Guest Editorial
PAN Yi and LUO Guangchun

# Cloud Computing, Fog Computing, and Dew Computing

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Dr. PAN Yi is currently a Regents' Professor and Chair of Computer Science at Georgia State University, USA. He has served as an Associate Dean and Chair of Biology Department during 2013–2017 and Chair of Computer Science during 2006–2013. Dr. PAN joined Georgia State University in 2000, was promoted to full professor in 2004, named a Distinguished University Professor in 2013 and designated a Regents' Professor (the highest recognition given to a faculty member by the University System of Georgia) in 2015. Dr. PAN received his B.Eng. and M. Eng. degrees in computer engineering from Tsinghua University, China, in 1982 and 1984, respectively, and his Ph.D. degree in computer science from the University of Pittsburgh, USA, in 1991. His profile has been featured as a distinguished alumnus in both Tsinghua Alumni Newsletter and University of Pittsburgh CS Alumni Newsletter. Dr. PAN's research interests include parallel and cloud computing, wireless networks, and bioinformatics. Dr. PAN has published more than 330 papers including over 180 SCI journal papers and 80 IEEE/ACM Transactions papers. In addition, he has edited/authored 40 books. His work has been cited more than 8300 times in GoogleScholar. Dr. PAN has served as an editor-in-chief or editorial board member for 15 journals including 7 IEEE Transactions. He is the recipient of many awards including IEEE Transactions Best Paper Award, 4 other international conference or journal Best Paper Awards, 4 IBM Faculty Awards, 2 JSPS Senior Invitation Fellowships, IEEE BIBE Outstanding Achievement Award, NSF Research Opportunity Award, and AFOSR Summer Faculty Research Fellowship. He has organized many international conferences and delivered keynote speeches at over 50 international conferences around the world.

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Dr. LUO Guangchun received his Ph.D. and M.S degrees from the University Electronic Science and Technology of China (UESTC) in 2004 and 1999, respectively. He joined the University of California at San Diego and University of Toronto, Canada as a visiting scholar. Currently, he is a professor and Vice President of Graduate School of the UESTC. He has published around 50 articles in international journals and conference proceedings. He is very active in a number of technical societies and serves as committee members of the Calculation of Sichuan Province Institute of High Performance Computer and China Education Information Council. He has received regular funds from many programs of the Chinese Government, including the National Natural Science Foundation of China, the National Hi-Tech R&D Program (the "863" Program), and the Science and Technology Department Foundation of Sichuan Province.

Since the first computer was invented in 1946, a few major milestones have stood along the way of Information Technology's development. Among them, most notable ones are personal computers (PC), the Internet, World Wide Web (WWW), and cloud computing. Cloud computing has drastically changed the landscape of IT industry by providing some major benefits to IT customers: eliminating upfront IT investment, scalability, proportional costs, and so on. In addition, cloud computing also prompts new challenges and brings in new progress. However, the delay-sensitive applications face the problem of large latency, especially when several smart devices are getting involved. Therefore, cloud computing is unable to meet the requirements of low latency, location awareness, and mobility support.

To overcome this problem, Cisco has first introduced a trusted and dependable solution through fog computing to put the services and resources of the cloud closer to users, which facilitates the leveraging of available services and resources in the edge networks. Edge devices such as routers, routing switches, integrated access devices provide an entry point into enterprise or service provider core networks. Fog computing is a scenario where a huge number of heterogeneous ubiquitous and decentralized devices communicate and potentially cooperate with each other and with the network to perform storage and processing tasks without the intervention of third-parties. Similar to cloud computing, fog computing provides data, compute, storage, and application services to end users.

Dew computing is an on-premises computer software-hardware organization paradigm in the cloud computing environment where the on-premises computer provides functionality that is independent of cloud services and is also collaborative with cloud services. The goal of dew computing is to fully realize the potentials of on-premises computers and cloud services. Roughly speaking, fog computing mainly involves automation devices while dew computing mainly involves computers; fog computing mainly involves devices such as routers and sensors in the Internet of Things (IoT), while dew computing mainly involves on-premises computers.

The definition and features of cloud computing, fog computing, and dew computing, the relationships among them, and their applications are still under heated discussions and are the focus of this special issue. This special issue aims to provide a unique and timely forum to address all issues and definition related to cloud computing, fog computing, and dew computing. The open call-for-papers of this special issue has attracted excellent submissions in both quality and quantity. After two-round careful reviews, seven excellent papers have been selected for publication in this special issue which is consists of six research papers and one review paper.

The basic idea of fog computing and edge computing is to bring cloud servers closer to end users at the edge of network, reducing the code/data trans-

ferring and/or exchanging time between mobile devices and servers. The first paper "A Transparent and User-Centric Approach to Unify Resource Management and Code Scheduling of Local, Edge, and Cloud" by ZHOU et al. addresses this challenging issue. The authors propose a software-defined code scheduling framework which allows the code execution or data storage of end applications to be adaptively done at appropriate machines under the help of a performance and capacity monitoring facility, intelligently improving application performance for end users. The pilot system is described and preliminary performance results are reported.

The proliferation of the Internet of Everything (IoE) has pulled the computing to the edge of the network, such as smart home, autonomous vehicles, robots, and so on. The operating system as the manager of the computing resources, is also facing new challenges. The second paper "An OS for Internet of Everything: Early Experience from A Smart Home Prototype" by CAO et al. presents Sofie, which is a smart operating system for IoE. The authors introduce the design of Sofie, and also show the implementation of Sofie for smart home. Their work shows that Sofie could be helpful for practitioners to better manage their IoE systems.

Cloud operating systems (COSs) working on the physical device and legacy operating system, manage and schedule all hardware and software resources, and provide fundamental resources and operation environment for cloud applications. The third paper "HCOS: A Unified Model and Architecture for Cloud Operating System" by CHEN et al. introduces a unified model and architecture for providing both Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) services.

The fourth paper "Dew Computing and Transition of Internet Computing Paradigms" by WANG et al. focuses on the development of dew computing, including its origins, research status, development status, and its impact on the transition history of Internet computing paradigms. The paper also creates two metrics to measure how important the Internet is and what data redundancy rates are in different stages of the Internet. The discussion and analysis there provide a systematical guideline for beginner researchers in dew computing.

Cloud computing platform, as the mainstream hosting platform for large-scale distributed computing, provides a parallel computing framework for big data job execution. The fifth paper "Online Shuffling with Task Duplication in Cloud" by ZANG and GUO studies minimization of the traffic cost for data pipelining task replications by transmitting non-overlapping data in a cloud computing network. To achieve this goal, the authors present a controller, which chooses the data generated by the first finished task replication and discards data generated later by other task replications belonging to the same task.

With the development of cloud computing, container technology becomes one of the hot issues in recent years. The sixth paper "Technical Analysis of Network Plug-In Flannel for Containers" by YANG et al. studies the technical implementation of the Flannel module, a network plug-in for Docker containers, including its functions, implementation principle, utilization, and performance.

The last paper "Virtualization Technology in Cloud Computing Based Radio Access Networks: A Primer" by ZHANG and PENG surveys the virtualization technology in cloud computing based radio access networks (CC-RAN), focusing on C-RAN, H-CRAN, and F-RAN. The background of network virtualization, virtualization architecture, key enabling technologies, as well as open issues are all discussed. The challenges and open issues mainly focus on virtualization levels for CC-RANs, signaling design for CC-RAN virtualization, performance analysis for CC-RAN virtualization, and network security for virtualized CC-RANs.

Finally, we would like to thank all the authors for contributing their papers to this special issue and the external reviewers for volunteering their time to review the submissions. We would also like to thank the staff at *ZTE Communications* for giving us the opportunity to organize this timely special issue in this esteemed journal and their help during the production of this special issue.