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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Interface for power management in network function virtualization environments – Green abstraction layer version 2

Recommendation ITU-T L.1362

ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

OPTICAL FIBRE CABLES	
Cable structure and characteristics	L.100–L.124
Cable evaluation	L.125–L.149
Guidance and installation technique	L.150–L.199
OPTICAL INFRASTRUCTURES	
Infrastructure including node elements (except cables)	L.200–L.249
General aspects and network design	L.250–L.299
MAINTENANCE AND OPERATION	
Optical fibre cable maintenance	L.300–L.329
Infrastructure maintenance	L.330–L.349
Operation support and infrastructure management	L.350–L.379
Disaster management	L.380–L.399
PASSIVE OPTICAL DEVICES	L.400–L.429
MARINIZED TERRESTRIAL CABLES	L.430–L.449

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T L.1362

Interface for power management in network function virtualization environments – Green abstraction layer version 2

Summary

Recommendation ITU-T L.1362 specifies a data model for energy discrete states within virtualized networks, and operations to interact on this model.

In virtualized networks, establishing a mapping between the energy discrete states of logical entities (e.g., virtualized network functions) and the energy consumption of the hardware hosting the virtual machines that execute these logical entities is a challenging task. Recommendation ITU-T L.1362 adapts the green abstraction layer specification (GALv1) to virtualized networks.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Energy efficiency, green abstraction layer, network function virtualization.

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Table of Contents

Introduction

The green abstraction layer (GAL) [ETSI ES 203 237] provides a means of exchanging information about capabilities and parameter settings between energy-aware networking devices and their network management primitives. It allows hiding the specificities of devices and their internal operations by means of an abstract interface, through which only a description of energy-related parameters can be conveyed, read and configured.

The scenario introduced by network function virtualization possibly accompanied by increased flexibility and programmability due to software-defined networking is changing network paradigms and associated GAL design. With network function virtualization (NFV), network functionalities become virtualized network functions that can be automatically deployed, migrated or reconfigured. The same physical machines in provider infrastructure may well serve the needs of different virtualized network functions (VNFs). In this NFV context, mapping between the energy-aware states of logical entities (e.g., virtualized network functions) and energy consumption of hardware hosting the virtual machines that execute these logical entities is a challenging task. There is therefore the need to adapt the GAL specification [ETSI ES 203 237] to the NFV environment (GALv2).

NOTE – The use of GALv2 will address the NFV architectural framework [ETSI GS NFV 002].

This Recommendation was developed jointly by ETSI TC EE and ITU-T Study Group 5. It is published by ITU and ETSI as Recommendation ITU-T L.1362 and [b-ETSI ES 203 682], respectively, which are technically equivalent.

Recommendation ITU-T L.1362

Interface for power management in network function virtualization environments – Green abstraction layer version 2

1 Scope

This Recommendation specifies a data model for energy discrete states within virtualized networks, and operations to interact on this model.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ETSI ES 203 237] ETSI ES 203 237 V1.1.1 (2014), *Environmental Engineering (EE); Green Abstraction Layer (GAL); Power management capabilities of the future energy telecommunication fixed network nodes*.

[ETSI GS NFV 002] ETSI GS NFV 002 V1.2.1 (2014), *Network Functions Virtualisation (NFV); Architectural framework.*

[ETSI GS NFV-EVE 001] ETSI GS NFV-EVE 001 V3.1.1 (2017), *Network Functions Virtualisation (NFV); Virtualisation Technologies; Hypervisor Domain Requirements specification; Release 3.*

[ETSI GS NFV-IFA 005] ETSI GS NFV-IFA 005 V3.1.1 (2018), *Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Or-Vi reference point – Interface and Information Model Specification.*

[ETSI GS NFV-IFA 006] ETSI GS NFV-IFA 006 V2.4.1 (2018), *Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Vi-Vnfm reference point – Interface and Information Model Specification*.

[ETSI GS NFV-IFA 007] ETSI GS NFV-IFA 007 V2.4.1 (2018), *Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vnfm reference point – Interface and Information Model Specification*.

[ETSI GS NFV-IFA 008] ETSI GS NFV-IFA 008 V3.1.1 (2018), *Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Ve-Vnfm reference point – – Interface and Information Model Specification.*

[ETSI GS NFV-IFA 011] ETSI GS NFV-IFA 011 V2.5.1 (2018), *Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; VNF Descriptor and Packaging Specification*.

[ETSI GS NFV-IFA 013] ETSI GS NFV-IFA 013 V3.1.1 (2018), *Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Os-Ma-Nfvo reference point – Interface and Information Model Specification*.

[ETSI GS NFV-IFA 014] ETSI GS NFV-IFA 014 V3.1.1 (2018), *Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Network Service Templates Specification*.

[ETSI GS NFV-INF 004] ETSI GS NFV-INF 004 V1.1.1 (2015), *Network Functions Virtualisation (NFV); Infrastructure; Hypervisor Domain.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 entity [ETSI ES 203 237]: Device or a sub-part of it, of which the GAL constitutes the energy-aware interface.

NOTE – At the lowest hierarchical levels, an entity can correspond to a chip, a network processor, a link interface. At medium hierarchical levels, it can correspond to line-cards, chassis, etc. At the highest level the entire device corresponds to an entity. Higher level entities can include one or more entities at lower levels. This hierarchical architecture is optional and the relative depth should depend on the specific internal architecture of the network device.

3.1.2 green abstraction layer (GAL) [ETSI ES 203 237]: Interface between data and control planes for exchanging data regarding the power status of a device.

3.1.3 green standard interface (GSI) [ETSI ES 203 237]: GAL interface designed to exchange power management data in a simplified way among data-plane elements and processes realizing control plane strategies.

3.1.4 hypervisor [ETSI GS NFV-EVE 001]: Piece of software which partitions the underlying physical resources, creates virtual machines, and isolates the VMs from each other.

NOTE [ETSI GS NFV-INF 004] – In essence, the hypervisor can emulate every piece of the hardware platform even in some cases, completely emulating a CPU instruction set such that the VM believes it is running on a completely different CPU architecture from the actual CPU on which it is running. Such emulation, however, has a significant performance cost. The number of actual CPU cycles needed to emulate virtual CPU cycle can be large.

3.1.5 hypervisor domain [ETSI GS NFV-EVE 001]: General area for focus which includes hypervisors.

3.1.6 network performance [b-ITU-T E.800]: The ability of a network or network portion to provide the functions related to communications between users.

NOTE 1 – Network performance applies to the network provider's planning, development, operations and maintenance and is the detailed technical part of quality of service offered.

NOTE 2 – Network performance parameters are meaningful to network providers and are quantifiable at the part of the network which they apply.

3.1.7 operating mode [ETSI ES 203 237]: Operating state of a given entity (i.e., active, standby – or idle).

NOTE – Two different types of energy-aware entity (EAE) can exist when the operating states are selected by the EAE itself (internal operating mode) and when the operating states are controlled and selected by external processes (external operating mode). Examples of such processes are local control policies or network control policies.

3.1.8 standby mode [ETSI ES 203 237]: Operating mode characterized by low power consumption and reduced functionality.

NOTE – The reduction can be done by cutting power to unused entity components. In standby mode, the entity provides a sub-set of functionality depending on the specific power profile.

3.1.9 virtualization container [b-ETSI GS NFV 003]: Partition of a compute node that provides an isolated virtualized computation environment.

3.1.10 virtualization deployment unit (VDU) [ETSI GS NFV 003]: Construct that can be used in an information model, supporting the description of the deployment and operational behaviour of a subset of a VNF, or the entire VNF if it was not componentized in subsets.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 energy-aware entity (EAE): Network entity that can adapt its energy consumption so that network performance levels are satisfied.

NOTE – Examples include a central processing unit (CPU), virtual CPU (vCPU), virtual machine, virtualized network function, virtualized network function component and a network service.

3.2.2 energy-aware state (EAS): A data structure containing power, network performance, available functionalities and responsiveness information characterizing an energy-aware entity.

NOTE – An EAS can be configured by control plane processes through the green standard interface.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API	Application Program Interface
BSS	Business Support System
CD	Compute Domain
CP	Connection Point
CPU	Central Processing Unit
DF	Deployment Flavour
EAE	Energy-Aware Entity
EAS	Energy-Aware State
EM	Element Manager
GAL	Green Abstraction Layer
GSI	Green Standard Interface
HD	Hypervisor Domain
HW	Hardware
ID	Identifier
LCM	Life Cycle Management
LPI	Low Power Idle
MANO	Management and Orchestration
ND	Network Domain
NFV	Network Functions Virtualization
NFVI	Network Functions Virtualization Infrastructure
NFVO	Network Functions Virtualization Orchestrator
NIC	Network Interface Controller
NS	Network Service
NSD	Network Service Descriptor
NS DF	Network Service Deployment Flavour

OSS Operations Support System
PM Performance Management
PNF Physical Network Function
PNFD Physical Network Function Descriptor
QoS Quality of Service
VC Virtualization Container
vCPU virtual Central Processing Unit
VDU Virtual Deployment Unit
VIM Virtual Infrastructure Manager
VL Virtual Link
VLD Virtual Link Descriptor
VM Virtual Machine
VNF Virtualized Network Function
VNFC Virtualized Network Function Component
VNFD Virtualized Network Function Descriptor
VNF DF Virtualized Network Function Deployment Flavour
VNFM Virtualized Network Function Manager

5 Conventions

None.

6 Foreground

6.1 Green abstraction layer

The green abstraction layer (GAL) [ETSI ES 203 237] provides the means of exchanging information about capabilities and parameter settings between energy-aware networking devices and their network management primitives. It allows hiding the specificities of devices and their internal operations by means of an abstract interface, through which only a description of energy-related parameters can be conveyed, read and configured. At the same time, a hierarchical structure is defined in order to propagate a similar abstract representation throughout the component parts of devices (chassis, subsystems, electronic boards, etc.) at the proper level of detail and granularity.

In this respect, [ETSI ES 203 237] specifies:

- the GAL general architecture;
- the energy-aware states (EASs) describing the different power configurations and corresponding network performance of an EAE;
- the green standard interface (GSI) used to discover EAEs, their autonomic provisioning, manual configuration, monitoring and decommissioning.

In an NFV network, functionalities become virtualized network functions (VNFs) that can be automatically deployed, migrated and reconfigured. The same physical machines of provider infrastructure may well serve the needs of different VNFs. In this NFV context, establishing a mapping between the EASs of logical entities (e.g., VNFs) and the energy consumption of the hardware (HW) hosting the virtual machines (VMs) that execute these logical entities is a challenging task.

There is therefore the need to adapt the GAL specification [ETSI ES 203 237] to the NFV environment (GALv2), and to address the use of GALv2 in the ETSI NFV architectural framework [ETSI GS NFV 002].

6.2 Network functions virtualization architectural framework

Network functions virtualization (NFV) envisages the implementation of network functions as software-only entities that run over the network functions virtualization Infrastructure (NFVI). As such, three main working domains are identified in NFV:

- virtualized network function, as the software implementation of a network function that is capable of running over the NFVI;
- NFV management and orchestration (MANO), which covers the orchestration and life cycle management (LCM) of physical or software resources that support the infrastructure virtualization, and the LCM of VNFs. The NFV MANO focuses on all virtualization-specific management tasks necessary in the NFV framework;
- NFVI, including the diversity of physical resources and how these can be virtualized; the NFVI supports the execution of the VNFs.

6.2.1 Network functions virtualization management and orchestration overview

NFV defines network services (NSs) as a composition of a set of network functions (NFs) with unspecified connectivity among them or according to one or more forwarding graphs [ETSI GS NFV-IFA 014].

The network service descriptor (NSD) [ETSI GS NFV-IFA 014] is a network-service deployment template that consists of information used by the NFV MANO system for the LCM of an NS. The NSD includes or references to the descriptors of its constituent objects:

- zero, one or more virtualized network function descriptors (VNFDs) [ETSI GS NFV-IFA 011], where a VNFD is a deployment template that describes a virtualized network function (VNF) in terms of resource requirements and operational behaviour requirements;
- zero, one or more virtual link descriptors (VLDs) used by the network functions virtualization orchestrator (NFVO) to deploy a virtual link (VL);
- zero, one or more physical network function descriptors (PNFDs) used by the NFV MANO to determine how to connect physical network functions (PNFs) to VLs;
- zero, one or more nested NSDs.

A virtualized network function can be composed of one or more virtualized network function components (VNFCs) [ETSI GS NFV-IFA 011].

The VNFC resource requirements and its operational behaviour are described in the virtual deployment unit (VDU). Figure 1 shows the VDU high-level structure in a unified modelling language representation [ETSI GS NFV-IFA 011].

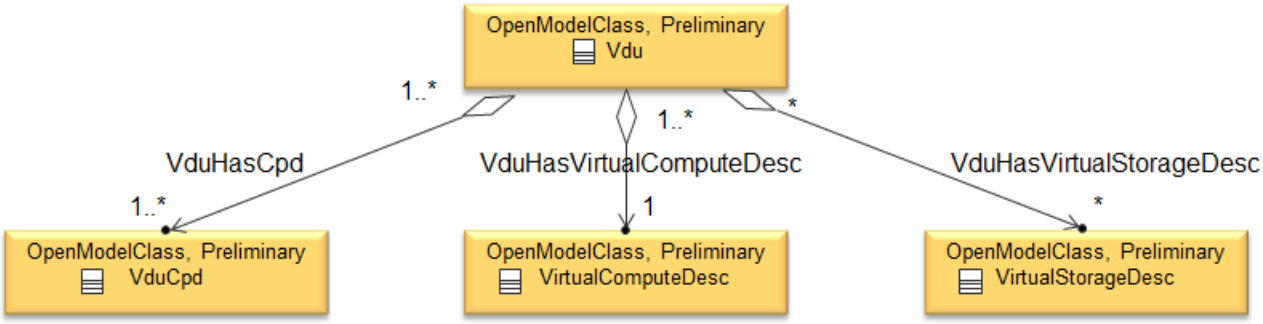

Figure 1 – Unified modelling language representation of the virtual deployment unit high-level structure

A VNFC instance created based on a VDU maps to a single virtualization container (VC) realizing this VDU.

6.2.1.1 Virtualized network function scaling

[ETSI GS NFV-IFA 007] provides methods to request scaling a VNF in multiple ways.

- Horizontal scaling:
  - scale out: adding additional VNFC instances to the VNF to increase capacity;
  - scale in: removing VNFC instances from the VNF, in order to release unused capacity.
- Vertical scaling ([ETSI GS NFV-IFA 007] currently does not support this method):
  - scale up: adding further resources to existing VNFC instances, e.g., increase memory, CPU capacity or storage size of the VC hosting a VNFC instance, in order to increase VNF capacity;
  - scale down: removing resources from existing VNFC instances, e.g., decrease memory, CPU capacity or storage size of the VC hosting a VNFC instance, in order to release unused capacity.

Different aspects of a VNF can be scaled independently. For example [ETSI GS NFV-IFA 007], a VNF could be designed to provide static capacity, such as database nodes, and dynamic capacity, such as query processing nodes. Such a VNF might be scaled with regard to two separate aspects: the static capacity aspect can be scaled by adding database VNFCs; and the dynamic capacity aspect can be scaled by adding query processing VNFCs.

When scaling a VNF for a particular aspect, the number of scaling steps to apply to that aspect can be provided as a parameter. A scaling step is the smallest unit by which a particular aspect of a VNF can be scaled, and is mapped by the virtualized network function manager (VNFM) to the addition (or removal) of a certain number of resources based on one or more VDUs. For each scaling aspect, the maximum scale level is defined in the VNFD and the minimum scale level is assumed to be zero; the maximum scale level corresponds to the maximum number of steps that can be performed within this aspect, starting at the minimum scale level. At each point in time between the completed VNF instantiation and the VNF termination, the "size" of the VNF with regard to a particular aspect can be expressed by the current scale level with regard to that aspect, and can be obtained, among other information, by invoking the QueryVNF operation. When the VNF is instantiated, the current scale level is initialized with values that are defined as part of the instantiation level in the VNFD for the associated aspect. Figure 2 illustrates the concepts described in this clause.

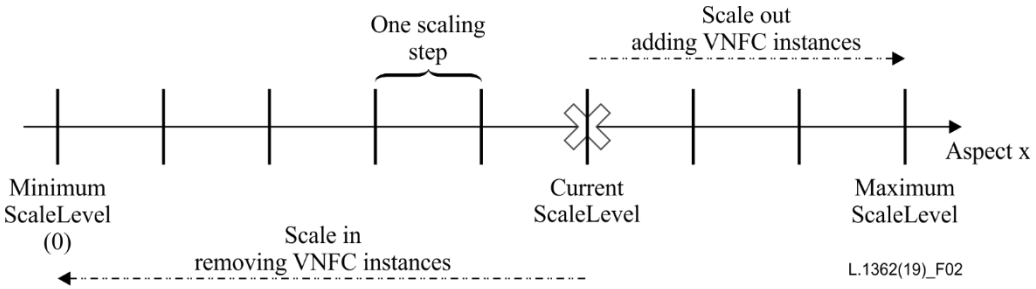

Figure 2 – Concepts of scale level and scaling steps for a given aspect

The NS level information element [ETSI GS NFV-IFA 014] describes the details of an NS level. An NS level consists of a list of involved entities, i.e., VNFs, VLs or nested NSs. For each VNF/nested NS involved, the number of instances required by the NS level is specified. For each VL involved, the bitrate requirements corresponding to the NS level are specified.

The VNFs involved in an NS level are characterized by two attributes: vnfProfileId, which identifies the profile to be used for a VNF involved in an NS level; and numberOfInstances, which specifies the number of VNF instances required for an NS level [ETSI GS NFV-IFA 014].

The vnfProfileId has three attributes of main interest: vnfdId, which references a VNFD, flavourId, which identifies a flavour within the VNF descriptor; and instantiationLevel, which identifies the instantiation level of the VNF flavour to be used for instantiation. If not present, the default instantiation level declared in the VNFD should be used.

The VNFD has three attributes of main interest:

- vdu;
- intVirtualLinkDesc: represents the type of network connectivity mandated by the VNF provider between two or more connection points (CPs), including at least one internal CP;
- deploymentFlavour: describes specific deployment flavour(s) (DF(s)) of a VNF with specific requirements for capacity and performance.

In deploymentFlavour, four attributes are of main interest:

- vduProfile: identifies a VDU, specifies the minimum-maximum number of VNFC instances based on this VDU, affinity or anti-affinity rules applicable between the VCs, and additional data for the VDU;
- virtualLinkProfile: identifies the quality of service (QoS), the maximum and the minimum bitrate requirements for this VL;
- instantiationLevel: indicates in the vduLevel attribute the number of instances to deploy for each VDU referenced in this DF; specifies in the virtualLinkBitRateLevel attribute the bitrate requirements applicable to the VLs referenced in this DF; represents in the scaleInfo attribute the scale level that corresponds to this instantiation level for the VNFs supporting scaling;
- scalingAspect: sets in the maxScaleLevel attribute the number of scaling steps; for each scaling step, the aspectDeltaDetails attribute specifies the deltas in terms of number of instances of VNFCs and VL bit rates.

Figure 3 depicts an example of a VNF profile in which the DF has three ScalingAspects: ScalingAspectId "x", ScalingAspectId "y", and ScalingAspectId "z". ScalingAspectId "x" is in the ScaleLevel "x", with MinScaleLevel "x" ≤ ScaleLevel "x" ≤ MaxScaleLevel "x"; ScalingAspectId "y" is in the ScaleLevel "y", with MinScaleLevel "y" ≤ ScaleLevel "y" ≤ MaxScaleLevel "y"; and ScalingAspectId "z" is in the ScaleLevel "z", with MinScaleLevel "z" ≤ ScaleLevel "z" ≤ MaxScaleLevel "z".

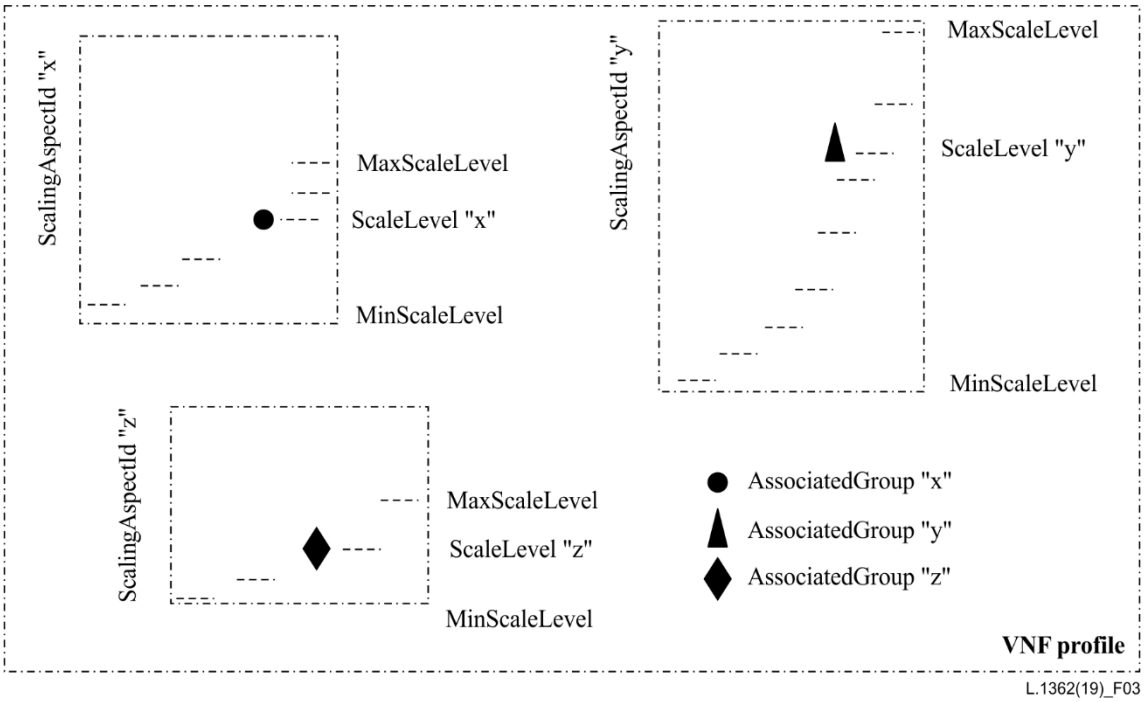

Figure 3 – Example of a virtualized network function profile with three scaling aspects

6.2.1.2 Network service scaling

The aim of NS scaling is to increase or decrease the capacity of an NS instance [ETSI GS NFV-IFA 013]. This can be achieved in various ways:

- scaling a VNF instance if a constituent VNF instance in the NS instance supports scaling and is not yet scaled to its limit;
- changing the DF of a VNF instance. If a VNF is already scaled to its limit, the next step of increasing the capacity of a VNF is to use the DF change, if there is a higher or lower capacity DF of the VNF. If the DF change of the VNF requires topology changes, the NFVO can create or modify the required VLs. Also the virtualized network function deployment flavour (VNF DF) changes may require an application level configuration task done by the traditional management system; therefore, interaction with an operations support system (OSS)/business support system (BSS) or element manager (EM) may be required;
- adding or removing VNF instance(s) to or from the NS. In this scenario, the capacity of the NS is changed by adding or removing VNF instance(s) to or from the NS instance. The NFVO needs to take care of creating the necessary links between the VNF instances according to the connectivity requirements defined in the NSD. This type of NS scaling may also require an application level configuration task performed by the OSS/BSS or EM;
- scaling to a new network service deployment flavour (NS DF). In this scenario, the NS DF is changed to a new one, which contains higher or lower capacities. The NFVO may require instantiation or termination of VNF instances according to the NSD of the new NS DF;
- scaling a nested NS. The capacity of an NS can also be changed by changing the capacity of a nested NS if there is one.
- Scaling of a VL. It may also be necessary as part of the capacity change need of an NS to change the capacity of a VL in an NS. This may be achieved either by changing the properties of a VL or by adding or removing a VL to or from an NS. The latter may require application level configuration as well, therefore interactions with OSS/BSS or EM may be required.

6.2.2 Network functions virtualization infrastructure overview

The NFVI is concerned with describing the hypervisor, compute and network domains (NDs), and their associated interfaces.

6.2.2.1 Hypervisor domain overview

The hypervisor domain (HD) abstracts the HW resources from the compute domain (CD) and implements services, such as starting a VM, terminating a VM, acting on policies, scaling, live migration and high availability. It overlaps with the ND in that it can include virtual switch and virtual router software elements and abstract network-related HW resources provided by the CD, such as network interface controller (NIC) and embedded switches [ETSI GS NFV-EVE 001].

Figure 4 shows the logical placement of the HD within the NFV architectural framework.

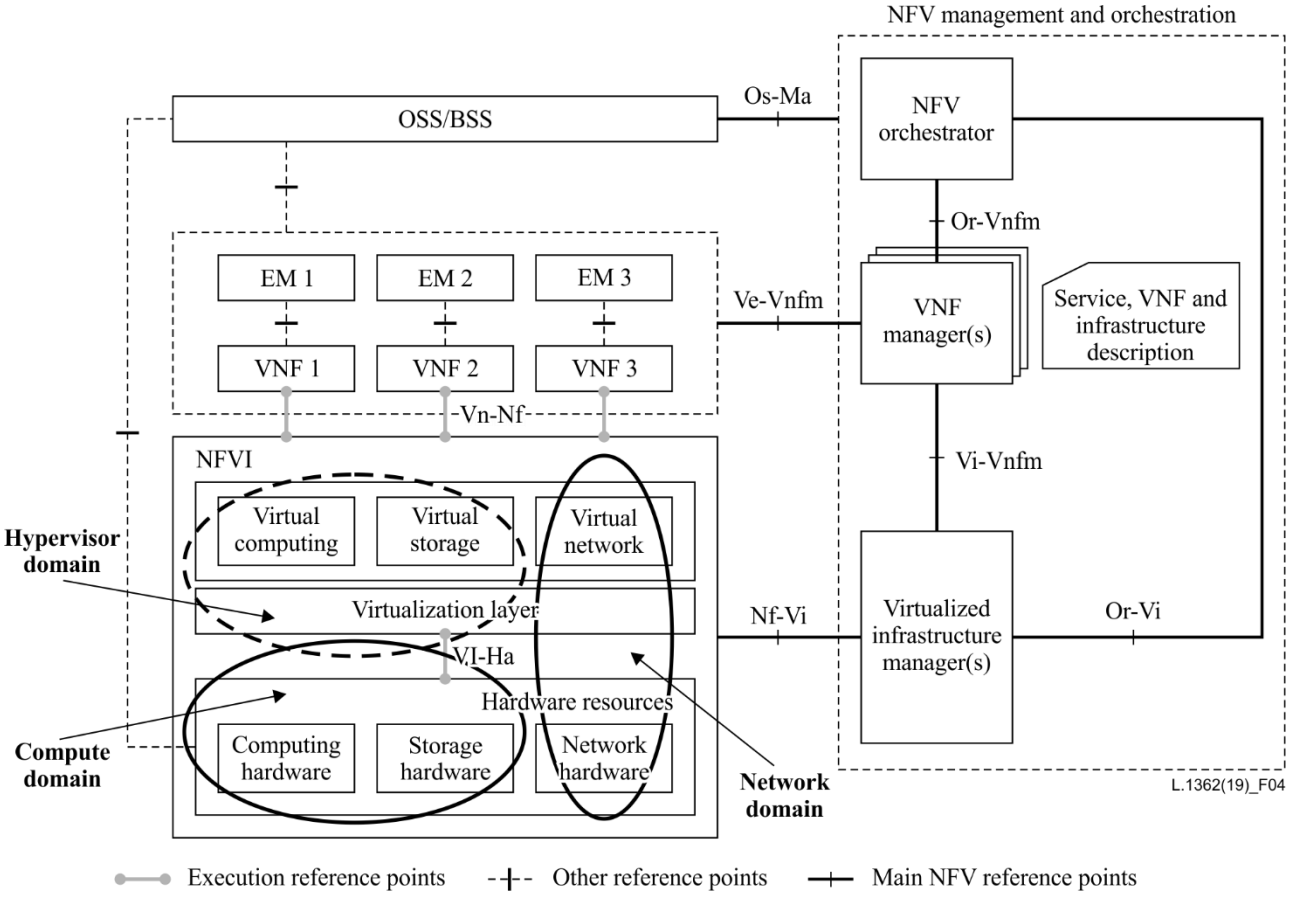

Figure 4 – Logical placement of the hypervisor domain

7 GALv2 energy-aware states specification

This clause specifies EASs for the EAEs that are relevant in the ETSI NFV context [ETSI GS NFV 002] in the same way as in [ETSI ES 203 237].

7.1 Identification of the ETSI network functions virtualization entities

The ETSI NFV entities that lie within the scope of this Recommendation are the VNFCs, VNFs and NSs.

7.1.1 Identification of a network service

The identification of a given NS *a* is done according to the following notation: NS~*a*, with *a* ϵ [*a*0, *a*1, *a*2, *a*3 …].

The *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, is identified with the following notation: $\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}$ with $i \in [1, 2, 3 \ldots]$.

7.1.2 Identification of a virtualized network function

The identification of a given virtualized network function *b* is done according to the following notation: VNF~*b*, with $b \in [b0, b1, b2, b3 \ldots]$.

The *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, is identified with the following notation: $\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ with $j \in [1, 2, 3 \ldots]$.

The *j*th instance of VNF~*b* belonging to $\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}$, and deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, is identified with the following notation: $\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#\text{l}_{\text{DF-X}}}$.

When the NS~*a* DF supports scaling, the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level, that belongs to the ASPECT-Ym at a given scale level l_{Ym}, is identified with the following notation: $\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Ym}\#l_{Ym}}$.

7.1.3 Identification of a virtualized network function component

The identification of a given VNFC *c* is done according to the following notation: VNFC~*c*, with $c \in [c0, c1, c2, c3 \ldots]$.

The *k*th instance of VNFC~*c* is identified with the following notation: VNFC~*c*#*k*, with $k \in [1, 2, 3 \ldots]$.

The *k*th instance of VNFC~*c* belonging to $\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ is identified with the following notation: $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$.

When the VNF~*b* DF supports scaling, the *k*th instance of VNFC~*c*, that belongs to the ASPECT-Ym at a given scale level, l_{Ym}, is identified with the following notation: $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Ym}\#l_{Ym}}$.

7.1.4 Identification of a virtualization container

The identification of a given VC, in which VNFC~*c*#*k* is deployed, is done according to the following notation: $\text{VC}_{\text{VNFC}\sim c\#k}$.

7.2 Identification of a given (CD, HD) combination

The identification of a given (CD, HD) combination on which a given VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ is deployed, is done with a function that takes $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ as an argument and returns the (CD, HD) combination identifier: $\text{ch}(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}})$.

NOTE – Anti-affinity rules make possible the deployment of the *k*th instance of VNFC~*c* on a (CD, HD) combination and the deployment of the *k*th instance of VNFC~*c* on a different (CD, HD) combination.

7.3 Identification of a given energy-aware state of a network functions virtualization entity

The identification of a given EAS of an ETSI NFV entity is done according to the following notation: $(\text{EAS}_x)^{\text{NFVentity}}$ with *x* being a real number.

NOTE – The *x*th EAS of an ETSI NFV entity depends on the (CD, HD) combination(s) on which the VC(s) associated with this entity is (are) deployed.

7.4 VNFC energy-aware states

7.4.1 VNFC energy-aware states definition

When the EAE is a VNFC, the EASs of this kind of entity should be associated with a VNFC instance which is mapped to a single VC.

The EASs associated with the deployment of the *k*th instance of VNFC~*c* depend on the (CD, HD) combination on which its mapped VC is deployed.

The *x*th EAS of $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ deployed on a given (CD, HD) combination should be defined according to the following formula:

$$(\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}} = \left\{(P_s)^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}, (S_{s'})^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}\right\}$$

with:

$$0 \le s \le L \quad \text{and} \quad 0 \le s' \le L'$$

- $(S_0)^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the 0th standby state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC is active;
- $(S_{s'})^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the s' th standby state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- $(S_{L'})^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the lowest standby state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC is completely off;
- $(P_0)^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the first power state of the active state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#\text{l}_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier In this state the VC power is maximum;
- $(P_s)^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the *s*th power state of the active state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC power is lower than the VC power of the first power state;
- $(P_L)^{\text{ch}\left(\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}\right)}$ identifies the lowest power state of the active state of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC power is minimum.

The real number *x* identifying an EAS of a VNFC instance is mapped with (*s*,*s*′) according to the following rules:

- negative values of *x* should regard the standby configurations ($s = 0, 0 < s' \le L'$); the sorting should be based on the power gain in ascending order;
- $x = 0$ corresponds to the pair with the highest power configuration among the ones allowed by the EAE ($s = 0$, $s' = 0$);
- the first *L* positive values of *x* should regard the power scaling configurations ($0 < s \le L$, $s' = 0$); the sorting should be based on the power gain in ascending order;

- the next positive values of x refer to the other possible configurations ($0 < s \leq L$, $0 < s' \leq L'$); this Recommendation does not define all the possible configurations.

Table 1 summarizes the different EAS configuration identifier values.

Table 1 – Energy-aware state configuration identifiers

EAS configuration identifier	EAS configuration name	(s, s') values
$x < 0$	Standby	$s = 0$ and $0 < s' \leq L'$
$x = 0$	Max performance and power consumption	$s = 0$ and $s' = 0$
$x > 0$	Power scaling	$0 < s \leq L$ and $s' = 0$
$x > 0$	Power scaling and standby	$0 < s \leq L$ and $0 < s' \leq L'$

The attributes associated with this EAS are defined as follows.

- $\text{power}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\text{performance}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\text{delay}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between this EAS and another EAS.

7.4.2 VNFC energy-aware states in the Vdu information element

The VnfcConfigurableProperties information element, containing configurable properties of a VNFC that can be modified through VNFM using the ModifyVnfInfo operation, provided in Table 7.1.6.7.2-1 of [ETSI GS NFV-IFA 011], should contain the VNFC EASs as defined in clause 7.4.1.

The MonitoringParameter information element, containing virtualized resource related performance metrics to be tracked by the VNFM, e.g., for auto-scaling purposes, provided in Table 7.1.11.3.2-1 of [ETSI GS NFV-IFA 011], should contain the attributes associated with the VNFC EASs as defined in clause 7.4.1.

7.5 Virtualized network function energy-aware states

7.5.1 Virtualized network function energy-aware states specification

When the EAE is a VNF, the EASs of this kind of entity should be associated with an instance of a given VNF deployed according to a given VNF DF in a given instantiation level [ETSI GS NFV-IFA 011].

The xth EAS of the jth instance of VNF~b deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, should be defined according to the following formula:

$$(\mathrm{EAS}_x)^{\mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}$$
$$= \left\{ \begin{array}{l} \begin{pmatrix} (\mathrm{EAS}_\alpha)^{\mathrm{VNFC}\sim c0\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}} \\ \vdots \\ (\mathrm{EAS}_\beta)^{\mathrm{VNFC}\sim c0\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}} \end{pmatrix}, \ldots, \begin{pmatrix} (\mathrm{EAS}_\gamma)^{\mathrm{VNFC}\sim cm\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}} \\ \vdots \\ (\mathrm{EAS}_\delta)^{\mathrm{VNFC}\sim cm\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}} \end{pmatrix}, \\ \begin{pmatrix} (\mathrm{EAS}_\varepsilon)^{\mathrm{VNFC}\sim cn\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y1}\#l_{Y1}}} \\ \vdots \\ (\mathrm{EAS}_\epsilon)^{\mathrm{VNFC}\sim cn\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y1}\#l_{Y1}}} \end{pmatrix}, \ldots, \begin{pmatrix} (\mathrm{EAS}_\theta)^{\mathrm{VNFC}\sim co\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y1}\#l_{Y1}}} \\ \vdots \\ (\mathrm{EAS}_\vartheta)^{\mathrm{VNFC}\sim co\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y1}\#l_{Y1}}} \end{pmatrix}, \\ \ldots, \\ \begin{pmatrix} (\mathrm{EAS}_\mu)^{\mathrm{VNFC}\sim cp\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y}m\#l_{Ym}}} \\ \vdots \\ (\mathrm{EAS}_\pi)^{\mathrm{VNFC}\sim cp\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y}m\#l_{Ym}}} \end{pmatrix}, \ldots, \begin{pmatrix} (\mathrm{EAS}_\rho)^{\mathrm{VNFC}\sim cq\#1 \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y}m\#l_{Ym}}} \\ \vdots \\ (\mathrm{EAS}_\sigma)^{\mathrm{VNFC}\sim cq\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}\text{-}\mathrm{ASP\text{-}Y}m\#l_{Ym}}} \end{pmatrix} \end{array} \right\}$$

The real number, *x*, identifying an EAS of a VNF instance is mapped with (α, β, γ …) according to rules that lie outside the scope of this Recommendation.

The attributes associated with this EAS are defined as follows:

- $\mathrm{power}\left((\mathrm{EAS}_x)^{\mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: power-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level;
- $\mathrm{performance}\left((\mathrm{EAS}_x)^{\mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: performance-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF in a given instantiation level;
- $\mathrm{delay}\left((\mathrm{EAS}_x)^{\mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: transition delay between this EAS and another EAS.

7.5.2 Virtualized network function energy-aware states in the virtualized network function descriptor information element

The additionalConfigurableProperty attribute of the VnfConfigurableProperties information element, containing VNF-specific configurable properties that can be modified by the VNFM, is provided in Table 7.1.12.2-1 of [ETSI GS NFV-IFA 011]. It should contain the VNF EASs as defined in clause 7.5.1.

The VnfInfoModifiableAttributes information element, containing VNF-specific extension and metadata attributes of the VnfInfo that are writeable via the ModifyVnfInfo operation, is provided in Table 7.1.14.2-1 of [ETSI GS NFV-IFA 011]. It should contain the VNF EASs as defined in clause 7.5.1.

The VnfIndicator information element, containing indicators the VNF supports, is provided in Table 7.1.11.2.2-1 of [ETSI GS NFV-IFA 011]. It should contain the VNF EASs as defined in clause 7.5.1.

7.5.3 Virtualized network function energy-aware states in the VnfDf information element

The VnfIndicator information element, containing indicators the VNF DF supports, is provided in Table 7.1.11.2.2-1 of [ETSI GS NFV-IFA 011]. It should contain the VNF DF EASs as defined in clause 7.5.1.

The MonitoringParameter information element, containing virtualized resource related performance metrics to be tracked by the VNFM, e.g., for auto-scaling purposes, provided in Table 7.1.11.3.2-1 of [ETSI GS NFV-IFA 011], should contain the attributes associated with the VNF DF EASs as defined in clause 7.5.1.

7.6 Network service energy-aware states

7.6.1 Network service energy-aware states definition

When the EAE is an NS, the EASs of this kind of entity should be associated with an instance of a given NS deployed according to a given NS DF at a given instantiation level [ETSI GS NFV-IFA 014].

The *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, should be defined according to the following formula:

$$(\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}} = \left\{ \begin{array}{l} \begin{pmatrix} (\text{EAS}_\alpha)^{\text{VNF}\sim b0\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}} \\ \vdots \\ (\text{EAS}_\beta)^{\text{VNF}\sim b0\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}} \end{pmatrix}, \ldots, \begin{pmatrix} (\text{EAS}_\gamma)^{\text{VNF}\sim bm\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}} \\ \vdots \\ (\text{EAS}_\delta)^{\text{VNF}\sim bm\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}} \end{pmatrix}, \\ \begin{pmatrix} (\text{EAS}_\varepsilon)^{\text{VNF}\sim bn\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y1}\#l_{Y1}}} \\ \vdots \\ (\text{EAS}_\epsilon)^{\text{VNF}\sim bn\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y1}\#l_{Y1}}} \end{pmatrix}, 1, \begin{pmatrix} (\text{EAS}_\theta)^{\text{VNF}\sim bo\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y1}\#l_{Y1}}} \\ \vdots \\ (\text{EAS}_\vartheta)^{\text{VNF}\sim bo\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y1}\#l_{Y1}}} \end{pmatrix}, \\ \ldots, \\ \begin{pmatrix} (\text{EAS}_\mu)^{\text{VNF}\sim bp\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y}m\#l_{Ym}}} \\ \vdots \\ (\text{EAS}_\pi)^{\text{VNF}\sim bp\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y}m\#l_{Ym}}} \end{pmatrix}, \ldots, \begin{pmatrix} (\text{EAS}_\rho)^{\text{VNF}\sim bq\#1_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y}m\#l_{Ym}}} \\ \vdots \\ (\text{EAS}_\sigma)^{\text{VNF}\sim bq\#j_{\text{DF-X}\#l_{\text{DF-X}}} \subset \text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}\text{-ASP-Y}m\#l_{Ym}}} \end{pmatrix} \end{array} \right\}$$

The real number *x* identifying an EAS of a NS instance is mapped with (α, β, γ …) according to rules that lie outside the scope of this Recommendation.

The attributes associated with this EAS are defined as follows:

- $\text{power}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the *i*th instance of a given NS deployed according to a given NS DF in a given instantiation level;
- $\text{performance}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the *i*th instance of a given NS deployed according to a given NS DF in a given instantiation level;
- $\text{delay}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between this EAS and another EAS.

7.6.2 Network service energy-aware states in the network service descriptor information element

The performanceMetric attribute in the MonitoringParameter information element, specifying a virtualized resource related performance metric to be monitored, provided in Table 6.2.8.2-1 of [ETSI GS NFV-IFA 011], should contain the attributes associated with the NS EASs as defined in clause 7.6.1.

8 GALv2 green standard interface

This clause specifies the GALv2 green standard interface supported over the reference points of the NFV MANO architectural framework, as well as the information elements exchanged over those interfaces.

The reference points (Figure 5) are Os-Ma-Nfvo [ETSI GS NFV-IFA 013], Or-Vnfm [ETSI GS NFV-IFA 007], Or-Vi [ETSI GS NFV-IFA 005], Vi-Vnfm [ETSI GS NFV-IFA 006], Ve-Vnfm-em [ETSI GS NFV-IFA 008], Ve-Vnfm-vnf [ETSI GS NFV-IFA 008].

The following operations are defined:

- provisioning: GALv2 provisioning configures EASs of virtualized resources;
- release: GALv2 release permits the virtualized resource to be put into its default EAS configuration;

- monitoring: The GALv2 monitoring command set permits energy parameters and values of an individual resource or a group of resources to be monitored.

NOTE – Provisioning, release, monitoring, discovery, commit, rollback operations are specified in GALv1 [ETSI ES 203 237]. Among them, discovery, commit and rollback operations are not relevant to the NFV MANO architectural framework.

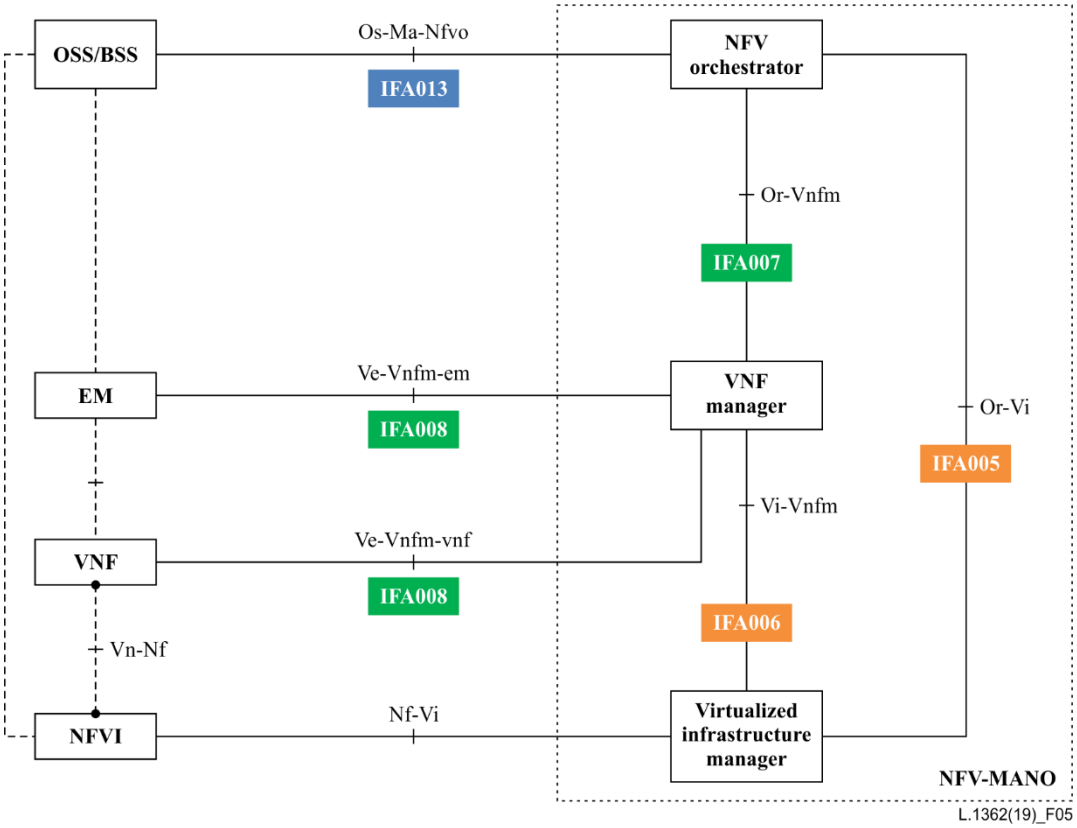

Figure 5 – Reference points of the network functions virtualization management orchestration architectural framework

8.1 Provisioning operations

GALv2 provisioning permits an EAS of an individual resource or a group of resources to be configured.

8.1.1 Os-Ma-Nfvo reference point

8.1.1.1 Instantiate network service operation

8.1.1.1.1 Description

This operation instantiates an NS in the NOT_INSTANTIATED state. The operation allows for references to existing VNF instances and NS instances that are to be used in the new NS (i.e., the NS being instantiated) and additional parameterization for new VNFs and NSs. The hierarchy of nested NSs and VNFs below the NS being instantiated should be acyclic (i.e., no loops) [ETSI GS NFV-IFA 013].

Table 2 lists the information flow exchanged between the OSS/BSS and NFVO [ETSI GS NFV-IFA 013].

Table 2 – Instantiate network service operation

Message	Requirement	Direction
InstantiateNsRequest	Mandatory	OSS/BSS → NFVO
InstantiateNsResponse	Mandatory	NFVO → OSS/BSS

8.1.1.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.3.3.2-1 of [ETSI GS NFV-IFA 013].

The additionalParamForNs parameter, allowing the OSS/BSS to provide additional parameter(s) at the NS level, should identify the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$. If not present, the default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the NSD should be used.

The additionalParamForVnf parameter, allowing the OSS/BSS to provide additional parameter(s) per VNF instance that is to be created by the NFVO as part of the NS instantiation and not for existing VNFs that are referenced for reuse, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$. If not present, the default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the VNFD should be used.

8.1.1.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.3.3-1 of [ETSI GS NFV-IFA 013].

8.1.1.1.4 Operation results

The operation results are specified in clause 7.3.3.4 of [ETSI GS NFV-IFA 013].

8.1.1.2 Scale network service operation

8.1.1.2.1 Description

This operation will scale an NS instance. Scaling an NS instance can be performed by explicitly adding or removing existing VNF instances to or from the NS instance, by leveraging on the abstraction mechanism provided by the NS scaling aspects and NS level information elements declared in the NSD, or by scaling individual VNF instances that are part of the NS itself. When adding VNFs and nested NSs, already existing or not, to the NS to be scaled, the NFV should follow the indications provided by the dependencies attribute, as specified in the corresponding NSD [ETSI GS NFV-IFA 013].

Table 3 lists the information flow exchanged between the OSS/BSS and NFVO [ETSI GS NFV-IFA 013].

Table 3 – Scale network service operation

Message	Requirement	Direction
ScaleNsRequest	Mandatory	OSS/BSS → NFVO
ScaleNsResponse	Mandatory	NFVO → OSS/BSS

8.1.1.2.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.3.4.2-1 of [ETSI GS NFV-IFA 013].

The scaleNsData parameter provides the information to scale the referenced NS instance. The ScaleNsData information element, provided in Table 8.3.4.6.2-1 of [ETSI GS NFV-IFA 013], describes the information needed to scale the instance either by explicitly adding or removing existing VNF instances or by leveraging on the abstraction mechanism provided by the NS scaling aspects and NS levels information elements declared in the NSD:

- the additionalParamForNs attribute, allowing the OSS/BSS to provide additional parameter(s) necessary for the scaling at the NS level, should identify the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$;
- the additionalParamForVnf attribute, allowing the OSS/BSS to provide additional parameter(s) per VNF instance that is to be created by the NFVO as part of the NS scaling, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

The scaleVnfData parameter provides the information to scale a given VNF instance that is part of the referenced NS instance. The ScaleVnfData information element, provided in Table 8.3.4.9.2-1 of [ETSI GS NFV-IFA 013], describes the information needed, either to scale a given VNF instance to a given level (ScaleToLevelData information element), or to scale a VNF instance by steps (ScaleByStepData information element).

The ScaleToLevelData information element, provided in Table 8.3.4.10.2-1 of [ETSI GS NFV-IFA 013], describes the information needed to scale the VNF instance to a given level, either expressed as an instantiation level of a given DF, or as a list of scale levels, one per scaling aspect of that DF. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) specific to the VNF instance being scaled, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to that DF, denoted DF-X at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

The ScaleByStepData information element, provided in Table 8.3.4.11.2-1 of [ETSI GS NFV-IFA 013], describes the information needed to scale the VNF instance by steps. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) specific to the VNF instance being scaled, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to that DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.1.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.4.3-1 of [ETSI GS NFV-IFA 013].

8.1.1.2.4 Operation results

The operation results are specified in clause 7.3.4.4 of [ETSI GS NFV-IFA 013].

8.1.1.3 Update network service operation

8.1.1.3.1 Description

This operation updates an NS instance. Only one type of update should be allowed per operation. This operation is also used to embed VNF LCM operations in support of a fine-grained NS LCM approach [ETSI GS NFV-IFA 013].

Table 4 lists the information flow exchanged between the OSS/BSS and NFVO [ETSI GS NFV-IFA 013].

Table 4 – Update network service operation

Message	Requirement	Direction
UpdateNsRequest	Mandatory	OSS/BSS → NFVO
UpdateNsResponse	Mandatory	NFVO → OSS/BSS

8.1.1.3.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.3.5.2-1 of [ETSI GS NFV-IFA 013].

- If updateType=InstantiateVnf: the instantiateVnfData parameter specifies the new VNF to be instantiated. The attributes of the InstantiateVnfData information element should follow the indications provided in Table 8.3.4.12.2-1 of [ETSI GS NFV-IFA 013]. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) specific to the VNF being instantiated, as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.
- If updateType=ChangeVnfDf: the changeVnfFlavourData parameter specifies the new DF of the VNF instance to be changed to. The attributes of the ChangeVnfFlavourData information element should follow the indications provided in Table 8.3.4.15.2-1 of [ETSI GS NFV-IFA 013]. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) to the flavour change process, specific to the VNF being modified, as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.
- If updateType=OperateVnf: the operateVnfData parameter specifies the state of the VNF instance to be changed. The attributes of the OperateVnfData information element should follow the indications provided in Table 8.3.4.16.2-1 of [ETSI GS NFV-IFA 013]. The changeStateTo attribute contains the desired state to change the VNF to. The allowed values are the identifiers of the VNF instance EAS. Among them, two identifiers should be mapped with STARTED and STOPPED. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) as input to the operate VNF process, specific to the VNF being operated, as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.
- If updateType=ChangeNsFlavourData: the changeNsFlavourData parameter specifies the new DF to be applied to the NS instance. The attributes of the ChangeNsFlavourData information element should follow the indications provided in Table 8.3.4.27.2-1 of [ETSI GS NFV-IFA 013]. The additionalParam attribute should be added in Table 8.3.4.27.2-1 of [ETSI GS NFV-IFA 013], to allow the OSS/BSS to provide additional parameter(s) to the flavour change process, specific to the NS being modified, as declared in the NFD, and to identify the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.
- If updateType=AddPnf: the addPnfData parameter specifies information about the PNF(s) that are being added into the NS instance. The attributes of the AddPnfData information element should follow the indications provided in Table 8.3.4.32.2-1 of [ETSI GS NFV-IFA 013]. The additionalParam attribute, allowing the OSS/BSS to provide additional parameter(s) specific to the PNF being instantiated, as declared in the PNFDs, should be added in Table 8.3.4.32.2-1 of [ETSI GS NFV-IFA 013].

NOTE – If updateType=AddPnf, the content of the additionalParam attribute should be defined with GALv1 [ETSI ES 203 237].

8.1.1.3.3 Output parameters

The output parameter returned by the operation should follow the indications provided in Table 7.3.5.3-1 of [ETSI GS NFV-IFA 013].

8.1.1.3.4 Operation results

The operation results are specified in clause 7.3.5.4 of [ETSI GS NFV-IFA 013].

8.1.1.4 Notify operation

8.1.1.4.1 Description

This operation notifies the OSS/BSS about events related to notifications about life cycle operation occurrences on NS instance, life cycle operation occurrences impacting NS components, as well as the creation or deletion of NS instance identifiers and the associated NsInfo information element instances. It is a one-way operation issued by the NFVO that cannot be invoked as an operation by the OSS/BSS. The following notifications can be notified by this operation: NsLcmOperationOccurenceNotification; NsChangeNotification; NsIdentifierCreationNotification; NsIdentifierObjectDeletionNotification [ETSI GS NFV-IFA 013].

Table 5 lists the information flow exchanged between the NFVO and OSS/BSS [ETSI GS NFV-IFA 013].

Table 5 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVO → OSS/BSS

8.1.1.4.2 NsLcmOperationOccurenceNotification

8.1.1.4.2.1 Description

This notification informs the receiver of changes in the NS life cycle caused by NS LCM operation occurrences, which may be triggered manually by the OSS/BSS or automatically by the NFVO. The automatic trigger inside NFVO includes auto-scaling, auto-healing and impact on the nested NS instances triggered by the NS life cycle operation on its composite NS. The support of the notification is mandatory [ETSI GS NFV-IFA 013].

8.1.1.4.2.2 Trigger conditions

This notification is produced when there is a change in the NS life cycle caused by NS LCM operation occurrences, including [ETSI GS NFV-IFA 013]:

- instantiation of the NS (start and result);
- scaling of the NS (start and result, including the auto-scaling);
- update of the NS (start and result);
- termination of the NS (start and result);
- healing of the NS (start and result, including the auto-healing);
- impact on the nested NS instances triggered by the NS life cycle operation on its composite NS.

If this is a notification about the start of an LCM operation occurrence, the notification should be sent before any action is taken, but after acknowledging the LCM operation request to the consumer.

If this is a notification about the result of an LCM operation, the notification should be sent after all other actions of the LCM operation have been executed.

8.1.1.4.2.3 Attributes

The attributes of the NsLcmOperationOccurenceNotification notification should follow the indications provided in Table 8.3.2.2.3-1 of [ETSI GS NFV-IFA 013].

When the notification represents the result of an LCM operation occurrence, the affectedVnf attribute contains information about VNF instances that were affected during the execution of the LCM operation.

The AffectedVnf information element should follow the indications provided in Table 8.3.2.3.2-1 of [ETSI GS NFV-IFA 013]. The vnfProfileId attribute references the VnfProfile that is used by the affected VNF instance. The attributes of the VnfProfile information element provided in Table 6.3.3.2-1 of [ETSI GS NFV-IFA 014] should contain an EAS as defined in clause 7.5.

When the notification represents the result of an LCM operation occurrence, the affectedPnf attribute contains information about PNF instances that were affected during the execution of the LCM operation.

The AffectedPnf information element should follow the indications provided in Table 8.3.2.4.2-1 of [ETSI GS NFV-IFA 013]. The pnfProfileId attribute references the PnfProfile that is used by the affected PNF instance. The attributes of the PnfProfile information element provided in Table 6.3.6.2-1 of [ETSI GS NFV-IFA 014] should contain an EAS as defined in [ETSI ES 203 237].

8.1.2 Or-Vnfm reference point

8.1.2.1 Instantiate virtualized network function operation

8.1.2.1.1 Description

This operation instantiates a particular DF of a VNF that has been in the NOT_INSTANTIATED instantiation state, based on the definition in the VNFD [ETSI GS NFV-IFA 007].

Table 6 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 6 – Instantiate virtualized network function operation

Message	Requirement	Direction
InstantiateVnfRequest	Mandatory	NFVO → VNFM
InstantiateVnfResponse	Mandatory	VNFM → NFVO

8.1.2.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.3.2-1 of [ETSI GS NFV-IFA 007].

The additionalParam parameter containing additional parameters, specific to the VNF being instantiated as declared in the VNFD, passed by the NFVO, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$. If not present, the default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the VNFD should be used.

8.1.2.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.3.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.1.4 Operation results

The operation results are specified in clause 7.2.3.4 of [ETSI GS NFV-IFA 007].

8.1.2.2 Scale virtualized network function operation

8.1.2.2.1 Description

This operation provides methods to request horizontal scaling a VNF [ETSI GS NFV-IFA 007]:

- scale out: adding additional VNFC instances to increase the VNF capacity;
- scale in: removing VNFC instances from the VNF in order to release unused capacity.

Table 7 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 7 – Scale virtualized network function operation

Message	Requirement	Direction
ScaleVnfRequest	Mandatory	NFVO → VNFM
ScaleVnfResponse	Mandatory	VNFM → NFVO

8.1.2.2.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.4.2-1 [ETSI GS NFV-IFA 007].

The additionalParam parameter containing additional parameters, specific to the VNF being scaled as declared in the VNFD, passed by the NFVO, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.2.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.4.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.2.4 Operation results

The operation results are specified in clause 7.2.4.4 of [ETSI GS NFV-IFA 007].

8.1.2.3 Scale virtualized network function to level operation

8.1.2.3.1 Description

This operation scales an instantiated VNF of a particular DF to a target size. The target size is either expressed as an instantiation level of that DF as described in the VNFD or given as a list of scale levels, one per scaling aspect of that DF. Instantiation levels and scaling aspects are declared in the VNFD [ETSI GS NFV-IFA 007].

Table 8 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 8 – Scale virtualized network function to level operation

Message	Requirement	Direction
ScaleVnfToLevelRequest	Mandatory	NFVO → VNFM
ScaleVnfToLevelResponse	Mandatory	VNFM → NFVO

8.1.2.3.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.5.2-1 of [ETSI GS NFV-IFA 007].

The additionalParam parameter containing additional parameters, specific to the VNF being scaled as declared in the VNFD, passed by the NFVO, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.2.3.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.5.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.3.4 Operation results

The operation results are specified in clause 7.2.5.4 of [ETSI GS NFV-IFA 007].

8.1.2.4 Change virtualized network function flavour operation

8.1.2.4.1 Description

This operation changes the DF of a VNF instance. It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF. This operation may be service-disruptive [ETSI GS NFV-IFA 007].

Table 9 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 9 – Change virtualized network function flavour operation

Message	Requirement	Direction
ChangeVnfFlavourRequest	Mandatory	NFVO → VNFM
ChangeVnfFlavourResponse	Mandatory	VNFM → NFVO

8.1.2.4.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.6.2-1 of [ETSI GS NFV-IFA 007].

The additionalParam parameter containing additional parameters passed by the NFVO as input to the flavour change process, specific to the VNF being modified as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.2.4.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.6.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.4.4 Operation results

The operation results are specified in clause 7.2.6.4 of [ETSI GS NFV-IFA 007].

8.1.2.5 Operate virtualized network function operation

8.1.2.5.1 Description

This operation enables a change to the state of a VNF instance, including starting and stopping the VNF instance, to be requested [ETSI GS NFV-IFA 007].

Table 10 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 10 – Operate virtualized network function operation

Message	Requirement	Direction
OperateVnfRequest	Mandatory	NFVO → VNFM
OperateVnfResponse	Mandatory	VNFM → NFVO

8.1.2.5.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.11.2-1 of [ETSI GS NFV-IFA 007].

The content of the changeStateTo parameter containing the desired state to change the VNF to should be modified to provide the set of the EAS(s) of the VNF instance. The STARTED value should be mapped to the *x*th EAS, and the STOPPED value should be mapped to the *y*th EAS.

The additionalParam parameter containing additional parameters passed by the NFVO as input to the operate VNF process, specific to the VNF being operated as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.2.5.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.11.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.5.4 Operation results

The operation results are specified in clause 7.2.11.4 of [ETSI GS NFV-IFA 007].

8.1.2.6 Modify virtualized network function information operation

8.1.2.6.1 Description

This operation allows information about a VNF instance to be updated. This operation should be supported for all VNFs [ETSI GS NFV-IFA 007].

Table 11 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

Table 11 – Modify virtualized network function information operation

Message	Requirement	Direction
ModifyVnfInfoRequest	Mandatory	NFVO → VNFM
ModifyVnfInfoResponse	Mandatory	VNFM → NFVO

8.1.2.6.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.12.2-1 of [ETSI GS NFV-IFA 007].

The newValues parameter should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.2.6.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.12.3-1 of [ETSI GS NFV-IFA 007].

8.1.2.6.4 Operation results

The operation results are specified in clause 7.2.12.4 of [ETSI GS NFV-IFA 007].

8.1.2.7 Notify operation

8.1.2.7.1 Description

This operation notifies the NFVO about events related to VNF life cycle changes as well as creation or deletion of VNF instance identifiers and the associated VnfInfo information element instances. The following notifications can be notified by this operation: VnfLcmOperationOccurrenceNotification, VnfIdentifierCreationNotification, VnfIdentifierDeletionNotification [ETSI GS NFV-IFA 007].

Table 12 lists the information flow exchanged between the VNFM and NFVO [ETSI GS NFV-IFA 007].

Table 12 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → NFVO

8.1.2.7.2 VnfLcmOperationOccurrenceNotification

8.1.2.7.2.1 Description

This notification informs the receiver of changes in the VNF life cycle caused by VNF LCM operation occurrences. The support of the notification is mandatory [ETSI GS NFV-IFA 007].

8.1.2.7.2.2 Trigger conditions

This notification is produced when there is a change in the VNF life cycle caused by VNF LCM operation occurrences, including [ETSI GS NFV-IFA 007]:

- instantiation of the VNF;
- scaling of the VNF instance (including auto-scaling);
- healing of the VNF instance (including auto-healing);
- operate VNF process;
- change of the DF of the VNF instance;
- changing the external VLs of the VNF instance;
- termination of the VNF instance;
- modification of VNF instance information or VNF configurable properties explicitly through the modify VNF information operation.

If this is a notification about the start of an LCM operation occurrence, the notification should be sent before any action (including sending the grant request) is taken, but after acknowledging the LCM operation request to the consumer.

If this is a notification about the result of an LCM operation occurrence, the notification should be sent after all other actions of the LCM operation have been executed.

8.1.2.7.2.3 Attributes

The VnfLcmOperationOccurrenceNotification should follow the indications provided in Table 8.6.2.3-1 of [ETSI GS NFV-IFA 007].

When the notification represents the result of an LCM operation occurrence, the affectedVnfc attribute contains information about VNFC instances that were affected during the execution of the LCM operation.

The AffectedVnfc information element should follow the indications provided in Table 8.6.3.2-1 of [ETSI GS NFV-IFA 007].

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in Table 7.1.6.2.2-1 of [ETSI GS NFV-IFA 011] should contain EASs as defined in clause 7.4.

The metadata attribute should contain an EAS of the VC, as defined in clause 7.4, associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

8.1.2.8 Virtualized resources management interfaces in indirect mode

8.1.2.8.1 Introduction

In indirect mode of VNF-related resource management, the NFVO produces towards VNFM the virtualized resource management interfaces defined in clause 6.4 of [ETSI GS NFV-IFA 007]. These

interfaces are related to the corresponding interfaces specified in [ETSI GS NFV-IFA 006] with an additional resource provider identifier.

This identifier is used by the NFVO to determine the entity responsible for the management of the virtualized resource, the management of the virtualized resources reservation or the management of the virtualized resources quota (usually one of multiple virtual infrastructure managers (VIMs) with which the NFVO interacts). It is used by the VNFM to uniquely identify resources, resource reservations or resource quotas by means of the pair of the resource provider identifier and the actual identifier of the resource, reservation or quota [ETSI GS NFV-IFA 007].

8.1.2.8.2 Virtualized compute interfaces

8.1.2.8.2.1 Virtualized compute resources management interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources management to the VNFM according to clause 6.4.2.1 of [ETSI GS NFV-IFA 007].

8.1.2.8.2.2 Virtualized compute resources change notification interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources change notifications to be consumed by the VNFM according to clause 6.4.2.2 of [ETSI GS NFV-IFA 007].

8.1.2.8.2.3 Virtualized compute resources information management interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources information management to the VNFM according to clause 6.4.2.3 of [ETSI GS NFV-IFA 007].

8.1.3 Or-Vi reference point

8.1.3.1 Allocate virtualized compute resource operation

8.1.3.1.1 Description

This operation allows the allocation of virtualized compute resources as indicated by the consumer functional block to be requested [ETSI GS NFV-IFA 005].

Table 13 lists the information flow exchanged between the NFVO and VIM [ETSI GS NFV-IFA 005].

Table 13 – Allocate virtualized compute resource operation

Message	Requirement	Direction
AllocateComputeRequest	Mandatory	NFVO → VIM
AllocateComputeResponse	Mandatory	VIM → NFVO

8.1.3.1.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.2.2-1 of [ETSI GS NFV-IFA 005]. The parameter computeFlavourId identifies the compute flavour that provides information about the particular memory, CPU and disk resources for the virtualized compute resource to allocate.

A new attribute of the VirtualComputeFlavour information element, provided in Table 8.4.2.2.2-1 of [ETSI GS NFV-IFA 005] should be added according to Table 14.

Table 14 – VirtualComputeFlavour energyAwareState attribute

Attribute	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. 1	Virtualized compute resource energy-aware state. See note.	Selected EAS from the set of EASs offered by the virtualized compute node resources. The cardinality can be 0, if no particular EAS is requested.
NOTE – The virtualized compute resource EAS should be associated with a VNFC instance.				

8.1.3.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.1.2.3-1 of [ETSI GS NFV-IFA 005]. Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 005], providing information about the newly instantiated virtualized compute resource, should contain a new energyAwareState attribute according to Table 15.

Table 15 – VirtualCompute energyAwareState attribute

Attribute	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. N	Virtualized compute resource energy-aware state.	Selected EASs from the set of EASs offered by the virtualized compute node resources. The cardinality can be 0, if no particular EAS is requested.

8.1.3.1.4 Operation results

The operation results are specified in clause 7.3.1.2.4 of [ETSI GS NFV-IFA 005].

8.1.3.2 Update virtualized compute resource operation

8.1.3.2.1 Description

This operation allows the configuration or parameters of an instantiated virtualized compute resource to be updated. This can include updating metadata, adding extra virtual network interfaces to a compute resource or attaching a virtual network interface to a specific network port [ETSI GS NFV-IFA 005].

Table 16 lists the information flow exchanged between the NFVO and VIM [ETSI GS NFV-IFA 005].

Table 16 – Update virtualized compute resource operation

Message	Requirement	Direction
UpdateComputeRequest	Mandatory	NFVO → VIM
UpdateComputeResponse	Mandatory	VIM → NFVO

8.1.3.2.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.4.2-1 of [ETSI GS NFV-IFA 005]. A new energyAwareState parameter should be added according to Table 17.

Table 17 – energyAwareState parameter

Parameter	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. 1	Virtualized compute resource energy-aware state.	The EAS to update on the virtualized compute resource. See note.
NOTE – Cardinality can be "0" as it is recommended that only one type of update is made in a single operation request.				

8.1.3.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.1.4.3-1 of [ETSI GS NFV-IFA 005]. Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 005], providing information about the newly instantiated virtualized compute resource, should contain a new energyAwareState attribute according to Table 15.

8.1.3.2.4 Operation results

The operation results are specified in clause 7.3.1.4.4 of [ETSI GS NFV-IFA 005].

8.1.3.3 Scale virtualized compute resource operation

8.1.3.3.1 Description

This operation allows scaling a virtualized compute resource by adding or removing capacity in terms of vCPUs and virtual memory [ETSI GS NFV-IFA 005].

Table 18 lists the information flow exchanged between the NFVO and VIM [ETSI GS NFV-IFA 005].

Table 18 – Scale virtualized compute resource operation

Message	Requirement	Direction
ScaleComputeRequest	Mandatory	NFVO → VIM
ScaleComputeResponse	Mandatory	VIM → NFVO

8.1.3.3.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.7.2-1 of [ETSI GS NFV-IFA 005].

A new attribute of the VirtualComputeFlavour information element, provided in Table 8.4.2.2.2-1 of [ETSI GS NFV-IFA 005] should be added according to Table 14.

8.1.3.3.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.3.1.7.3-1 of [ETSI GS NFV-IFA 005]. The content of the computeData parameter, containing information about the scaled virtualized compute resource, and provided in Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 005], should be updated according to Table 15.

8.1.3.3.4 Operation results

The operation results are specified in clause 7.3.1.7.4 of [ETSI GS NFV-IFA 005].

8.1.3.4 Notify operation

8.1.3.4.1 Description

This operation distributes notifications to the NFVO. It is a one-way operation issued by the VIM that cannot be invoked as an operation by the NFVO. The following notification is notified by this operation: VirtualisedResourceChangeNotification [ETSI GS NFV-IFA 005].

Table 19 lists the information flow exchanged between the VIM and NFVO [ETSI GS NFV-IFA 005].

Table 19 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → NFVO

8.1.3.4.2 VirtualisedResourceChangeNotification

8.1.3.4.2.1 Description

This notification informs the receiver of changes in the virtualized resources that are allocated. The support of the notification is mandatory [ETSI GS NFV-IFA 005].

8.1.3.4.2.2 Trigger conditions

This notification is produced when the virtualized resource will be impacted due to changes in underlying resources produced by maintenance and operation of the NFVI, including [ETSI GS NFV-IFA 005]:

- maintenance of NFVI components, e.g., physical maintenance or hypervisor software updates;
- operation and management of NFVI resources, e.g., to support energy efficiency or resource usage optimization;
- addition and removal of physical resources;
- evacuation of physical hosts.

NOTE – The operations in this clause could trigger further actions, e.g., migration of virtualized resources.

8.1.3.4.2.3 Attributes

The VirtualisedResourceChangeNotification should follow the indications provided in Table 8.4.9.3-1 of [ETSI GS NFV-IFA 005].

When one or more EAS(s) is (are) added or removed, the content of the changedResourceData attribute, which details the changes in the virtualized resource, should provide the added or removed EAS(s).

8.1.4 Vi-Vnfm reference point

8.1.4.1 Allocate virtualized compute resource operation

8.1.4.1.1 Description

This operation allows the allocation of virtualized compute resources as indicated by the consumer functional block to be requested [ETSI GS NFV-IFA 006].

Table 20 lists the information flow exchanged between the VNFM and VIM [ETSI GS NFV-IFA 006].

Table 20 – Allocate virtualized compute resource operation

Message	Requirement	Direction
AllocateComputeRequest	Mandatory	VNFM → VIM
AllocateComputeResponse	Mandatory	VIM → VNFM

8.1.4.1.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.2.2-1 of [ETSI GS NFV-IFA 006]. The parameter computeFlavourId identifies the compute flavour that provides information about the particular memory, CPU and disk resources for the virtualized compute resource to allocate.

A new attribute of the VirtualComputeFlavour information element, provided in Table 8.4.2.2.2-1 of [ETSI GS NFV-IFA 006] should be added according to Table 14.

8.1.4.1.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.3.1.2.3-1 of [ETSI GS NFV-IFA 006]. The content of the computeData parameter, containing information about the newly instantiated virtualized compute resource, and provided in Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 006], should be updated according to Table 15.

8.1.4.1.4 Operation results

The operation results are specified in clause 7.3.1.2.4 of [ETSI GS NFV-IFA 006].

8.1.4.2 Update virtualized compute resource operation

8.1.4.2.1 Description

This operation allows the configuration or parameters of an instantiated virtualized compute resource to be updated. This can include updating metadata, adding extra virtual network interfaces to a compute resource or attaching a virtual network interface to a specific network port [ETSI GS NFV-IFA 006].

Table 21 lists the information flow exchanged between the VNFM and VIM [ETSI GS NFV-IFA 006].

Table 21 – Update virtualized compute resource operation

Message	Requirement	Direction
UpdateComputeRequest	Mandatory	VNFM → VIM
UpdateComputeResponse	Mandatory	VIM → VNFM

8.1.4.2.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.4.2-1 of [ETSI GS NFV-IFA 006]. A new energyAwareState parameter should be added according to Table 17.

8.1.4.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.1.4.3-1 of [ETSI GS NFV-IFA 006]. Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 006], providing information about the newly instantiated virtualized compute resource, should contain a new energyAwareState attribute according to Table 15.

8.1.4.2.4 Operation results

The operation results are specified in clause 7.3.1.4.4 of [ETSI GS NFV-IFA 006].

8.1.4.3 Scale virtualized compute resource operation

8.1.4.3.1 Description

This operation allows scaling a virtualized compute resource by adding or removing capacity in terms of vCPUs and virtual memory [ETSI GS NFV-IFA 006].

Table 22 lists the information flow exchanged between the VNFM and VIM [ETSI GS NFV-IFA 006].

Table 22 – Scale virtualized compute resource operation

Message	Requirement	Direction
ScaleComputeRequest	Mandatory	VNFM → VIM
ScaleComputeResponse	Mandatory	VIM → VNFM

8.1.4.3.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.7.2-1 of [ETSI GS NFV-IFA 006].

A new attribute of the VirtualComputeFlavour information element, provided in Table 8.4.2.2.2-1 of [ETSI GS NFV-IFA 006] should be added according to Table 14.

8.1.4.3.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.3.1.7.3-1 of [ETSI GS NFV-IFA 006]. The content of the computeData parameter, containing information about the scaled virtualized compute resource, and provided in Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 006], should be updated according to Table 15.

8.1.4.3.4 Operation results

The operation results are specified in clause 7.3.1.7.4 of [ETSI GS NFV-IFA 006].

8.1.4.4 Notify operation

8.1.4.4.1 Description

This operation distributes notifications to the VNFM. It is a one-way operation issued by the VIM that cannot be invoked as an operation by the VNFM. In order to receive notifications the VNFM should have a subscription. The following notification is notified by this operation: VirtualisedResourceChangeNotification [ETSI GS NFV-IFA 006].

Table 23 lists the information flow exchanged between the VIM and VNFM [ETSI GS NFV-IFA 006].

Table 23 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → VNFM

8.1.4.4.2 VirtualisedResourceChangeNotification

8.1.4.4.2.1 Description

This notification informs the receiver of changes in the virtualized resources that are allocated. The support of the notification is mandatory [ETSI GS NFV-IFA 006].

8.1.4.4.2.2 Trigger conditions

This notification is produced when the virtualized resource will be impacted due to changes in underlying resources produced by maintenance and operation of the NFVI, including [ETSI GS NFV-IFA 006]:

- maintenance of NFVI components, e.g., physical maintenance or hypervisor software updates;
- operation and management of NFVI resources, e.g., to support energy efficiency or resource usage optimization;
- addition and removal of physical resources;
- evacuation of physical hosts.

NOTE – The operations in this clause could trigger further actions, e.g., migration of virtualized resources.

8.1.4.4.2.3 Attributes

The VirtualisedResourceChangeNotification notification should follow the indications provided in Table 8.4.9.3-1 of [ETSI GS NFV-IFA 006].

When one or more EAS(s) is (are) added or removed, the content of the changedResourceData attribute, that details the changes of the virtualized resource, should provide the added or removed EAS(s).

8.1.5 Ve-Vnfm-em reference point

8.1.5.1 Instantiate virtualized network function operation

8.1.5.1.1 Description

This operation instantiates a particular DF of a VNF that has been in the NOT_INSTANTIATED instantiation state, based on the definition in the VNFD [ETSI GS NFV-IFA 008].

Table 24 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

Table 24 – Instantiate virtualized network function operation

Message	Requirement	Direction
InstantiateVnfRequest	Mandatory	EM → VNFM
InstantiateVnfResponse	Mandatory	VNFM → EM

8.1.5.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.3.2-1 of [ETSI GS NFV-IFA 008].

The additionalParam parameter containing additional parameters, specific to the VNF being instantiated as declared in the VNFD, passed by the EM, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$. If not present, the default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the VNFD should be used.

8.1.5.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.3.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.1.4 Operation results

The operation results are specified in clause 7.2.3.4 of [ETSI GS NFV-IFA 008].

8.1.5.2 Scale virtualized network function operation

8.1.5.2.1 Description

This operation enables a VNF instance or EM to request a VNFM to perform a scaling procedure [ETSI GS NFV-IFA 008]:

- scale out: adding additional VNFC instances to increase the VNF capacity;
- scale in: removing VNFC instances from the VNF in order to release unused capacity.

Table 25 lists the information flow exchanged between the VNF/EM and VNFM [ETSI GS NFV-IFA 008].

Table 25 – Scale virtualized network function operation

Message	Requirement	Direction
ScaleVnfRequest	Mandatory	VNF → VNFM (See note) EM → VNFM
ScaleVnfResponse	Mandatory	VNFM → VNF (See note) VNFM → EM
NOTE – In the case of a VNF without EM, the scaling request is invoked by a management function within the VNF. The management function may implement the consumer part of the VNF LCM interface on the Ve-Vnfm-em reference point.		

8.1.5.2.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.4.2-1 of [ETSI GS NFV-IFA 008].

The additionalParam parameter containing additional parameters, specific to the VNF being scaled as declared in the VNFD, passed by the VNF/EM, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.5.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.4.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.2.4 Operation results

The operation results are specified in clause 7.2.4.4 of [ETSI GS NFV-IFA 008].

8.1.5.3 Scale virtualized network function to level operation

8.1.5.3.1 Description

This operation scales an instantiated VNF of a particular DF to a target size. The target size is either expressed as an instantiation level of that DF as defined in the VNFD or given as a list of scale levels, one per scaling aspect of that DF. Instantiation levels and scaling aspects are declared in the VNFD. Typically, the result of this operation is adding or removing NFVI resources to or from the VNF [ETSI GS NFV-IFA 008].

Table 26 lists the information flow exchanged between the VNF/EM and VNFM [ETSI GS NFV-IFA 008].

Table 26 – Scale virtualized network function to level operation

Message	Requirement	Direction
ScaleVnfToLevelRequest	Mandatory	VNF → VNFM EM → VNFM
ScaleVnfToLevelResponse	Mandatory	VNFM → VNF VNFM → EM

8.1.5.3.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.5.2-1 of [ETSI GS NFV-IFA 008].

The additionalParam parameter containing additional parameters, specific to the VNF being scaled as declared in the VNFD, passed by the VNF/EM, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.5.3.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.5.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.3.4 Operation results

The operation results are specified in clause 7.2.5.4 of [ETSI GS NFV-IFA 008].

8.1.5.4 Change virtualized network function flavour operation

8.1.5.4.1 Description

This operation changes the DF of a VNF instance. It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF. This operation may be service-disruptive [ETSI GS NFV-IFA 008].

Table 27 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

Table 27 – Change virtualized network function flavour operation

Message	Requirement	Direction
ChangeVnfFlavourRequest	Mandatory	EM → VNFM
ChangeVnfFlavourResponse	Mandatory	VNFM → EM

8.1.5.4.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.6.2-1 of [ETSI GS NFV-IFA 008].

The additionalParam parameter containing additional parameters passed by the EM as input to the flavour change process, specific to the VNF being modified as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.5.4.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.6.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.4.4 Operation results

The operation results are specified in clause 7.2.6.4 of [ETSI GS NFV-IFA 008].

8.1.5.5 Operate virtualized network function operation

8.1.5.5.1 Description

This operation enables a change of state of a VNF instance or VNFC instance(s), including starting and stopping the VNF/VNFC instance, to be requested [ETSI GS NFV-IFA 008].

Table 28 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

Table 28 – Operate virtualized network function operation

Message	Requirement	Direction
OperateVnfRequest	Mandatory	EM → VNFM
OperateVnfResponse	Mandatory	VNFM → EM

8.1.5.5.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.11.2-1 of [ETSI GS NFV-IFA 008].

The content of the changeStateTo parameter provides the set of the EAS(s) of the VNF instance. The STARTED value should be mapped to the *x*th EAS, and the STOPPED value should be mapped to the *y*th EAS.

The additionalParam parameter containing additional parameters passed by the EM as input to the operate VNF process, specific to the VNF being operated as declared in the VNFD, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.5.5.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.11.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.5.4 Operation results

The operation results are specified in clause 7.2.11.4 of [ETSI GS NFV-IFA 008].

8.1.5.6 Modify virtualized network function information operation

8.1.5.6.1 Description

This operation allows information about a VNF instance [ETSI GS NFV-IFA 008] to be updated.

Table 29 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

Table 29 – Modify virtualized network function information operation

Message	Requirement	Direction
ModifyVnfInfoRequest	Mandatory	EM → VNFM
ModifyVnfInfoResponse	Mandatory	VNFM → EM

8.1.5.6.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.12.2-1 of [ETSI GS NFV-IFA 008].

The newValues parameter should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{DF\text{-}X}$.

8.1.5.6.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.12.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.6.4 Operation results

The operation results are specified in clause 7.2.12.4 of [ETSI GS NFV-IFA 008].

8.1.5.7 Notify operation

8.1.5.7.1 Description

This operation notifies the EM or VNF about events related to VNF life cycle changes, as well as the creation or deletion of VNF instance identifiers and the associated VnfInfo information element instances. The following notifications can be notified by this operation: VnfLcmOperationOccurrenceNotification, VnfIdentifierCreationNotification, VnfIdentifierDeletionNotification [ETSI GS NFV-IFA 008].

Table 30 lists the information flow exchanged between the VNFM and EM or VNF [ETSI GS NFV-IFA 008].

Table 30 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → EM VNFM → VNF

8.1.5.7.2 VnfLcmOperationOccurrenceNotification

8.1.5.7.2.1 Description

This notification informs the receiver of changes in the VNF life cycle caused by VNF LCM operation occurrences. The support of the notification is mandatory [ETSI GS NFV-IFA 008].

8.1.5.7.2.2 Trigger conditions

This notification is produced when there is a change in the VNF life cycle caused by VNF LCM operation occurrences, including [ETSI GS NFV-IFA 008]:

- instantiation of the VNF;
- scaling of the VNF instance (including auto-scaling);
- healing of the VNF instance (including auto-healing);
- operate VNF process;
- change of the DF of the VNF instance;
- changing the external VLs of the VNF instance;
- termination of the VNF instance;
- modification of VNF instance information or VNF/VNFC configurable properties explicitly through the modify VNF information operation.

If this is a notification about the start of an LCM operation occurrence, the notification should be sent before any action (including sending the grant request) is taken, but after acknowledging the LCM operation request to the consumer.

If this is a notification about the result of an LCM operation occurrence, the notification should be sent after all other actions of the LCM operation have been executed.

8.1.5.7.2.3 Attributes

The VnfLcmOperationOccurrenceNotification should follow the indications provided in Table 9.5.2.3-1 of [ETSI GS NFV-IFA 008].

When the notification represents the result of an LCM operation occurrence, the affectedVnfc attribute contains information about VNFC instances that were affected during the execution of the LCM operation.

The AffectedVnfc information element should follow the indications provided in Table 9.5.3.2-1 of [ETSI GS NFV-IFA 008].

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in Table 7.1.6.2.2-1 of [ETSI GS NFV-IFA 011] should contain EASs as defined in clause 7.4.

The metadata attribute should contain an EAS of the VC, as defined in clause 7.4, associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

8.1.5.8 Set configuration

8.1.5.8.1 Description

This operation enables the VNFM to set the configuration parameters of a VNF instance and its VNFC instance(s) or individual VNFC instances [ETSI GS NFV-IFA 008].

Table 31 lists the information flow exchanged between the VNFM and the VNF [ETSI GS NFV-IFA 008].

Table 31 – SetConfiguration operation

Message	Requirement	Direction
SetConfigurationRequest	Mandatory	VNFM → VNF
SetConfigurationResponse	Mandatory	VNF → VNFM

8.1.5.8.2 Input parameters

The input parameters sent when invoking the operation are provided in Table 6.2.3.2-1 of [ETSI GS NFV-IFA 008].

The content of the vnfConfigurationData parameter, containing configuration data for the VNF instance, is defined in Table 9.2.2.2-1 of [ETSI GS NFV-IFA 008]. The attribute vnfSpecificData, providing a configuration object containing values of VNF configurable properties, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.1.5.8.3 Output parameters

The output parameters sent when responding to the operation is provided in Table 6.2.3.3-1 of [ETSI GS NFV-IFA 008].

8.1.5.8.4 Operation results

The operation results are specified in clause 6.2.3.4 of [ETSI GS NFV-IFA 008].

8.2 Release operations

GALv2 Release permits putting the virtualized resource in its default EAS configuration.

8.2.1 Os-Ma-Nfvo reference point

8.2.1.1 Update operation

8.2.1.1.1 Description

This operation updates an NS instance. Only one type of update should be allowed per operation. This operation is also used to embed VNF LCM operations in support of a fine-grained NS LCM approach [ETSI GS NFV-IFA 013].

Table 4 lists the information flow exchanged between the OSS/BSS and NFVO [ETSI GS NFV-IFA 013].

8.2.1.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.3.5.2-1 of [ETSI GS NFV-IFA 013]. A new action that can be performed with an update should be GALv2ReleaseNs:

- If updateType=GALv2ReleaseNs: the galv2 ReleaseNs parameter, defined in Table 32, should put the EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, to its default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the NSD.

Table 32 – galv2ReleaseNs parameter

Parameter	Qualifier	Cardinality	Content	Description
galv2ReleaseNs	M	0 .. 1	Default energy-aware state of the NS instance.	GALv2 Release should put the EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$, to its default EAS for this instance deployed according to a given DF and a given instantiation level as declared in the NSD. See note.
NOTE – Cardinality can be "0" as it is recommended that only one type of update is made in a single operation request.				

8.2.1.1.3 Output parameters

The output parameter returned by the operation should follow the indications provided in Table 7.3.5.3-1 of [ETSI GS NFV-IFA 013].

8.2.1.1.4 Operation results

The operation results are specified in clause 7.3.5.4 of [ETSI GS NFV-IFA 013].

8.2.2 Or-Vnfm reference point

8.2.2.1 Operate virtualized network function operation

8.2.2.1.1 Description

This operation enables a change to the state of a VNF instance, including starting and stopping the VNF instance, to be requested [ETSI GS NFV-IFA 007].

Table 10 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

8.2.2.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.11.2-1 of [ETSI GS NFV-IFA 007].

The additionalParam parameter containing additional parameters passed by the NFVO as input to the operate VNF process, specific to the VNF being operated as declared in the VNFD, should identify the default EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.2.2.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.11.3-1 of [ETSI GS NFV-IFA 007].

8.2.2.1.4 Operation results

The operation results are specified in clause 7.2.11.4 of [ETSI GS NFV-IFA 007].

8.2.2.2 Modify virtualized network function information operation

8.2.2.2.1 Description

This operation allows information about a VNF instance to be updated. This operation should be supported for all VNFs [ETSI GS NFV-IFA 007].

Table 11 lists the information flow exchanged between the NFVO and VNFM [ETSI GS NFV-IFA 007].

8.2.2.2.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.12.2-1 of [ETSI GS NFV-IFA 007].

The newValues parameter should identify the default EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.2.2.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.12.3-1 of [ETSI GS NFV-IFA 007].

8.2.2.2.4 Operation results

The operation results are specified in clause 7.2.12.4 of [ETSI GS NFV-IFA 007].

8.2.2.3 Notify operation

8.2.2.3.1 Description

This operation notifies the NFVO about events related to VNF life cycle changes, as well as the creation or deletion of VNF instance identifiers and the associated VnfInfo information element instances. The following notifications can be notified by this operation: VnfLcmOperationOccurrenceNotification, VnfIdentifierCreationNotification, VnfIdentifierDeletionNotification [ETSI GS NFV-IFA 007].

Table 12 lists the information flow exchanged between the VNFM and NFVO [ETSI GS NFV-IFA 007].

8.2.2.3.2 VnfLcmOperationOccurrenceNotification

8.2.2.3.2.1 Description

This notification informs the receiver of changes in the VNF life cycle caused by VNF LCM operation occurrences. The support of the notification is mandatory [ETSI GS NFV-IFA 007].

8.2.2.3.2.2 Trigger conditions

This notification is produced when there is a change in the VNF life cycle caused by VNF LCM operation occurrences, including [ETSI GS NFV-IFA 007]:

- instantiation of the VNF;
- scaling of the VNF instance (including auto-scaling);
- healing of the VNF instance (including auto-healing);
- operate VNF process;
- change of the DF of the VNF instance;
- changing the external VLs of the VNF instance;
- termination of the VNF instance;
- modification of VNF instance information or VNF configurable properties explicitly through the modify VNF information operation.

If this is a notification about the start of an LCM operation occurrence, the notification should be sent before any action (including sending the grant request) is taken, but after acknowledging the LCM operation request to the consumer.

If this is a notification about the result of an LCM operation occurrence, the notification should be sent after all other actions of the LCM operation have been executed.

8.2.2.3.2.3 Attributes

The VnfLcmOperationOccurrenceNotification should follow the indications provided in Table 8.6.2.3-1 of [ETSI GS NFV-IFA 007].

When the notification represents the result of an LCM operation occurrence, the affectedVnfc attribute contains information about VNFC instances that were affected during the execution of the LCM operation.

The AffectedVnfc information element should follow the indications provided in Table 8.6.3.2-1 of [ETSI GS NFV-IFA 007].The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in Table 7.1.6.2.2-1 of [ETSI GS NFV-IFA 011] should contain EASs as defined in clause 7.4.

The metadata attribute should contain the default EAS of the VC associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

8.2.2.4 Virtualized resources management interfaces in indirect mode

8.2.2.4.1 Introduction

In indirect mode of VNF-related resource management, the NFVO produces towards VNFM the virtualized resource management interfaces defined in clause 6.4 of [ETSI GS NFV-IFA 007]. These interfaces are related to the corresponding interfaces defined in [ETSI GS NFV-IFA 006] with an additional resource provider identifier.

This identifier is used by the NFVO to determine the entity responsible for the management of the virtualized resource, the management of the virtualized resources reservation or the management of the virtualized resources quota (usually one of multiple VIMs with which the NFVO interacts). It is used by the VNFM to uniquely identify resources, resource reservations or resource quotas by means of the pair of the resource provider identifier and the actual identifier of the resource, reservation or quota [ETSI GS NFV-IFA 007].

8.2.2.4.2 Virtualized compute interfaces

8.2.2.4.2.1 Virtualized compute resources management interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources management to the VNFM according to clause 6.4.2.1 of [ETSI GS NFV-IFA 007].

8.2.2.4.2.2 Virtualized compute resources change notification interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources change notifications to be consumed by the VNFM according to clause 6.4.2.2 of [ETSI GS NFV-IFA 007].

8.2.2.4.2.3 Virtualized compute resources information management interface

In indirect resource management mode, the NFVO produces an interface for virtualized compute resources information management to the VNFM according to clause 6.4.2.3 of [ETSI GS NFV-IFA 007].

8.2.3 Or-Vi reference point

8.2.3.1 Update virtualized compute resource operation

8.2.3.1.1 Description

This operation allows the configuration or parameters of an instantiated virtualized compute resource to be updated. This can include updating metadata, adding extra virtual network interfaces to a compute resource or attaching a virtual network interface to a specific network port [ETSI GS NFV-IFA 005].

Table 16 lists the information flow exchanged between the NFVO and VIM [ETSI GS NFV-IFA 005].

8.2.3.1.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.4.2-1 of [ETSI GS NFV-IFA 005].

The energyAwareState parameter defined in Table 17 should contain the default EAS of the virtualized compute resource.

8.2.3.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.1.4.3-1 of [ETSI GS NFV-IFA 005]. Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 005], providing information about the newly instantiated virtualized compute resource, should contain a new energyAwareState attribute according to Table 15.

8.2.3.1.4 Operation results

The operation results are specified in clause 7.3.1.4.4 of [ETSI GS NFV-IFA 005].

8.2.4 Vi-Vnfm reference point

8.2.4.1 Update virtualized compute resource operation

8.2.4.1.1 Description

This operation allows the configuration or parameters of an instantiated virtualized compute resource to be updated. This can include updating metadata, adding extra virtual network interfaces to a compute resource or attaching a virtual network interface to a specific network port [ETSI GS NFV-IFA 006].

Table 21 lists the information flow exchanged between the VNFM and VIM [ETSI GS NFV-IFA 006].

8.2.4.1.2 Input parameters

The parameters sent when invoking the operation should follow the indications provided in Table 7.3.1.4.2-1 of [ETSI GS NFV-IFA 006].

The energyAwareState parameter defined in Table 17 should contain the default EAS of the virtualized compute resource.

8.2.4.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.3.1.4.3-1 of [ETSI GS NFV-IFA 006]. Table 8.4.3.2.2-1 of [ETSI GS NFV-IFA 006], providing information about the newly instantiated virtualized compute resource, should contain a new energyAwareState attribute according to Table 15.

8.2.4.1.4 Operation results

The operation results are specified in clause 7.3.1.4.4 of [ETSI GS NFV-IFA 006].

8.2.5 Ve-Vnfm-em reference point

8.2.5.1 Operate virtualized network function operation

8.2.5.1.1 Description

This operation enables a change to the state of a VNF instance or VNFC instance(s), including starting and stopping the VNF/VNFC instance, to be requested [ETSI GS NFV-IFA 008].

Table 28 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

8.2.5.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.11.2-1 of [ETSI GS NFV-IFA 008].

The additionalParam parameter containing additional parameters passed by the EM as input to the operate VNF process, specific to the VNF being operated as declared in the VNFD, should identify the default EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.2.5.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.11.3-1 of [ETSI GS NFV-IFA 008].

8.2.5.1.4 Operation results

The operation results are specified in clause 7.2.11.4 of [ETSI GS NFV-IFA 008].

8.2.5.2 Modify virtualized network function information operation

8.2.5.2.1 Description

This operation allows information about a VNF instance [ETSI GS NFV-IFA 008] to be updated.

Table 29 lists the information flow exchanged between the EM and VNFM [ETSI GS NFV-IFA 008].

8.2.5.2.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.2.12.2-1 of [ETSI GS NFV-IFA 008].

The newValues parameter should identify the default EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.2.5.2.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.2.12.3-1 of [ETSI GS NFV-IFA 008].

8.2.5.2.4 Operation results

The operation results are specified in clause 7.2.12.4 of [ETSI GS NFV-IFA 008].

8.2.5.3 Notify operation

8.2.5.3.1 Description

This operation notifies the EM or VNF about events related to VNF life cycle changes, as well as the creation or deletion of VNF instance identifiers and the associated VnfInfo information element instances. The following notifications can be notified by this operation: VnfLcmOperationOccurrenceNotification, VnfIdentifierCreationNotification, VnfIdentifierDeletionNotification [ETSI GS NFV-IFA 008].

Table 30 lists the information flow exchanged between the VNFM and EM or VNF [ETSI GS NFV-IFA 008].

8.2.5.3.2 VnfLcmOperationOccurrenceNotification

8.2.5.3.2.1 Description

This notification informs the receiver of changes in the VNF life cycle caused by VNF LCM operation occurrences. The support of the notification is mandatory [ETSI GS NFV-IFA 008].

8.2.5.3.2.2 Trigger conditions

This notification is produced when there is a change in the VNF life cycle caused by VNF LCM operation occurrences, including [ETSI GS NFV-IFA 008]:

- instantiation of the VNF;
- scaling of the VNF instance (including auto-scaling);
- healing of the VNF instance (including auto-healing);
- operate VNF process;
- change of the DF of the VNF instance;
- changing the external VLs of the VNF instance;
- termination of the VNF instance;
- modification of VNF instance information or VNF/VNFC configurable properties explicitly through the modify VNF information operation.

If this is a notification about the start of an LCM operation occurrence, the notification should be sent before any action (including sending the grant request) is taken, but after acknowledging the LCM operation request to the consumer.

If this is a notification about the result of an LCM operation occurrence, the notification should be sent after all other actions of the LCM operation have been executed.

8.2.5.3.2.3 Attributes

The VnfLcmOperationOccurrenceNotification should follow the indications provided in Table 9.5.2.3-1 of [ETSI GS NFV-IFA 008].

When the notification represents the result of an LCM operation occurrence, the affectedVnfc attribute contains information about VNFC instances that were affected during the execution of the LCM operation.

The AffectedVnfc information element should follow the indications provided in Table 9.5.3.2-1 of [ETSI GS NFV-IFA 008].

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in Table 7.1.6.2.2-1 of [ETSI GS NFV-IFA 011] should contain EASs as defined in clause 7.4.

The metadata attribute should contain an EAS of the VC, as specified in clause 7.4, associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

8.2.5.4 Set configuration

8.2.5.4.1 Description

This operation enables the VNFM to set the configuration parameters of a VNF instance and its VNFC instance(s) or individual VNFC instances [ETSI GS NFV-IFA 008].

Table 31 lists the information flow exchanged between the VNFM and VNF [ETSI GS NFV-IFA 008].

8.2.5.4.2 Input parameters

The input parameters sent when invoking the operation are provided in Table 6.2.3.2-1 of [ETSI GS NFV-IFA 008].

The content of the vnfConfigurationData parameter, containing configuration data for the VNF instance, is defined in Table 9.2.2.2-1 of [ETSI GS NFV-IFA 008]. The attribute vnfSpecificData, providing a configuration object containing values of VNF configurable properties, should identify the default EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

8.2.5.4.3 Output parameters

The output parameters sent when responding to the operation is provided in Table 6.2.3.3-1 of [ETSI GS NFV-IFA 008].

8.2.5.4.4 Operation results

The operation results are specified in clause 6.2.3.4 of [ETSI GS NFV-IFA 008].

8.3 Monitoring operations

The GALv2 monitoring command set permits the energy parameters and values of an individual resource or a group of resources to be monitored.

8.3.1 Os-Ma-Nfvo reference point

This interface allows performance information related to NSs to be provided. Collection and reporting of performance information is controlled by a performance management (PM) job that groups details of performance collection and reporting information. Performance information on a given NS results from either collected performance information about the virtualized resources impacting the connectivity of this NS instance or VNF performance information, resulting from virtualized resource performance information, issued by the VNFM for the VNFs that are part of this NS instance [ETSI GS NFV-IFA 013].

8.3.1.1 Create performance management job operation

8.3.1.1.1 Description

This operation creates a PM job, enabling the OSS/BSS to specify an NS or set of NSs, which the NFVO is managing, for which it wants to receive performance information. This will allow the requesting OSS/BSS to specify its performance information requirements to the NFVO. The

OSS/BSS needs to issue a subscribe request for PerformanceInformationAvailable notifications in order to know when new collected performance information is available [ETSI GS NFV-IFA 013].

Table 33 lists the information flow exchanged between the OSS/BSS and NFVO.

Table 33 – Create performance management job operation

Message	Requirement	Direction
CreatePmJobRequest	Mandatory	OSS/BSS → NFVO
CreatePmJobResponse	Mandatory	NFVO → OSS/BSS

8.3.1.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.5.2.2-1 of [ETSI GS NFV-IFA 013].

The performanceMetric parameter, defining the type of performance metrics for the specified NSs, should contain the attributes associated with the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$:

- $\text{power}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$;
- $\text{performance}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the *x*th EAS of the *i*th instance of NS~*a* deployed according to a given NS DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$;
- $\text{delay}\left((\text{EAS}_x)^{\text{NS}\sim a\#i_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

8.3.1.1.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.5.2.3-1 of [ETSI GS NFV-IFA 013].

8.3.1.1.4 Operation results

The operation results are specified in clause 7.5.2.4 of [ETSI GS NFV-IFA 013].

8.3.1.2 Notify operation

8.3.1.2.1 Description

This operation distributes notifications to the OSS/BSS. It is a one-way operation issued by the NFVO that cannot be invoked as an operation by the OSS/BSS. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification [ETSI GS NFV-IFA 013].

Table 34 lists the information flow exchanged between the NFVO and OSS/BSS.

Table 34 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVO → OSS/BSS

8.3.1.2.2 PerformanceInformationAvailableNotification

8.3.1.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be NS instances [ETSI GS NFV-IFA 013].

8.3.1.2.2.2 Trigger conditions

The notification is produced when new performance information is available [ETSI GS NFV-IFA 013].

8.3.1.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification should follow the indications provided in Table 8.4.8.3-1 of [ETSI GS NFV-IFA 013].

8.3.1.2.3 ThresholdCrossedNotification

8.3.1.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be NS instances [ETSI GS NFV-IFA 013].

8.3.1.2.3.2 Trigger conditions

The notification is produced when a threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 013].

8.3.1.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification should follow the indications provided in Table 8.4.9.3-1 of [ETSI GS NFV-IFA 013].

8.3.2 Or-Vnfm reference point

This interface allows PM related to VNFs to be provided. Performance information on a given VNF results from performance information about the virtualized resources that is collected from the VIM and mapped to this VNF instance. Collection and reporting of performance information is controlled by a PM job that groups details of performance collection and reporting information [ETSI GS NFV-IFA 007].

8.3.2.1 Create performance management job operation

8.3.2.1.1 Description

This operation will create a PM job enabling the NFVO to specify a VNF or set of VNFs, which the VNFM is managing, for which it wants to receive performance information. This will allow the NFVO to specify its performance information requirements with the VNFM [ETSI GS NFV-IFA 007].

Table 35 lists the information flow exchanged between the NFVO and VNFM.

Table 35 – Create performance management job operation

Message	Requirement	Direction
CreatePmJobRequest	Mandatory	NFVO → VNFM
CreatePmJobResponse	Mandatory	VNFM → NFVO

8.3.2.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.4.2.2-1 of [ETSI GS NFV-IFA 007].

The performanceMetric parameter, defining the type of performance metric for the specified VNFs, should contain the attributes of the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$:

- $\text{power}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level;
- $\text{performance}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level;
- $\text{delay}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

8.3.2.1.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.4.2.3-1 of [ETSI GS NFV-IFA 007].

8.3.2.1.4 Operation results

The operation results are specified in clause 7.4.2.4 of [ETSI GS NFV-IFA 007].

8.3.2.2 Notify operation

8.3.2.2.1 Description

This operation distributes notifications to the NFVO. It is a one-way operation issued by the VNFM that cannot be invoked as an operation by the NFVO. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification [ETSI GS NFV-IFA 007].

Table 36 lists the information flow exchanged between the VNFM and NFVO.

Table 36 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → NFVO

8.3.2.2.2 PerformanceInformationAvailableNotification

8.3.2.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be VNF instances [ETSI GS NFV-IFA 007].

8.3.2.2.2.2 Trigger conditions

The notification is produced when new performance information is available [ETSI GS NFV-IFA 007].

8.3.2.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification should follow the indications provided in Table 8.7.8.3-1 of [ETSI GS NFV-IFA 007].

8.3.2.2.3 ThresholdCrossedNotification

8.3.2.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be VNF instances [ETSI GS NFV-IFA 007].

8.3.2.2.3.2 Trigger conditions

The notification is produced when a threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 007].

8.3.2.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification should follow the indications provided in Table 8.7.9.3-1 of [ETSI GS NFV-IFA 007].

8.3.3 Virtualized resources performance management interfaces in indirect mode

8.3.3.1 Introduction

In indirect resource management mode, the NFVO produces an interface for virtualized resource PM to be consumed by the VNFM. This interface should comply with the provisions in clause 7.7 of [ETSI GS NFV-IFA 006] and the related information elements with an additional resource provider identifier.

This identifier is used by the NFVO to determine the entity responsible for the management of the virtualized resource performance information and is used by the VNFM to uniquely identify resources [ETSI GS NFV-IFA 007].

8.3.4 Or-Vi reference point

This interface allows PM information related to virtualized resources including (but not limited to) resource consumption level, e.g., vCPU power consumption, VM memory usage oversubscription and VM disk latency, to be provided. Note that only types of resources that have been catalogued and offered through abstractions to consumer functional blocks lie within the scope of this Recommendation [ETSI GS NFV-IFA 005].

8.3.4.1 Create performance management job operation

8.3.4.1.1 Description

This operation will create a PM job, enabling the NFVO to specify a resource or set of resources, which the VIM is managing, for which it wants to receive performance information. This will allow the requesting NFVO to specify its performance information requirements to the VIM [ETSI GS NFV-IFA 005].

Table 37 lists the information flow exchanged between the NFVO and VIM.

Table 37 – Create performance management job operation

Message	Requirement	Direction
CreatePmJobRequest	Mandatory	NFVO → VIM
CreatePmJobResponse	Mandatory	VIM → NFVO

8.3.4.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.7.2.2-1 of [ETSI GS NFV-IFA 005].

The performanceMetric parameter, defining the type of performance metrics for the specified Virtual Compute, should contain the attributes of the *x*th EAS of $\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}$ deployed on a given (CD, HD) combination:

- $\mathrm{power}\left((\mathrm{EAS}_x)^{\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: power-related value of the VC associated with $\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}$ and deployed with a given (CD, HD) combination identifier;

- performance$\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- delay$\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

8.3.4.1.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.7.2.3-1 of [ETSI GS NFV-IFA 005].

8.3.4.1.4 Operation results

The operation results are specified in clause 7.7.2.4 of [ETSI GS NFV-IFA 005].

8.3.4.2 Notify operation

8.3.4.2.1 Description

This operation distributes notifications to the NFVO. It is a one-way operation issued by the VIM that cannot be invoked as an operation by the NFVO. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification [ETSI GS NFV-IFA 005].

Table 38 lists the information flow exchanged between the VIM and NFVO.

Table 38 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → NFVO

8.3.4.2.2 PerformanceInformationAvailableNotification

8.3.4.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be virtualized resources [ETSI GS NFV-IFA 005].

8.3.4.2.2.2 Trigger conditions

The notification is produced when new performance information is available [ETSI GS NFV-IFA 005].

8.3.4.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification should follow the indications provided in Table 8.5.8.3-1 of [ETSI GS NFV-IFA 005].

8.3.4.2.3 ThresholdCrossedNotification

8.3.4.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be virtualized resources [ETSI GS NFV-IFA 005].

8.3.4.2.3.2 Trigger conditions

The notification is produced when a threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 005].

8.3.4.2.3.3 Attributes

The attributes of the PerformanceInformationAvailableNotification should follow the indications provided in Table 8.5.8.3-1 of [ETSI GS NFV-IFA 005].

8.3.5 Vi-Vnfm reference point

This interface allows PM information related to virtualized resources including (but not limited to) resource consumption level, e.g., vCPU power consumption, VM memory usage oversubscription and VM disk latency, to be provided. Note that only types of resources that have been catalogued and offered through abstractions to consumer functional blocks lie within the scope of this Recommendation [ETSI GS NFV-IFA 006].

8.3.5.1 Create performance management job operation

8.3.5.1.1 Description

This operation will create a PM job, enabling the VNFM to specify a resource or set of resources, which the VIM is managing, for which it wants to receive performance information. This will allow the requesting VNFM to specify its performance information requirements to the VIM [ETSI GS NFV-IFA 006].

Table 39 lists the information flow exchanged between the VNFM and VIM.

Table 39 – Create performance management job operation

Message	Requirement	Direction
CreatePmJobRequest	Mandatory	VNFM → VIM
CreatePmJobResponse	Mandatory	VIM → VNFM

8.3.5.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.7.2.2-1 of [ETSI GS NFV-IFA 006].

The performanceMetric parameter, defining the type of performance metrics for the specified Virtual Compute, should contain the attributes of the *x*th EAS of $\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}$ deployed on a given (CD, HD) combination:

- $\mathrm{power}\left((\mathrm{EAS}_x)^{\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: power-related value of the VC associated with $\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\mathrm{performance}\left((\mathrm{EAS}_x)^{\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: performance-related value of the VC associated with $\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\mathrm{delay}\left((\mathrm{EAS}_x)^{\mathrm{VNFC}\sim c\#k \subset \mathrm{VNF}\sim b\#j_{\mathrm{DF\text{-}X}\#l_{\mathrm{DF\text{-}X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

8.3.5.1.3 Output parameters

The parameters returned by the operation should follow the indications provided in Table 7.7.2.3-1 of [ETSI GS NFV-IFA 006].

8.3.5.1.4 Operation results

The operation results are specified in clause 7.7.2.4 of [ETSI GS NFV-IFA 006].

8.3.5.2 Notify operation

8.3.5.2.1 Description

This operation distributes notifications to the VNFM. It is a one-way operation issued by the VIM that cannot be invoked as an operation by the VNFM. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification [ETSI GS NFV-IFA 006].

Table 40 lists the information flow exchanged between the VIM and VNFM.

Table 40 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → VNFM

8.3.5.2.2 PerformanceInformationAvailableNotification

8.3.5.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be virtualized resources [ETSI GS NFV-IFA 006].

8.3.5.2.2.2 Trigger conditions

The notification is produced when new performance information is available [ETSI GS NFV-IFA 006].

8.3.5.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification should follow the indications provided in Table 8.5.8.3-1 of [ETSI GS NFV-IFA 006].

8.3.5.2.3 ThresholdCrossedNotification

8.3.5.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be virtualized resources [ETSI GS NFV-IFA 006].

8.3.5.2.3.2 Trigger conditions

The notification is produced when a threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 006].

8.3.5.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification should follow the indications provided in Table 8.5.9.3-1 of [ETSI GS NFV-IFA 006].

8.3.6 Ve-Vnfm reference point

This interface allows PM related to VNFs to be provided. Performance information on a given VNF/VNFC results from performance information about the virtualized resources that is collected from the VIM and mapped to this VNF/VNFC instance. Collection and reporting of performance information is controlled by a PM job that groups details of performance collection and reporting information [ETSI GS NFV-IFA 008].

8.3.6.1 Create performance management job operation

8.3.6.1.1 Description

This operation will create a PM job, enabling an EM to specify a VNF/VNFC, that the VNFM is managing, for which it wants to receive performance information. This will allow the requesting EM to specify its performance information requirements with the VNFM [ETSI GS NFV-IFA 008].

Table 41 lists the information flow exchanged between the VNFM and EM.

Table 41 – Create performance management job operation

Message	Requirement	Direction
CreatePmJobRequest	Mandatory	EM → VNFM
CreatePmJobResponse	Mandatory	VNFM → EM

8.3.6.1.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 7.4.2.2-1 of [ETSI GS NFV-IFA 008].

The performanceMetric parameter, defining the type of performance metrics for the specified VNFC, should contain the attributes of the *x*th EAS of $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ deployed on a given (CD, HD) combination:

- $\text{power}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\text{performance}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the VC associated with $\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ and deployed with a given (CD, HD) combination identifier;
- $\text{delay}\left((\text{EAS}_x)^{\text{VNFC}\sim c\#k \subset \text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

The performanceMetric parameter, defining the type of performance metrics for the specified VNFs, should contain the attributes of the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given VNF DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$:

- $\text{power}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: power-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level;
- $\text{performance}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: performance-related value of the *j*th instance of VNF~*b* deployed according to a given VNF DF at a given instantiation level;
- $\text{delay}\left((\text{EAS}_x)^{\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}}\right)$: transition delay between the *x*th EAS and another EAS.

8.3.6.1.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 7.4.2.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.1.4 Operation results

The operation results are specified in clause 7.4.2.4 of [ETSI GS NFV-IFA 008].

8.3.6.2 Notify operation

8.3.6.2.1 Description

This operation distributes notifications to the EM or VNF. It is a one-way operation issued by the VNFM that cannot be invoked as an operation by the EM or VNF. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification [ETSI GS NFV-IFA 008].

Table 42 lists the information flow exchanged between the VNFM and EM or VNF.

Table 42 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → EM VNFM → VNF

8.3.6.2.2 PerformanceInformationAvailableNotification

8.3.6.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be VNF or VNFC instances [ETSI GS NFV-IFA 008].

8.3.6.2.2.2 Trigger conditions

The notification is produced when new performance information is available [ETSI GS NFV-IFA 008].

8.3.6.2.2.3 Attributes

The PerformanceInformationAvailableNotification should follow the indications provided in Table 9.7.8.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.2.3 ThresholdCrossedNotification

8.3.6.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be VNF or VNFC instances [ETSI GS NFV-IFA 008].

8.3.6.2.3.2 Trigger conditions

A threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 008].

8.3.6.2.3.3 Attributes

A threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values [ETSI GS NFV-IFA 008].

8.3.6.3 Notify operation

8.3.6.3.1 Description

This operation distributes notifications to the VNFM. It is a one-way operation issued by the VNF towards the VNFM that cannot be invoked as an operation by the VNFM. The following notifications can be notified by this operation: IndicatorValueChangeNotification [ETSI GS NFV-IFA 008].

Table 43 lists the information flow exchanged between the VNF and VNFM.

Table 43 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNF → VNFM

8.3.6.3.2 IndicatorValueChangeNotification

8.3.6.3.2.1 Description

This notification informs the receiver of a value change of an indicator related to the VNF [ETSI GS NFV-IFA 008].

8.3.6.3.2.2 Trigger conditions

The value of an indicator has changed [ETSI GS NFV-IFA 008].

8.3.6.3.2.3 Attributes

The IndicatorValueChangeNotification information element should follow the indications provided in Table 9.6.2.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.4 Get indicator value operation

8.3.6.4.1 Description

This operation enables the VNFM to request the actual value of a given indicator from the VNF [ETSI GS NFV-IFA 008].

Table 44 lists the information flow exchanged between the VNFM and VNF.

Table 44 – Get indicator value operation

Message	Requirement	Direction
GetIndicatorValueRequest	Mandatory	VNFM → VNF
GetIndicatorValueResponse	Mandatory	VNF → VNFM

8.3.6.4.2 Input parameters

The input parameters sent when invoking the operation should follow the indications provided in Table 6.3.4.2-1 of [ETSI GS NFV-IFA 008].

8.3.6.4.3 Output parameters

The output parameters returned by the operation should follow the indications provided in Table 6.3.4.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.4.4 Operation results

The operation results are specified in clause 6.3.4.4 of [ETSI GS NFV-IFA 008].

8.3.6.5 Notify operation

8.3.6.5.1 Description

This operation distributes notifications to the VNFM. It is a one-way operation issued by the EM towards the VNFM that cannot be invoked as an operation by the VNFM. The following notifications can be notified by this operation: IndicatorValueChangeNotification [ETSI GS NFV-IFA 008].

Table 45 lists the information flow exchanged between the EM and VNFM.

Table 45 – Notify operation

Message	Requirement	Direction
Notify	Mandatory	EM → VNFM

8.3.6.5.2 IndicatorValueChangeNotification

8.3.6.5.2.1 Description

This notification informs the receiver of a value change of an indicator related to the VNF [ETSI GS NFV-IFA 008].

8.3.6.5.2.2 Trigger conditions

The value of an indicator has changed [ETSI GS NFV-IFA 008].

8.3.6.5.2.3 Attributes

The IndicatorValueChangeNotification information element should follow the indications provided in Table 9.6.2.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.6 Get indicator value operation

8.3.6.6.1 Description

This operation enables the VNFM to request the actual value of a given indicator from the EM [ETSI GS NFV-IFA 008].

Table 46 lists the information flow exchanged between the VNFM and EM.

Table 46 – Get indicator value operation

Message	Requirement	Direction
GetIndicatorValueRequest	Mandatory	VNFM → EM
GetIndicatorValueResponse	Mandatory	EM → VNFM

8.3.6.6.2 Input operations

The input parameters sent when invoking the operation should follow the indications provided in Table 8.2.4.2-1 of [ETSI GS NFV-IFA 008].

8.3.6.6.3 Output operations

The output parameters returned by the operation should follow the indications provided in Table 8.2.4.3-1 of [ETSI GS NFV-IFA 008].

8.3.6.6.4 Operation results

The operation results are specified in clause 8.2.4.4 of [ETSI GS NFV-IFA 008].

Appendix I

GALv2 green standard interface

(This appendix does not form an integral part of this Recommendation.)

Figure I.1 outlines GALv2 GSI provisioning operations.

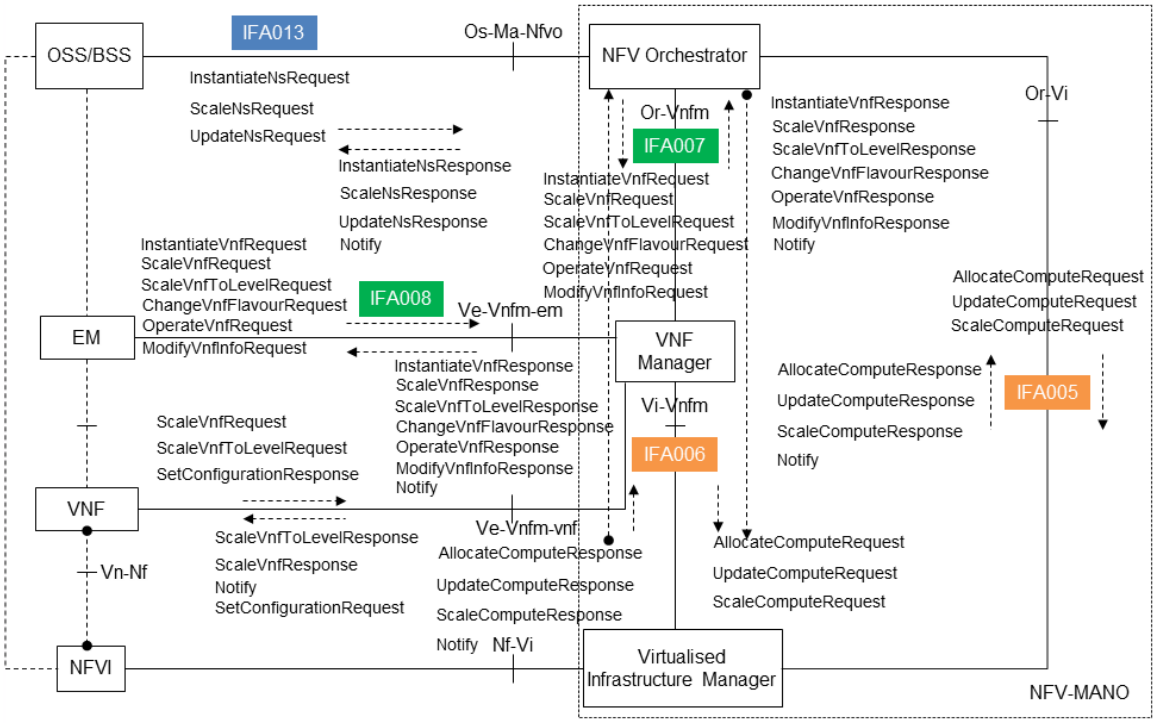

Figure I.1 – GALv2 green standard interface provisioning operations

Figure I.2 outlines GALv2 GSI release operations.

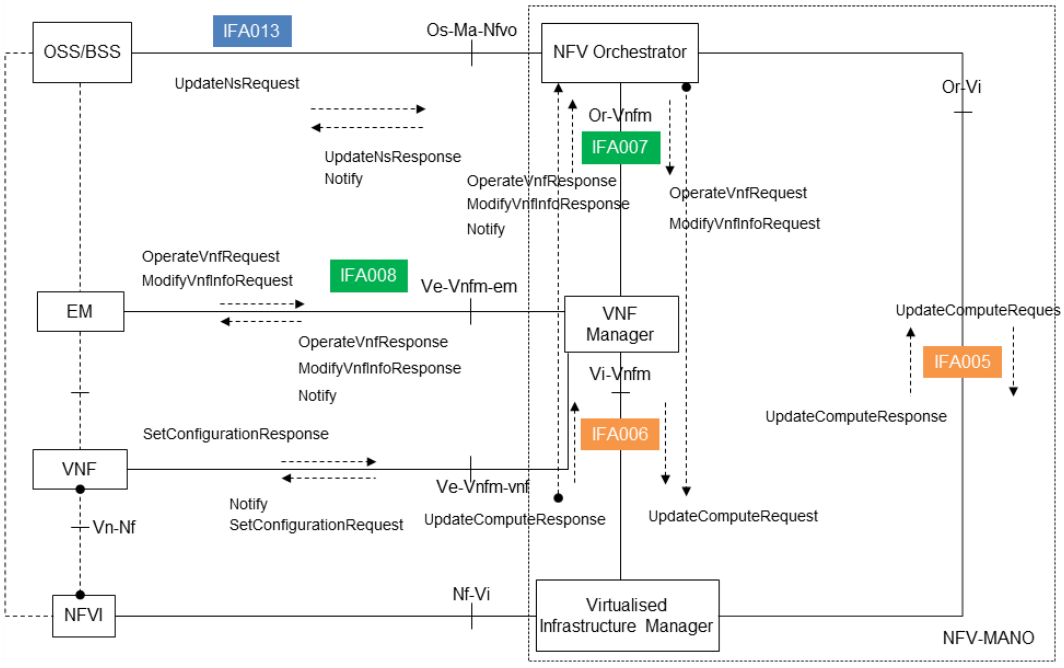

Figure I.2 – GALv2 green standard interface release operations

Figure I.3 outlines GALv2 GSI monitoring operations.

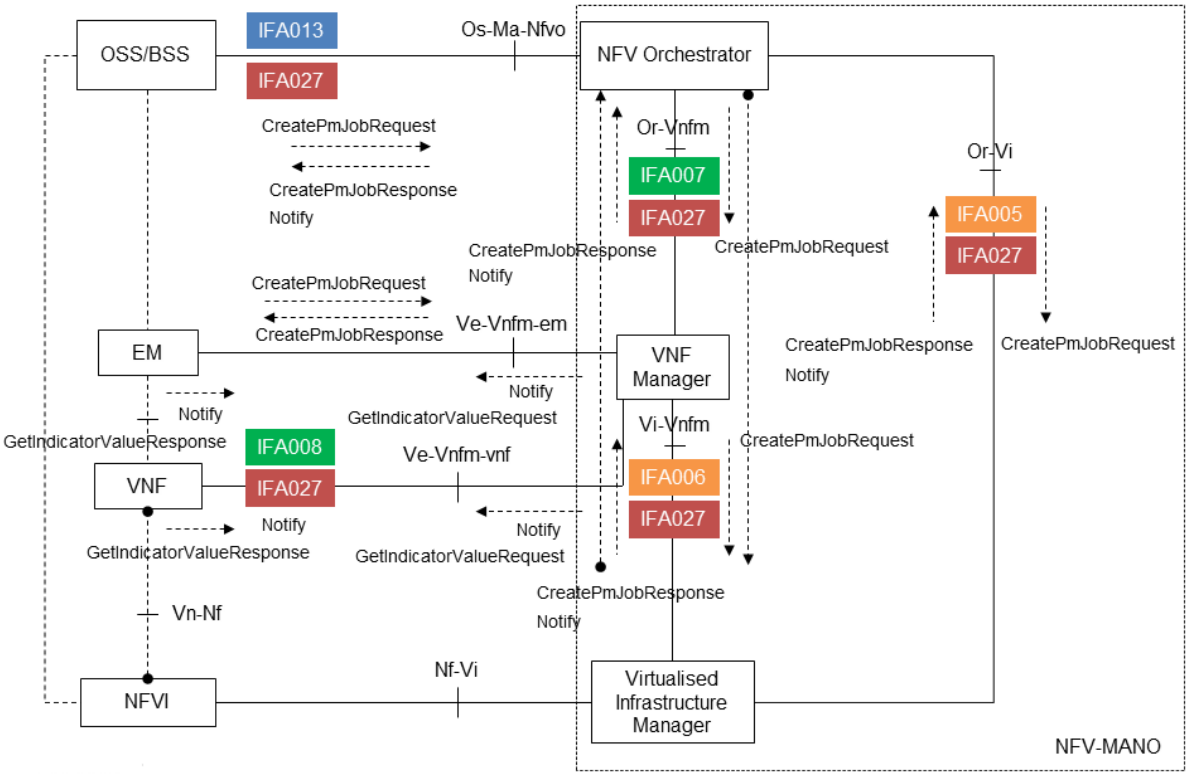

Figure I.3 – GALv2 green standard interface monitoring operations

Appendix II

Energy-aware state virtualized network function configuration flows

(This appendix does not form an integral part of this Recommendation.)

II.1 Change of virtualized network function configurable properties

Figure II.1 illustrates two alternative non-exhaustive examples of a VNF configuration triggered by explicit change of VNF configurable properties. The first alternative (steps 10a to 11a) shows a scenario where a VNF configuration interface is being used, the second alternative (steps 10b to 12b) shows a scenario where a VNF configuration interface is not being used and the VNF is capable of self-managing. Other alternatives for passing the configuration changes to the VNF instance are possible [ETSI GS NFV-IFA 008].

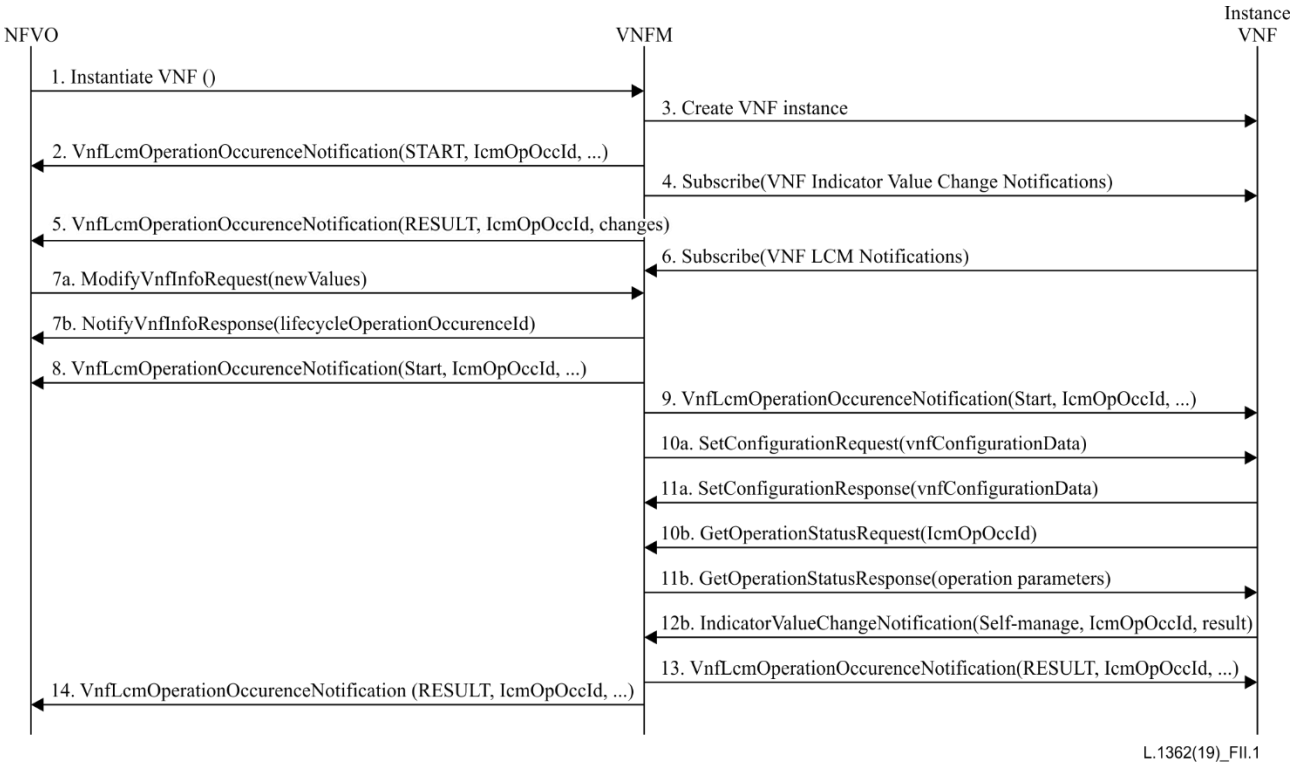

Figure II.1 – Change of virtualized network function configurable properties

1. The NFVO requests VNF instantiation (the trigger for VNF instantiation lies outside the scope of this appendix). The step of VNF identifier creation is omitted for simplicity.
2. The VNFM begins the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to the NFVO indicating the start of LCM operation, operation identifier (ID), etc.
3. The VNFM creates the new VNF instance (the interactions between the VNFM and VIM are omitted for simplicity).
4. The VNFM subscribes to VNF indicator value change notifications.
5. The VNFM completes the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to the NFVO indicating the result of LCM operation, operation ID, etc.
6. The VNF instance subscribes to VNF LCM notifications.

7a. The NFVO requests the VNFM to change certain VNF configurable properties with the ModifyVnfInfoRequest. The newValues parameter should identify the *x*th EAS of the *j*th

instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

7b. The VNFM sends to the NFVO the lifecycleOperationOccurrenceId with the ModifyVnfInfoResponse.

8. 9. The VNFM begins the operation and sends the VnfLcmOperationOccurrenceNotification to the NFVO; VNF indicating the start of LCM operation, operation ID, etc.

If the VNF configuration interface, as defined in clause 6.2 of [ETSI GS NFV-IFA 008], is used:

10a. The VNFM requests setting the configuration with SetConfigurationRequest and passes the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$ in the vnfConfigurationData parameter.

The VNF applies configuration:

11a. The VNF returns the result of setting the configuration with the SetConfigurationResponse and passes the applied configuration data as a parameter.

If the VNF configuration interface, as defined in clause 6.2 of [ETSI GS NFV-IFA 008], is not used and the VNF is self-managing, i.e., determines what configuration changes need to be applied and applies them:

10b. The VNF requests the LCM operation details with the GetOperationStatusRequest and passes the lcmOpOccId as a parameter.

11b. The VNFM returns the LCM operation details (including its parameters) with the GetOperationStatusResponse and passes the "LCM operation parameters" as a parameter.

The VNF determines what configuration changes need to be applied and applies them: the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$ is configured.

12b. The VNF sends the VNF indicator value change notification IndicatorValueChangeNotification with information about successful completion of self-managing and indication that configuration changes have been applied. The format and values of the VNF indicator, declared by the VNF provider in the VNFD, contain the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, in a given instantiation level, denoted DF-X#$l_{\text{DF-X}}$.

The VNFM updates the VnfInfo information element accordingly:

13. 14. The VNFM completes the operation and sends the VnfLcmOperationOccurrenceNotification to the NFVO and VNF indicating the result of LCM operation, operation ID, etc.

Figure II.2 graphically highlights the change of the EAS of $\text{VNF}\sim b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ with the ModifyVnfInfo operation.

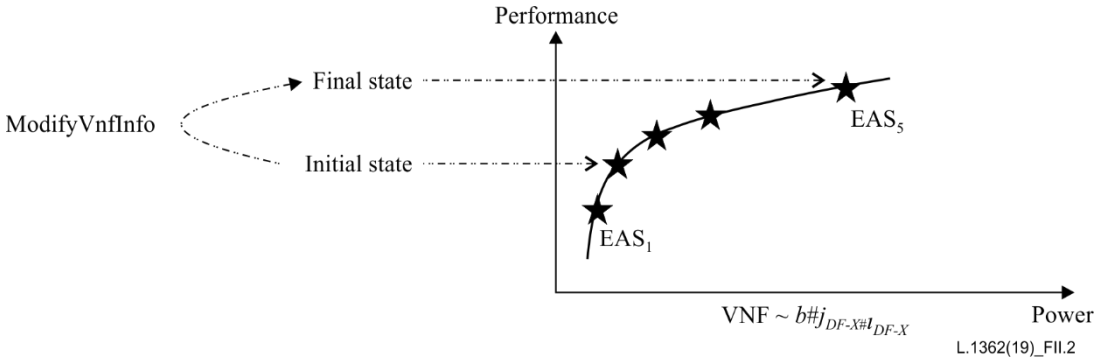

Figure II.2 – Change of virtualized network function energy-aware state with the modifyVnfInfo operation

II.2 Scale to level of virtualized network function

Figure II.3 illustrates the NFVO requesting the VNFM to scale an instantiated VNF of a particular DF to a target size. The target size is expressed as an instantiation level of that DF as defined in the VNFD. The result of this operation is adding NFVI resources to the VNF.

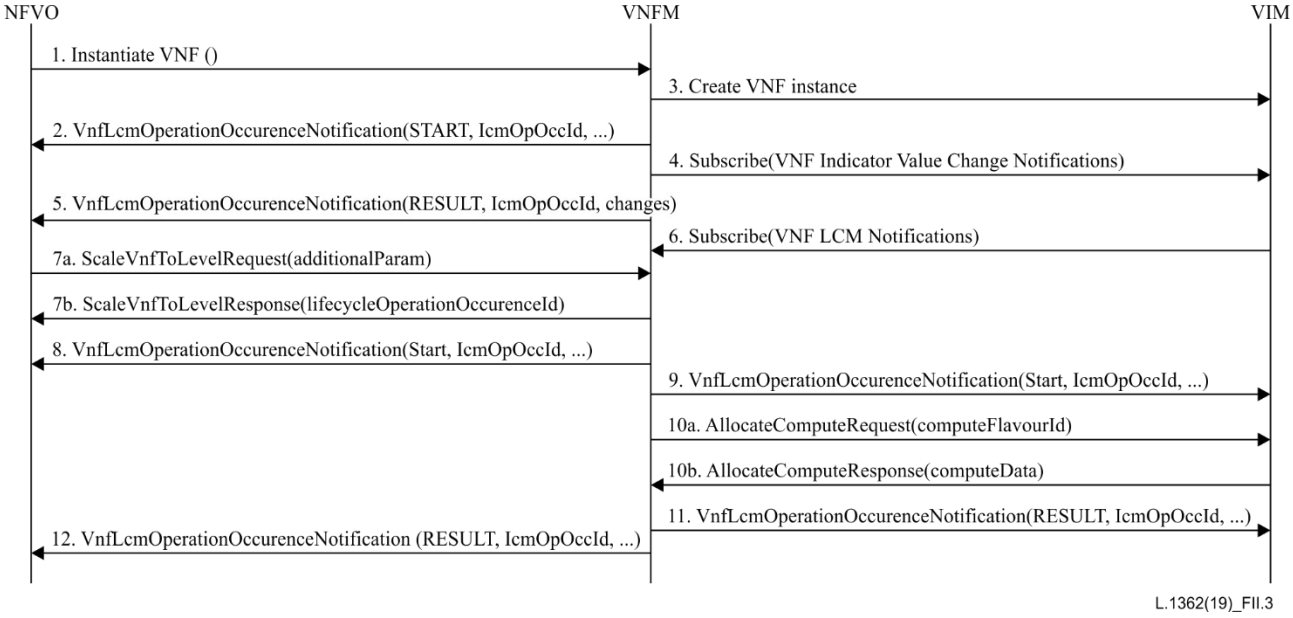

Figure II.3 – Scale virtualized network function to level

1. The NFVO requests VNF instantiation (the trigger for VNF instantiation lies outside the scope of this appendix). The step of VNF identifier creation is omitted for simplicity.
2. The VNFM begins the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to the NFVO indicating the start of LCM operation, operation ID, etc.
3. The VNFM creates the new VNF instance (the interactions between the VNFM and VIM are omitted for simplicity).
4. The VNFM subscribes for VNF indicator value change notifications.
5. The VNFM completes the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to the NFVO indicating the result of LCM operation, operation ID, etc.
6. The VNF instance subscribes for VNF LCM notifications.

7a. The NFVO requests the VNFM to scale an instantiated VNF of a particular DF to a target size. The target size is expressed as an instantiation level of that DF as defined in the VNFD.

The result of this operation is adding NFVI resources to the VNF. The additionalParam parameter containing additional parameters, specific to the VNF being scaled as declared in the VNFD, passed by the NFVO, should identify the *x*th EAS of the *j*th instance of VNF~*b* deployed according to a given DF, denoted DF-X, at a given instantiation level, denoted DF-X#$l'_{\text{DF-X}}$.

7b. The VNFM sends to the NFVO the lifecycleOperationOccurrenceId with the ScaleVnfToLevelResponse.

8. 9. The VNFM begins the operation and sends the VnfLcmOperationOccurrenceNotification to the NFVO; VNF indicating the start of LCM operation, operation ID, etc.

10a. The VNFM requests allocating virtualized compute resources with AllocateComputeRequest. The computeFlavourId parameter identifies the compute flavour that provides information about the particular memory, CPU and disk resources for the virtualized compute resource to allocate. The VirtualComputeFlavour information element contains the energyAwareState attribute according to Table 14. The VNF applies configuration:

10b. The VIM returns the result of the allocation with the AllocateComputeResponse. The content of the computeData parameter contains the energyAwareState attribute, defined in Table 15, of the newly instantiated virtualized compute resource.

The VNFM updates the VnfInfo information element accordingly.

11. 12. The VNFM completes the operation and sends the VnfLcmOperationOccurrenceNotification to the NFVO and VNF indicating the result of LCM operation, operation ID, etc.

Figure II.4 graphically highlights the change of the EAS from VNF~$b\#j_{\text{DF-X}\#l_{\text{DF-X}}}$ to VNF~$b\#j_{\text{DF}-\text{X}\#l'_{\text{DF}-\text{X}}}$ with the ScaleVnfToLevel operation.

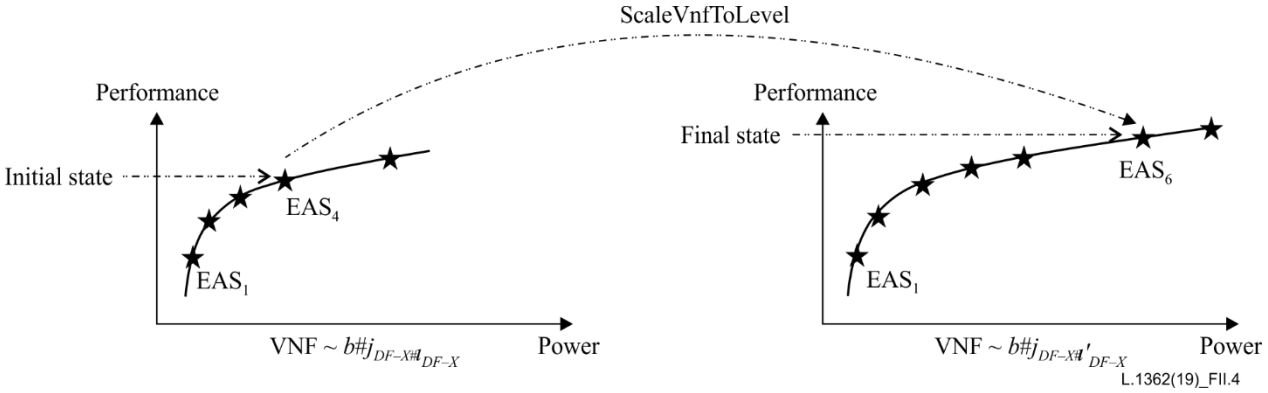

Figure II.4 – Change of virtualized network function energy-aware state with the ScaleVnfToLevel operation

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