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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: RECENT ADVANCES IN SOFTWARE DEFINED NETWORKING FOR 5G NETWORKS

The demand for flexible network management has been growing significantly over the last several decades, which comes with a series of other related demands in network virtualization, stringent security, tenant isolation in cloud, and high performance and reliability for broadband access. To meet these demands from both users and enterprises, numerous networking protocols had been designed and developed. However, these protocols were usually defined independently targeting various specific problems using different systems and sub-systems, without a holistic approach. On the other hand, cloud computing brings many challenges to traditional networking, from naming and addressing to the traditional routing. In addition, companies seek to use more standard and vendor-independent equipment to reduce the Capital Expenditure (CAPEX) and Operational Expenditure (OPEX).

Software Defined Networking (SDN) has attracted increasing attention from both industry and academia since it also brings potential benefits in terms of network management, new network function deployment, network architecture evolvement, and so on. Such benefits could be invaluable for many different networking environments including datacenter networks, wireless networks, broadband access networks, campus networks, and those experimental environments. In fact, a large number of successful SDN applications have already been developed, for example, those applications for inter-datacenter traffic engineering with high link utilization, flexible multi-tenant virtualization with low overhead, and software-defined radio access with effective load balancing and interference management. With attractive features and potential advantages, SDN is gaining momentum in the networking industry and research communities for the development of the fifth generation (5G) wireless networks during the last several years. However, SDN for 5G networks also comes with many challenges and technical issues that still need to be addressed before wide deployment.

By bringing together academic and industrial researchers to identify and discuss technical challenges and recent advances related to SDN for 5G networks, this Special Section aims to attract attention from both academia and industry in developing advanced and innovative SDN methods and techniques for 5G networks. In total we have received 13 original submissions, out of which 5 regular papers plus 1 invited paper were accepted for publication after a rigorous peer reviewing process. We regret that we were not able to accept other good papers due to the length limit of this Special Section.

The invited paper titled ''Spatial domain management and massive MIMO coordination in 5G SDN'' by S. Sun *et al.* explores the probability of utilizing SDN technology to form a centralized architecture of control plane, in which a lightweight channel state information acquisition based null-space precoding scheme is proposed for the implementation. Numerical simulation results justify that the proposed centralized architecture can significantly improve the throughput of intended users in small cells, while oppressing the impact on neighboring users.

The SDN implementations are gaining momentum, but its control plane is still suffering from scalability and performance issues for a very large 5G network. In the work by A. Aissioi *et al.* (Towards elastic distributed SDN/NFV controller for 5G mobile cloud management systems), an elastic distributed SDN controller tailored for mobile cloud computing and follow-me cloud (FMC)-based systems is proposed, in which the building blocks of the control plane framework are presented. The results obtained via analysis show that the proposed solution ensures better control plane management, performance maintenance and network resources preservation.

Device-to-Device (D2D) communication can potentially solve the capacity bottleneck problem of legacy cellular systems, while it should be flexible and powerful to meet the needs of commercial cellular scenarios as well as public safety applications. In a paper titled ''A software-defined device-to-device communication architecture for public safety applications in 5G networks'' by M. Usman *et al.*, the authors present a hierarchal D2D architecture where a centralized SDN controller communicates with the cloud head to reduce the number of requested long-term evolution (LTE) communication links, thereby improving

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energy consumption. Meanwhile, the robustness and potential of the proposed architecture by presenting a public safety scenario are evaluated.

To survey 5G cellular network architecture and some of the key emerging technologies that are helpful in improving the architecture and meeting the demands of users, a paper titled "A survey of 5G network: Architecture and emerging technologies" by A. Gupta *et al.* presents 5G cellular network architecture, massive multiple input multiple output technology, and D2D.

To realize ubiquitous spectrum access and improve the spectrum efficiency in a SDN, in work by D. Wang *et al.* (Reciprocally-benefited spectrum access scheme with joint power and subcarrier allocation in software-defined network), a joint subcarrier and power allocation scheme for reciprocally benefiting spectrum access with secondary users (SUs) cooperating with primary users (PUs) is presented, in which the closed-form expressions about the outage probability and average transmission of both PUs and SUs are derived.

In the work by Z. Ding *et al.* (A new evaluation criterion for non-orthogonal multiple access in 5G software defined networks), a new evaluation criterion is developed to investigate the performance of non-orthogonal multiple access (NOMA) for 5G networks from an information theoretic point of view. Using this evaluation criterion, the performance of a wireless NOMA system with user pairing has been evaluated in terms of both the sum rate and users' individual rates, by considering time division multiple access as the benchmark.

We are excited about the technical depth and span of this Special Section, and also recognize that it cannot cover all emerging SDN technologies for 5G networks. Before the end of this editorial, we would like to thank the anonymous reviewers for their great efforts in reviewing the submitted manuscripts, without which this Special Section would not have been published with such high quality. We would like to thank the Editor-in-Chief, the Managing Editor, the editorial staff, M. Pecht, B. M. Onat, K. Shumard, and M. Meyer, for their supportive guidance during the whole process in the organization of this Special Section.

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