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Environmental Engineering (EE); Green Abstraction Layer (GAL); Power management capabilities of the future energy telecommunication fixed network nodes; Enhanced Interface for power management in Network Function Virtualisation (NFV) environments

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Green Abstraction Layer (GAL) ETSI ES 203 237 [1] provides 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 the advent of Network Function Virtualisation possibly accompanied by the further increase in flexibility and programmability brought forth by Software Defined Networking, is changing the network paradigms and the associated GAL design. With NFV, network functionalities become virtualised network functions which can be automatically deployed, migrated, re-configured. The same physical machines of a provider's infrastructure may well serve the needs of different VNFs. In this NFV context, establishing a mapping between the Energy-Aware States of logical entities (e.g. virtualised network functions) and the energy consumption of the 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 [1] to the NFV environment (GALv2), and to address the use of GALv2 in the ETSI NFV architectural framework ETSI GS NFV 002 [i.1].

The present document was developed jointly by ETSI TC EE and ITU-T Study Group 5. It is published respectively by ITU and ETSI as ETSI ES 203 682 (the present document) and Recommendation ITU-T L.1362 [i.6], which are technically-equivalent.

1 Scope

The present document proposes an evolved version of the Green Abstraction Layer formulation capable of operating within ETSI NFV environments.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI ES 203 237: "Environmental Engineering (EE); Green Abstraction Layer (GAL); Power management capabilities of the future energy telecommunication fixed network nodes".

[2] ETSI GS NFV-IFA 005: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".

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

[4] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".

[5] ETSI GS NFV-IFA 008: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".

[6] ETSI GS NFV-IFA 011: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; VNF Descriptor and Packaging Specification".

[7] ETSI GS NFV-IFA 013: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Os-Ma-Nfvo reference point - Interface and Information Model Specification".

[8] ETSI GS NFV-IFA 014: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Network Service Templates Specification".

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GS NFV 002: "Network Functions Virtualisation (NFV); Architectural Framework".

[i.2] ETSI GS NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.3] ETSI GS NFV-EVE 001: "Network Functions Virtualisation (NFV); Virtualisation Technologies; Hypervisor Domain Requirements specification; Release 3".

[i.4] Recommendation ITU-T E.800: "Terms and definitions related to quality of service and network performance including dependability".

[i.5] ETSI GS NFV-INF 004: "Network Functions Virtualisation (NFV); Infrastructure; Hypervisor Domain".

[i.6] Recommendation ITU-T L.1362: "Interface for power management in NFV environments "Green Abstraction Layer 2".

[i.7] ETSI GS NFV-IFA 027: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Performance Measurements Specification".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

adaptive rate: technique to dynamically modulate the capacity of a network device or a sub-component in order to meet the traffic requirements

NOTE: Available in ETSI ES 203 237 [1].

Advanced Configuration and Power Interface: provides an open industrial standard for device configuration and power management by the operating system

NOTE: Available in ETSI ES 203 237 [1].

Convergence Layer Interface: GAL interface designed to map the GAL commands and data into low-level configuration registers/APIs

NOTE: Available in ETSI ES 203 237 [1].

Energy-Aware Entity (EAE): network entity that can adapt its energy consumption such as network performance levels are satisfied

NOTE: Examples include central processing unit (CPU), virtual CPU, virtual machine, virtualised network function.

Energy-Aware State (EAS): data structure containing power, network performance, available functionalities, and responsiveness information characterizing an Energy-Aware Entity

NOTE: It can be configured by control plane processes through the Green Standard Interface.

entity: device or a sub-part of it, of which the GAL constitutes the energy-aware interface

NOTE 1: 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.

NOTE 2: Available in ETSI ES 203 237 [1].

Green Abstraction Layer (GAL): interface between data and control planes for exchanging data regarding the power of a device

NOTE: Available in ETSI ES 203 237 [1].

Green Standard Interface (GSI): GAL interface designed to exchange power management data in a simplified way among data-plane elements and processes realizing control plane strategies

NOTE: Available in ETSI ES 203 237 [1].

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

NOTE 1: ETSI GS NFV-INF 004 [i.5]: 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 Virtual Machine 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.

NOTE 2: Available in ETSI GS NFV-EVE 001 [i.3].

Hypervisor Domain (HD): general area for focus which includes hypervisors

NOTE: Available in ETSI GS NFV-EVE 001 [i.3].

low power idle: technique to force a device (or a sub-component) to enter low power states when it does not forward/process packets

NOTE: Available in ETSI ES 203 237 [1].

network performance: 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.

NOTE 3: Available in Recommendation ITU-T E.800 [i.4].

operating mode: operating state of a given entity. The possible values are active or standby

NOTE 1: It is required to distinguish two different types of Energy-Aware Entity (EAE). 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.

NOTE 2: Available in ETSI ES 203 237 [1].

standby mode: operating mode characterized by low power and reduced functionality

NOTE 1: 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.

NOTE 2: Available in ETSI ES 203 237 [1].

Virtualisation Container (VC): partition of a compute node that provides an isolated virtualised computation environment

NOTE: Available in ETSI GS NFV 003 [i.2].

Virtual Deployment Unit (VDU): construct that can be used in an information model, supporting the description of the deployment and operational behaviour of a Virtualised Network Function Component

NOTE: Available in ETSI GS NFV 003 [i.2].

3.2 Symbols

Void.

3.3 Abbreviations

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

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
LCM	Lifecycle Management
MANO	NFV Management and Orchestration
ND	Network Domain
NFV	Network Functions Virtualisation
NFVI	Network Functions Virtualisation Infrastructure
NFVO	Network Functions Virtualisation Orchestrator
NIC	Network Interface Controller
NS	Network Service
NS DF	Network Service Deployment Flavour
NSD	Network Service Descriptor
OSS	Operations Support System
PM	Performance Management
PNF	Physical Network Function
QoS	Quality of Service
VC	Virtualisation Container
VDU	Virtual Deployment Unit
VIM	Virtual Infrastructure Manager
VL	Virtual Link
VM	Virtual Machine
VNF	Virtualised Network Function
VNF DF	Virtualised Network Function Deployment Flavour
VNFC	Virtualised Network Function Component
VNFD	Virtualised Network Function Descriptor
VNFM	Virtualised Network Function Manager

4 Foreground

4.1 Green Abstraction Layer

Green Abstraction Layer (GAL), see ETSI ES 203 237 [1] provides 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 [1] contains:

- The definition of the GAL general architecture.
- The definition of the Energy-Aware States (EASs) describing the different power configurations and corresponding network performance of an EAE.
- The definition of the Green Standard Interface (GSI) used to discover EAEs, their autonomic provisioning and manual configuration, their monitoring, and their decommissioning.

With NFV network functionalities become virtualised network functions (VNFs) which can be automatically deployed, migrated, re-configured. The same physical machines of a provider's 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 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 [1] to the NFV environment (GALv2), and to address the use of GALv2 in the ETSI NFV architectural framework, see ETSI GS NFV 002 [i.1].

4.2 NFV architectural framework

4.2.0 Generality

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

- Virtualised Network Function, as the software implementation of a network function which is capable of running over the NFVI;
- NFV Management and Orchestration, which covers the orchestration and lifecycle management of physical and/or software resources that support the infrastructure virtualisation, and the lifecycle management of VNFs. NFV Management and Orchestration focuses on all virtualisation-specific management tasks necessary in the NFV framework;
- NFV Infrastructure, including the diversity of physical resources and how these can be virtualised. NFVI supports the execution of the VNFs.

4.2.1 NFV Management and Orchestration overview

4.2.1.0 Generality

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 [8].

The Network Service Descriptor (NSD) ETSI GS NFV-IFA 014 [8] is a Network Service deployment template which consists of information used by the NFV Management and Orchestration (MANO) system for the lifecycle management of a NS. The NSD includes or references to the descriptors of its constituent objects:

- Zero, one or more Virtualised Network Function Descriptors (VNFDs) ETSI GS NFV-IFA 011 [6], where a VNFD is a deployment template which describes a Virtualised 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 Virtualisation Orchestrator (NFVO) to deploy VL.
- Zero, one or more Physical Network Function (PNF) Descriptors (PNFDs) used by the NFV MANO to determine how to connect PNFs to Virtual Links (VLs).
- Zero, one or more nested NSD.

A Virtualised Network Function can be composed of one or more Virtualised Network Function Components (VNFCs) ETSI GS NFV-IFA 011 [6].

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 UML representation ETSI GS NFV-IFA 011 [6].

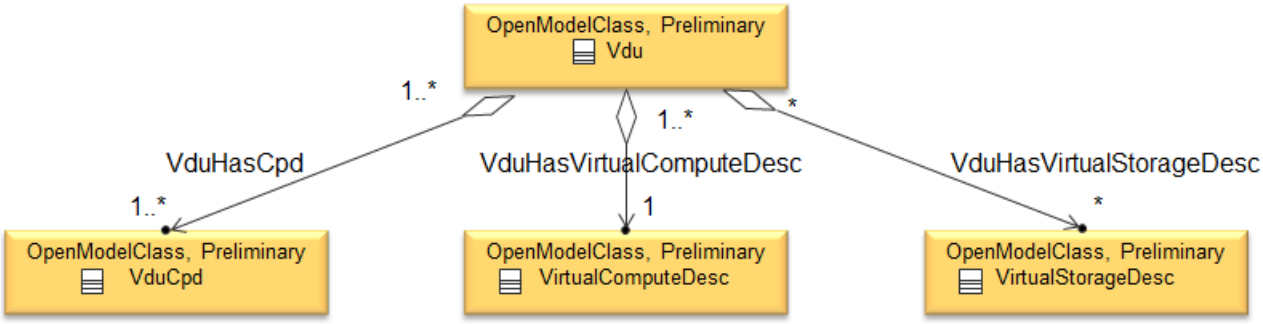

Figure 1: UML representation of the VDU high-level structure

A VNFC instance created based on a VDU maps to a single Virtualisation Container (VC) realising this VDU.

4.2.1.1 Virtualised Network Function scaling

ETSI NFV provides methods to request scaling a VNF in multiple ways ETSI GS NFV-IFA 007 [4]:

- 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 NFV currently does not support this method):
  - scale up: adding further resources to existing VNFC instances, e.g. increase memory, Central Processing Unit (CPU) capacity or storage size of the virtualisation container 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 virtualisation container 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 [4] 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 Virtualised 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 as 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 above.

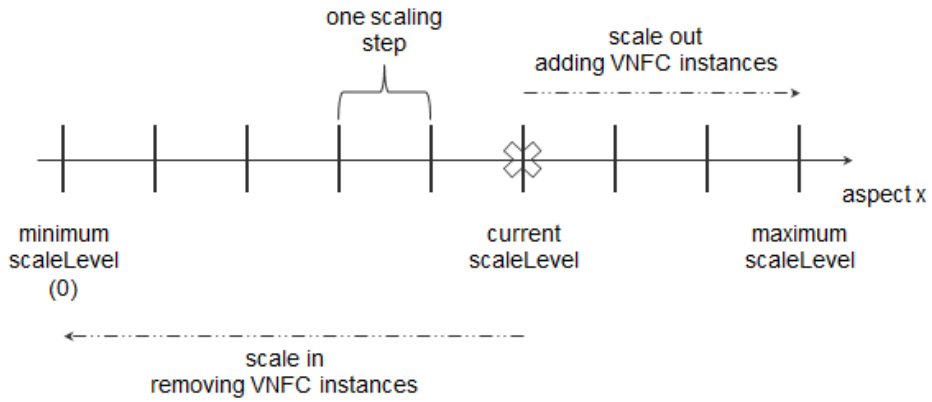

Figure 2: Concepts of scale level and scaling steps for a given aspect

The Network Service Level information element ETSI GS NFV-IFA 014 [8] describes the details of an NS level. An NS level consists of a list of involved entities, i.e. VNFs, VLs and/or nested NSs. For each involved VNF/nested NS, the number of instances required by the NS level is specified. For each involved VL, the bitrate requirements corresponding to the NS level are specified.

As regarding the VNFs involved in an NS level, they 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 [8].

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

The Virtualised Network Function Descriptor has three attributes of main interest:

- The "vdu" attribute.
- The "intVirtualLinkDesc" attribute which represents the type of network connectivity mandated by the VNF provider between two or more Connection Points (CPs) which includes at least one internal CP.
- The "deploymentFlavour" attribute which describes specific deployment flavour(s) of a VNF with specific requirements for capacity and performance.

In the "deploymentFlavour" attribute four attributes are of main interest:

- "vduProfile" attribute: identifies a Virtual Deployment Unit, specifies the minimum-maximum number of VNF Component instances based on this Virtual Deployment Unit, affinity or anti-affinity rules applicable between the virtualisation containers, and additional data for the Virtual Deployment Unit;
- "virtualLinkProfile" attribute: identifies the Quality of Service (QoS), the maximum and the minimum bitrate requirements for this VL;
- "instantiationLevel" attribute: indicates in the attribute "vduLevel" the number of instances to deploy for each vdu referenced in this deployment flavour; specifies in the attribute "virtualLinkBitRateLevel" the bitrate requirements applicable to the virtual links referenced in this deployment flavour; represents in the "scaleInfo" attribute the scale level that corresponds to this instantiation level for the VNFs supporting scaling;
- "scalingAspect" attribute: defines 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 virtual link bit rates.

Figure 3 depicts an example of a VNF profile in which the Deployment Flavour has three ScalingAspects: ScalingAspectId "x", ScalingAspectId "y" and ScalingAspectId "z". ScalingAspectId "x" is in the ScaleLevel "x", with MinScaleLevel "x" $\leq$ ScaleLevel "x" $\leq$ MaxScaleLevel "x"; ScalingAspectId "y" is in the ScaleLevel "y", with MinScaleLevel "y" $\leq$ ScaleLevel "y" $\leq$ MaxScaleLevel "y"; and scalingAspectId "z" is in the ScaleLevel "z", with MinScaleLevel "z" $\leq$ ScaleLevel "z" $\leq$ MaxScaleLevel "z".

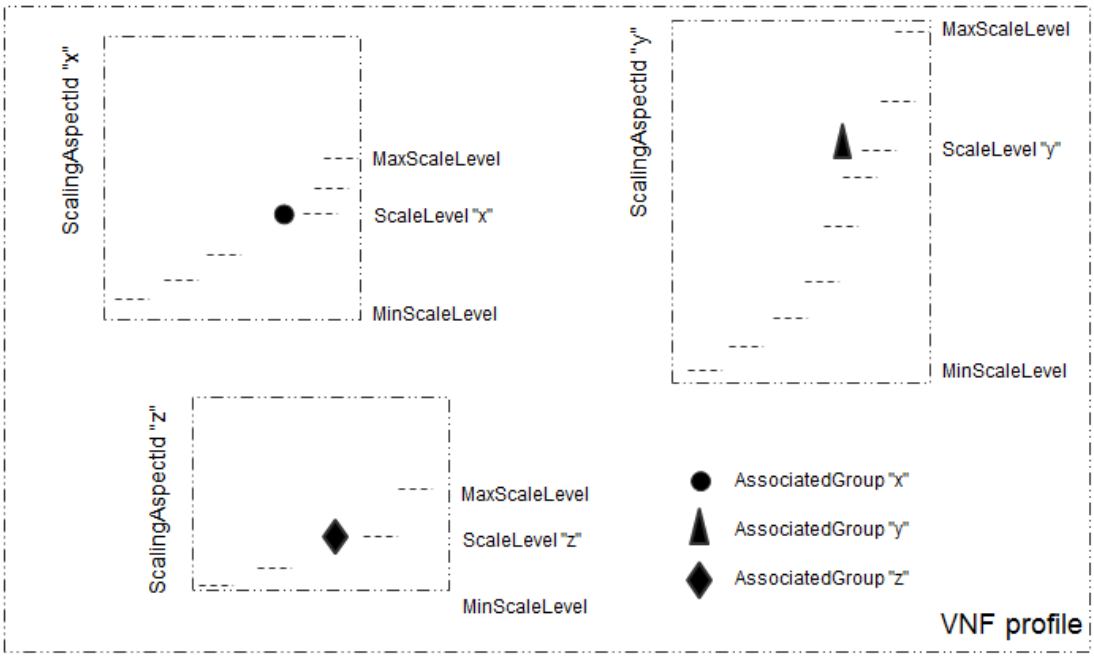

Figure 3: Example of a VNF profile with three ScalingAspects

4.2.1.2 Network Service scaling

The aim of NS scaling is to increase or decrease the capacity of a Network Service instance ETSI GS NFV-IFA 013 [7]. 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 deployment flavour 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 Deployment Flavour (DF) change if there is a higher/lower capacity DF of the VNF. If the DF change of the VNF requires topology changes, NFVO can create/modify the required VLs. Also the VNF Deployment Flavour (VNF DF) changes may require application level configuration task done by the traditional management system; therefore interaction with Operations Support System (OSS)/Business Support System (BSS) or Element Manager (EM) may be required.
- Adding/removing VNF instance(s) to/from the NS. In this scenario the capacity of the NS is changed by adding/removing VNF instance(s) to/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 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/lower capacities. The NFVO may requires instantiation/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 the network service contains a nested network service.
- 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/removing VL in an NS. The latter may require application level configuration as well, therefore interactions with OSS/BSS or EM may be required.

4.2.2 NFV Infrastructure overview

4.2.2.0 General overview

The NFV Infrastructure is concerned with describing the Hypervisor, Compute and Network domains, and their associated interfaces.

4.2.2.1 Hypervisor Domain overview

The Hypervisor Domain (HD) abstracts the hardware 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 Network Domain (ND) in that it can include virtual switch and virtual router software elements and abstract network-related hardware resources provided by the compute domain such as Network Interface Controller (NIC) and embedded switches ETSI GS NFV-EVE 001 [i.3].

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

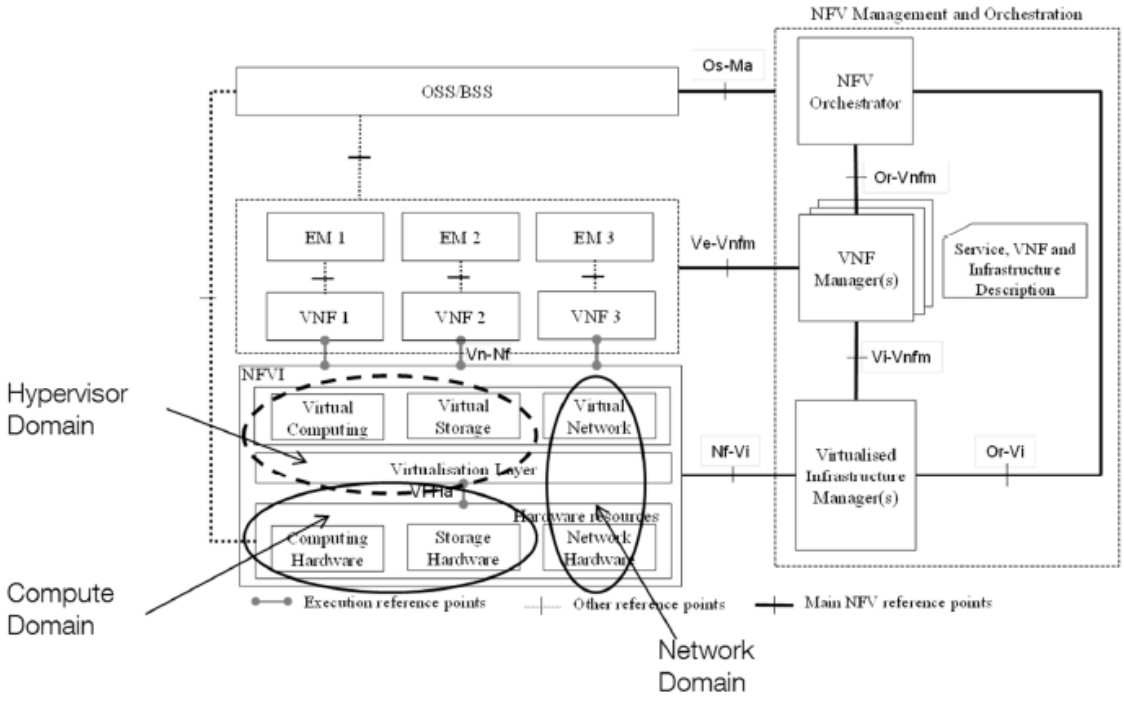

Figure 4: Logical placement of the Hypervisor Domain

5 GALv2 Energy-Aware States definition

5.0 General description

The objective of this clause is to define EASs for the EAEs that are relevant in the ETSI NFV context ETSI GS NFV 002 [i.1] in the same way as in ETSI ES 203 237 [1].

5.1 Identification of the ETSI NFV entities

5.1.0 NFV Entities type

The ETSI NFV entities that are in the scope of the present document are the VNFCs, the VNFs, and the NSs.

5.1.1 Identification of a Network Service

The identification of a given Network Service "a" is done according to the following notation: $NS\sim a, with\ a\ \epsilon\ [a0, a1, a2, a3, \dots,]$.

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

5.1.2 Identification of a Virtualised Network Function

The identification of a given Virtualised Network Function "b" is done according to the following notation: $VNF\sim b, with\ b\ \epsilon\ [b0, b1, b2, b3, \dots,]$.

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

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

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

5.1.3 Identification of a Virtualised Network Function Component

The identification of a given Virtualised Network Function Component "c" is done according to the following notation: $VNFC\sim c, with\ c\ \epsilon\ [c0, c1, c2, c3, \dots,]$.

The k^{th} instance of VNFC~c is identified with the following notation: $VNFC\sim c\#k, with\ k\ \epsilon\ [1, 2, 3, \dots,]$.

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

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

5.1.4 Identification of a Virtualisation Container

The identification of a given Virtualisation Container, in which $VNFC\sim c\#k$ is deployed, is done according to the following notation: $VC_{VNFC\sim c\#k}$.

5.2 Identification of a given (CD, HD) combination

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

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.

5.3 Identification of a given Energy-Aware State of a NFV entity

The identification of a given Energy-Aware State of an ETSI NFV entity is done according to the following notation: $(EAS_x)^{NFV\ entity}, with\ x\ being\ a\ real\ number.$

NOTE: The x^{th} Energy-Aware State of an ETSI NFV entity depends on the (CD, HD) combination(s) on which the Virtualisation Container(s) associated with this entity is (are) deployed.

5.4 VNFC Energy-Aware States

5.4.1 VNFC Energy-Aware States definition

When the EAE is a VNFC, the EASs of this kind of entity shall be associated to a VNFC instance which is mapped to a single Virtualisation Container.

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

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

With:

$0 \leq s \leq L \; and \; 0 \leq s' \leq L'$

- $(S_0)^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the $(0)^{th}$ standby state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC is active;
- $(S_{s'})^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the $(s')^{th}$ standby state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ and deployed with a given (CD, HD) combination identifier;
- $(S_{L'})^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the lowest standby state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC is completely off;
- $(P_0)^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the first power state of the active state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ and deployed with a given (CD, HD) combination identifier. In this state the VC power is maximum;
- $(P_s)^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the $(s)^{th}$ power state of the active state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ 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;
- $(P_L)^{ch\left(VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}\right)}$ identifies the lowest power state of the active state of the VC associated with $VNFC{\sim}c\#k \subset VNF{\sim}b\#j_{DF\text{-}X\#l_{DF\text{-}X}}$ 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 shall regard the standby configurations $(s = 0, 0 < s' \leq L')$. The sorting shall 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 shall regard the power scaling configurations $(0 < s \leq L, s' = 0)$. The sorting shall be based on the power gain in ascending order;
- the next positive values of x refer to the other possible configurations $(0 < s \leq L, 0 < s' \leq L')$. The present document does not define all the possible configurations.

Table 1 summarizes the different EAS configuration identifiers values.

Table 1: EAS 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:

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

5.4.2 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 ETSI GS NFV-IFA 011 [6], Table 7.1.6.7.2-1, shall contain the VNFC EASs as defined in clause 5.4.1.

The MonitoringParameter information element, containing virtualised resource related performance metrics to be tracked by VNFM, e.g. for auto-scaling purposes, provided in ETSI GS NFV-IFA 011 [6], Table 7.1.11.3.2-1, shall contain the attributes associated with the VNFC EASs as defined in clause 5.4.1.

5.5 VNF Energy-Aware States

5.5.1 VNF Energy-Aware States definition

When the EAE is a VNF, the EASs of this kind of entity shall be associated to an instance of a given VNF deployed according to a given VNF Deployment Flavour in a given instantiation level, see ETSI GS NFV-IFA 011 [6].

The x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted DF-X, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$, shall be defined according to the following formula:

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

The real number x identifying an EAS of a VNF instance is mapped with $(\alpha, \beta, \gamma, \ldots)$ according to rules that are out of the scope of the present document.

The attributes associated with this EAS are defined as follows:

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

5.5.2 VNF Energy-Aware States in the VNFD information element

The additionalConfigurableProperty attribute of the VnfConfigurableProperties information element, containing VNF specific configurable properties that can be modified by VFNM, is provided in ETSI GS NFV-IFA 011 [6], Table 7.1.12.2-1. It shall contain the VNF EASs as defined in clause 5.5.1.

The VnfInfoModifiableAttributes information element, containing VNF-specific extension and metadata attributes of the VnfInfo that are writeable via the ModifyVnfInfo operation, is provided in ETSI GS NFV-IFA 011 [6] Table 7.1.14.2-1. It shall contain the VNF EASs as defined in clause 5.5.1.

The VnfIndicator information element, containing indicators the VNF supports, is provided in ETSI GS NFV-IFA 011 [6], Table 7.1.11.2.2-1. It shall contain the VNF EASs as defined in clause 5.5.1.

5.5.3 VNF Energy-Aware States in the VnfDf information element

The VnfIndicator information element, containing indicators the VNF DF supports, is provided in ETSI GS NFV-IFA 011 [6], Table 7.1.11.2.2-1. It shall contain the VNF DF EASs as defined in clause 5.5.1.

The MonitoringParameter information element, containing virtualised resource related performance metrics to be tracked by VNFM, e.g. for auto-scaling purposes, provided in ETSI GS NFV-IFA 011 [6], Table 7.1.11.3.2-1, shall contain the attributes associated with the VNF DF EASs as defined in clause 5.5.1.

5.6 NS Energy-Aware States

5.6.1 NS Energy-Aware States definition

When the EAE is a NS, the EASs of this kind of entity shall be associated to an instance of a given NS deployed according to a given NS Deployment Flavour in a given instantiation level, see ETSI GS NFV-IFA 014 [8].

The x^{th} EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$, shall be defined according to the following formula:

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

The real number x identifying an EAS of a NS instance is mapped with $(\alpha, \beta, \gamma, \ldots)$ according to rules that are out of the scope of the present document.

The attributes associated with this EAS are defined as follows:

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

5.6.2 NS Energy-Aware States in the NSD information element

The performanceMetric attribute in the MonitoringParameter information element, specifying a virtualised resource related performance metric to be monitored, provided in ETSI GS NFV-IFA 011 [6], Table 6.2.8.2-1, shall contain the attributes associated with the NS EASs as defined in clause 5.6.1 of the present document.

6 GALv2 Green Standard Interface

6.0 GALv2 interface generality

The present 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 described in ETSI GS NFV-IFA 013 [7], Or-Vnfm described in ETSI GS NFV-IFA 007 [4], Or-Vi described in ETSI GS NFV-IFA 005 [2], Vi-Vnfm described in ETSI GS NFV-IFA 006 [3], Ve-Vnfm-em described in ETSI GS NFV-IFA 008 [5], Ve-Vnfm-vnf described in ETSI GS NFV-IFA 008 [5].

The following operations are defined:

- Provisioning: GALv2 Provisioning configures EASs of virtualised resources.
- Release: GALv2 Release permits to put the virtualised resource in its default EAS configuration.
- Monitoring: GALv2 Monitoring command set permits to monitor the energy parameters and values of an individual resource or a group of resources.

NOTE: Provisioning, Release, Monitoring, Discovery, Commit, Rollback operations are defined in GALv1 ETSI ES 203 237 [1]. Among them, Discovery/Commit/Rollback operations are not relevant in the NFV MANO architectural framework.

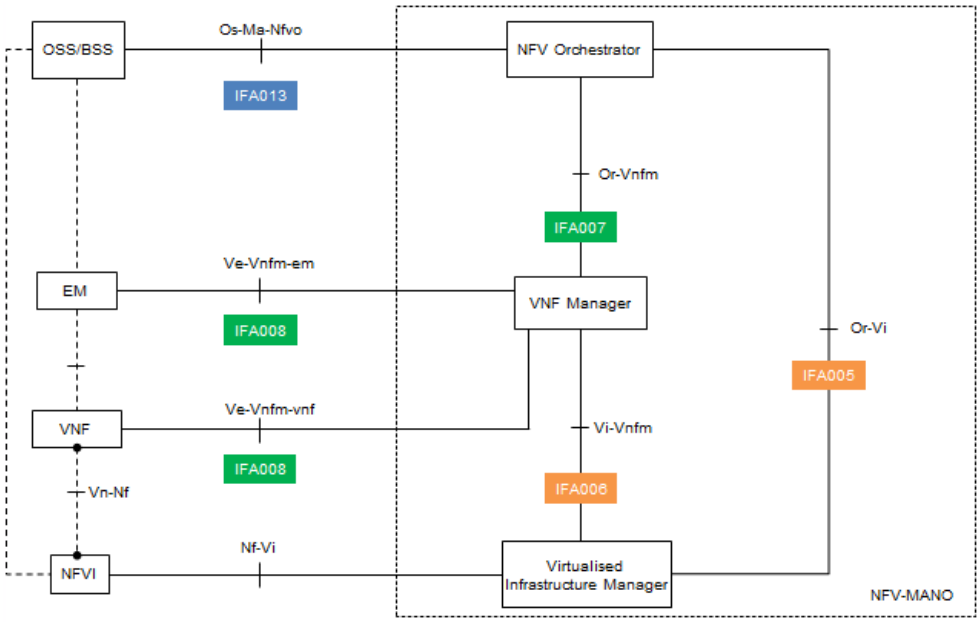

Figure 5: Reference points of the NFV MANO architectural framework

6.1 Provisioning operations

6.1.0 Generality

GALv2 Provisioning permits to configure EAS of an individual resource or a group of resources.

6.1.1 Os-Ma-Nfvo reference point

6.1.1.1 Instantiate NS operation

6.1.1.1.1 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 NS and VNFs below the NS being instantiated shall be acyclic (i.e. no loops), see ETSI GS NFV-IFA 013 [7].

Table 2 lists the information flow exchanged between OSS/BSS and NFVO, described in ETSI GS NFV-IFA 013 [7].

Table 2: Instantiate NS operation

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

6.1.1.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.3.2-1.

The additionalParamForNs parameter, allowing OSS/BSS to provide additional parameter(s) at the NS level, shall identify the x^{th} EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$. 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 shall be used.

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

6.1.1.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.3.3-1.

6.1.1.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 013 [7], clause 7.3.3.4.

6.1.1.2 Scale NS operation

6.1.1.2.1 Description

This operation will scale an NS instance. Scaling an NS instance can be performed by explicitly adding/removing existing VNF instances to/from the NS instance, by leveraging on the abstraction mechanism provided by the NS scaling aspects and NS levels 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 shall follow the indications provided by the dependencies attribute, as specified in the corresponding NSD, see ETSI GS NFV-IFA 013 [7].

Table 3 lists the information flow exchanged between OSS/BSS and NFVO described in ETSI GS NFV-IFA 013 [7].

Table 3: Scale NS operation

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

6.1.1.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.4.2-1.

The scaleNsData parameter provides the information to scale the referenced NS instance. The ScaleNsData information element, provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.6.2-1, describes the information needed to scale the instance either by explicitly adding/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 OSS/BSS to provide additional parameter(s) necessary for the scaling at the NS level, shall identify the x^{th} EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.
- The additionalParamForVnf attribute, allowing OSS/BSS to provide additional parameter(s) per VNF instance that is to be created by NFVO as part of the NS scaling, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

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 ETSI GS NFV-IFA 013 [7], Table 8.3.4.9.2-1, 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 ETSI GS NFV-IFA 013 [7], Table 8.3.4.10.2-1, describes the information needed to scale the VNF instance to a given level, either expressed as an instantiation level of a given Deployment Flavour, or as a list of scale levels, one per scaling aspect of that Deployment Flavour. The additionalParam attribute, allowing OSS/BSS to provide additional parameter(s) specific to the VNF instance being scaled, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to that Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

The ScaleByStepData information element, provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.11.2-1, describes the information needed to scale the VNF instance by steps. The additionalParam attribute, allowing OSS/BSS to provide additional parameter(s) specific to the VNF instance being scaled, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to that Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.1.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.4.3-1.

6.1.1.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 013 [7], clause 7.3.4.4.

6.1.1.3 Update NS operation

6.1.1.3.1 Description

This operation updates an NS instance. Only one type of update shall be allowed per operation. This operation is also used to embed VNF Lifecycle Management (LCM) operations in support of fine grained NS LCM approach, see ETSI GS NFV-IFA 013 [7].

Table 4 lists the information flow exchanged between OSS/BSS and NFVO ETSI GS NFV-IFA 013 [7].

Table 4: Update NS operation

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

6.1.1.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.5.2-1:

- If updateType=InstantiateVnf: the instantiateVnfData parameter specifies the new VNF to be instantiated. The attributes of the InstantiateVnfData information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.12.2-1. The additionalParam attribute, allowing OSS/BSS to provide additional parameter(s) specific to the VNF being instantiated, as declared in the VNFD, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.
- 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 shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.15.2-1. The additionalParam attribute, allowing OSS/BSS to provide additional parameter(s) to the flavour change process, specific to the VNF being modified, as declared in the VNFD, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

- If updateType=OperateVnf: the operateVnfData parameter specifies the state of the VNF instance to be changed. The attributes of the OperateVnfData information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.16.2-1. 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 shall be mapped with STARTED and STOPPED. The additionalParam attribute, allowing 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, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

- If updateType=ChangeNsFlavourData: the changeNsFlavourData parameter specifies the new DF to be applied to the NS instance. The attributes of the ChangeNsFlavourData information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.27.2-1. The additionalParam attribute shall be added in ETSI GS NFV-IFA 013 [7], Table 8.3.4.27.2-1 to allow 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 Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

- If updateType=AddPnf: the addPnfData parameter specifies information of the PNF(s) that are being added into the NS instance. The attributes of the AddPnfData information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.4.32.2-1. The additionalParam attribute, allowing OSS/BSS to provide additional parameter(s) specific to the PNF being instantiated, as declared in the PNFD, shall be added in ETSI GS NFV-IFA 013 [7], Table 8.3.4.32.2-1.

NOTE: If updateType=AddPnf, the content of the additionalParam attribute should be defined with GALv1, see ETSI ES 203 237 [1].

6.1.1.3.3 Output parameters

The output parameter returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.5.3-1.

6.1.1.3.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 013 [7], clause 7.3.5.4.

6.1.1.4 Notify operation

6.1.1.4.1 Description

This operation notifies OSS/BSS about events related to notifications about lifecycle operation occurrences on NS instance, lifecycle operation occurrences impacting NS components, as well as the creation/deletion of NS instance identifiers and the associated NsInfo information element instances. It is a one-way operation issued by NFVO that cannot be invoked as an operation by OSS/BSS. The following notifications can be notified by this operation: NsLcmOperationOccurenceNotification, NsChangeNotification, NsIdentifierCreationNotification, NsIdentifierObjectDeletionNotification, see ETSI GS NFV-IFA 013 [7].

Table 5 lists the information flow exchanged between NFVO and OSS/BSS, see ETSI GS NFV-IFA 013 [7].

Table 5: Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVO → OSS/BSS

6.1.1.4.2 NsLcmOperationOccurenceNotification

6.1.1.4.2.1 Description

This notification informs the receiver of changes in the NS lifecycle caused by NS lifecycle management operation occurrences, which may be manually triggered by OSS/BSS or automatically triggered by NFVO. The automatic trigger inside NFVO includes auto-scaling, auto-healing and impact on the nested NS instances triggered by the NS lifecycle operation on its composite NS. The support of the notification is mandatory ETSI GS NFV-IFA 013 [7].

6.1.1.4.2.2 Trigger conditions

This notification is produced when there is a change in the NS lifecycle caused by NS lifecycle management operation occurrences, including ETSI GS NFV-IFA 013 [7]:

- 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 lifecycle operation on its composite NS.

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

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

6.1.1.4.2.3 Attributes

The attributes of the NsLcmOperationOccurenceNotification notification shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.2.2.3-1.

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

The AffectedVnf information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.2.3.2-1. The vnfProfileId attribute references the VnfProfile which is used by the affected VNF instance. The attributes of the VnfProfile information element provided in ETSI GS NFV-IFA 014 [8], Table 6.3.3.2-1 shall contain an EAS as defined in clause 7.5.

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

The AffectedPnf information element shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.3.2.4.2-1. The pnfProfileId attribute references the PnfProfile which is used by the affected PNF instance. The attributes of the PnfProfile information element provided in ETSI GS NFV-IFA 014 [8], Table 6.3.6.2-1 shall contain an EAS as defined in ETSI ES 203 237 [1].

6.1.2 Or-Vnfm reference point

6.1.2.1 Instantiate VNF operation

6.1.2.1.1 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 [4].

Table 6 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

Table 6: Instantiate VNF operation

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

6.1.2.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.3.2-1.

The additionalParam parameter containing additional parameters, specific to the VNF being instantiated as declared in the VNFD, passed by NFVO, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$. 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 shall be used.

6.1.2.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.3.3-1.

6.1.2.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.3.4.

6.1.2.2 Scale VNF operation

6.1.2.2.1 Description

This operation provides methods to request horizontal scaling a VNF ETSI GS NFV-IFA 007 [4]:

- 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 NFVO and VNFM ETSI GS NFV-IFA 007 [4].

Table 7: Scale VNF operation

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

6.1.2.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.4.2-1.

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

6.1.2.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.4.3-1.

6.1.2.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.4.4.

6.1.2.3 Scale VNF to Level operation

6.1.2.3.1 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 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 ETSI GS NFV-IFA 007 [4].

Table 8 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

Table 8: Scale VNF to Level operation

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

6.1.2.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.5.2-1.

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

6.1.2.3.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.5.3-1.

6.1.2.3.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.5.4.

6.1.2.4 Change VNF Flavour operation

6.1.2.4.1 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,see ETSI GS NFV-IFA 007 [4].

Table 9 lists the information flow exchanged between NFVO and VNFM, see ETSI GS NFV-IFA 007 [4].

Table 9: Change VNF Flavour operation

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

6.1.2.4.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.6.2-1.

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

6.1.2.4.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.6.3-1.

6.1.2.4.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.6.4.

6.1.2.5 Operate VNF operation

6.1.2.5.1 Description

This operation enables requesting to change the state of a VNF instance, including starting and stopping the VNF instance ETSI GS NFV-IFA 007 [4].

Table 10 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

Table 10: Operate VNF operation

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

6.1.2.5.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.11.2-1.

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

The additionalParam parameter containing additional parameters passed by NFVO as input to the Operate VNF operation, specific to the VNF being operated as declared in the VNFD, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.2.5.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.11.3-1.

6.1.2.5.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.11.4.

6.1.2.6 Modify VNF Information operation

6.1.2.6.1 Description

This operation allows updating information about a VNF instance. This operation shall be supported for all VNFs ETSI GS NFV-IFA 007 [4].

Table 11 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

Table 11: Modify VNF Information operation

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

6.1.2.6.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.12.2-1.

The newValues parameter shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.2.6.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.12.3-1.

6.1.2.6.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.12.4.

6.1.2.7 Notify operation

6.1.2.7.1 Description

This operation notifies NFVO about events related to VNF lifecycle changes as well as creation/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 [4].

Table 12 lists the information flow exchanged between VNFM and NFVO ETSI GS NFV-IFA 007 [4].

Table 12: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → NFVO

6.1.2.7.2 VnfLcmOperationOccurrenceNotification

6.1.2.7.2.1 Description

This notification informs the receiver of changes in the VNF lifecycle caused by VNF lifecycle management operation occurrences. The support of the notification is mandatory ETSI GS NFV-IFA 007 [4].

6.1.2.7.2.2 Trigger conditions

This notification is produced when there is a change in the VNF lifecycle caused by VNF lifecycle management operation occurrences, including ETSI GS NFV-IFA 007 [4]:

- Instantiation of the VNF.
- Scaling of the VNF instance (including auto-scaling).
- Healing of the VNF instance (including auto-healing).
- Operate VNF.
- Change of the DF of the VNF instance.
- Changing the external virtual links of the VNF instance.
- Termination of the VNF instance.
- Modification of VNF instance information and/or VNF configurable properties explicitly through Modify VNF Information operation.

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

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

6.1.2.7.2.3 Attributes

The VnfLcmOperationOccurrenceNotification shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.6.2.3-1.

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

The AffectedVnfc information element shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.6.3.2-1.

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in ETSI GS NFV-IFA 011 [6], Table 7.1.6.2.2-1 shall contain EASs as defined in clause 5.4.

The metadata attribute shall contain an EAS of the VC, as defined in clause 5.4, associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

6.1.2.8 Virtualised Resources Management interfaces in indirect mode

6.1.2.8.1 Introduction

In indirect mode of VNF-related resource management, NFVO produces towards VNFM the virtualised resource management interfaces defined in ETSI GS NFV-IFA 007 [4], clause 6.4. These interfaces are related to the corresponding interfaces defined in ETSI GS NFV-IFA 006 [3] with an additional resource provider identifier.

This identifier is used by NFVO to determine the entity responsible for the management of the virtualised resource, the management of the virtualised resources reservation or the management of the virtualised resources quota (usually one of multiple VIMs with which NFVO interacts). It is used by 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/quota ETSI GS NFV-IFA 007 [4].

6.1.2.8.2 Virtualised Compute interfaces

6.1.2.8.2.1 Virtualised Compute Resources Management interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Management to VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.1.

6.1.2.8.2.2 Virtualised Compute Resources Change Notification interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Change Notifications to be consumed by VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.2.

6.1.2.8.2.3 Virtualised Compute Resources Information Management interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Information Management to VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.3.

6.1.3 Or-Vi reference point

6.1.3.1 Allocate Virtualised Compute Resource operation

6.1.3.1.1 Description

This operation allows requesting the allocation of virtualised compute resources as indicated by the consumer functional block ETSI GS NFV-IFA 005 [2].

Table 13 lists the information flow exchanged between NFVO and VIM ETSI GS NFV-IFA 005 [2].

Table 13: Allocate Virtualised Compute Resource operation

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

6.1.3.1.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.2.2-1. The parameter computeFlavourId identifies the Compute Flavour that provides information about the particular memory, CPU and disk resources for the virtualised compute resource to allocate.

A new attribute of the VirtualComputeFlavour information element, provided in ETSI GS NFV-IFA 005 [2], Table 8.4.2.2.2-1 shall be added according to Table 14.

Table 14: VirtualComputeFlavour energyAwareState attribute

Attribute	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. 1	Virtualised compute resource Energy-Aware State. See note.	Selected EAS from the set of EASs offered by the virtualised compute node resources. The cardinality can be 0, if no particular EAS is requested.
NOTE: The virtualised compute resource EAS shall be associated to a VNFC instance.				

6.1.3.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.2.3-1. The ETSI GS NFV-IFA 005 [2], Table 8.4.3.2.2-1, providing information of the newly instantiated virtualised compute resource, shall contain a new energyAwareState attribute according to Table 15.

Table 15: VirtualCompute energyAwareState attribute

Attribute	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. N	Virtualised compute resource Energy-Aware State.	Selected EASs from the set of EASs offered by the virtualised compute node resources. The cardinality can be 0, if no particular EAS is requested.

6.1.3.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 005 [2], clause 7.3.1.2.4.

6.1.3.2 Update Virtualised Compute Resource operation

6.1.3.2.1 Description

This operation allows updating the configuration and/or parameters of an instantiated virtualised compute resource. This can include, for instance, 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 [2].

Table 16 lists the information flow exchanged between NFVO and VIM ETSI GS NFV-IFA 005 [2].

Table 16: Update Virtualised Compute Resource operation

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

6.1.3.2.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.4.2-1. A new energyAwareState parameter shall be added according to Table 17.

Table 17: energyAwareState parameter

Parameter	Qualifier	Cardinality	Content	Description
energyAwareState	M	0 .. 1	Virtualised compute resource Energy-Aware State.	The EAS to update on the virtualised 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.				

6.1.3.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.4.3-1. The ETSI GS NFV-IFA 005 [2], Table 8.4.3.2.2-1, providing information of the newly instantiated virtualised compute resource, shall contain a new energyAwareState attribute according to Table 15.

6.1.3.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 005 [2], clause 7.3.1.4.4.

6.1.3.3 Scale Virtualised Compute Resource operation

6.1.3.3.1 Description

This operation allows scaling a virtualised compute resource by adding or removing capacity in terms of virtual CPUs and virtual memory ETSI GS NFV-IFA 005 [2].

Table 18 lists the information flow exchanged between NFVO and VIM ETSI GS NFV-IFA 005 [2].

Table 18: Scale Virtualised Compute Resource operation

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

6.1.3.3.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.7.2-1.

A new attribute of the VirtualComputeFlavour information element, provided in ETSI GS NFV-IFA 005 [2], Table 8.4.2.2.2-1 shall be added according to Table 14.

6.1.3.3.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.7.3-1. The content of the computeData parameter, containing information of the scaled virtualised compute resource, and provided in ETSI GS NFV-IFA 005 [2], Table 8.4.3.2.2-1, shall be updated according to Table 15.

6.1.3.3.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 005 [2], clause 7.3.1.7.4.

6.1.3.4 Notify operation

6.1.3.4.1 Description

This operation distributes notifications to NFVO. It is a one-way operation issued by VIM that cannot be invoked as an operation by NFVO. The following notification is notified by this operation: VirtualisedResourceChangeNotification ETSI GS NFV-IFA 005 [2].

Table 19 lists the information flow exchanged between VIM and NFVO ETSI GS NFV-IFA 005 [2].

Table 19: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → NFVO

6.1.3.4.2 VirtualisedResourceChangeNotification

6.1.3.4.2.1 Description

This notification informs the receiver of changes in the virtualised resources that are allocated. The support of the notification is mandatory ETSI GS NFV-IFA 005 [2].

6.1.3.4.2.2 Trigger conditions

This notification is produced when the virtualised resource will be impacted due to changes in underlying resources produced by maintenance and operation of NFVI, including ETSI GS NFV-IFA 005 [2]:

- 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 above operations could trigger further actions, e.g. migration of virtualised resources.

6.1.3.4.2.3 Attributes

The VirtualisedResourceChangeNotification shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 8.4.9.3-1.

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

6.1.4 Vi-Vnfm reference point

6.1.4.1 Allocate Virtualised Compute Resource operation

6.1.4.1.1 Description

This operation allows requesting the allocation of virtualised compute resources as indicated by the consumer functional block ETSI GS NFV-IFA 006 [3].

Table 20 lists the information flow exchanged between VNFM and VIM ETSI GS NFV-IFA 006 [3].

Table 20: Allocate Virtualised Compute Resource operation

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

6.1.4.1.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.2.2-1. The parameter computeFlavourId identifies the Compute Flavour that provides information about the particular memory, CPU and disk resources for the virtualised compute resource to allocate.

A new attribute of the VirtualComputeFlavour information element, provided in ETSI GS NFV-IFA 006 [3], Table 8.4.2.2.2-1 shall be added according to Table 14.

6.1.4.1.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.2.3-1. The content of the computeData parameter, containing information of the newly instantiated virtualised compute resource, and provided in ETSI GS NFV-IFA 006 [3], Table 8.4.3.2.2-1, shall be updated according to Table 15.

6.1.4.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 006 [3], clause 7.3.1.2.4.

6.1.4.2 Update Virtualised Compute Resource operation

6.1.4.2.1 Description

This operation allows updating the configuration and/or parameters of an instantiated virtualised compute resource. This can include, for instance, 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 [3].

Table 21 lists the information flow exchanged between VNFM and VIM ETSI GS NFV-IFA 006 [3].

Table 21: Update Virtualised Compute Resource operation

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

6.1.4.2.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.4.2-1. A new energyAwareState parameter shall be added according to Table 17.

6.1.4.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.4.3-1. The ETSI GS NFV-IFA 006 [3], Table 8.4.3.2.2-1, providing information of the newly instantiated virtualised compute resource, shall contain a new energyAwareState attribute according to Table 15.

6.1.4.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 006 [3], clause 7.3.1.4.4.

6.1.4.3 Scale Virtualised Compute Resource operation

6.1.4.3.1 Description

This operation allows scaling a virtualised compute resource by adding or removing capacity in terms of virtual CPUs and virtual memory ETSI GS NFV-IFA 006 [3].

Table 22 lists the information flow exchanged between VNFM and VIM ETSI GS NFV-IFA 006 [3].

Table 22: Scale Virtualised Compute Resource operation

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

6.1.4.3.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.7.2-1.

A new attribute of the VirtualComputeFlavour information element, provided in ETSI GS NFV-IFA 006 [3], Table 8.4.2.2.2-1 shall be added according to Table 14.

6.1.4.3.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.7.3-1. The content of the computeData parameter, containing information of the scaled virtualised compute resource, and provided in ETSI GS NFV-IFA 006 [3], Table 8.4.3.2.2-1, shall be updated according to Table 15.

6.1.4.3.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 006 [3], clause 7.3.1.7.4.

6.1.4.4 Notify operation

6.1.4.4.1 Description

This operation distributes notifications to VNFM. It is a one-way operation issued by VIM that cannot be invoked as an operation by VNFM. In order to receive notifications, VNFM shall have a subscription. The following notification is notified by this operation: VirtualisedResourceChangeNotification ETSI GS NFV-IFA 006 [3].

Table 23 lists the information flow exchanged between VIM and VNFM ETSI GS NFV-IFA 006 [3].

Table 23: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → VNFM

6.1.4.4.2 VirtualisedResourceChangeNotification

6.1.4.4.2.1 Description

This notification informs the receiver of changes in the virtualised resources that are allocated. The support of the notification is mandatory ETSI GS NFV-IFA 006 [3].

6.1.4.4.2.2 Trigger conditions

This notification is produced when the virtualised resource will be impacted due to changes in underlying resources produced by maintenance and operation of NFVI, including ETSI GS NFV-IFA 006 [3]:

- 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 above operations could trigger further actions, e.g. migration of virtualised resources.

6.1.4.4.2.3 Attributes

The VirtualisedResourceChangeNotification notification shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 8.4.9.3-1.

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

6.1.5 Ve-Vnfm-em reference point

6.1.5.1 Instantiate VNF operation

6.1.5.1.1 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 [5].

Table 24 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 24: Instantiate VNF operation

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

6.1.5.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.3.2-1.

The additionalParam parameter containing additional parameters, specific to the VNF being instantiated as declared in the VNFD, passed by EM, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$. 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 shall be used.

6.1.5.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.3.3-1.

6.1.5.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.3.4.

6.1.5.2 Scale VNF operation

6.1.5.2.1 Description

This operation enables a VNF instance or EM to request a VNFM to perform a scaling procedure ETSI GS NFV-IFA 008 [5]:

- 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 VNF/EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 25: Scale VNF operation

Message	Requirement	Direction
ScaleVnfRequest	Mandatory	VNF → VNFM (see note) EM → VNFM
ScaleVnfResponse	Mandatory	VNFM → VNF (see note) VNFM → EM
NOTE: In case of VNF without EM, the scaling request is invoked by 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.		

6.1.5.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.4.2-1.

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

6.1.5.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.4.3-1.

6.1.5.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.4.4.

6.1.5.3 Scale VNF to Level operation

6.1.5.3.1 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 and/or removing NFVI resources to/from the VNF ETSI GS NFV-IFA 008 [5].

Table 26 lists the information flow exchanged between VNF/EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 26: Scale VNF To Level operation

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

6.1.5.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.5.2-1.

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

6.1.5.3.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.5.3-1.

6.1.5.3.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.5.4.

6.1.5.4 Change VNF Flavour operation

6.1.5.4.1 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 [5].

Table 27 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 27: Change VNF Flavour operation

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

6.1.5.4.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.6.2-1.

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

6.1.5.4.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.6.3-1.

6.1.5.4.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.6.4.

6.1.5.5 Operate VNF operation

6.1.5.5.1 Description

This operation enables requesting to change the state of a VNF instance or VNFC instance(s), including starting and stopping the VNF/VNFC instance ETSI GS NFV-IFA 008 [5].

Table 28 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 28: Operate VNF operation

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

6.1.5.5.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.11.2-1.

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

The additionalParam parameter containing additional parameters passed by EM as input to the Operate VNF operation, specific to the VNF being operated as declared in the VNFD, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.5.5.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.11.3-1.

6.1.5.5.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.11.4.

6.1.5.6 Modify VNF Information operation

6.1.5.6.1 Description

This operation allows updating information about a VNF instance ETSI GS NFV-IFA 008 [5].

Table 29 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

Table 29: Modify VNF Information operation

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

6.1.5.6.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.12.2-1.

The newValues parameter shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.5.6.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.12.3-1.

6.1.5.6.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.12.4.

6.1.5.7 Notify operation

6.1.5.7.1 Description

This operation notifies EM or VNF about events related to VNF lifecycle changes as well as creation/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 [5].

Table 30 lists the information flow exchanged between VNFM and EM or VNF, see ETSI GS NFV-IFA 008 [5].

Table 30: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → EM VNFM → VNF

6.1.5.7.2 VnfLcmOperationOccurrenceNotification

6.1.5.7.2.1 Description

This notification informs the receiver of changes in the VNF lifecycle caused by VNF lifecycle management operation occurrences. The support of the notification is mandatory ETSI GS NFV-IFA 008 [5].

6.1.5.7.2.2 Trigger conditions

This notification is produced when there is a change in the VNF lifecycle caused by VNF lifecycle management operation occurrences, including ETSI GS NFV-IFA 008 [5]:

- Instantiation of the VNF.
- Scaling of the VNF instance (including auto-scaling).
- Healing of the VNF instance (including auto-healing).
- Operate VNF.
- Change of the DF of the VNF instance.
- Changing the external virtual links of the VNF instance.
- Termination of the VNF instance.
- Modification of VNF instance information and/or VNF/VNFC configurable properties explicitly through Modify VNF Information operation.

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

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

6.1.5.7.2.3 Attributes

The VnfLcmOperationOccurrenceNotification shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.5.2.3-1.

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

The AffectedVnfc information element shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.5.3.2-1.

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in ETSI GS NFV-IFA 011 [6], Table 7.1.6.2.2-1 shall contain EASs as defined in clause 5.4 of the present document.

The metadata attribute shall contain an EAS of the VC, as defined in clause 5.4 of the present document, associated with the AffectedVnfc and deployed with a given (CD, HD) combination identifier.

6.1.5.8 Set Configuration

6.1.5.8.1 Description

This operation enables VNFM to set the configuration parameters of a VNF instance and its VNFC instance(s) or individual VNFC instances ETSI GS NFV-IFA 008 [5].

Table 31 lists the information flow exchanged between the VNFM and the VNF, see ETSI GS NFV-IFA 008 [5].

Table 31: SetConfiguration operation

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

6.1.5.8.2 Input parameters

The input parameters sent when invoking the operation are provided in ETSI GS NFV-IFA 008 [5], Table 6.2.3.2-1.

The content of the vnfConfigurationData parameter, containing configuration data for the VNF instance, is defined in ETSI GS NFV-IFA 008 [5], Table 9.2.2.2-1. The attribute vnfSpecificData, providing configuration object containing values of VNF configurable properties, shall identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.1.5.8.3 Output parameters

The output parameters sent when responding to the operation is provided in ETSI GS NFV-IFA 008 [5], Table 6.2.3.3-1.

6.1.5.8.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 6.2.3.4.

6.2 Release operations

6.2.0 Generality

GALv2 Release permits to put the virtualised resource in its default EAS configuration.

6.2.1 Os-Ma-Nfvo reference point

6.2.1.1 Update operation

6.2.1.1.1 Description

This operation updates an NS instance. Only one type of update shall be allowed per operation. This operation is also used to embed VNF Lifecycle Management (LCM) operations in support of fine grained NS LCM approach ETSI GS NFV-IFA 013 [7].

Table 4 lists the information flow exchanged between OSS/BSS and NFVO in ETSI GS NFV-IFA 013 [7].

6.2.1.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.5.2-1. A new action that can be performed with an update shall be GALv2ReleaseNs:

- If updateType=GALv2ReleaseNs: the galv2 ReleaseNs parameter, defined in Table 32, shall put the EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$, 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 shall put the EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$, 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.				

6.2.1.1.3 Output parameters

The output parameter returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.3.5.3-1.

6.2.1.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 013 [7], clause 7.3.5.4.

6.2.2 Or-Vnfm reference point

6.2.2.1 Operate VNF operation

6.2.2.1.1 Description

This operation enables requesting to change the state of a VNF instance, including starting and stopping the VNF instance ETSI GS NFV-IFA 007 [4].

Table 10 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

6.2.2.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.11.2-1.

The additionalParam parameter containing additional parameters passed by NFVO as input to the Operate VNF operation, specific to the VNF being operated as declared in the VNFD, shall identify the default EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.2.2.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.11.3-1.

6.2.2.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.11.4.

6.2.2.2 Modify VNF Information operation

6.2.2.2.1 Description

This operation allows updating information about a VNF instance. This operation shall be supported for all VNFs ETSI GS NFV-IFA 007 [4].

Table 11 lists the information flow exchanged between NFVO and VNFM ETSI GS NFV-IFA 007 [4].

6.2.2.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in [4] ETSI GS NFV-IFA 007 [4], Table 7.2.12.2-1.

The newValues parameter shall identify the default EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.2.2.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.2.12.3-1.

6.2.2.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.2.12.4.

6.2.2.3 Notify operation

6.2.2.3.1 Description

This operation notifies NFVO about events related to VNF lifecycle changes as well as creation/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 [4].

Table 12 lists the information flow exchanged between VNFM and NFVO, see ETSI GS NFV-IFA 007 [4].

6.2.2.3.2 VnfLcmOperationOccurrenceNotification

6.2.2.3.2.1 Description

This notification informs the receiver of changes in the VNF lifecycle caused by VNF lifecycle management operation occurrences. The support of the notification is mandatory in ETSI GS NFV-IFA 007 [4].

6.2.2.3.2.2 Trigger conditions

This notification is produced when there is a change in the VNF lifecycle caused by VNF lifecycle management operation occurrences, including ETSI GS NFV-IFA 007 [4]:

- Instantiation of the VNF.
- Scaling of the VNF instance (including auto-scaling).
- Healing of the VNF instance (including auto-healing).
- Operate VNF.
- Change of the DF of the VNF instance.
- Changing the external virtual links of the VNF instance.

- Termination of the VNF instance.
- Modification of VNF instance information and/or VNF configurable properties explicitly through Modify VNF Information operation.

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

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

6.2.2.3.2.3 Attributes

The VnfLcmOperationOccurrenceNotification shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.6.2.3-1.

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

The AffectedVnfc information element shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.6.3.2-1. The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in ETSI GS NFV-IFA 011 [6], Table 7.1.6.2.2-1 shall contain EASs as defined in clause 5.4 of the present document.

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

6.2.2.4 Virtualised Resources Management interfaces in indirect mode

6.2.2.4.1 Introduction

In indirect mode of VNF-related resource management, NFVO produces towards VNFM the virtualised resource management interfaces defined in ETSI GS NFV-IFA 007 [4], clause 6.4. These interfaces are related to the corresponding interfaces defined in ETSI GS NFV-IFA 006 [3] with an additional resource provider identifier.

This identifier is used by NFVO to determine the entity responsible for the management of the virtualised resource, the management of the virtualised resources reservation or the management of the virtualised resources quota (usually one of multiple VIMs with which NFVO interacts). It is used by 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/quota ETSI GS NFV-IFA 007 [4].

6.2.2.4.2 Virtualised Compute interfaces

6.2.2.4.2.1 Virtualised Compute Resources Management interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Management to VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.1.

6.2.2.4.2.2 Virtualised Compute Resources Change Notification interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Change Notifications to be consumed by VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.2.

6.2.2.4.2.3 Virtualised Compute Resources Information Management interface

In indirect resource management mode, NFVO produces an interface for Virtualised Compute Resources Information Management to VNFM according to ETSI GS NFV-IFA 007 [4], clause 6.4.2.3.

6.2.3 Or-Vi reference point

6.2.3.1 Update Virtualised Compute Resource operation

6.2.3.1.1 Description

This operation allows updating the configuration and/or parameters of an instantiated virtualised compute resource. This can include, for instance, 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 [2].

Table 16 lists the information flow exchanged between NFVO and VIM ETSI GS NFV-IFA 005 [2].

6.2.3.1.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.4.2-1.

The energyAwareState parameter defined in Table 17 shall contain the default EAS of the virtualised compute resource.

6.2.3.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.3.1.4.3-1. The ETSI GS NFV-IFA 005 [2], Table 8.4.3.2.2-1, providing information of the newly instantiated virtualised compute resource, shall contain a new energyAwareState attribute according to Table 15.

6.2.3.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 005 [2], clause 7.3.1.4.4.

6.2.4 Vi-Vnfm reference point

6.2.4.1 Update Virtualised Compute Resource operation

6.2.4.1.1 Description

This operation allows updating the configuration and/or parameters of an instantiated virtualised compute resource. This can include, for instance, 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 [3].

Table 21 lists the information flow exchanged between VNFM and VIM ETSI GS NFV-IFA 006 [3].

6.2.4.1.2 Input parameters

The parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.4.2-1.

The energyAwareState parameter defined in Table 17 shall contain the default EAS of the virtualised compute resource.

6.2.4.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.3.1.4.3-1. The ETSI GS NFV-IFA 006 [3], Table 8.4.3.2.2-1, providing information of the newly instantiated virtualised compute resource, shall contain a new energyAwareState attribute according to Table 15.

6.2.4.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 006 [3], clause 7.3.1.4.4.

6.2.5 Ve-Vnfm-em reference point

6.2.5.1 Operate VNF operation

6.2.5.1.1 Description

This operation enables requesting to change the state of a VNF instance or VNFC instance(s), including starting and stopping the VNF/VNFC instance ETSI GS NFV-IFA 008 [5].

Table 28 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

6.2.5.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.11.2-1.

The additionalParam parameter containing additional parameters passed by EM as input to the Operate VNF operation, specific to the VNF being operated as declared in the VNFD, shall identify the default EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.2.5.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.11.3-1.

6.2.5.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.11.4.

6.2.5.2 Modify VNF Information operation

6.2.5.2.1 Description

This operation allows updating information about a VNF instance ETSI GS NFV-IFA 008 [5].

Table 29 lists the information flow exchanged between EM and VNFM ETSI GS NFV-IFA 008 [5].

6.2.5.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.12.2-1.

The newValues parameter shall identify the default EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.2.5.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.2.12.3-1.

6.2.5.2.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.2.12.4.

6.2.5.3 Notify operation

6.2.5.3.1 Description

This operation notifies EM or VNF about events related to VNF lifecycle changes as well as creation/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 [5].

Table 30 lists the information flow exchanged between VNFM and EM or VNF ETSI GS NFV-IFA 008 [5].

6.2.5.3.2 VnfLcmOperationOccurrenceNotification

6.2.5.3.2.1 Description

This notification informs the receiver of changes in the VNF lifecycle caused by VNF lifecycle management operation occurrences. The support of the notification is mandatory ETSI GS NFV-IFA 008 [5].

6.2.5.3.2.2 Trigger conditions

This notification is produced when there is a change in the VNF lifecycle caused by VNF lifecycle management operation occurrences, including ETSI GS NFV-IFA 008 [5]:

- Instantiation of the VNF.
- Scaling of the VNF instance (including auto-scaling).
- Healing of the VNF instance (including auto-healing).
- Operate VNF.
- Change of the DF of the VNF instance.
- Changing the external virtual links of the VNF instance.
- Termination of the VNF instance.
- Modification of VNF instance information and/or VNF/VNFC configurable properties explicitly through Modify VNF Information operation.

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

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

6.2.5.3.2.3 Attributes

The VnfLcmOperationOccurrenceNotification shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.5.2.3-1.

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

The AffectedVnfc information element shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.5.3.2-1.

The vduId attribute references the Vdu which is used by the affected VNFC instance. The attributes of the Vdu information element provided in ETSI GS NFV-IFA 011 [6], Table 7.1.6.2.2-1 shall contain EASs as defined in clause 7.4.

The metadata attribute shall 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.

6.2.5.4 Set Configuration

6.2.5.4.1 Description

This operation enables VNFM to set the configuration parameters of a VNF instance and its VNFC instance(s) or individual VNFC instances ETSI GS NFV-IFA 008 [5].

Table 31 lists the information flow exchanged between VNFM and VNF ETSI GS NFV-IFA 008 [5].

6.2.5.4.2 Input parameters

The input parameters sent when invoking the operation are provided in ETSI GS NFV-IFA 008 [5], Table 6.2.3.2-1.

The content of the vnfConfigurationData parameter, containing configuration data for the VNF instance, is defined in ETSI GS NFV-IFA 008 [5], Table 9.2.2.2-1. The attribute vnfSpecificData, providing configuration object containing values of VNF configurable properties, shall identify the default EAS of the j^{th} instance of VNF~b deployed according to a given VNF Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

6.2.5.4.3 Output parameters

The output parameters sent when responding to the operation is provided in ETSI GS NFV-IFA 008 [5], Table 6.2.3.3-1.

6.2.5.4.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 6.2.3.4.

6.3 Monitoring operations

6.3.0 Generality

GALv2 Monitoring command set permits to monitor the energy parameters and values of an individual resource or a group of resources.

6.3.1 Os-Ma-Nfvo reference point

6.3.1.0 Generality

This interface allows providing of performance information related to network services. 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 of the virtualised resources impacting the connectivity of this NS instance or VNF performance information, resulting from virtualised resource performance information, issued by the VNFM for the VNFs that is part of this NS instance ETSI GS NFV-IFA 013 [7].

6.3.1.1 Create PM Job operation

6.3.1.1.1 Description

This operation creates a PM job, enabling OSS/BSS to specify an NS or set of NSs, that NFVO is managing, for which it wants to receive performance information. This will allow the requesting OSS/BSS to specify its performance information requirements with NFVO. 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 [7].

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

Table 33: Create PM Job operation

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

6.3.1.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.5.2.2-1.

The performanceMetric parameter, defining the type of performance metrics for the specified network services, shall contain the attributes associated with the x^{th} EAS of the i^{th} instance of NS~a deployed according to a given NS Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$:

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

6.3.1.1.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 7.5.2.3-1.

6.3.1.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 013 [7], clause 7.5.2.4.

6.3.1.2 Notify operation

6.3.1.2.1 Description

This operation distributes notifications to OSS/BSS. It is a one-way operation issued by NFVO that cannot be invoked as an operation by OSS/BSS. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification ETSI GS NFV-IFA 013 [7].

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

Table 34: Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVO → OSS/BSS

6.3.1.2.2 PerformanceInformationAvailableNotification

6.3.1.2.2.1 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 [7].

6.3.1.2.2.2 Trigger conditions

The notification is produced when new performance information is available ETSI GS NFV-IFA 013 [7].

6.3.1.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.4.8.3-1.

6.3.1.2.3 ThresholdCrossedNotification

6.3.1.2.3.1 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 [7].

6.3.1.2.3.2 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 [7].

6.3.1.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification shall follow the indications provided in ETSI GS NFV-IFA 013 [7], Table 8.4.9.3-1.

6.3.2 Or-Vnfm reference point

6.3.2.0 Generality

This interface allows providing performance management related to VNFs. Performance information on a given VNF results from performance information of the virtualised resources that is collected from 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 [4].

6.3.2.1 Create PM Job operation

6.3.2.1.1 Description

This operation will create a PM job enabling NFVO to specify a VNF or set of VNFs, that VNFM is managing, for which it wants to receive performance information. This will allow NFVO to specify its performance information requirements with VNFM ETSI GS NFV-IFA 007 [4].

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

Table 35: Create PM Job operation

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

6.3.2.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.4.2.2-1.

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

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

6.3.2.1.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 7.4.2.3-1.

6.3.2.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 007 [4], clause 7.4.2.4.

6.3.2.2 Notify operation

6.3.2.2.1 Description

This operation distributes notifications to NFVO. It is a one-way operation issued by VNFM that cannot be invoked as an operation by NFVO. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification ETSI GS NFV-IFA 007 [4].

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

Table 36: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → NFVO

6.3.2.2.2 PerformanceInformationAvailableNotification

6.3.2.2.2.1 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 [4].

6.3.2.2.2.2 Trigger conditions

The notification is produced when new performance information is available ETSI GS NFV-IFA 007 [4].

6.3.2.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.7.8.3-1.

6.3.2.2.3 ThresholdCrossedNotification

6.3.2.2.3.1 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 [4].

6.3.2.2.3.2 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 [4].

6.3.2.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification shall follow the indications provided in ETSI GS NFV-IFA 007 [4], Table 8.7.9.3-1.

6.3.3 Virtualised Resources Performances Management interfaces in indirect mode

6.3.3.1 Introduction

In indirect resource management mode, NFVO produces an interface for Virtualised Resource Performance Management to be consumed by VNFM. This interface shall comply with the provisions in clause 7.7 of ETSI GS NFV-IFA 006 [3] and the related information elements with an additional resource provider identifier.

This identifier is used by NFVO to determine the entity responsible for the management of the virtualised resource performance information and is used by VNFM to uniquely identify resources ETSI GS NFV-IFA 007 [4].

6.3.4 Or-Vi reference point

6.3.4.0 Generality

This interface allows providing performance management information related to virtualised resources including (but not limited to) resource consumption level, e.g. vCPU power consumption, VM memory usage oversubscription, VM disk latency, etc. It has to be noted that only types of resources that have been catalogued and offered through abstractions to consumer functional blocks are in scope ETSI GS NFV-IFA 005 [2].

6.3.4.1 Create PM Job operation

6.3.4.1.1 Description

This operation will create a PM job, enabling NFVO to specify a resource or set of resources, that VIM is managing, for which it wants to receive performance information. This will allow the requesting NFVO to specify its performance information requirements with VIM ETSI GS NFV-IFA 005 [2].

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

Table 37: Create PM Job operation

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

6.3.4.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.7.2.2-1.

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

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

6.3.4.1.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 7.7.2.3-1.

6.3.4.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 005 [2], clause 7.7.2.4.

6.3.4.2 Notify operation

6.3.4.2.1 Description

This operation distributes notifications to NFVO. It is a one-way operation issued by VIM that cannot be invoked as an operation by NFVO. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification ETSI GS NFV-IFA 005 [2].

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

Table 38: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → NFVO

6.3.4.2.2 PerformanceInformationAvailableNotification

6.3.4.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be virtualised resources ETSI GS NFV-IFA 005 [2].

6.3.4.2.2.2 Trigger conditions

The notification is produced when new performance information is available ETSI GS NFV-IFA 005 [2].

6.3.4.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 8.5.8.3-1.

6.3.4.2.3 ThresholdCrossedNotification

6.3.4.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be virtualised resources ETSI GS NFV-IFA 005 [2].

6.3.4.2.3.2 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 [2].

6.3.4.2.3.3 Attributes

The attributes of the PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 005 [2], Table 8.5.8.3-1.

6.3.5 Vi-Vnfm reference point

6.3.5.0 Generality

This interface allows providing performance management information related to virtualised resources including (but not limited to) resource consumption level, e.g. vCPU power consumption, VM memory usage oversubscription, VM disk latency, etc. It has to be noted that only types of resources that have been catalogued and offered through abstractions to consumer functional blocks are in scope ETSI GS NFV-IFA 006 [3].

6.3.5.1 Create PM Job operation

6.3.5.1.1 Description

This operation will create a PM job, enabling VNFM to specify a resource or set of resources, that VIM is managing, for which it wants to receive performance information. This will allow the requesting VNFM to specify its performance information requirements with VIM ETSI GS NFV-IFA 006 [3].

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

Table 39: Create PM Job operation

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

6.3.5.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.7.2.2-1.

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

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

6.3.5.1.3 Output parameters

The parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 7.7.2.3-1.

6.3.5.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 006 [3], clause 7.7.2.4.

6.3.5.2 Notify operation

6.3.5.2.1 Description

This operation distributes notifications to VNFM. It is a one-way operation issued by VIM that cannot be invoked as an operation by VNFM. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification ETSI GS NFV-IFA 006 [3].

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

Table 40: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VIM → VNFM

6.3.5.2.2 PerformanceInformationAvailableNotification

6.3.5.2.2.1 Description

This notification informs the receiver that performance information is available. The object instances for this information element will be virtualised resources ETSI GS NFV-IFA 006 [3].

6.3.5.2.2.2 Trigger conditions

The notification is produced when new performance information is available ETSI GS NFV-IFA 006 [3].

6.3.5.2.2.3 Attributes

The attributes of the PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 8.5.8.3-1.

6.3.5.2.3 ThresholdCrossedNotification

6.3.5.2.3.1 Description

This notification informs the receiver that a threshold value has been crossed. The object instances for this information element will be virtualised resources ETSI GS NFV-IFA 006 [3].

6.3.5.2.3.2 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 [3].

6.3.5.2.3.3 Attributes

The attributes of the ThresholdCrossedNotification shall follow the indications provided in ETSI GS NFV-IFA 006 [3], Table 8.5.9.3-1.

6.3.6 Ve-Vnfm reference point

6.3.6.0 Generality

This interface allows providing performance management related to VNFs. Performance information on a given VNF/VNFC results from performance information of the virtualised 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 [5].

6.3.6.1 Create PM Job operation

6.3.6.1.1 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 [5].

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

Table 41: Create PM Job operation

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

6.3.6.1.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.4.2.2-1.

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

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

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

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

6.3.6.1.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 7.4.2.3-1.

6.3.6.1.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 7.4.2.4.

6.3.6.2 Notify operation

6.3.6.2.1 Description

This operation distributes notifications to EM or VNF. It is a one-way operation issued by VNFM that cannot be invoked as an operation by EM or VNF. The following notifications can be notified by this operation: PerformanceInformationAvailableNotification, ThresholdCrossedNotification ETSI GS NFV-IFA 008 [5].

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

Table 42: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNFM → EM VNFM → VNF

6.3.6.2.2 PerformanceInformationAvailableNotification

6.3.6.2.2.1 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 [5].

6.3.6.2.2.2 Trigger Conditions

The notification is produced when new performance information is available ETSI GS NFV-IFA 008 [5].

6.3.6.2.2.3 Attributes

The PerformanceInformationAvailableNotification shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.7.8.3-1.

6.3.6.2.3 ThresholdCrossedNotification

6.3.6.2.3.1 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 [5].

6.3.6.2.3.2 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 [5].

6.3.6.2.3.3 Attributes

A threshold has been crossed. Depending on threshold type, there might be a single or multiple crossing values ETSI GS NFV-IFA 008 [5].

6.3.6.3 Notify operation

6.3.6.3.1 Description

This operation distributes notifications to VNFM. It is a one-way operation issued by VNF towards VNFM that cannot be invoked as an operation by VNFM. The following notifications can be notified by this operation: IndicatorValueChangeNotification ETSI GS NFV-IFA 008 [5].

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

Table 43: Notify operation

Message	Requirement	Direction
Notify	Mandatory	VNF → VNFM

6.3.6.3.2 IndicatorValueChangeNotification

6.3.6.3.2.1 Description

This notification informs the receiver of a value change of an indicator related to the VNF ETSI GS NFV-IFA 008 [5].

6.3.6.3.2.2 Trigger Conditions

The value of an indicator has changed ETSI GS NFV-IFA 008 [5].

6.3.6.3.2.3 Attributes

The IndicatorValueChangeNotification information element shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.6.2.3-1.

6.3.6.4 Get Indicator Value operation

6.3.6.4.1 Description

This operation enables VNFM to request the actual value of a given indicator from VNF ETSI GS NFV-IFA 008 [5].

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

Table 44: GetIndicatorValue operation

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

6.3.6.4.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 6.3.4.2-1.

6.3.6.4.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 6.3.4.3-1.

6.3.6.4.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 6.3.4.4.

6.3.6.5 Notify operation

6.3.6.5.1 Description

This notification informs the receiver of a value change of an indicator related to the VNF ETSI GS NFV-IFA 008 [5].

6.3.6.5.2 Trigger Conditions

The value of an indicator has changed ETSI GS NFV-IFA 008 [5].

6.3.6.5.3 Attributes

The IndicatorValueChangeNotification information element shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 9.6.2.3-1.

6.3.6.6 Get Indicator Value operation

6.3.6.6.1 Description

This operation enables VNFM to request the actual value of a given indicator from EM ETSI GS NFV-IFA 008 [5].

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

Table 45: GetIndicatorValue operation

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

6.3.6.6.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 8.2.4.2-1.

6.3.6.6.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in ETSI GS NFV-IFA 008 [5], Table 8.2.4.3-1.

6.3.6.6.4 Operation results

The operation results are defined in ETSI GS NFV-IFA 008 [5], clause 8.2.4.4.

Annex A (informative): GALv2 GSI Provisioning operations

Annex A outlines in Figure A.1 the GALv2 GSI Provisioning operations.

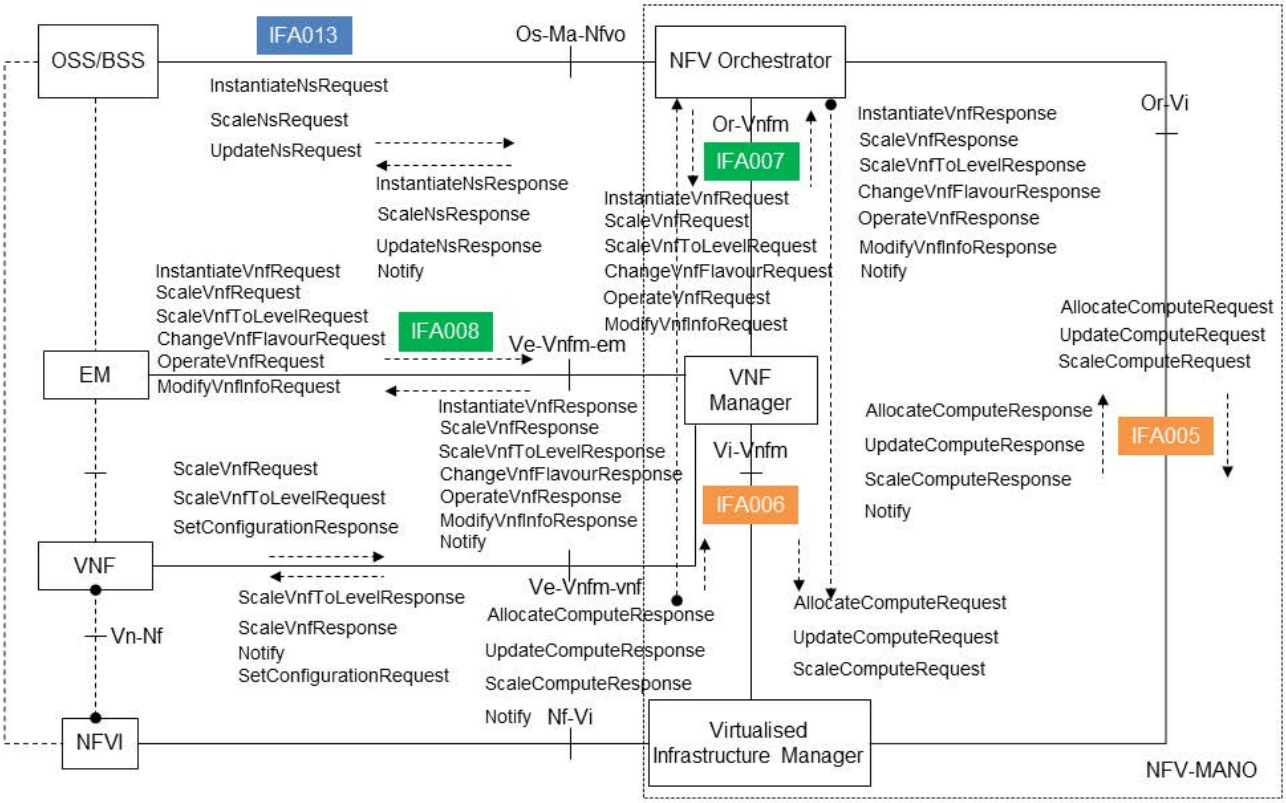

Figure A.1: GALv2 GSI Provisioning operations

Annex B (informative): GALv2 GSI Release operations

Annex B outlines in Figure B.1 the GALv2 GSI Release operations.

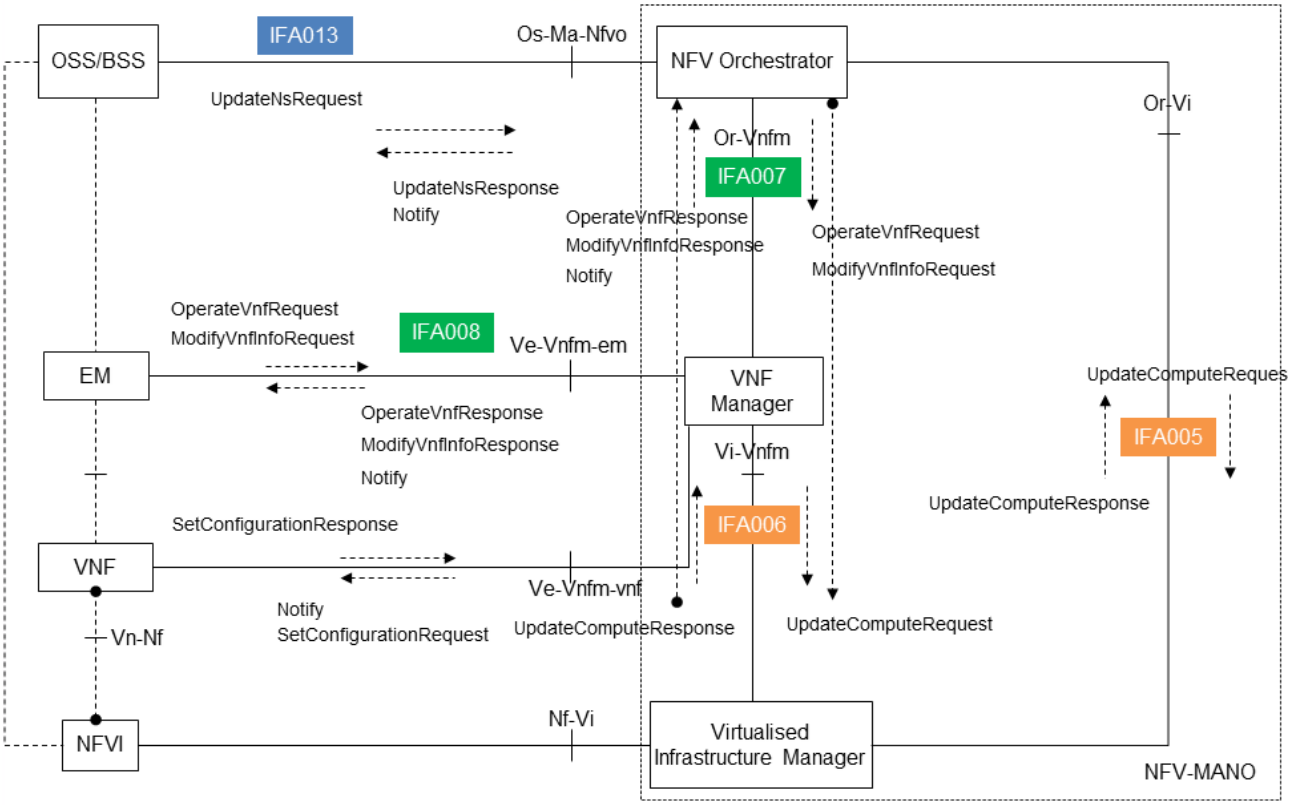

Figure B.1: GALv2 GSI Release operations

Annex C (informative): GALv2 GSI Monitoring operations

Annex C outlines in Figure C.1 the GALv2 GSI Monitoring operations.

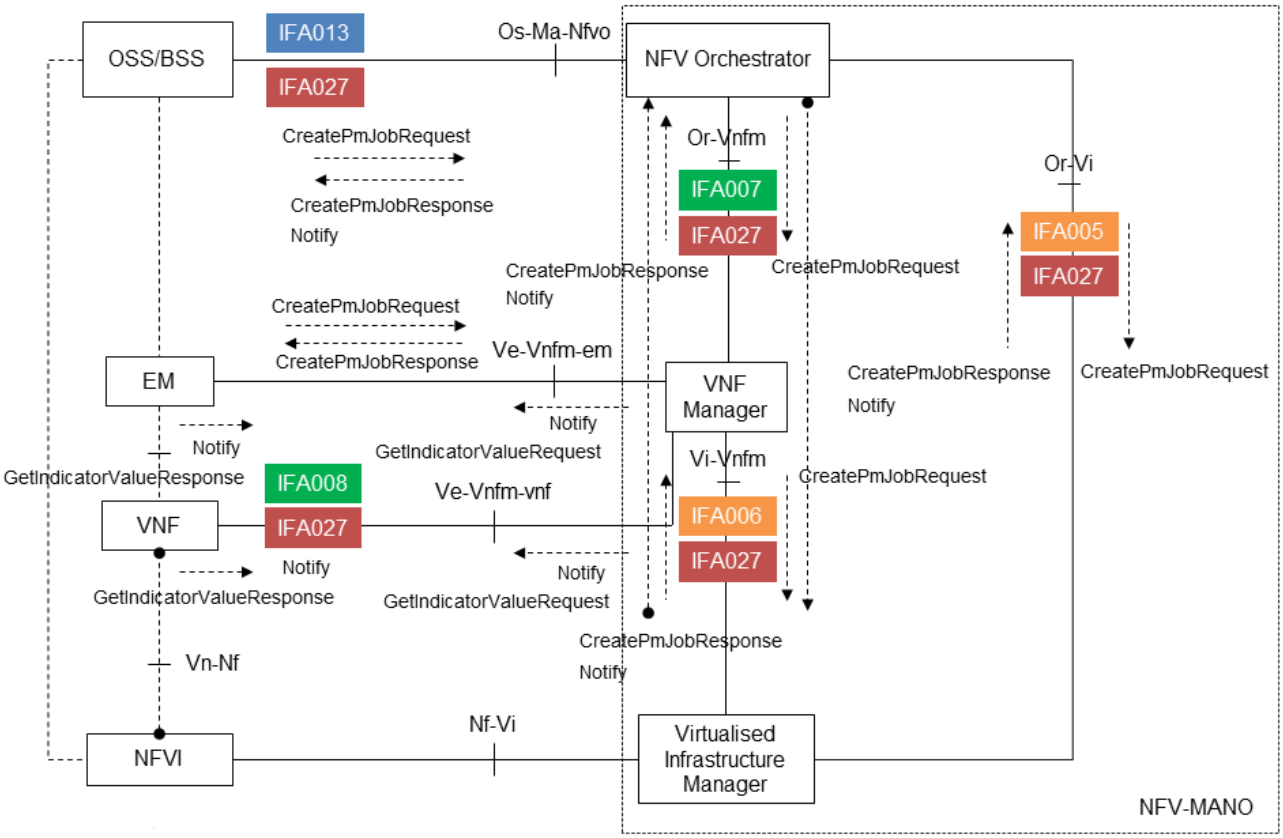

Figure C.1: GALv2 GSI Monitoring operations

Annex D (informative): EAS VNF Configuration Flows

D.1 Change of VNF Configurable Properties

Figure D.1 illustrates two alternative non-exhaustive examples of VNF configuration triggered by explicit change of VNF Configurable Properties. The first alternative (steps 10a – 11a) shows a scenario where VNF Configuration interface is being used, the second alternative (steps 10b – 12b) shows a scenario where VNF Configuration interface is not being used and VNF is capable of self-managing. Other alternatives for passing the configuration changes to the VNF instance are possible ETSI GS NFV-IFA 008 [5].

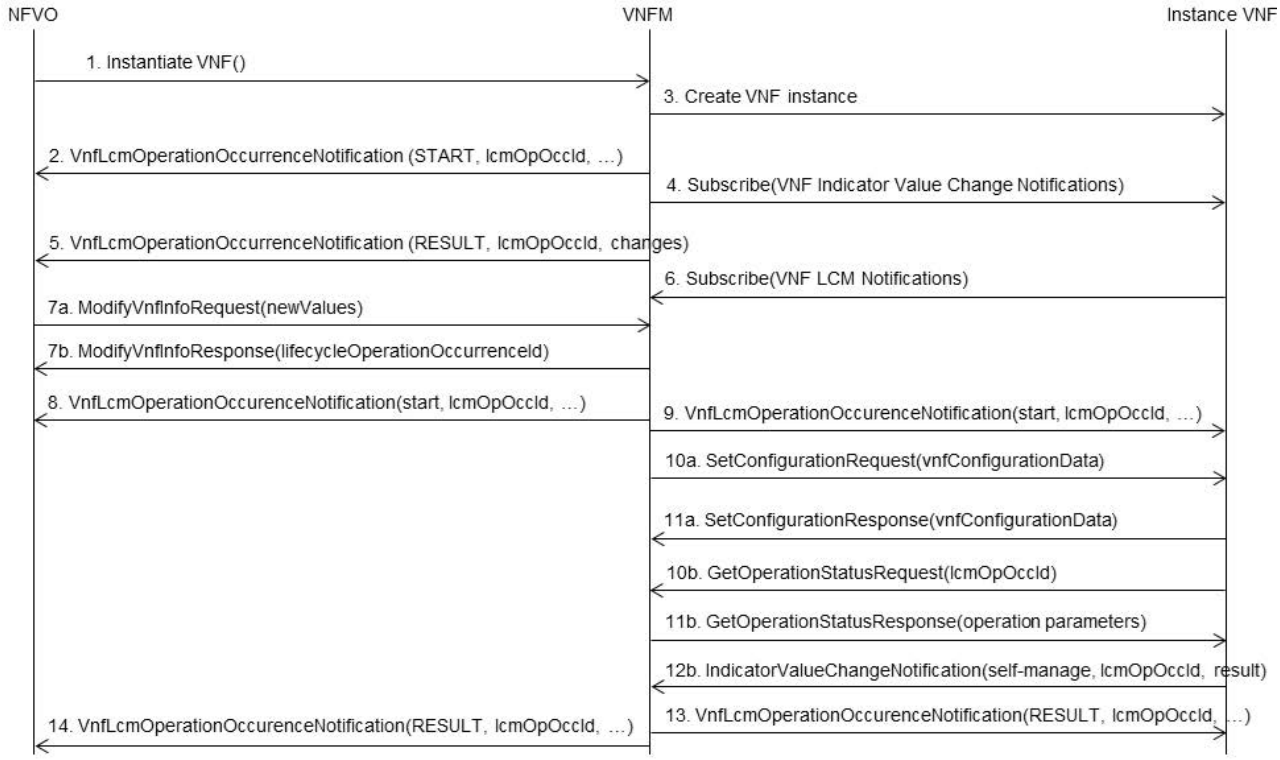

Figure D.1: Change of VNF Configurable Properties

1. NFVO requests VNF instantiation (the trigger for VNF instantiation is out of scope of this flow). The step of VNF identifier creation is omitted for simplicity.

2. VNFM begins the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to NFVO indicating the start of LCM operation, operation ID, etc.

3. VNFM creates the new VNF instance (the interactions between VNFM and VIM are omitted for simplicity).

4. VNFM subscribes for VNF indicator value change notifications.

5. VNFM completes the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to NFVO indicating the result of LCM operation, operation ID, etc.

6. VNF instance subscribes for VNF LCM notifications.

7a. NFVO requests 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 Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

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

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

If VNF Configuration interface, as defined in ETSI GS NFV-IFA 008 [5] clause 6.2, is used:

10a. 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 Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$ in the vnfConfigurationData parameter.

VNF applies configuration:

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

If VNF Configuration interface, as defined in ETSI GS NFV-IFA 008 [5] clause 6.2, is not used and VNF is self-managing, i.e. determines what configuration changes need to be applied and applies them:

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

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

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 Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$ is configured.

12b. VNF sends 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 Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l_{DF\text{-}X}$.

VNFM updates the VnfInfo information element accordingly:

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

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

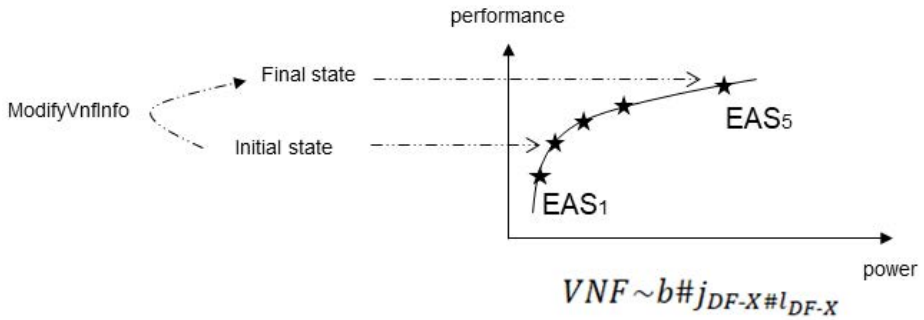

Figure D.2: Change of VNF EAS with the ModifyVnfInfo operation

D.2 Scale to Level of VNF

Figure D.3 illustrates NFVO requesting 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.

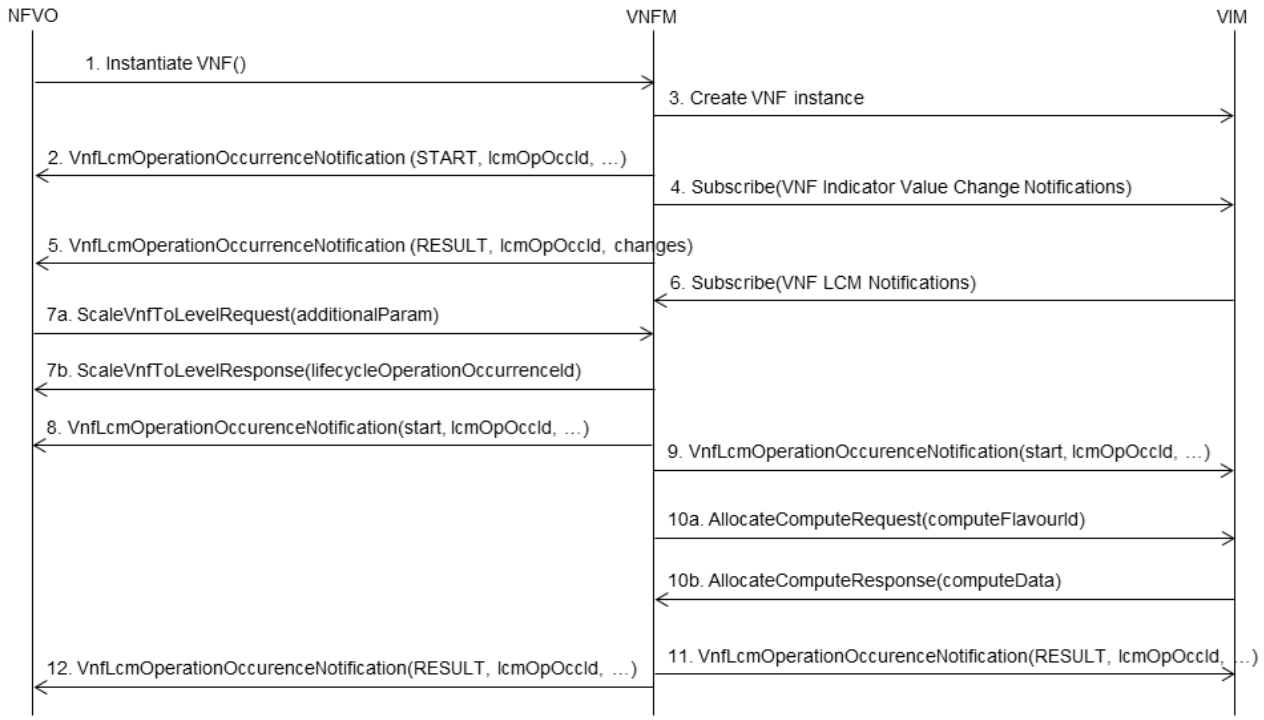

Figure D.3: Scale VNF To Level

1. NFVO requests VNF instantiation (the trigger for VNF instantiation is out of scope of this flow). The step of VNF identifier creation is omitted for simplicity.

2. VNFM begins the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to NFVO indicating the start of LCM operation, operation ID, etc.

3. VNFM creates the new VNF instance (the interactions between VNFM and VIM are omitted for simplicity).

4. VNFM subscribes for VNF indicator value change notifications.

5. VNFM completes the VNF instantiation and sends the VnfLcmOperationOccurrenceNotification to NFVO indicating the result of LCM operation, operation ID, etc.

6. VNF instance subscribes for VNF LCM notifications.

7a. NFVO requests 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 NFVO, should identify the x^{th} EAS of the j^{th} instance of VNF~b deployed according to a given Deployment Flavour, noted $DF\text{-}X$, in a given instantiation level, noted $DF\text{-}X\#l'_{DF\text{-}X}$.

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

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

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

10b. 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 virtualised compute resource.

VNFM updates the VnfInfo information element accordingly:

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

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

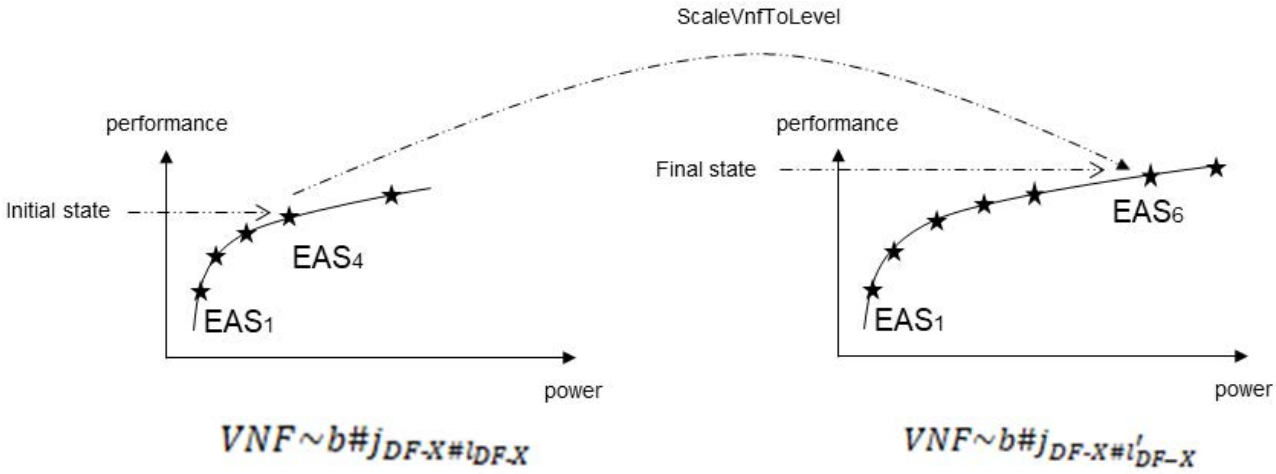

Figure D.4: Change of VNF EAS with the ScaleVnfToLevel operation

History

Document history			
V1.1.0	December 2019	Membership Approval Procedure	MV 20200208: 2019-12-10 to 2020-02-10