Block Chain and Big Data-Enabled Intelligent Vehicular Communication

IN the last decade, the number of vehicles worldwide has increased every year, and this growth is projected to continue unabated. Thus, the congestions, incidents, and environmental pollution which are caused by the increasing number of road vehicles and traffics have resulted in hundreds of millions of losses and become a major challenge to the sustainable development of recent human society. Both academia and industry have already reached a consensus that vehicular communication is a vital element to extend the sensing ability of vehicles for ensuring safety driving. Unfortunately, current vehicular communication cannot meet the security, reliability, and effectiveness and other needs of ITS. The industry needs a more intelligent vehicular communication to support secure and reliable transmission of data. Therefore, the research community has to focus more on enhanced and completely new communication techniques.

With the security threats and underutilization of vehicular data, intelligent vehicular communication appears more and more to be one of the key enabling technologies needed to address the bottlenecks of the currently vehicular communication networks. Novel techniques and technologies are needed to provide the necessary intelligence and adaptation for information security and cooperation of the more and more different existing vehicular communication systems. Under the so-called big data and blockchain technologies, the large volume of vehicular data can be well exploited to improve vehicular communication and the information can be managed in a more secure way. The blockchain infrastructure provides the ability for transaction records not to be tampered with or modified in vehicular communication. The technology of big data is conducive to real-time monitoring of vehicle status, road emergency prediction and road planning applications. In other applications, using big data to identify driver's driving habits and develop usage-based insurance as well as personalized recommend vehicle maintenance services. While some initial steps toward the implementation of intelligent vehicular communication concepts have already been taken, there are still big challenges that need to be tackled, before the full potential of vehicular communication techniques can be achieved. This Special Issue aims to report on new theoretical results and applications of intelligent vehicular communication.

The authors received a very good response to their Special Issue call for articles. During the review process, each article was assigned to and reviewed by at least three experts in the field. After a rigorous multiround review process the authors were able to accept 28 excellent articles covering various topics in blockchain and big data-enabled intelligent vehicular communication. In the following, the authors will introduce these articles and highlight their main contributions.

In the article "Multi-task travel route planning with a flexible deep learning framework," Huang *et al.* discuss a flexible multi-task deep travel route planning framework named MDTRP that integrates rich auxiliary information for more effective planning. Furthermore, the authors discuss the construction of a heterogeneous network through the relations between users and POIs and employ a heterogeneous network embedding method to learn the features of users and POIs.

In the article "Traffic jam probability estimation based on blockchain and deep neural networks," Hassija *et al.* present a blockchain-based secure crowdsourcing model to predict the traffic jam probability. The authors mention that the model ensures privacy preservation of the users and also provides them with an incentive to participate in the traffic prediction process willingly by incorporating a revenue model.

The article "Rate-compatible codes via recursive BMST for content-sharing in intelligent vehicular network" discusses on the construction of a new class of spatially coupled rate-compatible codes with recursive block Markov superposition. A semi-analytical method is used to compute the iterative decoding thresholds of the proposed codes.

In the article "An intelligent terminal based privacy-preserving multi-modal implicit authentication protocol for Internet of Connected Vehicles," Wei *et al.* discuss on a two intelligent terminal-based privacy-preserving multi-modal implicit authentication protocols to protect the security of the intelligent terminal in the Internet of Vehicles. The proposed protocols use the password and the vehicle owner's behaviour features as the authentication factors to protect the security of the intelligent terminal.

The article "Thresholds based image extraction schemes in big data environment in intelligent traffic management" presents a thresholds-based images extraction solution for ITS. At first, a faster region convolutional neural networks (RCNNs) model is used to segment a traffic image into multi-regions with different importance levels; then, multi-threshold image extraction schemes are designed based on progressive secret image sharing schemes to extract images containing key traffic information, such as reg number, and human faces.

The article "Machine-learning-based scenario identification using channel characteristics in intelligent vehicular communications" presents a machine-learning-based scenario identification model for intelligent vehicular communications. Channel characteristics extracted from channel measurements

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in different scenarios form the datasets used for training, then a back-propagation neural network (BPNN) is trained, and a scenario identification model is obtained.

In the article "A hierarchical blockchain-enabled federated learning algorithm for knowledge sharing in Internet of Vehicles," Chai *et al.* discuss a hierarchical blockchain framework for vehicular knowledge sharing. To reduce computation consumption, a light-weight proof-of-knowledge consensus mechanism is developed in the proposed framework.

The article "Intelligent group prediction algorithm of GPS trajectory based on vehicle communication" discusses the problem that the gravitational algorithm is difficult to minimize the complex function and easily fall into the local optimum, and presents an improved IGSA algorithm. Here, a gridding algorithm is introduced to initialize the population, and under the premise of ensuring the randomness of the initial individuals, improving the ergodicity of the population is conducive to improving the quality of the solution; then, an adaptive location-based update strategy of decreasing inertia weights is proposed.

The article "Blockchain based lightweight and secured V2V communication in Internet of Vehicles" presents a lightweight solution for the scalable IoVT in which real-time adversary is detected. Here, the hash is generated in real-time using blockchain technology which is shared with the vehicles.

The article, "CRT-BIoV: A Cognitive Radio Technique for Blockchain-enabled Internet of Vehicles," discusses security to IoV during spectrum sensing and information transmission using CRN by sensing the channels through a decision-making technique known as 'Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS),' a technique that evokes the trust of its Cognitive Users (CU) by analysing certain predefined attributes. Further, the blockchain is maintained in the network to trace every activity of stored information.

In the article, "MEC intelligence driven electro-mobility management for battery switch service," Cao *et al.* present a mobile edge computing (MEC) driven architecture to gear the intelligent battery switch service management for EVs. Here, the decision making on where to switch battery is operated by EVs in a distributed manner.

The article "Generalized quadrature spatial modulation and its application to vehicular networks with NOMA" investigates the practical application of GQSM to cooperative vehicular networks and proposes a cooperative GQSM with OMA (C-OMA-GQSM) and cooperative GQSM with NOMA (C-NOMA-GQSM) schemes.

The article "Spectral efficiency enhanced cooperative device-to-device systems with NOMA" presents a spectral efficiency enhanced cooperative device-to-device (D2D) system with non-orthogonal multiple access (NOMA). Here, the closed-form expressions of ergodic sum-rate (SR), outage probability, and outage capacity are analyzed.

In the article "Blockchain and learning-based secure and intelligent task offloading for vehicular fog computing," Liao *et al.* discuss a blockchain and learning-based secure and intelligent task offloading scheme for vehicular fog computing. It can ensure privacy, fairness, and security while simultaneously achieving queuing-delay awareness, handover-cost awareness, and trustfulness awareness without requiring the VFS-side information and channel state information.

The article "Efficient mining cluster selection for blockchain-based cellular V2X communications" presents an efficient solution for offloading mining tasks in cellular V2X networks. To satisfy the low-latency requirements of safety applications, the authors consider a short blocklength transmission architecture.

The article "Blockchain-based secure computation offloading in vehicular network" investigates the safety and offloading capabilities of a multi-vehicle ECCO system based on blockchain cloud services. An extended offloading algorithm based on deep reinforcement learning is proposed to achieve the optimal offloading strategy for all vehicles while meeting QoS requirements.

The article "Dynamic wireless information and power transfer scheme for nano-empowered vehicular networks" discusses the wireless power transfer and energy-efficiency (EE) optimization problem for nano-empowered vehicular networks operating over the terahertz band. The nano-sensors in air can harvest energy from a power station and then can transmit the position information to the micro-device under reconnaissance vehicular scenarios.

The article "Data driven service orchestration for vehicular networks" discusses a fusion of deep learning-based mobility prediction and genetic algorithm assisted service orchestration at the edge, for ultra-reliable low-latency users in vehicular networks.

The article "The resilience of big data enabled massive MIMO PNC to jamming attack in vehicular networks" investigates the resilience of massive MIMO physical layer network coding (PNC) to jamming attacks in vehicular networks.

In the article "Blockchain-enabled trustworthy group communications in UAV networks," Gao *et al.* present a novel blockchain-based technique to support multi-party authentication to facilitate trustworthy group communications. This allows to provide a secure P2P wireless communications and trusted group communication management for UAV networks, while ensuring service efficiency.

The article "Hierarchical spatial-temporal state machine for vehicle instrument cluster manufacturing" discusses a novel hybrid approach called hierarchical spatial-temporal state machine (HSTSM). The approach is based on a memory-prediction framework and deep neural networks (DNNs) and is used for fault detection and isolation (FDI) in automatic inspection and manufacturing of vehicle instrument cluster.

The article "Enhancing the performance of flow classification in SDN-based intelligent vehicular networks" presents an enhanced version of the KD-tree algorithm that uses the geometric space to display different fields and increases search speed by recursive decomposition of the search space and helps in efficient packet classification in intelligent vehicular networks.

In the article "Toward offloading Internet of Vehicles applications in 5G networks," Wan *et al.* discuss on a 5G-enabled EC-IoV system framework to enhance the performance of the existing EC-IoV system.

The article "A drone-aided blockchain-based smart vehicular network" investigates the wireless power transfer and energy-efficiency (EE) optimization problem for nano-empowered vehicular networks operating over the terahertz band. The nano-sensors in air can harvest energy from a power station and then can transmit the position information to the micro-device under reconnaissance vehicular scenarios.

The article "Resource efficient vehicle-to-grid (V2G) communication systems for electric vehicle enabled microgrids" presents a discussion on a resource efficiency (RE) framework for selecting suitable electric vehicles (EVs) to fulfil critical load (CL) demand in vehicle-to-grid (V2G) communication networks.

The article "Bit2CV: A novel Bitcoin anti-fraud deposit scheme for connected vehicles" aims to build an anti-fraud deposit scheme as a seamless bridge between CV networks and the Bitcoin payment platform. A Bitcoin-to-Connected-Vehicle deposit scheme (Bit2CV) with an outsourcing endorsement in order to build an anti-fraud deposit transaction is discussed in the article.

The article "BlockEV: Efficient and secure charging station selection for electric vehicles" studies the problem of the security and privacy issues in electric vehicles charging network along with the enhanced quality of service for the vehicle owners. A decentralized blockchain-based charging protocol called BlockEV is designed and implemented, which allows vehicle owners to reserve a charging slot at the charging station without sharing private information with central management and charging stations.

In the article "Mobility aware blockchain enabled offloading and scheduling in vehicular fog cloud networks," Lakhan *et al.* aim at an efficient secure task scheduling scheme in vehicular fog-cloud networks (VFCN) and propose a mobility aware blockchain-enabled offloading scheme (MABOS) to ensure the security, and also the burden of the maximum-likelihood detection.

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