Guest Editorial Special Issue on Collaborative Edge Computing for Social Internet of Things Systems

THE emerging applications for smart cities intend to promote the quality of citizens' life. Among them, ubiquitous user connectivity and real-time computation offloading are significant for the ever-increasing requirements of delay-sensitive and mission-critical applications. By integrating human social behaviors (such as relationship, similarity, community, and social ties) with physical Internet of Things (IoT) systems, social IoT systems are promising to provide ubiquitous connectivity among users. As the applications of social IoT systems are transferring from information dissemination to user entertainment (such as image identification, online games, and augmented reality), computation offloading is significant to reduce the execution delay of applications.

The proliferation of IoT pushes the horizon of edge computing. Since social features and connections among users are significant for both IoT systems and computation offloading, this specific issue focuses on collaborative edge computing (CEC) in social IoT systems. However, it is rather challenging to perform CEC for social IoT systems because of network heterogeneity, user privacy, user selfishness, and so on. Besides, different users and individuals may be interested in various kinds of information, distinct user requirements may require different task processing abilities, and spatio-temporal distribution character challenges the cooperation of IoT users. Consequently, novel design principles are advocated for CEC in social IoT systems.

In light of these potentials, this special issue solicits original research and practical contributions which advance CEC in social IoT systems, regarding the architecture, technologies, and applications. Surveys and state-of-the-art tutorials are also welcome. This special issue will focus on (but is not limited to) the following topics.

1) CEC-based architecture and framework in social IoT systems;
2) CEC-based real-time decision making in social IoT systems;
3) CEC and machine learning in social IoT systems;
4) CEC-based energy-aware approaches in social IoT systems;
5) collaborative and emotional computing-enabled social IoT systems;
6) resource management in CEC-based social IoT systems;
7) security and privacy-preserving approaches for CEC in social IoT systems;
8) use cases/applications highlighting the potential of CEC in social IoT systems;
9) the future for CEC in social IoT systems: challenges and open issues.

I. What Do We Cover in This Special Section?

In this special issue, 24 articles representing the latest CEC research in the area of social IoT systems have been accepted. Nine articles focus on user security privacy and security in edge networks, particularly in the areas of collaborative task offloading and mutual authentication between IoT devices and edge servers, as well as intrusion detection. There are four articles focusing on smart vehicle decision making, with investigations on traffic management in smart connected vehicle networks, collaborative vehicle localization, and network switching in vehicle movement states to alleviate traffic congestion in cities. In addition, three articles are about edge caching in collaborative edge computing, proposing some innovative collaborative caching resource allocation schemes to improve the quality of user experience. There are three articles targeting the aspects of human flow prediction and face tracking in social IoT, which plays an important role in recommending rich application services to users. In addition, there is one article on the applications, solutions and challenges of collaborative edge computing for social IoT, and two articles on information prefetching and mismatching problems in social IoT to achieve low-latency efficient transmission in CEC and high user mobility scenarios in social IoT. In addition to these, one article constructs a visible light localization system and another article discusses for healthy diet identification for social IoT.

Although the emergence of the CEC paradigm provides real-time computing and efficient communication for IoT devices, which greatly improves the efficiency of resource utilization, the highly dynamic environment faced by the edge devices of CEC makes the edge network vulnerable to attacks by malicious devices. Therefore, user privacy protection and security issues are crucial for CECs. In [A1], Cheng *et al.* integrated deep learning and federated learning techniques to address user data privacy security issues. A two-layer dynamic game model consisting of a low-level evolutionary game for model owners and a high-level differential game for mobile device groups was designed to investigate user incentives. In [A2], Zhang *et al.* conducted an interesting study on "secure edge-assisted computing for social IoT systems," where they explored the practice of outsourcing computation from the client to nearby edge servers and proposed a secure edge-assisted computing scheme for social IoT systems, aiming to assist resource-constrained IoT devices perform

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heavy computation in a secure and efficient manner. In [A3], Razaq *et al.* proposed an integer linear programming model and a dynamic programming algorithm to maximize the number of successfully served IoT data tasks to meet security requirements while minimizing end-to-end transmission latency. The scheme achieved this objective by classifying IoT tasks according to security level and dividing tasks with high-security level into segments served by fog nodes of different service providers. Zhang *et al.* [A4] proposed a data protection approach based on data disturbance and adversarial training views. In addition, this scheme adds a random dropout layer to the convolutional neural network to help solve the overfitting problem. In [A5], Wang *et al.* proposed a privacy-preserving architecture for vehicular edge computing systems to protect the contextual information of connected vehicles during the task offloading process. Also, differential privacy techniques are introduced in the joint task offloading and resource allocation algorithms, so that the privacy of real-time data of connected vehicles is also strongly protected by privacy-preserving techniques when the decision center is not fully trusted. In another article [A6], Wang *et al.* proposed a mobile crowdsensing task allocation scheme that blends task worker mapping accuracy and user location privacy-preserving effects. The scheme can enhance the location privacy-preserving effect based on Johnson–Lindenstrauss transform, which can achieve accurate task assignment while preserving the benefits of differential privacy.

To improve the security of edge networks, in [A7], Nie *et al.* designed an intrusion detection algorithm based on generative adversarial networks to achieve intrusion detection for multiple attacks through a three-stage design of feature extraction, an intrusion detection model for a single attack, and an intrusion detection model with multiple discriminators for multiple attacks. In [A8], Cheng *et al.* proposed a blockchain-based mutual authentication scheme for the CEC mutual authentication problem, which integrates blockchain, certificate-free cryptography, elliptic curve cryptography, and pseudonym-based cryptography to achieve anonymity and confidentiality, and caterd to the unique characteristics of IoT devices. In [A9], Qin *et al.* proposed a secure data sharing approach based on federated learning and blockchain technology for the marine IoT environment to solve the worker selection problem to ensure the reliability of federated learning.

With the convergence of information and communication technologies, smart and connected vehicles have inherited different analysis and communication technologies for road traffic monitoring and management, navigation assistance, and so on. In order to improve the reliability of vehicle control and traffic management, Manogaran *et al.* [A10] proposed a shared adaptive computing model, providing a basis for traffic management and assisted driving decisions through the analysis of multi-stream data. In another article [A11], Wang *et al.* focused on the design of a CEC-based traffic management system to reduce the average waiting time and used multi-intelligence deep learning techniques to enable MEC servers to control traffic smart lights. Kong *et al.* [A12] proposed a vehicle cooperative positioning system based on federated learning while using a collaborative data expansion strategy to accelerate the convergence of the error prediction model and introduced the idea of migration learning to improve the positioning accuracy. Qi *et al.* [A13] proposed a switching scheme using a social-LSTM model for track prediction, aiming at solving the frequent switching problem caused by the highspeed movement of vehicles and the changing network environment.

The development of content-centric IoT has enriched the services offered by IoT devices. However, repeated delivery of the same content can be a serious waste of system resources. Investigating edge caching schemes in CEC can efficiently utilize caching resources to reduce the link load caused by content delivery and forwarding. Song *et al.* [A14] explored the problem of cooperative caching of energy harvesting-driven ultradense networks integrated with CEC. An adaptive cooperative caching scheme for energy-delay trade-off was proposed. In [A15], Wang *et al.* proposed a collaborative caching scheme based on an improved genetic algorithm integrating on-path caching and off-path caching policies to optimize energy consumption during content requesting. In [A16], Zhang *et al.* studied socially aware vehicular edge computing and proposed a social system caching framework for digital twin empowered content. They proposed a deep learning-enhanced optimal caching scheme by considering the construction of social models, the formation of caching clouds, and the allocation of caching resources.

To address the problems of large computation time and high energy consumption in traditional face tracking systems using convolutional neural network techniques, in [A17], Liu *et al.* designed an efficient field-programmable gate array-based convolutional neural network gas pedal for artificial intelligence and IoT-enhanced edge-cloud collaborative computing system. In addition, accurate crowd flow prediction and cluster discovery can help groups of users to select services in rich IoT environments, which has a significant impact on recommendation performance. In [A18], Jiang *et al.* proposed an urban spatial crowd flow prediction method based on a detailed record dataset. In [A19], Yao *et al.* proposed a group discovery method based on collaborative filtering and knowledge graph, which mined users' implicit preferences and considered possible correlations between the preferences of users and other groups.

CEC for social IoT leverages the advantages of mobile edge computing and social relationships among social IoT users. In [A20], Dong *et al.* discussed the applications, solutions, and challenges of social IoT in CEC. In [A21], Wang *et al.* designed an edge-learning-based hierarchical prefetching architecture to achieve low-latency and efficient transmissions of CECs. In [A22], Ibrar *et al.* proposed a 3-D social identifier structure model to efficiently deal with the mismatch problem in CEC-based social IoT architectures. In addition, in [A23], Liu *et al.* designed a visible light positioning system that utilized a collaborative LED positioning algorithm and an efficient edge computing solution to enhance the robustness and flexibility of the visible light positioning system. In [A24], Gao *et al.* proposed a deep feature and attention mechanism-based method for dish health evaluation, aiming to apply the designed hand-deep local–global network to dish image recognition.

Social IoT integrates users' social behaviors and IoT to provide ubiquitous internet access to users. Furthermore, CEC can not only solve computation and storage problems but also combine with deep learning models to leverage edge computing capabilities, and plays an important role in social IoT. We strongly believe that CEC in social IoT deserves further investigation.

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Zhaolong Ning
School of Communication and Information Engineering
Chongqing University of Posts and Telecommunications
Chongqing 400065, China
e-mail: z.ning@ieee.org

Meng Chu Zhou
New Jersey Institute of Technology
Newark, NJ 07102 USA
e-mail: zhou@njit.edu

Yong Yuan
Institute of Automation
Chinese Academy of Sciences
Beijing 100045, China
e-mail: yong.yuan@ia.ac.cn

Edith C. H. Ngai
Department of Information Technology
Uppsala University
SE 751 05 Uppsala, Sweden
e-mail: edith.ngai@it.uu.se

Ricky Yu-Kwong Kwok
Department of Electrical and Electronic Engineering
The University of Hong Kong
Hong Kong
e-mail: ricky.kwok@hku.hk

Appendix: Related Works

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Zhaolong Ning received the M.S. and Ph.D. degrees from Northeastern University, Shenyang, China.

He was an Associate Professor with the Dalian University of Technology, Dalian, China. Currently, he is a Full Professor with the Chongqing University of Posts and Telecommunications, Chongqing, China. He has published over 100 scientific papers in international journals and conferences. His research interests include the Internet of Things, mobile edge computing, and artificial intelligence. He is a highly cited researcher.

Meng Chu Zhou (Fellow, IEEE) received the Ph.D. degree in computer and systems engineering from the Rensselaer Polytechnic Institute, Troy, NY, USA, in 1990.

He joined the New Jersey Institute of Technology (NJIT), Newark, NJ, USA, in 1990, where he is currently a Distinguished Professor of Electrical and Computer Engineering. He has over 900 publications, including 12 books, more than 600 journal articles (more than 500 in IEEE TRANSACTIONS), 29 patents, and 29 book chapters. His research interests are in Petri nets, intelligent automation, the Internet of Things, big data, web services, and intelligent transportation.

Dr. Zhou is a Life Member of the Chinese Association for Science and Technology-USA and served as its President in 1999. He is also a Fellow of the International Federation of Automatic Control (IFAC), the American Association for the Advancement of Science (AAAS), the Chinese Association of Automation (CAA), and the National Academy of Inventors (NAI). He is the Founding Editor of the IEEE Press Book Series on Systems Science and Engineering and the Editor-in-Chief of IEEE/CAA JOURNAL OF AUTOMATICA SINICA.

Yong Yuan received the B.S., M.S., and Ph.D. degrees in computer software and theory from the Shandong University of Science and Technology, Shandong, China, in 2001, 2004, and 2008, respectively.

He is currently an Associate Professor with the State Key Laboratory for Management and Control of Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China. He has authored over 90 articles published in academic journals and conferences. His research interests include blockchain, cryptocurrency, and smart contracts.

Dr. Yuan is the Chair of the IEEE Council on RFID Technical Committee on Blockchain, the Co-Chair of the IEEE SMC Technical Committee on Blockchain, and the Director of the Chinese Association of Automation (CAA) Technical Committee of Blockchain.

Edith C. H. Ngai received the Ph.D. degree from The Chinese University of Hong Kong, Hong Kong, in 2007.

She was a Postdoctoral Researcher at Imperial College London, London, U.K., from 2007 to 2008. She is currently an Associate Professor with the Department of Electrical and Electronic Engineering, The University of Hong Kong (HKU), Hong Kong. Before joining HKU in 2020, she was an Associate Professor with the Department of Information Technology, Uppsala University, Uppsala, Sweden. Her research interests include the Internet of Things, mobile cloud computing, network security and privacy, data analytics and machine learning for smart cities, and health informatics. She has published more than 100 journals and conference papers in the area.

Dr. Ngai was a VINNMER Fellow (2009) awarded by the Swedish Governmental Research Funding Agency VINNOVA.

Ricky Yu-Kwong Kwok (Fellow, IEEE) joined Hong Kong Metropolitan University (HKMU), Hong Kong, in February 2021, as the Vice-President (Students and Support). From January 2015 to December 2019, he was the Associate Vice-President (Teaching and Learning) at The University of Hong Kong (HKU), Hong Kong, for five years. His research focus has been on designing efficient communication protocols and robust resources management algorithms toward enabling large-scale distributed mobile computing. In these research areas, he has authored one textbook, coauthored another two textbooks, and published more than 200 technical papers in various leading journals, research books, and refereed international conference proceedings.

He is a Fellow of HKIE and IET.