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Network Functions Virtualisation (NFV); Infrastructure Overview

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

The present document gives an overview to the series of documents covering the NFV Infrastructure.

Infrastructure Architecture Document		Document #
Overview		GS NFV INF 001
Architecture of the Infrastructure Domains	Compute Domain	GS NFV INF 003
	Hypervisor Domain	GS NFV INF 004
	Infrastructure Network Domain	GS NFV INF 005
Architectural Methodology	Interfaces and Abstraction	GS NFV INF 007
Service Quality Metrics		GS NFV INF 010

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).

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1 Scope

The present document presents an overview of the architecture of the NFV Infrastructure (NFVI) which supports deployment and execution of Virtualised Network Functions (VNFs).

As well as presenting a general overview description of the NFV Infrastructure, the present document sets the NFV infrastructure and all the documents which describe it in the context of all the documents of the NFV. It also describes how the documents which describe the NFV infrastructure relate to each other.

The present document does not provide any detailed specification but makes reference to specifications developed by other bodies and to potential specifications, which, in the opinion of the NFV ISG could be usefully developed by an appropriate Standards Developing Organisation (SDO).

The overall objectives of the ISG NFV were set out in the white paper [i.1] that led to the founding of the ISG and updated in the white paper update [i.2].

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 reference 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 ETSI GS NFV 001 (V1.1.1) (10-2013): "Network Functions Virtualisation (NFV); Use Cases".

[2] ETSI ETSI GS NFV 002 (V1.1.1) (10-2013): "Network Functions Virtualisation (NFV); Architectural Framework".

[3] ETSI ETSI GS NFV 003 (V1.1.1) (10-2013): "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[4] ETSI ETSI GS NFV 004 (V1.1.1) (10-2013): "Network Functions Virtualisation (NFV); Virtualisation Requirements".

[5] ETSI GS NFV-PER 002 (V1.1.1) (10-2013): "Network Functions Virtualisation (NFV); Proofs of Concepts; Framework".

[6] ETSI GS NFV-SEC 001 (V1.1.1) (10-2014): "Network Functions Virtualisation (NFV); NFV Security; Problem Statement".

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 reference 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 Whitepaper: "Network Function Virtualization", issue 1, (2012).

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

[i.2] NFV Whitepaper: "Network Function Virtualization - Update White Paper", issue 2, (2013).

NOTE: Available at http://portal.etsi.org/NFV/NFV_White_Paper2.pdf.

[i.3] IEEE Cloud Computing 2009: "The Method and Tool of Cost Analysis for Cloud Computing", Ying Li, Tiancheng Liu, Jie Qiu, Fengchun Wang.

[i.4] IEEE System Science (HICSS) (2012): "Costing of Cloud Computing Services: A Total Cost of Ownership Approach", B. Martens, M. Walterbusch, F. Teuteberg.

[i.5] TR174 Enterprise-Grade IaaS Requirements Rev1.3.

NOTE: Available at http://www.tmforum.org/TechnicalReports/EnterpriseGradeExternal/50445/article.html.

[i.6] The Open Virtualization Format (OVF) Specification, Version 2.0, 2012, Distributed Management Task Force.

NOTE: Available at http://dmtf.org/sites/default/files/standards/documents/DSP0243_2.0.0.pdf.

[i.7] Master Usage Model: Compute Infrastructure as a Service, Rev 1, (2012), Open Data Center Alliance.

NOTE: Available at http://www.opendatacenteralliance.org/docs/ODCA_Compute_IaaS_MasterUM_v1.0_Nov2012.pdf.

[i.8] Usage Model: Guide to Interoperability Across Clouds, 2012, Open Data Center Alliance.

NOTE: Available at http://www.opendatacenteralliance.org/docs/ODCA_Interop_Across_Clouds_Guide_Rev1.0.pdf.

[i.9] USAGE: Input/Output (IO) Controls , Rev 1.1., 2012, Open Data Center Alliance.

NOTE: Available at http://www.opendatacenteralliance.org/docs/IO_Controls_Rev_1.1_b.pdf.

[i.10] NIST SP-800-145 (September 2011): "The NIST Definition of Cloud Computing," Peter Mell and Timothy Grance, US National Institute of Standards and Technology.

NOTE: Available at http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.

[i.11] Recommendation ITU-T Q.1741: "GSM evolved UMTS core network".

[i.12] ETSI GS NFV-INF 003: "Network Functions Virtualisation (NFV); Infrastructure; Compute Domain".

[i.13] ETSI GS NFV-INF 004: "Network Functions Virtualisation (NFV); Infrastructure; Hypervisor Domain".

[i.14] ETSI GS NFV-INF 005: "Network Functions Virtualisation (NFV); Infrastructure; Infrastructure Network Domain".

[i.15] ETSI GS NFV-INF 007: "Network Functions Virtualisation (NFV); Infrastructure; Methodology to describe Interfaces and Abstractions".

[i.16] A. Capiluppi, K-J.Stol, C. Boldyreff, "Software reuse in Open Source: A Case Study", Int"l J. of Open Source Software and Processes, Vol 3. Iss. 3, (2011).

[i.17] NIST SP-800-146: "Cloud Computing Synopsis and Recommendations".

[i.18] IEEE 802.1Q™: "Virtual LANs".

[i.19] IEEE 802.1ad™: "Support on Provider Bridges".

[i.20] ISO/IEC JTC1 SC 38: "Distributed application platforms and services (DAPS)".

NOTE: Available at http://www.iso.org/iso/home/standards_development/list_of_iso_technical_committees/jtc1_home/jtc1_sc38_home.htm.

[i.21] Recommendation ITU-T SG13: "Future networks including cloud computing, mobile and next-generation networks".

NOTE: Available at http://www.itu.int/en/ITU-T/studygroups/2013-2016/13/Pages/default.aspx.

[i.22] Recommendation ITU-T SG15: "Networks, Technologies and Infrastructures for Transport, Access and Home".

3 Definitions and abbreviations

3.1 Definitions

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

container interface: environment within a HFB which is configured in or to realize a VFB

NOTE 1: This includes the configurability and/or programming language of the environment. The container interface is ***not*** an interface between functional blocks.

NOTE 2: Container interface should not be confused with 'containers' as used in the context of Unix type operating systems as an alternative to full virtual machines.

NOTE 3: The relation between a container interface as defined in the present document and a virtualization container as defined in the ETSI GS NFV 003 [3] is for further study.

domain: specific part of a larger entity which is useful to separate out based on given criteria

NOTE: Domains can be defined for many different purposes and the features which distinguish domains may differ in different contexts.

EXAMPLE: The compute domain, hypervisor domain, and infrastructure network domain may not be administrative domains.

functional block: basis element of a system

NOTE: A Functional Block has interfaces (both input interfaces, output interfaces), can hold state, and evolves its state and output parameters according to a unchanging transfer function.

Host Functional Block (HFB): functional block which can be configured and/or programmed

NOTE: When suitable configured and/or programmed, a Host Function Block behaves as if it were one or more functional blocks with a more specific definition. A Host Functional Block is said to host one or more Virtual Functional Blocks.

hypervisor: piece of software which partitions the underlying physical resources and creates Virtual Machines, and isolates the VMs from each other

NOTE: The Hypervisor is a piece of software running either directly on top of the hardware (bare metal hypervisor) or running on top of a hosting operating system (hosted hypervisor). The abstraction of resources comprises all those entities inside a computer/server which are accessible, like processor, memory/storage, NICs. The hypervisor enables the portability of VMs to different Hardware.

infrastructure interface: interface between two HFBs

NOTE: An Infrastructure Interface can transport a virtualised interface without placing any dependency on the particular type of virtualised interface.

Network Element (NE): discrete telecommunications entity, which can be managed over a specific interface, e.g. the RNC (from Recommendation ITU-T Q.1741 [i.11])

Network Function (NF): Functional Block (FB) within a network infrastructure which has well-defined external interfaces and well-defined functional behaviour

NOTE: In practical terms, a Network Function is today often a network node or physical appliance.

Network Functions Virtualisation Infrastructure (NFVI): totality of all hardware and software components which build up the environment in which VNFs are deployed

NOTE: The NFV-Infrastructure can span across several locations, e.g. places where data centres are operated. The network providing connectivity between these locations is regarded to be part of the NFV-Infrastructure. NFV-Infrastructure and VNF are the top-level conceptual entities in the scope of Network Function Virtualization. All other components are sub-entities of these 2 main entities.

NFVI-Node: physical device deployed and managed as a single entity providing the NFVI functions required to support the execution environment for VNFs

NFVI-PoP: single geographic location where a number of NFVI-Nodes are sited

portability: ability to transfer data from one system to another without being required to recreate or re-enter data descriptions or to modify significantly the application being transported

Virtual Functional Block (VFB): functional block, defined in a logical, implementation independent way, which is implemented by configuring a host functional block

NOTE: Programming is a form of configuration.

Virtual Machine (VM): virtualized computation environment which behaves very much like a physical computer/server

NOTE: A VM has all its ingredients (processor, memory/storage, interfaces/ports) of a physical computer/server and is generated by a Hypervisor, which partitions the underlying physical resources and allocates them to VMs. Virtual Machines are capable of hosting a VNF Component (VNFC).

virtualized interface: interface, defined in a logical and abstract way, between two VFBs

virtual network: topological component used to affect forwarding of specific characteristic information

NOTE 1: The virtual network is bounded by its set of permissible network interfaces.

NOTE 2: In the NFVI architecture, a virtual network forwards information among the network interfaces of VM instances and physical network interfaces, providing the necessary connectivity and ensures secure isolation of traffic from different virtual networks.

Virtualised Network Function (VNF): implementation of an NF that can be deployed on a Network Functions Virtualisation Infrastructure (NFVI)

NOTE: A VNF is a VFB which provides exactly the same functional behaviour and interfaces as the equivalent Network Function.

Virtualised Network Function Component (VNFC): internal component of a VNF providing a VNF Provider-defined sub-set of that VNF's functionality, with the main characteristic that a single instance of this component maps 1:1 against a single VM Container Interface

NOTE: A VNFC which has been instantiated and deployed in a VM is called a VNFC Instance. A VNFC which is part of the resource pool is called a VNFC Resource, and a reserved VNFC is called a Reserved VNFC Resource. A more general VNF may be a functional composition of a number of VNFCs.

The following definitions relate to the specific domains of the NFVI, the compute domain, the hypervisor domain, and the infrastructure network domain. Further definitions relating to each domain are contained in each respective domain architecture document.

accelerator: co-processor or other specialized hardware entity deployed to offload processing, or otherwise improve performance of software running on a main processor

Central Processing Unit (CPU): device in the compute node which provides the primary container interface

NOTE: The CPU instruction set is the primary runtime and execution language of the compute node. A programme of CPU instructions loaded into memory and executing is the primary way by which a compute node acts as a HFB and hosts VFBs. A specific VFB is defined by the specific programme for that VFB running on the specific CPU.

compute domain: general area for focus which includes servers and storage

NOTE: The compute domain has its own architecture documentation within the Infrastructure architecture.

compute Nnde: single identifiable, addressable, and manageable element within an NFVI-Node that provides computing resource using compute, storage, and networking functions

NOTE: A Compute Node is normally programmable and can run a hypervisor which supports VM instances. Stand-alone acceleration devices are also compute nodes.

execution cycle: step in the evolution of state within a compute node

NOTE: Strictly, this can be defined abstractly, in practical terms, this will relate directly to a CPU clock cycle.

gateway node: single identifiable, addressable, and manageable element within an NFVI-Node that implements gateway functions

hypervisor domain: general area for focus which includes hypervisors

infrastructure connectivity service: connectivity service provided by the infrastructure network domain

NOTE: The Infrastructure Connectivity Services abstract the details of topology, switching equipment, and protocol/encapsulations of the infrastructure network domain. In practice relevant examples of Infrastructure Connectivity Service as likely to include E-Line and E-LAN services as defined by Metro-Ethernet Forum (MEF).

infrastructure network domain: general area for focus which includes all networking which interconnects compute/storage infrastructure and pre-exists the realisation of VNFs

Network Interface Controller (NIC): device in a compute node which provides a physical interface with the infrastructure network

network node: single identifiable, addressable, and manageable element within an NFVI-Node that provides networking (switching/routing) resource using compute, storage, and network forwarding functions

NOTE: This is a node in the NFV Infrastructure network and if the context is not clear should be called an Infrastructure Network Node.

offload: delegating processing (e.g. classification, forwarding, load balancing, cryptography, transcoding) to a different processor or other specialized hardware entity

state: set of all parameters held within a functional block

NOTE: For a compute node, in practice, this is the memory (volatile and non-volatile).

storage: non-volatile storage with in the compute domain

NOTE: In practice, this is likely to be implemented as spinning disks or as solid-state disks.

storage node: single identifiable, addressable, and manageable element within an NFVI-Node that provides storage resource using compute, storage, and networking functions

vCPU: virtualised CPU created for a VM by a hypervisor

NOTE: In practice, a vCPU may be a time sharing of a real CPU and/or in the case of multi-core CPUs, it may be an allocation of one or more cores to a VM. It is also possible that the hypervisor may emulate a CPU instruction set such that the vCPU instruction set is different to the native CPU instruction set (emulation will significantly impact performance).

vNIC: virtualised NIC created for a VM by a hypervisor

vStorage: virtualised non-volatile storage allocated to a VM

vSwitch: Ethernet switch implemented in the hypervisor domain which interconnects vNICs of VMs with each other and with the NIC of the compute node

NOTE: The vSwitch may be combined with the hypervisor as a single software package or provided as a standalone piece of software running on top of or aside the hypervisor.

3.2 Abbreviations

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

3GPP	3rd Generation Partnership Project
ACL	Access Control List
API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
ATIS	Alliance for Telecommunications Industry Solutions
BIOS	Basic Input Output System
BSS	Business Support System
CDN	Content Distribution Network
COTS	Commercial Off The Self
CPU	Central Processor Unit
CSA	[TBC by EG SEC]
CSCF	Call Session Control Function
DMA	Direct Memory Access
DMTF	Distributed Management Task Force
DNS	Domain Name System
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
DRAM	Dynamic Random Access Memory
E-LAN	Ethernet Local Area Network
E-Line	Ethernet Line
EPC	Evolved Packet Core
ETSI	European Telecommunications Standards Institute
FB	Functional Block
FIFO	First In First Out
GW	Gateway
HFB	Host Functional Block
HSS	Home Subscriber Server
HW	Hardware
IaaS	Infrastructure as a Service
I-CSCF	Interrogating Call Session Control Function
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
INCOSE	International Council on Systems Engineering
ISG	Industry Specification Group

ISO	International Standard Organisation
IT	Information Technology
ITU-T	International Telecommunications Union - Telecommunications
KLR	Kernel Level Rootkits
KQI	Key Quality Indicators
KVM	Kernel-Based Virtual Machine
LAN	Local Area Network
MAC	Media Access Control
MANO	Management and Orchestration
MEF	Metro Ethernet Forum
MME	Mobility Management Entity
NAPI	Network Application Programming Interface
NE	Network Element
NF	Network Function
NFV	Network Functions Virtualisation
NFVI	Network Functions Virtualisation Infrastructure
NFVI-Node	Network Functions Virtualisation Infrastructure Node
NFVI-PoP	Network Functions Virtualisation Infrastructure Point of Presence
NFVO	Network Functions Virtualisation Orchestration
NIC	Network Interface Card
NIST	National Institute for Standards and Technology
NSI	North American Association of State and Provincial Lotteries Standards Initiative
NVF	Network Functions Virtualisation
OAM	Operations, Administration, and Maintenance
OASIS	Organization for the Advancement of Structured Information Standards
OCP	Open Computing Project
ODCA	Open Data Centre Alliance
OMG	Object Management Group
ONF	Open Networking Foundation
OS	Operating System
OSS	Operational Support System
PaaS	Platform as a Service
PCEF	Policy and Charging Enforcement Function
PCIe	Peripheral Component Interconnect - Express
PCRF	Policy and Charging Rule Function
P-CSCF	Proxy Call Session Control Function
P-GW	Proxy Gateway
PSTN	Public Switched Telephone Network
RAM	Random Access Memory
SaaS	Software as a Service
SAN	Storage Area Network
S-CSCF	Serving Call Session Control Function
SDN	Software-Defined Networking
SDN-C	Software Defined Networking - Controller
SDO	Standards Developing Organisation
S-GW	Serving Gateway
SLA	Service Level Agreement
SNIA	Storage Networking Industry Association
SR-IOV	Single Root Input Output Virtualisation
SSD	Solid State Disk
SSH	Secure Shell
SSO	Standards Setting Organisation
SW	Software
SWA	SoftWare Architecture
TCP	Transport Control Protocol
TLS	Transport Layer Security
TMF	TM Forum
UML	Unified Modelling Language
vCPU	Virtual Central Processor Unit
VFB	Virtual Functional Block
VFND	Virtualised Network Function Descriptor
VIM	Virtual Infrastructure Manager

VLAN	Virtual Local Area Network
VM	Virtual Machine
VN	Virtual Network
VNF	Virtualised Network Function
VNFC	Virtualised Network Function Component
VNFD	Virtualised Network Function Descriptor
vNIC	Virtual Network Interface Card
XML	eXtensible Markup Language

4 Objectives of the NFV Infrastructure

The objectives of the Network Function Virtualisation Infrastructure emerge from consideration of the overall objectives for NFV and the role that the NFVI has in supporting the NFV ecosystem. The NFV Use Cases document [1] identifies 9 fields of application or use cases for NFV. The NFVI is the totality of the hardware and software components which build up the environment in which VNFs are deployed [3]. The NFVI is deployed as a distributed set of NFVI-nodes in various locations to support the locality and latency requirements of the different use cases and the NFVI provide the physical platform on which the diverse set of VNFs are executed; enabling the flexible deployment of network functions envisaged by the NFV Architectural Framework [2].

From a functional perspective, the NFVI provide the technology platform with a common execution environment for the NFV use cases as illustrated in figure 1. The NFVI provide the infrastructure that support one or more of these use cases simultaneously and is dynamically reconfigurable between these use cases through the installation of different VNFs.

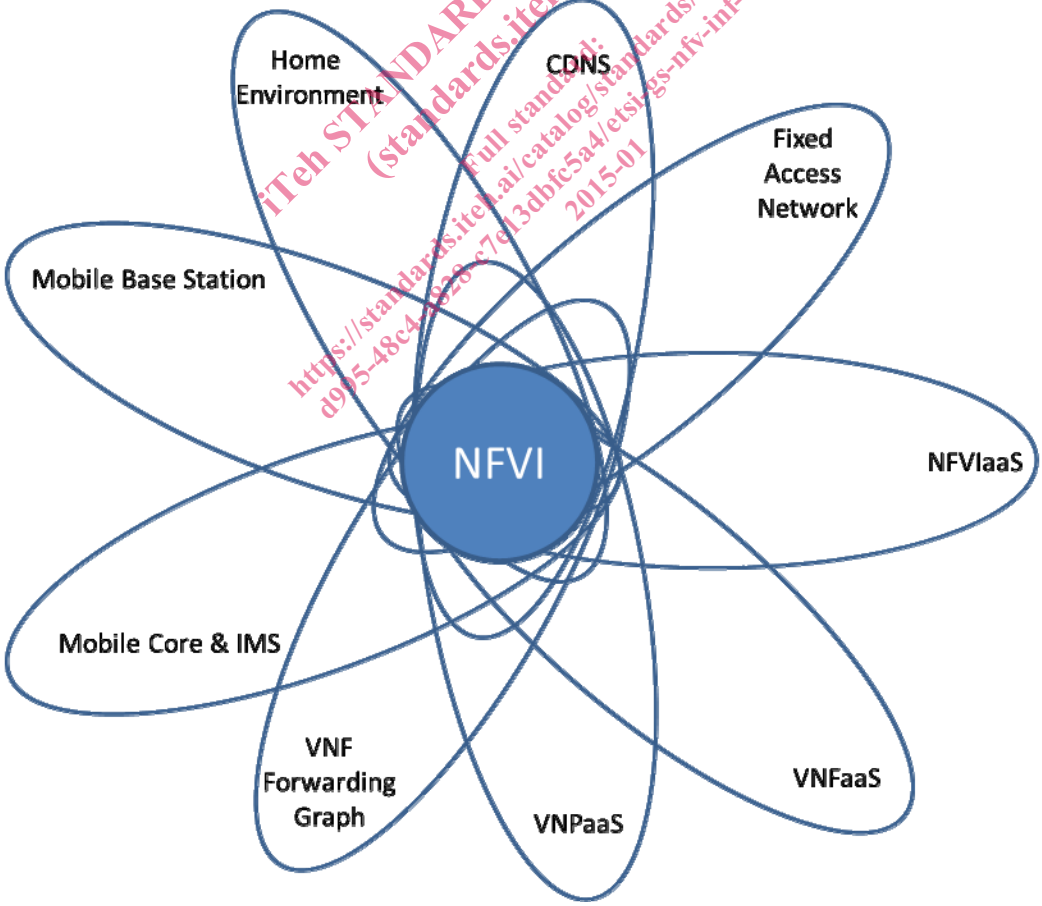

Figure 1: NFVI as the execution environment for NFV Use cases