Fog Computing and Networking: Part 1 [Guest editorial]

(Article begins on next page)

27 April 2024

Fog Computing and Networking: Part 1

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Fog rises as cloud descends to be closer to the end users. Building on the foundation of past work in related areas and driven by emerging new applications and capabilities, fog computing and networking is now presenting unique opportunities to university researchers and the industry.

This Feature Topic in IEEE Communications Magazine consists of overview articles that span much of this growing terrain of fog. Due to a much higher volume of submissions than expected, we could only accept a small portion of the submitted manuscripts even after expanding the Feature Topic into two parts, Part 1 in April and Part 2 in August. An exciting new area often faces questions about its scope. In a separate short article immediately following this editorial, the guest editors together provide a tutorial in the form of a Q&A. Here in the rest of this editorial, we highlight the articles appearing in Part 1 of this Feature Topic.

"Optimizations and Economics of Crowdsourced Mobile Streaming" identifies the increasing demand for mobile video streaming. It is timely and interesting to read. The article proposes to use edge resources in a cooperative manner, which is to be enabled by fog computing. It opens with a descriptive section listing four types of cooperative video streaming models that pool various network resources effectively in different application scenarios. They are mobile peer-to-peer (MP2P), device-to-device (D2D), (3) bandwidth aggregation (BA), and crowdsourced mobile streaming (CMS). The authors then focus on the CMS model and introduce the corresponding optimization methods for efficient resource allocation, as well as economic incentives. Finally, the current challenges and the areas of interest in cooperative video streaming models are summarized.

Another article, "Fog-Based Transcoding for Crowd-sourced Live Streaming" (CLS) looks at a very similar if not the same application in fog networks. The approach of transcoding is not a novel method, but the analysis that leads to the selection of viewers for video transcoding is. One of the noteworthy contributions of this article is that the authors propose a novel framework of a CLS system and provide experimental results to uphold their arguments. Specifically, the analysis of Twitch TV viewers' behavior and the implementation of the presented concept in a PlanetLab environment are interesting. Fog networks face redundancy. They can leverage redundancy for robustness, and they must manage redundancy to strike trade-offs.

In the article "Coding for Distributed Fog Computing," the authors provide a unifying framework for managing redundancy by optimizing coding. They illustrate the framework with two important special cases: minimum bandwidth coding and minimum latency coding. At the heart of the design choice is the trade-off between computation latency and communication load as modulated through coding. As a continuum from cloud to things, fog physically and functionally bridges the capabilities offered in cloud and those on the edge of networks. Smartphones offer a natural point for such a bridge.

In the article "RAINA: Reliability and Adaptability in Android for Fog Computing," the authors present such an architecture and zoom in on a particularly important attribute: the predictability of smartphones' service in bridging cloud and edge. The article overviews the challenges and proposes strategies for this key aspect of a smartphone-oriented fog architecture. Cloud-RAN has been discussed as a radio access network (RAN) technology for over a decade now. Fog-RAN is now rising as an alternative for decomposing the functionalities of 5G cellular networks along the edge and into the devices.

In the article "5G Radio Access Network Design with Fog Paradigm: Confluence of Communications and Computing," the authors discuss some of the key design issues, such as traffic forwarding, content caching, interworking, and security in Fog-RAN. Special attention is paid to the promise of communication and computation coming together. Mobile edge computing (MEC) extends the cloud computing to the edge of the RAN.

The article "Collaborative Mobile Edge Computing in 5G Networks: New Paradigms, Scenarios, and Challenges" shows the authors' vision on how context-aware collaboration among MEC servers and end-user devices can help achieve low-latency, high-bandwidth, and agile mobile services for 5G. In particular, they present three representative use cases, ranging from computation orchestration, to collaborative video caching and processing, to interference cancellation. In the August issue, Part 2 of this Feature Topic will appear along with an editorial introducing those papers.

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).