



GROUP SPECIFICATION

Network Functions Virtualisation (NFV) Release 3; Reliability; Maintaining Service Availability and Continuity Upon Software Modification

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Reference

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Foreword

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

Modal verbs terminology

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1 Scope

The present document specifies requirements for the purpose of Software Modifications, such that NFV service availability and continuity is maintained. All types of software related to Network Function Virtualisation (NFV) - e.g. Virtual Network Functions (VNF), Management and Orchestration (MANO) and Network Function Virtualisation Infrastructure (NFVI) as well as required controlling and supporting functionality will be addressed. Where applicable, external specifications may be referenced to avoid duplication of work. The present document contains normative provisions.

2 References

2.1 Normative 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.

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The following referenced documents are necessary for the application of the present document.

- [1] ETSI GS NFV 002 (V1.2.1): "Network Functions Virtualisation (NFV); Architectural Framework".
- [2] ETSI GS NFV-MAN 001 (V1.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration".
- [3] ETSI GS NFV-SWA 001 (V1.1.1): "Network Functions Virtualisation (NFV); Virtual Network Functions Architecture".
- [4] ETSI GS NFV-IFA 011 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; VNF Packaging Specification".
- [5] ETSI GS NFV-IFA 013 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Os-Ma-Nfvo reference point - Interface and Information Model Specification".
- [6] ETSI GS NFV-IFA 007 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".
- [7] ETSI GS NFV-IFA 005 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".
- [8] ETSI GS NFV-IFA 008 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".
- [9] ETSI GS NFV-SOL 004 (V2.3.1): "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; VNF Package specification".
- [10] ETSI GS NFV-SOL 005 (V2.4.1): "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; RESTful protocols specification for the Os-Ma-nfvo Reference Point".
- [11] ETSI GS NFV-SOL 003 (V2.3.1): "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; RESTful protocols specification for the Or-Vnfm Reference Point".

2.2 Informative references

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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] CRN website: "The 10 Biggest Cloud Outages Of 2013".

NOTE: Available at <http://www.crn.com/slide-shows/cloud/240165024/the-10-biggest-cloud-outages-of-2013.htm>.

[i.2] ETSI GR NFV-REL 007 (V1.1.1): "Network Functions Virtualisation (NFV); Reliability; Report on the resilience of NFV-MANO critical capabilities".

[i.3] ETSI GR NFV-IFA 021 (V0.11.0): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Report on management of NFV-MANO and automated deployment of EM and other OSS functions".

[i.4] ETSI GS NFV-TST 001 (V1.1.1): "Network Functions Virtualisation (NFV); Pre-deployment Testing; Report on Validation of NFV Environments and Services".

[i.5] ETSI GS NFV 001 (V1.1.1): "Network Functions Virtualisation (NFV); Use Cases".

[i.6] Iulian Meamtiu and Tudor Dumitras: "Cloud Software Upgrades: Challenges and Opportunities", IEEE conference International Workshop on the Maintenance and Evolution of Service-Oriented and Cloud-Based Systems (MESOCA), 2011.

NOTE: Available at <https://www.umiacs.umd.edu/~tdumitra/papers/MESOCA-2011.pdf>.

[i.7] ETSI GS NFV-IFA 018: "Network Functions Virtualisation (NFV); Acceleration Technologies; Network Acceleration Interface Specification".

[i.8] ETSI GS NFV-REL 003 (V1.1.2): "Network Functions Virtualisation (NFV); Reliability; Report on Models and Features for End-to-End Reliability".

[i.9] ETSI GR NFV-TST 006 (V0.0.8): "Network Functions Virtualisation (NFV); Testing; Report on NFV CICD and Devops".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

software rollback: software modification process that reverts the system from the newly deployed software version to the previously deployed software version

software update: software modification process for bug fixes or enhancements without adding, modifying or removing functionality, interfaces or protocols

software upgrade: software modification process aimed at adding, modifying or removing functionality, interfaces or protocols

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BSS	Business Support System
CompHost	Compute Host
DF	Deployment Flavor
DUT	Devices Under Test
EM	Element Manager
EMS	Element Management System
EPC	Evolved Packet Core
FUT	Functions Under Test
IE	Information Element
IMS	IP Multimedia System
KPI	Key Performance Indicator
LCM	Life Cycle Management
MANO	Management and Orchestration
NAT	Network Address Translation
NFV TST	ETSI NFV Test Working Group
NFV	Network Function Virtualisation
NFVI	NFV Infrastructure
NFVO	NFV orchestrator
NS	Network Service
NSD	Network Service Descriptor
O&M	Operation and Maintenance
OS	Operating System
OSS	Operations Support System
PNF	Physical Network Function
SDN	Software defined Network
SUT	System Under Test
VIM	Virtualised Infrastructure Manager
VNF	Virtual Network Function
VNFC	VNF Component
VNFD	VNF Descriptor
VNFFG	VNF Forwarding Graph
VNFM	VNF Manager
VPN	Virtual Private Network
VR	Virtualised Resource

4 Overview

The intent of the present document is to specify requirements for the purpose of Software Modifications, such that service availability and continuity in an NFV environment are maintained. All types of software related to NFV (e.g. VNFs, MANO and NFVI) are considered for the software modification process; in addition, required controlling and supporting functionality is addressed. Where applicable, external specifications may be referenced to avoid duplication of work.

It should be noted that supporting work on the test processes for Software Modification is addressed by the ETSI NFV Test Working Group (NFV TST). As appropriate, references to the TST work and/or brief descriptions of the developed test processes are provided. An overview of the overall document framework is as follows.

Software related to NFV may be of different types. Clause 5.1 refers to the three working domains identified for NFV in previous work [1] and associates specific software types to these domains. The purpose for delineating these individual software types is to align specific processes or methods that may apply to the modification of each type of software as well as the corresponding requirements to support such processes. The software types are as follows:

- Clause 5.1.2 - VNFs that support the full range of Network Services and Applications: note that components comprising a VNF are referred to as VNF Components (VNFC). Thus modifications may be done for individual VNFCs or VNFs. VNF Descriptors and Attributes are included as appropriate.
- Clause 5.1.3 - MANO Software: Software components that provide MANO functionality.

- Clause 5.1.4 - NFVI Software: Software components that support NFV Infrastructure.

Software Updates and Upgrades have been defined for VNFs as follows [3]:

- A VNF update does not introduce new functionality and/or new interfaces.
- A VNF upgrade might introduce new functionality and/or new interfaces.

Detailed definitions for these terms indicating precise intent for these actions are provided in clause 3.1. Note that they apply to VNFs, NFVI, and MANO software components.

Software modification implications are presented in clause 5.2.

The methods by which modifications are instituted are as follows:

- "NetOps" or Network Operations - This method involves significant manual involvement throughout the modification process followed by substantial levels of testing by the Network Operator. Typically, this method could be instituted when major changes in software are involved with careful management of resource utilization. Additionally, it is expected that major changes will not be very frequent; this may allow for a carefully planned modification and testing process.
- "DevOps" or Development Operations - This method is fully automated end-to-end. The magnitude of changes is expected to be small for each new version and allows for automated testing throughout the process delivery cycle. It is also expected that such changes could be fairly frequent (e.g. multiple changes on a daily basis). The DevOps method is out of scope for the present document.

Clause 6 is structured as follows

- Clause 6.1: This clause provides an overview and introduces the phases of the software modification process.
- Clause 6.2: This clause describes the overall software modification process.
- Clause 6.3: Software Modification Requirements. This clause provides detailed normative requirements for modification of VNFs, MANO components, and NFVI components.
- Clause 6.4: Rollback of Software Modifications. This clause provides requirements on how to deal with problem situations associated with the software modification process.
- Clause 6.5: Test Process Implications. The test processes developed in the ETSI NFV TST Working Group are referenced and briefly described as applicable.

Additional information that is relevant for the software modification process is provided in informative annexes A, B and C.

5 NFV Software

5.1 Types of NFV Software

5.1.1 Introduction

The types of NFV Software that are in scope for the software modification process are described in ETSI GS NFV 002 [1], clause 5.2 as follows:

"Network Functions Virtualisation" envisages the implementation of NFs as software-only entities that run over the NFV Infrastructure (NFVI). Figure 1 illustrates the high-level NFV framework. As such, three main working domains are identified in NFV:

- Virtualised Network Function, as the software implementation of a network function which is capable of running over the NFVI.
- NFV Infrastructure (NFVI), including the diversity of physical resources and how these can be virtualised. NFVI supports the execution of the VNFs.

- NFV Management and Orchestration, which covers the orchestration and lifecycle management of physical and/or software resources that support the infrastructure virtualisation, and the lifecycle management of VNFs. NFV Management and Orchestration focuses on all virtualisation-specific management tasks necessary in the NFV framework.

Figure 1 from clause 5.2 of ETSI GS NFV 002 [1] depicts the three working domains; this is shown below. The VNF domain is supported by the NFVI domain and both of these domains are managed by the MANO domain.

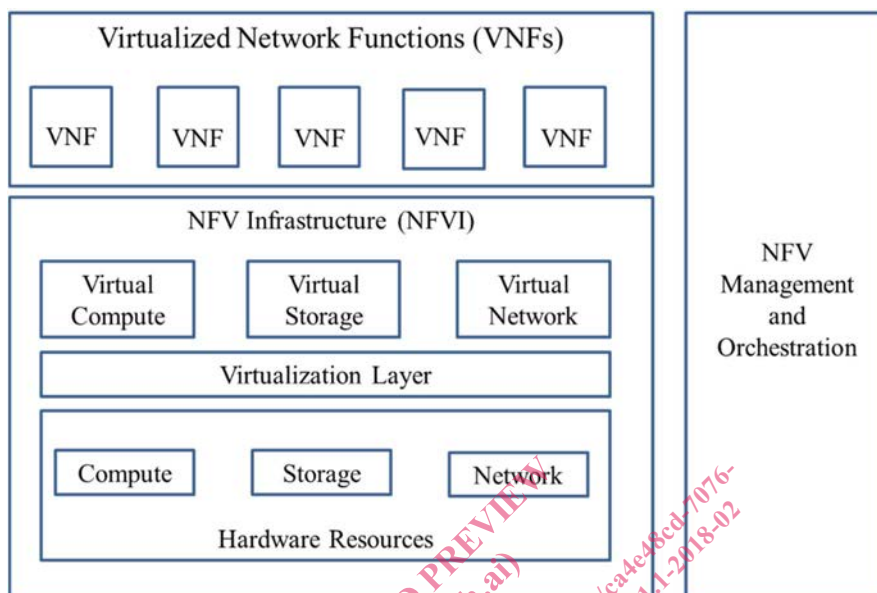


Figure 1: High Level NFV Framework as shown in clause 5.2 of ETSI GS NFV 002 [1]

The software in scope for the present document relates to these three domains.

5.1.2 VNF Domain Software

There are two types of VNF domain software:

- 1) Individual VNFs: Virtualised network functions that perform a given network task. Examples of individual VNFs include:
 - a) Network Address Translation (NAT)
 - b) Firewall
 - c) Load Balancer
- 2) Network Services: An end-to-end Network Service is defined in ETSI GS NFV 002 [1] as a Forwarding Graph (FG) of the necessary Network Functions that support the desired service. This FG of Network Functions can include a combination of Physical Network Functions (PNF) as well as VNFs. From the perspective of the present document, only the portion of the FG that contains VNFs is in scope. Examples of services include the following:
 - a) Mobile Voice/Data
 - b) Internet Access
 - c) Virtual Private Network (VPN)

5.1.3 MANO Domain Software

MANO domain software support the three MANO Functional Blocks in ETSI GS NFV-MAN 001[2]:

- 1) VNF Manager (VNFM).

- 2) Virtualised Infrastructure Manager (VIM).
- 3) NFV Orchestrator (NFVO).

It is assumed that the software for these Functional Blocks will need to be modified in their entirety; at the moment there is no breakdown available for splitting these blocks into smaller components.

5.1.4 NFVI Software

NFVI Software comprises the set of software that support all VNFs and Network Services. Examples of NFVI Software include:

- Operating System (OS),
- Hypervisor,
- Network Controller Software.

It is assumed that each of these software systems will need to be modified in their entirety unless individual software vendors create the software as a package of components.

5.2 Software Modification Implications

Network services do need to provide a defined level of availability. It is expected that service availability and service continuity will be maintained while modifying the software of any part of the NFV system. In DevOps environments in ETSI GR NFV-TST 006 [i.9], updates without functional changes may occur frequently and are deployed automatically. Therefore, the NFV system is expected to guarantee service continuity during software modifications at any time.

Especially when functional changes are introduced, the question of compatibility arises, e.g. data structure compatibility, internal and external interface compatibility, software functional compatibility, etc. In case of any incompatibility, the software modification needs to be carried out via upgrade procedures and different categories of incompatibilities need to be considered:

- Incompatibilities may arise among the entities to be modified for the duration of the software modification process, e.g. data structure incompatibility, internal interface incompatibility.
- As a result of software changes, incompatibilities may also occur between the modified entities and the rest of the system or the users of the modified entities, e.g. external interface incompatibility, software functional incompatibility.

The first category creates a reliability threat and needs to be considered in the solution design and resolved during the software modification process. The latter category cannot be resolved purely by the software modification process and the impact would become unavoidable for the environment and the users after the modifications if it was not considered in the software design. In order to avoid the outage from the latter category, the modified software needs to be backward compatible in external interfaces and software functions.

Incompatibilities may occur due to changes in the data structure, in the interfaces, their combinations, or even without interface and/or data structure changes due to behavioural changes. These changes need to be clearly indicated so that they can be taken into account in the design, planning and scheduling of the software modification process.

Even if data structures are changed in an incompatible manner, it is expected that the service continuity during the modification process will not be affected. This cannot be handled as an update. Instead an upgrade procedure has to be used to accomplish the software modification. It needs to be clearly indicated, if during the upgrade the reliability of network services is reduced. If so, then this upgrade can be scheduled at a proper time when the impact of reduced availability is (more) acceptable.

In addition, the software modification (e.g. upgrade) mechanism is expected to be implemented in such a way that the mechanism itself does not reduce the reliability of the running services.

6 Software Modification Process

6.1 Overview

The software modification process which is part of the overall Life Cycle Management process needs to consider the following tasks: downloading the new software to the network operator's domain, pre-deployment testing of the software in the network operator's lab environment, on-boarding the new software into the NFV system, preparing the deployment plans and any other prerequisite necessary for the software modification, deploying the new software, and the application of post-deployment field testing and follow up actions. These tasks can be grouped into two main phases:

- Software modification preparation phase: This phase includes:
 - the initial software download which is an interaction between the software vendor and the network operator for the purpose of software delivery to the network operator's domain;
 - testing the new software version in the network operator's lab environment;
 - on-boarding the new software into NFV system;
 - preparing the deployment plans and any other prerequisite necessary to carry out the software modification.
- Software deployment phase: This phase deploys the new software in the live NFV system. This means the instantiation of entities with the new software version to replace entities of the old software version. The switch over process may migrate the services to the new software instances gradually to ensure service continuity and/or to allow for post-deployment field testing and verification. To complete the software modification process follow up actions may be required as well as handling any failures that may occur in the process.

Further details on the overall software modification process are given in clause 6.2 while clause 6.3 elaborates on the software deployment phase for the different types of NFV software:

- Clause 6.3.1 - VNF software
- Clause 6.3.2 - Software related to NFV management and orchestration
- Clause 6.3.3 - NFVI software

Clause 6.4 discusses the considerations for handling failures during the software modification process and clause 6.5 provides a high-level overview of the pre-deployment testing process.

6.2 The Overall Software Modification Process

A high-level overview of the software modification process between the Software Vendor and Network Operator is as follows:

- 1) Software Vendor:
 - a) New Software Version is complete.
 - b) Vendor performs software version control testing that certifies accuracy and performance of the modified version.
 - c) Vendor signals to Network Operator(s) about impending software update/upgrade delivery.

2) Network Operator:

- a) Receives information of impending delivery of modified software:
 - Type of Software includes:
 - VNF Software.
 - NFVI Software.
 - Management and Orchestration Software.
 - Criticality of Modification:
 - Urgent: Critical bug fix; may require accelerated/instantaneous testing process followed by possible migration of existing traffic flows from old version to new version.
 - Normal: Can follow scheduled testing process with minimized level of migration of existing traffic flows.
- b) Network Operator and Software Vendor engage in software download processes.
 - Secure delivery of software from Software Vendor to Network Operator with following dependencies:
 - Protocol(s) used for download process.
 - Security of download (e.g. image authenticity).
 - Network Operator informs Software Vendor of receipt of software.
- c) Network Operator tests integration and performance of the new software in Lab.
 - Type of testing:
 - Urgent.
 - Normal.
 - Testing Phase:
 - Integration testing.
 - Test performance metrics.
 - Result of test:- certified or failed.
 - Network Operator informs Software Vendor if pre-deployment testing failed otherwise proceeds to onboard the new software.
- d) On boarding the new software.
 - For VNF software the VNF package which includes its VNFD is on-boarded into NFV MANO system according to the related NFV specifications using the standard VNF package management operations.
 - For MANO software if it is implemented as a VNF and delivered as VNF package, the on boarding is the same as for VNF software. Otherwise, the on-boarding procedure is MANO system or functional block specific.
 - For NFVI software, the new software is on-boarded by the NFVI software management system which is not in the scope of NFV specification currently.