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Network Functions Virtualisation (NFV); Management and Orchestration; VNF Packaging Specification

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Contents

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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

In the present document "**shall**", "**shall not**", "**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 requirements for the structure and format of a VNF Package to describe the VNF properties and associated resource requirements in an interoperable template.

The focus is on VNF packaging, meta-model descriptors (e.g. VNFD) and package integrity and security considerations.

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".

2.2 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.

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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-IFA 002: "Network Functions Virtualisation (NFV); Acceleration Technologies; VNF Interfaces Specification".

[i.2] ETSI GS NFV-IFA 006: "Network Functions Virtualisation (NFV); Management and Orchestration; Vi-Vnfm reference point - Interface and Information Model Specification".

[i.3] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".

[i.4] ETSI GS NFV-IFA 008: "Network Functions Virtualisation (NFV); Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".

[i.5] ISO/IEC 9646-7: "Information technology -- Open Systems Interconnection -- Conformance testing methodology and framework -- Part 7: Implementation Conformance Statements".

[i.6] ISO/IEC 9899: "Information Technology -- Programming languages -- C".

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 abbreviations given in ETSI GS NFV 003 [1] and the following apply:

API	Application Programming Interface
ARM	Advanced RISC Processor
CDN	Content Delivery Network
CP	Connection Point
CPD	Connection Point Descriptor
CPU	Central Processing Unit
DF	Deployment Flavour
DSL	Domain Specific Language
EM	Element Manager
GS	Group Specification
IFA	Infrastructure and Architecture Working Group
IP	Internet Protocol
ISG	Industry Specification Group
LAN	Local Area Network
LCM	Life Cycle Management
MAC	Media Access Control
MPLS	Multiprotocol Label Switching
NFV	Network Functions Virtualisation
NFVI	Network Functions Virtualisation Infrastructure
NFVO	Network Functions Virtualisation Orchestrator
NIC	Network Interface Controller
NS	Network Service
PM	Performance Management
QA	Quality Assurance
QoS	Quality of Service
RAM	Random Access Memory
RDMA	Remote Direct Memory Access
SAL	Service Availability Level
SR-IOV	Single Root Input/Output Virtualisation
SW	Software
UML	Unified Modelling Language
URL	Uniform Resource Locator
VDU	Virtual Deployment Unit
VIM	Virtualised Infrastructure Manager
VL	Virtual Link
VLD	Virtual Link Descriptor
VM	Virtual Machine
VNF	Virtualised Network Function
VNFC	Virtualised Network Function Component
VNFD	Virtualised Network Function Descriptor
VNFM	Virtualised Network Function Manager

4 General description

4.1 Introduction

The present document develops specifications for packaging of VNFs to be delivered to service providers, focusing on the holistic end-to-end view of the VNF Package lifecycle, from design to runtime, capturing development as well as operational views. The present document provides an analysis of end-to-end VNF Package lifecycle management operations based on use-cases and NFV Architectural Framework functional blocks.

A VNF Package contains all of the required files and meta-data descriptors required to validate and instantiate a VNF.

Standardized meta-data descriptors are required to:

- describe the NFV infrastructure resource requirements for a VNF in a service provider environment;
- describe design constraints and other dependencies in order for the VNF to successfully install, instantiate and terminate; and
- describe VNF operational behaviour including VNF lifecycle events (e.g. scaling, upgrading).

Standardized packaging and validation of VNFs is required to:

- provide a consistent, documented method for VNF providers to package VNFs;
- harmonize the service provider on-boarding process for VNFs coming from different VNF providers;
- ensure integrity, trust and auditability of a VNF Package;
- allow for a flexible and extensible VNF packaging structure that accommodates a wide variety of NFV infrastructure scenarios; and
- allow the packaged VNF-related meta-data to be interpreted and the packaged VNF to be instantiated in a wide variety of orchestration systems irrespective of technology choice or infrastructure environment.

4.2 Objectives

The present document delivers:

- A description of a set of use cases involving the handling of VNF Packages.
- A set of functional requirements to be fulfilled when packaging a VNF.
- A specification of the information elements and attributes applicable to the VNFD.

4.3 Conventions

The attributes of the VNFD and associated information elements are described in the tables provided in clause 7. Each table has 5 columns, with the following significance:

- The "Attribute" column provides the attribute name.
- The "Qualifier" column indicates whether the support of the attribute is mandatory, optional or conditional.
- The "Cardinality" column contains the minimum and maximum cardinality of this information element (e.g. 1, 2, 0..N, 1..N). A cardinality range starting with 0 indicates that the attribute need not always be included.
- The "Content" column provides information on the type of the attribute values. It can be the name of an Information Element, a primitive type (Identifier, DateTime, etc.) or a generic UML type (String, Integer, etc.). If a cell in the "Content" column is marked as "Not specified", this means that the specification of the type is left to the data model design stage.

- The "Description column" provides a brief explanatory description and additional constraints.

The following notations, defined in ISO/IEC 9646-7 [i.5], are used for the qualifier column:

- M mandatory - the attribute shall be supported;
- O optional - the attribute may, but need not to, be supported;
- CM conditional mandatory - the attribute shall be supported under certain conditions. If the specified conditions are met then the attribute shall be supported. These conditions are specified in the Description column;
- CO conditional optional - the attribute may, but need not to, be supported under certain conditions. These conditions are specified in the Description column.

A Mandatory qualifier would imply that NFVO/VNFM shall understand/parse the particular element but the presence (inclusion in an occurrence of a VNFD) of the element is dictated by Cardinality. The lower bound of "1.." cardinality would imply that the attribute shall be present in the VNFD.

The following notations are used for the content column of information elements, input parameters, notifications, etc.:

- Parameters are of type "Identifier" when referring to an identifier of an actual object.
- For a "true" identifier identifying an object (information element or structure) the content type "Identifier" and the description "Identifier of this <object_name> <notification/information element/…>" is used.
  Example: Identifier "resourceId" of the "NetworkSubnet information element" shall have the description "Identifier of this NetworkSubnet information element".
- Object(s) are referenced by their identifier using the syntax "Identifier (Reference to <object_name1> [, <object_name2>…][, or <object_nameN>])".
- Names for attributes and parameters of type Identifier shall be of the following pattern: <name>Id.

4.4 Levels of NFV Entities

For NFV management, there are four levels of entities, i.e.:

- Descriptors - general type definitions for entities such as VNFs and VLs, e.g. VNFD and VLD.
- Descriptor objects - an instance of a descriptor, e.g. an instance of a VNFD (not an instance of a VNF instantiated according to this VNFD):
  - A descriptor object may provide (among other things) value ranges and default values for the attributes in the associated NFV entity class.
  - In the present document, the creation of subclasses of generic descriptors (e.g. VNFD_x as a subclass of VNFD) has been avoided, since this approach would create a proliferation of descriptor classes.
- NFV Entity Classes - these are classes that represent various NFV entities such as VNF and VL. There is one-to-one mapping between a descriptor object and an NFV entity class. An example of an NFV Entity Class is CDN Cache VNF.
- NFV Entity Instances - these are instances of a given NFV entity class. An NFV entity instance is used to represent the current state and attribute values for a given NFV entity. Each NFV entity instance is bound by the associated descriptor object, e.g. value ranges and default values for attributes. An example of an NFV Entity Instance is a CDN Cache VNF instance.

Each level puts constraints on the subsequent levels.

Information in a lower level does not appear in a higher level, e.g. NFV entity instance information does not appear in the associated NFV entity class, descriptor object or descriptor.

For example:

- A VNFD has parameters such as virtualisationDeploymentUnit, intVirtualLinkDesc, extConnectionPointDesc and deploymentFlavour. These same parameters apply to every type of VNF.
- For a given type of VNF (e.g. a firewall), one would create an instance of the VNFD and populate the various VNFD parameters with values specific to the given type of firewall: specific VDU instances describing the resource requirements for this VNFD instance, VLD instances describing the various types of VL needed, specific deployment flavour (DF), etc.
- Next, one defines the class for the given VNF firewall. The class includes the attributes that are seen across the given reference point.
- Finally, one can instantiate one or more VNF firewall by populating the various attributes in the VNF class with actual values.

5 VNF Packaging use-cases (informative)

5.1 General

The following use cases describe the steps involving the VNF Package as it transitions from the VNF Provider to the Service Provider. They capture the generic processes as well as the actions required to be performed by actors playing different roles in order to identify the requirements for the standard packaging format.

All the use cases presented in this clause are informative.

For the purpose of the use cases, the roles identified in table 5.1-1 have been identified.

Table 5.1-1: List of roles

Role	Description
VNF Provider	The role providing the VNF. Actors that can play this role include, but are not limited to, vendor, integrator or in-house developer.
Supply Chain Specialist	Service provider function responsible for recommending or identifying VNFs required for desired services.
Service Designer	Service provider function responsible for defining and providing requirements (functional and non-functional) for required services. Also responsible for creating services to be deployed by the service provider.
Service Acceptance Specialist	Service provider function responsible to validate, certificate and on-board VNFs.
Service Deployment Manager	Service provider function responsible for managing the deployment (e.g. instantiation, update) of the VNFs and VLs validated by the Service Acceptance Specialist.

5.2 VNF Package bundling for distribution

A VNF is, from a delivery point of view a software application so most of the general principles and processes associated with the software development lifecycle apply. After a VNF provider completes the development and functional testing for the VNF it needs to bundle all the necessary binaries and corresponding metadata for distribution to potential customers.

Roles

#	Role
1	VNF Provider

Pre-conditions

#	Pre-conditions	Comment
1	Functional Testing was performed and the version of the VNF has been identified	

Post-conditions

#	Post-conditions	Comment
1	A versioned single file package	

Base Flow

#	Role	Action/Description
1	VNF Provider	Using their own software development lifecycle tools and procedures, retrieve all the software components associated with the version to be built. This includes but not limited to own developed code, configuration files as well as third party components with their code, license agreements as well as build scripts.
2	VNF Provider	Capture the release notes including clear description of the functionality the release delivers, any external dependencies, known bugs fixed relative to the prior releases as well as known issues in specific configurations.
3	VNF Provider	Bundle the release, sign the package and place it in a distribution repository.

5.3 VNF Package testing

The VNF Package testing encompasses steps to guarantee that the package adheres to the standard structure and contains the mandatory metadata required in order to be considered compliant with the industry format.

Roles

#	Role
1	VNF Provider

Pre-conditions

#	Pre-conditions	Comment
1	Versioned Package is signed and available for distribution	

Post-conditions

#	Post-conditions	Comment
1	Package is flagged as Validated	

Base Flow

#	Role	Action/Description
1	VNF Provider	Using parsing tools to perform a final test on the package in order to make sure that: • VNF Package signature can be validated. • VNF Package can be unbundled. • VNF Package has the right structure (files, directories) as expected by onboarding tools.

5.4 VNF pre procurement

Prior to acquiring the VNFs, the Service Provider will match the VNF against their needs allowing them to compare different offers from different suppliers.

Roles

#	Role
1	Supply Chain Specialist
2	Service Designer

Pre-conditions

#	Pre-conditions	Comment
1	Supply Chain Specialist has received clear functional and non-functional requirements from Service Designers	
2	Supply Chain Specialist obtained versioned package from VNF Provider	

Post-conditions

#	Post-conditions	Comment
1	Recommendation for purchase	

Base Flow

#	Role	Action/Description
1	Supply Chain Specialist	Identifies and quantifies the VNF attributes against the service requirements by retrieving VNF metadata describing the scalability, reliability, manageability and security attributes of the package.

5.5 VNF Package validation and certification

A VNF Package is composed of several components like e.g. VNFD, software images, scripts, etc. During the on-boarding of the VNF Package, a validation of the package is performed. The validation is a procedure that verifies the integrity of the VNF Package.

A package is certified by performing acceptance testing and full functional testing against the VNF including configuration, management and service assurance.

Roles

#	Role
1	Service Acceptance Specialist

Pre-conditions

#	Pre-conditions	Comment
1	VNF Package is available for onboarding	

Post-conditions

#	Post-conditions	Comment
1	VNF Package is validated	
2	VNF Package is marked as certified	

Base Flow

#	Role	Action/Description
1	Service Acceptance Specialist	Validate the package signature, origin, contents and structure.
2	Service Acceptance Specialist	Perform a full onboard, setup, install in a QA environment and certify the VNF for functionality as well as authenticity, integrity and packaging compliance.

5.6 VNF install

VNF is installed and ready to be configured and used for network services.

Roles

#	Role
1	Service Deployment Manager

Pre-conditions

#	Pre-conditions	Comment
1	VNF is on-boarded and available for Service Orchestration	

Post-conditions

#	Post-conditions	Comment
1	VNF is installed and ready to be configured for use in network services.	

Base Flow

#	Role	Action/Description
1	Service Deployment Manager	Identify the desired VNFs, configure and instantiate them according to the deployment policies. VNF configuration is based on parameterization captured at design time, included in the VNF Package, and complemented during VNF instantiation.

5.7 Keeping NFV management and orchestration in sync about a VNF application software modification

For currently deployed VNFs on-boarding of new versions will need the ability to keep track of multi version, multi environment multi instance and allow the service provider team to perform updates/upgrades with clear expectations of service continuity based on metadata information including component dependencies.

The use case below focuses on updating the information about a VNF instance stored in NFV management and orchestration as a result of a VNF application software modification performed through service provider's management system, wherein such a process only comprises modifying the VNF's application software without requiring a change of the VNF's underlying virtualised resources or internal VNF component (VNFC) topology/composition (see figure 5.7-1). Examples of VNF application software modification are: update, upgrade, and downgrade. Such modification may be performed without requiring the termination of the VNF instance with the prior VNF application software version. Consequently, the relevant VNF Package is replaced by a different VNF Package which includes the VNF application software used in the modification.

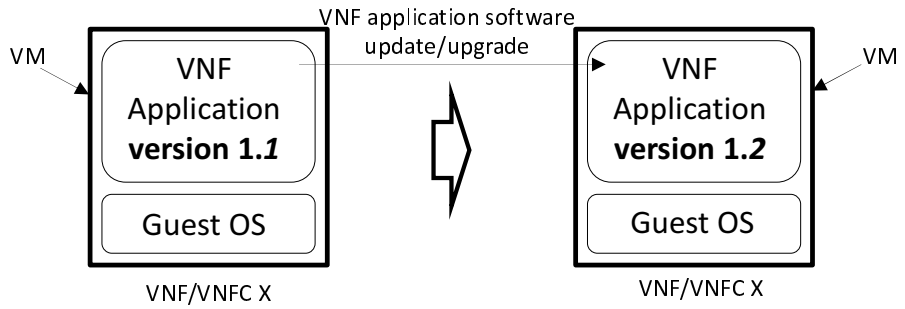

Figure 5.7-1: Example of VNF application software modification

Roles

#	Role
1	VNF Provider, Service Acceptance Specialist, Service Deployment Manager

Pre-conditions

#	Pre-conditions	Comment
1	Prior version of VNF already instantiated and in use.	
2	A VNF application software version to be used for the modification of a VNF instance has been certified.	

Post-conditions

#	Post-conditions	Comment
1	The VNF instance with the modified application software is available.	
2	The VNF Package with the VNF application software used in the modification is on-boarded.	
3	The VNF instance information refers to the VNF Package with the VNF application software used in the modification.	

Base Flow

#	Role	Action/Description
1	VNF Provider	Provide the VNF Package including the VNF application software to be used in the modification.
2	Service Acceptance Specialist	On-board the VNF Package of step 1 to the NFVO.
3	Service Deployment Manager	Perform the modification of the VNF instance's application software through Service Provider's management system.
4	Service Deployment Manager	Modify the VNF instance information in the NFVO/VNFM to refer to the VNF Package that includes the VNF application software used in the modification.

5.8 VNF configurable parameter provisioning

The VNFD is a static description file, not a dynamic configuration file. The metadata description in the VNFD is not changed during the whole VNF lifecycle. Some VNF parameters described in the VNFD can be declared to be configurable during the VNF design phase, and further be configured by the VNFM during or after VNF instantiation. This use case provides a scenario where the VNF configurable parameters described in the VNFD are provisioned.

Roles

#	Role
1	Service Acceptance Specialist, Service Deployment Manager

Pre-conditions

#	Pre-conditions	Comment
1	The description of the VNF configurable parameters that is described or declared in the VNFD has been encapsulated in the VNFD during the VNF design phase.	

Post-conditions

#	Post-conditions	Comment
1	The VNF configurable parameters in the VNFD are provisioned (configured with a real value) after VNF instantiation, and can also be re-configured at any time of VNF lifecycle.	

Base Flow

#	Role	Action/Description
1	Service Acceptance Specialist	The NFVO on-boards the VNF Package and stores the VNFD.
2	Service Deployment Manager	The VNFM accesses to the VNFD, reads the description of each VNF parameter and determines whether it is configurable. See note 1.
3	Service Deployment Manager	For each configurable VNF parameter in the VNFD, based on the interaction with the NFVO, the VNFM configures the value of VNF parameter during VNF instantiation (i.e. when the VNF is deployed). See note 2.
NOTE 1: VNF configurable parameters in the VNFD (e.g. the IP address of element manager for the VNF) belong to virtualisation-related configuration parameters of the VNF as specified in ETSI GS NFV-IFA 008 [i.4]. NOTE 2: This configuration step is a part of VNF instantiation instead of VNF update.		

6 Functional requirements for VNF Packaging

6.1 Generic Functional Requirements

Table 6.1-1 specifies generic functional requirements applicable to VNF Packaging.

Table 6.1-1: Generic functional requirements for VNF Packaging

Req Number	Requirement Description	Comments
VNF_PACK.GEN.001	The VNF Package contents, including the VNF descriptor, VNF Binaries, configuration, scripts and software images, as well as manifest file, checksum, etc. as appropriate constitutes a single delivery unit from a distribution perspective. Any changes to the constituency of this unit shall be considered as a change to the whole and therefore shall be versioned, tracked and inventoried as one.	

6.2 Functional requirements for VNF Packaging specification

6.2.1 Requirements for the structure of a VNF Package

Table 6.2.1-1 specifies requirements applicable to the structure of a VNF Package.

Table 6.2.1-1: Requirements for the structure of a VNF Package

Req Number	Requirement Description	Comments
VNF_PACK.STRUCT.001	The VNF Package shall be assembled in one file.	
VNF_PACK.STRUCT.002	The VNF Package shall be digitally signed by the VNF Provider.	
VNF_PACK.STRUCT.003	The VNF Package should contain files for one VNF and its corresponding metadata.	
VNF_PACK.STRUCT.004	The VNF Package shall enable including VNF specific files organized according to the design of the VNF, or referencing these files if they are external to the package. See note.	
VNF_PACK.STRUCT.005	The VNF Package shall provide means to address individually the files which it contains and/or which it references.	
VNF_PACK.STRUCT.006	If an external reference (e.g. URL) is used, file integrity information (such as checksum/signature) shall be specified to guarantee the integrity of the referenced file, so it cannot be substituted with a different file by the same name.	
NOTE: This can include e.g. software images and additional specific files to run and manage the VNF, supplied by the VNF provider.		

6.2.2 Requirements for the description of VNF Package content

Table 6.2.2-1 specifies requirements applicable to the content of a VNF Package.

Table 6.2.2-1: Requirements for the description of VNF Package content

Req Number	Requirement Description	Comments
VNF_PACK.DESC.001	The VNF Package shall contain the license terms information under which the packaged VNF is released.	
VNF_PACK.DESC.002	The VNF Package should contain other license terms information corresponding with all the components included in the package if different than the one of the VNF.	
iVNF_PACK.DESC.003	The VNF Package should contain a Change Log. Change log captures the changes from one version to another including but not limited to features added/removed, issues fixed as well as known issues not resolved.	
VNF_PACK.DESC.004	VNF Package shall contain or reference one or more software images.	
VNF_PACK.DESC.005	The VNF Package may contain at most one software image per VNFC.	In case different virtualisation environments require different SW images of a VNFC they will be delivered in separate VNF Packages.
VNF_PACK.DESC.006	The VNF Package shall provide a mechanism to describe the package and its contents including, not limited to, version of the package, provider of the package and identification of the included metadata/artefacts.	
VNF_PACK.DESC.007	The VNF Package shall contain VNFD metadata.	
VNF_PACK.DESC.008	VNFD metadata shall not be modified once the package is assembled.	
VNF_PACK.DESC.009	VNFD metadata shall be placed in a well-known location within the VNF Package in order for the compliant parsers to find and extract.	

6.2.3 Requirements for VNF Identification

Proper VNF Identification is required across the VNF lifecycle from development to retirement/decommission.

Table 6.2.3-1 specifies requirements applicable to the VNF identification.

Table 6.2.3-1: Requirements for the VNF Identification

Req Number	Requirement Description	Comments
VNF_PACK.ID.001	There shall be a way to identify the version of the VNF Package Specification associated with a particular VNF.	This should guarantee compliance with the spec and allow systems parsing the metadata in the template to associate data elements with schema definition for compatibility reasons.
VNF_PACK.ID.002	VNF Package shall be globally uniquely identifiable. The globally unique identifier for the VNF Package shall be used to uniquely identify the VNFD and the VNF included in the package.	The unique identification is needed by the service provider for onboarding, operations and in order to properly associate subsequent upgrades, patches and fixes delivered to the service provider.

Req Number	Requirement Description	Comments
VNF_PACK.ID.003	VNF Package Identification Metadata shall contain: • VNF Provider. • VNF Product name. • VNF Release Date/Time. • VNF Package Version (version of the VNF release).	This is similar to current asset management practices for physical equipment by Make, Model and version.
VNF.PACK.ID.004	VNF Product Name and VNF Provider shall not be changed throughout the lifespan of the VNF. This is to aid with correlation between different versions of a VNF with the same code base.	VNF lifespan is defined and set by the VNF Provider on a case by case basis considering the product management, portfolio roadmap or any other commercially related factors.

6.2.4 Requirements for security and integrity of a VNF Package

Table 6.2.4-1 specifies the requirements applicable to the security and integrity of a VNF Package.

Table 6.2.4-1: Requirements for security and integrity of a VNF Package

Req Number	Requirement Description	Comments
VNF_PACK.SEC.001	The digest and the public key of the entity signing VNF Package shall be included in the package along with the corresponding certificate.	
VNF_PACK.SEC.002	For each signed artefact, corresponding public key, algorithm and certificate used shall be stored in a well-known location within the VNF Package.	
VNF_PACK.SEC.003	Security sensitive artefacts shall be encrypted. Encryption keys for these artefacts should be different than the VNF Package key to allow for better access control within the provider environment.	

6.2.5 Requirements for VNFD Metadata

Table 6.2.5-1 specifies requirements applicable to VNFD metadata.

Table 6.2.5-1: Requirements for VNFD Metadata

Req Number	Requirement Description	Comments
VNF_PACK.META.001	The VNFD shall support a description of deployment policies.	
VNF_PACK.META.002	The VNFD shall support a description of required virtualisation containers in terms of e.g. amount, characteristics and capabilities for virtual CPUs and virtual RAM and virtual disks.	
VNF_PACK.META.003	The description of a virtualisation container in the VNFD shall support a description of attached additional virtual devices and their characteristics and capabilities.	The description of additional virtual devices may include, but is not limited to, virtual CDROM drives, virtual NICs and special configuration drives.
VNF_PACK.META.004	The description of a virtualisation container in the VNFD shall support a description of acceleration capabilities and characteristics.	The description of acceleration capabilities may include, but is not limited to, crypto, video transcoding, or RDMA.
VNF_PACK.META.005	The VNFD shall support a description of the minimum and maximum number of instances of each particular virtualisation container that conform to the VNF.	

Req Number	Requirement Description	Comments
VNF_PACK.META.006	The VNFD shall support a description of the VNF internal connectivity, including the connectivity between virtualisation containers, and associated connectivity resource requirements.	
VNF_PACK.META.007	The VNFD shall support a description of one or more DFs to choose a particular variant of the VNF to be instantiated.	
VNF_PACK.META.008	The VNFD shall support a description of parameters which can be monitored for the VNF after instantiation.	
VNF_PACK.META.009	The VNFD shall support a description of parameters which can be configured for the VNF and whether the parameters can be configured after VNF instantiation.	The parameters may be combined with default values.
VNF_PACK.META.010	The VNFD shall support a description of lifecycle events and related actions which can be performed for the VNF.	
VNF_PACK.META.011	The VNFD shall support a description of metadata about the VNF product.	The metadata shall include, but is not limited to, name, version, unique identifier and provider name of the VNF.
VNF_PACK.META.012	The VNFD shall support a description of metadata about placement of virtualisation containers relative to each other.	Placement may include, but is not limited to, affinity or anti-affinity.
VNF_PACK.META.013	The VNFD shall support a description of the supported VNF instance scaling.	
VNF_PACK.META.014	The VNFD shall support a description of rules for auto-scaling describing which actions shall be executed if a threshold for a monitoring parameter is crossed.	An action may be the trigger of a lifecycle event or an alarm.
VNF_PACK.META.015	The VNFD shall support a description of metadata to determine if an EM is used for the VNF and parameters describing how to connect to the EM.	Deployment specific information e.g. the IP address of the EM may be specified using instantiation specific parameters (see VNF_PACK.META.018).
VNF_PACK.META.016	The VNFD shall support a description of metadata about dependencies between virtualisation containers.	Dependencies may include, but is not limited to existence of a dependency.
VNF_PACK.META.017	The VNFD shall support a description of Service Availability Level (SAL) requirements for virtual resources on the underlying NFVI.	SAL requirements may be described for a VNF as well as for individual VDUs.
VNF_PACK.META.018	The VNFD shall support a description of parameters whose values have to be specified as input to the instantiation process.	
VNF_PACK.META.019	The VNFD shall support metadata related to network addresses to be assigned to Connection Point(s) (CP).	For example the metadata for layer 3 network addresses can include IP address type, range, and allocation scheme.
VNF_PACK.META.020	The VNFD shall support the description of VNF indicators.	See note.
VNF_PACK.META.021	The VNFD shall support a description of external CP supported by the VNF enabling connectivity with one or more external entities.	
VNF_PACK.META.022	The description of a virtualisation container in a VNFD shall support a description of meta data about software image(s).	
VNF_PACK.META.023	The VNFD shall provide the possibility to reference information elements via URLs e.g. to external files provided by the VNF provider.	
VNF_PACK.META.024	The VNFD shall provide a reference to the VNFM(s) compatible with the VNF described in the VNFD.	
NOTE: VNF Indicators are information supplied by the VNF or the EM to provide some indication on the VNF behaviour. VNFM can use these indicators in conjunction with virtualised resource data to perform auto-scaling decisions or to trigger a VNF LCM script.		
DISCLAIMER: Not all listed requirements are supported by the information elements specified in clause 7.		

6.2.6 Requirements for LCM scripts

6.2.6.1 General

Table 6.2.6.1-1 specifies requirements for life cycle management (LCM) scripts.

Table 6.2.6.1-1: Requirements for LCM scripts

Req Number	Requirement Description	Comments
VNF_PACK.LCM.001	LCM scripts embedded in the VNF Package and to be used in the LCM execution environments provided by generic VNF Managers shall be specified using a Domain Specific Language (DSL) that fulfils the requirements specified in the following clauses.	See note.
NOTE: The specification of a DSL fulfilling the requirements specified in the following clauses is outside the scope of the present document.		

6.2.6.2 Requirements for DSL

Table 6.2.6.2-1 specifies requirements that shall be fulfilled by the DSL used to specify lifecycle management scripts embedded in the VNF Package.

Table 6.2.6.2-1: DSL requirements for LCM scripts

Req Number	Requirement Description	Comments
VNF_PACK.LCMDSL.001	The DSL shall support arithmetic, comparison and logical operators defined in ISO/IEC 9899 [i.6].	
VNF_PACK.LCMDSL.002	The DSL shall support expressing policy rules associating conditions with actions.	
VNF_PACK.LCMDSL.003	The DSL shall enable expressing a condition that is the receipt of a request invoking one of the operations of the VNF Lifecycle Management interface.	
VNF_PACK.LCMDSL.004	The DSL shall enable expressing a condition that is the receipt of a notification.	
VNF_PACK.LCMDSL.007	The DSL shall enable expressing conditions on the values of the parameters of an operation request.	
VNF_PACK.LCMDSL.008	The DSL shall enable using extended regular expressions to express conditions on the values of the parameters of an operation request. See example.	
VNF_PACK.LCMDSL.009	The DSL shall enable expressing as a condition the detection that the value of an internal variable used by the script is equal, greater or less than a threshold defined by the script.	
VNF_PACK.LCMDSL.010	The DSL shall enable expressing actions leading to setting, incrementing and decreasing internal variables.	

Req Number	Requirement Description	Comments
VNF_PACK.LCMDSL.011	The DSL shall enable expressing actions leading to: • Invoke an operation of the Software Image Management interface; • Invoke an operation of the Virtualised Resources Information Management interface; • Invoke an operation of the Virtualised Resource Management interface; • Invoke an operation of the Virtualised Resources Change Notification interface; • Invoke an operation of the Virtualised Resources Reservation Management interface; • Invoke an operation of the Virtualised Resources Performance Management interface; and • Invoke an operation of the Virtualised Resources Fault Management interface; • Invoke an operation of the VNF Configuration interface; • Invoke an operation of the VNF Indicator interface; and • Invoke an operation of the VNF Lifecycle Operation Granting interface. See note 2.	
VNF_PACK.LCMDSL.012	The DSL shall enable mapping LCM script variables on to: • Parameters of the VNFD; • Parameters of operation requests and results.	
VNF_PACK.LCMDSL.013	The DSL shall enable a LCM script to access arbitrary artefacts in the VNF Package.	
NOTE 1: The DSL does not provide means to specify where to send the operation request. The VNFM script execution environment will determine where to send the operation request based on local policies and/or information received from the NFVO. NOTE 2: Operations that can be invoked correspond to operations specified in ETSI GS NFV-IFA 006 [i.2], ETSI GS NFV-IFA 007 [i.3], and ETSI GS NFV-IFA 008 [i.4], where the VNFM acts as request consumer.		
EXAMPLE: Assuming the case that virtualised container instances have an attribute "name" and there are two instances named "boba" and "bobb", while listing virtualised container instances information, usage of the regular expression "bob." would request the producer to return information from instances named "boba" and "bobb".		

7 Virtualised Network Function information elements

7.1 VNF Descriptor (VNFD)

7.1.1 Introduction

The clauses below define the information elements related to the VNFD. A UML representation of the VNFD high-level structure is shown in figure 7.1.1-1.

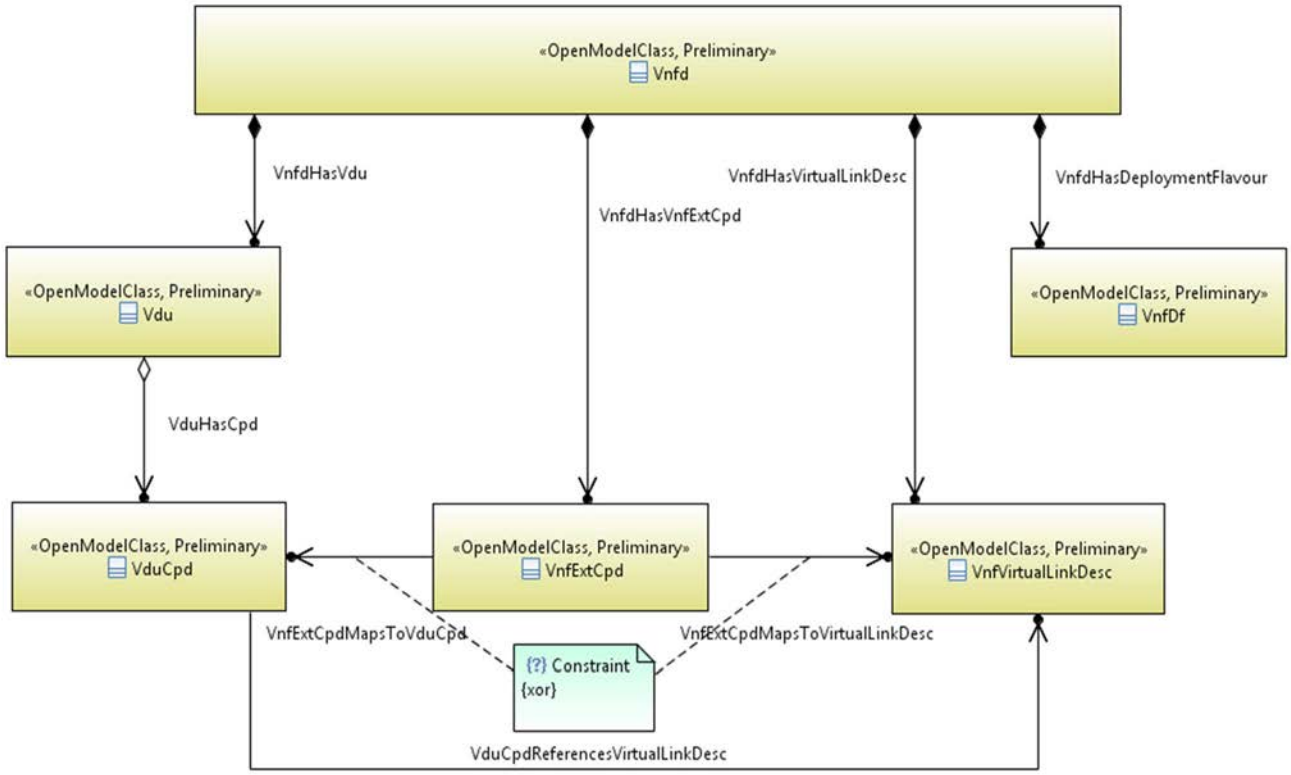

Figure 7.1.1-1: VNFD high-level structure

7.1.2 VNFD information element

7.1.2.1 Description

A VNFD is a deployment template which describes a VNF in terms of deployment and operational behaviour requirements. It also contains connectivity, interface and virtualised resource requirements.

7.1.2.2 Attributes

The attributes of the VNFD information element shall follow the indications provided in table 7.1.2.2-1.

Table 7.1.2.2-1: Attributes of the VNFD information element

Attribute	Qualifier	Cardinality	Content	Description
vnfdId	M	1	Identifier	Identifier of this VNFD information element. This attribute shall be globally unique. The format will be defined in the data model specification phase. See note 1.
vnfProvider	M	1	String	Provider of the VNF and of the VNFD.
vnfProductName	M	1	String	Name to identify the VNF Product. Invariant for the VNF Product lifetime.
vnfSoftwareVersion	M	1	Version	Software version of the VNF. This is changed when there is any change to the software that is included in the VNF Package.
vnfdVersion	M	1	Version	Identifies the version of the VNFD.
vnfProductInfoName	M	0..1	String	Human readable name for the VNF Product. Can change during the VNF Product lifetime.

Attribute	Qualifier	Cardinality	Content	Description
vnfProductInfoDescription	M	0..1	String	Human readable description of the VNF Product. Can change during the VNF Product lifetime.
vnfmInfo	M	1..N	String	Identifies VNFM(s) compatible with the VNF described in this version of the VNFD.
localizationLanguage	M	0..N	Not specified	Information about localization languages of the VNF (includes e.g. strings in the VNFD). See note 4.
defaultLocalizationLanguage	M	0..1	Not specified	Default localization language that is instantiated if no information about selected localization language is available. Shall be present if "localizationLanguage" is present and shall be absent otherwise.
vdu	M	1..N	Vdu	Virtualisation Deployment Unit. See clause 7.1.6.
virtualComputeDesc	M	0..N	VirtualComputeDesc	Defines descriptors of virtual compute resources to be used by the VNF. See clause 7.1.9.2.2.
virtualStorageDesc	M	0..N	VirtualStorageDesc	Defines descriptors of virtual storage resources to be used by the VNF. See clause 7.1.9.4.2.
intVirtualLinkDesc	M	0..N	VnfVirtualLinkDesc	Represents the type of network connectivity mandated by the VNF provider between two or more CPs which includes at least one internal CP. See clause 7.1.7.
vnfExtCpd	M	1..N	VnfExtCpd	Describes external interface(s) exposed by this VNF enabling connection with a VL. See clause 7.1.3.
deploymentFlavour	M	1..N	VnfDf	Describes specific DF(s) of a VNF with specific requirements for capacity and performance. See clause 7.1.8.
configurableProperties	M	0..1	VnfConfigurableProperties	Describes the configurable properties of the VNF (e.g. related to auto scaling and auto healing). See clause 7.1.12.
modifiableAttributes	M	1	VnfInfoModifiableAttributes	Describes the modifiable attributes of the VNF. See clause 7.1.14.
lifeCycleManagementScript	M	0..N	LifeCycleManagementScript	Includes a list of events and corresponding management scripts performed for the VNF. See clause 7.1.13.
elementGroup	M	0..N	VnfdElementGroup	Describes the associated elements of a VNFD for a certain purpose during VNF lifecycle management. See clause 7.1.4.
vnfIndicator	M	0..N	VnfIndicator	Declares the VNF indicators that are supported by this VNF.
autoScale	M	0..N	Rule	Rule that determines when a scaling action needs to be triggered on a VNF instance e.g. based on certain VNF indicator values or VNF indicator value changes or a combination of VNF indicator value(s) and monitoring parameter(s). See notes 2 and 3.

NOTE 1: The VNFD Identifier shall be used as the unique identifier of the VNF Package that contains this VNFD. Any modification of the content of the VNFD or the VNF Package shall result in a new VNFD Identifier.
NOTE 2: Monitoring parameters are specified as part of VNF flavour, VDU and VL descriptions.
NOTE 3: The rule (conditions and actions) can be expressed as a script.
NOTE 4: This allows to provide one or more localization languages to support selecting a specific localization language at VNF instantiation time.

7.1.3 Information elements related to VnfExtCpd

7.1.3.1 Introduction

The clauses below define the information elements related to the VnfExtCpd.

7.1.3.2 VnfExtCpd information element

7.1.3.2.1 Description

A VnfExtCpd is a type of Cpd and describes an external interface, a.k.a external CP, exposed by this VNF enabling connection with a VL.

A VnfExtCpd inherits from the Cpd Class (see clause 7.1.6.3). All attributes of the Cpd are also attributes of the VnfExtCpd.

When the VnfExtCpd is mapped to a VduCpd, the values for the attributes type, subType and description shall be identical for both elements.

7.1.3.2.2 Attributes

The attributes of the VnfExtCpd information element shall follow the indications provided in table 7.1.3.2.2-1.

Table 7.1.3.2.2-1: Attributes of the VnfExtCpd information element

Attribute	Qualifier	Cardinality	Content	Description
intVirtualLinkDesc	M	0..1	Identifier (Reference to VnfVirtualLinkDesc)	Reference to the internal Virtual Link Descriptor (VLD) to which CPs instantiated from this external CP Descriptor (CPD) connect. Either intVirtualLinkDesc or intCpd shall be present.
intCpd	M	0..1	Identifier (Reference to VduCpd)	Reference to the internal VDU CPD which is used to instantiate internal CPs. These internal CPs are, in turn, exposed as external CPs defined by this external CPD. Either intVirtualLinkDesc or intCpd shall be present.
virtualNetworkInterfaceRequirements	M	0..N	VirtualNetworkInterface Requirements	Specifies requirements on a virtual network interface realising the CPs instantiated from this CPD.
(inherited attributes)				All attributes inherited from Cpd.

7.1.3.3 AddressData information element

7.1.3.3.1 Description

The AddressData information element supports providing information about the addressing scheme and parameters applicable to a CP.

7.1.3.3.2 Attributes

The attributes of the AddressData information element shall follow the indications provided in table 7.1.3.3.2-1.

Table 7.1.3.3.2-1: Attributes of the AddressData information element

Attribute	Qualifier	Cardinality	Content	Description
addressType	M	1	Enum	Describes the type of the address to be assigned to the CP instantiated from the parent CPD. Value: • MAC address. • IP address. • … The content type shall be aligned with the address type supported by the layerProtocol attribute of the parent CPD.
l2AddressData	M	0..1	Not specified	Provides the information on the MAC addresses to be assigned to the CP(s) instantiated from the parent CPD. Shall be present when the addressType is MAC address.
l3AddressData	M	0..1	L3AddressData	Provides the information on the IP addresses to be assigned to the CP instantiated from the parent CPD. Shall be present when the addressType is IP address. See clause 7.1.3.3.1.

7.1.3.4 L3AddressData information element

7.1.3.4.1 Description

The L3AddressData information element supports providing information about Layer 3 level addressing scheme and parameters applicable to a CP.

7.1.3.4.2 Attributes

The attributes of the L3AddressData information element shall follow the indications provided in table 7.1.3.4.2-1.

Table 7.1.3.4.2-1: Attributes of the L3AddressData information element

Attribute	Qualifier	Cardinality	Content	Description
iPAddressAssignment	M	1	Boolean	Specify if the address assignment is the responsibility of management and orchestration function or not. If it is set to True, it is the management and orchestration function responsibility.
floatingIpActivated	M	1	Boolean	Specify if the floating IP scheme is activated on the CP or not.
iPAddressType	M	0..1	Enum	Define address type. Value: • IPv4 address. • IPv6 address. See note.
numberOfIpAddress	M	0..1	Integer	Minimum number of IP addresses to be assigned based on this L3AddressData information element.
NOTE: The address type should be aligned with the address type supported by the layerProtocol attribute of the parent VnfExtCpd.				

7.1.4 VnfdElementGroup information element

7.1.4.1 Description

A VNFD Element Group is a mechanism for associating elements of a VNFD (Vdus and VnfVirtualLinkDesc(s)) for a certain purpose, for example, scaling aspects.

A given element can belong to multiple groups.

7.1.4.2 Attributes

The attributes of the VnfdElementGroup information element shall follow the indications provided in table 7.1.4.2-1.

Table 7.1.4.2-1: Attributes of the VnfdElementGroup information element

Attribute	Qualifier	Cardinality	Content	Description
vnfdElementGroupId	M	1	Identifier	Unique identifier of this group in the VNFD.
description	M	1	String	Human readable description of the group.
vdu	M	0..N	Identifier (Reference to Vdu)	References to Vdus that are part of this group.
virtualLinkDesc	M	0..N	Identifier (Reference to VnfVirtualLinkDesc)	References to VnfVirtualLinkDesc that are part of this group.

7.1.5 Information elements related to the configuration of VNF lifecycle management operations

7.1.5.1 Introduction

This clause defines information elements which represent information to configure lifecycle management operations as specified in ETSI GS NFV-IFA 007 [i.3].

7.1.5.2 VnfLcmOperationsConfiguration information element

7.1.5.2.1 Description

This information element is a container for all attributes that affect the invocation of the VNF Lifecycle Management operations, structured by operation.

7.1.5.2.2 Attributes

The VnfLcmOperationsConfiguration information element shall follow the indications provided in table 7.1.5.2.2-1.

7.1.5.2.2-1: Attributes of the VnfLcmOperationsConfiguration information element

Attribute	Qualifier	Cardinality	Content	Description
instantiateVnfOpConfig	M	0..1	InstantiateVnfOpConfig	Configuration parameters for the InstantiateVnf operation.
scaleVnfOpConfig	M	0..1	ScaleVnfOpConfig	Configuration parameters for the ScaleVnf operation.
scaleVnfToLevelOpConfig	M	0..1	ScaleVnfToLevelOpConfig	Configuration parameters for the ScaleVnfToLevel operation.
healVnfOpConfig	M	0..1	HealVnfOpConfig	Configuration parameters for the HealVnf operation.
terminateVnfOpConfig	M	0..1	TerminateVnfOpConfig	Configuration parameters for the TerminateVnf operation.
operateVnfOpConfig	M	0..1	OperateVnfOpConfig	Configuration parameters for the OperateVnf operation.

7.1.5.3 InstantiateVnfOpConfig information element

7.1.5.3.1 Description

This information element defines attributes that affect the invocation of the InstantiateVnf operation.

7.1.5.3.2 Attributes

The InstantiateVnfOpConfig information element shall follow the indications provided in table 7.1.5.3.2-1.

Table 7.1.5.3.2-1: Attributes of the InstantiateVnfOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
parameter	M	0..N	Not specified	VNF-specific parameter to be passed when invoking the InstantiateVnf operation.

7.1.5.4 ScaleVnfOpConfig information element

7.1.5.4.1 Description

This information element defines attributes that affect the invocation of the ScaleVnf operation.

7.1.5.4.2 Attributes

The ScaleVnfOpConfig information element shall follow the indications provided in table 7.1.5.4.2-1.

Table 7.1.5.4.2-1: Attributes of the ScaleVnfOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
parameter	M	0..N	Not specified	VNF-specific parameter to be passed when invoking the ScaleVnf operation.
scalingByMoreThanOneStepSupported	M	0..1	Boolean	Signals whether passing a value larger than one in the numScalingSteps parameter of the ScaleVnf operation is supported by this VNF. Default is FALSE, i.e. "not supported".

7.1.5.5 ScaleVnfToLevelOpConfig information element

7.1.5.5.1 Description

This information element defines attributes that affect the invocation of the ScaleVnfToLevel operation.

7.1.5.5.2 Attributes

The ScaleVnfToLevelOpConfig information element shall follow the indications provided in table 7.1.5.5.2-1.

Table 7.1.5.5.2-1: Attributes of the ScaleVnfToLevelOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
parameter	M	0..N	Not specified	VNF-specific parameter to be passed when invoking the ScaleVnfToLevel operation.
arbitraryTargetLevelsSupported	M	1	Boolean	Signals whether scaling according to the parameter "scaleInfo" is supported by this VNF.

7.1.5.6 HealVnfOpConfig information element

7.1.5.6.1 Description

This information element defines attributes that affect the invocation of the HealVnf operation.

7.1.5.6.2 Attributes

The HealVnfOpConfig information element shall follow the indications provided in table 7.1.5.6.2-1.

Table 7.1.5.6.2-1: Attributes of the HealVnfOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
parameter	M	0..N	Not specified	VNF-specific parameter to be passed when invoking the HealVnf operation.
cause	M	0..N	String	Supported "cause" parameter values.

7.1.5.7 TerminateVnfOpConfig information element

7.1.5.7.1 Description

This information element defines attributes that affect the invocation of the TerminateVnf operation.

7.1.5.7.2 Attributes

The TerminateVnfOpConfig information element shall follow the indications provided in table 7.1.5.7.2-1.

Table 7.1.5.7.2-1: Attributes of the TerminateVnfOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
minGracefulTermination Timeout	M	1	Number	Minimum timeout value for graceful termination of a VNF instance.
maxRecommendedGracefulTermination timeout	M	0..1	Number	Maximum recommended timeout value that can be needed to gracefully terminate a VNF instance of a particular type under certain conditions, such as maximum load condition. This is provided by VNF provider as information for the operator facilitating the selection of optimal timeout value. This value is not used as constraint.

7.1.5.8 OperateVnfOpConfig information element

7.1.5.8.1 Description

This information element defines attributes that affect the invocation of the OperateVnf operation.

7.1.5.8.2 Attributes

The OperateVnfOpConfig information element shall follow the indications provided in table 7.1.5.8.2-1.

Table 7.1.5.8.2-1: Attributes of the OperateVnfOpConfig information element

Attribute	Qualifier	Cardinality	Content	Description
minGracefulStopTimeout	M	1	Number	Minimum timeout value for graceful stop of a VNF instance.
maxRecommendedGracefulStopTimeout	M	0..1	Number	Maximum recommended timeout value that can be needed to gracefully stop a VNF instance of a particular type under certain conditions, such as maximum load condition. This is provided by VNF provider as information for the operator facilitating the selection of optimal timeout value. This value is not used as constraint.

7.1.6 Information elements related to the Vdu

7.1.6.1 Introduction

The clauses below define the information elements related to the Vdu.

7.1.6.2 Vdu information element

7.1.6.2.1 Description

The Virtualisation Deployment Unit (VDU) is a construct supporting the description of the deployment and operational behaviour of a VNFC.

A VNFC instance created based on the VDU maps to a single virtualisation container (e.g. a VM).

A UML representation of the Vdu high-level structure is shown in figure 7.1.6.2.1-1.

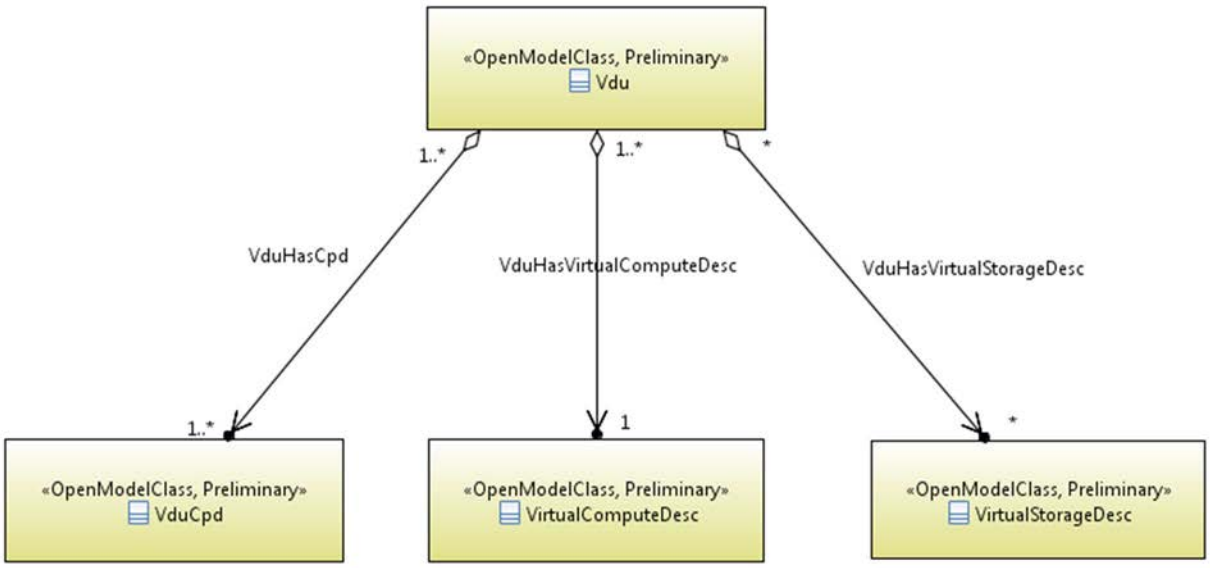

Figure 7.1.6.2.1-1: Vdu deployment view

7.1.6.2.2 Attributes

The attributes of the Vdu information element shall follow the indications provided in table 7.1.6.2.2-1.

Table 7.1.6.2.2-1: Attributes of the Vdu information element

Attribute	Qualifier	Cardinality	Content	Description
vduId	M	1	Identifier	Unique identifier of this Vdu in VNFD.
name	M	1	String	Human readable name of the Vdu.
description	M	1	String	Human readable description of the Vdu.
intCpd	M	1..N	VduCpd	Describes network connectivity between a VNFC instance (based on this Vdu) and an internal Virtual Link (VL). See clause 7.1.6.4.
virtualComputeDesc	M	1	Identifier (reference to VirtualComputeDesc)	Describes CPU, Memory and acceleration requirements of the Virtualisation Container realizing this Vdu. See clause 7.1.9.2.2.
virtualStorageDesc	M	0..N	Identifier (reference to VirtualStorageDesc)	Describes storage requirements for a VirtualStorage instance attached to the virtualisation container created from virtualComputeDesc defined for this Vdu. See clause 7.1.9.4.
bootOrder	M	0..N	KeyValuePair	The key indicates the boot index (lowest index defines highest boot priority). The Value references a descriptor from which a valid boot device is created e.g. VirtualStorageDesc from which a VirtualStorage instance is created. See note 1.
swImageDesc	M	0..1	SwImageDesc	Describes the software image which is directly loaded on the virtualisation container realizing this Vdu. See clause 7.1.6.5. See note 2.
nfviConstraint	M	0..N	String	Describes constraints on the NFVI for the VNFC instance(s) created from this Vdu. For example, aspects of a secure hosting environment for the VNFC instance that involve additional entities or processes. See note 3.
monitoringParameter	M	0..N	MonitoringParameter	Defines the virtualised resources monitoring parameters on VDU level. MonitoringParameter is defined in clause 7.1.11.3.
configurableProperties	M	1	VnfcConfigurableProperties	Describes the configurable properties of all VNFC instances based on this VDU. See clause 7.1.6.7.

NOTE 1: If no boot order is defined the default boot order defined in the VIM or NFVI shall be used.
NOTE 2: More software images can be attached to the virtualisation container using VirtualStorage resources. See clause 7.1.9.4.
NOTE 3: These are constraints other than stipulating that a VNFC instance has access to a certain resource, as a prerequisite to instantiation. The attributes virtualComputeDesc and virtualStorageDesc define the resources required for instantiation of the VNFC instance.

7.1.6.3 Cpd information element

7.1.6.3.1 Description

A Cpd information element describes network connectivity to a compute resource or a VL. This is an abstract class used as parent for the various Cpd classes.

7.1.6.3.2 Attributes

The attributes of the Cpd information element shall follow the indications provided in table 7.1.6.3.2-1.

Table 7.1.6.3.2-1: Attributes of the Cpd information element

Attribute	Qualifier	Cardinality	Content	Description
cpdId	M	1	Identifier	Identifier of this Cpd information element.
layerProtocol	M	1	Enum	Identifies which protocol the CP uses for connectivity purposes (Ethernet, MPLS, ODU2, IPV4, IPV6, Pseudo-Wire, etc.). See note.
cpRole	M	0..1	String	Identifies the role of the port in the context of the traffic flow patterns in the VNF or parent NS. For example a VNF with a tree flow pattern within the VNF will have legal cpRoles of ROOT and LEAF.
description	M	0..1	String	Provides human-readable information on the purpose of the CP (e.g. CP for control plane traffic).
addressData	M	0..N	AddressData	Provides information on the addresses to be assigned to the CP(s) instantiated from this CPD.
NOTE: This information determines, amongst other things, which type of address to assign to the access point at instantiation time.				

7.1.6.4 VduCpd information element

7.1.6.4.1 Description

A VduCpd information element is a type of Cpd and describes network connectivity between a VNFC instance (based on this VDU) and an internal VL.

A VduCpd inherits from the Cpd Class (see clause 7.1.6.3). All attributes of the Cpd are also attributes of the VduCpd.

7.1.6.4.2 Attributes

The attributes of the VduCpd information element shall follow the indications provided in table 7.1.6.4.2-1.

Table 7.1.6.4.2-1: Attributes of the VduCpd information element

Attribute	Qualifier	Cardinality	Content	Description
intVirtualLinkDesc	M	0..1	Identifier (Reference to VnfVirtualLinkDesc)	Reference of the internal VLD which this internal CPD connects to.
bitrateRequirement	M	0..1	Number	Bitrate requirement on this CP.
virtualNetworkInterfaceRequirements	M	0..N	VirtualNetworkInterfaceRequirements	Specifies requirements on a virtual network interface realising the CPs instantiated from this CPD.
(inherited attributes)				All attributes inherited from Cpd.

7.1.6.5 SwImageDesc information element

7.1.6.5.1 Description

This information element describes requested additional capability for a particular VDU. Such a capability may be for acceleration or specific tasks.

7.1.6.5.2 Attributes

The attributes of the RequestedAdditionalCapabilityData information element shall follow the indications provided in table 7.1.6.5.2-1.

Table 7.1.6.5.2-1: Attributes of the SwImageDesc information element

Attribute	Qualifier	Cardinality	Content	Description
id	M	1	Identifier	The identifier of this software image.
name	M	1	String	The name of this software image.
version	M	1	String	The version of this software image.
checksum	M	1	String	The checksum of the software image file.
containerFormat	M	1	String	The container format describes the container file format in which software image is provided.
diskFormat	M	1	String	The disk format of a software image is the format of the underlying disk image.
minDisk	M	1	Number	The minimal disk size requirement for this software image. The value of the "size of storage" attribute of the VirtualStorageDesc referencing this SwImageDesc shall not be smaller than the value of minDisk.
minRam	M	0..1	Number	The minimal RAM requirement for this software image. The value of the "size" attribute of VirtualMemoryData of the Vdu referencing this SwImageDesc shall not be smaller than the value of minRam.
size	M	1	Number	The size of this software image.
swImage	M	1	Identifier (Reference to a SwImage)	This is a reference to the actual software image. The reference can be relative to the root of the VNF Package or can be a URL.
operatingSystem	M	0..1	String	Identifies the operating system used in the software image. This attribute may also identify if a 32 bit or 64 bit software image is used.
supportedVirtualisationEnvironment	M	0..N	String	Identifies the virtualisation environments (e.g. hypervisor) compatible with this software image.

7.1.6.6 VirtualNetworkInterfaceRequirements information element

7.1.6.6.1 Description

This information element specifies requirements on a virtual network interface.

7.1.6.6.2 Attributes

The attributes of the VirtualNetworkInterfaceRequirements information element shall follow the indications provided in table 7.1.6.6.2-1.

Table 7.1.6.6.2-1: Attributes of the VirtualNetworkInterfaceRequirements information element

Attribute	Qualifier	Cardinality	Content	Description
name	M	0..1	String	Provides a human readable name for the requirement.
description	M	0..1	String	Provides a human readable description of the requirement.
supportMandatory	M	1	Boolean	Indicates whether fulfilling the constraint is mandatory (TRUE) for successful operation or desirable (FALSE).
requirement	M	1	Not specified	Specifies a requirement such as the support of SR-IOV, a particular data plane acceleration library, an API to be exposed by a NIC, etc.

7.1.6.7 VnfcConfigurableProperties information element

7.1.6.7.1 Description

This information element defines the configurable properties of a VNFC. For a VNFC instance, the value of these properties can be modified through the VNFM.

7.1.6.7.2 Attributes

The attributes of the VnfcConfigurableProperties information element shall follow the indications provided in table 7.1.6.7.2-1.

Table 7.1.6.7.2-1: Attributes of the VnfcConfigurableProperties information element

Attribute	Qualifier	Cardinality	Content	Description
additionalVnfcConfigurableProperty	M	0..N		It provides VNFC configurable properties.

7.1.7 Information elements related to the VLD

7.1.7.1 Introduction

The clauses below define the information elements related to the VLD.

7.1.7.2 VnfVirtualLinkDesc information element

7.1.7.2.1 Description

The VnfVirtualLinkDesc information element supports providing information about an internal VNF VL.

7.1.7.2.2 Attributes

The attributes of the VnfVirtualLinkDesc information element shall follow the indications provided in table 7.1.7.2.2-1.

Table 7.1.7.2.2-1: Attributes of the VnfVirtualLinkDesc information element

Attribute	Qualifier	Cardinality	Content	Description
virtualLinkDescId	M	1	Identifier	Unique identifier of this internal VLD in VNFD.
virtualLinkDescFlavour	M	1..N	VirtualLinkDescFlavour	Describes a specific flavour of the VL with specific bitrate requirements. See clause 7.1.8.5.
connectivityType	M	1	ConnectivityType	See clause 7.1.7.3.
testAccess	M	0..N	String	Specifies test access facilities expected on the VL (e.g. none, passive monitoring, or active (intrusive) loopbacks at endpoints.
description	M	0..1	String	Provides human-readable information on the purpose of the VL (e.g. control plane traffic).
monitoringParameter	M	0..N	MonitoringParameter	Defines the virtualised resources monitoring parameters on VLD level. MonitoringParameter is defined in clause 7.1.11.3.

7.1.7.3 ConnectivityType information element

7.1.7.3.1 Description

The contents of a ConnectivityType type shall comply with the indications provided in table 7.1.7.3.2-1.

7.1.7.3.2 Attributes

The attributes of the ConnectivityType information element shall follow the indications provided in table 7.1.7.3.2-1.

Table 7.1.7.3.2-1: Attributes of the ConnectivityType information element

Attribute	Qualifier	Cardinality	Content	Description
layerProtocol	M	1	Enum	Identifies the protocol this VL gives access to (Ethernet, MPLS, ODU2, IPV4, IPV6, Pseudo-Wire).
flowPattern	M	0..1	String	Identifies the flow pattern of the connectivity (Line, Tree, Mesh).

7.1.8 Information elements related to the DeploymentFlavour

7.1.8.1 Introduction

The clauses below define the information elements related to the DF.

7.1.8.2 VnfDf information element

7.1.8.2.1 Description

The VnfDf describes a specific deployment version of a VNF.

7.1.8.2.2 Attributes

The attributes of the VnfDf information element shall follow the indications provided in table 7.1.8.2.2-1.

Table 7.1.8.2.2-1: Attributes of the VnfDf information element

Attribute	Qualifier	Cardinality	Content	Description
flavourId	M	1	Identifier	Identifier of this DF within the VNFD.
description	M	1	String	Human readable description of the DF.
vduProfile	M	1..N	VduProfile	Describes additional instantiation data for the VDUs used in this flavour.
virtualLinkProfile	M	0..N	VirtualLinkProfile	Defines the internal VLD along with additional data which is used in this DF. See notes 1 and 2.
instantiationLevel	M	1..N	InstantiationLevel	Describes the various levels of resources that can be used to instantiate the VNF using this flavour. Examples: Small, Medium, Large. If there is only one "instantiationLevel" entry, it shall be treated as the default instantiation level for this DF.
defaultInstantiationLevelId	M	0..1	Identifier	This attribute references the "instantiationLevel" entry which defines the default instantiation level for this DF. It shall be present if there are multiple "instantiationLevel" entries.
supportedOperation	M	0..N	Enum	Indicates which operations are available for this DF via the VNF LCM interface. Instantiate VNF, Query VNF and Terminate VNF are supported in all DF and therefore need not be included in this list.
vnfLcmOperationsConfiguration	M	1	VnfLcmOperationsConfiguration	Configuration parameters for the VNF Lifecycle Management operations.
affinityOrAntiAffinityGroup	M	0..N	AffinityOrAntiAffinityGroup	Specifies affinity or anti-affinity relationship applicable between the virtualisation containers (e.g. virtual machines) to be created using different VDUs or internal VLs to be created using different VnfVirtualLinkDesc(s) in the same affinity or anti-affinity group. See clause 7.1.8.12. (See note)
monitoringParameter	M	0..N	MonitoringParameter	Defines the virtualised resources monitoring parameters on VNF level. MonitoringParameter is defined in clause 7.1.11.3.
scalingAspect	M	0..N	ScalingAspect	The scaling aspects supported by this DF of the VNF. scalingAspect shall be present if the VNF supports scaling.

NOTE 1: This allows for different VNF internal topologies between DFs.
NOTE 2: virtualLinkProfile needs to be provided for all VLs that the CPs of the VDUs in the VDU profiles connect to.
NOTE 3: In the present specification, including either VDU(s) or VnfVirtualLinkDesc(s) into the same affinity or anti-affinity group is supported. Extension to support including both VDU(s) and VnfVirtualLinkDesc(s) into the same affinity or anti-affinity group is left for future specification.

7.1.8.3 VduProfile information element

7.1.8.3.1 Description

The VduProfile describes additional instantiation data for a given VDU used in a DF.

7.1.8.3.2 Attributes

The attributes of the VduProfile information element shall follow the indications provided in table 7.1.8.3.2-1.

Table 7.1.8.3.2-1: Attributes of the VduProfile information element

Attribute	Qualifier	Cardinality	Content	Description
vduId	M	1	Identifier (Reference to Vdu)	Uniquely identifies a VDU.
minNumberOfInstances	M	1	Integer	Minimum number of instances of the VNFC based on this VDU that is permitted to exist for this flavour.
maxNumberOfInstances	M	1	Integer	Maximum number of instances of the VNFC based on this VDU that is permitted to exist for this flavour.
localAffinityOrAntiAffinityRule	M	0..N	LocalAffinityOrAntiAffinityRule	Specifies affinity or anti-affinity rules applicable between the virtualisation containers (e.g. virtual machines) to be created based on this VDU. See clause 7.1.8.11. When the cardinality is greater than 1, both affinity rule(s) and anti-affinity rule(s) with different scopes (e.g. "Affinity with the scope resource zone and anti-affinity with the scope NFVI node") are applicable to the virtualisation containers (e.g. virtual machines) to be created based on this VDU.
affinityOrAntiAffinityGroupId	M	0..N	Identifier	Identifier(s) of the affinity or anti-affinity group(s) the VDU belongs to. See note.
NOTE: Each identifier references an affinity or anti-affinity group which expresses affinity or anti-affinity relationships between the virtualisation container(s) (e.g. virtual machine(s)) to be created using this VDU and the virtualisation container(s) (e.g. virtual machine(s)) to be created using other VDU(s) in the same group.				

7.1.8.4 VirtualLinkProfile information element

7.1.8.4.1 Description

The VirtualLinkProfile describes additional instantiation data for a given VL used in a DF.

7.1.8.4.2 Attributes

The attributes of the VirtualLinkProfile information element shall follow the indications provided in table 7.1.8.4.2-1.

Table 7.1.8.4.2-1: Attributes of the VirtualLinkProfile information element

Attribute	Qualifier	Cardinality	Content	Description
vnfVirtualLinkDescId	M	1	Identifier (Reference to VnfVirtualLinkDesc)	Uniquely identifies a Vnf VLD.
flavourId	M	1	Identifier (Reference to VirtualLinkDescFlavour)	Identifies a flavour within the VnfVirtualLinkDesc.
localAffinityOrAntiAffinityRule	M	0..N	LocalAffinityOrAntiAffinityRule	Specifies affinity or anti-affinity rules applicable between the VLs based on this VnfVirtualLinkDesc. See clause 7.1.8.4. When the cardinality is greater than 1, both affinity rule(s) and anti-affinity rule(s) with different scopes are applicable to the VLs based on this VnfVirtualLinkDesc.
affinityOrAntiAffinityGroupId	M	0..N	Identifier	Identifier(s) of the affinity or anti-affinity group(s) the VnfVirtualLinkDesc belongs to. See note.
NOTE: Each identifier references an affinity or anti-affinity group which expresses affinity or anti-affinity relationship between the VL(s) using this VnfVirtualLinkDesc and the VL(s) using other VnfVirtualLinkDesc(s) in the same group.				

7.1.8.5 VirtualLinkDescFlavour information element

7.1.8.5.1 Description

The VirtualLinkDescFlavour describes additional instantiation data for a given internal VL used in a DF.

7.1.8.5.2 Attributes

The attributes of the VirtualLinkDescFlavour information element shall follow the indications provided in table 7.1.8.5.2-1.

Table 7.1.8.5.2-1: Attributes of the VirtualLinkDescFlavour information element

Attribute	Qualifier	Cardinality	Content	Description
flavourId	M	1	Identifier	Identifies a flavour within a VnfVirtualLinkDesc.
bitrateRequirements	M	0..1	LinkBitrateRequirements	Bitrate requirements for a VL created from this VirtualLinkDescFlavour. See note.
qos	M	0..1	QoS	QoS of the VL.
NOTE: If not present, it is assumed that the bitrate requirements can be derived from those specified in the VduCpd instances applicable to the internal VL. If present in both the VirtualLinkDescFlavour and the VduCpd instances applicable to the internal VL, the highest value takes precedence.				

7.1.8.6 LinkBitrateRequirements information element

7.1.8.6.1 Description

The LinkBitrateRequirements information element describes the requirements in terms of bitrate for a VL.

7.1.8.6.2 Attributes

The attributes of the LinkBitrateRequirements information element shall follow the indications provided in table 7.1.8.6.2-1.

Table 7.1.8.6.2-1: Attributes of the LinkBitrateRequirements information element

Attribute	Qualifier	Cardinality	Content	Description
root	M	1	Number	Throughput requirement of the link (e.g. bitrate of E-Line, root bitrate of E-Tree, aggregate capacity of E-LAN).
leaf	M	0..1	Number	Throughput requirement of leaf connections to the link when applicable to the connectivity type (e.g. for E-Tree and E-LAN branches). See note.
NOTE: The present document does not specify the means to declare different bitrate requirements for leaf connections (e.g. E-LAN leaves).				

7.1.8.7 InstantiationLevel information element

7.1.8.7.1 Description

The InstantiationLevel information element describes a given level of resources to be instantiated within a DF in term of the number of VNFC instances to be created from each VDU.

All the VDUs referenced in the level shall be part of the corresponding DF and their number shall be within the range (min/max) for this DF.

7.1.8.7.2 Attributes

The attributes of the InstantiationLevel information element shall follow the indications provided in table 7.1.8.7.2-1.

Table 7.1.8.7.2-1: Attributes of the InstantiationLevel information element

Attribute	Qualifier	Cardinality	Content	Description
levelId	M	1	Identifier	Uniquely identifies a level with the DF.
description	M	1	String	Human readable description of the level.
vduLevel	M	1..N	VduLevel	Indicates the number of instance of this VDU to deploy for this level.
scaleInfo	M	0..N	ScaleInfo	Represents for each aspect the scale level that corresponds to this instantiation level. scaleInfo shall be present if the VNF supports scaling.

7.1.8.8 ScaleInfo information element

7.1.8.8.1 Description

The ScaleInfo information element represents a scale level for a particular scaling aspect.

7.1.8.8.2 Attributes

The attributes of the ScaleInfo information element shall follow the indications provided in table 7.1.8.8.2-1.

Table 7.1.8.8.2-1: Attributes of the ScaleInfo information element

Attribute	Qualifier	Cardinality	Content	Description
aspectId	M	1	Identifier	Identifier of the scaling aspect.
scaleLevel	M	1	Integer	The scale level, greater than or equal to 0.
NOTE: Vertical scaling (scale up, scale down) is not supported in the present document.				

7.1.8.9 VduLevel information element

7.1.8.9.1 Description

The VduLevel information element indicates for a given VDU in a given level the number of instances to deploy.

7.1.8.9.2 Attributes

The attributes of the VduLevel information element shall follow the indications provided in table 7.1.8.9.2-1.

Table 7.1.8.9.2-1: Attributes of the VduLevel information element

Attribute	Qualifier	Cardinality	Content	Description
vduId	M	1	Identifier (Reference to Vdu)	Uniquely identifies a VDU.
numberOf Instances	M	1	Integer	Number of instances of VNFC based on this VDU to deploy for this level.

7.1.8.10 QoS information element

7.1.8.10.1 Description

The QoS information element describes QoS data for a given VL used in a DF.

7.1.8.10.2 Attributes

The attributes of the QoS information element shall follow the indications provided in table 7.1.8.10.2-1.

Table 7.1.8.10.2-1: Attributes of the QoS information element

Attribute	Qualifier	Cardinality	Content	Description
latency	M	1	Number	Maximum latency in ms.
packetDelayVariation	M	1	Number	Maximum jitter in ms.
packetLossRatio	M	0..1	Number	Maximum packet loss ratio. Cardinality is 0 if no packetLossRatio requirement exists.

7.1.8.11 LocalAffinityOrAntiAffinityRule information element

7.1.8.11.1 Description

The LocalAffinityOrAntiAffinityRule describes the affinity or anti-affinity rule applicable between the virtualization containers to be created based on a particular VDU, or between internal VLs to be created based on a particular VnfVirtualLinkDesc.

Per VNF, the affinity/anti-affinity rules defined using this information element, using the AffinityOrAntiAffinityGroup information element, and using the placement constraints in the GrantLifecycleOperation as defined in ETSI GS NFV-IFA 007 [i.3] should be conflict-free. In case of conflicts, the placement constraints in the GrantLifecycleOperation shall take precedence.

7.1.8.11.2 Attributes

The attributes of the LocalAffinityOrAntiAffinityRule information element shall follow the indications provided in table 7.1.8.11.2-1.

Table 7.1.8.11.2-1: Attributes of the LocalAffinityOrAntiAffinityRule information element

Attribute	Qualifier	Cardinality	Content	Description
type	M	1	Enum	Specifies whether the rule is an affinity rule or an anti-affinity rule.
scope	M	1	Enum	Specifies the scope of the rule, possible values are "NFVI-PoP", "Zone", "ZoneGroup", "NFVI-node".

7.1.8.12 AffinityOrAntiAffinityGroup information element

7.1.8.12.1 Description

The AffinityOrAntiAffinityGroup describes the affinity or anti-affinity relationship applicable between the virtualization containers to be created based on different VDUs, or between internal VLs to be created based on different VnfVirtualLinkDesc(s).

Per VNF, the affinity/anti-affinity rules defined using this information element, using the LocalAffinityOrAntiAffinityRule information element, and using the placement constraints in the GrantLifecycleOperation as defined in ETSI GS NFV-IFA 007 [i.3] should be conflict-free. In case of conflicts, the placement constraints in the GrantLifecycleOperation shall take precedence.

7.1.8.12.2 Attributes

The attributes of the AffinityOrAntiAffinityGroup information element shall follow the indications provided in table 7.1.8.12.2-1.

Table 7.1.8.12.2-1: Attributes of the AffinityOrAntiAffinityGroup information element

Attribute	Qualifier	Cardinality	Content	Description
groupId	M	1	Identifier	Identifies an affinity or anti-affinity group to which the affinity or anti-affinity rule applies.
type	M	1	Enum	Specifies whether the rule is an affinity rule or an anti-affinity rule.
scope	M	1	Enum	Specifies the scope of the rule, possible values are "NFVI-PoP", "Zone", "ZoneGroup", "NFVI-node".

7.1.9 Information elements related to Virtual Resource descriptors

7.1.9.1 Introduction

The clauses below define the Information elements related to Virtual Resource descriptors.

7.1.9.2 Information elements related to Virtual CPU

7.1.9.2.1 Introduction

The clauses below define the information elements related to Virtual CPU.

7.1.9.2.2 VirtualComputeDesc information element

7.1.9.2.2.1 Description

The VirtualComputeDesc information element supports the specification of requirements related to virtual compute resources.

7.1.9.2.2.2 Attributes

The attributes of the VirtualComputeDesc information element shall follow the indications provided in table 7.1.9.2.2.2-1.

If the VIM supports the concept of virtual compute resource flavours, it is assumed that a flavour is selected or created based on the information in the VirtualComputeDesc information element.

Table 7.1.9.2.2.2-1: Attributes of the VirtualComputeDesc information element

Attribute	Qualifier	Cardinality	Content	Description
virtualComputeDescId	M	1	Identifier	Unique identifier of this VirtualComputeDesc in the VNFD.
requestAdditionalCapabilities	M	0..N	RequestedAdditional CapabilityData	Specifies requirements for additional capabilities. These may be for a range of purposes. One example is acceleration related capabilities. See clause 7.1.9.5.
virtualMemory	M	1	VirtualMemoryData	The virtual memory of the virtualised compute. See clause 7.1.9.3.
virtualCpu	M	1	VirtualCpuData	The virtual CPU(s) of the virtualised compute. See clause 7.1.9.2.

7.1.9.2.3 VirtualCpuData information elements

7.1.9.2.3.1 Description

The VirtualCpuData information element supports the specification of requirements related to virtual CPU(s) of a virtual compute resource.

7.1.9.2.3.2 Attributes

The attributes of the VirtualCpuData information element shall follow the indications provided in table 7.1.9.2.3.2-1.

Table 7.1.9.2.3.2-1: Attributes of the VirtualCpuData information element

Attribute	Qualifier	Cardinality	Content	Description
cpuArchitecture	M	0..1	String	CPU architecture type. Examples are x86, ARM. The cardinality can be 0 during the allocation request, if no particular CPU architecture type is requested.
numVirtualCpu	M	1	Integer	Number of virtual CPUs.
virtualCpuClock	M	0..1	Number	Minimum virtual CPU clock rate (e.g. in MHz). The cardinality can be 0 during the allocation request, if no particular value is requested.
virtualCpuOversubscriptionPolicy	M	0..1	Not specified	The CPU core oversubscription policy e.g. the relation of virtual CPU cores to physical CPU cores/threads. The cardinality can be 0 during the allocation request, if no particular value is requested.
virtualCpuPinning	M	0..1	VirtualCpuPinningData	The virtual CPU pinning configuration for the virtualised compute resource. See clause 7.1.9.2.4.

7.1.9.2.4 VirtualCpuPinningData information element

7.1.9.2.4.1 Description

The VirtualCpuPinningData information element supports the specification of requirements related to the virtual CPU pinning configuration of a virtual compute resource.

7.1.9.2.4.2 Attributes

The attributes of the VirtualCpuPinningData information element shall follow the indications provided in table 7.1.9.2.4.2-1.

Table 7.1.9.2.4.2-1: Attributes of the VirtualCpuPinningData information element

Attribute	Qualifier	Cardinality	Content	Description
cpuPinningPolicy	M	0..1	Enum	Indicates the policy for CPU pinning. The policy can take values of "static" or "dynamic". The cardinality can be 0 during the allocation request, if no particular value is requested.
cpuPinningMap	M	0..1	Not specified	If cpuPinningPolicy is defined as "static", the cpuPinningMap provides the map of pinning virtual CPU cores to physical CPU cores/threads. Cardinality is 0 if cpuPinningPolicy has a different value than "static".

7.1.9.3 Information elements related to Virtual Memory

7.1.9.3.1 Introduction

The clauses below define the information elements related to Virtual Memory.

7.1.9.3.2 VirtualMemoryData information element

7.1.9.3.2.1 Description

The VirtualMemoryData information element supports the specification of requirements related to virtual memory of a virtual compute resource.

7.1.9.3.2.2 Attributes

The attributes of the VirtualMemoryData information element shall follow the indications provided in table 7.1.9.3.2.2-1.

Table 7.1.9.3.2.2-1: Attributes of the VirtualMemoryData information element

Attribute	Qualifier	Cardinality	Content	Description
virtualMemSize	M	1	Number	Amount of virtual Memory (e.g. in MB).
virtualMemOversubscriptionPolicy	M	0..1	Not specified	The memory core oversubscription policy in terms of virtual memory to physical memory on the platform. The cardinality can be 0 during the allocation request, if no particular value is requested.
numaEnabled	M	0..1	Boolean	It specifies the memory allocation to be cognisant of the relevant process/core allocation. The cardinality can be 0 during the allocation request, if no particular value is requested.

7.1.9.4 Information elements related to Virtual Storage

7.1.9.4.1 Introduction

The clauses below define the information elements related to Virtual Storage.

7.1.9.4.2 VirtualStorageDesc information element

7.1.9.4.2.1 Description

The VirtualStorageDesc information element supports the specifications of requirements related to virtual storage resources.

7.1.9.4.2.2 Attributes

The attributes of the VirtualStorageDesc information element shall follow the indications provided in table 7.1.9.4.2.2-1.

Table 7.1.9.4.2.2-1: Attributes of the VirtualStorageDesc information element

Attribute	Qualifier	Cardinality	Content	Description
id	M	1	Identifier	Unique identifier of this VirtualStorageDesc in the VNFD.
typeOfStorage	M	1	String	Type of virtualised storage resource (e.g. volume, object).
sizeOfStorage	M	1	Number	Size of virtualised storage resource (e.g. size of volume, in GB).
rdmaEnabled	M	0..1	Boolean	Indicate if the storage support RDMA.
swImageDesc	M	0..1	Identifier (Reference to a SwImageDesc)	Software image to be loaded on the VirtualStorage Resource created based on this VirtualStorageDesc.

7.1.9.5 RequestedAdditionalCapabilityData information element

7.1.9.5.1 Description

This information element describes requested additional capability for a particular VDU. Such a capability may be for acceleration or specific tasks.

7.1.9.5.2 Attributes

The attributes of the RequestedAdditionalCapabilityData information element shall follow the indications provided in table 7.1.9.5.2-1.

Table 7.1.9.5.2-1: Attributes of the RequestedAdditionalCapabilityData information element

Attribute	Qualifier	Cardinality	Content	Description
requestedAdditionalCapabilityName	M	1	String	Identifies a requested additional capability for the VDU. ETSI GS NFV-IFA 002 [i.1] describes acceleration capabilities.
supportMandatory	M	1	Boolean	Indicates whether the requested additional capability is mandatory for successful operation.
minRequestedAdditionalCapabilityVersion	M	0..1	String	Identifies the minimum version of the requested additional capability.
preferredRequestedAdditionalCapabilityVersion	M	0..1	String	Identifies the preferred version of the requested additional capability.
targetPerformanceParameters	M	1..N	KeyValuePair	Identifies specific attributes, dependent on the requested additional capability type.

7.1.10 Information elements related to scaling

7.1.10.1 Introduction

The clauses below define the information elements related to scaling.

7.1.10.2 ScalingAspect information element

7.1.10.2.1 Description

The ScalingAspect information element describes the details of an aspect used for horizontal scaling.

7.1.10.2.2 Attributes

The attributes of the ScalingAspect information element shall follow the indications provided in table 7.1.10.2.2-1.

Table 7.1.10.2.2-1: Attributes of the ScalingAspect information element

Attribute	Qualifier	Cardinality	Content	Description
id	M	1	Identifier	Unique identifier of this aspect in the VNFD.
name	M	1	String	Human readable name of the aspect.
description	M	1	String	Human readable description of the aspect.
associatedGroup	M	0..1	Identifier (Reference to VnfdElementGroup)	Reference to the group of Vnfd elements defining this aspect. If present, scaling for this aspect is limited to the elements of the group, but there is no assumption that all the elements of the groups will be increased at each step. See note 1.
maxScaleLevel	M	1	PositiveInteger	The maximum scaleLevel for total number of scaling steps that can be applied w.r.t. this aspect. The value of this attribute corresponds to the number of scaling steps can be applied to this aspect when scaling it from the minimum scale level (i.e. 0) to the maximum scale level defined by this attribute. See note 2.
NOTE 1: In the present release of the specification, support for modifying the internal VNF topology during the scaling of the internal VLs, is not required. NOTE 2: A scaling step is the smallest increment by which a VNF can be scaled for a particular aspect. Scaling by a single step does not imply that only one VNFC instance is created or removed. It means that one or more VNFC instances are created from the same VDU or from different VDUs, or that a more complex setup occurs.				

7.1.11 Information elements related to monitoring

7.1.11.1 Introduction

The clause below define the information elements related to monitoring.

7.1.11.2 VnfIndicator information element

7.1.11.2.1 Description

The VnfIndicator information element defines the indicator the VNF supports.

7.1.11.2.2 Attributes

The attributes of the VnfIndicator information element shall follow the indications provided in table 7.1.11.2.2-1.

Table 7.1.11.2.2-1: Attributes of the VnfIndicator information element

Attribute	Qualifier	Cardinality	Content	Description
id	M	1	Identifier	Unique identifier.
name	M	0..1	String	The human readable name of the VnfIndicator.
indicatorValue	M	1..N	String	Defines the allowed values or value ranges of this indicator.
source	M	1	Enum	Describe the source of the indicator. The possible values are: • VNF. • EM. • Both. This tells the consumer where to send the subscription request.

7.1.11.3 MonitoringParameter information element

7.1.11.3.1 Description

This information element specifies the virtualised resource related performance metrics to be monitored.

7.1.11.3.2 Attributes

The attributes of the MonitoringParameter information element shall follow the indications provided in table 7.1.11.3.2-1.

Table 7.1.11.3.2-1: Attributes of the MonitoringParameter information element

Attribute	Qualifier	Cardinality	Content	Description
id	M	1	Identifier	Unique identifier of the monitoring parameter.
name	M	0..1	String	Human readable name of the monitoring parameter.
performanceMetric	M	1	String	Defines the virtualised resource performance metric. The VNFM collects the performance metrics defined in this attribute from the VIM using one or more PM Jobs.

7.1.12 VnfConfigurableProperties information element

7.1.12.1 Description

This information element defines the configurable properties of a VNF (e.g. related to auto scaling and auto healing). For a VNF instance, the value of these properties can be modified by the VNFM.

7.1.12.2 Attributes

The attributes of the VnfConfigurableProperties information element shall follow the indications provided in table 7.1.12.2-1.

Table 7.1.12.2-1: Attributes of the VnfConfigurableProperties information element

Attribute	Qualifier	Cardinality	Content	Description
autoScalable	M	0..1	Boolean	It permits to enable (TRUE) / disable (FALSE) the auto-scaling functionality. See note.
autoHealable	M	0..1	Boolean	It permits to enable (TRUE) / disable (FALSE) the auto-healing functionality. See note.
additionalConfigurableProperty	M	0..N	Not specified	It provides VNF specific configurable properties that can be modified using the ModifyVnfConfiguration operation.
NOTE: A cardinality of "0" indicates that configuring this present VNF property is not supported.				

7.1.13 LifeCycleManagementScript information element

7.1.13.1 Description

Clause 7.1.13.2 defines the information elements related to the lifecycle management script for the VNF.

7.1.13.2 Attributes

The content of the LifeCycleManagementScript type shall comply with the indications provided in table 7.1.13.2-1.

Table 7.1.13.2-1: Attributes of the LifeCycleManagementScript information element

Attribute	Qualifier	Cardinality	Content	Description
event	M	1..N	String	Describes VNF lifecycle event(s) or an external stimulus detected on a VNFM reference point. See notes 1 and 2.
script	M	1	Not specified	Includes a VNF LCM script (e.g. written in a DSL as specified in requirement VNF_PACK.LCM.001) triggered to react to one of the events listed in the event attribute.
NOTE 1: A minimum set of lifecycle events triggered internally by the VNFM includes: start instantiation, end instantiation, start scaling, end scaling, start healing, end healing, start termination, end termination, start VNF flavour change, end VNF flavour change, start VNF operation state change, end VNF operation state change. NOTE 2: A minimum set of external stimulus includes: the receipt of request message of instantiation, scaling, healing, termination, change of VNF flavour, change of the operation state of the VNF or the receipt of VNF indication with a changed value.				

7.1.14 VnfInfoModifiableAttributes information element

7.1.14.1 Description

This information element defines the VNF-specific extension and metadata attributes of the VnfInfo that are writeable via the ModifyVnfInfo operation.

7.1.14.2 Attributes

The attributes of the VnfInfoModifiableAttributes information element shall follow the indications provided in table 7.1.14.2-1.

Table 7.1.14.2-1: Attributes of the VnfInfoModifiableAttributes information element

Attribute	Qualifier	Cardinality	Content	Description
extension	M	0..N	Not specified	"Extension" attributes of VnfInfo that are writeable. See note.
metadata	M	0..N	Not specified	"Metadata" attributes of VnfInfo that are writeable. See note.
NOTE: The exact data structure describing the attribute is left for data model solution specification, but it should include: name, and any constraints on the values, such as ranges, predefined values, etc.				

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Annex B (informative): Bibliography

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

History

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