Guest Editorial: Special Issue on High-Confidence City IoT for Collaborative Smart City Services

INTERNET OF THINGS (IoT) is a critical infrastructure component as well as an enabling technology to support the fast-developing cross-region, cross-application, and diversified collaborative smart city services that require systematic cooperation among multiple smart city systems. Such services put forward the high-confidence demands of city IoT, namely, city IoT infrastructures and their offered services should be accountable, expandable, reliable, secure, and privacy-savvy, and can self-adapt to accommodate new environments and self-evolve to support emerging applications.

Making city IoT high confidence to assist collaborative smart city services is a nontrivial task, facing the challenges from the physical world, cyber world, and application services. In the physical world, city IoT is an open giant complex system; in the cyber world, IoT data are massive, heterogeneous, and multisourced; while the application services are cross-region, cross-application, and diversified. Although an enormous amount of effort has been made in both academia and industry all over the world to address these challenges, the solutions are mainly isolated and fragmented, with few jointly considering all the high-confidence features; moreover, accountability/traceability needed by collaborative smart city services is largely ignored. Therefore, it is essential to pursue research on new theories, architectures, and techniques about high-confidence IoT to support collaborative smart city services. This special issue aims to create a platform for researchers from both academia and industry to disseminate state-of-the-art results and to advance the high-confidence city IoT for collaborative smart city services.

The response to our call for papers for this special issue was overwhelming, as we received in total 111 submissions from all over the world. During our rigorous multiround review process, we assigned to each article at least three domain experts to ensure that each paper receives at least three professional reviews at each round. Thanks to the great support from the former Editor-in-Chief, Prof. Xuemin (Sherman) Shen, the current Editor-in-Chief, Prof. H. Wang, and the numerous dedicated reviewers, we were able to accept 25 excellent articles covering various topics in high-confidence city IoT. In the following, we briefly introduce these articles and highlight their main contributions.

In "BC-SABE: Blockchain-aided searchable attribute-based encryption for cloud-IoT," Liu *et al.* investigated a distributed searchable attribute-based encryption scheme by utilizing the blockchain to manage the large amount of data for cloud-assisted IoT. Three major functions of the coalition blockchain were adopted to improve the robustness and security of IoT. The proposed scheme addresses the security issue with the assistance of blockchain.

In "Blockchain-enhanced high-confidence energy sharing in Internet of Electric Vehicles," Sun *et al.* proposed a local vehicle-to-vehicle (V2V) energy trading architecture based on fog computing in social hotspots and modeled a social welfare maximization (SWM) problem to balance the interests of charging and discharging PHEVs. A consortium blockchain was employed in the designed energy trading architecture to reduce the reliance on trusted third parties. An energy iterative bidirectional auction (EIDA) mechanism was designed to resolve the SWM problem and obtain optimal charging and discharging decisions and energy pricing.

The article "A collaborative mechanism for private data publication in smart cities" presented a novel framework for data publications by the workers in smart city systems. Differential privacy was applied to guarantee that the workers do not disclose personal information to the requestors. Three algorithms and strategies were designed for different cases. All the algorithms were theoretically analyzed based on their performances on releasing high-confidence results.

In "Multiplex labeling graph for near-online tracking in crowded scenes," Zhang *et al.* introduced a novel detection multiplexing method to handle occlusion for tracking in crowded scenes. Multiples labeling graph (MLG) was proposed to formulate tracking as a graph optimization problem. Two LSTM networks, namely, motion association network (MAN) and appearance association network (AAN), were constructed to learn temporal features on motion and appearance. The optimization algorithm was shown to achieve near online performance and competitive tracking results.

In "HomeShield: A credential-less authentication framework for smart home systems," Xiao *et al.* proposed HomeShield, a novel credential-less authentication framework to shield smart home systems by effectively defending against attacks without the need for sensitive credentials. The presented HomeShield implementation was tested on a real-world smart home system and the SmartApps of the Samsung SmartThings platform. The results indicated that HomeShield can successfully defend against over 90% attack trials with an average latency less than 1 s.

In "Intelligent offloading for collaborative smart city services in edge computing," Xu *et al.* studied an intelligent offloading method (IOM) for smart city applications, considering privacy preservation, offloading efficiency, and edge utility. Technically, an information entropy mechanism was employed to be integrated with edge computing for weighing

Digital Object Identifier 10.1109/JIOT.2020.3021495

the balance between privacy preservation and collaborative service performance.

In "Privacy protection based on stream cipher for spatiotemporal data in IoT," Liu *et al.* focused on cryptography-based methods to protect participants' private information in unsecured network channels for dynamic and real-time sensing tasks. The RC4 stream cipher and logistic mapping were combined to deal with the problems of participants' limited resources and untruthful third-party platforms. Then, the product algebra and logistic mapping were jointly considered to tackle the problems of large-scale participants' accesses and poor randomness of the keystream.

The article "Queuing without patience: A novel transaction selection mechanism in blockchain for IoT enhancement" presented a novel transaction selection mechanism by leveraging the Lyapunov optimization and large deviation theory. The proposed mechanism is featured by fairness and sustainability, taking into account both the miner's personal utility and the system utility.

In "LH-ABSC: A lightweight hybrid attribute-based signcryption scheme for cloud-fog-assisted IoT," Yu *et al.* explored LH-ABSC, a lightweight ABSC scheme which adopts ciphertext-policy attribute-based encryption (CPABE) and key-policy attribute-based signature (KPABS). It was demonstrated that the proposed signature scheme has a constant signature size and satisfies public verification which is important for IoT systems.

The article "Secure data transportation with software-defined networking and *k-n* secret sharing for high-confidence IoT services" presented an approach to secure the data transportation among smart city IoT devices, which combines a *k-n* secret-sharing mechanism with the software-defined networking (SDN) technique to securely transport IoT data. Two SDN-based transmission strategies, which leverage the SDN's advantages on network management and scheduling, were applied to overcome the challenges of an unstable network state in IoT.

In "A secure and fine-grained scheme for data security in industrial IoT platforms for smart city," Fang *et al.* examined the logic and requirements of different industrial IoT scenarios to abstract them into a universal model. A security scheme was designed to capture attacks based on the conditional proxy re-encryption primitive. The proposed scheme ensures that data cannot be accessed by an unauthorized user, and the scheme can achieve the functionality and security requirements with low overhead.

In "Characterizing DNS behaviors of Internet of Things in edge networks," Xu *et al.* investigated DNS behavioral patterns of IoT systems in edge networks as the first step of characterizing their communication patterns and interactions with IoT users, cloud servers, and other IoT or non-IoT devices in the same edge network. A simple yet effective bloom filter was developed to detect anomalous traffic patterns based on unusual DNS queries and answers.

The article "Adaptive offloading for time-critical tasks in heterogeneous Internet of Vehicles" presented a novel vehicular fog computing (VFC) architecture to explore the synergistic effect of the cloud, the static fog, and the mobile fog on serving time-critical tasks in Internet of Vehicles. An offloading model was formulated to maximize the completion ratio of time-critical tasks. It was shown that the proposed adaptive task offloading algorithm (ATOA) has great superiority in terms of task completion ratio.

In "Spatiotemporal congestion-aware path planning toward intelligent transportation systems in software-defined smart city IoT," Lin *et al.* proved that the spatiotemporal features of traffic congestion can be forecasted, and the path for delay-sensitive urban traffics can be accurately planed before they start. An SDN-enabled smart city paradigm and a grid-based model were proposed to quantify the traffic-congestion probability of the transportation network. A polynomial-time algorithm and a path-planning algorithm were deployed in a real ITS of SDN-enabled smart city.

The article "Watchdog: Detecting ultrasonic-based inaudible voice attacks to smart home systems" validated the effectiveness of ultrasonic-based inaudible voice attacks to voice-controllable smart home devices and proposed a signal processing-based hidden voice attack detection approach. A two-step lightweight detecting algorithm was deployed to identify the attack signals. The algorithm was shown to effectively detect the ultrasonic-based inaudible voice attack.

In "A dynamic virus propagation model based on social attributes in city IoT," Xia *et al.* explored a virus propagation model (IDEPSR) focusing on two social attributes, i.e., an intelligent device's propagation capability and identification ability. A new algorithm titled DKs-HN and a Pvirus method were developed to measure the above two attributes, respectively. The IDEPSR was shown to be more reasonable in design and good in performance by simulating a smart city environment.

The article "Online joint placement and allocation of virtual network functions with heterogeneous servers" investigated a novel capability function to measure the potential of locating VNF instances for each server in the proposed OJPA-HS model and presented a provable best-possible deterministic online algorithm. Two additional randomized heuristics, namely, the Las Vegas (LV) and the Monte Carlo (MC) randomized algorithms, were developed to conquer the high complexity of dynamic programming (DP).

In "RJCC: Reinforcement-learning-based joint communicational-and-computational resource allocation mechanism for smart city IoT," Xu *et al.* presented a reinforcement learning-based joint communication-and-computational resource allocation mechanism (RJCC) to optimize the overall processing delay under energy limits. A Q-learning-based online offloading algorithm and a Lagrange-based migration algorithm were designed to jointly optimize computing offloading crossing multisegment and on edge platform, respectively. The proposed RJCC outperforms the delay-optimal, energy-optimal, and edge-to-terminal offloading algorithms by 42%–74% in long-term average energy consumption, while maintaining a relatively low delay.

In "R^2PEDS: A recoverable and revocable privacy-preserving edge data sharing scheme," Pu *et al.* studied a privacy-preserving, recoverable, and revocable edge data-sharing scheme. For the hijacked edge servers, a detection

and dispose mechanism was also presented. The scheme was shown to be more comprehensive by comparison with several other advanced schemes.

The article "Blockchain-based model for nondeterministic crowdsensing strategy with vehicular team cooperation" investigated the first secure model, called blockchain-based nondeterministic teamwork cooperation (BNTC), for nondeterministic teamwork cooperation in a vehicular crowdsensing system. Based on the reverse auction method, a WTS algorithm and a CTP algorithm for BNTC were proposed to maximize the social welfare and minimize the time consumption. The proposed model was demonstrated to achieve the maximum social welfare.

In "Collaborate edge and cloud computing with distributed deep learning for smart city Internet of Things," Wu *et al.* considered the heterogeneity of edge and central cloud servers in the offloading destination selection. A distributed deep-learning-driven task offloading (DDTO) algorithm was proposed to generate near-optimal offloading decisions over the mobile devices, the edge cloud server, and the central cloud server. The DDTO algorithm was shown to be able to effectively and efficiently generate near-optimal offloading decisions in edge and cloud computing environments.

The article "Crowd density computation and diffusion via Internet of Things" investigated an emergency management strategy that can provide efficient support for crowd density monitoring and diffusion. Fast algorithms for crowd density computation and crowd diffusion that are fully distributed were presented. The proposed strategy only relies on the nodes themselves to provide information on the situation.

In "Software-defined networking-assisted content delivery at edge of mobile social networks," Li *et al.* designed the SDN-assisted content delivery architecture and mechanisms for MSNs. Applying centralized control through SDN, this article proposed the sparse mode and dense mode routing mechanisms, which could be flexibly switched between modes according to network density.

The article "Emotion detection in online social networks: A multilabel learning approach" addressed the multiple emotion detection in OSNs from the user level view and formulated the problem as a multilabel learning one. Accordingly, a multilabel learning algorithm was proposed, which was demonstrated to outperform other existing baselines.

In "Batch-assisted verification scheme for Reducing Message Verification Delay of the Vehicular *Ad Hoc* Networks," Wu *et al.* proposed a message-batch-assisted verification scheme applied in areas with heavy traffic, which could greatly lower the pressure of RSU message verification by selecting appropriate assisted verification terminals responsible for message verification of certain terminal nodes within their communication range. The verification delay of this scheme was shown to be optimized by ten times compared to the scheme only verified by RSU.

We would like to express our sincere thanks to all the authors for submitting their papers and all the reviewers for their valuable comments and suggestions that significantly helped to enhance the quality of the articles. We are also grateful to Prof. X. Shen, the former Editor-in-Chief, and Prof. H. Wang, the current Editor-in-Chief, of the IEEE INTERNET OF THINGS JOURNAL, for their great support throughout the whole review and publication process of this special issue. Our special thanks go to all the editorial staff for their timely and professional services. We expect that this special issue can serve as a useful reference for researchers, scientists, engineers, and academics in the field of high-confidence city IoT for collaborative smart city services.

DONGXIAO YU, *Guest Editor*
School of Computer Science
and Technology
Shandong University
Qingdao 266237, China

XIUZHEN CHENG, *Guest Editor*
Department of Computer Science
George Washington University
Washington, DC 20052 USA

FALKO DRESSLER, *Guest Editor*
School of Electrical Engineering
and Computer Science
TU Berlin
10623 Berlin, Germany

DARIUSZ R. KOWALSKI, *Guest Editor*
Department of Computer
and Cyber Sciences
Augusta University
Augusta, GA 30912 USA

WEIFENG LV, *Guest Editor*
School of Computer Science
and Engineering
Beihang University
Beijing 100191, China