ETSI GS NFV 002 V1.2.1 (2014-12)

Network Functions Virtualisation (NFV); Architectural Framework

Disclaimer

This document has been produced and approved by the Network Functions Virtualisation (NFV) ETSI Industry Specification Group (ISG) and represents the views of those members who participated in this ISG.
It does not necessarily represent the views of the entire ETSI membership.

Reference
RGS/NFV-002

Keywords
architecture, NFV

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
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the only prevailing document is the print of the Portable Document Format (PDF) version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

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

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**may not**", "**need**", "**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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document describes the high-level functional architectural framework and design philosophy of virtualised network functions and of the supporting infrastructure. The document also defines the scope of the NFV Industry Specification Group (ISG) activities to realize this framework.

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.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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 necessary for the application of the present document.

[1] ETSI GS NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[2] ETSI GS NFV 004: "Network Functions Virtualisation (NFV); Virtualisation Requirements".

[3] ETSI GS NFV 001: "Network Functions Virtualisation (NFV); Use Cases".

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] NFV White paper: "Network Functions Virtualisation, An Introduction, Benefits, Enablers, Challenges & Call for Action. Issue 1".

NOTE: Available at http://portal.etsi.org/NFV/NFV_White_Paper.pdf.

[i.2] ETSI TS 123 002: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Network architecture (3GPP TS 23.002)".

NOTE: Available at http://www.3gpp.org/ftp/Specs/html-info/23002.htm.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI GS NFV 003 [1] apply.

3.2 Abbreviations

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

BSS	Business Support System
CDN	Content Delivery Network
CMS	Cloud Management System
COTS	Commercial-Off-The-Shelf
DHCP	Dynamic Host Configuration Protocol
E2E	End-to-End
EM	Element Management
EMS	Element Management System
EPC	Evolved Packet Core
GW	Gateway
IT	Information Technology
LAN	Local Area Network
MME	Mobility Management Entity
NAS	Network Attached Storage
NAT	Network Address Translation
NF	Network Function
NFV	Network Functions Virtualisation
NFVI	NFV Infrastructure
NFVI-PoP	NFV Infrastructure Point of Presence
NMS	Network Management System
OS	operating system
OSS	Operations Support System
PGW	Packet Data Network Gateway
PNF	Physical Network Function
RGW	Residential Gateway
SDO	Standards Development Organization
SGW	Serving Gateway
VLAN	Virtual Local Area Network
VM	Virtual Machine
VNF	Virtualised Network Function
VNF-FG	VNF Forwarding Graph
VPLS	Virtual Private LAN Service

4 Overview

4.1 Document Structure and Purpose

The present document is structured as follows: Clause 4 presents the main purpose, objectives and approach of NFV. Clause 5 presents the NFV framework and scope. Clause 6 introduces main concepts behind the virtualisation process and its impact on end-to-end network services. Clause 7 presents the NFV reference architectural framework. Clause 8 describes some future study items and focus areas in NFV. Finally, clause 9 concludes and proposes some recommendations to realize the NFV paradigm.

Network Functions Virtualisation is a powerful emerging technique with widespread applicability. The initial focus is on the subset of network services described in ETSI GS NFV 001 [3]. ETSI GS NFV 001 [3] further identifies a number of use cases for the virtualisation of network functions. The present document supports these use cases, although it does not explicitly map them to the NFV framework.

The purpose of the present document is to abstract the overall problem space in such a way that the requirements and aspects unique to NFV [2] are clearly identified so that the work can be scoped and organized. The resulting network architectural framework aims at positioning NFV among relevant telecommunications and IT industry stakeholders, including network operators, solution vendors, service integrators and providers, as well as serving as a reference to NFV ISG working groups.

Another purpose of the present document is to provide guidance to the industry Standards Development Organizations (SDOs) to align existing network related specifications with the NFV architectural framework outlined in the present document. Any further standardization of network functions, architecture and interfaces that are required to properly operate in a virtualised environment will be carried out in relevant SDOs. The resulting standards are expected to support the NFV high-level architectural requirements for both intra- and inter-provider domains.

4.2 Summary of Objectives of NFV

A detailed description of the NFV objectives is contained in [i.1]. Briefly, high-level objectives of NFV are:

- Improved capital efficiencies compared with dedicated hardware implementations. This is achieved by using commercial-off-the-shelf (COTS) hardware (i.e. general purpose servers and storage devices) to provide Network Functions (NFs) through software virtualisation techniques. These network functions are referred as Virtualised Network Functions (VNFs). Sharing of hardware and reducing the number of different hardware architectures in a network also contribute to this objective.

- Improved flexibility in assigning VNFs to hardware. This aids both scalability and largely decouples functionality from location, which allows software to be located at the most appropriate places, referred to in the present document as NFVI-PoPs [1], e.g. at customers' premises, at network exchange points, in central offices, data centres, etc. This enables time of day reuse, support for test of alpha/beta and production versions, enhance resilience through virtualisation, and facilitates resource sharing.

- Rapid service innovation through software-based service deployment.

- Improved operational efficiencies resulting from common automation and operating procedures.

- Reduced power usage achieved by migrating workloads and powering down unused hardware.

- Standardized and open interfaces between virtualised network functions and the infrastructure and associated management entities so that such decoupled elements can be provided by different vendors.

4.3 Approach

Current networks are comprised of diverse network functions. These network functions are connected, or chained, in a certain way in order to achieve the desired overall functionality or service that the network is designed to provide. Most current network services are defined by statically combining network functions in a way that can be expressed using an NF Forwarding Graph or NF Set construct. A major change brought by NFV is that virtualisation enables additional dynamic methods rather than just static ones to construct and manage the network function graphs or sets combining these network functions. A major focus of NFV is to enable and exploit the dynamic construction and management of network function graphs or sets, and their relationships regarding their associated data, control, management, dependencies and other attributes as detailed in clause 5. For example, the term Network Function Forwarding Graph focuses on relations that express connectivity between network functions and the aspects that virtualisation introduces as detailed in clause 6.

Furthermore, future network services may be quite different to current network services. These services will be comprised of a diverse set of non-virtualised and/or virtualised network functions, the latter supported by virtualised computing and network infrastructure, requiring interoperability among legacy and NFV-based network domains. The overall service attributes, in particular reliability, availability, manageability, security and performance will depend on the individual (virtualised) network function attributes, as well as how these functions are connected. These attributes are not necessarily independent. It is therefore important to formulate an architecture that supports the diversity of network functions that can potentially be virtualised.

The approach taken here is to describe how the elements necessary to realize NFV can be implemented in a standardized way to enable interoperability. This allows different VNFs to be deployed over the virtualised infrastructure to support End-to-End (E2E) network services and be applicable to diverse use cases and operator network scenarios with minimal integration effort and maximum reuse.

Virtualisation means that a network function and part of the infrastructure are implemented in software, and hence, the NFV software architecture is an important aspect of the NFV architectural framework.

5 NFV Framework and Scope

5.1 General

In non-virtualised networks, NFs are implemented as a combination of vendor specific software and hardware, often referred to as network nodes or network elements. Network Functions Virtualisation represents a step forward for the diverse stakeholders in the telecommunication network environment. As such, NFV introduces a number of differences in the way network service provisioning is realized in comparison to current practice. In summary, these differences can be listed as:

- *Decoupling software from hardware:* As the network element is no longer a collection of integrated hardware and software entities, the evolution of both are independent of each other. This enables the software to progress separately from the hardware, and vice versa.

- *Flexible network function deployment:* The detachment of software from hardware helps reassign and share the infrastructure resources, thus together, hardware and software, can perform different functions at various times. Assuming that the pool of hardware or physical resources is already in place and installed at some NFVI-PoPs, the actual network function software instantiation can become more automated. Such automation leverages the different cloud and network technologies currently available. Also, this helps network operators deploy new network services faster over the same physical platform.

- *Dynamic operation:* The decoupling of the functionality of the network function into instantiable software components provides greater flexibility to scale the actual VNF performance in a more dynamic way and with finer granularity, for instance, according to the actual traffic for which the network operator needs to provision capacity.

Based upon the previous definitions and description, the present document provides an architectural framework that focuses on the aspects unique to virtualisation by:

- Outlining an architecture that supports VNF operation across different hypervisors and computing resources and which provides access to shared storage, computation, and physical/virtual networking.

- Outlining a software architecture with VNFs as building blocks to construct VNF Forwarding Graphs.

- Interfacing management and orchestration of NFV with other management systems, such as EMS, NMS, and OSS/BSS.

- Supporting a range of network services with different reliability and availability levels leveraging virtualisation techniques.

- Ensuring the virtualisation does not cause any new security threat.

- Addressing performance related issues unique to virtualisation.

- Minimizing the interworking impact between virtualised and non-virtualised network functions.

- Leveraging existing data centre technology.

A number of aspects of the network functions and network infrastructure are common to Physical and Virtualised Network Functions, and therefore are out of scope of the NFV reference architectural framework. At a high level, these are:

- The specifics of the network functions themselves, their interface protocols, including any syntax and semantics of the internally or externally stored state, as well as management functions related to the functionality performed by the NF.
- Direct control, operation and management of physical network infrastructure.
- The actual packet flow, control, operation and management of the E2E network service. These should be independent of whether specific end points, network functions and/or network infrastructure are virtualised or not.
- Implementation details of the architecture itself.

5.2 High-Level NFV Framework

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.

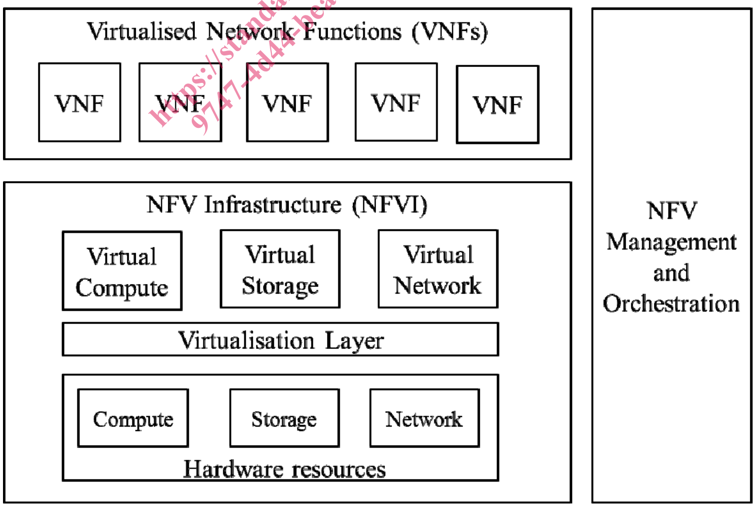

Figure 1: High-level NFV framework

The NFV framework enables dynamic construction and management of VNF instances and the relationships between them regarding data, control, management, dependencies and other attributes. To this end, there are at least three architectural views of VNFs that are centred around different perspectives and contexts of a VNF. These perspectives include:

- a virtualisation deployment/on-boarding perspective where the context can be a Virtual Machine (VM);