Guest Editorial
Software Defined Internet of Vehicles

INTERNET of Vehicles (IoV) is a large interactive network composed of information such as vehicle location, speed and route. Vehicles can collect their own environment and state information through GPS, RFID, sensors, camera image processing, and other devices. They can transmit their various information to the central processing unit through Internet technology. These large amounts of vehicle information can be analyzed and processed through computer technology to calculate the optimal route for different vehicles, and report road conditions in time and schedule signal light cycles. Internet of Vehicles (IoV) is a large-scale system network for wireless communication and information exchange between vehicles and people, vehicles and roads, vehicles and the Internet, which is based on intra-vehicle network, inter-vehicle network and vehicle mobile Internet, in accordance with the agreed communication protocols and data interaction standards. The system realizes the integrated network of intelligent traffic management, intelligent dynamic information service, and intelligent vehicle control by "filtering and cleaning" massive data and processing data on the platform. Internet of Vehicles (IoV) system utilizes advanced IoT technology, cloud computing, and big data to make the system fully aware of roads and traffic. It enables all vehicles to collect information through their own environment and state, and upload all kinds of information to the Internet big data platform. The central processing unit collects, analyzes, and processes a large amount of uploaded information. The system will control every vehicle involved in the traffic and control every road in real time to provide users with traffic efficiency and safety.

SDN can provide a feasible, cost-effective way to manage IoV and ensure network security. What's more, it can furthest improve the application programs and analyze performance. Due to the explosive growth of IoV and the chaotic nature of the public Internet, traffic in this area needs to be migrated to private channels; otherwise, there will be delays in key communications services and applications. Service providers and their users can transmit traffic of key services through these private channels, and transport the less important traffic through the public Internet. This requires the ability of SDN technology to respond to all kinds of requests.

SDN enables the network to be automatically and intensively managed, which can be achieved through remote configuration and management. The time to manage data center switches and USB device profiles by manpower have passed, IoV requires providers to rapidly configure devices around the world. That's why centralized management points will be essential components of the solution.

From a centralized point, automated protocols which allow macro-management of data traffic can be created. Augmented reality, advertising, threat evaluation, and mitigation, even navigation, all these require dynamic response from network devices. Through SDN, people can set up the strategy of new devices to access IoV in advance, which basically enables users to predict and then respond to IoV access devices. The inherent scalability of SDN enables new IoV devices to be added quickly. Programming the response protocols for these new network devices means that the network can expand (or shrink) as needed, and the dynamic response system greatly reduces the risk of IoV.

The virtualization of SDN components enables dynamic reconfiguration of network devices and traffic, automatic bandwidth configuration, and bandwidth de-configuration. Therefore, with the growth of IoV traffic, high-traffic instantaneous bandwidth or traffic related to health and safety applications will be given priority. The global IoV nature means the influx of large amounts of data, but the analysis of this information will lead to more intelligent and automated predictions. If the devices know each other better, traffic issues can be solved automatically without relying on well-planned solutions.

Due to the high mobility, dynamic nature, and legacy vehicular networks, the seamless connectivity and reliability become a new challenge in software-defined internet of vehicles-based intelligent transportation systems (ITS). Thus, there is an urgent need to optimize the link by managing and monitoring the high speed of vehicles in ITS. Thus, "Link Optimization in Software Defined IoV driven Autonomous Transportation System" proposes a novel reliable connectivity framework by developing a stable, and scalable link optimization (SSLO) algorithm, state-of-the-art system model. The numerical experimental results are extracted from software defined-Internet of Vehicle (SD-IoV) platform which shows high stability and reliability of the proposed SSLO under different test scenarios, such as vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and vehicle to anything (V2X). Finally, the validated results reveal that SSLO algorithm optimizes connectivity (95%), energy efficiency (67%), throughput (4Kbps) and delay (3 sec).

"User-Oriented Virtual Mobile Network Resource Management for Vehicle Communications" proposes a virtual network resource management based on user behavior to further optimize the existing vehicle communications through user-centric mobile services. The experimental results show that the proposed scheme can significantly improve the quality of services and experiences and that it provides a novel idea for optimizing vehicle networks.

An efficient and reliable data routing decision scheme is critical for VANETs (Vehicular Ad Hoc Networks). "V2VR:

Digital Object Identifier 10.1109/TITS.2021.3080875

Reliable Hybrid-Network-Oriented V2V Data Transmission and Routing Considering RSUs and Connectivity Probability" propose a reliable VANET routing decision scheme based on the Manhattan mobility model, which considers the integration of roadside units (RSUs) into wireless and wired modes for data transmission and routing optimization. First, the author analyze the frequently moving vehicles and network connectivity based on urban road structures and rules. Second, an improved greedy algorithm for vehicle wireless communication is used for network optimization, and a wired RSU network is also applied. Finally, comprehensive experiments show that our proposed method can support real-time planning and improve network transmission performance in terms of package delivery ratio, time delay and wireless hops.

The research efforts on cellular vehicle-to-everything (V2X) communications are gaining momentum with each passing year. "Efficient Power-Splitting and Resource Allocation for Cellular V2X Communications" aims to further push the state-of-the-art of cellular V2X communications by providing an optimization framework for wireless charging, power allocation, and resource block assignment. The author design a network model where roadside objects use wireless power from RF signals of electric vehicles for charging and information processing. Moreover, due to the resource-constraint nature of cellular V2X, the power allocation and resource block assignment are performed to efficiently use the resources. The proposed optimization framework shows an improvement in terms of the overall energy efficiency of the network when compared with the baseline technique.

To detect the anomalous behavior of the nodes in the IoV environment, a hybrid approach using probabilistic data structures is proposed in "A Probabilistic Data Structures-based Anomaly Detection Scheme for Software-defined Internet of Vehicles" which works in the following phases. In phase I, a traffic monitoring scheme using Count-Min-Sketch is designed to identify the suspicious nodes. In phase II, to detect an anomaly, a Bloom filter-based control scheme is used for signature verification of suspicious nodes. In phase III, a Quotient filter is used for fast and efficient storage of malicious nodes. In phase IV, a Hyperloglog counter is used to measure the cardinality of each flow passing through the switches. The proposed scheme has been evaluated in a simulated environment. The results obtained depict that the proposed scheme is faster, accurate, and efficient concerning detection ratio and false-positive ratio.

"Vehicle Trajectory Clustering Based on Dynamic Representation Learning of Internet of Vehicles" propose an accurate vehicle trajectory clustering method based on dynamic network representation learning. The proposed method first constructs the dynamic vehicle network based on the k-nearest neighbors. Then, it learns the low-dimensional representations of vehicles by performing dynamic network representation learning on the constructed network. Finally, vehicle trajectories are clustered with machine learning methods based on vehicle vectors. Results on a real-world dataset show the effectiveness of the proposed method.

Benefits from artificial intelligence and Internet of Vehicles (IoV), Management of modern transportation have a great progress, especially in urban areas. However, traditional traffic video process and visualization are usually conducted in offsite and textural environments, i.e., text and number, which do not promote user's sensorial perception and interaction. Thus, the problem that how to use modern novel techniques to analyze traffic video for improving intelligent transportation is so emergency. In "Joint 3D reconstruction and Object Tracking for Traffic Video Analysis under IoV Environment," the author introduces a joint 3D reconstruction and object tracking approach to traffic video analysis under IoV environment, which is an integrative framework and consists of 3D reconstruction, object detection, and tracking. The 3D reconstruction system is connected to the internet of vehicles and integrated into the system to retrieve image data for recovering 3D model of vehicles, and then, visualizing vehicle's trajectories in real time by augmented reality. And the system can also locate vehicle's position in real time. The experiments in both laboratory and practice show great feedback, which will effectively contribute to intelligent transportation in a cheap manner.

A probabilistic threshold k-ANN query method based on uncertain Voronoi diagram is proposed in "Probabilistic Threshold k-ANN Query Method based on Uncertain Voronoi Diagram in Internet of Vehicles". The method includes three phases: processing phase, pruning phase and refinement phase. For the three kinds of aggregate functions, the corresponding pruning strategy to prune the points that cannot be the result is proposed and the qualified points are added into candidate set. The algorithm of refinement phase is given. The experiments show the effectiveness and efficiency of the proposed algorithms.

In "Autonomous Vehicle Source Enumeration Exploiting Non-cooperative UAV in Software Defined Internet of Vehicles," the author constructs a novel system architecture consisting of multiple non-cooperative unmanned aerial vehicles (UAVs) and a SDN-IoV. The non-cooperative UAV is equipped with an antenna array to receive the signals from the vehicles and pedestrians of SDN-IoV. In order to locate the positions of vehicles and pedestrians, two source enumeration methods are proposed in a complex SDN-IoV environment with color noise. The projection matrix of the low dimensional signal subspace is constructed by the proposed criterion based on signal subspace projection (SSP). The sequence of the projected difference values of the local covariance matrix is applied to estimate the number of vehicles and pedestrians. The eigenvalues can be grouped to construct different subspaces by the proposed eigen-subspace projection (ESP). By projecting a new covariance matrix into the eigen-subspaces, the variance of values represents the projection difference can be exploited to estimate the number of vehicles and pedestrians.

"Blockchain-Based Adaptive Trust Management in Internet of Vehicles Using Smart Contract" proposes a blockchain-based decentralized trust management scheme using smart contracts. Authors aim to utilize the blockchain for storing reliable trust scores and use it as a platform for maintaining behavior-based incentives earned by the vehicles. The CA/TA is responsible for the deployment of the smart contracts whereas the blockchain is maintained by the RSUs. In addition to that, they propose to use sharding for the vehicular blockchain to increase the transaction throughput.

Testbed-based experiments were performed to check the feasibility of the proposed system.

The mobility of people is at the center of transportation planning and decision-making of the cities of the future. A fundamental aspect of a smart and sustainable city is to be able to sense the pulse of the city, to perform short and long-term analysis of mobility phenomena and to provide valuable information to decision makers. The simulations are relevant in this context as they support administrators, operators and users in the assessment of how innovative mobility solutions will meet their needs to help plan for the future. "Agent-based Framework for Self-Organization of Collective and Autonomous Shuttle Fleets" propose an agent-based simulation framework for the creation and simulation of mobility scenarios to investigate the impact of new mobility modes on the daily life of a city. It is multi-agent with decentralized control and models a city with its inhabitants and cars to explore the benefits and challenges of the integration of Autonomous Shuttles into the traffic system of the city.

Social Internet of Vehicles (SIoV) has witnessed a significant R&D attention from the industries and academic research divisions focusing on smart city centric intelligent transportation system developments. In this context, green traffic data dissemination in SIoV environments is modelled as an NP-hard problem focusing on heterogeneous traffic data, transmission distance from next generation smart devices and probabilistic delay in transmissions due to disruptive vehicular environment. An adopted meta-heuristic solution namely Two-Way Particle Swarm Optimization (TWPOS) is developed in "Green Computing in Software Defined Social Internet of Vehicles" for the green traffic data dissemination problem in SIoV considering software defined vehicular network architecture. Extensive simulation experiments were performed to assess the performance of TWPSO as compared to the state-of-the-art techniques. The critical analysis of the comparative results attest the green computing oriented benefits of TWPSO under realist SIoV environments.

Intelligent Transportation System (ITS) serves as the on-the wheel communication and service platform for the real-world driving users. Navigation service and traffic information flow among the connected vehicles relies on the available resources and infrastructure units. Appropriate sensing and selection of infrastructure units for seamless navigation responses and information flow in the dynamic environment is facilitated using bio-inspired learning in this article. This method named as ant-inspired recurrent learning model (ARLM) introduced in "Ant-Inspired Recurrent Learning Model for Improving the Service Flow of Intelligent Transportation Systems" which is focused to improve the sensing and response rate of the navigation-based services for the vehicles. This model relies on forward and backward ant agents and recurrent learning for maximizing the navigation service response rate of the vehicles. In this model, the training sets are differentiated on the basis of connection probability and learning depreciation to retain the service rate through different learning iterates. The conditional verification for sensing and retaining active link helps to reduce the sensing and response time irrespective of the varying vehicle and request densities.

In "A Novel Cost Optimization Strategy for SDN-enabled UAV-assisted Vehicular Computation Offloading". A novel SDN-enabled UAV-assisted vehicular computation offloading optimization framework is proposed to minimize the system cost of vehicle computing tasks. In the framework, the UAV and the Mobile Edge Computing (MEC) sever are deployed to assist vehicle users to execute the delay-sensitive and compute-intensive tasks. Furthermore, the UAV can also be deployed as a relay node to assist in forwarding computation tasks to the MEC server. The vehicular computation offloading problem is described as a multi-players computation offloading sequential game, and the UAV-assisted Vehicular computation Cost Optimization (UVCO) algorithm to solve this problem. The experimental results demonstrate the efficiency of the proposed algorithm.

The development cost optimization under the functional safety requirement for a safety-aware Software Defined Vehicles (SDV) is addressed, which is the first time to consider both of the real-time and reliability requirements. A two-stage solution based on the automotive safety integrity level (ASIL) decomposition defined in ISO 26262 is proposed in "Risk Assessment and Development Cost Optimization in Software Defined Vehicles". First, a new fast risk assessment (FRA) algorithm is developed to assess the functional safety requirement efficiently. Then, a dual requirement guarantee (DRG) algorithm is proposed to optimize the development cost while guaranteeing both of the real-time and reliability requirements. The experimental results demonstrate that the technique is more in line with the requirements of functional safety standards by considering the real-time and reliability requirements, especially for large-scale SDV functionalities.

A parallel deep neural network based on dual fusions including feature and decision is proposed in "Behavior Prediction for Unmanned Driving Based on Dual Fusions of Feature and Decision," called DFFD-Net. DFFD-NET is composed of two parts, the feature fusion network and the driving data network. Experiments show DFFD-NET can get state-of-the-art results on both perplexity and precision by only using the images captured from the front-facing camera as well as a few sensing data.

"Adaptive Traffic Engineering Based on Active Network Measurement towards Software Defined Internet of Vehicles" proposes a software-defined networking (SDN)-enabled architecture for vehicular networks. Based on the proposed network architecture, an adaptive traffic engineering (TE) mechanism is proposed to guarantee the V2V continuous traffic in vehicular networks with dynamic network topology. The proposed TE is based on a proposed active network measurement mechanism under the assistance of the centralized management ability of the SDN technique. In particular, the artificial bee colony (ABC) algorithm is utilized to optimize the TE mechanism that can be deployed and executed in the SDN controller. The simulation results demonstrate that the proposed TE can perform reliable data forwarding.

"A Performance Measurement and Analysis Method for Software-defined Networking of IoV" studies the measurement and analysis technology for software-defined networking

of IoV. A new software-defined networking-based IoV heterogeneous networking measurement framework is proposed to build software-defined networking of IoV. A performance measurement and analysis method is presented to measure and characterize its performance. The performance indexes and measure methods about the delay, loss, throughput, delay jitter is in detail derived. The switch selection mechanism is proposed to establish optimal measurement points of advantage. The packet sampling process is presented to quickly obtain the needed measurement information from massive traffic flows. To validate our measurement method and fairly characterize its measurement performance for different controllers, the author conduct massive simulation experiments to systematically analyze and compare current famous controllers. Experiments results show that our measurement approach is feasible and effective.

In "Secure Service Offloading for the Internet of Vehicles in SDN-Enabled Mobile Edge Computing," the secure service offloading method (SOME) is proposed, aiming at promoting IoV service utility and edge utility, meanwhile ensuring privacy. The system model and the problem formulation are given and an SDN-based framework is developed to integrate edge-computing with the ability to timely adjust offloading and address the inherent uncertainty of edge network. Besides, the locality-sensitive hash (LSH) is leveraged to realize privacy-aware service selection. Abundant experiment results in different indicators verify the effectiveness of SOME. In addition, the advantages and differences of this paper compared to the work in other literature are discussed in detail.

In "Distributed Learning for Vehicle Routing Decision in Software Defined Internet of Vehicles". A new software defined Internet of Vehicles architecture based on edge intelligence is introduced to alleviate the pressure of cloud centralized computing and reduce the delay caused by transferring data to the remote cloud, which supports real-time vehicle routing decision through distributed multi-agent reinforcement learning model. Based on the designed device collaboration optimization method, a distributed-learning-based vehicle routing decision algorithm is proposed to adaptively adjust vehicle routing online and improve the efficiency of distributed training. The performed simulations show that the proposed algorithm can successfully realize real-time routing decision for vehicles and effectively reduce the training time, and has excellent performance in alleviating traffic congestion.

As the growth of vehicles and the acceleration of urbanization, the urban traffic congestion problem becomes a burning issue in our society. Constructing a software defined Internet of things (SD-IoT) with a proper traffic control scheme is a promising solution for this issue. In "Urban Traffic Control in Software Defined Internet of Things via a Multi-agent Deep Reinforcement Learning Approach," the author proposes Modified Proximal Policy Optimization (Modified PPO) algorithm. This algorithm is ideally suited as the traffic control scheme of SD-IoT. The author adaptively adjust the clip hyperparameter to limit the bound of the distance between the next policy and the current policy. What's more, based on the collected data of SD-IoT, the proposed algorithm controls traffic lights and vehicles in a global view to advance the performance of urban traffic control. The experimental results under different vehicle numbers show that the proposed method is more competitive and stable than the original algorithm. The proposed method improves the performance of SD-IoT to relieve traffic congestion.

The integration of Software-Defined Networking and Internet of Vehicles, namely SDN-IoV, can enrich many SDN-IoV applications for intelligent transportation, in which the spatial crowdsourcing has been adopted as an effective data collection technology. However, as huge amounts of data are generated in spatial crowdsourcing services, the data privacy has become a key challenge for SDN-IoV. To overcome abovementioned challenge, a Deep reinforcement learning and Blockchain empowered Spatial Crowdsourcing System (DB-SCS) is proposed in "Blockchain and Deep Reinforcement Learning Empowered Spatial Crowdsourcing in Software-Defined Internet of Vehicles". In DB-SCS, the author design an improved multi-blockchain structure and a blockchain-based hierarchical task management method, which divide the spatial tasks into different categories, and then decompose tasks and task receivers into sub-blockchains. While guaranteeing the data privacy, DB-SCS can also enhance the spatial crowdsourcing performance by dynamically selecting the consensus algorithm, block size, and block generation rule. Extensive experiments demonstrate that the DB-SCS can obtain high throughput, low overhead, and data privacy under various SDN-IoV scenarios.

"Blockchain-based Trust Management Model for Location Privacy Preserving in VANET" proposes a blockchain-based trust management model for location privacy preserving. To ensure the privacy security of vehicles, the proposed method allows vehicles to use certificate to construct anonymous cloaking region without revealing their personal information. The scheme also proposes a trust management algorithm to constrain and standardize the behavior of vehicles, and use blockchain to implement the data security of vehicles. Security analysis and experiments show that the system is resilient to sorts of trust model attacks, which can better preserve the privacy security of vehicles. The simulation results reveal that the proposed system is effective and feasible in collect.

In Internet of Vehicles (IoV), accurate traffic flow prediction is helpful for analyzing road condition and then timely feedback traffic information to managers as well as travelers. In "Traffic Flow Prediction Based on Deep Learning in Internet of Vehicles," a traffic flow prediction framework for urban road network based on deep learning is proposed. Firstly, the feature engineering is introduced to extract the features from a large volume of traffic dataset, with the anomaly nodes eliminated. Next, the big traffic dataset is compressed through the spectral clustering compression scheme. Finally, they designed a hybrid traffic flow prediction scheme based on LSTM (Long Short-Term Memory) and Sparse Auto-Encoder (SAEs). The experimental results show that our proposed model is superior to other models with an average prediction accuracy approaching 97.7%.

"Autonomous Shuttle-as-a-Service (ASaaS): Challenges, Opportunities, and Social Implications" analyses the state-of-art on autonomous shuttles by proposing four application scenarios targeting the last-mile delivery of goods, the tourist

experiences, and the shared and integrated mobility. The author contributes with the proposition of the Autonomous Shuttles-as-a service (ASaaS) concept as the key pillar for the realization of innovative and sustainable proximity mobility. The author propose new research challenges for ASaaS, and discuss social implications and governance challenges that consider user engagement and sustainability.

The maritime communication network is assembled by emergent network technologies. However, the adverse maritime environment impedes the efficiency of resources allocation in maritime communication network. "Efficient Energy and Delay Tradeoff for Vessel Communications in SDN based Maritime Wireless Networks" shows a joint sleeping scheduling and opportunistic transmission scheme in delay-tolerant maritime wireless communication networks based on software defined networking (SDN) to find a better tradeoff between the energy consumption and the delay. To further save the energy, a long-term energy minimization problem is formulated with sleeping scheduling and opportunistic transmission. Both mathematical analyses and simulation results demonstrate how the maritime communication network allocates satisfactorily with the proposed allocation scheme.

"An Energy Aware Offloading Scheme for Interdependent Applications in Software-Defined IoV with Fog Computing Architecture" studies the offloading problem in IoV systems with fog computing architecture. An energy-aware dynamic offloading scheme is proposed to prolong the running time of the IoV system by leveraging available battery power to execute interdependent applications. The remaining battery power is defined as a dynamic weight factor in the execution cost model to adjust the optimization objective. A heuristic optimization algorithm for this model is presented.

Smart vehicles not only have networks connecting their internal components e.g. via Controller Area Network (CAN) bus, but also are connected to the outside world through road side units and other vehicles. Any misconfiguration opens a window for the hackers to intrude into vehicles' internal components e.g. central lock system, Engine Control Unit (ECU), Anti-lock Braking System (ABS) or Adaptive Cruise Control (ACC) system. Compromise of any of these can lead to disastrous outcomes. "On the Security of Networked Control Systems in Smart Vehicle and its Adaptive Cruise Control" study the security of smart vehicles' ACC systems in the presence of covert attacks. The author define two covert/stealth attacks in the context of ACC and propose a novel intrusion detection and compensation method to disclose and respond to such attacks. If any anomaly is detected by the IDS engine, an embedded substitute controller kicks in and takes over the control. they conducted extensive experiments to evaluate the proposed scheme.

In a complex and dynamic IoV environment, to manage these computing resources with different attributes effectively and provide high-quality services, it is necessary to design an efficient architecture and a resource allocation algorithm. Therefore, in "Resource Allocation in 5G IoV Architecture Based on SDN and Fog-Cloud Computing," on the basis of the fog-cloud computing and software-defined networking (SDN), a new 5G IoV architecture is designed. In addition, after fully considering the service requirements of the IoV, a model of four objectives is established, and a many-objective optimization algorithm is proposed. The proposed algorithm outperforms other state-of-the-art algorithms in the IoV environment.

The development of Internet of Vehicle (IoV) makes the transportation system become an intelligent network. However, with the increase of vehicles, more and more data need to be analyzed and processed. In "Large-Scale Many-Objective Deployment Optimization of Edge Servers," the placement problem of ESs in IoV is studied, and the six-objective ES deployment optimization model is constructed by considering transmission delay, workload balancing, energy consumption, deployment costs, network reliability, and ES quantity simultaneously. Besides, the deployment problem of ESs is optimized by a many-objective optimization evolutionary algorithm. By comparing with the state-of-the-art methods, the effectiveness of the algorithm and model are verified.

Internet of connected vehicles (IoCV) is one of the popular subclasses of vehicle ad hoc networks and an up-rising form based on new Internet, 5G, cloud, and edge computing features. For efficient data communication among the vehicle nodes and address the existing routing protocol issues, "An Enhanced Multi-Hop Intersection based Geographical Routing Protocol for the Internet of Connected Vehicles Network" presents the Intersection Gateway and Connectivity based Routing (IGCR) protocol for IoCV networks. The proposed protocol uses important traffic-aware routing metrics, including traffic density and direction of nodes towards the destination for route and next forwarder node selection.

In software-defined IoV, messages transmitted by vehicles are transferred using wireless communication technology, so attackers can easily attack specific vehicles and Road-Side Units (RSUs) within the wireless communication range. Building a highly reliable and fault-tolerant software-defined IoV is of high importance. One of the most well-known problems in a fault-tolerant distributed system is the consensus problem. In "Fault-Tolerance Mechanisms for Software-Defined Internet of Vehicles," the author visits the consensus problem in software-defined IoV. By solving the consensus problem in software-defined IoV, they can enhance the reliability and fault tolerance of the software-defined IoV. By doing so, they can promote the application of intelligent transportation systems where higher reliability is demanded.

"Data Security Through Zero-knowledge Proof and Statistical Fingerprinting in Vehicle-to-Healthcare Everything (V2HX) Communications" presents a smart zero-knowledge proof and statistical fingerprinting-based trusted secure communication framework for a fog computing environment. A zero-knowledge proof is used for vehicle authentication, and statistical fingerprinting is employed to secure communication between VANETs and HEs. Authenticity verification of the operations is performed at the on-board unit (OBU) fitted in the vehicle based on the service executions at the resident hardware platform. The processor clock cycles are acquired from the service executions in a complete sandboxed environment. The calculated cycles assist in developing the blueprint signature for the OBU of the vehicle. Hence, the fingerprint

signature helps build trust and plays a key role in authenticating the vehicle's horizontal movement to everything and/or to different sections of the HEs.

Data of the train communication network (TCN) are becoming more complicated, which results in higher requirements of the data processing unit—the multifunction vehicle bus controller (MVBC) connected within the TCN. Developing an MVBC is challenging because of the integrated hardware software solutions to support reactions in real time and dynamic environment. Hence, there is an urgent need for a rigorous design framework to facilitate the development of MVBC. In this paper, In "Formal Design of Multi-function Vehicle Bus Controller", the author proposes a design framework TooMVBC to generate executable MVBC code from formal verified computation model. TooMVBC uses formal computation model MVBChart to capture the specification of the MVBC at high level. First, primitive syntax of MVBChart is designed to model MVBC features (e.g. hierarchy structure, data flow of the encoder. Then, semantics-preserving code generation algorithms are designed to generate VHDL code for partitioned hardware implementations and C code for partitioned software implementations from verified MVBChart model. Finally, supporting graphical model editor, simulator, verification translator, partitioning and code generator are implemented and seamlessly integrated into TooMVBC. When they apply TooMVBC to design MVBC with the highest class 5 according to the description of the standard IEC 61375, several critical ambiguousness or bugs in the standard are detected during formal verification of the constructed system model.

In "Software-Defined Internet of Vehicles For Flexible Automation and Orchestration", the authors have developed a novel data networking approach to the Internet of Vehicles (IoV) for their automation and orchestration by rethinking the wireless edge framework. They proposed to expand the Software Defined Networking (SDN) functionality from the edge network to the cars, i.e., equipping our vehicles with mobile base stations having extensive SDN capabilities. By adopting such a new approach, most of the impending IoV automation and orchestration challenges are resolved, which have been extremely difficult and non-trivial by employing standard existing approaches.

ZHIHAN LV, *Guest Editor*
College of Computer Science and Technology
Qingdao University
Qingdao 266071, China
e-mail: lvzhihan@gmail.com

JAIME LLORET, *Guest Editor*
Department of Communications
Universitat Politecnica de Valencia
46022 Valencia, Spain
e-mail: jlloret@dcom.upv.es

HOUBING SONG, *Guest Editor*
Department of Electrical Engineering and
Computer Science
Embry–Riddle Aeronautical University
Daytona Beach, FL 32114 USA
e-mail: h.song@ieee.org

Zhihan Lv (Senior Member, IEEE) received the dual Ph.D. degree from Paris7 University and the Ocean University of China in 2012. He was a Research Associate with University College London (UCL). He worked with CNRS, France, as a Research Engineer, the Umea University/KTH Royal Institute of Technology, Sweden, as a Post-Doctoral Research Fellow, and Fundacion FIVAN, Spain, as an Experienced Researcher. He is currently a Professor with Qingdao University, China. He has contributed more than 200 articles in the related fields on journals, such as IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS (TII) and *ACM Transactions on Multimedia Computing, Communications, and Applications* (ACM TOMM), and conferences, such as ACM MM, ACM CHI, ACM Siggraph, ICCV, and IEEE Virtual Reality. His research interests include multimedia, augmented reality, virtual reality, computer vision, 3D visualization and graphics, serious game, HCI, big data, and GIS. He was a Marie Curie Fellow of the European Union's Seventh Framework Program LANPERCEPT. He is also a Program Committee Member of ACM IUI 2015, 2016, and 2019, the IEEE BIGDATA4HEALTH Workshop 2016, the IEEE/CIC WIN Workshop 2016, IIKI 2016, WASA 2016, IEEE PDGC 2016, and ACM SAC 2017-WCN Track. He has served as a reviewer for journals, such as IEEE TRANSACTION ON MULTIMEDIA, IEEE MULTIMEDIA, *Neurocomputing*, *Computer Networks* (Elsevier), *Telecommunication Systems* (Springer), *Multimedia Tools and Applications*, *KSII Transactions on Internet and Information Systems*, *Journal of Medical Internet Research*, *Intelligent Service Robotics*, and *Presence: Teleoperators & Virtual Environments*, and conference, e.g., ACM MUM 2013, ACM CHI 2014 and 2015, ACM DIS 2014 and 2016, IEEE Info-Vis 2014, ACM UIST 2014 and 2016, ACM Mobile-HCI 2014, 2015, and 2016, ACM CHIPLAY 2014, 2015, and 2016, ACM CSCW 2015 and 2016, ACM SUI 2014 and 2015, ACM ITS 2014 and 2015, IEEE VAST 2014, IEEE VR 2015 and 2016, ACM IUI 2015 and 2016, IEEE 3DUI 2015 and 2016, ACM TVX 2015, IEEE Euro-Vis 2015 and 2016, ACM Creativity and Cognition 2015, ACM EICS 2015, ACM IDC 2015 and 2016, IEEE ICSIPA 2015, GI 2016, IEEE ITSC 2016, IEEE Sensors 2016, ACM ACI 2016, ACM VRST 2016, and ACM ISS 2016. He is also the Guest Editor of the IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, *Future Generation Computer Systems*, *Neurocomputing*, *Neural Computing and Applications*, *Computers & Electrical Engineering*, *IET Image Processing*, *Multimedia Tools and Applications*, and *Journal of Intelligent & Fuzzy Systems*.

Jaime Lloret (Senior Member, IEEE) received the B.Sc.+M.Sc. degree in physics in 1997, the B.Sc.+M.Sc. degree in electronic engineering in 2003, and the Ph.D. degree in telecommunication engineering in 2006. He worked as a network designer and administrator in several enterprises. He is currently a Cisco Certified Network Professional Instructor. He is also an Associate Professor with the Polytechnic University of Valencia. He is also the Head of the "Active and collaborative techniques and use of technologic resources in the education (EITACURTE)" Innovation Group. He is also the Director of the University Diploma "Redes y Comunicaciones de Ordenadores." He had been the Director of the University Master "Digital Post Production" for the term 2012–2016. He has authored 22 book chapters and has more than 450 research articles published in national and international conferences and international journals (more than 200 with ISI Thomson JCR). He has been involved in more than 450 Program committees of international conferences, and more than 150 organization and steering committees. He has led many local, regional, national, and European projects. He is also a Senior Member of ACM and a fellow of IARIA. He is also the Chair of the Integrated Management Coastal Research Institute (IGIC). He was the Vice-Chair for the Europe/Africa Region of Cognitive Networks Technical Committee (IEEE Communications Society) for the term 2010–2012 and the Internet Technical Committee (IEEE Communications Society and Internet Society) for the term 2011–2013. He had been the Internet Technical Committee Chair (IEEE Communications Society and Internet Society) for the term 2013–2015. He is also the Chair of the Working Group of the Standard IEEE 1907.1. He had been the General Chair (or the Co-Chair) of 40 international workshops and conferences (the Chairman of SENSORCOMM 2007, UBICOMM 2008, ICNS 2009, ICWMC 2010, eKNOW 2012, SERVICE COMPUTATION 2013, COGNITIVE 2013, ADAPTIVE 2013, 12th AICT 2016, 11th ICIMP 2016, 3rd GREENETS 2016, 13th IWCMC 2017, and 10th WMNC 2017, and the Co-Chairman of ICAS 2009, INTERNET 2010, MARSS 2011, IEEE MASS 2011, SCPA 2011, ICDS 2012, 2nd IEEE SCPA 2012, GreeNets 2012, 3rd IEEE SCPA 2013, SSPA 2013, AdHocNow 2014, MARSS 2014, SSPA 2014, IEEE CCAN 2015, 4th IEEE SCPA 2015, IEEE SCAN 2015, ICACCI 2015, SDRANCAN 2015, FMEC 2016, 2nd FMEC 2017, 5th SCPA 2017, JITEL 2017, SDS 2018, and IoTSMS 2018, and the Local Chair of MIC-WCMC 2013 and IEEE Sensors 2014). He has been the co-editor of 40 conference proceedings and a guest editor of several international books and journals. He is also the Editor-in-Chief of the *Ad Hoc and Sensor Wireless Networks* (with ISI Thomson Impact Factor), the international journal *Networks Protocols and Algorithms*, and the *International Journal of Multimedia Communications*. Moreover, he is also an Associate Editor-in-Chief of *Sensors* in the Section Sensor Networks, an Advisory Board Member of the *International Journal of Distributed Sensor Networks* (both with ISI Thomson Impact Factor), and the IARIA journals board chair (eight journals). Moreover, he is (or has been) an associate editor of 46 international journals (16 of them with ISI Thomson Impact Factor).

Houbing Song (Senior Member, IEEE) received the Ph.D. degree in electrical engineering from the University of Virginia, Charlottesville, VA, USA, in August 2012, and the M.S. degree in civil engineering from The University of Texas at El Paso, El Paso, TX, USA, in December 2006.

In August 2017, he joined the Department of Electrical, Computer, Software, and Systems Engineering, Embry–Riddle Aeronautical University, Daytona Beach, FL, USA, where he is currently an Assistant Professor and the Director of the Security and Optimization for Networked Globe Laboratory (SONG Laboratory). He has served on the faculty for West Virginia University from August 2012 to August 2017. In 2007, he was an Engineering Research Associate with the Texas A&M Transportation Institute. He is the author of more than 100 articles. His research interests include cyber-physical systems, cybersecurity and privacy, the Internet of Things, edge computing, big data analytics, unmanned aircraft systems, connected vehicle, smart and connected health, and wireless communications and networking. He is also a Senior Member of ACM. He was a recipient of the prestigious Air Force Research Laboratory's Information Directorate (AFRL/RI) Visiting Faculty Research Fellowship in 2018, and the very first recipient of the Golden Bear Scholar Award and the highest campus-wide recognition for research excellence at the West Virginia University Institute of Technology (WVU Tech) in 2016. He also serves as an Associate Technical Editor for *IEEE Communications Magazine*. He is also the Editor of six books, including *Big Data Analytics for Cyber-Physical Systems: Machine Learning for the Internet of Things* (Elsevier, 2019), *Smart Cities: Foundations, Principles and Applications* (Hoboken, NJ, USA: Wiley, 2017), *Security and Privacy in Cyber-Physical Systems: Foundations, Principles and Applications* (Chichester, U.K.: Wiley-IEEE Press, 2017), *Cyber-Physical Systems: Foundations, Principles and Applications*, (Boston, MA, USA: Academic Press, 2016), and *Industrial Internet of Things: Cybermanufacturing Systems* (Cham, Switzerland: Springer, 2016).