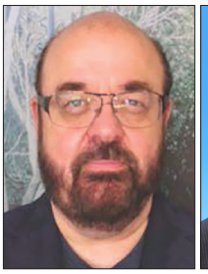
TELECOM SOFTWARE, NETWORK VIRTUALIZATION, AND SOFTWARE DEFINED NETWORKS


Walter Cerroni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Software-based networking and virtualization are radically changing the way communication infrastructures are designed, programmed, integrated and operated, enabling rapid and innovative network functions and network services creation with easy deployment. The *IEEE Communications Magazine* series on "Telecom Software, Network Virtualization, and Software Defined Networks" aims at bringing together high-quality articles covering several challenges of software-based network technologies.

This first publication of the Series features three papers that deal with critical aspects of network service development, validation, and orchestration in the network function virtualization (NFV).

The first article, "Empowering Network Service Developers: Enhanced NFV DevOps and Programmable MANO" by Thomas Soenen *et al.*, discusses challenges and opportunities of NFV from the perspective of a Network Service (NS) developer. In particular, the possibility to provision end-to-end services by properly chaining software-based elements such as Virtual Network Functions (VNFs) enables NS developers to take advantage of MANO frameworks with unprecedented programmable capabilities, which can be customized by defining workflows at the NS level. The authors propose a modular MANO framework architecture offering such capabilities, as well as a set of software tools that can help NS developers test their services and manage the NFV DevOps lifecycle.

The second article, "Introducing Automated Verification and Validation for Virtualized Network Functions and Services" by Manuel Peuster *et al.*, discusses the need for testing software-based NS and their composing VNFs before their deployment in production environments, in order to make sure that they operate correctly and meet the expected performance requirements. To achieve this goal, the authors investigate how Verification and Validation (V&V) procedures, that were originally defined in the realm of software engineering, could be applied in the case of software-based VNFs and NSes. They hence propose a fully-automated V&V platform and discuss its integration into the NFV ecosystem and the resulting business models.

The third article, "MANOaaS: A Multi-tenant NFV MANO for 5G Network Slices" by Faqir Zarrar Yousaf *et al.*, examines the effective involvement of a number of technical challenges for managing and orchestrating physical and virtualized slice resources. The paper's main contribution is the description of the benefits and implementation aspects of abstracting the MANO framework into customized and distributed MANO instances, thereby empowering the MANO-as-a-Service (MANOaaS) paradigm toward full network slicing. It presents a novel MANOaaS architecture showing the interconnections between distributed instances and the centralized MANO stack, and detailed autonomy negotiation process of the Management Level Agreements (MLAs).

We would like to thank all the authors and reviewers who contributed to the series, as well as the *IEEE Communications Magazine* editors and staff for their continuous support. We hope that you will enjoy this first issue and find these papers as inspiring and impactful as we do. While we are currently selecting the articles for the next issue, we invite interested authors to submit their work.

BIOGRAPHIES

WALTER CERRONI [M'01, SM'16] (walter.cerroni@unibo.it) is an Assistant Professor of communication networks at the University of Bologna, Italy. His recent research interests include software-defined networking, network function virtualization, service function chaining in cloud computing platforms, intent-based northbound interfaces for multi-domain/multi-technology virtualized infrastructure management, modeling and design of inter-data and intra-data center networks. He has co-authored more than 120 articles published in the most renowned international journals, magazines and conference proceedings. He serves/served as Associate Editor for *IEEE Communications Letters* and Technical Program Co-Chair for IEEE-sponsored international workshops and conferences.

ALEX GALIS is a Professor in Networked and Service Systems at University College London (UCL) (www.ee.ucl.ac.uk/~agalis/). His current interests are in 5G and beyond 5G networking, AI and networking, virtualization and softwarization, network and cloud programmability. He has co-authored more than 250 publications in the future Internet areas and standards including 10 research books. He is a co-editor of the *IEEE Communications Magazine* series on Telecom Software, Network Virtualization, and Software Defined Networks, the IEEE JSAC series on Network Softwarization and Enablers, and the ETRI Journal published by Wiley.

KOHEI SHIOMOTO [M'90, SM'15]] is a Professor at Tokyo City University, Tokyo Japan. He has been engaged in R&D in the data communication industry for over 25 years. He has been active in the areas of network virtualization, data-mining for network management, traffic & QoE management since he joined Tokyo City University in 2017. He served as Guest Co-Editor for a series of special issues established in IEEE TNSM on Management of Softwareized Networks. He has served in various roles organizing IEEE ComSoc high profile conferences such as IEEE NOMS, IEEE IM, and IEEENetSoft.

MOHAMED FATEN ZHANI is an Associate Professor at ÉTS Montreal, the University of Quebec, Canada. His research interests include network function virtualization, software-defined networking and resource management in large-scale infrastructures. He has co-authored several research papers published in renowned conferences and journals. He has served as the general/technical program chair of several international conferences and workshops. He is a co-editor of *IEEE Transactions on Network and Service Management* and the IEEE softwarization newsletter. He received the IEEE/IFIP IM 2017 Young Researchers and Professionals Award for outstanding research contributions and leadership in the field of network and service management.