Special Issue on Fog Networks

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Fog computing as an extension of cloud computing is able to deploy data storage, computing and communication, control and management along the cloud to things continuum. From a systematic perspective, fog networks provide a distributed computing system with a hierarchical topology. Fog networks aim at meeting stringent latency requirements, reducing power consumption of end devices, providing real-time data processing and control with localized computing resources, and decreasing the burden of backhaul traffic to centralized data centers. However, in the era of fog computing and networks, we need to rethink about end-to-end network architecture, fog-enabled service management mechanisms, computing offloading and task allocation among fog-cloud or fog-fog nodes, context-aware computing and communication tradeoff analysis, fogonomics and operational models, and scalability and security issues.

This special issue received sixteen submitted manuscripts, of which six papers have been accepted for publication. The editors would like to thank the authors of all papers for their submissions and special thanks go to the reviewers for their help in allowing us to complete the reviews and decisions in a timely fashion. The papers in this special issue will report research advances in three main areas, namely Resource Allocation in Fog Networks, Virtual Machines in Fog Computing and Security and Protection in Fog Services.

Resource Allocation in Fog Networks: In this section are presented papers that propose new resource allocation techniques and approaches for three-layer fog computing networks. Firstly, the paper "Resource Allocation and Distributed Uplink Offloading Mechanism in Fog Environment" by Ruan *et al.* presents an architecture of a three-layer Fog Radio Access Network (F-RAN) and adopts differential game and bipartite graph multiple matching algorithm to solve bandwidth resource allocation problem. Next, the paper "Double-matching Resource Allocation Strategy in Fog Computing Networks Based on Cost Efficiency" by Jia *et al.* presents a double-matching strategy for the resource allocation problem in fog computing networks based on cost efficiency, which extends the deferred acceptance algorithm from two-side matching to three-side matching. Numerical results show that high cost efficiency performance can be achieved with stable results that each participant cannot change its paired partner unilaterally for more cost efficiency.

Virtual Machines in Fog Computing: This part presents papers that propose new techniques to effectively deploy virtual machines in fog computing networks. Firstly, the paper "Mitigation Technique for Performance Degradation of Virtual Machine owing to GPU Pass-Through in Fog Computing" by Kang *et al.* analyzes the effects of the VM performing the General Purpose computing on Graphic Processing Unit (GPGPU) operations (GPGPU-intensive VM) on other VMs. Then it proposes a method to mitigate the performance degradation of other VMs by dynamically allocating the resource usage time of the VM and preventing the priority preemption of the

GPGPU-intensive VM. The manuscript "Virtual Machine Placement in Cloudlet Mesh" by Li *et al.* addresses the VM placement optimization problem in cloudlet mesh networks. The algorithms solve the problems about how to determine the maximum number of accepted VMs into the cloud-fog networks and to minimize the total inter-cloudlet communication traffic.

Security and Protection in Fog Services: This section focusses on proposals to design secure and reliable schemes for various the Internet of Things (IoT) applications by utilizing fog computing techniques. To begin with, the paper "Design of Cognitive Fog Computing for Intrusion Detection in Internet of Things" by Prabavathy *et al.* proposes a novel intrusion detection technique based on fog computing using Online Sequential Extreme Learning Machine (OS-ELM) which can intelligently interpret the attacks from the IoT traffic. In the proposed scheme, the existing centralized cloud intelligence in detecting the attack is distributed to local fog nodes to detect the attack at a faster rate for IoT applications. Then, the paper "Fog-based File Sharing for Secure and Efficient File Management in Personal Area Network with Heterogeneous Wearable Devices" explores the operational ability and larger battery capacity of fog nodes to accelerate the preparation of file storage and retrieval considering confidentiality and integrity in a personal area network (PAN) with wearable devices. The heterogeneous characteristics of wearable devices are further utilized to generate the shared files. Mathematical analysis and simulation results are presented for algorithm evaluation.

Yang Yang received the B.Eng. and M.Eng. degrees in Radio Engineering from Southeast University, Nanjing, China, in 1996 and 1999, respectively; and the Ph.D. degree in Information Engineering from the Chinese University of Hong Kong in 2002. He is currently a Professor with the School of Information Science and Technology, ShanghaiTech University, China, serving as a Co-Director of Shanghai Institute of Fog Computing Technology (SHIFT). Prior to that, he has held faculty positions at The Chinese University of Hong Kong, Brunel University (UK), University College London (UCL, UK), and SIMIT, Chinese Academy of Sciences (CAS, China). Yang is a member of the Chief Technical Committee of the National Science and Technology Major Project "New Generation Mobile Wireless Broadband Communication Networks" (2008-2020), which is funded by the Ministry of Industry and Information Technology (MIIT) of China. In addition, he is on the Chief Technical Committee for the National 863 Hi-Tech R&D Program "5G System R&D Major Projects", which is funded by the Ministry of Science and Technology (MOST) of China. Since January 2017, he has been serving the OpenFog Consortium as a Board Member and the Director of Greater China Region. Yang's current research interests include wireless sensor networks, Internet of Things, fog computing, Open 5G, and advanced wireless testbeds. He has published more than 180 papers and filed over 80 technical patents in wireless communications. He is a Fellow of the IEEE.

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Dr. John K. Zao is the founding chairman of the new IEEE Standard Working Group on Fog Computing and Networking Architecture Framework and the founding vice-chairman of the new IEEE Standard Committee on Edge/Fog/Cloud Communications with IoT and Big Data. He is also the co-chairman of the Security Working Group of OpenFog Consortium and its Greater China Regional Committee. In his regular job, Dr. Zao is an Associate Professor of Computer Science in the Hsinchu Chiao-Tung University in Taiwan. His is also the Chief Technology Officer of NGoggle Inc. in San Diego, USA. Dr. Zao is an expert in Internet Security and Pervasive Computing. He received his PhD in Computer Science at Harvard University in 1995 and was elected a Senior Member of IEEE in 2001.

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