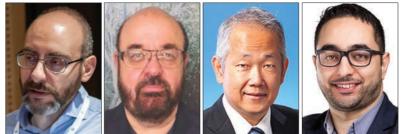# Network Softwarization and Management

Walter Cerroni   Alex Galis   Kohei Shiomoto   Mohamed Faten Zhani

This series focuses on softwarization, management, and their integration in communication networks and services. "Network Softwarization" advocates for network architectures that separate the software implementing network functions, protocols and services from the hardware running them. "Network Management" aims to integrate fault, configuration, accounting, performance, and security capabilities in the network and to support self-management features, integral automation, and autonomic capabilities, empowering the network with inbuilt cognition and intelligence. The critical role that software and Management are increasingly playing in telecommunications is enabling unprecedented levels of abstraction, disaggregation, operation, integration, robustness, optimization, intelligence, precision delivery, programmability and cost and complexity reduction of infrastructures and services. Such an approach is resulting in even greater attainment of non-functional characteristics (e.g., qualities of the operation of a network, rather than specific behaviors, integrability, interoperability, operational guarantees, deployability, auditability and control, reliability, adaptability, elasticity, effectiveness, extensibility, automation and autonomicity).

This series selects and publishes in-depth, cutting-edge articles on state-of-the-art technologies and solutions, bringing together the latest advances, technical innovations, open-source projects, case studies, research, and development in Network Softwarization and Management in terms of the main paradigms and systems, architectures and methodologies, software approaches, resources, functions, modelling, measurement, performance analysis and cyber-networking. This series also welcomes experience reports from experimental testbeds, Network Softwarization and Management standards, open-source projects, and solutions.

Softwarization and Management would help innovate network and cloud-network tasks, accelerate service deployment, and facilitate infrastructure management efficiency. Artificial Intelligence (AI)/Machine Learning (ML) based awareness and resolutions would be applied to address the complexity increasing rapidly, making current network control and management techniques based on analytical models and simulations impractical. This series' third issue features four papers considering these trends: AI/ML-assisted Softwarization and Management, edge cloud-native networking, service chaining, network slicing, and data plane programmability.

Service Function Chaining

The first article, "HASFC: A MANO-compliant Framework for Availability Management of Service Chains" by Di Mauro et al., deals with the relevant issue of service availability when services are offered as chains of Virtualized Network Functions (VNFs). VNFs can share the same underlying infrastructure; the presence of "nested" layers (hardware, virtual machine, VNF) has the drawback of amplifying the so-called common-mode failures, meaning that an undesired malfunctioning of the virtual machine causes the breakdown of all the VNFs sharing the same virtual machine. Service function chaining (SFC), a concatenation of VNFs, could cause a single point of failure problem that implies that the malfunctioning of a single VNF may disrupt the whole service chain operation. The authors present a framework called HASFC (High Availability SFC) designed to automatically build service chains respecting a desired availability target at the minimum cost. They developed a system that empowers the basic MANO functionalities through a dedicated REST interface, receiving information about the desired chain to build and returning a short list of SFCs satisfying availability/cost requirements.

Network Programmability

The second article, "Consistent Composition and Modular Data Plane Programming" by Parizotto et al., offers interesting insights on programmable data planes. Data plane programmability allows new features to be introduced into the forwarding device using abstractions. Data plane programmability provides greater flexibility in the management and control of computer networks, but this comes at a cost. A promising approach to specifying data plane configurations is to use high-level languages to develop modular programs and synthesize them into a single concrete network configuration. This paper presents new extension mechanisms, called PRIME Programming In-Network Modular Extensions, to compose data plane program modules and define how to steer traffic through these modules as part of the programmable data plane. The authors also present a system for

synthesizing multiple modularized data plane programs. This system dynamically synthesizes programs using emulation, performs synthesis in offline mode, and dynamically steers the flow. The system does not need to distinguish between test packets, thus reducing the size of the structures required for synthesis. It also supports the technique of synthesizing multiple programs to guide packets and consistent end-to-end updates across various switches.

Edge Cloud-native Networking

The third article, "DEEP: A Vertical-Oriented Intelligent and Automated Platform for the Edge and Fog" by Guimarães *et al.*, focuses on a novel integration of the cloud-to-things continuum and bringing intelligence to Edge and Fog Computing enabling 5G end-to-end vertical services. Vertical industries' adoption of 5G technology requires abstracted and simplified interfaces that hide unnecessary details and complexities so those vertical sectors can focus on their business areas. They need to devise support tools that ease and automate the Management of vertical services, replacing the complex and very time-consuming manual configuration and validation of traditional management tools. The authors propose a support platform named 5G-DIVE Elastic Edge Platform (DEEP), which hides the underlying complexity through a vertically oriented interface tailored to the needs of the vertical industry, and replaces the vertical industry with vertical service lifecycle management, and automates business processes on behalf of vertical industries.

Network Slicing

The fourth article, "5G Autonomous Network Slicing Prototype Using Machine Learning-Based Forecasting for Radio Resources" by Salhab *et al.*, deals with the use of Machine Learning (ML) to autoconfigure radio resources for network slicing. The fifth-generation (5G) and beyond (B5G) of mobile communications will enhance machine-to-machine communications driving various applications across multiple industries. Vertical applications with varying requirements for latency, reliability, mobility support, energy efficiency, throughput, and connection/traffic density will evolve with 5G/B5G. To support these numerous applications, the network must be agile by providing a tailor-made infrastructure. Network slicing is expected to offer an end-to-end logical infrastructure deployed over a shared physical infrastructure to meet specific use cases and their requirements. The authors have developed a prototype 5G architecture that automatically configures the radio resources of a network slice through ML-driven decisions based on performance metrics captured in real-time. A prototype has been deployed based on microservices. The authors also developed special scripts for a data processing engine with a northbound application interface for autonomous configuration management.

We hope that you will enjoy this third issue of the series and find these papers as inspiring and impactful as we do. We welcome paper submissions any time during the year. The call for papers is available at

https://www.comsoc.org/publications/magazines/ieee-communications-magazine/cfp/network-softwarization-and-management. The submitted papers will undergo a rigorous peer-review process and, if accepted, they will be published in the first slot available for this series. In our role as series editors, we strive to achieve distinguished quality and a selective review process for all submissions to swiftly recommend publishing high-quality and cutting-edge papers on relevant topics in the Network Softwarization and Management areas.

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