Guest Editorial

Fog Computing and Networking: Part 1

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Due to the large number of submissions responding to the Call for Papers on “Fog Computing and Networking,” the Guest Editors selected additional papers based on reviewer comments that are now published in Part 2. The overview provided by the Guest Editors in the form of Q&A was published in Part 1 in April. Here, in this August issue of the magazine, we continue to see a range of perspectives, some qualitative and others quantitative. Collectively, they expand the scope of edge research labs that started a decade ago to the current momentum in fog research and deployment and academia-industry collaboration such as the OpenFog Consortium. In the following, we briefly overview the articles in this issue.

In “Architectural Imperatives for Fog Computing,” the author presents an industry perspective on the use cases, requirements, and techniques for the fog-enabled Internet of Things (IoT). Driven especially by latency-sensitive applications, the author discusses a list of attributes that are useful for such fog networks. Some of these are natural advantages of fog: lower latency, reduced network bandwidth usage, enhanced security and privacy, geographic locality of control, data rich mobility, reliability and robustness, support for analytics and automation, hierarchical organization, energy efficiency, and so on, while others are desirable goals to achieve in designing fog networks: scalability, agility, modularity, and openness.

In “IoT Stream Processing and Analytics in the Fog,” the authors present the general models and architecture of fog data streaming services by analyzing the common properties of several typical applications. Based on the above considerations, they analyze the design space of streaming services by focusing on four essential dimensions: system, data, human, and optimization. In this respect, the article presents both the new design challenges and the issues that may arise when leveraging existing techniques, such as cloud stream processing, computer networks, and mobile computing.

“The Unavoidable Convergence of NFV, 5G, and Fog: A Model-Driven Approach to Bridge Cloud and Edge” argues that fog computing will become part of the convergence between IoT, network functions virtualization (NFV), and fifth generation (5G). As a consequence, the article introduces an architecture that offers uniform management of IoT services spanning the continuum from the cloud to the edge that is compliant with European Telecommunications Standards Institute (ETSI) management and orchestration (MANO). The proposed architecture also introduces the first YANG models for fog nodes for IoT services involving cloud, network, and/or fog, and expands the concept of “orchestrated assurance” to provision carrier-grade service assurance in IoT. Finally, the article discusses the application of the proposed model in a pilot in the Spanish city of Barcelona.

Also, “TelcoFog: A Unified Flexible Fog and Cloud Computing Architecture for 5G Networks” proposes a novel convergent architecture that targets the extreme edge of a wired/wireless network and is particularly suitable for low-latency services. The architecture includes a scalable computing node, operating at the edge of the network, and a controller, aimed at guaranteeing service assurance and based on YANG data models.

“A Fog Operating System for User-Oriented IoT Services: Challenges and Research Directions” presents the high-level introduction of a fog computing architecture for IoT services, FogOS. It is composed of service/resource abstraction, a resource manager, an application manager, and edge resource identification/registration. The article further identifies some of the challenges facing IoT services and possible solutions through FogOS; notably, how the diversity and heterogeneity of IoT services and edge devices can be managed.

In “A Hierarchical Game Framework for Resource Management in Fog Computing,” the authors consider a scenario with three types of entities: fog nodes (FNs), authorized data service subscribers (ADSSs), and data service operators (DSOs). Resources in FNs are owned by independent users or providers. ADSSs request data from DSOs in the cloud, which communicate with FNs. This is a particular realization of fog-cloud interaction. The authors propose a three-layer hierarchical game, with three types of game theoretic models for each of the three pair-wise interactions, leveraging the specific nature of the interaction in each case. The goal is to obtain stable and optimal utilities for three parties in a distributed way.

Biographies

Mung Chiang (chiangm@princeton.edu) is an Arthur LeGrand Doty Professor of Electrical Engineering at Princeton University. He serves as inaugural Chairman of the Princeton Entrepreneurship Council and Director of the Keller Center for Innovation in Engineering Education. The recipient of a Waterman Award, an IEEE Tomiyasu Award, and a Guggenheim Fellowship, he works in areas such as NUM, SDP, and fog. He created the Princeton Edge Lab and co-founded the OpenFog Consortium. His MOOC reached 250,000 people, and his textbook received an ASEE Terman Award.

Sangtae Ha is an assistant professor in computer science at the University of Colorado Boulder. He received his Ph.D. in computer science from North Carolina State University. He is a co-founder and founding CTO/VP Engineering of DataMi, a mobile network startup. His research focuses on building and deploying practical network systems. He received the INFORMS ISS Design Science Award in 2014, and serves as an Associate Editor for the IEEE Internet of Things Journal.

Chih-Lin I received her Ph.D.E.E. from Stanford University. She is CMCC Chief Scientist of Wireless Technologies, launched 5G R&D in 2011, and leads the C-RAN, Green, and Soft initiatives. She was on the IEEE ComSoc Board, GreenTouch EB, IEEE M&C Board Chair, and WCNC SC Founding Chair. She is on the IEEE 5G Initiative SC and Publication WG Chair, ComSoc SPC and SDB, ETSI/NFV NOC, WWRF SB, and Singapore NRF SAB. She received the IEEE Transactions on Communications Best Paper Award and the ComSoc Industrial Innovation Award.

Fulvio Risso (Italy, 1971) received his B.Sc. and Ph.D. degrees from Politecnico di Torino, Italy, in 1995 and 2000, respectively. Since 2000, he has been with the Politecnico di Torino, where he is currently an associate professor and in charge of the Network and Multimedia Lab. His main areas of research interest are high-speed and flexible in-network processing, SDN, and NFV. He is an author of 90+ papers and is very active in open-source software, starting with WinPcap in 1999.

Tao Zhang [F] joined Cisco in 2012 as the chief scientist of its Smart Connected Vehicles business. He is a cofounder and Board Director of the Open Fog Consortium, and the CIO and a member of the Board of Governors of IEEE Communications Society. He has been directing R&D for over 25 years, holds 50+ U.S. patents, and has co-authored two books, Vehicle Safety Communications: Protocols, Security, and Privacy (2012) and IP-Based Next Generation Wireless Networks (2004).