

Charging Factors for Enabling SDN/NFV Accounting Management

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Abstract—The SDN/NFV technologies, where SDN detaches the control plane and the data plane and NFV enables the virtualization of various network appliances, will transform the traditional networking paradigms. Both technologies create enormous opportunities for telecommunications operators by transforming their networks into low-cost, elastically scaling cloud environments. SDN/NFV is challenging the traditional accounting management with its high flexibility. It is thus very important for telecom operators to identify new charging factors introduced by SDN/NFV in the new telecom ecosystem. In this paper, we report our research results in identifying these new charging factors of SDN/NFV. Furthermore, we briefly explain how to utilize them to define new charging models to enable SDN/NFV accounting management that would benefit both operators and customers in the 5G era.

Keywords—network function virtualization; software defined network; charging factors; charging models

I. INTRODUCTION

Nowadays the mobile network operators are facing many disruptive changes due to the new technologies. The conventional policy and online charging systems that have been in place within operator environments for years are no longer sufficient and in fact will prevent the telecom operators from making good use of the advantages offered by the virtualization and softwarization of SDN/NFV.

The SDN/NFV technologies, will introduce new actors like VNF (Virtual Network Function) vendor, VNF market place, VNFaaS (VNF as a Service) provider and NFVIaaS (Network Functions Virtualization Infrastructure as a Service) provider into the telecom ecosystem. These new actors will promote competition hence demand for more flexible pricing with real-time / prepaid charging models. Moreover, service providers will charge their customers in different ways by using the opportunities offered via these actors. For example, a service provider can play the role of NFVIaaS by leveraging its infrastructure and network capabilities.

In this research we address the challenges and the market opportunities created by the technologies of SDN and NFV and their impact on the future of accounting management. Our solutions are based on the ETSI MANO (European Telecommunications Standards Institute Management and

Orchestration) architecture. First, we list and classify the charging factors, then identify the MANO events that are associated with each particular charging factor. Second, based on the charging factors discovered, suitable charging models can be defined according to different assumptions under a desired business model. Finally, the charging architecture for SDN/NFV accounting management can be designed based on the notions of charging factors and charging models. This paper is primarily for identifying and analyzing new charging factors of SDN/NFV. Further results will be reported in the subsequent papers.

The rest of the paper is organized as follows. Section II introduces background and related work. Section III introduces MANO and its events. Section IV identifies charging factors for SDN/NFV. Section V relates MANO events to charging factors. Finally, Section VI gives our conclusion and future work.

II. BACKGROUND & RELATED WORK

Virtualization enabled by SDN/NFV has multiple impacts on different areas. Below, we introduce the impacts of SDN/NFV on several domains.

1) *Impact to Network Architecture* - SDN/NFV will impact the network architecture gradually. The migration from non-virtualized networks to all virtualized networks will be made gradually. The network as of now is based on physical hardware and each Physical Network Function (PNF) is managed by their individual EMS that is further under control of the OSS/BSS (Operation Support System/Business Support System). At the second stage, the network functions are semi virtualized and the network connectivity will be partially provided by an SDN network with data plane and control plane separation, and partially by the physical network integrated with an NFV Infrastructure. At the last stage, the network functions will be fully virtualized where the network connectivity would be completely provided by SDN/NFV[1].

2) *Impact to Business Models* - The Virtualization of SDN/NFV, by introducing new actors such as VNF vendor/VNF market place, VNFaaS provider, NFVIaaS provider, can create three new business models [2][3][4] as follows.

a) *Service Providers (SP) using the NFVI from NFVaaS providers* - In this business model, the NFVaaS will provide the infrastructure resources to the service provider. In this case the service provider will be charged according to its use of these resources. The infrastructure resource of NFVI includes compute, storage and network.

b) *SPs/VNFaaS provider offering VNF as a service to xVNOs (Virtual Network Operators)* - In this business model, the service provider or the VNF as a service provider offers the VNF as a service to the VNOs. VNFaaS offers not only the VNF as a service but also provides the infrastructure resources required to support the VNF. The VNOs will thus be charged both for the VNF as service such as vEPC, vIMS, vFirewall etc. and for the infrastructure resources such as compute, storage, and network.

c) *Communication Service Providers (CSPs) leasing the VNF S/W from VNF Providers* - In this business model the CSPs will only lease the VNF software from VNF providers without the infrastructure resources. In contrary with the other two businesses models, the CSPs will be charged only when they buy the VNF software or when they make use of the VNF service.

3) *Impact of Introducing New Charging Factors* - SDN and NFV, by changing the traditional networking paradigms, not only creates the opportunity for new revenue streams but also introduces new charging factors into the telecom ecosystem, which will challenge the traditional pricing and charging model with its high flexibility. Consequently, new charging models can be defined according to different assumptions under a desired business model. For example, assume a business model where the CSPs lease the VNF software from the VNF providers, then the charging factors under consideration may include the type of VNF and its number of instances and the business models thus derived can be based on the quality and/or the quantity of these charging factors.

Charging factors for SDN/NFV are new but the ones defined before for Cloud and M2M services can be leveraged to define these new charging factors. The charging factors defined for each type of cloud services are different. For example, in IaaS the charging is based on how much compute and storage resources are consumed. On the other hand, in SaaS the charging is based on the type and duration of services delivered to the customers. Furthermore, new charging factors and new charging models have been invented and defined based on unique characteristics of M2M communications [5][6][7][8].

III. ETSI MANAGEMENT AND ORCHESTRATION (MANO)

As depicted in Figure 1 NFV MANO (Network Functions Virtualization Management and Orchestration) is defined by European Telecommunications Standards Institute Industry Specification Group (ETSI ISG) as an architectural framework for management and orchestration of virtualized network functions (VNFs) and other software components. NFV MANO supports the management and orchestration of all resources in the cloud data center including Compute, Network, Storage and Virtual Machine (VM). It enables flexible on-

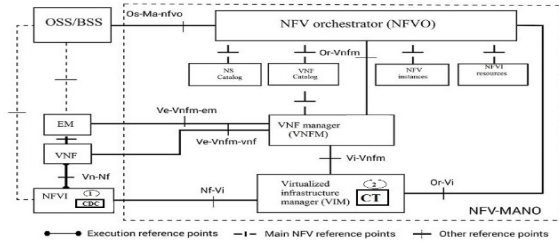


Figure 1. NFV MANO & Online Architecture for NFVI as a Service boarding of new services and supports rapid scalability of network components. MANO is split into three main functional blocks [9]: NFV Orchestrator (NFVO), VNF Manager (VNFM) and Virtualized Infrastructure Manager (VIM). In MANO, eight reference points as depicted in Figure 1 can be found such as Ve-Vnfm-em, Nf-Vi, Ve-Vnfm-vnf, Os-Ma-nfvo, Vn-Nf [10][11][12][13][14][15][16]. Each of these reference points manages the event exchange between different functional blocks in MANO. In this research we make use of the following two references points:

- Ve-Vnfm-em: This reference point [10] is for event exchange between EM and VNFM. The events consist of VNF instantiation, VNF instance scaling out/in, and up/down, VNF instance termination, etc.
- Nf-Vi: This reference point [11][12][13] is for event exchange between NFVI and VIM. The events consist of Allocate VM with indication of compute resource, Update VM resources allocation, Terminate VM, etc.

IV. CHARGING FACTORS OF SDN/NFV

Charging factors are the criteria that operators use to charge the services offered to their customers. In traditional telecom networks, operators usually charge the services based on the duration of a session or the amount of data transmission [5]. SDN and NFV together will modify the traditional networking paradigms by introducing new charging factors. In this section, we will clarify these new charging factors under each potential business model.

A. Charging Factors for “SP using the NFVI from NFVaaS Provider” Business Model

As we have mentioned earlier, in this business model the SP will be charged by the usage of the NFVI resources. We have identified seven such charging factors as described below:

1) *Type of CPU used* - A virtual CPU (vCPU) also known as a virtual processor, is a physical central processing unit (CPU) that is assigned to a virtual machine (VM). This charging factor refers to what type of CPU resource is offered to the service provider. Examples include single core CPU, Dual core CPU, Quad core CPU, etc.

2) *How much CPU time used* - The CPU time is the amount of processor time consumed by a service. The service provider will be charged correspondingly.

3) *Type of storage used* - This charging factor refers to what type of storage the service provider will use from the NFVI. There are different types of storage such as primary storage or secondary storage.

4) *How much storage used* - This charging factor measures the amount of storage that is offered to the service provider. The service providers may be charged according to the size, the duration and the location of the storage it actually consumes from the NFVI.

5) *Bandwidth* - The Bandwidth describes the maximum data transfer rate of a network or Internet connection. A service provider will be charged based on the bandwidth offered.

6) *QoS Level* - The QoS level is a service guarantee the NFVaaS provider provides to the service provider.

7) *Type of Accelerator used* - This charging factor refers to what type of accelerator resource is offered to the service provider. Examples include hardware accelerator, graphics accelerator, cryptographic accelerator, web accelerator, etc.

B. Charging Factors for “CSPs leasing the VNF S/W from VNF Providers” Business Model

In this business model, since the communication service provider will lease the VNF software from VNF providers, the charging factors will depend on what type of VNF used. For this business model, we have selected some VNFs like vEPC, vIMS, NAT, Parents’ Filter, vFirewall as examples and define their charging factors:

1) *Number and Duration of PDP Context* - This charging factor is specific for the vEPC VNF type. A PDP context specifies access to an external packet-switching network. The data of the PDP context has the information such as the type of packet-switching network, the IP address, the reference of GGSN, and the requested QoS. Whenever the CSPs lease vEPC from the VNF provider, they will be charged depending on the number or the duration of PDP context.

2) *During of sessions* - This charging factor is specific for the VNF type vIMS (virtual IP Multimedia Subsystem). It refers to the duration of a multimedia session such as a voice or video call.

3) *Number of sessions* - This charging factor is also specific for the vIMS VNF, it reports how many sessions has been created using IMS.

4) *Type of session* - The type of session is also specific for the vIMS VNF. The user might make different type of sessions such as voice call, video, or IP Streaming. According to the type of the sessions, the user will be charged accordingly.

5) *Number of Instances of VNF* - This is the most common charging factor for this business model because it is important to know how many instances of VNF have been instantiated in order to apply charging accordingly.

C. Charging Factors for “SPs/VNFaaS provider offering VNF as a service to xVNOs” Business Model

As we have mentioned earlier, in this business model the VNOs (Virtual Network Operators) will be charged both for the VNF as service and for the infrastructure resources offered by a VNFaaS provider. Thus, all the charging factors defined for the previous two business models are applicable for this business model.

V. RELATION BETWEEN CHARGING FACTORS AND CHARGEABLE EVENTS

In MANO, not all the events are considered as chargeable events. Only those events that can provide charging and billing information are defined as chargeable events. This information could relate to usage of resources such as compute and storage or to management tasks such as reservation, instantiation, scaling, and termination of virtual resources. Below we will discuss the relation of the charging factors with the MANO events under each business model.

A. Key Events under “SP using the NFVI from NFVaaS Provider” Business model

The charging factors in this business model will be based on how much virtual compute, virtual storage and virtual network resources are used. As shown in Table 1, our research concludes that there are seven charging factors: type of CPU, CPU time used, storage type, amount of storage, type of accelerator, bandwidth and QoS. Our research also identifies how to get information for these charging factors from related MANO events. For example, for these 3 events from NF-VI reference point: Allocate VM with indication of compute resource, Update VM resources allocation and Terminate VM, we can get the information for the “CPU type” charging factor. On the other hand, for the following three MANO events at the NF-VI reference point: Create connection between VMs, configure connection between VMs and Remove connection between VMs, we can get the information for the “Bandwidth” charging factor.

B. Key Events under “CSPs leasing the VNF S/W from VNF Providers” Business Mode

As we have explained earlier the charging factors in this business model will depend on what type of VNF the CSP will lease from the VNF provider. As shown in Table 2, we have identified the charging factors for VNFs vEPC, NAT, Parent’s Filter, vFirewall, and vIMS. The charging factors identified for vEPC include “Number and Duration of PDP Contexts”. The information for this charging factor can be found from the MANO events over the Ve-Vnm-em reference point including

Table 1. Relation between Charging Factors and MANO Events for “SP using the NFVI from NFVaaS Provider” Business Model

Charging Factors	Reference Points	Examples of Events
Type of CPUs used	NF-VI	1. Allocate VM with indication of compute resource 2. Update VM resources allocation 3. Terminate VM
How much CPU time used	NF-VI	1. Allocate VM with indication of compute resource 2. Update VM resources allocation 3. Terminate VM
Type of storage	NF-VI	1. Allocate VM with indication of storage resource 2. Update VM resources allocation 3. Terminate VM
How much storage allocated	NF-VI	1. Allocate VM with indication of storage resource 2. Update VM resources allocation 3. Terminate VM
Type of accelerator used	NF-VI	1. Allocate VM with indication of storage resource 2. Update VM resources allocation 3. Terminate VM
Bandwidth	NF-VI	1. Create connection between VMs 2. Configure connection between VMs 3. Remove connection between VMs
Level of QOS	NF-VI	1. Create connection between VMs 2. Configure connection between VMs 3. Remove connection between VMs

Table 2. Relation between Charging Factors and MANO Events for “CSPs leasing the VNF S/W from VNF Providers” Business Model.

Type of VNF	Charging Factors	Source of Information	Examples of Events
EPC (consists of three VNFs: MME, S-GW, P-GW)	Number of PDP Contexts	MANO Ve-Vnfm-em Interface	1. VNF instantiation 2. VNF instance scaling out/in, and up/down 3. VNF instance termination
NAT, Parents' Filter, Firewall	Number of instances of VNF	P-GW MANO Ve-Vnfm-em Interface	Creation and Deletion of PDP Contexts 1. VNF instantiation 2. VNF instance scaling out/in, and up/down 3. VNF instance termination
vIMS (Function of IMS)	• Duration of session • Number of session • Type of session (voice, video, IP Streaming)	MANO Ve-Vnfm-em Interface IMS (S-CSCF)	1. VNF instantiation 2. VNF instance scaling out/in, and up/down 3. VNF instance termination Invite Re-Invite or Update Bye

“VNF instantiation”, “VNF instance scaling out/in, and up/down” and “VNF instance termination”. Furthermore, we can get information about the creation and deletion of PDP contexts from the P-GW in the EPC. Likewise, the charging factors defined for vIMS are: “duration of session”, “number of session” and “type of session” (voice, video, IP Streaming). Then the information needed for the charging factors of vIMS can be collected from the MANO events over the Ve-Vnfm-em reference point including “VNF Instantiation”, “VNF instance scaling out/in, and up/down” and “VNF instance termination”. Furthermore, the information about the beginning and the end of an IMS session can be found from the S-CSCF of IMS.

C. Key Events under “SPs/VNFaaS provider offering VNF as a service to xVNOs” Business Model

As mentioned before, since the charging factors of this business model will be based on previous two business models on both the usage of infrastructure resources and the type of VNF, the relation between those charging factors and the MANO events will be a combination of Table 1 and Table 2.

VI. CONCLUSION AND FUTURE WORK

The virtualization of SDN/NFV will create new business models in the telecom system with the introduction of new actors such as VNF Vendor/VNF Market place, VNFaaS Provider and NFVIaaS provider. In this paper, we have explained these three business models and also define their respective charging factors. It is worth noting that the charging factors for VNF Vendor/VNF Market place are VNF-dependent. Consequently, as new VNFs are created and offered, they will also create new charging factors for billing consideration. We discuss the key MANO chargeable events under each business model that supply information required for the charging factors. Finally, we briefly clarify how various charging models can be defined under each business model based on the use of charging factors.

Our future work is to address in more detail how to use charging factors to flexibly define various SDN/NFV charging models needed for different business models [17]. For example, we can use the “level of QoS” charging factor to define an NFVI charging model “Postpaid periodic billing based on level of QoS” without considering any other NFVI charging factors. Alternatively, we can also define an NFVI charging model based on “Type of storage” and “Amount of storage” charging

factors without considering other factors such as CPU or QoS. SDN/NFV is just one of perspectives to address the upcoming 5G charging and billing issues. Other alternative perspectives include charging and billing for MEC (Multi-access Edge Computing) and for slicing provision and associated SLAs (Service Level Agreements). These perspectives are also in our future research plan.

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