NETWORK SOFTWARIZATION AND MANAGEMENT


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The broad scope of the *IEEE Communications Magazine* Series on Network Softwarization and Management covers two aspects of communication networks that have become highly relevant nowadays. On one hand, network softwarization advocates for architectures where software and programmability aspects in the implementation of network functions, protocols, and services are decoupled from the underlying infrastructure, fostering unprecedented levels of flexibility, abstraction, automation, and intelligence. On the other hand, network management aims at integrating fault, configuration, accounting, performance, and security (FCAPS) capabilities in the network, and supporting advanced autonomic and self-management features, often taking advantage of the potential offered by network softwarization. The intent of this Series is to provide a timely source of in-depth, cutting-edge articles on state-of-the-art technologies and solutions for network softwarization and management.

The four articles published in this fifth installment of the Series cover different topics that are highly relevant nowadays for successful service deployment on virtualized environments and effective network management. From a bottom-up perspective, the presented articles deal with accurate network testing and monitoring using programmable network hardware; anomaly detection to improve security in network function virtualization (NFV); feasible adoption of artificial intelligence (AI) for networking; and the use of blockchain to establish federations of dynamic NFV environments.

The first article, "Network Testing Utilizing Programmable Network Hardware" by Kundel *et al.*, addresses the essential tasks of network testing and monitoring. In this perspective, the authors leverage P4STA, an open source network measurement framework, for network testing and monitoring using programmable switches. They describe and demonstrate experimentally how P4STA combined with programmable network hardware can achieve high levels of accuracy and flexibility in testing and monitoring network functions, before and after deployment.

In the second article, "NFV Anomaly Detection: Case Study through a Security Module" by Bondan *et al.*, the authors deal with the relevant issue of detecting security breaches in virtualized network functions (VNFs) and service function chains (SFCs). In particular, they adopt anomaly detection techniques to identify threats in diverse network contexts, such as those leveraging NFV. An architectural framework called the NFV Security Module (NSM) is presented and discussed in the context of a realistic case study, leading to the design, development, and evaluation of three distinct entropy-based anomaly detection mechanisms. Results prove that anomaly detection effectively identifies potential threats in NFV environments with an accuracy of up to 98 percent.

The third article, "Interpreting AI for Networking: Where We Are and Where We Are Going" by Zhang *et al.*, overviews explainable AI on networking. XAI is essential in achieving real deployments and commercial success of AI-based solutions in modern communication networks because it enables interpretable, manageable, and trustworthy AI models; traditional AI-based networking is non-transparent and hard to interpret. A guideline on XAI is introduced to encourage network practitioners to improve AI-based networking solutions. The article also envisions future challenges and directions for making XAI a reality in the networking domain.

In the fourth article, "Federation in Dynamic Environments: Can Blockchain Be the Solution?" by Antevski *et al.*, the authors discuss the issue of deploying multi-domain network services in federated NFV environments where challenging dynamic resource orchestration is required. To address this problem they propose to complement NFV management and orchestration (MANO) with blockchain techniques that allow to dynamically establish prompt, short-term, secure, and trustworthy federation agreements. The design of an application-based blockchain solution is introduced, which is then experimentally validated using a Tendermint network of nodes from three administrative domains, proving the feasibility of the approach.

We hope that the reader will find the published articles as inspiring and impactful as we do. While we are in the process of selecting the contributions for the next issue, we invite scientists, researchers, practitioners, and professionals to submit new papers on advancements in the state of the art of network softwarization and management. Last but not least, we wish to thank all the authors and reviewers who contributed to the success of this Series, and the *IEEE Communications Magazine* Editorial Board and staff members for their invaluable and continuous support.

BIOGRAPHIES

OSCAR CAICEDO [GS'11, M'15, SM'20] is a full professor at the Universidad del Cauca, Colombia, where he is a member of the Telematics Engineering Group. He received his Ph.D. degree in computer science (2015) from the Federal University of Rio Grande do Sul, Brazil, and his M.Sc. in telematics engineering (2006) and his degree in electronics and telecommunications engineering (2001) from the University of Cauca. His recent research interests include network and service management, network functions virtualization, software-defined networking, machine learning for networking, and network softwarization. He has served and continues to serve as Technical Program Co-Chair for IEEE-sponsored international workshops and conferences.

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