



HAL
open science

SDN and NFV for satellite infrastructures

George Agapiou, Ramon Ferrus, Harilaos Koumaras, Oriol Sallent, Tinku Rasheed,
Nicolas Kuhn, Toufik Ahmed

► **To cite this version:**

George Agapiou, Ramon Ferrus, Harilaos Koumaras, Oriol Sallent, Tinku Rasheed, et al.. SDN and NFV for satellite infrastructures. Institute of Electronics, Information and Communications Engineers (IEICE), Jul 2016, Patras, Greece. pp.0. <hal-04129478>

HAL Id: hal-04129478

<https://hal.science/hal-04129478v1>

Submitted on 15 Jun 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

SDN and NFV for satellite infrastructures

George Agapiou¹⁾, R. Ferrús²⁾, H. Koumaras³⁾, O. Sallent²⁾, T. Rasheed⁴⁾, N. Kuhn⁵⁾, T. Ahmed⁶⁾

¹⁾Hellenic Telecommunications Organization S.A., Greece; ²⁾Universitat Politècnica de Catalunya, Spain; ³⁾National Centre for Scientific Research "Demokritos", Greece; ⁴⁾Center for Research and Telecommunication Experimentation for Networked communities, Italy; ⁵⁾Centre National d'Etudes Spatiales, France; ⁶⁾CNRS-LaBRI, University of Bordeaux, France

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.

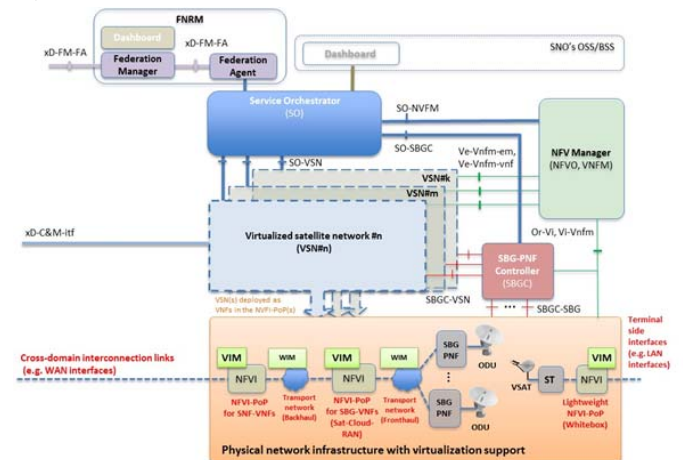


Figure II-1. Satellite-Terrestrial architecture

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). NFVI-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 ODU 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.

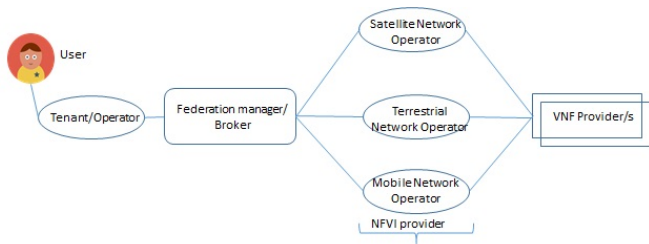


Figure III-1: Business actors involved when a service is requested



Dr. George Agapiou is a telecommunications engineer, holding a PhD from the Georgia Institute of Technology. He is the Head of the Measurements and Wireless Technologies Research Laboratory of the Hellenic Telecommunications Organization (OTE S.A.) where he tests

and evaluates major technologies, terminals and services. He has participated in various IST, STREP, Eurescom, e-ten, FP6, FP7, H2020, 5G-PPP research projects with major role, has published more than 55 papers in scientific journals, proceedings and workshops and is the co-author of two books. His research interests include next generation wired and wireless access networks and novel broadband technologies and services.



Ramon Ferrús (ramon.ferrus@upc.edu) is Associate Professor at the Universitat Politècnica de Catalunya (UPC). His research interests include network architectures, protocols, radio resource and spectrum management in wireless communications. He has participated in several research projects within the

European Commission 6th and 7th Framework Programmes as well as in research and technology transfer projects for private companies. He is co-author of one book on mobile communications and one book on mobile broadband Public Safety communications. He has co-authored over 100 papers published in peer-reviewed journals, magazines, conference proceedings and workshops.



Dr. Harilaos Koumaras was born in Athens, Greece in 1980. He received his BSc degree in Physics in 2002 from the University of Athens, Physics Department, his MSc in Electronic Automation and Information Systems in 2004, being scholar of the non-profit

organization Alexander S Onassis, from the University of

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.

ACKNOWLEDGMENT

This work was conducted within the framework of the H2020 VITAL project, which is partially funded by the Commission of the European Union (Grant Agreement No. 644843).

REFERENCES

- [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

Athens, Computer Science Department and his PhD in 2007 at Computer Science from the University of Athens, Computer Science Department. Dr. Harilaos Koumaras is an active researcher in the field of evaluation of the perceived quality of multimedia services, including video and picture quality assessment, media distribution over SDN/NFV, video traffic modeling, digital terrestrial television and video compression techniques. Dr. Koumaras has been an active research associate since 2003 of Media Net Lab at the National Centre of Scientific Research "Demokritos".



Oriol Sallent (sallent@tsc.upc.edu) is a Professor at the Universitat Politècnica de Catalunya (UPC). He has participated in a wide range of european projects with diverse responsibilities as WPLleader and Coordinator partner and contributed to standardisation bodies such as 3GPP, IEEE and ETSI. He has published 200+ papers

mostly in IEEE journals and conferences. His research interests include, among others, Cognitive management in cognitive radio networks, Dynamic spectrum access and management, Self-organising networks and radio network optimization, Integration of satellite and terrestrial networks and QoS provisioning in heterogeneous wireless networks.



Dr. Tinku Rasheed is a Senior Research staff member, heading the Future Networks Area within CREATE-NET. Before joining CREATE-NET, Dr. Rasheed was research engineer with Orange Labs for a period of 4 years. He received his Ph.D. degree from the Computer Science Department of the University of Paris-Sud XI., in 2007, M.S. degree in 2003 from Aston University, U.K. and bachelor degree in 2002 in Telecommunications from University of Kerala, India. Dr. Rasheed has extensive industrial and academic research

experience in the mobile wireless communication area, end-to-end network architectures and services. He has several granted patents and has published more than 60 articles in major journals and conferences. He is a member of the IEEE and ACM.



Toufik Ahmed is a full professor at ENSEIRB-MATMECA school of engineers in Institut Polytechnique de Bordeaux (Bordeaux-INP) and performing research activities in CNRS-LaBRI Lab-UMR 5800 at University Bordeaux. T.

Ahmed's main research activities concern end-to-end Quality of Service (QoS) management and provisioning for multimedia wired and wireless networks, media streaming, and cross-layer optimization. T. Ahmed has also worked on a number of national and international projects. He is serving as TPC member for international conferences and journals.