Towards 5G as a Service for Over the Top Players

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***Abstract*—Following the convergence of the mobile communications and cloud computing industries, current 4G services evolve towards 5G cloud native ones. Mobile Network Operators (MNOs) leverage cloud-computing paradigms for this shift. This approach should help MNOs reduce Operational Expenditures and propose a larger 5G usecases portfolio. To execute this vision, Virtualized Network Functions need to become cloud-native themselves. This paper introduces a cloud native platform allowing MNOs to expose their assets: networking resources, mobile services, and cloud computing to Over-The-Top (OTT) players such as entertainment and media companies, in an as a service fashion.**

***Index Terms*—Cloud-native, Network Function Virtualization, Over-The-Top, 5G**

I. Introduction

A mobile network is composed of multiple networking functions to deliver multiple services. Today, the functions live in their dedicated physical appliances (e.g. routers, SGSN/GGSN, firewalls, load-balancers). Currently, MNOs are actively working in standard development bodies to define 5G building blocks, in particular, the management of network functions on a cloud infrastructure. This paradigm is commonly known as networking softwarization or Network Function Virtualization (NFV). NFV decouples software and hardware of a network function to allow the resulting VNF to be implemented by different providers and deployed on generic computing resources [1].

The NFV Management and Orchestration (NFV-MANO) standard of the European Telecommunications Standards Institute (ETSI) defines 3 main building blocks of 5G cloud-native infrastructure: Virtualized Infrastructure Manager (VIM), VNF Manager (VNFM), and NFV Orchestrator (NFVO) [2]. The VIM is responsible for the management of the underlying NFV Infrastructure (NFVI) of the mobile networking system. The VNFM is responsible for managing the life cycle of VNFs, i.e. create, start, stop, scale, and update operations. The VNFM communicates with the NFVI to execute those management tasks. Finally, the VNFO has a larger view of the resources and orchestrates VNFs on top of multiple VIMs to deliver a global networking service and execute the MNO logic.

To establish a 5G cloud-native architecture, each component needs to expose an Application Programming Interface (API). Recently, the 3rd Generation Partnership Project (3GPP) has initiated a new study topic on APIs [3]. The goal of this study is to define standard APIs for multiple components of the mobile network such as: Packet Core Network, Radio Access Network (RAN), User Equipment (UE), and more.

In this paper, we propose a 5G as a service software platform supporting multi-radio access technologies to provide a slice of connectivity to Over-The-Top (OTT) players and Mobile Virtual Network Operators (MVNOs). Our proposal leverages commodity hardware and open source software in a cloud-based design to achieve efficient and multi-tenant access to MNO's mobile cloud resources. Main contributions of this paper are two fold: the cloud-based architecture for a mobile cloud network, and our open source development framework we used to implement for our Cloud Native VNFs.

II. Related Work

Sustainability of 5G networks, RAN in particular, have recently received significant attention. The Cloud-RAN allows multiple Remote Radio Heads (RRH) connected to a remote Base Band Unit (BBU) which is located in a centralized cloud (Point of Presence, or PoP) [4]. This design helps reducing CAPEX/OPEX of the access network [4]. It also allows a more fine grained control of the BBU pool by offering an on-demand and elastic Virtual Network Functions (VNF) deployment.

The FP7 Mobile Cloud Networking (MCN) project [5] sets the building blocks of the cloudification of the mobile network functions. The proposed C-RAN architecture follows the Service-Oriented Architecture design patterns where services are autonomous, loosely coupled and communicate through APIs [6]. This design provides service chaining by composing multiple services based on 3 main elements. A Service Manager which exposes an API to the end user. A Service Orchestrator created by the manager, responsible for the orchestration and composition of services. Finally, a Cloud Controller that connects to multiple cloud providers by implementing the Open Cloud Computing Interface standard.

Cloud-native VNFs (CN-VNFs) run in a container rather than a Virtual Machine, their life cycle is orchestrated by a container orchestration engine (e.g. Kubernetes), using cloud orchestration paradigms. In other words, the control/management planes follow a 12-factor app (12FA) design [7]. Depending on the programming language of the VNF, several cloud-native toolkits may exist. For instance, Ligato [8] is a Golang framework intended for development of custom management/control plane agents for cloud-native VNFs. The framework includes a set of specific functionalities: logging, health checks, messaging, REST and gRPC APIs.

III. 5G as a Service Architecture

Our proposal is to provide a mobile networking cloud that verticals can use to leverage connectivity in a specific geographical location with a specific Service Level Agreement (SLA). Use cases may involve different OTTs: entertainment and media companies, MVNOs, or public transportation. Figure 1 shows the system layers. Similar to how an SDN controller exposes a northbound API to accept network configuration requests, our architecture exposes a northbound interface on which the OTT consumes MNO assets. This interface includes a Selfcare web interface and an external 3rd party API system. The NFVO provides an extra layer of control to the MNO, in compliance with NFV-MANO. With regards to the MCN architecture, this Northbound layer corresponds to the Service Manager API.

The MNO's assets are split among verticals using tenant slices. A tenant slice is transformed (by the NFVO) into technical requirements that must be executed by the VNFM localized in the edge cloud. These requirements may include configuration parameters of an eNodeB, MME, or carrier aggregation and MIMO. The VNFM will then manage the life cycle of several VNFs to achieve the SLA requested by the OTT. This control/management plane is handled dynamically using a container orchestration engine.

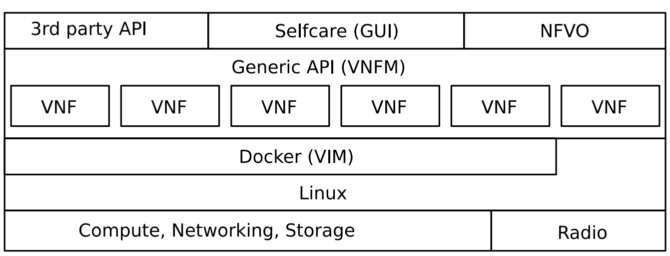

Fig. 1. 5G as a Service architecture overview.

IV. Cloud-native VNF design

In order to take full advantage of the MNO's assets, VNFs need to be cloud-native. In particular, the VNFM should interact with their API to manage their life cycle. We propose [9] a modular and extensible framework for cloud-native VNFs design. Our CN-VNF framework emulates slicing to VNFs that are not multi-tenant by design. Our framework allows the VNFM to interact with the CN-VNF's HTTP REST API to:

- Create, update and remove sessions identified by a unique user ID (UUID). A session allows the isolation of tenants on the same NFVI.
- Create, update, remove configurations per session. Each VNF can have several configuration templates.
- Start, stop, and terminate VNF instances per session. An instance is associated with a configuration in the same session.
- Get the status of a session or a given VNF instance (e.g. created, started, stopped, load average, network consumption).

To demonstrate this concept, we implemented CN-VNFs for LTE (based on OpenAirInterface) and WiFi (based on Hostapd and Dhcpd). Both CN-VNFs can run on top of the Docker-based VIM or on the host operating system (i.e. Linux), the only NFVIs we currently provide. Our framework adds the following interfaces and behavior to those two VNFs:

- A configuration interface that accepts configuration from files, environment variables, and command line interface.
- A logging interface to standard output, flat files, and Logstash as its recipients. This allows streaming logs to logging as a service platforms (e.g. elastic stack).
- A scheduler interface. This supports different types of scheduling, by default the underlying Linux system and Docker.
- Templates interface that supports configuration versionning to comply with the VNF version.
- Storage interface to store the state of the CN-VNF to recover from failures and support migration from one NFVI to another.

V. Conclusion and Perspectives

We proposed a cloud platform to deliver 5G as a service for OTT players. The platform is composed of (i) a northbound interface that receives OTTs slices requests of MNO's assets, (ii) a VNFM which manages the life cycle of different VNFs to comply with the slices requests, and finally (iii) an extensible library for cloud-native design of VNFs. The proposed NFVI is based on Docker/Linux. Other types of NFVI such as OpenStack or Kubernetes may be explored in the future.

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