Internet of vehicles based on reinforcement learning,'' by Wang *et al*., a novel quality of service (QoS) grid routing protocol is proposed in wireless multimedia sensor networks (WMSNs) to guarantee the quality of service in WMSN based on the sensing layer of the Internet of vehicles (IoVs). Reliable requirement is achieved through the selection of GCs with high reliability to accomplish the transmission task.

The article by Qureshi *et al*., ''Self-assessment based clustering data dissemination for sparse and dense traffic conditions for Internet of vehicles,'' proposes a SACBR (self-assessment cluster-based routing) protocol in which the cluster heads (CHs) can communicate with other CHs. Proposed protocol suites sparse and dense traffic scenarios where most of the time vehicle nodes are moving in platoons or snaking structures.

In the article ''Joint computation offloading and URLLC resource allocation for collaborative MEC-assisted cellular-V2X networks,'' by Feng *et al*., a joint computation and URLLC resource allocation strategy for collaborative MEC-assisted cellular-V2X networks is proposed, and a joint power consumption optimization problem guaranteeing the network stability is formulated. By using the V2X network supporting 5G, vehicles connected by cellular base stations can support a variety of computing-intensive services.

The article by Ye *et al*., ''Federated learning in vehicular edge computing: A selective model aggregation approach,'' investigates a selective model aggregation approach. The proposed approach is demonstrated to outperform the original federated averaging (FedAvg) approach in terms of accuracy and efficiency.

In the article ''A new vehicular fog computing architecture for cooperative sensing of autonomous driving,'' by Du *et al*., a vehicular fog computing (VFC) architecture is developed to implement cooperative sensing among multiple adjacent vehicles driving in the form of a platoon. The sensing coverage and accuracy of vehicles is vital for autonomous driving.

The article by Lien *et al*., ''3GPP NR side link transmissions toward 5G V2X,'' provides the essential knowledge of 3GPP NR side link transmissions and performance evaluation to assess the gains brought from the new control channel design.

In the article ''Software defined network-based multi-access edge framework for vehicular networks,'' by Nkenyereye *et al*., an SDN-based multi-access edge computing framework for the vehicular networks (SDMEVs) is proposed. In this article, traditional e-commerce is extended to multiple access edge computing (MEC), and the edge computing server is combined with wireless access networks.

The article by Wu *et al*., ''A task offloading scheme in vehicular fog and cloud computing system,'' studies the optimal offloading scheme that considers the departure of occupied vehicles. Moreover, the value iteration algorithm is designed in this article for the SMDP to maximize the total long-term reward of the VFCC system.

In the article ''Regional intelligent resource allocation in mobile edge computing based vehicular network,'' by Wang and Xu, a novel regional intelligent management vehicular system with dual-MEC planes is studied. In this article, MEC servers in the same region cooperate with each other to achieve resource sharing.

In the article ''Edge-based V2X communications with big data intelligence,'' by Guleng *et al*., proposes a scheme that enhances V2V communications through the integration of vehicle edge-based forwarding and learning-based edge selection policy optimization. The authors used real traffic big

data and realistic vehicular network simulations to evaluate the performance of the proposed scheme and show the advantage over other baseline approaches.

In the article "Destination prediction-based scheduling algorithms for message delivery in IoVs," by Wang *et al.*, a real-time destination prediction framework with machine learning models and a delivery profit maximization algorithm are proposed.

The article by Qiu *et al.*, "Optimal access scheme for security provisioning of C-V2X computation offloading network with imperfect CSI," proposes a dynamic threshold-based access scheme for security provisioning of C-V2X computation-offloading network by considering an imperfect CSI. The proposed scheme can maximize the secrecy throughput under a connection outage constraint of the D2D-V links, with the total area spectral efficiency optimized under the security performance criterion for the offloading link.

In the article "Certificate revocation schemes in vehicular networks: A survey," by Wang *et al.*, a comprehensive survey on revocation schemes in vehicular networks is provided. This article also points out the challenging problems and key enabled techniques in each stage.

The article by Arooj *et al.*, "Cyber-physical and social networks in IoV (CPSN-IoV): A multimodal architecture in edge-based networks for optimal route selection using 5G technologies," proposes cyber-physical and social networks (CPSN) for two fundamental operations in IoV (Internet of vehicles) as CPSN-IoV. This article can link advanced 5G vehicle network technology.

In the article "Optimization of energy consumption in the MEC-assisted multi-user FD-SWIPT system," by Fu *et al.*, the optimization problems of communication, computation, and energy resources, are studied to minimize energy consumption in the mobile terminal.

In the article "StabTrust—A stable and centralized trust-based clustering mechanism for IoT-enabled vehicular *ad hoc* networks," by Awan *et al.*, a trust-based clustering mechanism is proposed. This article uses machine learning to achieve intelligent control of vehicles.

The article by Wang *et al.*, "Generalized intrusion detection mechanism for empowered intruders in wireless sensor networks," proposes a vehicle collaboration sensing network model. In the proposed model, mobile sensing vehicles and static sensor nodes cooperate to provide intrusion detection against empowered intruders.

In the article "MIGRATE: Mobile device virtualisation through state transfer," by Santa *et al.*, the concept of virtual mobile devices (vMDs) is implemented as virtual functions (VxF).

The article by Yang *et al.*, "Toward efficient NDN framework for connected vehicle applications," proposes a NDN-based CV application framework and a distributed adaptive caching strategy. This article can be linked to ICV mobility modeling and management.

In the article "A lightweight privacy-preserving communication protocol for heterogeneous IoT environment," by Luo *et al.*, a communication protocol involving only the symmetric key-based scheme is proposed.

In the article "Traffic chain: A blockchain-based secure and privacy-preserving traffic map," by Wang *et al.*, a secure and privacy-preserving decentralized traffic information collection system on the blockchain is proposed. Furthermore, an incentive mechanism is designed to motivate users to participate in the system.

The article by Wu *et al.*, "Bilateral satisfaction aware participant selection with MEC for mobile crowd sensing," proposes a bilateral satisfaction aware participant selection mechanism in the edge-cloud collaboration MCS system.

In the article "An edge-based framework for enhanced road safety of connected cars," by Malinverno *et al.*, an enhanced collision avoidance (eCA) service that leverages vehicle connectivity through a cellular network to avoid vehicle collisions and increase road safety at intersections is presented.

The article by Wang *et al.*, "Online offloading scheduling and resource allocation algorithms for vehicular edge computing system," designs a three-layer VEC architecture and proposes an online offloading scheduling and resource allocation (OOSRA) algorithm to improve the system performance.

In conclusion, the Guest Editors would like to thank all the authors who submitted their research articles to our Special Section. They highly appreciate the contributions of the reviewers for their constructive comments and suggestions. They would also like to acknowledge the guidance from IEEE Access Editor-in-Chief and staff members.

LEI SHU, *Guest Editor*
College of Artificial Intelligence
Nanjing Agricultural University
Nanjing 210095, China
School of Engineering
University of Lincoln
Lincoln LN6 7TS, U.K.

JUNHUI ZHAO, *Guest Editor*
School of Information Engineering
East China Jiaotong University
Nanchang 330013, China
School of Electronics and Information Engineering
Beijing Jiaotong University
Beijing 100044, China

YI GONG, *Guest Editor*
Department of Electrical and Electronic Engineering
Southern University of Science and Technology
Shenzhen 518055, China

CHANGQING LUO, *Guest Editor*
Department of Computer Science
Virginia Commonwealth University
Richmond, VA 23284, USA

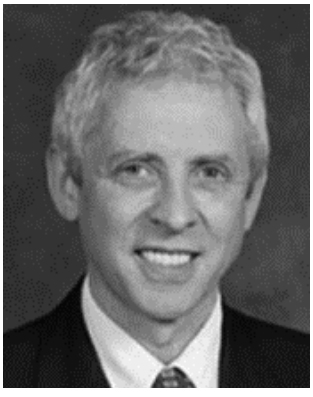
TIM GORDON, *Guest Editor*
School of Engineering
University of Lincoln
Lincoln LN6 7TS, U.K.

LEI SHU (Senior Member, IEEE) received the B.S. degree in computer science from South Central University for Nationalities, China, in 2002, the M.S. degree in computer engineering from Kyung Hee University, South Korea, in 2005, and the Ph.D. degree from the Digital Enterprise Research Institute, National University of Ireland, Galway, Ireland, in 2010. He was a Specially Assigned Researcher with the Department of Multimedia Engineering, Graduate School of Information Science and Technology, Osaka University, Japan, in 2012. He is currently a Distinguished Professor with Nanjing Agricultural University, China, and a Lincoln Professor with the University of Lincoln, U.K. He is also the Director of the NAU-Lincoln Joint Research Center of Intelligent Engineering. He has published more than 400 papers in related conferences, journals, and books in the areas of sensor networks and the Internet of Things. His current H-index is 61 and i10-index is 240 in Google Scholar Citation. His current research interests include wireless sensor networks and the Internet of Things. He has also served as a TPC member for more than 150 conferences, such as ICDCS, DCOSS, MASS, ICC, GLOBECOM, ICCCN, WCNC, and ISCC. He was a recipient of the 2014 Top Level Talents in Sailing Plan of Guangdong Province, China, the 2015 Outstanding Young Professor of Guangdong Province, and the GLOBECOM 2010, ICC 2013, ComManTel 2014, WICON 2016, SigTelCom 2017 Best Paper Awards, the 2017, 2018 and 2020 IEEE *Systems Journal* Best Paper Awards, the 2017 *Journal of Network and Computer Applications* Best Research Paper Award, and the Outstanding Associate Editor Award of IEEE Access in 2017 and 2018. He has also served as Co-Chair for more than 50 various international conferences, such as IWCMC, ICC, ISCC, ICNC, and Chinacom; the Symposium Co-Chair for IWCMC 2012, ICC 2012, the General Co-Chair for Chinacom 2014, Qshine 2015, Collaboratecom 2017, DependSys 2018, and SCI 2019; and the TPC Chair for InisCom 2015, NCCA 2015, WICON 2016, NCCA 2016, Chinacom 2017, InisCom 2017, WMNC 2017, NCCA 2018, ISITC 2019, ICNCC 2019, IndustrialIoT 2020, and ITIA2020.

JUNHUI ZHAO (Senior Member, IEEE) received the master's and Ph.D. degrees from Southeast University, Nanjing, China, in 1998 and 2004, respectively. From 1998 to 1999, he worked with the Nanjing Institute of Engineers, ZTE Corporation. He worked as an Assistant Professor with the Faculty of Information Technology, Macao University of Science and Technology in 2004, where he continued as an Associate Professor, until 2008. He was also a short-term Visiting Scholar with Yonsei University, South Korea, in 2004, and a Visiting Scholar with Nanyang Technological University, Singapore, from 2013 to 2014. He joined Beijing Jiaotong University, as an Associate Professor, in 2008, where he is currently a Professor with the School of Electronics and Information Engineering. Since 2016, he has been also with the School of Information Engineering, East China Jiaotong University. He is the Main Technical Leader of the Key Technology Engineering Laboratory of IoV, Jiangxi, and it was recognized as the Key Laboratory by Jiangxi Development and Reform Commission in 2016. His current research interests include wireless and mobile communications and related applications, including 5G mobile communication technology, vehicle network communication, wireless localization, and cognitive radio. He is a Fellow of the Institution of Engineering and Technology (IET). He received the Best Paper Awards from APCC 2018, IEEE ICCC 2018, IEEE WCSP 2017, and WICON 2016.

YI GONG (Senior Member, IEEE) received the B.Sc. and M.Sc. degrees from Southeast University, Nanjing, China, in 1995 and 1998, respectively, and the Ph.D. degree in electrical engineering from the Hong Kong University of Science and Technology, Hong Kong, in 2002. He then joined the Hong Kong Applied Science and Technology Research Institute, Hong Kong, as a Member of Professional Staff. He is currently a Professor with the Southern University of Science and Technology, Shenzhen, China. Prior to his current appointment, he was employed at Nanyang Technological University, Singapore, with which he still has active collaborations. His research interests include cognitive radio, cooperative communications, MIMO, OFDM, and cross-layer design for wireless systems. He has served on the editorial boards of the IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS and the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY since 2006. He received the IEEE WCSP 2017 and WICON 2016 Best Paper Award.

CHANGQING LUO (Member, IEEE) received the Ph.D. degree in computer engineering from Case Western Reserve University (CWRU) in 2018. He joined the Department of Computer Science, Virginia Commonwealth University, Richmond, VA, USA, in 2018, where he is currently an Assistant Professor. His research interests include mobile edge computing, wireless communications, wireless networks, security and privacy, and artificial intelligence. He has served as the Technical Program Committee (TPC) Chair of IEEE GreenCom 2019, the Publicity and Social Media Chair of EAI MobiQuitous 2019, the Publication Co-Chair of I-SPAN 2017, and the Publicity Co-Chair of IEEE iThings 2011. He has also served as the Technical Program Committee (TPC) member of many international academic conferences, including ICC, GLOBECOM, ICNC, and ICCC.



TIM GORDON received the Ph.D. degree from the University of Cambridge, U.K., in 1983. He joined the University of Lincoln, in 2014, having spent ten years with the University of Michigan (UM), as a Professor of mechanical engineering with the College of Engineering, and heading the Engineering Research Division at UM's Transportation Research Institute. He was formerly a Ford Professor with Loughborough University and has worked extensively in the automotive industry. He is currently the Head of the School of Engineering, College of Science, University of Lincoln. His research is based around vehicle dynamics and control, using automation for safe guidance and collision avoidance in road vehicles. His research interests include active safety of highway vehicles, vehicle autonomous systems, and vehicle control and vehicle dynamics. He received the Kenneth M. Reese Outstanding Research Scientist Award.