ETSI GR NFV-IFA 034 V4.1.1 (2021-10)

Network Functions Virtualisation (NFV) Release 4; Management and Orchestration; Report on Architectural enhancement for VNF License Management support and use of VNF licenses

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Reference
DGR/NFV-IFA034

Keywords
license schemes, management, NFV, VNF

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Sous-Préfecture de Grasse (06) N° w061004871

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Foreword

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

Modal verbs terminology

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

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1 Scope

The present document studies potential enhancements to the architectural framework of NFV-MANO for the VNF license management support and use of VNF licenses. Recommendations for the updates of the existing ETSI NFV-IFA specifications are provided.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

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

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

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

[i.1] ETSI GR NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.2] ISO/IEC 19770-5:2015: "Information technology - IT asset management - Part 5: Overview and vocabulary".

NOTE: Available at https://www.iso.org/standard/68291.html.

[i.3] TM Forum IG1141M R18.0.0 (July 2018): "Onboarding Automation: Metrics and Support".

[i.4] ETSI GR NFV-EVE 010 (V3.1.1) (2017-12): "Network Functions Virtualisation (NFV) Release 3; Licensing Management; Report on License Management for NFV".

[i.5] ETSI GS NFV-IFA 027: "Network Functions Virtualisation (NFV) Release 4; Management and Orchestration; Performance Measurements Specification".

[i.6] ISO/IEC 19770-3:2016: "Information technology - IT asset management - Part 3: Entitlement schema".

[i.7] ETSI GS NFV-IFA 013: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Os-Ma-nfvo reference point - Interface and Information Model Specification".

[i.8] ETSI GS NFV-IFA 011: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; VNF Descriptor and Packaging Specification".

[i.9] ETSI GS NFV-SOL 004: "Network Functions Virtualisation (NFV) Release 3; Protocols and Data Models; VNF Package and PNFD Archive specification".

[i.10] ETSI GS NFV-IFA 008: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".

[i.11] ETSI GS NFV-SOL 005: "Network Functions Virtualisation (NFV) Release 3; Protocols and Data Models; RESTful protocols specification for the Os-Ma-nfvo Reference Point".

[i.12] ETSI GS NFV-SOL 002: "Network Functions Virtualisation (NFV) Release 3; Protocols and Data Models; RESTful protocols specification for the Ve-Vnfm Reference Point".

[i.13] ETSI TS 102 165-1: "CYBER; Methods and protocols; Part 1: Method and pro forma for Threat, Vulnerability, Risk Analysis (TVRA)".

[i.14] ETSI GR NFV-EVE 018: "Network Functions Virtualisation (NFV) Release 5; Evolution and Ecosystem; Report on Multi-tenancy in NFV".

[i.15] ETSI NFV NFVI Platform Capability Registry.

NOTE: Available at http://register.etsi.org/NFV.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GR NFV 003 [i.1] and the following apply:

license terms information: human readable document by which the licensor of the VNF (e.g. VNF provider) describes the terms and conditions for granting the usage of the software to a licensee

product Stock Keeping Unit (product SKU): identification of a particular product that allows it to be tracked for inventory and license entitlement purposes

NOTE 1: The Stock Keeping Unit (SKU) is assigned by the provider of the product, e.g. by the VNF provider in case of a VNF Product. The SKU can identify one instance or group of instances of the product.

NOTE 2: This definition has been specialized from the term "stock keeping unit" as defined in International Standard ISO/IEC 19770-3 [i.6].

VNF license: legal rights to use a VNF in accordance with terms and conditions specified by the VNF licensor

NOTE 1: "Using a VNF" can include: accessing, copying, distributing, installing and executing the VNF software, depending on the license's terms and conditions.

NOTE 2: Specified license terms and conditions can include VNF components' license information if different than the one of the VNF.

NOTE 3: This definition has been specialized from the term "software license" as defined in International Standard ISO/IEC 19770-5 [i.2].

VNF licensee: person or organization granted a license to use a specific VNF

NOTE: This definition has been specialized from the term "software licensee" as defined in International Standard ISO/IEC 19770-5 [i.2].

VNF license entitlement: VNF license use rights as defined through agreements between a VNF licensor and a VNF licensee

NOTE 1: Effective use rights take into account any contracts and all applicable licenses, including full licenses, upgrade licenses and maintenance agreements.

NOTE 2: This definition has been specialized from the term "software entitlement" as defined in International Standard ISO/IEC 19770-5 [i.2].

VNF license entitlement data: VNF license entitlement presented in form of a data structure following a standardized schema

NOTE: The VNF license entitlement data is integrity and authenticity protected by the issuer.

VNF license entitlement enforcement: functionality that ensures that the VNF is used within the bounds of VNF license entitlement agreed between the Service Provider and VNF Provider

VNF license entitlement information: runtime information related to VNF license entitlement

EXAMPLE: Current status of license entitlement rights.

VNF license entitlement right: privilege or benefit granted by a VNF license entitlement

NOTE 1: A VNF license entitlement right can be associated to a quantification value, metrics and limitations (e.g. time limit, location, etc.).

NOTE 2: This definition has been specialized from the term "right" as defined in International Standard ISO/IEC 19770-3 [i.6].

VNF licence entitlement right set: collection of VNF license entitlement right units for a single VNF/VNFC instance to run

VNF license entitlement right unit: unit used for quantifying a VNF license entitlement right

VNF license management: functionality that manages VNF license entitlement and makes the VNF license entitlement information available for use by other functions like VNF license entitlement enforcement functionality, etc.

NOTE: This management includes:

- maintaining a consistent and reliable status of VNF license entitlement information; and
- notifying the need of change or extension of VNF license entitlement.

VNF licensor: person or organization who owns or holds the rights to issue a VNF license for a specific VNF Package

NOTE 1: This entity might or might not create the VNF software.

NOTE 2: This definition has been specialized from the term "software licensor" as defined in International Standard ISO/IEC 19770-5 [i.2].

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GR NFV 003 [i.1] and the following apply:

SKU	Stock Keeping Unit
VNF-LM	VNF License Management
TVRA	Threat and Vulnerability Risk Assessment

4 Concepts on license management

4.1 Introduction

In traditional network deployments, the Network Functions are implemented in specialized hardware appliances. The Network Function providers sell their specific appliances based on an entry fee for the hardware platform and a licensing model for the software. When the demand for functions, capacity, or features increases, the communication service provider upgrades the license or in some case buys new hardware.

New licensing models are anticipated for the NFV environment to fit with the dynamicity, flexibility, scalability and agility characteristics of the NFV system such as usage-based or capacity-based licensing models. It is expected that the NFV system supports various types of licensing models as described in clause 4.2 of the present document, and that NFV-MANO is able to orchestrate and manage VNF instances irrespective of the associated licensing model used.

The potential interaction of the license management entities with NFV-MANO during management and orchestration operations is analysed in the present document. This clause describes license management concepts related to NFV system. Clause 5 gives an analysis on interactions between license management entities and NFV-MANO based on license management concepts and builds the foundation for the support of architectural impact analysis on NFV-MANO described in clause 6.

4.2 VNF license entitlements

4.2.1 Introduction

The concept of licenses in the context of VNFs is based on the relevant standards [i.2], [i.3] and [i.6] in this field as well as ETSI GR NFV-EVE 010 [i.4] on this topic. The present document focuses on proprietary VNF licenses as identified in clause 4.2.3 of [i.4].

Service providers will deploy VNFs from many VNF providers with various VNF license terms and agreements for use. A VNF License Management functionality (VNF-LM) handling different VNF license entitlements from various VNF providers has importance for service providers.

A VNF license entitlement provides information about VNF rights, limits and associated metrics, agreed between the VNF licensor (i.e. the VNF provider) and the VNF licensee (i.e. the service provider) for the usage of the VNF, taking into account the service provider's requirements, e.g. avoid impact on the service continuity.

The VNF license entitlements that the VNF licensor grants to the VNF licensee can evolve over time through transactions between the VNF provider (i.e. the VNF licensor) and the service provider (i.e. VNF licensee) and possibly also other actors. These changes can have different origins, including e.g. deployment or use of the VNF for different purposes (e.g. try, test, production and backup), increasing/decreasing the VNF capacity (e.g. an auto-scaling mechanism to fit the business evolution or development), use of the VNF in other business verticals.

4.2.2 VNF license entitlement data

The VNF license entitlement data describes the terms associated to the license and contains information about VNF entitlements rights, in a format that will be both human-readable and machine-readable. The VNF license entitlement data is integrity and authenticity protected by the issuer.

The VNF license entitlement data exchanged between the VNF licensor and the VNF licensee allows, at least, for:

- Identifying the entitlement itself.
- Identifying the involved parties between which the entitlement is established.
- Identifying the related licensed objects on which the use rights apply.
- Specifying VNF license entitlement rights and optionally their limits and associated metrics defining how the use of the VNF license entitlement's rights are measured.

And furthermore it could contain some other fields such as:

- Identifying any VNF license entitlement keys (e.g. proprietary activation code, serial number and proprietary license string).

NOTE: ISO/IEC 19770-3 [i.6] provides an entitlement schema which allows for a flexible description of VNF license entitlements' rights, limits and metrics.

4.2.3 Licensing models

A licensing model is an implementation method of the license entitlement. A licensing model defines the usage of license entitlement data with associated metrics that are used to measure the actual utilization of the VNF and verify that the VNF is used within the bounds of the license entitlement rights and limits.

The rights, limits and metrics are conveyed in the VNF license entitlement data as explained in clause 4.2.2 to be used by the VNF-LM. In an NFV environment, the entitlement description is expected to be flexible enough to cover any kind of licensing model agreed between the VNF provider and the service provider.

Table 4.2.3-1 describes some licensing models examples commonly used in virtualised environment. In this table, the NFV-MANO involvement column gives an indication of a potential involvement of NFV-MANO in the license management of the corresponding licensing model.

Table 4.2.3-1: VNF licensing model examples

Licensing model	Description	NFV-MANO involvement
Licensing per VNF instances	The VNF license entitlement allows for a fixed maximum number of concurrently running VNF instances.	Notification for VNF LCM operation and NS LCM operation
Subscription licensing model	The VNF license entitlement is only valid for a subscription period (e.g. month or year) and it expires if it is not renewed.	Not involved
Licensing based on capacity	The VNF license entitlement is valid in the bounds of an overall capacity offered by the VNFs One possible capacity could be on the number of subscribers, on the number of packets processed, number of compute/storage and network resources used.	Providing VNF performance measurements associated to virtualised resources usage
Feature-based licensing	The VNF license entitlement enables features in the VNF to be activated by the service provider.	Not involved
Usage-based licensing	The VNF license entitlement allows the service provider to be charged only for what it actually uses. This model is based on usage data that is reported in usage reports. Usage data can be the compute, storage or network resources used, number of packets processed, number of simultaneous active users, etc.	Not involved

4.2.4 VNF license entitlement enforcement

The VNF license entitlement enforcement ensures that the VNF is used within the bounds of VNF license entitlement (rights and limits) agreed between the service provider and VNF provider.

The VNF license entitlement enforcement can rely on:

- An identification of the deployed licensed VNF instances.
- A source of data used for VNF utilization measurement (example of data are: time, NFVI resources, number of VNF instantiations, service provider identification, etc.).
- A measurement of the utilization of the deployed VNF instances in accordance with the related license entitlement metrics.
- A means of verification that the uses are in accordance with acquired rights and limits.

NOTE: Above data listed in the bullet list are to be provided in an unambiguous, reliable and secure (non-falsifiable) manner.

4.3 Actors and their roles

The actors for license management and their role in the license management are given in table 4.3-1.

Table 4.3-1: Actors and roles in license management

Actors	Roles
Service provider (SP)	SP purchases VNF Package and associated license from VNF provider, i.e. the SP plays the role of VNF licensee. SP is responsible for the use of VNF in accordance with the related VNF license entitlements (see note).
VNF provider	VNF provider develops and issues VNF Package and associated license to the SP, i.e. the VNF provider plays the role of VNF licensor. The VNF provider is responsible for granting the license entitlements. The VNF provider can charge the SP for the usage of the VNF according to license agreement.
NOTE: SP in this context can be a network operator, a communication service provider or a client of the communication service provider providing a service on top of the communication network.	

4.4 VNF license management scope in NFV-MANO

This clause describes how the VNF-LM interacts with NFV-MANO entities. These interactions are limited to the consumption by the VNF-LM of information provided by NFV-MANO after a subscription by the VNF-LM to NFV-MANO notifications.

During on-boarding of a VNF Package, the VNF-LM might discover the following:

- if the VNF needs a VNF license entitlement to operate; and
- license terms information included in the VNF Package.

NOTE 1: This information is generic in the sense that it does not contain any deployment and service provider specific information.

For operation of the VNF instances which is covered by a VNF license entitlement, the VNF-LM interacts with NFV-MANO by subscribing to VNF LCM notifications to get information such as:

- the type of VNF LCM operation (e.g. instantiation, scaling and termination);
- the deployment flavour;
- the amount of resources used.

With these information the VNF-LM can:

- Reserve/release a VNF license entitlement right set for the VNF.

NOTE 2: Reservation/releasing is not applicable to all licensing models.

- Report the usage of the VNF license entitlement right for the VNF.
- Report the VNF usage measurement results or information related to metrics associated with VNF licenses:
  - There are two types of VNF usage to be considered:
    - Application-specific usage, e.g. number of simultaneous calls.
    - Resource-specific usage, e.g. number of CPUs, bandwidth, storage capacity and LCM information.

- NFV-MANO is not aware of any measurement results or information related to application-specific usage of VNFs. NFV-MANO can only report measurement results or information based on resource-specific usage metrics. VNF licenses based on application-specific usage metrics are out of scope of the present document.

- Additionally NFV-MANO provides reliable environment information (e.g. timestamps, geolocation, service provider identity, etc.) for the VNF license entitlement enforcement to operate. How this information will be captured is out of scope of the present document.

5 Interactions related to license management

5.1 Introduction

The present document describes the management of the VNF licenses realized by the VNF-LM which acts as NFV-MANO consumer using, as far as possible, existing mechanisms, to minimize impact on NFV-MANO. The VNF-LM is a functionality managing licenses, license entitlement rights and units.

NOTE: The functionality and details of the VNF-LM are not specified in the present document.

The interactions between the VNF-LM and NFV-MANO can be based on the following mechanisms described in ETSI GS NFV-IFA 013 [i.7] and ETSI GS NFV-IFA 008 [i.10] and potentially others:

- The VNF-LM uses notifications from NFV-MANO about VNF Package management and VNF lifecycle management.

- The VNF-LM retrieves VNF specific licensing information from VNF Package(s) as non-MANO artifact(s).

- If VNF provider defined in the VNFD the VNF indicator(s) relevant for licensing situation, NFV-MANO can be notified about changes of VNF indicator(s) values as described in annex C. However, NFV-MANO does not process licensing related notifications, as the semantics of the VNF indicator is not understood by NFV-MANO.

- The VNF-LM can be part of the OSS/BSS or consume Os-Ma-nfvo reference point as described in ETSI GS NFV-IFA 013 [i.7] directly as an authorized entity acting on behalf of the OSS/BSS.

- The VNF-LM can be part of EM or consume Ve-Vnfm-em reference point as described in ETSI GS NFV-IFA 008 [i.10] directly as an authorized entity acting as an EM from the interface consumption point of view.

5.2 VNF license management activities

This clause gives in table 5.2-1, a high level description of the VNF license management activities that could be relevant for interactions between the VNF-LM and NFV-MANO. Described interactions do not assume direct communication between the VNF-LM and NFV-MANO. Table 5.2-1 refers to the following clauses for the further detailed descriptions of the activities.

NOTE: In the table 5.2-1, some VNF license management activities could be optional.

Table 5.2-1: VNF license management activities

LM Activities	Description	Relevant interactions between the VNF-LM and NFV-MANO
Reservation of VNF license entitlement right unit(s)	The VNF-LM reserves a VNF license entitlement right set during VNF lifecycle operation (e.g. instantiation and scaling).	Detailed in clause 5.6: VNF license use in operations of NS and VNF
Allocation of VNF license entitlement right unit(s)	The VNF-LM allocates VNF license entitlement right unit(s), e.g. after a successful VNF instantiation.	Detailed in clause 5.6: VNF license use in operations of NS and VNF
Notification for lack of VNF license entitlement right unit	The VNF-LM notifies lack of VNF license entitlement right unit(s) when a threshold on metrics measurement is crossed.	Detailed in clause 5.6: VNF license use in operations of NS and VNF
Notification for the change of VNF license entitlement	The VNF-LM notifies the change in the VNF license entitlement right unit(s) for the VNF in operation.	Detailed in clause 5.6: VNF license use in operations of NS and VNF
Release of VNF license entitlement right set	The VNF-LM releases of allocated/reserved VNF license entitlement right set triggered by VNF lifecycle operation.	Detailed in clause 5.6: VNF license use in operations of NS and VNF
License management information retrieval	The VNF-LM retrieves the license management related information from the VNF Package.	Detailed in clause 5.3: VNF Packaging and clause 5.4: On boarding VNF and NS
VNF license entitlement on-boarding	On-boarding of VNF license entitlements to the VNF-LM.	Detailed in clause 5.5 Use of VNF License information
VNF license entitlement enforcement during VNF operation	Using information from VNF license entitlement data and measurements, the VNF license entitlement enforcement functionality ensures that the VNF is used within the bounds of VNF license entitlement (rights and limits).	Detailed in the clause 5.7: VNF license enforcement
VNF usage collection	Collecting VNF usage information and making it available.	Detailed in clause 5.8: VNF License usage and event collection
VNF license entitlement usage reporting	Status report of VNF license entitlement usage.	Detailed in clause 5.8: VNF License usage and event collection

5.3 VNF packaging

5.3.1 Introduction

If the VNF is not covered by a VNF license entitlement or if NFV-MANO involvement is not relevant for the license management, the VNF Package contains no information concerning license management. The license information can be provided via another channel outside NFV-MANO, out of scope of the present document.

If the VNF is covered by a VNF license entitlement and if NFV-MANO involvement is relevant for the license management, the VNF Package contains additional license management information listed below:

- License terms information.
- Optional specific information that the VNF-LM might use to check the availability of license entitlement rights for the VNF.

NOTE: This information might be also provided via another channel outside NFV-MANO, out of scope of the present document.

5.3.2 License terms Information

The VNF-LM can retrieve from the VNF Package the license terms information applicable to the VNF.

5.3.3 VNF specific licensing information

This VNF specific licensing information is an optional information that the VNF-LM might use to check the availability of license entitlement rights for the VNF.

At the time of the VNF design, if the VNF provider decides to use licensing that is relative to the VNF LCM for this VNF (e.g. licensing depending on the deployment flavour or scaling steps, or depending on virtualised resources), VNF provider defines the generic licensing structure of a VNF. This might include:

- Granularity of the licensing (e.g. right unit(s) per VNF/per VNFC, etc.)
- Licensing depending on deployment flavours or scaling aspects/steps

That licensing structure might be reflected in the VNF Package as specific licensing information. In this case, this VNF licensing information is specific to the VNF-LM and is opaque to NFV-MANO. This VNF specific licensing information is contained in the VNF Package as a non-MANO artifact and fetched by the VNF-LM after receiving a notification from NFV-MANO about the on-boarding of the VNF Package, as described in clause 5.4.

During LCM operation of a VNF, which is covered by a VNF license entitlement (e.g. instantiation in a specific deployment flavour and scaling of the VNF), NFV-MANO notifies the VNF-LM about the LCM operation on the VNF according to received subscriptions, as described in clause 5.6.

The VNF-LM, using the VNF specific licensing information, checks availability and reserves required VNF license entitlement right unit(s) based on the VNF license entitlement and the LCM operation as described in clause 5.6.

Annex A gives examples of a VNF for which the licensing information depends on deployment flavors and scaling aspects/steps.

The retrieval of the VNF specific licensing information by the VNF-LM during the VNF Package on-boarding to the NFVO is described in clause 5.4.1.

The requirement for this capability to store in the VNF Package, artifacts to be used by functions beyond NFV-MANO is described in ETSI GS NFV-IFA 011 [i.8] as VNF_PACK.DESC 011.

The non-MANO artifact identification and declaration in the VNF Package is described in clause 4.3.7 of ETSI GS NFV-SOL 004 [i.9] and the registration of the non-MANO artifact set identifier in the ETSI NFV registry is described in annex B of ETSI GS NFV-SOL 004 [i.9].

As described above, the VNF specific licensing information is specific to the VNF-LM. If the VNF-LM uses VNF specific licensing information, such information can be fetched from the non-MANO artifact file in the VNF Package. The content of the artifact files can provide information about the applicability of the licensing information to specific VNF(s). To identify such files in the VNF Package, non-MANO artifacts set identifiers can be registered in the ETSI NFV registry. The <specificPart> of the non-MANO artifacts set identifier represents the actual non-MANO artifact set. For private non-MANO artifacts sets, the <specificPart> string is scoped by <registrant>. Provisions for the use of the "Non-MANO artifacts sets registry" and rules for determining the non-MANO artifact set identifier are specified in annex B of ETSI GS NFV-SOL 004 [i.9].

5.4 On-boarding of VNF Package and NSD

5.4.1 Description

On-boarding of an NSD does not need any license management related actions.

On-boarding of a VNF Package can be done without any license verification. However, during VNF Package on-boarding some preparations can be done for subsequent license management actions during LCM operations.

The following example flow shows how NFV Release 4 mechanisms can be used in support of the license management to allow a VNF-LM to verify the availability of necessary license entitlement rights for an LCM operation performed by NFV-MANO.

For this operation, the VNF-LM can be a part of OSS/BSS or consume Os-Ma-nfvo as described in ETSI GS NFV-IFA 013 [i.7] directly as an authorized entity acting on behalf of OSS/BSS.

Configuration and initialization:

1) The VNF-LM obtains information about NFVO(s) and optionally VNFM(s) from the OSS/BSS.

2) The VNF-LM subscribes for notifications of the VNF Package Management interface of the NFVO(s).

   The subscribe operation is described in clause 7.7.7 of ETSI GS NFV-IFA 013 [i.7].

3) The VNF-LM subscribes at all known VNFMs for LCM notifications.

   The subscribe operation is described in clause 7.2.14 of ETSI GS NFV-IFA 008 [i.10].

During on-boarding:

1) The NFVO notifies the VNF-LM of a VNF Package onboarding, as per the VNF-LM's subscription. The notify operation is described in clause 7.7.8 of ETSI GS NFV-IFA 013 [i.7]. The VNF-LM will receive a VnfPackageOnBoardingNotification, which contains the onboardedVnfPkgInfoId and the vnfdId.

2) The VNF-LM retrieves license related information (e.g. license terms and license specific information) from the VNF Package, or from an external source. For the requirement mandating to have the license terms information in the VNF Package see VNF_PACK.DESC.001 and VNF_PACK.DESC.002 in clause 6.2.2 of ETSI GS NFV-IFA 011 [i.8]. For more details on the non-MANO artifacts see VNF_PACK.DESC 011, clause 6.2.2 of ETSI GS NFV-IFA 011 [i.8] and further described in ETSI GS NFV-SOL 004 [i.9], clause 4.3.7.

   For this step, the VNF-LM first queries information about the license artifact path using "Query VNF Package Info" operation of the Os-Ma-nfvo reference point as described in clause 7.7.6 of ETSI GS NFV-IFA 013 [i.7], with the "onboardedVnfPkgInfoId" received in step 4 as filter and using an attribute selector to select information of additional artifacts. The VNF-LM uses the path of the specific artifacts information returned by the previous operation as input of the "Fetch VNF Package Artifacts" operation of the Os-Ma-nfvo reference point as described in clause 7.7.11 of ETSI GS NFV-IFA 013 [i.7] to fetch the license related artifact, if it exists in the VNF Package.

5.5 Use of VNF license information

The VNF license information is used by the VNF-LM to track and make sure that the VNF license usage is compliant to the VNF license agreement. The VNF license information includes:

- VNF license entitlement data (see clause 4.2.2).
- License management information (see clause 5.3.2).
- VNF specific licensing information provided as non-MANO artifact (see clause 5.3.3).
- License terms information in the VNF Package (see clause 6.2.2 of ETSI GS NFV-IFA 011 [i.8]).

For the purpose to track the VNF license usage, the VNF-LM uses notifications as well as measurements collected from NFV-MANO (see clause 5.6). The VNF-LM might collected data about VNF license usage from other sources by means, which are out of scope of the present document.

The VNF license entitlements are used by the VNF-LM, but no interaction with NFV-MANO is needed even for VNF license entitlements on-boarding and is therefore out of scope of the present document.

5.6 VNF license use in operations of NS and VNF

5.6.1 VNFM centric licensing flow

The following example flow shows how NFV Release 4 mechanisms can be used to allow a VNF-LM to verify the availability of necessary license entitlement right unit(s) and reserve them based on interactions with NFV-MANO during LCM operation. It also allows a VNF-LM to allocate license entitlement right unit(s) during the LCM operations.

For this interaction with NFV-MANO, the VNF-LM can be part of EM or consume Ve-Vnfm-em reference point as described in ETSI GS NFV-IFA 008 [i.10] directly as an authorized entity acting as an EM from the interface consumption point of view.

NOTE: The use of Ve-Vnfm-vnf reference point by the VNF-LM is out of scope of the present document.

Only the steps relevant for the licensing are shown:

1) The VNFM is triggered to instantiate a VNF.

2) The VNFM starts to execute the LCM operation.

3) The VNFM sends the "START" VnfLcmOperationOccurrenceNotification to subscribers, including the VNF-LM.

   The notification contains all necessary information about the LCM operation to be executed, see ETSI GS NFV-IFA 008 [i.10], clause 9.5.2.3 or ETSI GS NFV-SOL 002 [i.12], clause 5.5.2.17.

4) The VNF-LM checks the license entitlement right unit(s) needed for the LCM operation and if possible reserves necessary license entitlement right unit(s) for this LCM operation.

NOTE: The VNF provider can define in the VNFD of the VNF a VNF Indicator relevant for licensing situation. Example use of VNF Indicator notifications by VNFM is described in annex C.

5) The VNFM instantiates the VNF.

6) The VNFM notifies completion of an instantiation operation to subscribers, including the VNF-LM via "RESULT" VnfLcmOperationOccurrenceNotification (see clause 9.5.2 in ETSI GS NFV-IFA 008 [i.10] or ETSI GS NFV-SOL 002 [i.12], clause 5.5.2.17).

7) If the notification indicates that the LCM operation was completed successfully, the VNF-LM finally allocates the license entitlement right unit(s). If the LCM operation was not successful, the VNF-LM releases the reservation of license entitlement right unit(s).

5.6.2 NFVO centric licensing flow

In this clause a NFVO centric licensing flow is described that uses existing mechanisms, so to minimize impact on NFV-MANO. Information obtained by the VNF-LM from the NFVO is used by the VNF-LM for the purpose of VNF license management.

The interactions between the VNF-LM and the NFVO are based on notifications and queries, as described in ETSI GS NFV IFA-013 [i.7]. The VNF-LM can be part of the OSS/BSS or consume Os-Ma-nfvo reference point directly as an authorized entity acting on behalf of the OSS/BSS.

The flow showing interactions between the VNF-LM and the NFVO is as following:

1) The VNF-LM subscribes for notifications sent by the NFVO of the VNF Package Management, as described in clause 5.4.1 of the present document.

2) The VNF-LM receives notifications sent by the NFVO about new on-boarded VNF Packages, as described in clause 5.4.1 of the present document.

3) The VNF-LM retrieves VNF license specific information that is contained in VNF Packages as a non-MANO artifacts, if artifacts are included in the VNF Packages, as described in clause 5.4.1 of the present document.

NOTE 1: In line with recommendations provided in ETSI GR NFV-EVE 010 [i.4] regarding the decoupling of license terms from the VNF Package, the non-MANO artifact related to VNF license specific information does not convey VNF license entitlement information (e.g. associated rights and limits).

4) The VNF-LM subscribes with filter for notifications of the NS Lifecycle Management interface exposed by the NFVO. The subscribe operation is described in clause 7.3.11 of ETSI GS NFV-IFA 013 [i.7]. Use of filter allows the VNF-LM to obtain from the NFVO only the information, which is necessary for the VNF-LM for the purpose of VNF license management. The detailed specification of filters is provided in ETSI GS NFV-SOL 005 [i.11].

NOTE 2: Information needed to define filter can be extracted by the VNF-LM from non-MANO artifact or is made available for the VNF-LM by means, which are out of scope of the present document.

5) The NVFO notifies the VNF-LM about LCM operations according to received subscriptions. The notify operation is described in clause 7.3.12 of ETSI GS NFV-IFA 013 [i.7].

6) The VNF-LM can query additional information from the NFVO using Query NS operation of the NS Lifecycle Management interface. The Query NS operation is described in clause 7.3.6 of ETSI GS NFV-IFA 013 [i.7].

The VNF-LM can reserve necessary license entitlement right unit(s) for a VNF(s) impacted by NS LCM operation, if the information obtained from NFV-MANO includes identification of impacted VNF(s) and information about start of VNF LCM operation(s).

The VNF-LM allocates license entitlement right unit(s) for a VNF(s) impacted by NS LCM operation, when NFV-MANO notifies the VNF-LM about completion of VNF LCM operation(s).

5.6.3 Conclusions

This clause proposes several solutions enabling the VNF-LM for the reservation and allocation of license(s) during VNF LCM. Clauses 5.6.1 and 5.6.2 propose example flows which use the existing reference points defined for NFV-MANO and are therefore the preferred solutions.

Clause 5.6.1 uses the Ve-Vnfm-em reference point as described in ETSI GS NFV-IFA 008 [i.10] and ETSI GS NFV-SOL 002 [i.12].

Clause 5.6.2 uses the Os-Ma-nfvo reference point as described in ETSI GS NFV IFA-013 [i.7] and ETSI GS NFV-SOL 005 [i.11].

The VNF-LM using the Os-Ma-nfvo reference point is able to manage license entitlement right unit(s) using NsLcmOperationOccurrenceNotification notifications from NFV-MANO but at NS level only. Using this type of notification on the reference point, the VNF-LM is informed of the VNF affected by the NS LCM operation only at the result of the NS LCM as described in clause B.2. Using this type of notifications, the VNF-LM is only able to allocate license entitlement right unit(s) after the instantiation or the scaling of the NS.

The VNF-LM using the Os-Ma-nfvo reference point, is able to manage license entitlement right unit(s) also using NsChangeNotification notifications to be informed on change on NS instance that directly or indirectly impacts its NS component at the start of the LCM operation or result of LCM operation as described in clause B.3. But the filtering for the subscription for this type of notifications is, at VNF level, restricted to the vnfdId. Therefore the VNF-LM is able to reserve license entitlement right unit(s) at the start of LCM operation and then allocate licenses after the instantiation or the scaling of the NS, but is not able to filter efficiently the notifications for specific VNF instances.

The VNF-LM using the Ve-Vnfm-em reference point is able to manage license entitlement right unit(s) using VNF LCM notifications from NFV-MANO at VNF or VNFC level (e.g. license for a specific feature implemented in a VNFC). The VNF-LM is able to reserve license entitlement right unit(s) at the start of instantiation or scaling, and allocate license entitlement right unit(s) at the finalization of the instantiation or scaling, with a filtering offering additional possibilities as vnfdId, vnfProvider, vnfdVersions.

Therefore depending of the VNF-LM functionality and licensing models used, the VNF-LM can use Os-Ma-nfvo reference point or Ve-Vnfm-em reference point.

5.7 VNF license enforcement

The VNF license enforcement functionality ensures that the VNF is used within the bounds of VNF license entitlement agreed between the Service Provider and VNF Provider, including the various licensing models (e.g. subscription-based, perpetual model, resources-based and usage-based).

The license enforcement functionality includes the following activities:

1) Check that the VNF is used within the constraints and limits specified in the license entitlement on the basis of measurements and notifications relevant for VNF. Measurements and notifications might be provided by NFV-MANO or other sources. The source of measurements is expected to be reliable and trustworthy.

2) Decide on the enforcement actions when usage exceed some limits (e.g. threshold level and maximum value) in compliance with enforcement policies. In the specific case of perpetual license model and if license management is in place, the decision might be that no action is needed. How the VNF license enforcement functionality gets the enforcement policies is out of scope of the present document and no specific interface with NFV-MANO is needed to get the enforcement policies.

3) Initiate appropriate enforcement action.

The VNF license enforcement functionality is provided by entities outside NFV-MANO scope.

5.8 VNF license usage and event collection

The VNF license usage and event collection is an important feature of the VNF-LM. The reporting of VNF license usage and events aggregated by the VNF-LM can be used by the two parties (VNF provider and service provider) as a proof of usage of the VNF. The collection of information and events that are used for VNF license usage and events reporting is expected to be secured.

The types of events and usage information included in the report, depends on the license entitlement information and can be the following but are not limited to:

- LCM events
- Virtualised resource usage
- Measurement information according to metrics (e.g. number of concurrent connections)

The source of events and usage information can be NFV-MANO or other sources outside NFV-MANO including the VNF instance(s).

Each event is logged with its associated timestamp provided by a trusted time source.

The VNF Performance Management interface of Ve-Vnfm-em reference point as described in ETSI GS NFV-IFA 008 [i.10] and ETSI GS NFV-SOL 002 [i.12] is a solution for the VNF-LM to get the VNF/VNFC resource performance measurements from NFV-MANO. The performance measurements provided by the VNFM on this reference point are further described in clause 7.2 of ETSI GS NFV-IFA 027 [i.5].

5.9 Security considerations

5.9.1 Introduction

This clause provides a threat analysis for the VNF-LM functionality. This clause describes only the threats, that can impact NFV-MANO entities, NFVI, VNF(s), so can potentially falsify the license related information collected by the VNF-LM from NFV-MANO.

This threat analysis uses the Threat and Vulnerability Risk Assessment (TVRA) method described in ETSI TS 102 165-1 [i.13].

For the identification of threats, it is essential firstly to know the critical assets of the VNF-LM (clause 5.9.2), consisting of anything that has value for an organization (for business or to fulfil legal obligations) and needs to be protected and secondly to identify the threat agents (clause 5.9.3), the entities that can adversely act on the asset to derive some benefit.

The associated threats for VNF license management are identified in the clause 5.9.4.

5.9.2 VNF license management assets

This clause lists the VNF license management assets, information that is expected to be protected.

VNF license management assets include:

- VNF license management:
  - VNF license entitlements rights
  - VNF license key (optional)
  - Service provider ID
  - VNF LCM events:
    - Event + timestamp
  - VNF usage:
    - Logs + timestamp
  - VNF license usage and events report:
    - Logs + timestamp
- VNF license enforcement:
  - Metrics of interest declared in the VNF entitlement right(s)
  - Limits and constraints
  - Measurement values corresponding to the metrics:
    - Resource usage
    - Geo-location
    - Time

5.9.3 VNF license management threat agents

The threat agents identified for the VNF license management are organizations (VNF provider, service provider, infrastructure manufacturer, infrastructure operator, or other third party organization) or insiders (e.g. employees) that act on behalf of such organizations or on their own interest. The insiders use their knowledge of the NFV system and their legitimate access to the system to mount the attack.

5.9.4 VNF license management threats

Table 5.9.4-1 lists the threats against the VNF license management assets listed in clause 5.9.2, with the associated threat agents and the reference to the associated mitigation recommendations of the clause 5.9.5. The list is not exhaustive.

The threat agents that are capable to mount the attacks are described in clause 5.9.3.

Table 5.9.4-1: List of threats against VNF license management assets

Threat				
Item	**Description of threat**	**Assets concerned**	**Threat Agents**	**Mitigation Id**
VNF-LM.1	Malicious VNF or software in NFVI that gains access to the VNF license entitlement rights storage used by the VNF-LM and modify/falsify the rights/metrics/limits for the usage of the VNF to e.g. gain a perpetual right or extend the entitlement rights to the VNF software, or conversely remove license entitlement rights, or provoke additional requests for new license entitlement rights.	VNF license entitlement rights, metrics, limits and constraints	Service provider; VNF provider; third-party; infrastructure (NFVI) operator employee; infrastructure (NFV-MANO) operator employee	MITIG.1
VNF-LM.2	Injection of concealed software in NFVI that modifies data used for license enforcement (e.g. time, location and resource usage) to e.g. gain a perpetual right or extend the entitlement rights for a VNF or conversely decease license entitlement right or provoke additional requests for new license entitlement rights.	Resource usage, geo-location, time, measurement values, usage report	Service provider; VNF provider; third-party; infrastructure (NFVI) manufacturer; infrastructure (NFVI) operator employee	MITIG.2; MITIG.3; MITIG.4
VNF-LM.3	Malicious software in NFVI that manipulates the service provider identity associated to the VNF and invalidates the license management enforcement process for the licenses locked to this service provider.	Service provider ID	Service provider; VNF provider; third-party; infrastructure (NFVI) operator employee	
VNF-LM.4	Attacker that is able to activate a licensed feature inside one or more VNF.	VNF feature activation key	Service provider; VNF provider; third-party; infrastructure (NFVI) operator employee; infrastructure (NFV-MANO) operator employee	MITIG.5
VNF-LM.5	Injection of concealed software in NFV-MANO that modifies timestamping data of the LCM events in notifications to gain a perpetual right or extend the entitlement rights for a VNF or conversely decease license entitlement right or provoke additional requests for new license entitlement rights.	Timestamp, VNF LCM events, measurement values, logs, usage report	VNF provider; infrastructure (NFV-MANO) operator employee	MITIG.4; MITIG.6
VNF-LM.6	Injection of concealed software in NFV-MANO that modifies information in the VNF LCM notification for the VNF-LM to e.g. gain a perpetual right or extend the entitlement rights for a VNF, or conversely decease license entitlement right, or provoke additional requests for new license entitlement rights.	Measurement values, VNF LCM events, logs, usage report	VNF provider; infrastructure (NFV-MANO) operator employee	MITIG.4
VNF-LM.7	Malicious software that manipulates the service provider identity associated to the VNF and invalidates the license management enforcement process for the licenses locked to this service provider.	Service provider ID	Infrastructure (NFV-MANO) operator employee	

5.9.5 VNF license management mitigations

The following table 5.9.5-1 lists the mitigations for the risks described in the VNF license management threats clause 5.9.4.

Table 5.9.5-1: List of mitigations

Mitigation		
Mitigation Id	**Description of risk mitigation**	**Threats**
MITIG.1	The mitigations by the VNF-LM for VNF license management entitlement rights data are the following: - Isolation protection - Access restriction - Confidentiality protection - Verifiable integrity protection - Notification of malicious access events - Trustable time source	VNF-LM.1
MITIG.2	NFVI and NFV-MANO timestamping is aligned with secure time sources.	VNF-LM.2; VNF-LM5
MITIG.3	Trustable geo-location of the virtual resources used by a VNF instance.	VNF-LM.2
MITIG.4	Resource usage data transmitted over NFV-MANO interfaces is integrity protected.	VNF-LM.2, VNF-LM.6
MITIG.5	The resources used for implementing license enforcement within a VNF are protected.	VNF-LM.4
MITIG.6	Timestamping transmitted over NFV-MANO interfaces is integrity protected.	VNF-LM.5

6 Architectural aspects related to VNF license management

6.1 Overview

According to the study of clause 5, the VNF-LM can interact with NFV-MANO by communicating with the NFVO directly or indirectly, via the Os-Ma-nfvo reference point specified in ETSI GS NFV-IFA 013 [i.7], or by communicating with the VNFM directly or indirectly, via the Ve-Vnfm-em reference point specified in ETSI GS NFV-IFA 008 [i.10].

6.2 Architectural aspects considerations

From architectural perspective, the VNF-LM is the functionality that performs the VNF license lifecycle management. This function is out of the scope of NFV-MANO. The VNF license lifecycle management depends on the licensing model and on the VNF/VNFC lifecycle.

The VNF-LM interacts with NFV-MANO to get information used for this VNF license lifecycle management, for example:

- VNF/VNFC lifecycle management operations (e.g. instantiation, scaling and termination)
- Resource usage
- Time information
- Location information

The current interface specifications over Os-Ma-nfvo and Ve-Vnfm-em reference points can be used by the VNF-LM for purpose of collecting NFV-MANO information useful for VNF licence lifecycle management.

As a result of interactions with NFV-MANO, the different steps of VNF license lifecycle management inside the VNF-LM include:

- Reservation of VNF license entitlement right unit/set
- Release of reservation of VNF license entitlement right unit/set
- Allocation of VNF license entitlement right unit/set
- Release of allocation of VNF license entitlement right unit/set

7 Recommendations related to VNF packaging and NFV-MANO interfaces

7.1 Overview

This clause provides recommendations on the normative specifications related to VNF packaging and NFV-MANO interfaces, according to interaction processes study between the VNF-LM and NFV-MANO in clause 5 and architectural impact analysis in clause 6.

7.2 VNF packaging recommendations

7.2.1 License terms information

7.2.1.1 What has been specified already

The license terms information is introduced in the requirements VNF_PACK.DESC.001 and VNF_PACK.DESC.002 of the clause 6.2.2 of ETSI GS NFV-IFA 011 [i.8].

This license terms information is read by the VNF-LM in the VNF package during on-boarding of the VNF Package as described in clause 5.4.1 of the present document. In ETSI GS NFV-SOL 005 [i.11], in the definition of the VnfPkgInfo data type, it is specified that the license file is considered as an artifact, that is readable using the Fetch VNF Package Artifacts operation over Os-Ma-nfvo reference point.

License terms information is included in the VNF Package licensing information as described in clause 4.3.5 of ETSI GS NFV-SOL 004 [i.9] as an artifact file in the VNF Package. The location of this artifact file is described in the TOSCA.meta file under the keyname ETSI-Entry-Licenses in case the CSAR contains a TOSCA-Metadata directory, otherwise the artifact file is in a directory named "licenses" at the root of the archive as described in clause 4.3.5 of ETSI GS NFV-SOL 004 [i.9].

The TOSCA.meta file and the "licenses" directory allow several licensing information files and their signature to be included in the VNF Package as described in ETSI GS NFV-SOL 004 [i.9].

In ETSI GS NFV-SOL 004 [i.9], it is also specified that *"The license information shall include a single license term for the whole VNF. In addition the license information may also include license terms for each of the VNF Package artifacts if different from the one of the released VNF"*.

7.2.1.2 Recommendations

The following recommendations can be derived according to gap analysis to corresponding VNF packaging specifications in NFV-MANO:

1) The term "License terms information" is neither defined in ETSI GS NFV-IFA 011 [i.8] nor in ETSI GS NFV-SOL 004 [i.9].

Rec-VNF-PACK-LM-001: It is recommended to add the definition of the license terms information to ETSI GR NFV 003 [i.1].

The present document provides a definition that could be used for subsequent specification work.

2) The use of license term information by NFV-MANO is not described.

As the license terms information is human readable, NFV-MANO will not use this information for the management and orchestration of the VNF.

Rec-VNF-PACK-LM-002: It is recommended to add a note in ETSI GS NFV-SOL 004 [i.9] to clarify that NFV-MANO will not use the license term information for the management and orchestration of the VNF.

3) How and where the license terms information for each of the VNF package artifacts are included in the license information is not described in ETSI GS NFV-SOL 004 [i.9]. This is the case for example when a VNFC software image artifact has its own license terms information.

Rec-VNF-PACK-LM-003: It is recommended to add in ETSI GS NFV-SOL 004 [i.9] an example of VNF using some VNFC for which the license terms information is different from the one from the VNF.

4) As described in clause 8 of the present document.

Rec-VNF-PACK-LM-004: It is recommended to update table 6.2.2-1 of ETSI GS NFV-IFA 011 [i.8] and clauses 4.1.2.3 and 4.3.5 of ETSI GS NFV-SOL 004 [i.9] to make the presence of license terms information optional in the VNF Package.

7.2.2 VNF specific licensing information

7.2.2.1 Recommendations

As explained in clause 5.3.1, if the VNF is covered by a VNF license entitlement and NFV-MANO involvement is required for the license management, the VNF Package contains additional license management information.

Rec-VNF-PACK-LM-005: It is recommended that the specific licensing information that the VNF-LM uses to check the availability of license entitlement rights for the VNF, if provided as part of the VNF Package, is defined as a non-MANO artifact.

Rec-VNF-PACK-LM-005-1: It is recommended that this specific licensing information is optional.

Rec-VNF-PACK-LM-005-2: It is recommended that the specific information for the VNF-LM is opaque to NFV-MANO entities.

No gap in VNF packaging specifications is identified for the registration and declaration of the non-MANO artifact in the VNF Package for the VNF specific licensing information, and to allow the VNF-LM to fetch the relevant artifact file.

7.3 NFV-MANO interface recommendations

No gap in NFV-MANO interface operations specifications is identified for the management of license entitlement right unit(s) during the VNF LCM operations over Os-Ma-Nfvo or Ve-Vnfm-em reference points.

8 VNF license information model recommendations

This clause provides recommendations on VNF license information model, according to the study of interactions between the VNF-LM and NFV-MANO in clause 5 and architectural impact analysis in clause 6.

Generally, VNF Package is independent of the license agreement between the VNF provider and the service provider to de-correlate the VNF Package update with the license agreement changes. Therefore it is recommended that the VNF package contains no license entitlement rights information agreed between the VNF provider and the service provider.

It is recommended that the optional VNF specific licensing information (e.g. information giving the licensing structure and product SKU) as described in clause 5.3.3 is contained in a non-MANO artifact of the VNF Package and opaque to NFV-MANO. Therefore the metadata format of the optional information is out of scope of the present document.

The VNF license entitlements are not used by NFV-MANO and therefore the VNF license metadata format is out of scope of the present document.

Based on the above recommendations, the requirements in table 6.2.2-1 of ETSI GS NFV-IFA 011 [i.8] and clauses 4.1.2.3 and 4.3.5 of ETSI GS NFV-SOL 004 [i.9], are expected to be updated to make the VNF license directory inside the VNF Package optional, and if such directory is present, it is expected to only contain a human readable file with licensing terms of agreement.

9 Security recommendations

9.1 Introduction

Recommendations provided in this clause are derived from security analysis in clause 5.9 of the present document.

Some of these recommendations apply to the VNF packaging and are listed in clause 9.2.

Some recommendations apply to NFV-MANO interfaces and are listed in clause 9.3.

Some recommendations are for NFV-MANO functional entities and are listed in clause 9.4.

9.2 VNF packaging security recommendations

No security recommendations are provided for the VNF packaging itself but an informative recommendation for the NFVI Platform Capability Registry as described in [i.15] that centralizes the definitions of infrastructure capabilities enabling to use them in VNF descriptors is concluded.

NOTE: The following recommendation on the NFVI Platform Capability registry is not intended for normative specification purposes, and is just listed below for information.

It is recommended that any additional security NFVI Platform capabilities needed, not yet listed in the NFVI Platform Capability Registry, are submitted to the registry following the NFVI Platform Capability registration procedures.

9.3 Interfaces security recommendations

The following security recommendations related to NFV-MANO interfaces are derived:

Rec-INTER-SEC-LM-001: It is recommended that a requirement of an integrity protection including the timestamping is defined for all VNF LCM operation interfaces and notification interfaces.

9.4 NFV-MANO security recommendations

The following security recommendations related to NFV-MANO functional entities are derived:

Rec-MANO-SEC-LM-001: It is recommended that a requirement of secure timestamping and secure time source is supported in NFV-MANO.

Rec-MANO-SEC-LM-002: It is recommended that a requirement of integrity protection is defined for all resource usage collection in NFV-MANO.

10 Conclusion

In the present document, different activities of the VNF-LM are described and corresponding interactions between the VNF-LM and NFV-MANO are studied.

In clauses 7, 8 and 9, gap analysis and recommendations on VNF packaging, NFV-MANO interfaces, VNF license information model and security to allow or facilitate the above interactions have been provided.

It is acknowledged that ETSI GR NFV-EVE 018 [i.14] studies about the multi-tenancy enhancements to NFV-MANO, which could derive into additional impacts for license management of VNF. Nonetheless, the present document does not provide any specific recommendation regarding multi-tenancy aspects of the VNF-LM.

For the next steps, it is recommended to implement the recommendations provided in clauses 7, 8 and 9 in the corresponding normative specifications.

Annex A:
VNF specific licensing information examples

A.1 Example #1: Licensing based on number of VNF instances

Figure A.1-1 shows an example of a VNF that consists of 2 types of VNFCs, VNFC_A and VNFC_B.

In this example, each running VNF instance needs to have a license entitlement right unit associated to it (represented as the red box in figure A.1-1).

There is only a single deployment flavour and no scaling steps in this example.

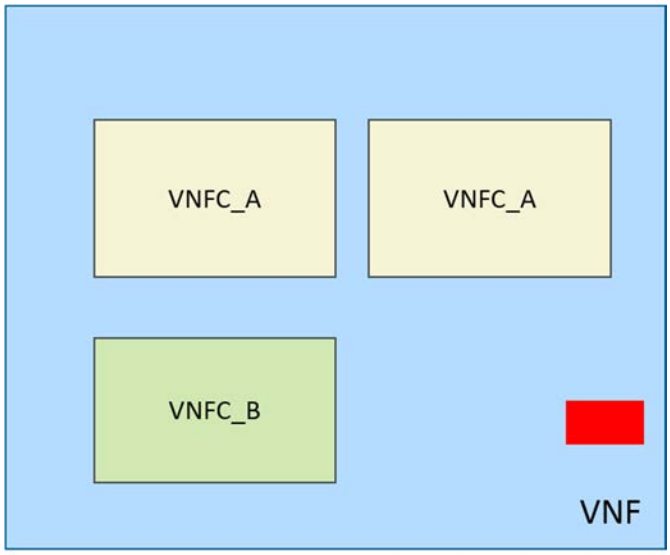

Figure A.1-1: Example of a VNF with licensing based on number of VNF instances

This example assumes that the VNF Package contains some specific licensing information as a non-MANO artifact, which gives the VNF-LM additional information. This information indicates that each VNF instance requires one license entitlement right unit (represented as the red box in figure A.1-1).

This specific licensing information is fetched by the VNF-LM when it receives a notification from NFV-MANO about the on-boarding of the VNF Package.

This example also assumes that the VNF-LM has subscribed to the VNF LCM notifications. When the VNF is instantiated by the VNFM, the VNFM notifies the VNF-LM about this VNF instantiation. With the specific licensing information, the VNF-LM checks the availability of the license entitlement right unit in the license entitlement agreed between the licensor and the licensee, and reserves it accordingly.

Table A.1-1 describes an example of content of the specific licensing information for this VNF.

Table A.1-1: Example of the specific licensing information for a VNF

License Entitlement Right Name	Quantity	Description
VNF_Base_License	1	Base license for the VNF

A.2 Example #2: Licensing based on number of VNFC instances with different deployment flavours

In this example, each running VNFC_B component instance needs to have a license entitlement right unit associated to it (represented as the green box in figure A.2-1).

There are two deployment flavours described in the VNFD of the VNF, one deployment flavour with one VNFC_B and another deployment flavour implementing two VNFC_B components as shown in figure A.2-1.

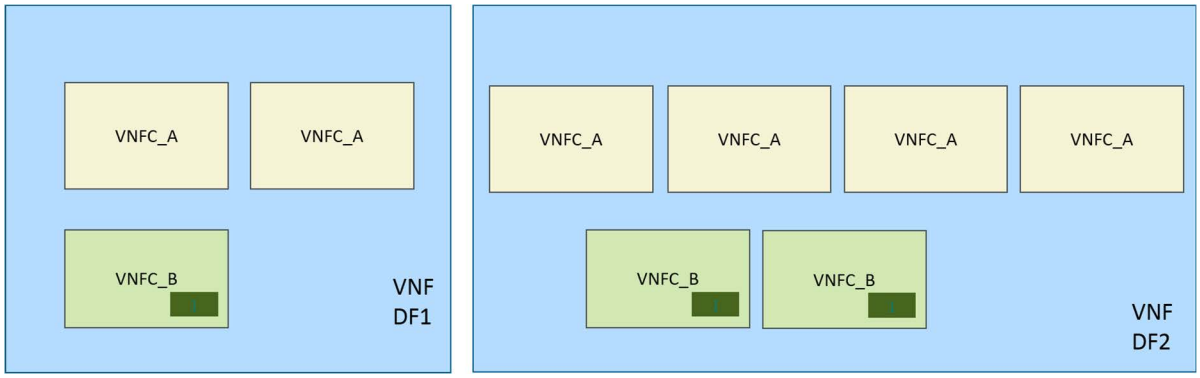

Figure A.2-1: Example of a VNF with licensing based on number of VNFC instances with different deployment flavours

This example assumes that the specific licensing information describes the requirement of 1 license right unit for running a VNFC_B instance for DF1 and 2 license right units for running a VNFC_B instance for DF2.

This specific licensing information is fetched by the VNF-LM when it receives a notification from NFV-MANO about the on-boarding of the VNF Package.

This example also assumes that the VNF-LM has subscribed to the VNF LCM notifications. When the VNF is instantiated by the VNFM in DF1 or DF2, the VNFM notifies the VNF-LM about this VNF instantiation. With the deployment flavour information sent in the notification and the specific licensing information, the VNF-LM checks the availability of the license entitlement right unit in the license entitlement agreed between the licensor and the licensee, and reserves it accordingly.

Table A.2-1 describes an example of content of the specific licensing information for this VNF.

Table A.2-1: Example of the specific licensing information for a VNF in different deployment flavours

Deployment Flavour Number	License Entitlement Right Name	Quantity	Description
1	VNFC_B_License	1	Number of VNF_B instances
2	VNFC_B_License	2	Number of VNF_B instances

Annex B:
Use of NFVO notifications

B.1 Introduction

Clause 5.6.2 of the present document describes an NFVO centric licensing flow, which allows the VNF-LM to obtain from the NFVO necessary information to be used for the purpose of VNF license management. The VNF-LM subscribes with filters to the notifications of NS Lifecycle Management interface exposed by the NFVO.

In this annex, the operation of NS scaling is considered as example for the description. In the following clauses of this annex, two cases are distinguished:

- The NFVO triggers expansion/contraction of an NS when certain conditions are met. This is called NFVO "auto-scaling".
- The NFVO manages the expansion/contraction of an NS instance based on a request from the OSS/BSS.

As part of the NS scaling flows for those two cases, the VNF-LM can receive the following notifications:

- NsLcmOperationOccurrenceNotification (see clause 8.3.2.2 of ETSI GS NFV-IFA 013 [i.7]).
- NsChangeNotification (see clause 8.3.2.11 of ETSI GS NFV-IFA 013 [i.7]).

Details provided in the following clauses are not exhaustive, they are selected for illustration of possible NFVO notifications used by the VNF-LM.

B.2 Use of NsLcmOperationOccurrenceNotification notification

If the VNF-LM has subscribed to receive NsLcmOperationOccurrenceNotification notifications from the NFVO, the following attributes are provided in the notifications sent by the NFVO:

- the identifier of the NS instance affected, i.e. NsId;
- the NS LCM operation type: SCALE (since this example is about NS scaling);
- timeStamp: Date-time of the generation of the notification;
- subscriptionId: identifier of the subscription to the notification;
- notificationStatus: indicates START or RESULT (final or intermediate) of the NS LCM operation occurrence;
- operationState: the state of the NS LCM operation occurrence (PROCESSING, COMPLETED, PARTIALLY_COMPLETED, FAILED_TEMP, FAILED, ROLLING_BACK, ROLLED_BACK);
- affectedVnf (information about the VNF instances affected during the lifecycle operation, only present if the notificationStatus is set to RESULT): For each affected VNF, the following attributes are provided:
    - vnfInstanceId: identifier of the VNF instance;
    - vnfdId: identifier of the VNFD of the VNF instance;
    - vnfName: name of the VNF instance;
    - change Type: INSTANTIATE, TERMINATE, SCALE, CHANGE_FLAVOUR;
    - changeResult: COMPLETED, ROLLED_BACK, FAILED.

On receipt of the notification, the VNF-LM can extract the following information (NS LCM operation type being received indicating SCALE):

- If the notificationStatus is set to START: in this case, no AffectedVnf attribute is provided in the notification, so the VNF-LM cannot relate the notification to particular VNF without additional requests towards the NFVO e.g. using QueryNs operation (see clause B.4).
- If the notificationStatus is set to RESULT (final or intermediate): in this case, AffectedVnf attribute is provided in the notification so the VNF-LM can relate the notification to particular VNF e.g. some entitlement rights units check for each affected VNF (whose VNF descriptor is identified by vnfdId):
  - If changeType is INSTANTIATE: this means that the auto-scaling of the NS leads to the creation of new instance of the VNF (and therefore a new "vnfInstanceId"). For example in case the changeResult for the VNF is set to COMPLETED, the VNF-LM can "reserve" VNF entitlement rights in case the operationState at the NS LCM level indicates an enumerated value (e.g. PROCESSING, PARTIALLY_COMPLETED, ROLLING_BACK) taking note of/registering the timeStamp attribute as well. If the operationState at the NS LCM level indicates COMPLETED, then the VNF-LM can allocate VNF entitlement right units (already reserved or not) for the VNF that has been instantiated.
  - If changeType is TERMINATE: this means that the auto-scaling of the NS has led to the termination of an existing instance of the VNF. For example, in case the changeResult for the VNF is set to COMPLETED, the VNF-LM can keep the allocation of VNF entitlement rights as they are in case the operationState at the NS LCM level indicates PROCESSING or PARTIALLY_COMPLETED, but taking note of/registering the timeStamp attribute. If the operationState at the NS LCM level indicates COMPLETED, then the VNF-LM can free the already allocated VNF entitlement right units for that VNF instance being now terminated.
  - If changeType indicates SCALE or CHANGE_FLAVOUR, then the VNF-LM can request additional information from the NFVO e.g. by using QueryNs operation (see clause B.4).

B.3 Use of NsChangeNotification notification

If the VNF-LM has subscribed to receive NsChangeNotification notifications from the NFVO, the following attributes are provided in the notifications sent by the NFVO (see clause 8.3.2.11 of ETSI GS NFV-IFA 013 [i.7]):

- nsInstanceId: the identifier of the NS instance affected;
- nsComponentType: the type of the impacted NS component: VNF (in this case), PNF or nested NS;
- nsComponentId: identifier of the impacted NS component (vnfInstanceId in case of nsComponentType = VNF);
- lcmOpOccIdImpactingNsComponent: identifier of the lifecycle management operation occurrence impacting the NS component;
- lcmOpOccNameImpactingNsComponent: name of the lifecycle management operation occurrence impacting the NS component. Clause 6.5.4.6 of ETSI GS NFV-SOL 005 [i.11] includes the following values related to VNF as LcmOpNameForChangeNotificationType: VNF_INSTANTIATE, VNF_SCALE, VNF_SCALE_TO_LEVEL, VNF_CHANGE_FLAVOUR, VNF_TERMINATE (not exhaustive list);
- lcmOpOccStatusImpactingNsComponent: status of the lifecycle management operation occurrence impacting the NS component; clause 6.5.4.7 of ETSI GS NFV-SOL 005 [i.11] includes the following values as LcmOpOccStatusForChangeNotificationType: START, COMPLETED, PARTIALLY_COMPLETED, FAILED, ROLLED_BACK;

It should be noted that clause 6.5.2.8 of ETSI GS NFV-SOL 005 [i.11] includes a timeStamp attribute in the NsChangeNotification while not present in ETSI GS-NFV IFA 013 [i.7].

On receipt of the notification, depending on the combination of received LcmOpNameForChangeNotificationType and LcmOpOccStatusForChangeNotificationType, the VNF-LM can potentially take actions regarding the VNF entitlement right units, as proposed in table B.3-1. Certain action can be dependent on the direction of changes: e.g. up in case of extending and down in case of reducing VNF entitlement right units.

Table B.3-1: Potential actions performed on license unit by the VNF-LM

Status of LCM operation /Name of LCM operation	VNF_INSTANTIATE	VNF_SCALE UP/DOWN	VNF_SCALE_TO_LEVEL UP/DOWN	VNF_CHANGE_FLAVOUR UP/DOWN	VNF_TERMINATE
START	Reserve	Reserve/No change	Reserve/No change	Reserve/No change	No change
COMPLETED	Allocate	Allocate/Release	Allocate/Release	Allocate/Release	Release
PARTIALLY COMPLETED	No change	No change	No change	No change	No change
FAILED	Release reservation	Release reservation/No change	Release reservation/No change	Release reservation/No change	No change
ROLLED_BACK	Release reservation	Release reservation/No change	Release reservation/No change	Release reservation/No change	No change
Legend Reserve: The VNF-LM reserves an entitlement right unit for the VNF. Allocate: The VNF-LM allocates the reserved entitlement right unit for the VNF. No change: The VNF-LM keeps as it is the reservation or allocation of the entitlement right unit for the VNF. Release: The VNF-LM releases the allocated entitlement right unit for the VNF. Release reservation: The VNF-LM releases the reservation of the entitlement right unit for the VNF.					

Table B.3-1 is intended only to illustrate the examples of potential actions of the VNF-LM in order to manage VNF entitlement right units and does not impose any functionality of the VNF-LM.

B.4 Use of QueryNs operation

The VNF-LM can use QueryNs operation if the information received in the notifications described in clauses B.2 and B.3 occur not sufficient for license management. In order to manage entitlement rights units related to VNF scaling or entitlement rights units related to VNFCs scaling, the VNF-LM on receipt of NsChange notification (see table B.3-1), can send a QueryNsRequest to the NFVO with a filter defining the NS on which the query applies (e.g. using the NsId received in the NsChange notification or the vnfInstanceId received in the nsComponentId of that notification) (see clause 7.3.6 of ETSI GS NFV-IFA 013 [i.7]).

The VNF-LM will receive a QueryNsResponse that provides as a result an NsInfo (see clause 8.3.3.2 of ETSI GS NFV-IFA 013 [i.7]) matching the input filter, with one or more VnfInfo (see clause 8.3.3.2 of ETSI GS NFV-IFA 013 [i.7]) each carrying the vnfdId and vnfInstanceId (both are mandatory attributes), each of which contains instantiatedVnfInfo (see clause 8.3.3.4 of ETSI GS NFV-IFA 013 [i.7]) which in turns contains one or more vnfcResourceInfo information element(s) (see clause 8.3.3.5 of ETSI GS NFV-IFA 013 [i.7]).

The vnfcResourceInfo information element contains (not exhaustive list):

- vnfcInstanceId attribute allowing to identify the VNFC instance.
- computeResource attribute allowing to reference the VirtualCompute resource of the VNFC instance via the ResourceHandle information element specified in clause 8.3.3.8 of ETSI GS NFV-IFA 013 [i.7].
- storageResource attributes allowing to reference the VirtualStorage resource(s) of the VNFC instance via reference(s) to VirtualStorageResourceInfo information element(s) specified in clause 8.3.3.7 of ETSI GS NFV-IFA 013 [i.7]. Each of the VirtualStorageResourceInfo information elements contains a storageResource attribute allowing to reference a given VirtualStorage resource of the VNFC instance via the ResourceHandle information element (see clause 8.3.3.8 of ETSI GS NFV-IFAf013 [i.7]).
- vnfcCpInfo attributes allowing to provide information about the CPs(s) of the VNFC instance via VnfcCpInfo information specified in clause 8.3.3.23 of ETSI GS NFV-IFA 013 [i.7].

Clause B.5 provides more details on how the resource related information provided by the vnfcResourceInfo information element can be used in case that license terms would include resource related consumption metrics.

B.5 Use of resource related information in QueryNSResponse

In case when some of the license terms for a VNF are based on resource related consumption metrics, the following information available from the details of notifications and queries (as illustrated in clauses B.2, B.3 and B.4) can be obtained by the VNF-LM:

- Compute resources: ResourceHandle contains vimId (Identifier of the VIM under whose control this resource is placed), resourceId (Identifier of the resource in the scope of the VIM or the resource provider), vimLevelResourceType (Type of the resource in the scope of the VIM or the resource provider. The value set of the "vimLevelResourceType" attribute is within the scope of the VIM or the resource provider and can be used as information that complements the ResourceHandle). Combination of those attributes can be used to identify amount or type of compute resources used by the VNF.

- Storage resources: ResourceHandle contains vimId (Identifier of the VIM under whose control this resource is placed), resourceId (Identifier of the resource in the scope of the VIM or the resource provider), vimLevelResourceType (Type of the resource in the scope of the VIM or the resource provider. The value set of the "vimLevelResourceType" attribute is within the scope of the VIM or the resource provider and can be used as information that complements the ResourceHandle). Combination of those attributes can be used to identify amount or type of storage resources used by the VNF.

NOTE: InstantiatedVnfInfo also contains attribute virtualStorageResourceInfo, which identifies (through ResourceHandle) amount or type of storage resources used for the VNF, but not belonging to VNFCs.

- Network resources: Content of VnfcCpInfo can be used to count the number of external connection points of the VNF (if vnfExtCpId is present). InstantiatedVnfInfo contains attribute vnfVirtualLinkResourceInfo, which identifies (through ResourceHandle) amount or type of network resources used for the VNF.

Annex C:
Notifications on VNF licensing situation change

During the runtime of a VNF, the VNF or EM can send "VnfIndicatorValueChangeNotification" messages to notify about VNF indicator value changes. In the present annex, it is described how VNF indicators could be used to notify about various licensing situations (e.g. a future lack of VNF license entitlement right unit when a threshold on metrics measurement is crossed, a lack of license entitlement right unit for the VNF instance), if notification is send by EM.

However, since NFV-MANO does not process the semantics of VNF indicators, this implies that NFV-MANO does not explicitly process licensing related notifications.

This process uses the VNF Indicator interface, an existing mechanism defined in clause 6.3 of ETSI GS NFV-IFA 008 [i.10] and in clause 8 of ETSI GS NFV-SOL 002 [i.12], and assumes that the VNF-LM is a part of EM or acts as an authorized entity as an EM from the interface consumption point of view.

In order to enable this functionality, the VNF provider defines a VNF indicator in the VNFD of the VNF. The "source" attribute value is set to "EM" indicating that the VNF-LM uses the Ve-Vnfm-em reference point.

The VnfIndicator information element is described in clause 7.1.11.2 of ETSI GS NFV-IFA 011 [i.8].

EXAMPLE: An example of "VNF licensing situation" indicator values could be:

- Green = there are license entitlement right units for the VNF instance.
- Orange = a threshold on metrics measurement is crossed.
- Red = no more license entitlement right unit for the VNF instance.

The NFV-MANO (VNFM) subscribes to "VnfIndicatorValueChangeNotification" notifications.

When the indicator value changes, the VNF-LM sends a "VnfIndicatorValueChangeNotification" notification on the Ve-Vnfm-em reference point to the VNFM. The VNFM can further get additional information using Get Indicator Value operation as described in ETSI GS NFV-IFA 008 [i.10].

The VNFM can notify the NFVO on the indicator value changes. Further operations and relevance for licensing situation depend on VNF indicator design.

Annex D:
Use of VNFM notifications

D.1 Introduction

Clause 5.6.1 of the present document describes a VNFM centric licensing flow, which allows the VNF-LM to obtain from the VNFM necessary information to be used for the purpose of VNF license management. The VNF-LM subscribes with filters to the notifications of VNF Lifecycle Management interface exposed by the VNFM.

In this annex, the operation of VNF scaling is considered as example for the description. In the following clauses of this annex, two cases are distinguished:

- The VNFM triggers expansion/contraction of a VNF instance when certain conditions are met. This is called VNFM "auto-scaling".
- The VNFM manages the expansion/contraction of a VNF instance based on a request from the NFVO or from the VNF/EM.

As part of the VNF scaling flows for those two cases, the VNF-LM can receive the following notification:

- VnfLcmOperationOccurrenceNotification (see clause 9.5.2.of ETSI GS NFV-IFA 008 [i.10]).

Details provided in the following clauses are not exhaustive, they are selected for illustration of possible VNFM notifications used by the VNF-LM.

D.2 Use of VnfLcmOperationOccurrenceNotification notification

If the VNF-LM has subscribed to receive VnfLcmOperationOccurrenceNotification notifications from the VNFM, the following attributes are provided in the notifications sent by the VNFM:

- The identifier of the VNF instance affected, i.e. vnfInstanceId.
- The VNF LCM operation: SCALE (since this example is about VNF scaling).
- isAutomaticInvocation: is set to TRUE if this VNF LCM operation occurrence has been triggered by an automated procedure inside the VNFM (i.e. ScaleVnf/ScaleVnfToLevel triggered by auto-scale). This attribute is set to FALSE otherwise.
- timeStamp: date-time of the generation of the notification (see clause 5.5.2.17 of ETSI GS NFV-SOL 002 [i.12]. Not specified in ETSI GS NFV-IFA 008 [i.10]).
- subscriptionId: identifier of the subscription to the notification (see clause 5.5.2.17 of ETSI GS NFV-SOL 002 [i.12]. Not specified in ETSI GS-IFA 008 [i.10]).
- status: indicates START or RESULT (final or intermediate) of the VNF LCM operation occurrence (see clause 5.5.2.17 of ETSI GS NFV-SOL 002 [i.12], which is called notificationStatus).
- operationState: the state of the VNF lifecycle operation occurrence (STARTING, PROCESSING, COMPLETED, FAILED_TEMP, FAILED, ROLLING_BACK, ROLLED_BACK), (see clause 5.5.2.17 in ETSI GS NFV-SOL 002 [i.12]. Not specified in ETSI GS NFV-IFA 008 [i.10]).
- affectedVnfc (information about the VNFC instances affected during the VNF lifecycle operation, only present if the notificationStatus is set to RESULT): For each affected VNFC, the following attributes are provided:
  - vnfcInstanceId: identifier of the VNFC instance;
  - vduId: identifier of the VDU in the VNFD;

- changeType: signals the type of change (ADDED, REMOVED, MODIFIED, TEMPORARY);
- computeResource: reference to the VirtualCompute resource. Detailed information is (for new and modified resources) or has been (for removed resources) available from the VIM;
- metadata: metadata about this resource. The content of this attribute is a copy of the content of the "metadata" attribute of the VnfcResourceInfo information element;
- addedStorageresourceIds: reference(s) to VirtualStorage resource(s) that have been added. Each value refers to a VirtualStorageResourceInfo item in the VnfInfo that was added to the VNFC;
- removedStorageResourceIds: reference(s) to VirtualStorage resource(s) that have been removed. The value contains the identifier of a VirtualStorageResourceInfo item that has been removed from the VNFC, and might no longer exist in the VnfInstance.

- affectedVirtualLink: information about VL instances that were affected during the lifecycle operation. Only present if the notificationStatus is set to RESULT.
- affectedVirtualStorage: information about added, deleted, modified and temporary virtual storage resources during the VNF lifecycle operation. Only present if the notificationStatus is set to RESULT.

On receipt of the notification, the VNF-LM can extract the following information (VNF LCM operation type being received indicating SCALE):

- If the notificationStatus is set to START: in this case, no affectedVnfc attribute is provided in the notification, so the VNF-LM cannot relate the notification to a particular VNFC instance without additional requests towards VNFM e.g. using QueryVnf operation (see clause D.3).
- If the notificationStatus is set to RESULT (final or intermediate): in this case, affectedVnfc attributes are provided in the notification for VNFC instances, that were affected during the execution of the SCALE operation. In this case the VNF-LM can relate the notification to the corresponding VNFCs and identify entitlement rights units relevant for each affected VNFC:
  - If changeType is ADDED: this means that the scaling of the VNF is related to the creation of new instance of the affected VNFC (and therefore a new "vnfcInstanceId" is created). For example, in case the operationState for the VNF LCM operation is set to STARTING, the VNF-LM can reserve VNFC entitlement rights units taking note of the timeStamp attribute as well. If the operationState at the VNF LCM operation is set to COMPLETED, then the VNF-LM can allocate VNFC entitlement right units (already reserved or not) for the VNFC instance that has been added.
  - If changeType is REMOVED: this means that the scaling of the VNF has led to the termination of an existing instance of this affected VNFC. For example, in case the operationState for the VNF LCM operation is set to STARTING, the VNF-LM can keep the allocation of VNFC entitlement rights units as they are, but taking note of the timeStamp attribute as well. If the operationState at the VNF LCM level indicates COMPLETED, then the VNF-LM can free the already allocated VNFC entitlement right units for that VNFC instance being now terminated.
  - If changeType indicates MODIFIED or TEMPORARY, then the VNF-LM can request additional information to be able to take a decision, e.g. from the NFVO using QueryNs operation (see clause B.4).

D.3 Use of QueryVnf operation

The VNF-LM can use QueryVnf operation if the information received in the notifications described in clause D.2 occur not sufficient for license management. In order to manage entitlement rights units related to VNF scaling, the VNF-LM can send a QueryVnfRequest to the VNFM with a filter defining the VNF instances on which the query applies (e.g. using the VnfInstanceId received in the VnfLcmOperationOccurrenceNotification notification) (see clause 9.5.2 of ETSI GS NFV-IFA 008 [i.10]).

The VNF-LM will receive a QueryVnfResponse that provides as a result one or more vnfInfo (see clause 7.2.9.3 of ETSI GS NFV-IFA 008 [i.10]) matching the input filter, with the VnfInfo (see clause 9.4.2 of ETSI GS NFV-IFA 008 [i.10]) each carrying the vnfdId and vnfInstanceId (both are mandatory attributes), and if the VNF instance is in the INSTANTIATED state, an instantiatedVnfInfo attribute (see clause 9.4.3.2 of ETSI GS NFV-IFA 008 [i.10]) which in turns contains one or more vnfcResourceInfo information element(s) (see clause 9.4.4.2 of ETSI GS NFV-IFA 008 [i.10]).

The vnfcResourceInfo information element contains (not exhaustive list):

- vnfcInstanceId attribute allowing to identify the VNFC instance.
- computeResource attribute allowing to reference the VirtualCompute resource of the VNFC instance via the ResourceHandle information element specified in clause 9.4.7 of ETSI GS NFV-IFA 008 [i.10].
- storageResource attributes allowing to reference the VirtualStorage resource(s) of the VNFC instance via reference(s) to VirtualStorageResourceInfo information element(s) specified in clause 9.4.6 in ETSI GS NFV-IFA 008 [i.10]. Each of the VirtualStorageResourceInfo information elements contains a storageResource attribute allowing to reference a given VirtualStorage resource of the VNFC instance via the ResourceHandle information element (see clause 9.4.7 of ETSI GS NFV-IFA 008 [i.10]).
- vnfcCpInfo attributes allowing to provide information about the CPs(s) of the VNFC instance via VnfcCpInfo information specified in clause 9.4.15 of ETSI GS NFV-IFA 008 [i.10].

Clause D.4 provides more details on how the resource related information provided by the vnfcResourceInfo information element can be used in case that license terms would include resource related consumption metrics.

D.4 Use of resource related information in QueryVNFResponse

In case when some of the license terms for a VNF are based on resource related consumption metrics, the following information available from the details of notifications and queries (as illustrated in clauses D.2 and D.3) can be obtained by the VNF-LM:

- Compute resources: ResourceHandle contains vimId (Identifier of the VIM under whose control this resource is placed), resourceId (Identifier of the resource in the scope of the VIM or the resource provider), vimLevelResourceType (Type of the resource in the scope of the VIM or the resource provider. The value set of the "vimLevelResourceType" attribute is within the scope of the VIM or the resource provider and can be used as information that complements the ResourceHandle). Combination of those attributes can be used to identify amount or type of compute resources used by the VNF.
- Storage resources: ResourceHandle contains vimId (Identifier of the VIM under whose control this resource is placed), resourceId (Identifier of the resource in the scope of the VIM or the resource provider), vimLevelResourceType (Type of the resource in the scope of the VIM or the resource provider. The value set of the "vimLevelResourceType" attribute is within the scope of the VIM or the resource provider and can be used as information that complements the ResourceHandle). Combination of those attributes can be used to identify amount or type of storage resources used by the VNF.

NOTE: InstantiatedVnfInfo also contains attribute virtualStorageResourceInfo, which identifies (through ResourceHandle) amount or type of storage resources used for the VNF, but not belonging to VNFCs.

- Network resources: content of VnfcCpInfo can be used to count the number of external connection points of the VNF (if vnfExtCpId is present). InstantiatedVnfInfo contains attribute vnfVirtualLinkResourceInfo, which identifies (through ResourceHandle) amount or type of network resources used for the VNF.

Annex E:
Change History

Date	Version	Information about changes
2018-12-18	V0.0.2	Included the following approved contributions: NFVIFA(18)000925r3 NFVIFA(18)000997r3 NFVIFA(18)0001031r2
2019-02-26	V0.0.3	Included the following approved contributions: NFVIFA(18)000808 NFVIFA(18)000823r2 NFVIFA(19)000098r2 NFVIFA(19)000010r2 NFVIFA(19)000009r4 NFVIFA(19)000011r4
2019-04-02	V0.0.4	Included the following approved contributions: NFVIFA(19)000173r3, NFVIFA(19)000174r3, NFVIFA(19)000175r3, NFVIFA(19)000177r4, NFVIFA(19)000178r4, NFVIFA(19)000249r2, NFVIFA(19)000250r1, NFVIFA(19)000281r1, NFVIFA(19)000176r4 Missed changes of NFVIFA(19)000011r4 included. Editorial changes made by Rapporteur v004.
2019-06-25	V0.0.5	Included the following approved contributions: NFVIFA(19)000316r1, NFVIFA(19)000372, NFVIFA(19)000370r1, NFVIFA(19)000391r3, NFVIFA(19)000536r1, NFVIFA(19)000392r4
2020-02-12	V0.0.6	Included the following approved contributions: NFVIFA(19)000751r3, NFVIFA(19)000952r3, NFVIFA(19)000676r8, NFVIFA(19)000929r6 Editorial changes made by Rapporteur due to addition of new section and changing the lower case of "package" in "VNF package" and "provider" in "VNF provider"
2020-03-05	V0.0.7	Included the following approved contributions from IFA F2F Meeting in the month of Feb, 2020. NFVIFA(19)000750r8, NFVIFA(20)000092r1, NFVIFA(19)000958r4
2020-08-03	V0.0.8	Included the following approved contributions: NFVIFA(20)000217r2, NFVIFA(20)000218r1, NFVIFA(20)000219r1, NFVIFA(20)000220r1, NFVIFA(20)000221r1, NFVIFA(19)000970r5, NFVIFA(20)000237r2
2020-11-30	V0.0.9	Included the following approved contributions: NFVIFA(20)000634r4_IFA034_VNF_license_enforcement NFVIFA(20)000635r5_IFA034_VNF_license_usage_and_event_collection NFVIFA(20)000636r3_IFA034_VNF_Security_considerations_Assets NFVIFA(20)000637r3_IFA034_VNF_Security_considerations_Threats NFVIFA(20)000696r1_IFA034_VNF_Security_considerations_Threat_Agents
2021-01-04	V0.0.10	Included the following approved contributions: NFVIFA(20)000573_IFA034___New_Annex_X_- _Use_of_VNFM_notifications__clause_X_1 NFVIFA(20)000574_IFA034___New_Annex_X_- _clause_X_2_Use_of_VnfLcmOperationOccu NFVIFA(20)000575_IFA034___New_Annex_X_- _clause_X_3_Use_of_QueryVnf_operation NFVIFA(20)000576_IFA034___New_Annex_X_- _clause_X_4_Use_of_resource_related_in
2021-01-20	V0.0.11	Included the following approved contributions: NFVIFA(20)000687r5_IFA034___Clause_5_5___Use_of_VNF_license_informatio n NFVIFA(20)000866r3_IFA034_Architecture
2021-03-10	V0.0.12	Included the following approved contributions: NFVIFA(21)000084r2_IFA034_Security_recommendations NFVIFA(21)000161r1_IFA034_Section_8 NFVIFA(21)000162r1_IFA034_Section_6
2021-04-07	V0.0.13	Included the following approved contributions: NFVIFA(21)000026r7_IFA034_Security_considerations_Mitigations
2021-04-28	V0.0.14	Included the following approved contributions: NFVIFA(21)000296r1_IFA034_License_Terms_Information_definition

Date	Version	Information about changes
		NFVIFA(21)000297r2_IFA034_Section_10_Conclusion_license_terms_info NFVIFA(21)000298r3_IFA034_Section_10_Conclusion_specific_licensing_information NFVIFA(21)000300r2_IFA034_Section_10_Conclusion_LM_during_VNF_LCM NFVIFA(21)000301r1_IFA034_Clarification_on-boarding NFVIFA(21)000319r1_IFA034_VNF_Resource_usage_collection_clarification
2021-05-17	V0.0.15	Included the following approved contribution: NFVIFA(21)000371r2_IFA034_Service_Provider_Identification
2021-06-09	V0.0.16	Included the following approved contribution: NFVIFA(21)000326r3_IFA034_VNF_Product_Identifier_indication
2021-06-16	V0.0.17	Included the following approved contributions: NFVIFA(21)000472_IFA034_deletion_normative_words NFVIFA(21)000473_IFA034_deletion_Editor_s_Notes_1 NFVIFA(21)000474r2_IFA034_deletion_Editor_s_Notes_2 NFVIFA(21)000475r1_IFA034_deletion_Editor_s_Notes_3 NFVIFA(21)000476_IFA034_deletion_Editor_s_Notes_4_5 NFVIFA(21)000477r1_IFA034_deletion_Editor_s_Notes_6 NFVIFA(21)000478r1_IFA034_Clause_5_2_clean-up NFVIFA(21)000479_IFA034_deletion_Editor_s_Notes_7 NFVIFA(21)000480_IFA034_deletion_Editor_s_Notes_8 NFVIFA(21)000481_IFA034_deletion_Editor_s_Notes_9 NFVIFA(21)000482r1_IFA034_deletion_Editor_s_Notes_10
2021-08-25	V0.0.18	Included the following approved contributions: NFVIFA(21)000483_IFA034_deletion_Editor_s_Notes_11 NFVIFA(21)000484_IFA034_deletion_Editor_s_Notes_12 NFVIFA(21)000569r1_IFA034_Review_clause_1__2__3_editorial_clean-up NFVIFA(21)000570_IFA034_Review_clause_4_editorial_clean-up NFVIFA(21)000571r1_IFA034_Review_clause_5_editorial_clean-up NFVIFA(21)000579_IFA034_review_1_Scope NFVIFA(21)000580_IFA034_review_4_2_2_VNF_license_entitlement_data NFVIFA(21)000588r1_IFA034_Review_clause_10_editorial_clean-up NFVIFA(21)000591_IFA034_Review_clause_7_editorial_clean-up NFVIFA(21)000596r3_IFA034_review_5_4_On_boarding_VNF_and_NS NFVIFA(21)000597r1_IFA034_review_5_8_VNF_license_usage_and_event_collection NFVIFA(21)000612r1_IFA034_Section_4_4_consistency NFVIFA(21)000589r2_IFA034_Review_refining_clause_4_and_5_content_to_align_with_ NFVIFA(21)000613r1_IFA034_deletion_of_normative_provisions NFVIFA(21)000614r1_IFA034_Section_5_3_consistency NFVIFA(21)000627r2_IFA034_review_5_6__VNF_License_use_in_operations_of_NS_and_V NFVIFA(21)000628r1_IFA034_review_5_9_Security_considerations NFVIFA(21)000629r1_IFA034_review_5_3_VNF_Packaging NFVIFA(21)000630_IFA034_review_5_2_License_Management_Activities NFVIFA(21)000631r3_IFA034_review_5_1_Introduction_and_Annex_C NFVIFA(21)000636r1_IFA034_Review_clause_8_editorial_clean-up NFVIFA(21)000637r2_IFA034_Review_clause_9_editorial_clean-up NFVIFA(21)000679r2_IFA034_Review_Annex_A_editorial_clean-up NFVIFA(21)000680r1_IFA034_Review_Annex_B_editorial_clean-up NFVIFA(21)000681_IFA034_Review_Annex_D_editorial_clean-up NFVIFA(21)000590r3_IFA034_Review_clause_6_refinement NFVIFA(21)000732_IFA034_review_editorial_cleanup NFVIFA(21)000731r1_IFA034_review_harmonization_for_use_of_Ve-Vnfm-em And some other editorial changes

History

Document history		
V4.1.1	October 2021	Publication