SDN and NFV for satellite infrastructures

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***Abstract*— the integration of SDN and NFV enablers into the satellite network could prove to be an essential means to save on physical sites, improve the time to bring new services to the market and open new ways to improve network resiliency, availability and efficiency. It can be considered that the above two enablers can play a central role in the integration of satellite to terrestrial technologies by using federated management of the network resources**

Keywords— Integration, SDN, NFV, virtualization;

I. INTRODUCTION

The VITAL project [1] aims to combine the integration of Terrestrial and Satellite networks by pursuing two key innovation areas, by bringing Network Functions Virtualization (NFV) into the satellite domain and by enabling Software-Defined-Networking, (SDN)-based, federated resources management in hybrid SatCom-terrestrial networks. Enabling NFV into SatCom domain will provide operators with appropriate tools and interfaces in order to establish end-to-end fully operable virtualized satellite networks to be offered to third-party operators/service providers. Enabling SDN-based, federated resource management paves way for a unified control plane that would allow operators to efficiently manage and optimize the operation of the hybrid network. The benefits of the above two technologies is shown on three key application scenarios: Satellite Virtual Network Operator (SVNO) services, Satellite backhauling and hybrid telecom service delivery.

Satellite benefits: the integration of the satellite component with the terrestrial backhaul network will be able to provide coverage and also overall capacity increase. Besides, it also provides a new path for routing the traffic that increases the network resilience against link failures or congestion. Therefore, several satellite terminals can be deployed throughout the backhaul network by giving more flexibility to the hybrid network and providing more backup solutions.

SDN and NFV benefits: The introduction of SDN and NFV promises to disrupt the networking ecosystem, each in its own way. However, by exploiting a combination of SDN and NFV, SNOs can manifest solutions that, at once, will lower cost and render satellite networks to be more flexible and efficient. With SDN and NFV combined, it is possible to manipulate and program multi-vendor network elements, to optimize traffic while considering power consumption and other operator-defined policies.

In this paper, we will deal with what is unique about the satellite components virtualization and the federation of the resources of the combined satellite-terrestrial network.

II. INTEGRATED SATELLITE-TERRESTRIAL ARCHITECTURE

The combined satellite-terrestrial architecture is shown in the underlying Figure II-1 where the SDN/NFV enabled satellite ground components, the layered domains, the functional components and the interfaces between the layers.

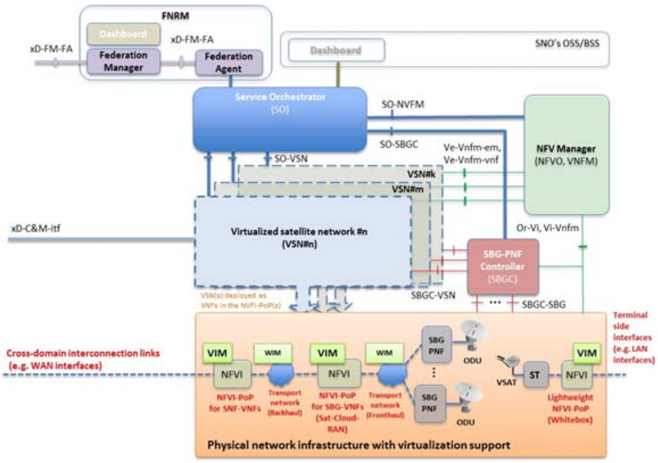

Figure II-1. Satellite-Terrestrial architecture

The VITAL system architecture is composed of the following building blocks:

- **Physical network infrastructure with virtualization support**. This building block consists of the virtualization-capable physical network elements on top of which Virtualized Satellite Networks (VSNs) are deployed. This infrastructure includes:

  - NFV Infrastructure-Point(s) of Presence (NFVI-PoP(s)) for the deployment of VNFs. The main resources in these

NFVI-PoPs are network, computing (CPU) and storage. There could be several distributed NFVI-PoPs, including a lightweight NFVI-PoP at the satellite terminal side. Resources in each NFVI-PoP are managed by a Virtualization Infrastructure Manager (VIM). NVFI-PoPs can also include SDN and non-SDN based network elements, which provides the programmable network interfaces that will provide the connectivity establishment and will support the VNF chaining within a NFVI PoP.

  - Satellite Baseband Gateway (SBG) Physical Network Function (SBG-PNF). A SBG-PNF hosts the non-virtualized part of the satellite baseband gateway and is directly connected to the ODUs for satellite signal transmission/reception.
  - Transport network between the several NFVI-PoPs (backhaul), between the NFVI-PoP where the VNFs are run and the location that hosts SBG-PNFs (fronthaul), and cross-domain interconnection links. Each transport network segment is assumed to be managed by a WAN Infrastructure Manager (WIM), potentially including SDN and non-SDN network control.
  - Satellite Terminals (STs), which provide the satellite connectivity and interworking between the satellite connection and a premises network on the terminal side. A lightweight NFVI-PoP can be co-located with the satellite terminal.

- **Virtualized Satellite network (VSN)**. The VSN is a satellite communications network in which most of its functions are supplied as VNFs running in one or several of the NFVI-PoPs of the physical network infrastructure. Several isolated VSNs can be deployed over the same physical network infrastructure. The non-virtualized functions of a VSN are provided through one or several SBG-PNFs, which could be dedicated to a given VSN or shared among several VSNs. The operation of each VSN could be delegated to the customer/tenant, acting as a satellite virtual network operator (SVNO). Each of the VSNs may be customized to the customer/tenant's needs, including a variety of different network services running as VNFs (e.g. PEP, VPN, etc.).

- **Management components.** This contains the set of functional entities needed for the provision and lifecycle management of the VSNs. In particular, VSNs can be instantiated, terminated, monitored, and modified (e.g. scaled up/down, VNFs added/removed, satellite carriers added/removed, etc.) through the following management entities:
  - **NFV Manager**. This is the entity responsible for the management of the VNFs that form part of the VSN, taking care of the instantiation, the dimensioning and the termination of the VNFs. The NFV manager receives appropriate commands from Service Orchestrator (SO), which include the Network Service (NS) descriptors. The NFV Manager maintains a complete view of the whole virtualization infrastructure of the domain; it keeps a record of installed and available resources, as well as of the infrastructure topology. For the sake of scalability, the NFV Manager maintains only a high-level view of the resources and the services, while the detailed mapping of services to resources is undertaken by the local managers in each NFVI-PoP (e.g. Virtual Infrastructure Manager - VIM).
  - **Service Orchestrator (SO)**. The role of the Service Orchestrator (SO) within the architecture, is mainly to provide service composition and to provide support for the OSS/BSS functionalities independently of the nature of the service (virtualized or not). Regarding the service composition, the SO decides, for example, on the capabilities and the composition (VNFs and PNFs configuration) of the VSN. On the other hand, regarding the OSS/BSS functionality support, this means that the SO will provide support for the FCAPS functionalities of VSNs. The SO which normally closely interacts with (or ideally is integrated in) the SNO's OSS/BSS, which may include other components such as dashboards/customer portals that the customers of the SNO can use to order the provisioning of VSNs and related SLA management.
  - **Federation Network Resource Manager (FNRM)**. This element is in charge of multi-domain service orchestration. It consists of two separate components: a Federation Manager (FM) and a Federation Agent (FA). The FM hosts the logic to federate different domains and orchestrating Multi-Domain Network Services (MD-NSs). It is assumed that each domain is (usually) capable to orchestrate its own intra-domain NSs. Indeed, the FM acts as a super-orchestrator, having an overall view of the underlying orchestrators and domains. On the other hand, the FA is a component intended to handle the heterogeneity of the various underlying orchestrators and management entities of each domain, interfacing them with the FM. In addition to the FM and FA, a dashboard/customer portal is included as part of the FNRM to perform MD-NSs deployment, instantiation and orchestration.
  - **SBG-PNF Controller (SBGC)**. The SBGC manages the pool of SGB-PNFs. Through the SBGC, the SO can request the allocation of SGB-PNFs resources (e.g. forward/return channels) for a given VSN. To that end, the SBGC is in charge of slicing the resources of the SBG-PNF so that a logically isolated portion of those resources are allocated to a particular VSN. In addition, the SBGC may provide a SDN abstraction of the allocated resources so that control and management of these resources can be integrated within the VSN.

III. BUSINESS PROCESSES

A business process starts when a user/tenant is asking for a service. First, the FB is responsible to provide the overall lifecycle management of the service. The service usually involves the initialization of a number of VNFs from the satellite, mobile and/or terrestrial networks. The VNF provider is responsible for the provision of these VNFs which formulate the service. These VNFs are implemented and installed in the NFVI layer. The business actor responsible to provide this layer is the NFVI provider. These business processes are seen in Figure III-1.

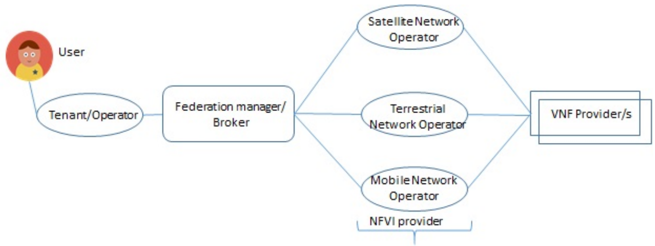

Figure III-1: Business actors involved when a service is requested

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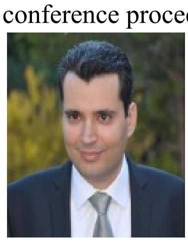

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IV. Conclusions

In this extended abstract, we investigate the possibility of exploiting the NFV virtualization concepts at the satellite technology and SDN at the combined satellite-terrestrial technologies by utilizing a federated management of the resources and services.

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[1] *H2020, VIrtualized hybrid satellite-TerrestriAl systems for resilient and fLexible future networks ''VITAL'', research project website at* http://www.ict-vital.eu/, contract 644843

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