EMERGING TOPICS: SPECIAL ISSUE ON CONTENT DISTRIBUTION OVER SDN AND NFV ARCHITECTURES

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The networking industry has seen rapid and steady increase in the adoption of Software-Defined Networking (SDN) and Network Function Virtualization (NFV) technologies in recent years. For service providers and network operators, this opens up interesting new possibilities for enhancing the performance of media content delivery. While SDN improves network management visibility and programmability, an NFV-enabled infrastructure allows for dynamic resource provisioning and network service scaling according to user and traffic demand. This new and evolving networking paradigm – with more focus on software rather than hardware – also means finer granularity of control, faster adaptation capabilities, thus greater agility in innovation.

In this Special Issue, we bring to our readers a collection of four invited articles that address various aspects of SDN/NFV-enabled architectures for media content delivery. Authors from academia and industry share their individual perspectives regarding the opportunities and challenges brought forth by the rapid spread of SDN/NFV technologies, outlooks for the future of media content delivery in an increasingly mobile and heterogeneous environment, as well as ongoing research efforts in leveraging SDN/NFV for enhanced media content delivery.

The first article, *"Multimedia Content Delivery in SDN & NFV based Towards-5G Networks"* by Liberal et al., paints in broad strokes several leading trends in the evolution of cellular networks from 4G to 5G. The authors then focus their discussions around the potential implications of network *cloudification* through SDN and NFV, and how it can enable true convergence between Content Delivery Networks (CDNs) and 5G networks. Using Dynamic Adaptive Streaming over HTTP (DASH) as a case study, they further describe the evolution of media adaptation strategies from purely client-driven to a combination of core- and access network-assisted architecture. Finally, the article highlights a number of challenges and research opportunities in toward-5G networks.

In *The Surrogate vNF approach for Content Distribution,* Herbaut, Xilouris, and Négru demonstrate the potential and benefits of novel media streaming solutions based on more flexible resource management over NFV infrastructures. The paper introduces the concept of Surrogate vNF which aims at taking advantage of the standards execution environments of Home Gateways to collaborate with vNFs deployed in operator Point-of-Presences (POPs). Simulation evaluations of the proposed solution show that it improves QoS for media delivery by mitigating violation of Service-Level Agreements (SLAs).

Taking a different approach, authors of the third article, *Caching of Viral Content in NFV Architectures,* shows how NFV-based data centers can be used for caching viral content (e.g., extremely popular YouTube videos) with improved energy efficiency. Krishnan et al. introduce an open NFV architectural framework for managing application viral behavior. The paper discusses ongoing work in the industry in the area of viral content caching, connecting it with the overall energy efficiency in the context of NFV. More specifically, the paper examines an integrated NFV architectural framework for managing viral content, where the application virality information can be modelled as a non-linear constraint along with the existing placement and scheduling constraints, which are typically linear.

Finally, Ferrús et al. present a conceptual framework for the combination of terrestrial and satellite communication segments, leveraging NFV/SDN as enabling technologies. Their article, *Enhancing Satellite and Terrestrial Networks Integration through NFV/SDN technologies,* starts with an excellent overview of multiple compelling benefits of a single, integrated telecom network. It then reviews key challenges and barriers that hamper such integration. The authors point out how the introduction of new SDN/NFV-based paradigms can help to facilitate a combined terrestrial/satellite networking infrastructure in term of more flexible integration, network service innovation, and end-to-end network resource management spanning both satellite and terrestrial segments. The paper further describes several ongoing research efforts along this direction undertaken by the UE H2020 VITAL research project.

This Special Issue has, by no means, presented a complete picture on the emerging topic of SDN/NFV-enabled innovations for media content delivery. In fact, given the highly active involvement of both academic researchers and industry practitioners in this field, we expect that more exciting results from expanded explorations will appear soon on the horizon. We nevertheless hope that our readers will enjoy sampling through the list of invited articles and get a flavor of the interesting possibilities offered by SDN/NFV for next-generation media delivery networks.

Our special thanks goes to all authors for contributing their interesting research work to this Special Issue and sharing with us their individual perspectives. We would also like to acknowledge the gracious support from the MMTC E-Letter Board.

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Xiaoqing Zhu is currently a Technical Leader in the Chief Technology and Architecture Office (CTAO) at Cisco Systems. Her research interests span multimedia applications, networking, and wireless communications. At Cisco, she has worked on HTTP-based adaptive streaming, congestion control for low-latency interactive video, fog computing, media delivery over vehicular networks, and video traffic modeling and synthesis. Dr. Zhu has published over 60 journal and conference papers, receiving the Best Student Paper Award at ACM Multimedia in 2007 and the Best Presentation Award at IEEE Packet Video Workshop in 2013. She is author of 4 granted U.S. patents, with 16 applications pending. Within the research community, she has served extensively as reviewer, and TPC member for numerous journals and conferences. Previously, she was guest editor for several previous special issues in *IEEE Trans. Multimedia*, *IEEE Journal on Selected Areas in Communications,* and *MMTC E-Letters*. Dr. Zhu holds a B.Eng. in Electronics Engineering from Tsinghua University, Beijing, China, She graduated with M.S and Ph.D. in Electrical Engineering from Stanford University, California. Prior to joining Cisco, she interned at IBM Almaden Research Center in 2003, and at Sharp Labs of America in 2006.