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# Network Functions Virtualisation (NFV); Virtual Network Functions Architecture

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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 objective is to identify the most common and relevant software architectural patterns present when virtualising network functions and therefore to identify and specify functional requirements necessary to enable such patterns. The information consolidated is reflecting the experience from vendors and operators going through virtualisation of a number of network functions, with a focus on the use case list provided by the NFV Use Cases GS document [i.7].

The present document describes the Network Function Virtualisation abstract software architecture comprising of the following topics:

- Defining the functions, and interfaces of software architecture relative to the NFV overall architecture.
- Supporting Management and Orchestration Functional requirements.
- Supporting Infrastructure requirements.
- Describing best practices for NFV Design.
- Functional Decomposition types and use cases.

The present document does not provide any detailed specification. However, the present document makes reference to specifications developed by other bodies, gap, and to potential specifications.

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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] ETSI GS NFV-INF 001: "Network Functions Virtualisation (NFV); Infrastructure Overview".

[i.2] ETSI GS NFV-INF 005: "Network Functions Virtualisation (NFV); Infrastructure; Network Domain".

[i.3] ETSI GS NFV-MAN 001: "Network Functions Virtualisation (NFV); Management and Orchestration".

[i.4] ETSI GS NFV 002 (V1.1.1): "Network Functions Virtualisation (NFV); Architectural Framework".

[i.5] ETSI GS NFV 004 (V1.1.1): "Network Functions Virtualisation (NFV); Virtualisation Requirements".

[i.6] ETSI GS NFV 003 (V1.1.1): "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.7] ETSI GS NFV 001 (V1.1.1): "Network Functions Virtualisation (NFV); Use Cases".

[i.8] ETSI GS NFV-PER 001: "Network Functions Virtualisation (NFV); NFV Performance & Portability Best Practises".

[i.9] ETSI GS NFV-REL 001: "Network Functions Virtualisation (NFV); Resiliency Requirements".

[i.10] Open Data Center Alliance, ODCA Service Orchestration Master Usage Model, ODCA.

NOTE: Available at http://www.opendatacenteralliance.org/docs/ODCA_Service_Orch_MasterUM_v1.0_Nov2012.pdf.

[i.11] ETSI TS 123 228: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia Subsystem (IMS); Stage 2 (3GPP TS 23.228)".

[i.12] ETSI TS 123 218: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia (IM) session handling; IM call model; Stage 2 (3GPP TS 23.218)".

[i.13] ISO/IEC 42010:2011: "Systems and Software Engineering - Architecture Description".

[i.14] ATIS-I-0000044 (October 2013): "Operational opportunities and challenges of SDN/NFV programmable infrastructure", section 4.2.1.1 "Service Provider Devops".

[i.15] ETSI TS 123 203: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Policy and charging control architecture (3GPP TS 23.203)".

[i.16] ETSI TS 132 251: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Packet Switched (PS) domain charging (3GPP TS 32.251)".

[i.17] ETSI TS 132 240: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Charging management; Charging architecture and principles (3GPP TS 32.240)".

[i.18] Open Network Foundation, ONF.

NOTE: Available at https://www.opennetworking.org/sdn-resources/sdn-definition.

[i.19] PCI Single Route I/O Virtualization (SR-IOV). [Online].

NOTE: Available at http://www.pcisig.com/specifications/iov/.

[i.20] Recommendation ITU-T H.248.1 (03/2013): "Gateway control protocol: Version 3".

[i.21] Technical Report Draft TR H.Sup.OpenFlow (2014): "Protocol evaluation - OpenFlow versus H.248".

NOTE: Latest draft available at http://wftp3.itu.int/av-arch/avc-site/2013-2016/1403_Gen/TD-19.zip.

[i.22] Recommendation ITU-T M.3050.1 (03/2007): "Enhanced Telecom Operations Map (eTOM) - The business process framework".

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[i.23] Recommendation ITU-T M.3010 (02/2000): "Principles for a telecommunications management network".

[i.24] Recommendation ITU-T M.3400 (02/2000): "TMN management functions".

[i.25] Recommendation ITU-T X.700 (09/1992): "Management framework for Open Systems Interconnection (OSI) for CCITT applications".

[i.26] ETSI GS NFV-PER 002 (V1.1.1): "Network Functions Virtualisation (NFV); Proofs of Concepts; Framework".

[i.27] IETF RFC 3031 (January 2001): "Multiprotocol Label Switching Architecture", E. Rosen, A. Viswanathan and R. Callon.

[i.28] IETF RFC 3069 (February 2001): "VLAN Aggregation for Efficient IP Address Allocation", D. McPherson and B. Dykes.

[i.29] IETF RFC 3809 (June 2004): "Generic Requirements for Provider Provisioned Virtual Private Networks (PPVPN)", A. Nagarajan.

[i.30] IETF RFC 4385 (February 2006): "Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN", S. Bryant, G. Swallow, L. Martini and D. McPherson.

[i.31] IETF RFC 4464 (May 2006): "Signaling Compression (SigComp) Users' Guide", A. Surtees and M. West.

[i.32] IETF RFC 4761 (January 2007): "Virtual Private LAN Service (VPLS) Using BGP for Auto-Discovery and Signaling", K. Kompella and Y. Rekhter.

[i.33] Recommendation ITU-T Y.3300 (06/2014): "Framework of software-defined networking".

[i.34] ETSI TS 129 333: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Multimedia Resource Function Controller (MRFC) - Multimedia Resource Function Processor (MRFP) Mp interface; Stage 3 (3GPP TS 29.333)".

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# 3 Definitions and abbreviations

## 3.1 Definitions

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

**compute node:** See ETSI GS NFV-INF 001 [i.1].

**Network Function (NF):** See ETSI GS NFV 003 [i.6].

**Network Function Virtualisation Infrastructure (NFVI):** See ETSI GS NFV 003 [i.6].

**Network Functions Virtualisation Orchestrator (NFVO):** See ETSI GS NFV-MAN 001 [i.3].

**NF Forwarding Graph:** See ETSI GS NFV 003 [i.6].

**NF Set:** See ETSI GS NFV 003 [i.6].

**Physical Network Function (PNF):** See ETSI GS NFV 003 [i.6].

**network service:** See ETSI GS NFV 003 [i.6].

**Virtual Machine (VM):** See ETSI GS NFV 001 [i.1].

**virtualisation container:** partition of a compute node that provides an isolated virtualised computation environment

NOTE: Examples of virtualisation container includes virtual machine and OS container.

**Virtualisation Deployment Unit (VDU):** See ETSI GS NFV-MAN 001 [i.3].

**Virtualised Network Function (VNF):** See ETSI GS NFV 003 [i.6].

**Virtualised Network Function Component (VNFC):** See ETSI GS NFV 003 [i.6].

**Virtualised Network Function Component (VNFC) Instance:** See ETSI GS NFV 003 [i.6].

**VNF Descriptor (VNFD):** See ETSI GS NFV-MAN 001 [i.3].

**VNF Forwarding Graph (VNF-FG):** See ETSI GS NFV 003 [i.6].

**VNF Instance:** See ETSI GS NFV-MAN 001 [i.3].

**VNF Network Connectivity Topology (VNF-NCT):** graph that defines the connectivity topology among (v)NFs by describing how its nodes are connected to one another

**VNF Package:** See ETSI GS NFV-MAN 001 [i.3].

**VNF Provider:** entity that provides VNF Package(s)

**VNF Set:** See ETSI GS NFV 003 [i.6].

## 3.2 Abbreviations

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

| | |
|---|---|
| ADC | Application Detection and Control |
| API | Application Programming Interface |
| AppVM | Application Virtual Machines |
| ATM | Asynchronous Transfer Mode |
| BFCP | Binary Floor Control Protocol |
| BGP | Border Gateway Protocol |
| BGP-LS | Border Gateway Protocol - Link State |
| BRAS | Broadband Remote Access Server |
| CDN | Content Delivery Network |
| COTS | Commercial off the Shelf |
| CPU | Central Processing Unit |
| CSCF | Call Session Control Function |
| DB | DataBase |
| DDoS | Distributed Denial of Service |
| DHCP | Dynamic Host Configuration Protocol |
| DNS | Domain Nane Server |
| DPDK | Data Plane Development Kit |
| DPI | Deep Packet Inspection |
| DRA | Diameter Routing Agent |
| DSCP | Differentiated Services Code Point |
| DSP | Digital Signal Processor |
| DSR | Direct Server Return |
| ELAN | Ethernet Virtual Private LAN |
| EM | Element Management |
| EPC | Evolved Packet Core |
| ETH | Ethernet |
| eTOM | enhanced Telecom Operations Map |
| EVPN | Ethernet VPN |
| FAB | Fulfilment, Assurance, Billing |
| FCAPS | Fault, Configuration, Accounting, Performance, Security |
| FORCES | FOrwarding and Control Element Separation |
| FRR | Fast ReRoute |
| GGSN | Gateway GPRS Service Node |
| GTP | GPRS Tunnel Protocol |
| GW | Gateway |
| HDW | Hardware |
| HTTP | Hypertext Transfer Portocol |
| HW | Hardware |

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| | |
|---|---|
| I2SR | Interface 2 the Routing System |
| IB | Infiniband |
| IDPS | Intrusion Detection And Prevention Systems |
| IGMP | Internet Group Management Protocol |
| IGP | Internet Gateway Protocol |
| IMS | IP Multimedia Subsystem |
| IO | Input Output |
| IP | Internet Protocol |
| IPS | Intrusion Prevention System |
| ISA | Industry Standard Architecture |
| ISO | International Organisation for Standardization |
| IT | Information Technology |
| LAG | Link Aggregation Groups |
| LAN | Local Area Network |
| LB | Load Balancer |
| LISP | Location Identifier Separation Protocol |
| LSP | Label Switched Paths |
| MAC | Media Access Control |
| MEF | Metro Ethernet Forum |
| MME | Mobility Management Entity |
| MPLS | Multiprotocol Label Switching |
| MRB | Media Resource Broker |
| MRF | Media Resource Function |
| MRF-C | Multimedia Resource Function Controller |
| MRF-P | Multimedia Resource Function Processor |
| MSRP | Message Session Relay Protocol |
| NAT | Network Address Translation |
| NF | Network Function |
| NFV | Network Function Virtualisation |
| NFVI | NFV Infrastructure |
| NFVO | Network Functions Virtualisation Orchestrator |
| NIC | Network Interface Controller |
| NVFI | Network Functions Virtualisation Infrastructure |
| NVGRE | Network Virtualisation using Generic Routing Encapsulation |
| OAM | Operations, Administration and Maintenance/Management |
| OCS | Online Charging Function |
| OF | OpenFlow |
| OFCS | Offline Charging Function |
| OFLS | OpenFlow Logical Switch |
| ONF | Open Networking Foundation |
| OS | Operating System |
| OSS | Operations Support System |
| PCC | Policy and Charging Control |
| PCEF | Policy and Charging Enforcement Function |
| PCRF | Policy and Charging Rules Function |
| PGW | Packet Data Network Gateway |
| PMIP | Proxy Mobile IP |
| PNF | Physical Network Function |
| RAM | Random Access Memory |
| RDBMS | Relational Data Base Management System |
| REQ | Requirement |
| RFC | Request For Comment |
| RLOC | Routing Locator |
| RTCP | Real-time Transport Control Protocol |
| RTP | Real-time Transport Protocol |
| SCSI | Small Computer System Interface |
| SDK | Software Development Kit |
| SDN | Software Defined Networks |
| SIP | Session Initiation Protocol |
| SLA | Service Level Agreement |
| SNMP | Signalling Network Management Protocol |
| SSL | Secure Socket Layer |

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| | |
|---|---|
| SWA | Software Architecture |
| TCP | Transfer Control Protocol |
| TDF | Traffic Detection Function |
| TDF-C | Traffic Detection Function - Control |
| TDF-LB | Traffic Detection Function - Load Balancer |
| TDF-P | Traffic Detection Function - Processing |
| TE | Traffic Engineering |
| TMN | Telecommunications Management Network |
| UDP | Unreliable Datagram Protocol |
| VDC | Virtual Data Centre |
| VIM | Virtualised Infrastructure Manager |
| VLAN | Virtual Local Area Network |
| VM | Virtual Machine |
| VNF | Virtualised Network Function |
| VNFC | Virtualised Network Function Component |
| VNFD | Virtualised Network Function Descriptor |
| VNFFG | VNF Forwarding Graph |
| VNFM | Virtualised Network Function Manager |
| VNF-NCT | VNF Network Connectivity Topology |
| vNIC | Virtualised NIC |
| VoLTE | Voice over LTE |
| VPLS | Virtual Private LAN Service |
| VxLAN | Virtual eXtensible LAN |
| WAF | Web Application Firewall |
| WAN | Wide Access Network |

# 4 Overview of VNF in the NFV Architecture

## 4.1 Introduction

A Virtualised Network Function (VNF) is a functional element of the NFV architecture framework [i.4] as represented on figure 1. Reference points in-scope of the present document are those between a VNF and a VNF Manager (Ve-Vnfm) and between a VNF and NFVI (Vn-Nf), see red dashed line circle in figure 1. The present document addresses functional requirements for virtualising network functions in the form of software components deployed within an NFVI, in support of the deployment of network services.

Software architectures describe the functionality of software systems from the viewpoints of various stakeholders [i.13]. ETSI NFV-PER 002 [i.26] identified Proof of Concept Framework stakeholders from the membership categories (e.g. Service Provider, Network Operator, and Manufacturer) defined in the ETSI Directives. A Manufacturer of VNFs may have particular concerns with the software development aspects in creation of VNFs. A Network Operator may have particular concerns with the efficient deployment and operation of VNFs within his NFVI. A Service Provider may have particular concerns with the fulfilment, assurance and billing of services based on VNFs delivered to end users. ETSI GS NFV 004 [i.5] also identifies requirements impacting functions based on the roles, as defined in [i.5] Requirement [Sec. 5] of the actors initiating operations. Such roles impacting the VNF may extend beyond those identified by the ETSI Directives' membership categories, as defined in [i.7]. Commercial entities may need to act in multiple roles in order to meet certain NFV objectives; for example the objectives of NFV for automation, as defined in [i.5], Requirement [OaM.1] and rapid service innovation and deployment, as defined in [i.4], clause 4.2 may lead some entities to consider "devops" [i.14] to automate the process of development and deployment of VNFs and the end-end network services constructed from them.

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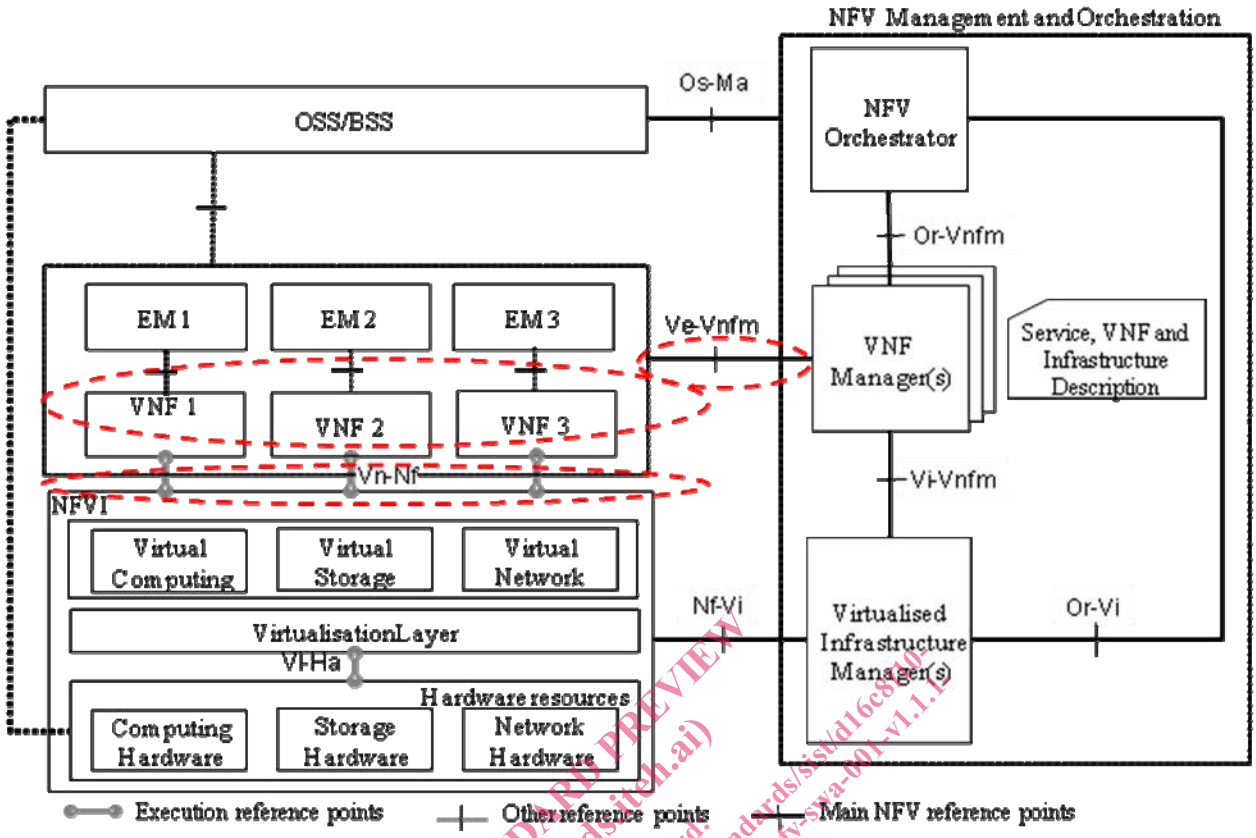


**Figure 1: NFV Software Architecture Scope within the NFV Reference Architecture Framework**

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As defined in [i.6] a network service is a composition of network functions, in the form of a network functions sets and/or network forwarding graphs. The present document also addresses the requirements for deploying network services involving at least one virtual network function.

The present document supports distributed VNF deployment models in support of end-to-end network services as defined in [i.5], Requirement "Mod7", delivered across multiple NFVI Nodes deployed in disparate NFVI-PoPs as defined in [i.5], Requirement "Port. 1". It shall be possible to deploy end-to-end network services across independently operated NFVI nodes as defined in Use Case #1 (NFVIaaS) in [i.7] and Requirement "Mod 7" in [i.5], a mix of NFVI Nodes and non-virtualised PNFs as defined in [i.5] Requirements "Mod 2", "Mig.1", and "Gen.4" and coexist with other network services deployed in parallel in the same NFVI as defined in [i.5] Requirements "Mod. 10" and "Sec. 1".

## 4.2 VNF Architecture

Figure 2 shows the internal architecture of a VNF. It provides more details on the entities and interfaces relevant for the discussion in the present document while deliberately leaving out those aspects that fall into the infrastructure and management and orchestration domains. See [i.3] and [i.1] for details on those.