



## Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Report on Management and Connectivity for Multi-Site Services

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**Keywords**interface, management, NFV, orchestration,  
service**ETSI**650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C  
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# Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Network Functions Virtualisation (NFV).

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# Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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# 1 Scope

The present document provides a report on the functional architecture necessary to provision and manage multi-site network services. To this end, a set of multi-site use cases are described, analysed and used to produce a set of recommendations for normative work.

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## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI GS NFV 001: "Network Functions Virtualisation (NFV); Use Cases".
- [i.2] ETSI GS NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".
- [i.3] ETSI GS NFV-EVE 005: "Network Functions Virtualisation (NFV); Ecosystem; Report on SDN Usage in NFV Architectural Framework".
- [i.4] ETSI GS NFV-INF 005 (V1.1.1): "Network Functions Virtualisation (NFV); Infrastructure; Network Domain".
- [i.5] ETSI GS NFV-MAN 001: "Network Functions Virtualisation (NFV); Management and Orchestration".
- [i.6] ETSI GS NFV-IFA 010: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Functional requirements specification".
- [i.7] ETSI GS NFV-IFA 005: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".
- [i.8] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".
- [i.9] ETSI GS NFV-IFA 008: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".
- [i.10] ETSI GS NFV-IFA 011: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; VNF Descriptor and Packaging Specification".
- [i.11] ETSI GS NFV-IFA 013: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Os-Ma-Nfvo reference point - Interface and Information Model Specification".
- [i.12] ETSI GS NFV-IFA 014: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Network Service Templates Specification".

- [i.13] ETSI GR NFV-IFA 015: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Report on NFV Information Model".
- [i.14] IETF RFC 4364: "BGP/MPLS IP Virtual Private Networks (VPNs)".
- [i.15] IETF RFC 4448: "Encapsulation Methods for Transport of Ethernet over MPLS Networks".
- [i.16] IETF RFC 4761: "Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling".
- [i.17] IETF RFC 4762: "Virtual Private LAN Service (VPLS) Using Label Distribution Protocol (LDP) Signaling".
- [i.18] IETF RFC 7080: "Virtual Private LAN Service (VPLS) Interoperability with Provider Backbone Bridges".
- [i.19] IETF RFC 7348: "Virtual eXtensible Local Area Network (VXLAN): A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Networks".
- [i.20] IETF RFC 7432: "BGP MPLS-Based Ethernet VPN".
- [i.21] IETF RFC 7637: "NVGRE: Network Virtualization Using Generic Routing Encapsulation".
- [i.22] IETF RFC 4090: "Fast Reroute Extensions to RSVP-TE for LSP Tunnels".
- [i.23] ETSI GS NFV-REL 001: "Network Functions Virtualisation (NFV); Resiliency Requirements".
- [i.24] ONF TR-512: "Core Information Model".
- [i.25] ONF TR-527: "Functional Requirements for Transport API".
- [i.26] ONF TAPI: "Transport API (TAPI) 2.0 Overview".
- [i.27] 3GPP TS 38.401: "NG-RAN; Architecture description (Release 15)".
- [i.28] ETSI TS 123 401: "LTE; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (3GPP TS 23.401)".
- [i.29] 3GPP TS 23.501: "System Architecture for the 5G System".
- [i.30] Broadband Forum TR-345: "Broadband Network Gateway and Network Function Virtualization", Issue: 1, October 2016.
- [i.31] Broadband Forum TR-359: "A Framework for Virtualization", Issue: 1, October 2016.
- [i.32] ONUG: "ONUG Software-Defined WAN Use Case", October, 2014.
- [i.33] ONF TR-522: "SDN Architecture for Transport Networks".
- [i.34] ETSI GS NFV-SEC 004 (V1.1.1): "Network Functions Virtualisation (NFV); NFV Security; Privacy and Regulation; Report on Lawful Interception Implications".
- [i.35] ETSI GS NFV-SEC 006 (V1.1.1): "Network Functions Virtualisation (NFV); Security Guide; Report on Security Aspects and Regulatory Concerns".
- [i.36] ETSI GS NFV-SEC 010 (V1.1.1): "Network Functions Virtualisation (NFV); NFV Security; Report on Retained Data problem statement and requirements".
- [i.37] ETSI GS NFV-SEC 012 (V3.1.1): "Network Functions Virtualisation (NFV) Release 3; Security; System architecture specification for execution of sensitive NFV components".
- [i.38] IEEE STD 802.1ad: "Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks - Amendment 4: Provider Bridges", 2005.
- [i.39] ANSI/IEEE Standard 802.1Q: "IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks", 1998.

## 3 Definitions and abbreviations

### 3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI GS NFV 003 [i.2] and the following apply:

**site:** A Network Point of Presence (N-PoP), as defined in ETSI GS NFV 003 [i.2].

**multi-site network service:** network service whose constituent Network Functions/NSs are deployed in more than one site

### 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS NFV 003 [i.2] and the following apply:

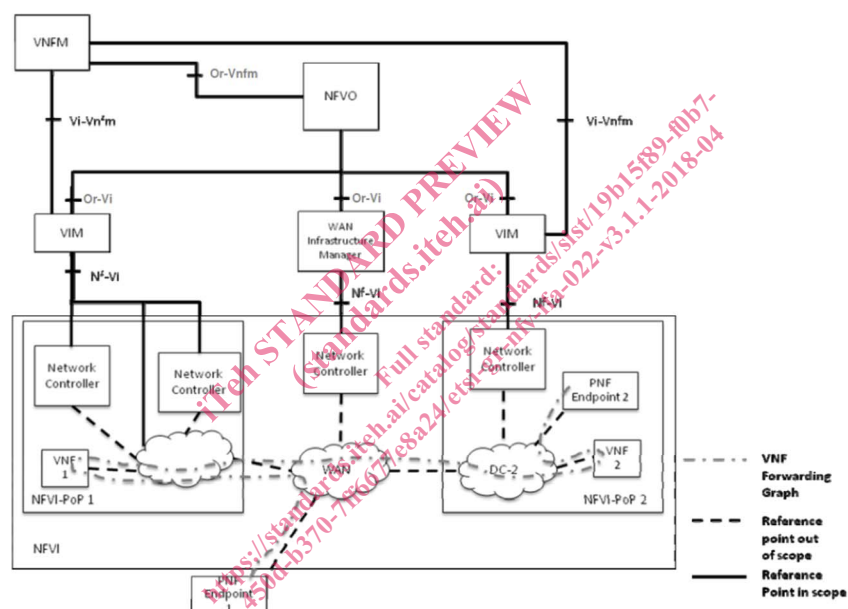
AS	Autonomous System
ASBR	Autonomous System Border Router
BGP	Border Gateway Protocol
CE	Customer Edge
CU	Centralized Unit
DU	Distributed Unit
e-BGP	external BGP
EvCPE	Enterprise vCPE
EVPN	Ethernet VPN
GRE	Generic Routing Encapsulation
LAN	Local Area Network
LSP	Label-Switched Path
MP-BGP	Multiprotocol BGP
MPLS	Multiprotocol Label Switching
MPLS-OAM	MPLS Operations, Administration and Maintenance
NS	Network Service
NVGRE	Network Virtualisation using Generic Routing Encapsulation
NVO	Network Virtualisation Overlay
OSPF	Open Shortest Path First
PE	Provider Edge
RAN	Radio Access Network
RD	Route Distinguisher
RSVP-TE	ReSource reserVation Protocol Traffic Engineering
ToR	Top of Rack
UE	User Equipment
vAPL	virtual Appliance
vBNG	virtual Broadband Network Gateway
vCDN	virtual Content Delivery Network
vCPE	virtual Customer Premises Equipment
vCU	virtualised CU
VID	VLAN Identifier
VNI	VXLAN Network Identifier
vRAN	virtual Radio Access Network
VPN	Virtual Private Network
VPLS	Virtual Private LAN Service
VTEP	VXLAN Tunnel End Point
VXLAN	Virtual Extensible LAN

## 4 Overview

### 4.1 Introduction

In the near future it is anticipated that there will be Network Services (NS) deployed such that connectivity among the service components, e.g. VNF, VNFC, PNF, will be necessary across wide area networks (WAN), or access networks (collectively called WANs here), both legacy and SDN-enabled. In these services, the endpoints and network functions will reside in two or more locations, which may be customer premises, N-PoPs or NFVI-PoPs.

The method by which these services are to be supported is left largely undefined in the release 1 and 2 NFV ISG documents. Documents from release 1 provide only high-level descriptions for how WAN connectivity might be supported. Clause 5.4.3 of [i.5] introduces the concept of the WIM, "a specialized VIM is a WAN Infrastructure Manager (WIM), typically used to establish connectivity between PNF endpoints in different NFVI-PoPs". Clause 5.6 of [i.5] references a figure, 5.2, which is included below as Figure 4.1-1. It shows a "hybrid network environment example illustrating the goal of NFV to have fully programmatic open interfaces for service and Resource Orchestration within and across NFVI-PoPs". Clause 5.6 further describes establishing end-2-end connectivity across virtualised networks in the PoPs and the WAN, under the control of the VIMs and the PoP VIMs and WAN WIMs.



**Figure 4.1-1: Release 1 Concept of WIM Role for Services over WAN (from [i.5])**

This intent of the present document is to:

- 1) examine and analyse, through use cases, the issues surrounding support for network services distributed among multiple sites and across multiple networks and domains; and
- 2) based on use cases and analysis, define a set of recommendations regarding how best to support these services.

This is a deep analysis, so that there is a clear understanding of how, where and when network service descriptions, and specifically the links between NF (and VNFC), are translated to the underlying infrastructure to establish connectivity. The scope of the recommendations includes clarifying the role of the WIM and how it integrates and communicates with MANO functional blocks, as well as possible updates to existing MANO functional block roles and reference points.

## 5 Use Cases

### 5.1 Introduction

The purpose of the use cases introduced in the present document is twofold: first, to examine and analyse the issues and capabilities related to supporting network services distributed among multiple sites; and second, to analyse how the connectivity between NF (and VNFC) can be mapped to the underlying infrastructure. The use cases cover different aspects of multi-site connectivity management, including fulfilment and assurance aspects.

The list of use cases introduced is as follows:

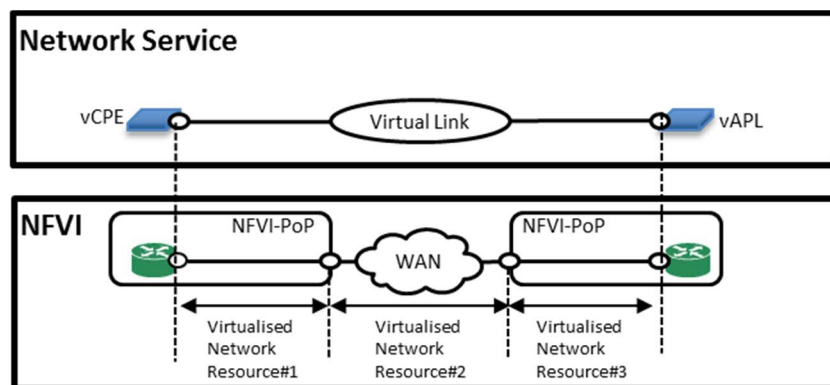
- Related to fulfilment processes:
  - Use Case 1: Network Service for E2E Enterprise vCPE.
  - Use Case 2: Network Service for E2E Enterprise vCPE across two WANs.
  - Use Case 3: NS Expansion to other NFVI-PoPs over WAN.
  - Use Case 4: Network Service Virtual Link aggregation.
  - Use Case 5: checking multi-site connectivity.
  - Use Case 8: multi-site VNF deployment.
  - Use Case 9: Addressing multi-site deployment requirements in NSDs.
  - Use Case 12: Network Service for vRAN.
  - Use Case 13: Use of WAN connectivity by compute-only NFVI-PoP deployments.
- Related to assurance processes:
  - Use Case 6: multi-site Virtual Link redundancy.
  - Use Case 7: multi-site Virtual Link healing.
  - Use Case 10: UE (user equipment) Location Triggered Network Service Migration Across NFVI-PoPs.
  - Use Case 11: Modification to the WAN Connectivity Resource of a Multi-site NS.

For each one of the use cases the following items are provided: an introduction, use case description (actors, triggers, pre-conditions, post-conditions, operation flows), other considerations, and analysis.

## 5.2 Use Case 1: Network Service for E2E Enterprise virtual Customer Premises Equipment (vCPE)

### 5.2.1 Introduction

This use case is discussed in the context of the Enterprise vCPE (EvCPE) network service orchestration. As shown in Figure 5.2.1-1, the overall model focuses on two NFVI-PoPs located at two different sites connected over a shared WAN infrastructure (e.g. IP/ Multiprotocol Label Switching (MPLS), optical network, etc.).



**Figure 5.2.1-1: Connectivity overview for enabling Network Service**

A network service (NS) consisting of two VNFs is instantiated as shown in Figure 5.2.1-1. Each VNF comes from one of two groups of VNFs, namely vCPE and Virtual Appliance (vAPL). Each group is installed in a different site, and the VNFs of the NS are connected across the WAN infrastructure.

**NOTE:** vCPE, or virtual CPE, represents a set of VNFs providing the functionality of an enterprise CPE. vAPL represents a set of virtualised appliances of any type that may be combined with the previous ones form a meaningful NS.

The virtualised network resources for Site#1, for WAN, and for Site#2 are referred to as virtualised network resource#1, #2 and #3, respectively. The virtualised network resources assigned to the vCPE and vAPL VNFs are terminated at virtual network ports which are attached to the WAN infrastructure. As a result, a unified Virtual Link is created by combining the virtualised network resource#1, #2 and #3.

Base operational flows for deploying NSs across the two sites are examined. VNFs are deployed in each of two sites, Site#1 and Site#2 and network connectivity is configured between those sites. The VNF deployments at each site and the network connectivity between the two sites should be coordinated in such a way as to deliver a unified service. The VNFs at each site will be connected across the WAN. The connectivity of VNFs over the WAN can be performed:

- a) through gateways at each site that translate/map between the in-site and WAN virtual networks; or
- b) as an overlay network using tunnelling protocols (see clause 5.2.4.2.1 in ETSI GS NFV-EVE 005 [i.3]). Examples of tunnelling protocols typically used in data centres include VXLAN and Network Virtualisation using Generic Routing Encapsulation (NVGRE). Tunnelling protocols offer the ability to stack/aggregate different customer private networks across a provider network.

Two base operational flows, namely BF#1.1 and BF#1.2, corresponds to connectivity approach a), and one base operational flow, namely BF#1.3 corresponds to connectivity approach b). These are described below.

Figure 5.2.1-2 provides a more detailed view of the use case. The architectural model is derived from Figure 5.2 in [i.5]. It shows a multi-site model managed by a single Service Provider. The figure also shows the related architectural components (e.g. WIM, Network Controller, NFVO, etc.) and reference points, which are further referred in the present use case.