Enabling Software-Defined Networking Technologies in Carrier Networks

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***Abstract*-Adopting software-defined networking (SDN) in carrier networks is now gaining momentum. Carriers and vendors are rushing into this new domain, hoping to solve some most urgent problems which arise along with the process when fixed high-speed data access and mobile broadband (MBB) get increasingly popular across the globe. To the same end, this paper elaborates novel software-defined fixed networking (SDFN) and software-defined mobile networking (SDMN) architectures, leveraging a set of emerging and promising technologies including SDN, clouding computing, network virtualization (NV), network functions virtualization (NFV), and dynamic service chaining. Furthermore, in the light of the irreversible trend towards fixed mobile convergence (FMC), this paper also proposes a forward-looking software-defined converged networking (SDCN) architecture. The three proposed architectures can effectively help carriers to reduce cost and enhance service performance, and therefore can serve as a good reference for the next-generation carrier network designing.**

Keywords: Next-Generation Networking Architecture, Network Design, Software-defined Networking (SDN), Carrier Network, Fixed Mobile Convergence (FMC).

I. INTRODUCTION

SDN refers to an emerging network architecture, which decouples the network control plane and data/forwarding plane. Particularly, control plane is designed to be implemented in software, while data plane is implemented in commercial-off-the-shelf hardware. The industry has already witnessed the successful application of SDN in the fields of data center networking. At present, adopting SDN in carrier networks is gaining gigantic momentum. Carriers and vendors are rushing into this new domain, expecting to solve the most urgent issues and challenges which arise along with the process when fixed high-speed data access and MBB become increasingly popular around the world. More precisely, carriers are mainly annoyed by:

- Ever rising capital expenditure (CAPEX) due to continuous updating of network infrastructure;
- Extremely high operational expenditure (OPEX) owing to complex operation, administration, and maintenance (OAM) tasks in legacy networks;
- Revenue loss as a result of competition with over-the-top (OTT) applications operated by Internet companies;
- Hard to provide finer-granular and differentiated services for both subscribers and applications, since the current carrier networks are not flexible, intelligent and agile enough.

Consequently, the overall challenges from carrier's perspective are to decrease the total cost (CAPEX & OPEX) while enhancing service, so as to increase the revenue.

To help carriers solving the aforementioned problems, quite a few research efforts have been carried out or are ongoing. In industry, Ericsson recently published its Service Provider SDN approach [1], aiming to extend virtualization and OpenFlow with three additional key enablers, i.e., integrated network control, orchestrated network and cloud management, and service exposure. Huawei has also unveiled its SoftCOM strategy [2] for applying SDN and cloud computing in carrier networks. Juniper has developed JunosVContrail SDN product line [3] for carrier networks. In academia, Bansal et al. [4] from Stanford established OpenRadio project, targeting at a programmable wireless network data plane. Li et al. in [5] sketched out a software-defined cellular network architecture called CellSDN. Naudts et al. in [6] conducted a techno-economic analysis of SDN as architecture for the virtualization of a mobile network. In [7], Gudipati et al. recently proposed SoftRAN, a centralized control plane for radio access network (RAN). Pentikousis et al. in [8] introduced the SDN-based MobileFlow architecture.

Many existing proposals only concern one or several specific parts of a carrier network, more detailed holistic solutions for enabling SDN in carrier networks are highly desirable. In order to bridge the gap, this paper elaborates novel SDFN and SDMN architectures for carrier fixed network and mobile network, respectively, leveraging a set of emerging and promising technologies i.e., SDN, clouding computing, network virtualization [9], NFV [10], and dynamic service chaining. Furthermore, in the light of the irreversible trend towards future FMC, the paper proposes a forward-looking SDCN architecture for carriers. It is believed that, as the major contribution, the proposed SDFN, SDMN, and SDCN architectures are of great help for carriers to keep profit and sustainability. Meanwhile, they can significantly enhance both capacity and efficiency regarding network OAM, as well as accelerate business innovation to new application fields.

The remaining part of this paper proceeds as follows. The SDFN and SDMN architectures are proposed in Sections II and III, respectively. In Section IV, this paper further elaborates a future-facing SDCN architecture following both SDN and FMC concepts, aiming to reduce cost while