



Software Defined Networking (SDN) and Network Function Virtualization (NFV)

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Abstract: The role of Software Defined Networking (SDN) and Network Function Virtualization (NFV) have been instrumental in realizing the transition and vision “from black boxes to a white box towards facilitating 5G network architectures”. Though significant research results and several deployments have occurred and realized over the last few years focusing on the NFV and SDN technologies, several issues—both of theoretical and practical importance—remain still open. Accordingly, the papers of this special issue are significant contributions samples within the general ecosystem highlighted above, ranging from SDN and NFV architectures and implementations, to SDN-NFV integration and orchestration approaches, while considering issues associated with optimization, network management and security aspects. In particular, a total of nine excellent articles (one review and eight original research articles) have been accepted, following a rigorous review process, and addressing many of the aforementioned challenges and beyond.

Keywords: SDN architectures and design; NFV architectures and design; SDN-NFV integration; SDN-NFV orchestration; autonomic network management; security in SDN

1. Introduction

Next generation communication networks are expected to be implemented on virtualized infrastructures where network functions are deployed on virtual machines instead of current proprietary equipment. Moving away from an architecture that is based on a multitude of black boxes that are equipped with specialized network hardware and pre-loaded with specialized software to a new architecture consisting of a “white box” running a multitude of specialized network software appears to be the dominant choice and the direction in current and future communication and computing infrastructures. This is also required to support the 5G vision, calling for a new network architecture that directs flexible, dynamically configurable network elements to provide on-demand customized services to traffic demands that may be dynamic in time and space, all while supporting heterogeneity and diversity.

Towards realizing such a technological paradigm shift software defined networking (SDN) and network function virtualization (NFV) have been proven as two promising technologies for managing future networks. With their enormous benefits, including reducing operational costs, better resource utilization, and easier management requirements, the adoption of such technologies is gaining significant momentum. Increasing network resource utilization and decreasing operational costs have traditionally been among the key objectives in the era of network management and control. NFV allows for even further flexibility by migrating network functions from dedicated hardware to virtual machines that are running on commodity hardware. SDN has emerged as a key driver for innovation and change in networking as several market and technology factors converge. Such factors include the growth of cloud applications and services across enterprise and cloud providers, a focus on converged infrastructures (compute/storage/network), and software-defined datacenters.

2. Contributions

The papers included in this Special Issue of the Future Internet journal highlight some of the emerging issues that are associated with the NFV and SDN technologies—both of theoretical and practical importance—along with their applicability in the merging of the next generation networking era in an innovative and insightful way.

The first paper [1] provides a systematic literature review of the use of SDN technologies, along with the associated services and tools, in the broader area of tactile networks, coalition networks, ad-hoc networks, military networks, and/or mission-critical infrastructures.

The second paper [2] explores the issue of creating isolated and dynamically secured overlay networks and overcoming the limitations of current NFV implementations that are designed for deployment within trusted domains, where overlay networks with static trusted links are utilized to enable network security. This is achieved by introducing a novel tiered architecture for the automated establishment of encrypted tunnels in NFV in a multi-domain environment.

The third paper [3] introduces a resource consolidation scheme that implements network resource management concepts through software-defined networking (SDN) control features, allowing for the realization of application aware concepts. The goal of the paper is to establish a necessary baseline for a tool-based decision support method aiming at facilitating the selection of cloud services in a multi-cloud environment.

The fourth paper [4] introduces a novel autonomic network management (ANM) and optimization framework that demonstrates how SDN and software defined radios (SDRs) can be effectively combined to achieve reconfiguration flexibility, improved performance, and the efficient use of available resources in SDR-based cognitive radio networks (CRNs). The authors also provide a realization and evaluation of the proposed framework in two different realistic testbeds, namely Implementing Radio in Software (IRIS) and Open-Access Research Testbed for Next-Generation Wireless Networks (ORBIT) of the Orchestration and Reconfiguration Control Architecture (ORCA) federation.

The fifth paper [5] focuses on the effective and efficient virtualized network functions (VNF) placement within edge and cloud infrastructures in order to provide enhanced networking services to Internet of Things (IoT) applications. In particular, the authors propose a novel approach to facilitate the placement and deployment of service-chained VNFs in a network cloud infrastructure that can be extended by using the mobile edge computing (MEC) infrastructure for accommodating mission-critical and delay-sensitive traffic.

The sixth paper [6] deals with the design and evaluation of a scalable NFV orchestration architecture that supports elastic cloud and bandwidth resource allocation. A further contribution of the paper is the use of segment routing (SR) to implement the data plane of the proposed architecture, achieving an overall solution of reduced complexity with respect to the corresponding of traditional orchestrations.

The seventh paper [7] builds on the emerging trend of using SDN technology to make the 5G network functional and programmable in order to deal with the heterogeneity in traditional 5G networks. The authors propose a robust security architecture for SDN-based 5G networks in order to treat inherent security issues due to the intelligence centralization that is used in SDN. The proposed security architecture is based on the synchronized secret approach and, in principle, leverages a common secret shared by the back-end system and the network users to avoid illegal service requests from malicious network attackers.

The eighth paper [8] capitalizes on the extensive flexibility and programmability that are offered by SDN technology, and it proposes the realization of an SDN-powered mobile edge computing (MEC) architecture to deal with the joint problem of intelligent MEC server selection and end-users' data offloading in multiple MEC servers and multiple end-user environments. The intelligence and novelty of the proposed framework lie in the use of reinforcement learning and game theoretic techniques, both of which allow for a distributed and efficient realization.

The last paper [9] deals with the inherent complexities and challenges that are associated with service and platform deployment in cloud-based environments, as required for the successful

adoption of 5G technologies. The authors offer a solution to this problem by introducing a novel workflow for the composition, deployment, and management of platforms and services in multi-cloud environments, agnostic to the underlying technologies, protocols, and application program interfaces (APIs). The adopted model in this work is built around the principles of micro-services, modularity, and build-to-order.

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