How to Create a Network Slice? - A 5G Core Network Perspective

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Abstract—**Initially, the 5G system architecture is required with very diverse and extreme requirements. These requirements related with four main mega trends. Those are the explosion of date traffic, the rapid increase of number of devices, the increase of cloud's dependency, and the advent of new various mobile converged services. Mobile business stake holders define three categories of services and their characteristics such as eMBB (enhanced Mobile Broadband), mMTC (massive Machine Type Communications) and URLLC (Ultra-Reliable and Low Latency Communications). To support these services, KPIs (Key Performance Index) such as user experience data rate, peak data rate, mobility, latency, connection density, energy efficiency, spectrum efficiency, and traffic volume density are elicited. With these KPIs and service scenarios, 3gpp working groups has been studied requirements, standards, and use cases for the 5G system. To support these 5G's requirements, a network slicing technology is required. Network Slicing provides multiple logical networks on top of a partially shared network infrastructure. Each instance of a network slice represents an independent end-to-end network that allows deployment of different architectural flavours in parallel slices. This paper proposes an architecture for the network slicing in 5G communication system.**

Keywords— **5G networks, network slice, NFV, SDN, ONAP**

I. Introduction

The previous 4G system was optimized only for one specific featured device as a user equipment (UE), however, 5G system has to provide services for various devices with different attributes.

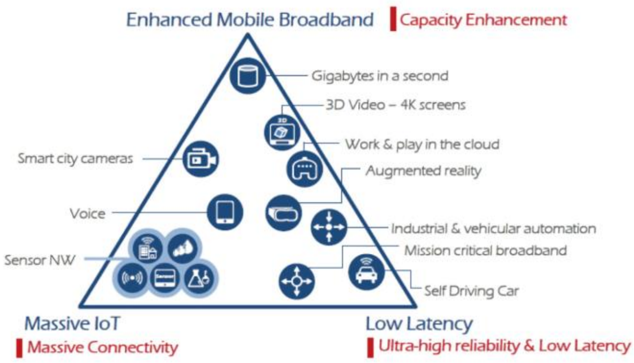

Figure 1. Use cases in 5G (source: ETRI graphic, from ITU-R IMT2020 requirements)

The representative use cases in 5G, enhanced mobile Broadband, massive IoT and low latency services have their own attribute and network requirements in terms of mobility, charging, security, police control, latency and reliability. Figure 1 shows the use cases in 5G communication system [1].

To support these 5G's requirements, a network slicing technology is essentially required. A network slice is a type of virtual proprietary network and network slicing is a technology to provide certain network slices on a shared physical network [2]. To implement network slicing, it definitely needs software-defined networking (SDN) and network functions virtualization (NFV). These two closely related network virtualization technologies that are moving modern networks toward virtualization and software-based automation. SDN and NFV allow far better network flexibility through the partitioning of network architectures into virtual elements. Thus, network slicing allows the creation of multiple virtual networks on top of a shared physical infrastructure using SDN and NFV technology. A network slice has its own requirement and needs its own virtual functions to provides its own service. To come up with the special feature of network slices, we need to utilize the technology of NFV and SDN essentially. Figure 2 shows the major components for network slicing in 5G communication system.

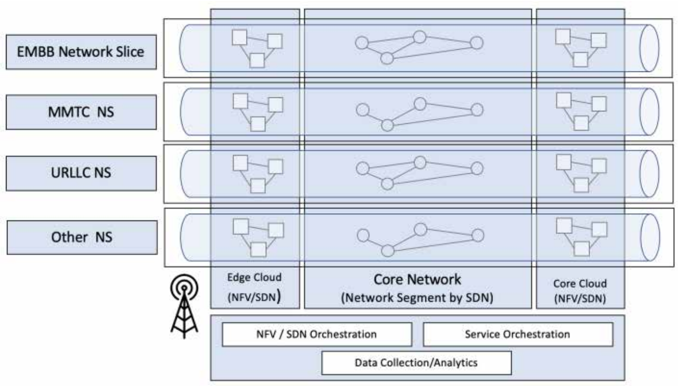

Figure 2. Major Components for Network Slicing in 5G

[3] summarizes about NFV and SDN as key technology enablers for 5G networks and provides some of those questions/issues. It says that NFV and SDN technologies are widely considered as the key enablers in network architecture, design, operation and management in order to be able to

maintain and run these networks over 5G slices. And, it emphasizes that several organizations (ONF, ETSI MEC, ETSI NFV, NGMN, 3GPP, IEEE, BBF, MEF etc.) are working on standardizing the architecture frameworks and interfaces required for combining the multitude of components into a functional system that can be implemented within the provider/operator systems based on a variety of business models and use cases [3].

This paper is organized as follows. In the second section we introduce ONAP and its features. The following section takes a close look at how to create a network slice in the ONAP based 5G core network. In the fourth section we conclude with comments about the ONAP platform in regarding network slicing in 5G communication system and discussion of future work.

II. ONAP

ONAP stands for Open Network Automation Platform and allows end users to automate, design, orchestrate, and manage services and virtual functions. It is an initiative created by the combination of the ECOMP (Enhanced Control, Orchestration, Management & Policy) and Open-O (Open Orchestrator) projects into ONAP, to bring the capabilities for designing, creating, orchestrating and handling of the full lifecycle management of Virtual Network Functions, Software Defined Networks, and the services. ECOMP, created by AT&T, is the operating system that manages the network. In this sense, because 5G communication system has the service-based architecture.

ONAP is a comprehensive platform for real-time, policy-driven orchestration and automation of physical and virtual network functions that will enable software, network, IT and cloud providers and developers to rapidly automate new services and support complete lifecycle management.

Many engineers of large networks have been challenged to keep up with the scale and cost of manual changes required to implement new service offerings, from installing new data centre equipment to upgrading on-premises customer equipment. Many are seeking to exploit SDN and NFV to improve service integrity, simplify equipment interoperability and integration, and reduce overall CapEx and OpEx costs.

ONAP is tackling these problems by developing global and massive scale orchestration capabilities for both physical and virtual network elements. It facilitates service agility by providing a common set of Northbound REST APIs that are open and interoperable, and by supporting YANG and TOSCA data models. ONAP's modular and layered nature improves interoperability and simplifies integration, allowing it to support multiple VNF environments by integrating with multiple VIMs, VNFMs, SDN Controllers, and even legacy equipment.

ONAP allows network and cloud operators to optimize their physical and virtual infrastructure for cost and performance. The use of standard models in ONAP reduces integration and

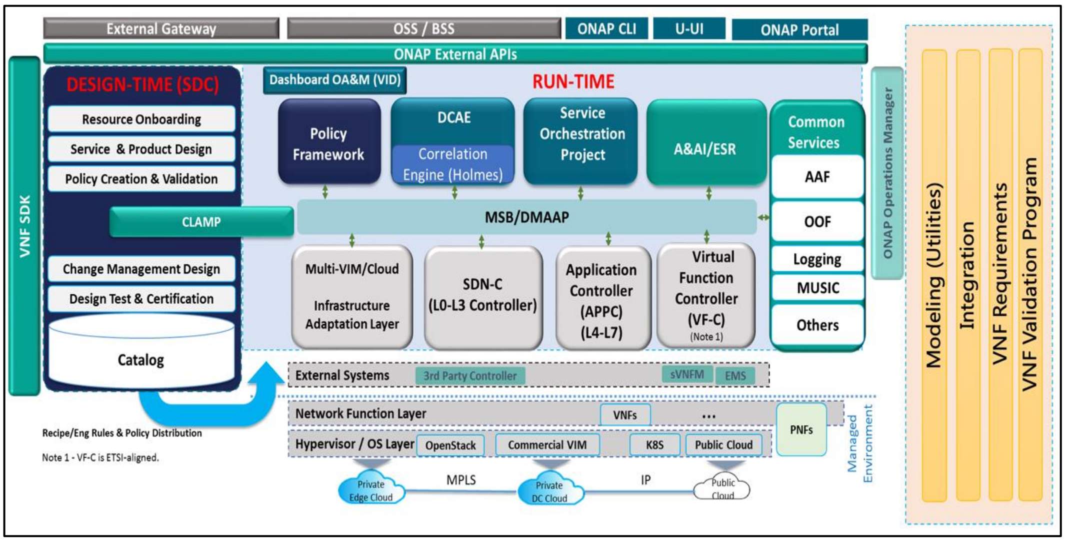

Figure 3. ONAP Platform Architecture (source: https://wiki.onap.org/)

ONAP has the evolving platform to manage and control the NFV/SDN based complicated infrastructure [4].

ONAP is designed as a microservices-based system, with all components released as Docker containers. With this, ONAP is highly reliable, scalable, secure and easy to manage. When users may want to select a portion of the ONAP components to integrate into their own systems, ONAP is flexible enough to suit the different scenarios and purposes for various operator environments. ONAP is the top in the list of open management platforms for NFV/SDN based 5G infrastructure systems deployment costs of heterogeneous equipment, while minimizing management fragmentation. The ONAP platform allows end user organizations and their network/cloud providers to collaboratively instantiate network elements and services in a dynamic, closed-loop process, with real-time response to actionable events. Currently, the version of ONAP is 'Beijing'. Figure 3 shows a high-level view of the ONAP architecture and microservices-based platform components.

III. How to Create a Network Slice?

In the design time framework, resources, services, products, and their management and control functions can be estimated using a specific network slice set of specifications and policies. This process can decide the location and resources of VNFs to satisfy the specific network slice's requirement. Figure 4 shows the sequence diagram for the creation of a network slice in OLAP.

The Service Orchestrator (SO) component executes the specified processes by automating sequences of activities, tasks, rules and policies needed for on-demand creation, modification or removal of network, application or infrastructure services and resources. The SO provides orchestration at a very high level, with an end-to-end view of the infrastructure, network, and applications. The Service Orchestrator (SO) manages orchestration at the top level and facilitates additional orchestration that takes place within underlying controllers. It also marshals data between the various controllers so that the process steps and components required for execution of a task or service are available when needed. The SO creates the end-to-end service instance as a network slice. The SO is responsible for the instantiation and release, and subsequent migration and relocation of VNFs in support of overall end-to-end service instantiation, operations and management.

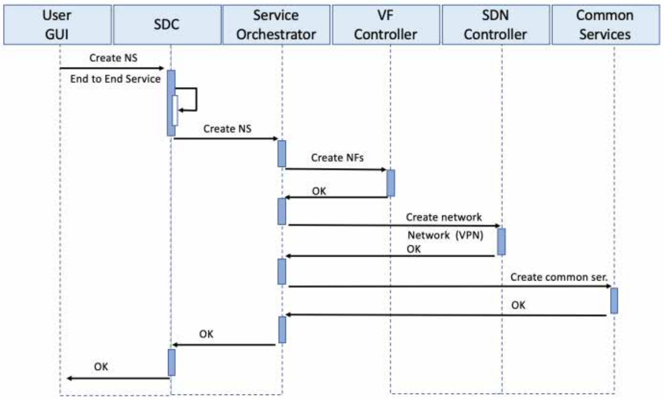

Figure 4. Network Slice Creation

Controllers are applications which are coupled with cloud and network services and execute the configuration, real-time policies, and control the state of distributed components and services. Operators can choose to use multiple distinct Controller types that manage resources in the execution environment corresponding to their assigned controlled domain such as cloud computing resources. Also, the Virtual Function Controller (VF-C) provides an ETSI NFV compliant NFV-O function that is responsible for lifecycle management of virtual services and the associated physical COTS server infrastructure. VF Controller provides a generic VNFM capability but also integrates with external VNFMs and VIMs as part of a NFV MANO stack. SDN Controller creates and manages the network segment as a specific VPN for network slices. VF Controller creates and manages the VMs and their resources for network slices.

The ONAP Optimization Framework (OOF) provides a policy-driven and model-driven framework for creating optimization applications for a broad range of use cases. OOF Homing and Allocation Service (HAS) is a policy- driven workload optimization service that enables optimized placement of services across multiple sites and multiple clouds, based on a wide variety of policy constraints including capacity, location, platform capabilities, and other service specific constraints.

In the design time framework, the SDC has to be consider the resources and locations for virtual network functions in terms of Service-Based Architecture. As shown in Figure 5, the 5G core network is based on what is called "Service-Based Architecture" (SBA), centred around services that can register themselves and subscribe to other services. This enables a more flexible development of new services, as it becomes possible to connect to other components without introducing specific new interfaces. The new system architecture is specified in 3GPP technical specification [5]. ONAP needs to create and manage the network functions as VNFs, such as NRF, PCF, UDM, AMF.

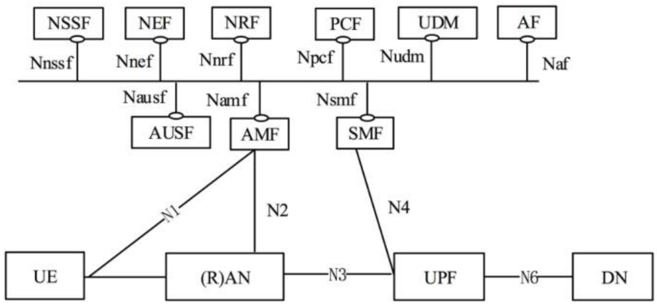

Figure 5. Service-Based Architecture in 5G

NEF(Network Exposure Function) provides a means to securely expose the services and capabilities provided by 3GPP network functions. NRF(Network Repository Function) supports the service discovery function. As such, it is able to receive NF Discovery Request from a NF instance and can provide information about discovered NF instances. PCF(Policy Control Function) supports the unified policy framework that governs network behavior. In so doing, it provides policy rules to control plane function(s) to enforce them. In order to facilitate this the subscription information is gathered from the Unified Data Management function(UDM). UDM supports the ARPF (Authentication Credential Repository and Processing Function) and stores the long-term security credentials used in authentication. AMF(Access & Mobility Management Function)'s tasks include: Registration Management, Connection Management, Reachability Management, Mobility Management and various function relating to security and access management and authorization.

IV. Conclusions and Future Works

This paper summarises ONAP architecture and its major components for supporting network slicing in 5G communication system. Moreover, we present the new functions to create a network slice in ONAP. ONAP has the evolving platform to manage and control the NFV/SDN based complicated infrastructure and is suitable for network slicing.

Network slicing is a very rich research area. How to create and manage the resources for that, what resources are to be sliced, and how to integrated with other networks are those issues. We need more research works to come up with these issues.

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