Software-Defined Carrier Wireless Networks


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The telecommunication industry is entering a new era. The increased traffic demands imposed by the huge number of always-on connections require a quantum leap in the field of enabling techniques. Furthermore, subscribers expect ever increasing quality of experience with its joys and wonders, while network operators and service providers aim for cost-efficient networks. These requirements require a revolutionary change in the telecommunications industry, as shown by the success of virtualization in the IT industry, which is now driving the deployment and expansion of cloud computing. Telecommunications providers are currently rethinking their network architecture from one consisting of a multitude of black boxes with specialized network hardware and software to a new architecture consisting of "white box" hardware running a multitude of specialized network software. This network software may be data plane software providing network functions virtualization (NVF) or control plane software providing centralized network management — software defined networking (SDN). It is expected that these architectural changes will permeate networks as wide ranging in size as the Internet core networks, to metro networks, to enterprise networks and as wide ranging in functionality as converged packet-optical networks, to wireless core networks, to wireless radio access networks.

SDN problems will be especially pronounced in future wireless networks. To tackle unprecedented traffic growth imposed by the introduction of smartphones and tablets at acceptable cost, as well as to support society's increased dependence on wireless communications, the radio access networks are expected to evolve to ever denser cell structures, which create the wireless cloud. Future radio access networks will rely on the coexistence of multiple deployment scenarios and diverse radio access specifications, and support a rich variety of services and applications. Satisfying high traffic volume at reasonable cost may only be accomplished with diversified resource pooling. This requires a new wireless network architecture, which directs flexible, dynamically configurable network elements to provide on-demand customized services to traffic demands that may be dynamic in time and space (geography). SDN and NVF are recognized to be the key technology enablers for meeting these requirements. These advanced concepts are under consideration for the fifth generation (5G) of mobile wireless networks, which are expected to be commercially available by 2020. Against this backdrop, this timely Feature Topic sheds light on the fundamental technology components of radically new software defined carrier wireless networks (SD-CWN). In response to the Call for Papers, we received 26 effective submissions, of which eight are included in this Feature Topic after rigorous review and careful revision, presenting an acceptance ratio of 30.77 percent.

The Feature Topic begins with the article "Software Defined Virtual Wireless Network: Framework and Challenges," which is a comprehensive survey of combining the concept of SDN and wireless network virtualization for SD-CWN. In this article, Cao *et al.* provide a deep discussion on open research issues in addition to a literature review. Following that are three articles addressing SD-CWN from an architectural point of view. In the article "5G Wireless Network: MyNET and SONAC," Zhang *et al.* address that the goal of future 5G wireless networks is to provide service-customized networks. They present their vision on 5G including MyNET, a future wireless network architecture framework, and an enabling technique — service oriented virtual network auto-creation (SONAC). In the article "Software-Defined Wireless Mesh Networks: Architecture and Traffic Orchestration," Huang *et al.* propose an architecture of software defined wireless mesh networks and identify several critical challenges. The authors further present three spectrum allocation and scheduling algorithms that orchestrate both control and data traffic, along with simulation-based performance evaluation. In the article "Software-Defined Wireless Networking: Centralized, Distributed, or Hybrid?" Abolhasan *et al.* propose hybrid architecture for operability and scalability concerns. In the architecture, network nodes are

allowed to make distributed decisions on routes to deduce the computational load on the SDN controller; furthermore, multihop flooding is eliminated during route discovery by using two separate frequency bands for network control and data forwarding.

The last section of the Feature Topic contains four articles on technical issues in connection to SD-CWN. In the article "SDN Rule Caching in Mobile Access Networks," Dong *et al.* consider forwarding rule space limitations in SDN-enabled devices and study rule caching mechanisms for improving network performance. They design a two-layer rule space and a cache prefetching mechanism. Through simulation, they demonstrate that their proposal outperforms original rule space management under various network settings. In the article "Device-to-Device Communications for Enhancing Quality of Experience in Software Defined Multi-Tier LTE-A Networks," Liu *et al.* discuss open research issues on applying SDN to LTE networks and propose a device-to-device-communication-based algorithm to enhance the QoE of users. They also present numerical results to illustrate the performance gains that can be achieved by applying the proposed algorithm to a typical Third Generation Partnership Project (3GPP) network scenario. In the article "An OpenFlow Architecture for Energy-Aware Traffic Engineering in Mobile Networks," Donato *et al.* investigate energy efficiency issues. The authors propose an OpenFlow framework for traffic engineering in mobile networks with energy awareness. The feasibility of the proposal is demonstrated by a real-life prototype based on commercial off-the-shelf devices. Finally, in the article "A Novel Design for Content Delivery over Software Defined Mobile Social Networks," Su *et al.* study content sharing among mobile users. They design a flow table for SDN switches based on social features and introduce a novel social switch for delivering content among mobile users according to social degree and social stay time.

In closing, we would like to thank all the authors who have submitted their research work to this Feature Topic. We would also like to acknowledge the contribution of many experts in the field who have participated in the review process and provided helpful suggestions to the authors on improving the content and presentation of the articles. We would also like to express our gratitude to the Editor-in-Chief, Dr. Xuemin Shen, for his support and help in bringing forward this Feature Topic. We hope you will enjoy the articles presented here.

Biographies

XU LI (Xu.LiCA@huawei.com) is a senior researcher at Huawei Technologies Canada. He received a Ph.D. (2008) degree from Carleton University, Canada, an M.Sc. (2005) degree from the University of Ottawa, Canada, and a B.Sc. (1998) degree from Jilin University, China, all in computer science. Before joining Huawei, he was a research scientist (with tenure) at Inria, France. His research interests are in 5G networking, along with 80+ refereed publications and nearly 30 patent applications. He is/was an Associate Editor of *IEEE Transactions on Parallel and Distributed Systems*, *IEEE Communications Magazine*, *Transactions on Emerging Telecommunications Technologies*, *Ad Hoc & Sensor Wireless Networks*, and *Parallel and Distributed Computing and Networks*. He received a best paper award at IEEE ICNC 2016.

PETAR DJUKIC received B.A.Sc., M.A.Sc., and Ph.D. degrees from the University of Toronto in 1999, 2002, and 2007, respectively. In 2010 he founded MeshIntelligence Inc., a provider of virtualized TDMA solutions for 802.11-based wireless networks. Since 2014 he has been with Ciena solving software-defined networking problems in converged packet-optical networks. His research interests are in network management protocols for wireless and converged packet-optical networks, data and control plane protocols for network function virtualization, and MAC protocol design. He has over 30 referreed publications and over 20 patent applications and patents in the areas of wireless networking and software-defined networks.

IVAN STOJMENOVIC* [F] received his Ph.D. degree in mathematics from the University of Zagreb, Zagreb, Croatia, in 1985. He was a full professor with the University of Ottawa, Ontario, Canada. He held regular and visiting positions in Saudi Arabia, China, Serbia, Japan, the United States, Canada, France, Mexico, Spain, the United Kingdom, Hong Kong, Brazil, Taiwan, and Australia. He published over 300 different papers, and edited seven books on wireless, ad hoc, sensor and actuator networks, and applied algorithms with Wiley. From 2010 to 2013, he was the Editor-in-Chief of *IEEE Transactions on Parallel and Distributed Systems* and was founder and Editor-in-Chief of three journals. He was a Fellow of the Canadian Academy of Engineering and a Member of the Academia Europaea.

ZHI-QUAN LUO received his B.Sc. degree in applied mathematics in 1984 from Peking University, China, and a Ph.D. degree in operations research in 1989 from MIT. From 1989 to 2003, he held a faculty position with the Department of Electrical and Computer Engineering, McMaster University, Hamilton, Canada, where he eventually became the department head and held a Canada Research Chair in Information Processing. Since April of 2003, he has been with the Department of Electrical and Computer Engineering at the University of Minnesota (Twin Cities) as a full professor and holds an endowed ADC Chair in digital technology. His research interests include optimization algorithms, signal processing, and digital communication. He is a fellow of IEEE and SIAM.

**During the course of organizing this Feature Topic, our co-Guest Editor Dr. Ivan Stojmenovic passed away in a horrific car accident. We are deeply saddened by his sudden, tragic death. We greatly appreciate his contributions to this Feature Topic. May he rest in peace.*