



Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; RESTful protocols specification for the Or-Vnfm Reference Point

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Foreword

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

Modal verbs terminology

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

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1 Scope

The present document specifies a set of RESTful protocols and data models fulfilling the requirements specified in ETSI GS NFV-IFA 007 [1] for the interfaces used over the Or-Vnfm reference point, except for the "Virtualised Resources Management interfaces in indirect mode" as defined in clause 6.4 of ETSI GS NFV-IFA 007 [1].

2 References

2.1 Normative references

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

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

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

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

- [1] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".
- [2] ETSI GS NFV-SOL 004: "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; VNF Package specification".
- [3] IETF RFC 2818: "HTTP Over TLS".
NOTE: Available at <https://tools.ietf.org/html/rfc2818>.
- [4] IETF RFC 3339: "Date and Time on the Internet: Timestamps".
NOTE: Available at <https://tools.ietf.org/html/rfc3339>.
- [5] IETF RFC 3986: "Uniform Resource Identifier (URI): Generic Syntax".
NOTE: Available at <https://tools.ietf.org/html/rfc3986>.
- [6] IETF RFC 4918: "HTTP Extensions for Web Distributed Authoring and Versioning (WebDAV)".
NOTE: Available at <https://tools.ietf.org/html/rfc4918>.
- [7] IETF RFC 5246: "The Transport Layer Security (TLS) Protocol Version 1.2".
NOTE: Available at <https://tools.ietf.org/html/rfc5246>.
- [8] IETF RFC 5646: "Tags for Identifying Languages".
NOTE: Available at <https://tools.ietf.org/html/rfc5646>.
- [9] IETF RFC 6585: "Hypertext Transfer Protocol (HTTP/1.1): Additional HTTP Status Codes".
NOTE: Available at <https://tools.ietf.org/html/rfc6585>.
- [10] IETF RFC 6749: "The OAuth 2.0 Authorization Framework".
NOTE: Available from <https://tools.ietf.org/html/rfc6749>.
- [11] IETF RFC 6750: "The OAuth 2.0 Authorization Framework: Bearer Token Usage".
NOTE: Available from <https://tools.ietf.org/html/rfc6750>.

- [12] IETF RFC 7159: "The JavaScript Object Notation (JSON) Data Interchange Format".
NOTE: Available at <https://tools.ietf.org/html/rfc7159>.
- [13] IETF RFC 7231: "Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content".
NOTE: Available at <https://tools.ietf.org/html/rfc7231>.
- [14] IETF RFC 7232: "Hypertext Transfer Protocol (HTTP/1.1): Conditional Requests".
NOTE: Available at <https://tools.ietf.org/html/rfc7232>.
- [15] IETF RFC 7233: "Hypertext Transfer Protocol (HTTP/1.1): Range Requests".
NOTE: Available at <https://tools.ietf.org/html/rfc7233>.
- [16] IETF RFC 7235: "Hypertext Transfer Protocol (HTTP/1.1): Authentication".
NOTE: Available at <https://tools.ietf.org/html/rfc7235>.
- [17] IETF RFC 7396: "JSON Merge Patch".
NOTE: Available at <https://tools.ietf.org/html/rfc7396>.
- [18] IETF RFC 7617: "The 'Basic' HTTP Authentication Scheme".
NOTE: Available from <https://tools.ietf.org/html/rfc7617>.
- [19] IETF RFC 7807: "Problem Details for HTTP APIs".
NOTE: Available at <https://tools.ietf.org/html/rfc7807>.
- [20] Recommendation ITU-T X. 733: "Information technology - Open Systems Interconnection - Systems Management: Alarm reporting function".

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 GS NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".
- [i.2] ETSI GS NFV-SOL 002: "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; RESTful protocols specification for the Ve-Vnfm Reference Point".
- [i.3] ETSI TS 133 310: "Universal Mobile Telecommunications System (UMTS); LTE; Network Domain Security (NDS); Authentication Framework (AF)".
- [i.4] Hypertext Transfer Protocol (HTTP) Status Code Registry at IANA.
NOTE: Available at <http://www.iana.org/assignments/http-status-codes>.
- [i.5] ETSI NFV registry of VIM-related information.
NOTE: Available at <http://register.etsi.org/NFV/VimConnectionInfo>.
- [i.6] ETSI GS NFV-SOL 001: "Network Functions Virtualisation (NFV) Release 2; Protocols and Data Models; NFV Descriptors based on TOSCA".

[i.7] OpenStack® documentation: "Disk and container formats for images".

NOTE: Available from <http://docs.openstack.org/image-guide/image-formats.html>.

3 Definitions and abbreviations

3.1 Definitions

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

LCM workflow: set of operations, including resource management operations towards the VIM, that are executed by the VNFM to perform a lifecycle management operation

NOTE: Examples for LCM workflows are VNFM-internal procedures associated with an LCM operation, and LCM scripts contained in the VNF package.

3.2 Abbreviations

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

CP	Connection Point
CPD	CP Descriptor
EM	Element Manager
ETSI	European Telecommunications Standards Institute
FM	Fault Management
GMT	Greenwich Mean Time
GS	Group Specification
GUI	Graphical User Interface
HATEOAS	Hypermedia As The Engine Of Application State
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
HTTPS	HTTP Secure
IETF	Internet Engineering Task Force
IFA	Interfaces and Architecture
IP	Internet Protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JSON	JavaScript Object Notation
LCCN	Life Cycle Change Notifications
LCM	Lifecycle Management
MANO	Management and Orchestration
MIME	Multipurpose Internet Mail Extensions
NFV	Network Functions Virtualisation
NFVO	NFV Orchestrator
NS	Network Service
PM	Performance Management
REST	Representational State Transfer
RFC	Request for Comments
TLS	Transport Layer Security
TOSCA	Topology and Orchestration Specification for Cloud Applications
URI	Uniform Resource Identifier
VDU	Virtualisation Deployment Unit
VIM	Virtualised Infrastructure Manager
VL	Virtual Link
VLD	VL Descriptor
VNF	Virtualised Network Function
VNFC	VNF Component

VNFD	VNF Descriptor
VNFM	VNF Manager
YAML	YAML Ain't Markup Language

4 General aspects

4.1 Overview

The present document defines the protocol and data model for the following interfaces used over the Or-Vnfm reference point, in the form of RESTful Application Programming Interface (APIs) specifications:

- VNF Lifecycle Management interface (as produced by the VNFM towards the NFVO).
- VNF Performance Management interface (as produced by the VNFM towards the NFVO).
- VNF Fault Management interface (as produced by the VNFM towards the NFVO).
- VNF Indicator interface (as produced by the VNFM towards the NFVO).
- VNF Lifecycle Operation Granting interface (as produced by the NFVO towards the VNFM).
- VNF Package Management interface (as produced by the NFVO towards the VNFM).
- Virtualised Resources Quota Available Notification interface (as produced by the NFVO towards the VNFM).

The design of the protocol and data model for the above interfaces is based on the information model and requirements defined in ETSI GS NFV-IFA 007 [1]. In clause 4, general aspects such as URI structure and supported content formats, general procedures, common data types and authorization of API requests and notifications are specified.

In the subsequent clauses, the protocol and data model for the individual interfaces are specified. Per interface, the resource structure with associated HTTP methods is defined and applicable flows are provided. Further, the resources and the data model are specified in detail.

Annex A provides the mapping of the combination of resources and methods defined in the present document to the operations defined in ETSI GS NFV-IFA 007 [1]. Annex B contains explanations of key concepts. Annex C defines the structure of the VimConnectionInfo registry.

Even though the different interfaces defined in the present document (apart from the Virtualised Resources Quota Available Notification Interface) are related, implementations shall not assume a particular order of messages that arrive via different interfaces.

4.2 URI structure and supported content formats

This clause specifies the URI prefix and the supported formats applicable to the APIs defined in the present document.

All resource URIs of the APIs shall have the following prefix:

`{apiRoot}/{apiName}/{apiVersion}/`

where:

- | | |
|---------------------------|--|
| <code>{apiRoot}</code> | indicates the scheme ("http" or "https"), the host name and optional port, and an optional prefix path. |
| <code>{apiName}</code> | indicates the interface name in an abbreviated form. The <code>{apiName}</code> of each interface is defined in the clause specifying the corresponding interface. |
| <code>{apiVersion}</code> | indicates the current version of the API and is defined in the clause specifying the corresponding interface. |

For HTTP requests and responses that have a body, the content format JSON (see IETF RFC 7159 [12]) shall be supported. The JSON format shall be signalled by the content type "application/json".

All APIs shall support and use HTTP over TLS (also known as HTTPS) (see IETF RFC 2818 [3]). TLS version 1.2 as defined by IETF RFC 5246 [7] shall be supported.

NOTE 1: The HTTP protocol elements mentioned in the present document originate from the HTTP specification; HTTPS runs the HTTP protocol in a TLS layer. The present document therefore uses the statement above to mention "HTTP request", "HTTP header", etc., without explicitly calling out whether or not these are run over TLS.

NOTE 2: There are a number of best practices and guidelines how to configure and implement TLS 1.2 in a secure manner, as security threats evolve. A detailed specification of those is beyond the scope of the present document; the reader is referred to external documentation such as Annex E of ETSI TS 133 310 [i.3].

All resource URIs of the API shall comply with the URI syntax as defined in IETF RFC 3986 [5]. An implementation that dynamically generates resource URI parts (path segments, query parameter values) shall ensure that these parts only use the character set that is allowed by IETF RFC 3986 [5] for these parts.

NOTE 3: This means that characters which are not part of this allowed set need to be escaped using percent-encoding as defined by IETF RFC 3986 [5].

4.3 Common procedures

4.3.1 Introduction

This clause specifies procedures applicable to all interfaces.

4.3.2 Attribute-based filtering

4.3.2.1 Overview and example (informative)

Attribute-based filtering allows to reduce the number of objects returned by a query operation. Typically, attribute-based filtering is applied to a GET request that reads a resource which represents a list of objects (e.g. child resources). Only those objects that match the filter are returned as part of the resource representation in the payload body of the GET response.

Attribute-based filtering can test a simple (scalar) attribute of the resource representation against a constant value, for instance for equality, inequality, greater or smaller than, etc. Attribute-based filtering is requested by adding a set of URI query parameters, the "attribute-based filtering parameters" or "filter" for short, to a resource URI.

The following example illustrates the principle. Assume a resource "container" with the following objects:

EXAMPLE 1: Objects

```
obj1: {id:123, weight:100, parts:[{id:1, color:red}, {id:2, color:green}]}
obj2: {id:456, weight:500, parts:[{id:3, color:green}, {id:2, color:green}]}
```

A GET request on the "container" resource would deliver the following response:

EXAMPLE 2: Unfiltered GET

```
Request:
GET .../container
```

```
Response:
[
  {id:123, weight:100, parts:[{id:1, color:red}, {id:2, color:green}]},
  {id:456, weight:500, parts:[{id:3, color:green}, {id:2, color:blue}]}
]
```

A GET request with a filter on the "container" resource would deliver the following response:

EXAMPLE 3: GET with filter

```
Request:
GET .../container?weight.eq=100 or GET .../container?weight=100

Response:
[
  {id:123, weight:100, parts:[{id:1, color:red}, {id:2, color:green}]}
]
```

For hierarchically-structured data, filters can also be applied to attributes deeper in the hierarchy. In case of arrays, a filter matches if any of the elements of the array matches. In other words, when applying the filter "parts.color.eq=green" (or "parts.color=green") to the objects in Example 1, the filter matches obj1 when evaluating the second entry in the "parts" array of obj1, and matches obj2 already when evaluating the first entry in the "parts" array of obj2. As the result, both obj1 and obj2 match the filter.

If a filter contains multiple sub-parts that only differ in the leaf attribute (i.e. they share the same attribute prefix), they are evaluated together per array entry when traversing an array. As an example, the filter "parts.color.eq=green"&"parts.id.eq=3" (or "parts.color=green&parts.id=3") would be evaluated together for each entry in the array "parts". As the result, obj2 matches the filter.

4.3.2.2 Specification

A set of filter parameters shall be represented as a part of the URI query string. This means, it shall consist of one or more strings formatted according to "simpleFilterExpr", concatenated using the "&" character:

```
simpleFilterExpr := <attrName>["."<attrName>]*["."<op>]?="<value>["<value>]*
filterExpr      := <simpleFilterExpr>["&"<simpleFilterExpr>]*
op              := "eq" | "neq" | "gt" | "lt" | "gte" | "lte" | "cont" |
                  "ncont"
attrName        := string
value           := scalar value
```

where:

```
* zero or more occurrences
? zero or one occurrence
[] grouping of expressions to be used with ? and *
" quotation marks for marking string constants
<> name separator
```

"AttrName" is the name of one attribute in the data type that defines the representation of the resource. The dot (".") character in "simpleFilterExpr" allows concatenation of <attrName> entries to filter by attributes deeper in the hierarchy of a structured document. "Op" stands for the comparison operator. If the expression has concatenated <attrName> entries, it means that the operator "op" is applied to the attribute addressed by the last <attrName> entry included in the concatenation. All simple filter expressions are combined by the "AND" logical operator.

In a concatenation of <attrName> entries in a <simpleFilterExpr>, the rightmost <attrName> entry is called "leaf attribute". The concatenation of all "attrName" entries except the leaf attribute is called the "attribute prefix". If an attribute referenced in an expression is an array, an object that contains a corresponding array shall be considered to match the expression if any of the elements in the array matches all expressions that have the same attribute prefix.

The leaf attribute of a <simpleFilterExpr> shall not be structured, but shall be of a simple (scalar) type such as String, Number or DateTime, or shall be an array of simple (scalar) attributes. Attempting to apply a filter with a structured leaf attribute shall be rejected with "400 Bad request". A <filterExpr> shall not contain any invalid <simpleFilterExpr> entry.

The operators "op" listed in table 4.3.2.2-1 shall be supported.

Table 4.3.2.2-1: Operators for attribute-based filtering

Operator <op>	Meaning
<attrName>.eq=<value>[,<value>]*	Attribute equal to one of the values in the list
<attrName>=<value>[,<value>]*	Alternative representation of equality. See note
<attrName>.neq=<value>[,<value>]*	Attribute not equal to any of the values in the list
<attrName>.gt=<value>	Attribute greater than <value>
<attrName>.gte=<value>	Attribute greater than or equal to <value>
<attrName>.lt=<value>	Attribute less than <value>
<attrName>.lte=<value>	Attribute less than or equal to <value>
<attrName>.cont=<value>[,<value>]*	Attribute contains (at least) one of the values in the list
<attrName>.ncont=<value>[,<value>]*	Attribute does not contain any of the values in the list
NOTE: This representation shall not be used for attributes whose name is equal to the name of a defined URI query parameter.	

All objects that match the filter shall be returned as response to a GET request that contains a filter.

A <value> entry shall contain a scalar value, such as a number or string. The content of a <value> entry shall be formatted the same way as the representation of the related attribute in the resource representation, for instance as String, Integer, Boolean or DateTime. Attribute-based filters are supported for certain resources. Details are defined in the clauses specifying the actual resources.

4.3.3 Attribute selectors

4.3.3.1 Overview and example (informative)

Certain resource representations can become quite big, in particular, if the resource is a container for multiple sub-resources, or if the resource representation itself contains a deeply-nested structure. In these cases, it can be desired to reduce the amount of data exchanged over the interface and processed by the API consumer application. On the other hand, it can also be desirable that a "drill-deep" for selected parts of the omitted data can be initiated quickly.

An attribute selector allows the API consumer to choose which attributes it wants to be contained in the response. Only attributes that are not required to be present, i.e. those with a lower bound of zero on their cardinality (e.g. 0..1, 0..N) and that are not conditionally mandatory, are allowed to be omitted as part of the selection process. Attributes can be marked for inclusion or exclusion.

If an attribute is omitted, a link to a resource may be added where the information of that attribute can be fetched. Such approach is known as HATEOAS which is a common pattern in REST, and enables drilling down on selected issues without having to repeat a request that may create a potentially big response.

4.3.3.2 Specification

4.3.3.2.1 GET request

The URI query parameters for attribute selection are defined in table 4.3.3.2.1-1.

In the provisions below, "complex attributes" are assumed to be those attributes that are structured, or that are arrays.

Table 4.3.3.2.1-1: Attribute selector parameters

Parameter	Definition
all_fields	This URI query parameter requests that all complex attributes are included in the response, including those suppressed by exclude_default. It is inverse to the "exclude_default" parameter. The API producer shall support this parameter for certain resources. Details are defined in the clauses specifying the actual resources.
fields	This URI query parameter requests that only the listed complex attributes are included in the response. The parameter shall be formatted as a list of attribute names. An attribute name shall either be the name of an attribute, or a path consisting of the names of multiple attributes with parent-child relationship, separated by ".". Attribute names in the list shall be separated by comma (","). Valid attribute names for a particular GET request are the names of all complex attributes in the expected response that have a lower cardinality bound of 0 and that are not conditionally mandatory. The API producer should support this parameter for certain resources. Details are defined in the clauses specifying the actual resources.
exclude_fields	This URI query parameter requests that the listed complex attributes are excluded from the response. For the format, eligible attributes and support by the API producer, the provisions defined for the "fields" parameter shall apply.
exclude_default	Presence of this URI query parameter requests that a default set of complex attributes shall be excluded from the response. The default set is defined per resource in the present document. Not every resource will necessarily have such a default set. Only complex attributes with a lower cardinality bound of zero that are not conditionally mandatory can be included in the set. The API producer shall support this parameter for certain resources. Details are defined in the clauses specifying the actual resources. This parameter is a flag, i.e. it has no value. If a resource supports attribute selectors and none of the attribute selector parameters is specified in a GET request, the "exclude_default" parameter shall be assumed as the default.

4.3.3.2.2 GET response

Table 4.3.3.2.2-1 defines the valid parameter combinations in a GET request and their effect on the GET response.

Table 4.3.3.2.2-1: Valid combinations of attribute selector parameters

Parameter combination	The GET response shall include...
(none)	... same as "exclude_default".
all_fields	... all attributes.
fields=<list>	... all attributes except all complex attributes with minimum cardinality of zero that are not conditionally mandatory, and that are not provided in <list>.
exclude_fields=<list>	... all attributes except those complex attributes with a minimum cardinality of zero that are not conditionally mandatory, and that are provided in <list>.
exclude_default	... all attributes except those complex attributes with a minimum cardinality of zero that are not conditionally mandatory, and that are part of the "default exclude set" defined in the present specification for the particular resource.
exclude_default and fields=<list>	... all attributes except those complex attributes with a minimum cardinality of zero that are not conditionally mandatory and that are part of the "default exclude set" defined in the present specification for the particular resource, but that are not part of <list>.

If complex attributes were omitted in a GET response, the response may contain a number of links that allow to obtain directly the content of the omitted attributes. Such links shall be embedded into a structure named "_links" at the same level as the omitted attribute. That structure shall contain one entry for each link, named as the omitted attribute, and containing an "href" attribute that contains the URI of a resource that can be read with GET to obtain the content of the omitted attribute. A link shall not be present if the attribute is not present in the underlying resource representation. The resource URI structure of such links is not standardized, but may be chosen by the VNF implementation. Performing a GET request on such a link shall return a representation that contains the content of the omitted attribute.

EXAMPLE:

```
"_links" : {
  "vnfcs" : {"href" : ".../vnflcm/v1/vnf_instances/1234/vnfcs"},
  "extVirtualLinks" : {"href" : ".../vnflcm/v1/_dynamic/7d6bef4e-d86b-4abc-97ed-9dc9b951f206"}
}
```

4.3.4 Usage of HTTP header fields

4.3.4.1 Introduction

HTTP headers are components of the header section of the HTTP request and response messages. They contain the information about the server/client and metadata of the transaction. The use of HTTP header fields shall comply with the provisions defined for those header fields in the specifications referenced from tables 4.3.4.2-1 and 4.3.4.3-1. The following clauses describe the HTTP header fields that are explicitly mentioned in the present document.

4.3.4.2 Request header fields

This clause describes the usage of HTTP header fields of the request messages applicable to the APIs defined in the present document. The HTTP header fields used in the request messages are specified in table 4.3.4.2-1.

Table 4.3.4.2-1: Header fields supported in the request message

Header field name	Reference	Example	Descriptions
Accept	IETF RFC 7231 [13]	application/json	Content-Types that are acceptable for the response. This header field shall be present if the response is expected to have a non-empty message body.
Content-Type	IETF RFC 7231 [13]	application/json	The MIME type of the body of the request. This header field shall be present if the request has a non-empty message body.
Authorization	IETF RFC 7235 [16]	Bearer mF_9.B5f-4.1JqM	The authorization token for the request. Details are specified in clause 4.5.3.
Range	IETF RFC 7233 [15]	1000-2000	Requested range of bytes from a file.

4.3.4.3 Response header fields

This clause describes the usage of HTTP header fields of the response messages applicable to the APIs defined in the present document. The HTTP header fields used in the response messages are specified in table 4.3.4.3-1.

Table 4.3.4.3-1: Header fields supported in the response message

Header field name	Reference	Example	Descriptions
Content-Type	IETF RFC 7231 [13]	application/json	The MIME type of the body of the response. This header field shall be present if the response has a non-empty message body.
Location	IETF RFC 7231 [13]	http://www.example.com/vnflcm/v1/vnf_instances/123	Used in redirection, or when a new resource has been created. This header field shall be present if the response status code is 201 or 3xx. In the present document this header field is also used if the response status code is 202 and a new resource was created.
WWW-Authenticate	IETF RFC 7235 [16]	Bearer realm="example"	Challenge if the corresponding HTTP request has not provided authorization, or error details if the corresponding HTTP request has provided an invalid authorization token.
Accept-Ranges	IETF RFC 7233 [15]	bytes	Used by the server to signal whether or not it supports ranges for certain resources.
Content-Range	IETF RFC 7233 [15]	bytes 21 010 - 47 021/47 022	Signals the byte range that is contained in the response, and the total length of the file.
Retry-After	IETF RFC 7231 [13]	Fri, 31 Dec 1999 23:59:59 GMT or 120	Used to indicate how long the user agent ought to wait before making a follow-up request. It can be used with 503 responses. The value of this field can be an HTTP-date or a number of seconds to delay after the response is received.

4.3.5 Error reporting

4.3.5.1 Introduction

In RESTful interfaces, application errors are mapped to HTTP errors. Since HTTP error information is typically not enough to discover the root cause of the error, there is the need to deliver additional application specific error information. The following clauses define such a mechanism to be used by the interfaces specified in the present document.

4.3.5.2 General mechanism

When an error occurs that prevents the API producer from successfully fulfilling the request, the HTTP response shall include in the response a status code in the range 400..499 (client error) or 500..599 (server error) as defined by the HTTP specification (see IETF RFC 7231 [13], IETF RFC 7232 [14], IETF RFC 7233 [15] and IETF RFC 7235 [16], as well as by IETF RFC 6585 [9]). In addition, the response body should contain a JSON representation of a "ProblemDetails" data structure according to IETF RFC 7807 [19] that provides additional details of the error. In that case, as defined by IETF RFC 7807 [19], the "Content-Type" HTTP header shall be set to "application/problem+json".

4.3.5.3 Type: ProblemDetails

The definition of the general "ProblemDetails" data structure from IETF RFC 7807 [19] is reproduced in table 4.3.5.3-1. Compared to the general framework defined in IETF RFC 7807 [19], the "status" and "detail" attributes are mandated to be included by the present document, to ensure that the response contains additional textual information about an error. IETF RFC 7807 [19] foresees extensibility of the "ProblemDetails" type. It is possible that particular APIs in the present document, or particular implementations, define extensions to define additional attributes that provide more information about the error.

The description column only provides some explanation of the meaning to facilitate understanding of the design. For a full description, see IETF RFC 7807 [19].

Table 4.3.5.3-1: Definition of the ProblemDetails data type

Attribute name	Data type	Cardinality	Description
type	URI	0..1	A URI reference according to IETF RFC 3986 [5] that identifies the problem type. It is encouraged that the URI provides human-readable documentation for the problem (e.g. using HTML) when dereferenced. When this member is not present, its value is assumed to be "about:blank".
title	String	0..1	A short, human-readable summary of the problem type. It should not change from occurrence to occurrence of the problem, except for purposes of localization. If type is given and other than "about:blank", this attribute shall also be provided.
status	Integer	1	The HTTP status code for this occurrence of the problem.
detail	String	1	A human-readable explanation specific to this occurrence of the problem.
instance	URI	0..1	A URI reference that identifies the specific occurrence of the problem. It may yield further information if dereferenced.
(additional attributes)	Not specified.	0..N	Any number of additional attributes, as defined in a specification or by an implementation.
NOTE:	It is expected that the minimum set of information returned in ProblemDetails consists of "status" and "detail". For the definition of specific "type" values as well as extension attributes by implementations, guidance can be found in IETF RFC 7807 [19].		

4.3.5.4 Common error situations

The following common error situations are applicable on all REST resources and related HTTP methods specified in the present document, and shall be handled as defined in the present clause.

400 Bad Request: If the request is malformed or syntactically incorrect (e.g. if the request URI contains incorrect query parameters or a syntactically incorrect payload body), the API producer shall respond with this response code. The "ProblemDetails" structure shall be provided, and should include in the "detail" attribute more information about the source of the problem.

400 Bad request: If the request contains a malformed access token, the API producer should respond with this response. The details of the error shall be returned in the WWW-Authenticate HTTP header, as defined in IETF RFC 6750 [11] and IETF RFC 7235 [16]. The ProblemDetails structure may be provided.

400 Bad Request: If there is an application error related to the client's input that cannot be easily mapped to any other HTTP response code ("catch all error"), the API producer shall respond with this response code. The "ProblemDetails" structure shall be provided, and shall include in the "detail" attribute more information about the source of the problem.

NOTE 1: It is by design to represent this application error situation with the same HTTP error response code as the previous one.

- 401 Unauthorized:** If the request contains no access token even though one is required, or if the request contains an authorization token that is invalid (e.g. expired or revoked), the API producer should respond with this response. The details of the error shall be returned in the WWW-Authenticate HTTP header, as defined in IETF RFC 6750 [11] and IETF RFC 7235 [16]. The ProblemDetails structure may be provided.
- 403 Forbidden:** If the API consumer is not allowed to perform a particular request to a particular resource, the API producer shall respond with this response code. The "ProblemDetails" structure shall be provided. It should include in the "detail" attribute information about the source of the problem, and may indicate how to solve it.
- 404 Not Found:** If the API producer did not find a current representation for the resource addressed by the URI passed in the request, or is not willing to disclose that one exists, it shall respond with this response code. The "ProblemDetails" structure may be provided, including in the "detail" attribute information about the source of the problem, e.g. a wrong resource URI variable.
- 405 Method Not Allowed:** If a particular HTTP method is not supported for a particular resource, the API producer shall respond with this response code. The "ProblemDetails" structure may be omitted in that case.
- 406 Not Acceptable:** If the "Accept" HTTP header does not contain at least one name of a content type that is acceptable to the API producer, the API producer shall respond with this response code. The "ProblemDetails" structure may be omitted in that case.
- 422 Unprocessable Entity:** If the payload body of a request contains syntactically correct data (e.g. well-formed JSON) but the data cannot be processed (e.g. because it fails validation against a schema), the API producer shall respond with this response code. The "ProblemDetails" structure shall be provided, and should include in the "detail" attribute more information about the source of the problem.

NOTE 2: This error response code is only applicable for methods that have a request body.

- 500 Internal Server Error:** If there is an application error not related to the client's input that cannot be easily mapped to any other HTTP response code ("catch all error"), the API producer shall respond with this response code. The "ProblemDetails" structure shall be provided, and shall include in the "detail" attribute more information about the source of the problem.
- 503 Service Unavailable:** If the API producer encounters an internal overload situation of itself or of a system it relies on, it should respond with this response code, following the provisions in IETF RFC 7231 [13] for the use of the "Retry-After" HTTP header and for the alternative to refuse the connection. The "ProblemDetails" structure may be omitted.

NOTE 3: The error handling defined above only applies to REST resources defined in the present document. For the token endpoint defined in IETF RFC 6749 [10] and re-used in the present document as defined in clause 4.5.3, the error handling provisions are defined in clause 4.5.3.

4.3.5.5 Overview of HTTP error status codes

Table 4.3.5.5-1 lists the HTTP error status codes that are explicitly mentioned in the present document. The full definition of each error code can be obtained from the referenced specification.

Table 4.3.5.5-1: HTTP error status codes used in the present document

Code	Status text	Reference	Explanation
400	Bad Request	IETF RFC 7231 [13] IETF RFC 6750 [11] IETF RFC 7235 [16]	Required information for the request was missing, the request had syntactical errors, or the request contains a malformed access token or malformed credentials. In the present document, this code is also used as "catch-all" code for client errors.
401	Unauthorized	IETF RFC 7235 [16]	Client is required to include valid credentials in the request. See clause 4.5.3.
403	Forbidden	IETF RFC 7231 [13]	The client is not allowed to perform the request on that resource.
404	Not Found	IETF RFC 7231 [13]	The requested URI was not found. A reason can e.g. be that resource URI variables were set wrongly.
405	Method Not Allowed	IETF RFC 7231 [13]	See clause 4.3.5.4.
406	Not Acceptable	IETF RFC 7231 [13]	See clause 4.3.5.4.
409	Conflict	IETF RFC 7231 [13]	Another request is in progress that prohibits the fulfilment of the current request, or the current resource state is inconsistent with the request.
412	Precondition Failed	IETF RFC 7232 [14]	This code is used in conjunction with conditional requests (typically used to protect resources consistency when using PUT or PATCH in a multi-client scenario) to indicate that a precondition has failed.
416	Range Not Satisfiable	IETF RFC 7233 [15]	This code is returned if the requested byte range in the Range HTTP header is not present in the requested resource.
422	Unprocessable Entity	IETF RFC 4918 [6]	The server understands the content type of the request entity and the syntax of the request entity is correct but was unable to process the contained instructions.
500	Internal Server Error	IETF RFC 7231 [13]	Server is unable to process the request. Retrying the same request later might eventually succeed. In the present document, this code is also used as "catch-all" code for server errors.
503	Service Unavailable	IETF RFC 7231 [13]	Server is unable to process the request due to internal overload.

In general, error response codes used for application errors should be mapped to the most similar HTTP error status code. If no such code is applicable, one of the codes 400 (Bad Request, for client errors) or 500 (Internal Server Error, for server errors) should be used. Implementations may use additional error response codes on top of the ones listed in table 4.3.5.5-1, as long as they are valid HTTP response codes; and should include a ProblemDetails structure in the payload body as defined in clause 4.3.5.2. A list of all valid HTTP response codes and their specification documents can be obtained from the HTTP status code registry [i.4].

4.4 Common data types

4.4.1 Structured data types

4.4.1.1 Introduction

This clause defines data structures that are referenced from data structures in multiple interfaces.

4.4.1.2 Type: Object

An object contains structured data, and shall comply with the provisions of clause 4 of IETF RFC 7159 [12].

4.4.1.3 Type: Link

This type represents a link to a resource. It shall comply with the provisions defined in table 4.4.1.3-1.

Table 4.4.1.3-1: Definition of the Link data type

Attribute name	Data type	Cardinality	Description
href	Uri	1	URI of the referenced resource

4.4.1.4 Type: KeyValuePairs

This type represents a list of key-value pairs. The order of the pairs in the list is not significant. In JSON, a set of key-value pairs is represented as an object. It shall comply with the provisions defined in clause 4 of IETF RFC 7159 [12]. In the following example, a list of key-value pairs with four keys ("aString", "aNumber", "anArray" and "anObject") is provided to illustrate that the values associated with different keys can be of different type.

EXAMPLE:

```
{
  "aString" : "ETSI NFV SOL",
  "aNumber" : 0.03,
  "anArray" : [1,2,3],
  "anObject" : {"organization" : "ETSI", "isg" : "NFV", "workingGroup" : "SOL"}
}
```

4.4.1.5 Type: VnfInstanceSubscriptionFilter

This type represents subscription filter criteria to match VNF instances. It shall comply with the provisions defined in table 4.4.1.5-1.

Table 4.4.1.5-1: Definition of the VnfInstanceSubscriptionFilter data type

Attribute name	Data type	Cardinality	Description
vnfdIds	Identifier	0..N	If present, match VNF instances that were created based on a VNFD identified by one of the vnfdIds values listed in this attribute. See note 1.
vnfProductsFromProviders	Structure (inlined)	0..N	If present, match VNF instances that belong to VNF products from certain providers. See note 1.
>vnfProvider	String	1	Name of the VNF provider to match.
>vnfProducts	Structure (inlined)	0..N	If present, match VNF instances that belong to VNF products with certain product names, from one particular provider.
>>vnfProductName	String	1	Name of the VNF product to match.
>>versions	Structure (inlined)	0..N	If present, match VNF instances that belong to VNF products with certain versions and a certain product name, from one particular provider.
>>>vnfSoftwareVersions	Version	1	Software version to match.
>>>vnfdVersions	Version	0..N	If present, match VNF instances that belong to VNF products with certain VNFD versions, a certain software version and a certain product name, from one particular provider.
vnfInstanceIds	Identifier	0..N	If present, match VNF instances with an instance identifier listed in this attribute. See note 2.
vnfInstanceNames	String	0..N	If present, match VNF instances with a VNF Instance Name listed in this attribute. See note 2.
NOTE 1: The attributes "vnfdIds" and "vnfProductsFromProviders" are alternatives to reference to VNF instances that are based on certain VNFDs in a filter. They should not be used both in the same filter instance, but one alternative should be chosen.			
NOTE 2: The attributes "vnfInstanceIds" and "vnfInstanceNames" are alternatives to reference to particular VNF Instances in a filter. They should not be used both in the same filter instance, but one alternative should be chosen.			

4.4.1.6 Type: VimConnectionInfo

This type represents parameters needed to connect to a VIM for managing the resources of a VNF instance. It shall comply with the provisions defined in table 4.4.1.6-1.

This structure is used to convey VIM-related parameters over the Or-Vnfm interface. Additional parameters for a VIM may be configured into the VNFM by means outside the scope of the present document, and bound to the identifier of that VIM.

Table 4.4.1.6-1: Definition of the VimConnectionInfo data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	The identifier of the VIM Connection. This identifier is managed by the NFVO.
vimId	Identifier	0..1	The identifier of the VIM instance. This identifier is managed by the NFVO. Shall be present to address additional information about the VIM if such information has been configured into the VNFM by means outside the scope of the present document, and should be absent otherwise.
vimType	String	1	Discriminator for the different types of the VIM information. The value of this attribute determines the structure of the "interfaceInfo" and "accessInfo" attributes, based on the type of the VIM. The set of permitted values is expected to change over time as new types or versions of VIMs become available. The ETSI NFV registry of VIM-related information [i.5] provides access to information about VimConnectionInfo definitions for various VIM types. The structure of the registry is defined in Annex C.
interfaceInfo	KeyValuePairs	0..1	Information about the interface or interfaces to the VIM, if applicable, such as the URI of an interface endpoint to communicate with the VIM. The applicable keys are dependent on the content of vimType. Alternatively, such information may have been configured into the VNFM and bound to the vimId.
accessInfo	KeyValuePairs	0..1	Authentication credentials for accessing the VIM, and other access-related information such as tenants or infrastructure resource groups (see note). The applicable keys are dependent on the content of vimType. If the VimConnectionInfo structure is part of an HTTP response payload body, sensitive attributes that are children of this attributes (such as passwords) shall not be included.
extra	KeyValuePairs	0..1	VIM type specific additional information. The applicable structure, and whether or not this attribute is available, is dependent on the content of vimType.
NOTE: If applicable, this attribute also provides information about the resourceGroupIds that are accessible using a particular set of credentials. See definition of "resourceGroupId" in clause 9.5.3.3.			

4.4.1.7 Type: ResourceHandle

This type represents the information that allows addressing a virtualised resource that is used by a VNF instance. Information about the resource is available from the VIM. The ResourceHandle type shall comply with the provisions defined in table 4.4.1.7-1.

Table 4.4.1.7-1: Definition of the ResourceHandle data type

Attribute name	Data type	Cardinality	Description
vimConnectionId	Identifier	0..1	Identifier of the VIM connection to manage the resource. This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable. The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnfInstance" structure.
resourceProviderId	Identifier	0..1	Identifier of the entity responsible for the management of the resource. This attribute shall only be supported and present when VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
resourceId	IdentifierInVim	1	Identifier of the resource in the scope of the VIM or the resource provider.
vimLevelResourceType	String	0..1	Type of the resource in the scope of the VIM or the resource provider. See note.
NOTE: 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. This value set is different from the value set of the "type" attribute in the ResourceDefinition (refer to clause 9.5.3.2).			

4.4.1.8 Type: FixedNetworkAddressData

This type represents a network address that is requested to be assigned. It shall comply with the provisions defined in table 4.4.1.8-1.

Table 4.4.1.8-1: Definition of the FixedNetworkAddressData data type

Attribute name	Data type	Cardinality	Description
macAddress	MacAddress	0..1	MAC address. If it is not present, it will be chosen by the VIM. See note.
ipAddress	IpAddress	0..1	IP address. If it is not present, no IP address will be assigned. See note.
subnetId	IdentifierInVim	0..1	Identifier of the subnet in the VIM. This attribute may be present if the "ipAddress" attribute is present, and shall be absent otherwise.
NOTE: At least one of "macAddress" and "ipAddress" shall be present.			

4.4.1.9 Type: DynamicNetworkAddressData

This type represents a network address that is requested to be assigned. It shall comply with the provisions defined in table 4.4.1.9-1.

Table 4.4.1.9-1: Definition of the DynamicNetworkAddressData data type

Attribute name	Data type	Cardinality	Description
macAddress	MacAddress	0..1	MAC address. Shall not be present if numIPAddresses > 1. If it is not present, it will be chosen by the VIM.
numIpAddresses	UnsignedInt	1	Number of IP addresses to assign dynamically. Shall be greater than zero.
subnetId	IdentifierInVim	0..1	Subnet defined by the identifier of the subnet resource in the VIM. In case this attribute is present, an IP addresses from that subnet will be assigned; otherwise, IP addresses not bound to a subnet will be assigned. See note.
subnetIpRanges	Structure (inlined)	0..N	Subnet defined as one or more IP address ranges. In case this attribute is present, IP addresses from one of the ranges will be assigned; otherwise, IP addresses not bound to a subnet will be assigned. See note.
>>minIpAddress	IpAddress	1	Lowest IP address belonging to the range.
>>maxIpAddress	IpAddress	1	Highest IP address belonging to the range.
NOTE: At most one of "subnetId" and "subnetIpRanges" shall be present.			

4.4.1.10 Type: VnfExtCpData

This type represents an external CP. It shall comply with the provisions defined in table 4.4.1.10-1.

Table 4.4.1.10-1: Definition of the VnfExtCpData data type

Attribute name	Data type	Cardinality	Description
cpId	IdentifierInVnfd	1	The identifier of the CPD in the VNFD.
fixedAddresses	FixedNetworkAddressData	0..N	List of (fixed) network addresses that need to be configured on the CP. This attribute shall be present if fixed addresses need to be configured.
dynamicAddresses	DynamicNetworkAddressData	0..N	List of network addresses to be assigned dynamically. This attribute shall be present if dynamic addresses need to be configured.

4.4.1.11 Type: ExtVirtualLinkData

This type represents an external VL. It shall comply with the provisions defined in table 4.4.1.11-1.

Table 4.4.1.11-1: Definition of the ExtVirtualLinkData data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	The identifier of the external VL instance.
vimConnectionId	Identifier	0..1	Identifier of the VIM connection to manage this resource. This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifies the entity responsible for the management of this resource. This attribute shall only be supported and present if VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
resourceId	IdentifierInVim	1	The identifier of the resource in the scope of the VIM or the resource provider.
extCps	VnfExtCpData	1..N	External CPs of the VNF to be connected to this external VL.

4.4.1.12 Type: ExtManagedVirtualLinkData

This type represents an externally-managed internal VL. It shall comply with the provisions defined in table 4.4.1.12-1.

Table 4.4.1.12-1: Definition of the ExtManagedVirtualLinkData data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	The identifier of the externally-managed internal VL instance.
virtualLinkDescId	IdentifierInVnfd	1	The identifier of the VLD in the VNFD for this VL.
vimConnectionId	Identifier	0..1	Identifier of the VIM connection to manage this resource. This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifies the entity responsible for the management of this resource. This attribute shall only be supported and present if VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
resourceId	IdentifierInVim	1	The identifier of the resource in the scope of the VIM or the resource provider.

4.4.2 Simple data types and enumerations

4.4.2.1 Introduction

This clause defines simple data types and enumerations that can be referenced from data structures defined in multiple interfaces.

4.4.2.2 Simple data types

Table 4.4.2.2-1: Simple data types

Type name	Description
Identifier	An identifier with the intention of being globally unique. Representation: string of variable length.
IdentifierInVnfd	An identifier that is unique within a VNF descriptor. Representation: string of variable length.
IdentifierInVim	An identifier maintained by the VIM or other resource provider. It is expected to be unique within the VIM instance. Representation: string of variable length.
IdentifierInVnf	An identifier that is unique for the respective type within a VNF instance, but that need not be globally unique. Representation: string of variable length.
IdentifierLocal	An identifier that is unique within a limited local scope other than above listed identifiers, such as within a complex data structure or within a request-response pair. Representation: string of variable length.
DateTime	Date-time stamp. Representation: String formatted according to IETF RFC 3339 [4].
Uri	String formatted according to IETF RFC 3986 [5].
Boolean	The Boolean is a data type having two values (true and false).
MacAddress	A MAC address. Representation: string that consists of groups of two hexadecimal digits, separated by hyphens or colons.
IpAddress	An IPV4 or IPV6 address. Representation: In case of an IPV4 address, string that consists of four decimal integers separated by dots, each integer ranging from 0 to 255. In case of an IPV6 address, string that consists of groups of zero to four hexadecimal digits, separated by colons.
Version	A Version. Representation: string of variable length.

4.4.2.3 Enumeration: LcmOperationType

The enumeration LcmOperationType represents those lifecycle operations that trigger a VNF lifecycle management operation occurrence notification. It shall comply with the provisions defined in table 4.4.2.3-1.

Table 4.4.2.3-1: Enumeration LcmOperationType

Enumeration value	Description
INSTANTIATE	Represents the "Instantiate VNF" LCM operation.
SCALE	Represents the "Scale VNF" LCM operation.
SCALE_TO_LEVEL	Represents the "Scale VNF to Level" LCM operation.
CHANGE_FLAVOUR	Represents the "Change VNF Flavour" LCM operation.
TERMINATE	Represents the "Terminate VNF" LCM operation.
HEAL	Represents the "Heal VNF" LCM operation.
OPERATE	Represents the "Operate VNF" LCM operation.
CHANGE_EXT_CONN	Represents the "Change external VNF connectivity" LCM operation.
MODIFY_INFO	Represents the "Modify VNF Information" LCM operation.

4.5 Authorization of API requests and notifications

4.5.1 Introduction

The ETSI NFV MANO APIs are only allowed to be accessed by authorized consumers. Handling of authorization differs between making an API call, and sending a notification. In the former case, OAuth 2.0 is used. In the latter case, OAuth 2.0 or HTTP Basic authentication is used, and the flows differ from those used in the former case.

The following terms (set in *italics* below) are used as defined by IETF RFC 6749 [10]: *client*, *resource server*, *authorization server*, *token endpoint*, *access token*. The description below is based on the "client credentials" grant type as defined by IETF RFC 6749 [10].

For API calls, the producer functional block of an API in NFV terms corresponds to the "*resource server*", and the consumer functional block of an API corresponds to the "*client*" as defined by IETF RFC 6749 [10]. For sending a notification, these roles are reversed: The producer (notification sender) corresponds to the "*client*", and the consumer (notification receiver) corresponds to the "*resource server*".

Before invoking an HTTP method on a REST resource provided by a *resource server*, a functional block (referred to as "*client*" from now on) first obtains authorization from another functional block fulfilling the role of the "*authorization server*". The present document makes no assumption about which functional block in the architecture plays the role of the *authorization server*. It is however assumed that the address of the *token endpoint* exposed by the *authorization server* and further specified in the clauses below is provisioned to the *client* together with additional authorization-related configuration parameters, such as valid client credentials. The *client* requests an *access token* from the *token endpoint*. As part of the request, it authenticates towards the *authorization server* by presenting its client credentials, consisting of client identifier and client password. The *authorization server* responds with an *access token* which the *client* will present to the *resource server* with every HTTP method invocation. An *access token* represents a particular access right (defining the particular set of protected resources to access in a particular manner) with a defined duration. The token is opaque to the *client*, and can typically be used by the *authorization server* and the *resource server* as an identifier to retrieve authorization information, such as information that identifies the client, its role and access rights. An *access token* expires after a certain time, or can be revoked. If that happens, the *client* can try to obtain a new *access token* from the *authorization server*.

In order to ensure that no third party can eavesdrop on sensitive information such as client credentials or access tokens, HTTP over TLS is used to protect the transport.

4.5.2 Flows (informative)

4.5.2.1 Authorization of API requests

The flow below illustrates the authorization of API requests that the API consumer sends to the API producer.

NOTE: Typical choices for the implementation of the authorization server include the authorization server as a component of the API producer, or as an external component.

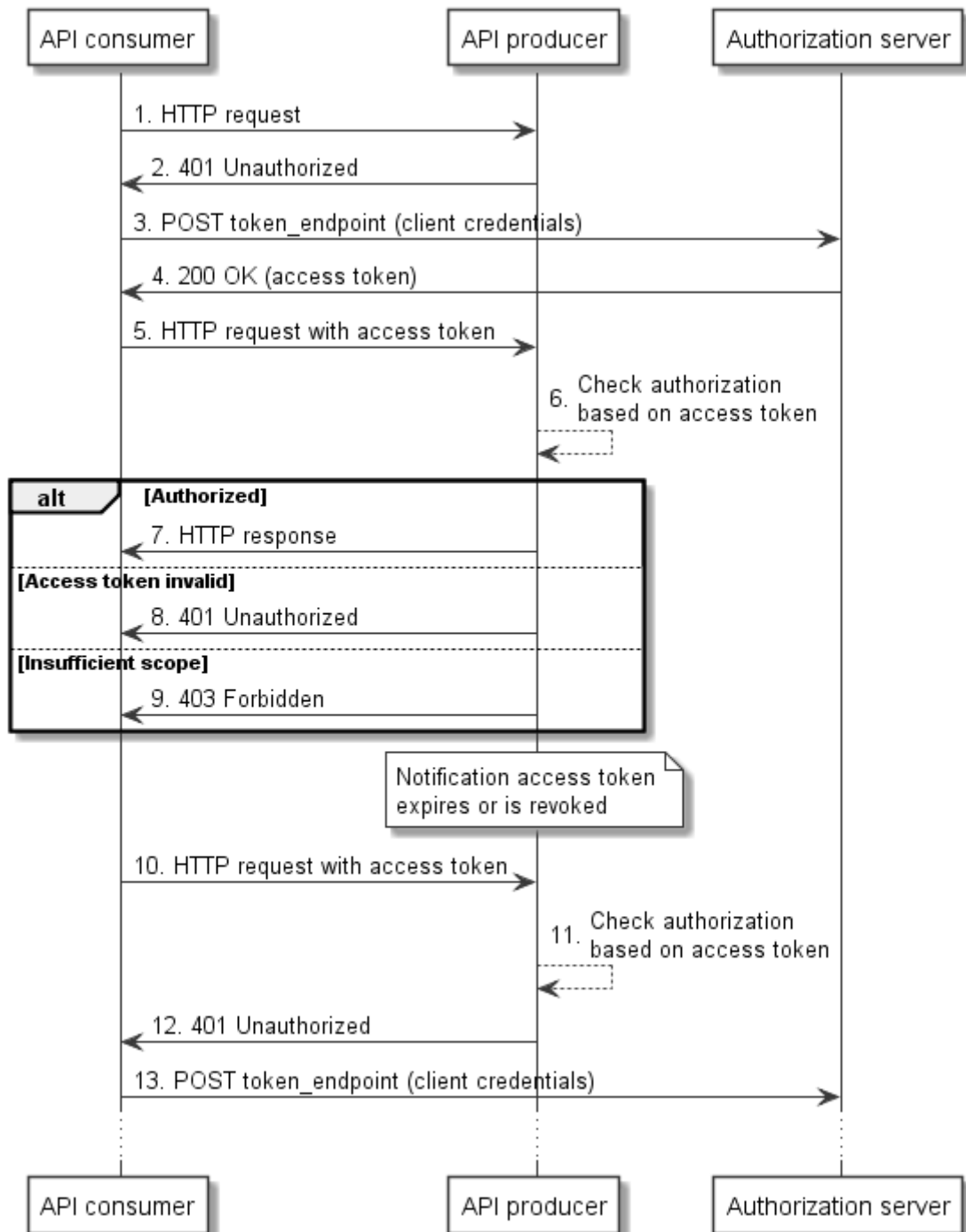


Figure 4.5.2.1-1: Authorization of API requests

The flow consists of the following steps:

- 1) The API consumer sends an HTTP request to a resource provided by the API producer, without including an access token.
- 2) The API producer responds with "401 Unauthorized" and includes a challenge to authorize.
- 3) To obtain an access token, the API consumer sends a POST request to the token endpoint of the authorization server and includes its client credentials.
- 4) The authorization server responds to the API consumer with an access token, and possibly additional information such as expiry time.

- 5) The API consumer sends an HTTP request to a resource provided by the API producer and includes the received access token.
- 6) The API producer checks the token for validity. This assumes that it has received information about the valid access tokens, and additional related information (e.g. time of validity, client identity, client access rights) from the authorization server. Such exchange is outside the scope of the present document, and assumed to be trivial if deployments choose to include the authorization server as a component into the API producer.
- 7) In case the token is valid and refers to access rights that allow accessing the actual resource with the actual request and its parameters, the API producer returns the HTTP response.
- 8) In case the token is invalid or expired, the API producer returns a "401 Unauthorized" response.
- 9) In case the access rights are insufficient to access the resource or to use the parameters, the API producer returns a "403 Forbidden" response.
- 10) The API consumer sends an HTTP request to the API producer and includes in the request the access token.
- 11) The API producer checks the token for validity, and establishes that it has expired, or has been revoked by the authorization server using means outside the scope of the present document.
- 12) The API producer responds with a "401 Unauthorized" response, indicating that the access token is invalid.
- 13) The API consumer attempts to obtain a new access token, as defined in step 3. This may eventually succeed or fail, depending on whether access is allowed for that API consumer any longer.

4.5.2.2 Authorization of notifications using the HTTP Basic authentication scheme

The flow below illustrates the authorization of notifications that the API producer sends to the API consumer based on the HTTP Basic authentication scheme (see IETF RFC 7617 [18]). In this flow, no authorization server is needed.

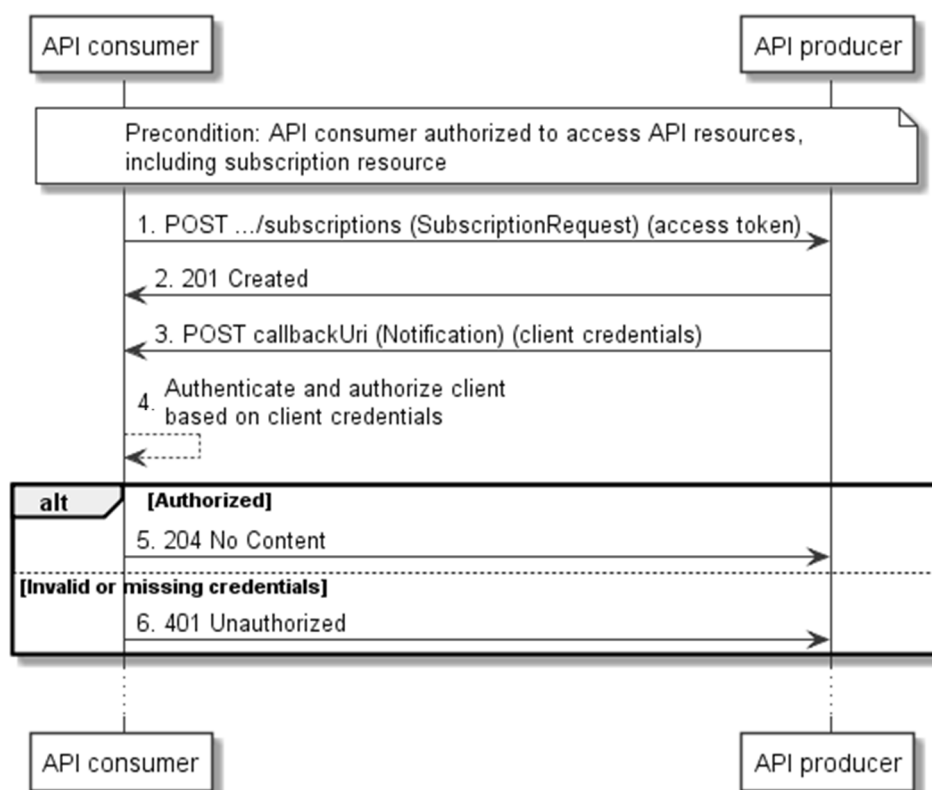


Figure 4.5.2.2-1: Authorization of notifications using the HTTP Basic authentication scheme

It is a precondition for this flow that the API consumer is authorized to access the "subscriptions" resource provided by the API producer, using the procedure illustrated in clause 4.5.2.1.

The flow consists of the following steps:

- 1) The API consumer sends a request to create a new subscription resource to the API producer and includes in the request a valid access token to prove that it is authorized to access the API. Also, it includes in the subscription client credentials that the API producer can use to authenticate towards the API consumer when subsequently sending notifications. Note that these credentials are typically different from the client credentials used in the flow in clause 4.5.2.1.
- 2) The API producer creates the subscription resource and responds with "201 Created".
- 3) The API consumer sends an HTTP POST request with a notification to the callback URI registered by the API consumer during subscription, and includes the client credential in the request to authenticate.
- 4) The API consumer checks the credentials against the information it has sent in step 1.
- 5) In case the credentials are valid, the API producer returns a "204 No Content" HTTP response to indicate successful delivery of the notification.
- 6) In case the credentials are invalid, the API producer returns a "401 Unauthorized" response.

4.5.2.3 Authorization of notifications using OAuth 2.0

The flow below illustrates the authorization of notifications that the API producer sends to the API consumer using OAuth 2.0. In this flow, the authorization server can be a different entity than the authorization server in clause 4.5.2.1.

NOTE: Typical choices for the implementation of the authorization server include the authorization server as a component of the API producer, or as an external component.

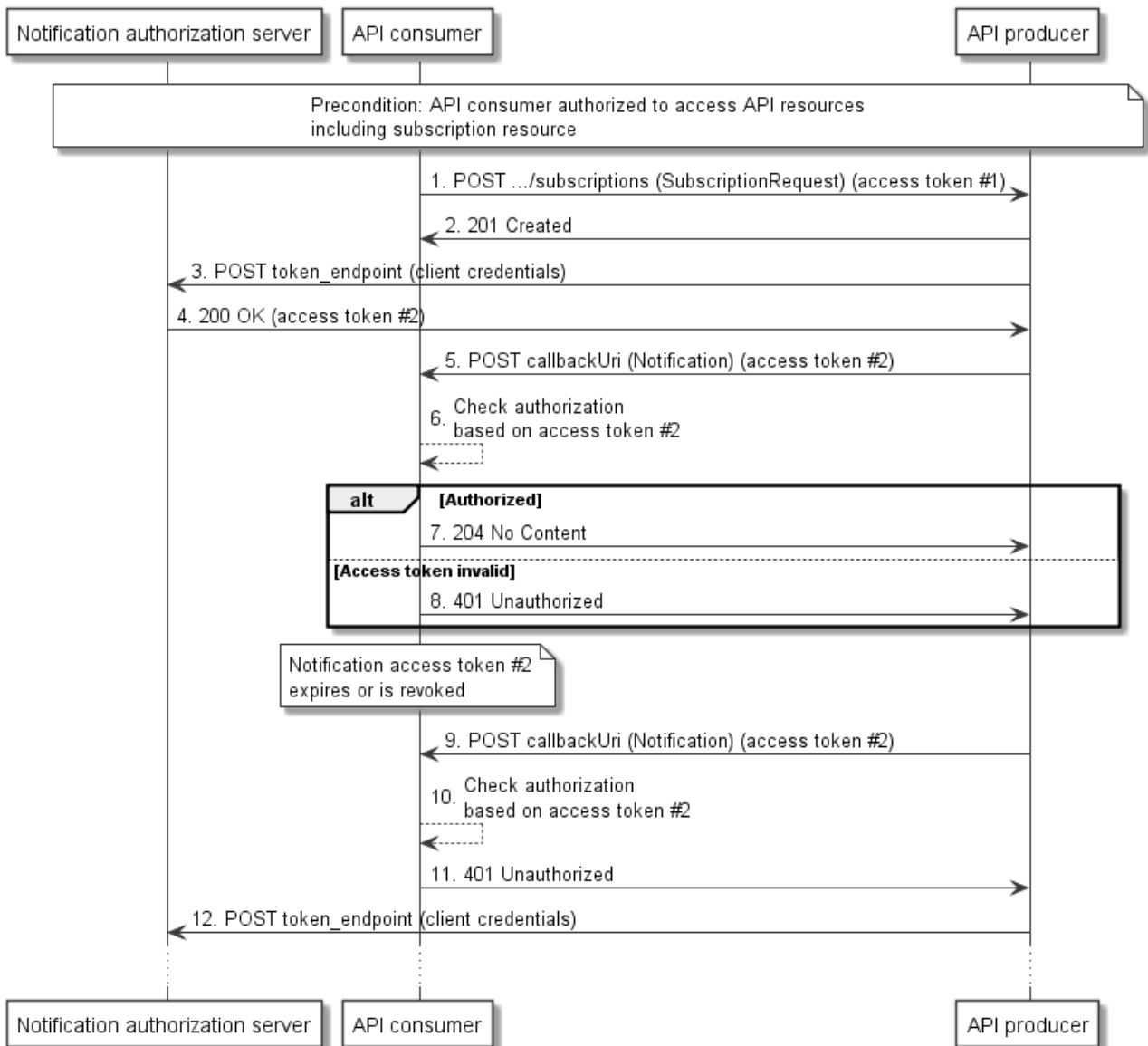


Figure 4.5.2.3-1: Authorization of notifications using OAuth 2.0

It is a precondition for this flow that the API consumer is authorized to access the "subscriptions" resource provided by the API producer, using the procedure illustrated in clause 4.5.2.1.

The flow consists of the following steps:

- 1) The API consumer sends a request to create a new subscription resource to the API producer and includes in the request a valid access token #1 to prove that it is authorized to access the API. Also, it includes in the subscription request parameters that the API producer can use to obtain authorization to send notifications to the API consumer, such as client credentials and a token endpoint. Note that these are typically different from the credentials and token endpoint used in the flow in clause 4.5.2.1.
- 2) The API producer creates the subscription resource and responds with "201 Created".
- 3) Subsequently, and prior to sending any notification to the API consumer, the API producer obtains authorization to do so by requesting an access token from the authorization server, using the end point and notification client credentials that were sent in the subscription request, or provisioned otherwise.
- 4) The authorization server responds to the API producer with an access token, hereafter called access token #2, and possibly additional information such as expiry time.

- 5) The API consumer sends an HTTP POST request with a notification to the callback URI registered by the API consumer during subscription, and includes the received access token #2.
- 6) The API consumer checks the token for validity. This assumes that it has received information about the valid access tokens, and additional related information (e.g. time of validity, client identity, client access rights) from the authorization server. Such exchange is outside the scope of the present document, and assumed to be trivial if deployments choose to include the authorization server as a component into the API consumer.
- 7) In case the token #2 is valid, the API producer returns a "204 No Content" HTTP response to indicate successful delivery of the notification.
- 8) In case the token #2 is invalid or expired, the API producer returns a "401 Unauthorized" response.
- 9) The API producer sends another notification in an HTTP POST request to the API consumer and includes in the request the access token #2.
- 10) The API consumer checks the token #2 for validity, and establishes that it has expired, or has been revoked by the authorization server using means outside the scope of the present document.
- 11) The API consumer responds with a "401 Unauthorized" response, indicating that the access token #2 is invalid.
- 12) The API producer attempts to obtain a new access token. This may eventually succeed or fail, depending on whether access is allowed for that API producer any longer.

4.5.3 Specification

4.5.3.1 Introduction

OAuth 2.0 provides a framework for authorization of web applications that has multiple modes and options. This clause profiles the framework for use in the context of the Or-Vnmf reference point. Clause 4.5.3.2 specifies the general mechanism. Two different uses of the general mechanism, actually for API requests and for sending notifications, are defined in clauses 4.5.3.3 and 4.5.3.4.

4.5.3.2 General mechanism

For all requests to an API defined in the present document, and for all notifications sent via such an API, authorization as defined below shall be used. Requests and notifications without authorization credentials shall be rejected.

To allow the *client* to obtain an access token, the *authorization server* shall expose a *token endpoint* that shall comply with the provisions defined by the OAuth 2.0 specification for the *client credentials* grant type (see IETF RFC 6749 [10]). A *client* shall use the access token request and response according to this grant type, as defined by IETF RFC 6749 [10], to obtain an *access token* for access to the REST resources defined by the present document. The content of the *access token* is out of the scope of the present document; however, it shall not be possible for an attacker to easily guess it. The *access token* shall be a string. The set of allowed characters is defined in IETF RFC 6749 [10].

A *client* that invokes an HTTP request towards a resource defined by one of the APIs of the present document shall include the *access token* as a bearer token in every HTTP method in the "Authorization" HTTP header, as defined by IETF RFC 6750 [11]. A *resource server* that receives an HTTP request with an invalid *access token*, or without an *access token*, shall reject the request, and shall signal the error in the HTTP response according to the provisions for the error codes and the "WWW-Authenticate" response HTTP header as defined by IETF RFC 6750 [11].

A *client* that receives a rejection of an *access token* may obtain a new *access token* from the *token endpoint* of the *authorization server*, and retry the request.

4.5.3.3 Authorizing API requests

A consumer of an API that wishes to issue HTTP requests towards resources provided by that API shall act as a *client* according to clause 4.5.3.2 to obtain an access token, and shall include this access token in every HTTP request, as defined in clause 4.5.3.2. The respective API producer shall act as a *resource server* as defined in clause 4.5.3.2.

4.5.3.4 Authorizing the sending of notifications

The procedure defined in clause 4.5.2 allows an API consumer to obtain authorization to perform API requests towards the API producer, including subscription requests. For sending the actual notifications matching a subscription, the API producer needs to obtain separate authorization to actually *send* the notification to the API consumer.

If an API consumer requires the API producer to authorize for sending notifications to that API consumer, it shall include in the subscription request a data structure that defines the authorization requirements, as defined in table 4.5.3.4-1.

Table 4.5.3.4-1: Definition of the SubscriptionAuthentication data type

Attribute name	Data type	Cardinality	Description
authType	Enum (inlined)	1	Defines the type of Authentication / Authorization to use when sending a notification. Permitted values: <ul style="list-style-type: none"> - BASIC: In every POST request that sends a notification, use HTTP Basic authentication with the client credentials. - OAUTH2_CLIENT_CREDENTIALS: In every POST request that sends a notification, use an OAuth 2.0 Bearer token, obtained using the client credentials grant type.
paramsBasic	Structure (inlined)	0..1	Parameters for authentication/authorization using BASIC. Shall be present if authType is "BASIC" and the contained information has not been provisioned out of band. Shall be absent otherwise.
>userName	String	0..1	Username to be used in HTTP Basic authentication. Shall be present if it has not been provisioned out of band.
>password	String	0..1	Password to be used in HTTP Basic authentication. Shall be present if it has not been provisioned out of band.
paramsOauth2Client Credentials	Structure (inlined)	0..1	Parameters for authentication/authorization using OAUTH2_CLIENT_CREDENTIALS. Shall be present if authType is "OAUTH2_CLIENT_CREDENTIALS" and the contained information has not been provisioned out of band. Shall be absent otherwise.
>clientId	String	0..1	Client identifier to be used in the access token request of the OAuth 2.0 client credentials grant type. Shall be present if it has not been provisioned out of band. See note.
>clientPassword	String	0..1	Client password to be used in the access token request of the OAuth 2.0 client credentials grant type. Shall be present if it has not been provisioned out of band. See note.
>tokenEndpoint	Uri	0..1	The <i>token endpoint</i> from which the access token can be obtained. Shall be present if it has not been provisioned out of band.
NOTE:	The clientId and clientPassword passed in a subscription shall not be the same as the clientId and clientPassword that are used to obtain authorization for API requests. Client credentials may differ between subscriptions. The value of clientPassword should be generated by a random process.		

If the value of "authType" is "OAUTH2_CLIENT_CREDENTIALS":

- The API producer shall, prior to sending any notification, obtain an *access token* from the *token endpoint* using the OAuth 2.0 client credentials grant type as defined in IETF RFC 6749 [10]. The API consumer should include expiry information with the token response.
- The API producer shall include that *access token* as a Bearer token in every POST request that sends a notification (according to IETF RFC 6750 [11]).
- If the *access token* is expired, the API consumer shall reject the notification. In that case, the API producer shall obtain a new *access token*, and repeat sending the notification.
- If the token expiry time is known to the API producer, it may obtain proactively a new access token.

If the value of "authType" is "BASIC":

- The API producer shall pass its client credentials in every POST request that sends a notification, as defined in IETF RFC 7617 [18].

4.5.3.5 Client roles

An *access token* allows the API producer to identify information about the *client* that has obtained the access token, such as client identity, client role or client access rights. By having this property, *access tokens* can be used as a means to distinguish between different roles (and consequently different access rights) to the same set of resources.

The mechanism for this works as follows: By means out of scope of the present document, the role of the client identified by a particular client identifier is provisioned to the authorization server. When that client obtains an access token, it sends its client identifier and client password to the authorization server. The authorization sever can obtain the role of the client by evaluating the data that were provisioned for the client identifier, and associate that information to the access token. By means out of scope of the present document, that association is shared with the API producer. This enables the API producer to detect the role based on the access token.

In ETSI NFV, certain interfaces are exposed on multiple different reference points, i.e. the same interface is exposed to different consumer functional blocks. Depending on the consumer block that originates an HTTP request, not all resources / HTTP methods / request and parameters might be available. From the point of view of the producer functional block, this can be seen as consumers acting in different roles when accessing a particular interface, such as the VNF LCM interface.

Implementations may use the OAuth *access token* to differentiate between these cases, assuming that an *access token* can determine whether a consumer functional block acts in the role of the VNFM or the NFVO. This assumes that the role of the consumer functional block is bound to its client credentials. The means of creating this binding is out of scope of the present document (e.g. a configuration step or policy).

5 VNF Lifecycle Management interface

5.1 Description

This interface allows the NFVO to invoke VNF lifecycle management operations of VNF instances towards the VNFM, and to subscribe to notifications regarding VNF lifecycle changes provided by the VNFM.

The operations provided through this interface are:

- Create VNF Identifier
- Query VNF
- Modify VNF Information
- Delete VNF Identifier
- Instantiate VNF

- Scale VNF
- Scale VNF to Level
- Change VNF Flavour
- Terminate VNF
- Heal VNF
- Operate VNF
- Change external VNF connectivity
- Get Operation Status
- Subscribe
- Query Subscription Information
- Terminate Subscription
- Notify

This interface also enables to invoke error handling procedures (Retry, Rollback, Cancel, Fail) on the actual VNF lifecycle management operation occurrences.

5.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "vnflcm" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present document. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 5.2-1 shows the overall resource URI structure defined for the VNF lifecycle management interface.

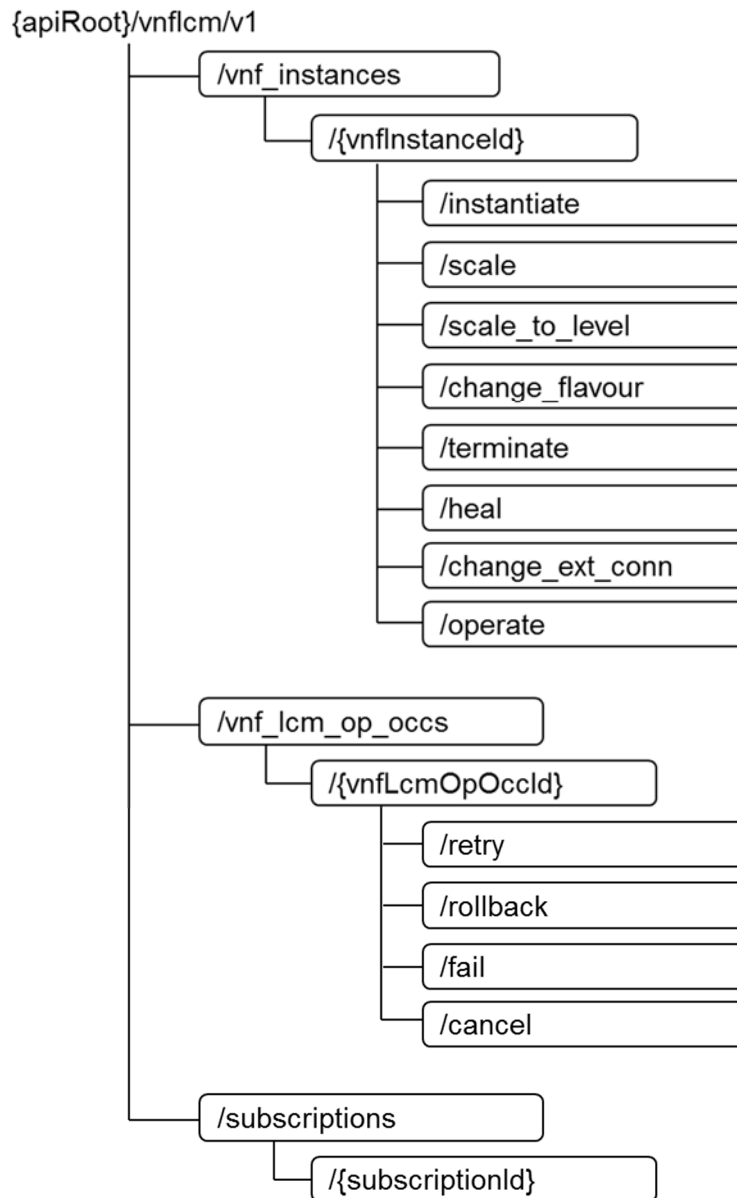


Figure 5.2-1: Resource URI structure of the VNF Lifecycle Management Interface

Table 5.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 5.2-1: Resources and methods overview of the VNF Lifecycle Management interface

Resource name	Resource URI	HTTP Method	Meaning
VNF instances	/vnf_instances	GET	Query multiple VNF instances
		POST	Create a VNF instance resource
Individual VNF instance	/vnf_instances/{vnfInstanceId}	GET	Read an individual VNF instance resource
		PATCH	Modify VNF instance information
		DELETE	Delete VNF instance resource
Instantiate VNF task	/vnf_instances/{vnfInstanceId}/instantiate	POST	Instantiate a VNF
Scale VNF task	/vnf_instances/{vnfInstanceId}/scale	POST	Scale a VNF instance incrementally
Scale VNF to Level task	/vnf_instances/{vnfInstanceId}/scale_to_level	POST	Scale a VNF instance to a target level
Change VNF flavour task	/vnf_instances/{vnfInstanceId}/change_flavour	POST	Change the deployment flavour of a VNF instance
Terminate VNF task	/vnf_instances/{vnfInstanceId}/terminate	POST	Terminate a VNF instance
Heal VNF task	/vnf_instances/{vnfInstanceId}/heal	POST	Heal a VNF instance
Operate VNF task	/vnf_instances/{vnfInstanceId}/operate	POST	Operate a VNF instance
Change external VNF connectivity task	/vnf_instances/{vnfInstanceId}/change_ext_conn	POST	Change the external connectivity of a VNF instance
VNF LCM operation occurrences	/vnf_lcm_op_occs	GET	Query multiple VNF lifecycle management operation occurrences
Individual VNF LCM operation occurrence	/vnf_lcm_op_occs/{vnfLcmOpOcclId}	GET	Read an individual VNF lifecycle management operation occurrence
Retry operation task	/vnf_lcm_op_occs/{vnfLcmOpOcclId}/retry	POST	Retry a VNF lifecycle management operation occurrence
Rollback operation task	/vnf_lcm_op_occs/{vnfLcmOpOcclId}/rollback	POST	Rollback a VNF lifecycle management operation occurrence
Fail operation task	/vnf_lcm_op_occs/{vnfLcmOpOcclId}/fail	POST	Mark a VNF lifecycle management operation occurrence as failed
Cancel operation task	/vnf_lcm_op_occs/{vnfLcmOpOcclId}/cancel	POST	Cancel a VNF lifecycle management operation occurrence
Subscriptions	/subscriptions	POST	Subscribe to VNF lifecycle change notifications
		GET	Query multiple subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Read an individual subscription resource
		DELETE	Terminate a subscription
Notification endpoint	(client-provided)	POST	Notify about VNF lifecycle change
		GET	Test the notification endpoint

5.3 Sequence diagrams (informative)

5.3.1 Flow of the creation of a VNF instance resource

This clause describes the procedure for the creation of a VNF instance resource.

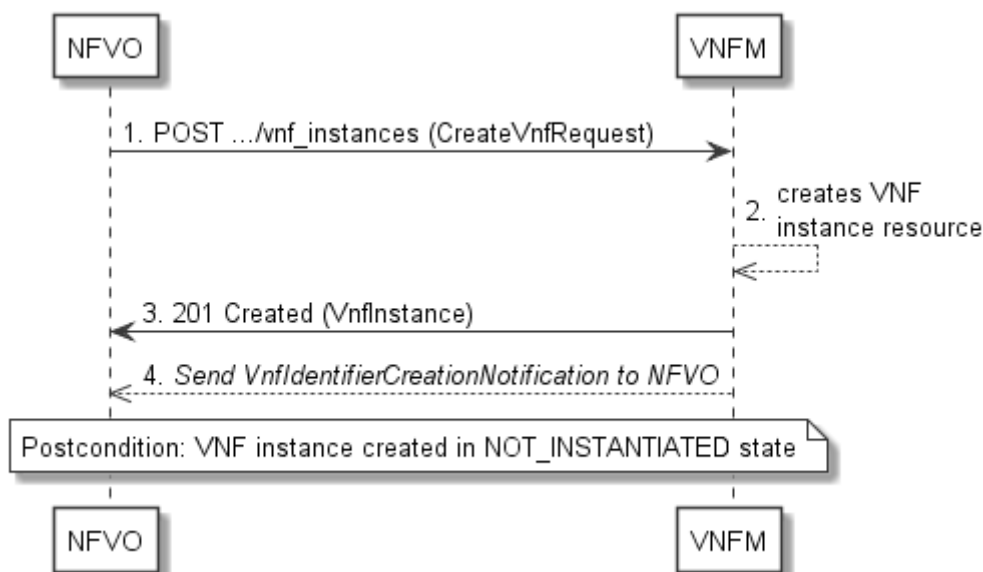


Figure 5.3.1-1: Flow of the creation of a VNF instance resource

The procedure consists of the following steps as illustrated in figure 5.3.1-1:

- 1) The NFVO sends a POST request to the "VNF Instances" resource including in the payload body a data structure of type "CreateVnfRequest".
- 2) The VNFM creates a new VNF instance resource in NOT_INSTANTIATED state, and the associated VNF instance identifier.
- 3) The VNFM returns a 201 Created response containing a representation of the VNF instance resource just created by the VNFM, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 4) The VNFM sends a VNF Identifier Creation Notification (see clause 5.3.9) to the NFVO to indicate the creation of the VNF instance resource and the associated VNF instance identifier.

Postcondition: Upon successful completion, the VNF instance resource has been created in "NOT_INSTANTIATED" state.

5.3.2 Flow of the deletion of a VNF instance resource

This clause describes the procedure for the deletion of a VNF instance resource.

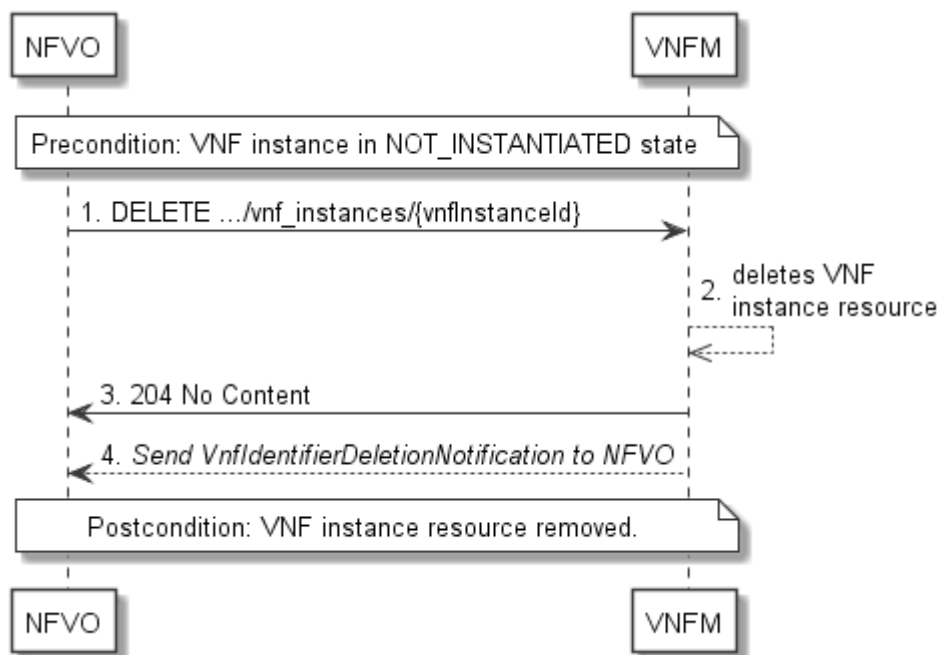


Figure 5.3.2-1: Flow of the deletion of a VNF instance resource

Precondition: The resource representing the VNF instance to be deleted needs to be in NOT_INSTANTIATED state.

The procedure consists of the following steps as illustrated in figure 5.3.2-1:

- 1) NFVO sends a DELETE request to the "Individual VNF Instance" resource.
- 2) The VNFM deletes the VNF instance resource and the associated VNF instance identifier.
- 3) The VNFM returns a "204 No Content" response with an empty payload body.
- 4) The VNFM sends to the NFVO a VnfIdentifierDeletionNotification to indicate the deletion of the VNF instance resource and the associated VNF instance identifier.

Postcondition: The resource representing the VNF instance has been removed from the list of VNF instance resources.

Error handling: If the VNF instance is not in NOT_INSTANTIATED state, the VNFM rejects the deletion request.

5.3.3 Flow of VNF lifecycle management operations triggered by task resources

This clause describes the general sequence for VNF Lifecycle Management operations that operate on VNF instance resource and are triggered by task resources. The flows for these operations are very similar. The differences between the individual operations are covered in the table at the end of this clause.

This flow is applicable to the following operations:

- Instantiate VNF
- Scale VNF
- Scale VNF to Level
- Change VNF flavour
- Operate VNF

- Heal VNF
- Change external VNF connectivity
- Terminate VNF

Figure 5.3.3-1 illustrates the general lifecycle management flow. Placeholders in this flow allow for differentiating between the operations and are marked with double angular brackets "<<...>>".

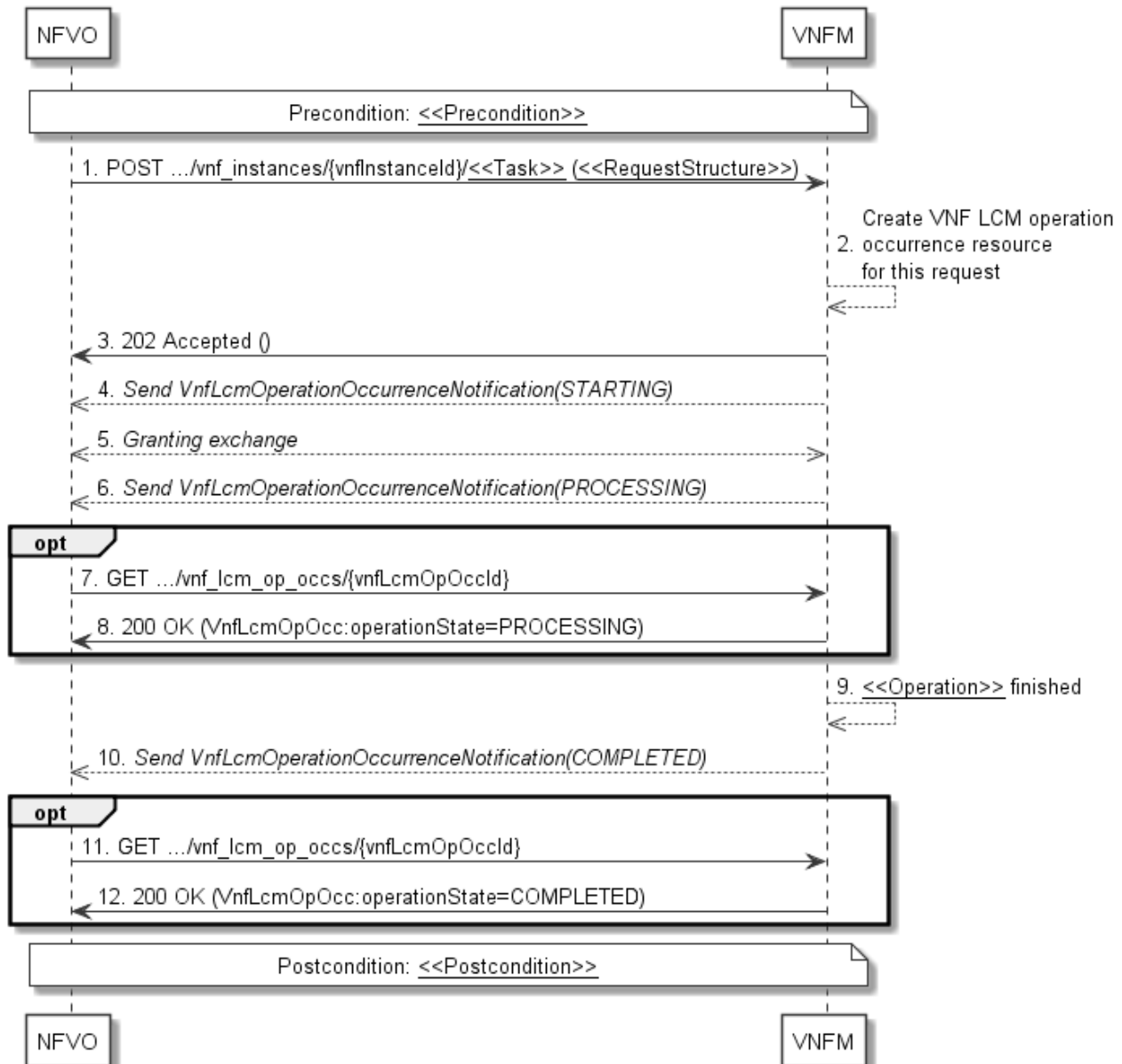


Figure 5.3.3-1: General flow of VNF lifecycle management operations triggered by task resources

NOTE: Due to possible race conditions, the 202 response, the "STARTING" notification and the request of the Granting exchange can arrive out of order at the NFVO.

Precondition: The precondition depends on the actual operation and is described by the template parameter <<Precondition>> in table 5.3.3-1.

A VNF lifecycle operation, as illustrated in figure 5.3.3-1, consists of the following steps:

- 1) The NFVO sends a POST request to the <<Task>> resource that represents the lifecycle operation to be executed on the VNF instance, and includes in the payload body a data structure of type <<RequestStructure>>. The name <<Task>> of the task resource and the <<RequestStructure>> depend on the operation and are described in table 5.3.3-1.
- 2) The VNFM creates a "VNF LCM operation occurrence" resource for the request.
- 3) The VNFM returns a "202 Accepted" response with an empty payload body and a "Location" HTTP header that points to the new "VNF LCM operation occurrence" resource, i.e. it includes the URI of that resource which is ".../vnf_lcm_op_occs/{vnfLcmOpOccId}". See note.
- 4) The VNFM sends to the NFVO a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the start of the lifecycle management operation occurrence with the "STARTING" state. See note.
- 5) VNFM and NFVO exchange granting information (see VNF Lifecycle Operation Granting interface, clause 9.3). See note.
- 6) The VNFM sends to the NFVO a VNF lifecycle management operation occurrence notification (see clause 5.3.8) to indicate that the VNF LCM operation occurrence enters the "PROCESSING" state.
- 7) If desired, the NFVO can poll the "VNF LCM operation occurrence" resource to obtain information about the ongoing operation by sending a GET request to the resource that represents the VNF LCM operation occurrence.
- 8) In the response to that request, the VNFM returns to the NFVO information of the operation, such as the operation status, by providing in the payload body a data structure of type "VnfLcmOpOcc".
- 9) The VNFM has finished the operation <<Operation>>.
- 10) The VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the completion of the lifecycle management operation occurrence with the success state "COMPLETED".
- 11) If desired, the NFVO can send a new GET request to the "VNF LCM operation occurrence" resource.
- 12) In the response to that request, the VNFM returns to the NFVO information about the result of the operation, by providing in the payload body a data structure of type "VnfLcmOpOcc".

Postcondition: The postcondition depends on the actual operation and is described by the template parameter <<Postcondition>> in table 5.3.3-1.

Error handling: If the VNF lifecycle management operation fails, error information is provided in the notification message that reports the erroneous completion of the procedure, and is also available in the resource that represents the actual VNF lifecycle management operation occurrence related to this VNF lifecycle management operation.

Table 5.3.3-1 defines how the flow described above is parameterized for the different VNF lifecycle management operations.

Table 5.3.3-1: Parameterization of the flow for different VNF lifecycle management operations

Operation	Precondition	Task	RequestStructure	Postcondition
Instantiate VNF	VNF instance created and in NOT_INSTANTIATED state	instantiate	InstantiateVnfRequest	VNF instance in INSTANTIATED state
Scale VNF	VNF instance in INSTANTIATED state	scale	ScaleVnfRequest	VNF instance still in INSTANTIATED state and VNF was scaled
Scale VNF to Level	VNF instance in INSTANTIATED state	scale_to_level	ScaleVnfToLevel Request	VNF instance still in INSTANTIATED state and VNF was scaled
Change VNF flavor	VNF instance in INSTANTIATED state	change_flavour	ChangeVnfFlavour Request	VNF instance still in INSTANTIATED state and VNF deployment flavour changed
Operate VNF	VNF instance in INSTANTIATED state	operate	OperateVnfRequest	VNF instance still in INSTANTIATED state and VNF operational state changed
Heal VNF	VNF instance in INSTANTIATED state	heal	HealVnfRequest	VNF instance still in INSTANTIATED state
Change external VNF connectivity	VNF instance in INSTANTIATED state	change_ext_con n	ChangeExtVnfConnectiv ityRequest	VNF instance still in INSTANTIATED state and external connectivity of the VNF is changed
Terminate VNF	VNF instance in INSTANTIATED state	terminate	TerminateVnfRequest	VNF instance in NOT_INSTANTIATED state

5.3.4 Flow of automatic invocation of VNF scaling and VNF healing

This clause describes the sequence for the automatic invocation of "Scale VNF", "Scale VNF to Level" and "Heal VNF" operations by the VNFM, also known as "auto-scale" and "auto-heal". The criteria based on which the VNFM decides when to invoke an automatic scaling or automatic healing are outside the scope of the present document and can include certain changes in monitoring parameters that are monitored by the VNFM by PM jobs or thresholds, changes in VNF indicator values that are polled by the VNFM or that are reported to the VNFM via "VnfIndicatorValueChangeNotification" messages. Auto-scaling and auto-healing can be enabled and disabled by the NFVO by modifying the appropriate "isAutoscaleEnabled" and "isAutohealEnabled" configurable properties of the VNF using the sequence flow according to clause 5.3.6.

This flow is applicable to the automatic invocation of the following operations:

- Scale VNF
- Scale VNF to Level
- Heal VNF

Figure 5.3.4-1 illustrates the flow.

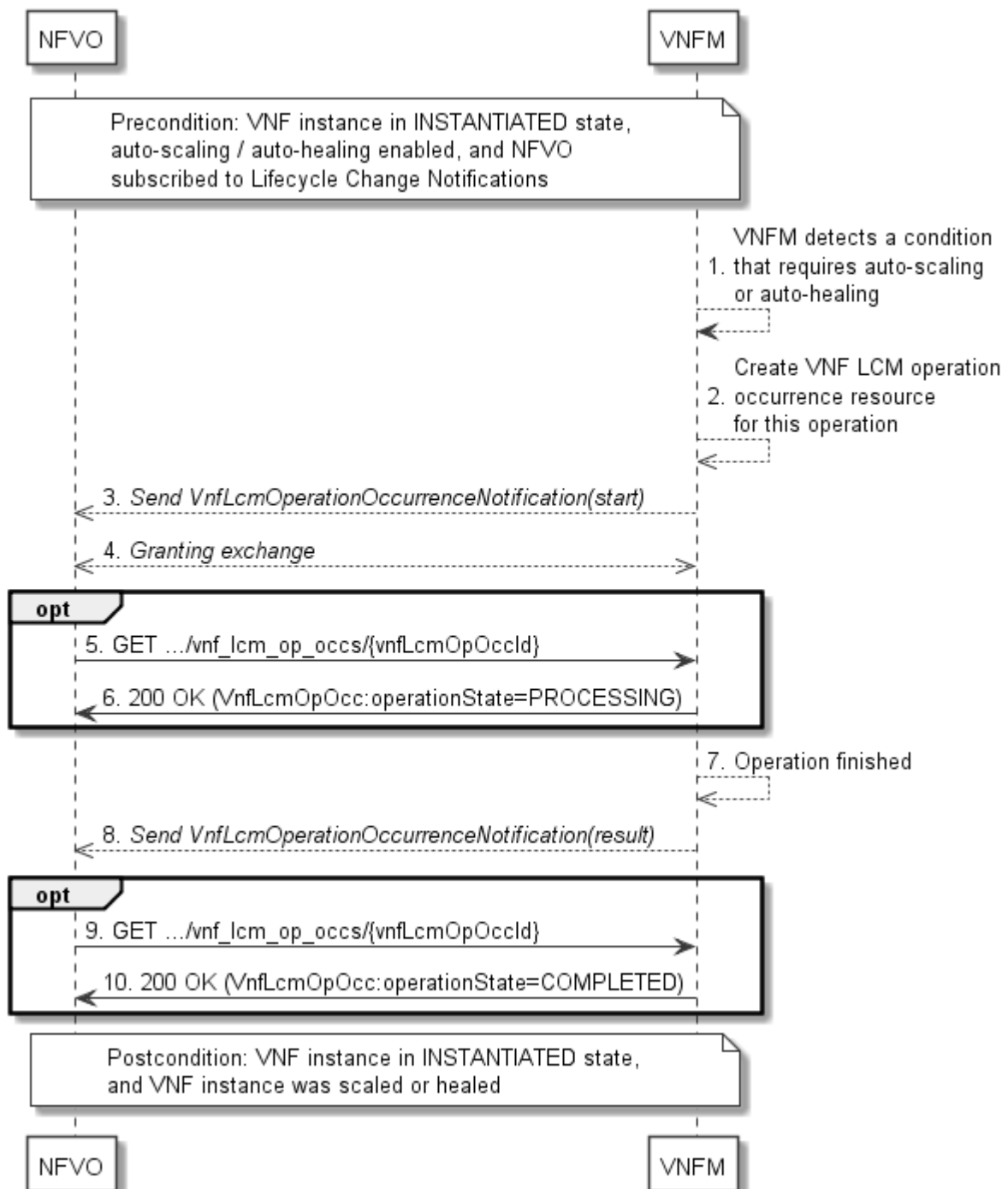


Figure 5.3.4-1: Flow of auto-scaling and auto-healing

Precondition: The VNF instance is in INSTANTIATED state, auto-scaling / auto-healing is enabled, and the NFVO is subscribed to VNF Lifecycle Change Notifications.

The automatic invocation of a VNF scaling or VNF healing operation, as illustrated in figure 5.3.4-1, consists of the following steps:

- 1) The VNFM detects a condition that triggers auto-scaling (Scale VNF or Scale VNF To Level) or auto-healing (Heal VNF) of the VNF, and selects the appropriate parameters for the operation.
- 2) The VNFM creates a "VNF LCM operation occurrence" resource for the operation.

- 3) The VNFM sends to the NFVO a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the start of the lifecycle management operation occurrence.
- 4) VNFM and NFVO exchange granting information (see VNF Lifecycle Operation Granting interface, clause 9.3).
- 5) If desired, the NFVO can poll the "VNF lifecycle management operation occurrence" resource to obtain information about the ongoing operation by sending a GET request to the resource that represents the VNF lifecycle management operation occurrence.
- 6) In the response to that request, the VNFM returns to the NFVO information of the operation, such as the operation status, by providing in the payload body a data structure of type "VnfLcmOpOcc".
- 7) The VNFM has finished the operation.
- 8) The VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the completion of the lifecycle management operation occurrence.
- 9) If desired, the NFVO can send a new GET request to the "VNF lifecycle management operation occurrence" resource.
- 10) In the response to that request, the VNFM returns to the NFVO information about the result of the operation, by providing in the payload body a data structure of type "VnfLcmOpOcc".

Postcondition: The VNF instance in INSTANTIATED state, and the VNF instance was scaled or healed as appropriate.

Error handling: If the VNF lifecycle management operation fails, error information is provided in the notification message that reports the erroneous completion of the procedure, and is also available in the resource that represents the actual VNF lifecycle management operation occurrence related to this VNF lifecycle management operation.

5.3.5 Flow of the Query VNF operation

This clause describes a sequence for querying/reading information about a VNF instance.

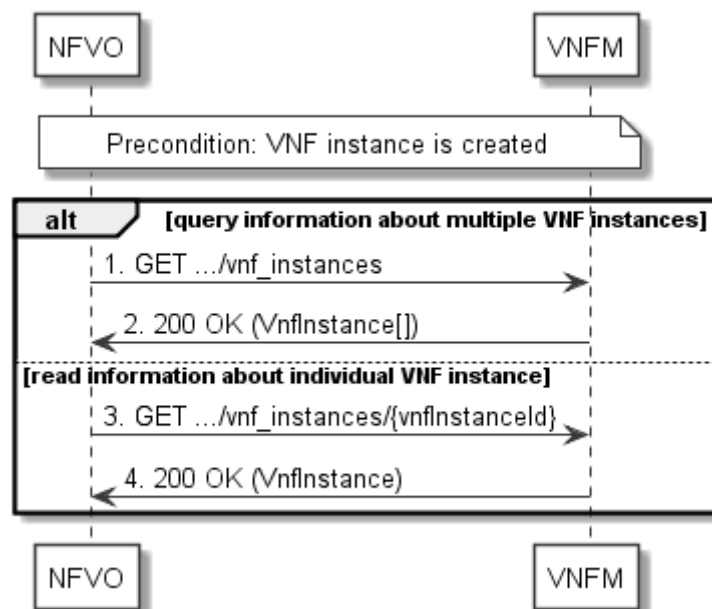


Figure 5.3.5-1: Flow of VNF instance query/read

Precondition: The resource representing the VNF instance has been created.

VNF instance query, as illustrated in figure 5.3.5-1, consists of the following steps:

- 1) If the NFVO intends to query all VNF instances, it sends a GET request to the "VNF instances" resource.

- 2) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "VnfInstance" in the payload body.
- 3) If the NFVO intends to read information about a particular VNF instance, it sends a GET request to the "Individual VNF instance" resource, addressed by the appropriate VNF instance identifier in its resource URI.
- 4) The VNFM returns a "200 OK" response to the NFVO, and includes one data structure of type "VnfInstance" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

5.3.6 Flow of the Modify VNF Information operation

This clause describes a sequence for updating information about a VNF instance.

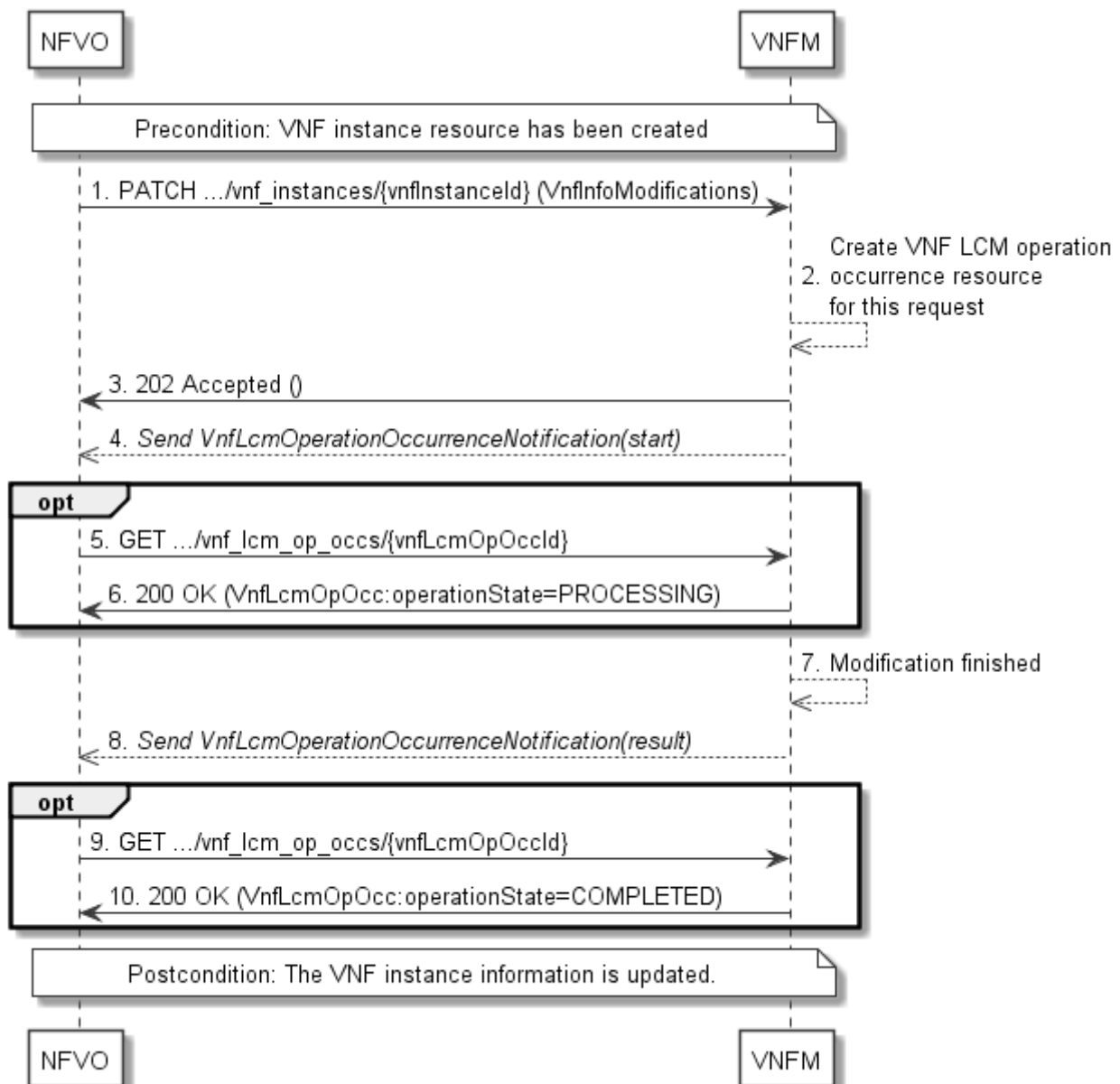


Figure 5.3.6-1: Flow of the modification of VNF instance information

Precondition: The resource representing the VNF instance has been created.

Updating the VNF instance information, as illustrated in figure 5.3.6-1, consists of the following steps:

- 1) The NFVO sends a PATCH request to the "Individual VNF instance" resource of the VNF instance that is to be operated and includes in the payload body a data structure of type "VnfInfoModifications".
- 2) The VNFM creates a "VNF LCM operation occurrence" resource for the request.
- 3) The VNFM returns a "202 Accepted" response with an empty payload body and a "Location" HTTP header that points to the new "VNF LCM operation occurrence" resource, i.e. it includes the URI of that resource which is ".../vnf_lcm_op_occs/{vnfLcmOpOccId}".
- 4) The VNFM sends to the NFVO a lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the start of the operation.
- 5) If desired, the NFVO can poll the "VNF LCM operation occurrence" resource to obtain information about the ongoing operation by sending a GET request to the resource that represents the VNF lifecycle management operation occurrence.
- 6) In the response to that request, the VNFM returns to the NFVO information of the operation, such as the operation status, by providing in the payload body a data structure of type "VnfLcmOpOcc".
- 7) The VNFM has finished the modification operation.
- 8) The VNFM sends a lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the completion of the operation, and the performed changes.
- 9) If desired, the NFVO can send a new GET request to the "VNF LCM operation occurrence" resource.
- 10) In the response to that request, the VNFM returns to the NFVO information about the result of the operation, by providing in the payload body a data structure of type "VnfLcmOpOcc".

Postcondition: Upon successful completion, information of the VNF instance is updated.

Error handling: If the updating of VNF instance information fails, error information is provided in the notification message that reports the erroneous completion of the procedure, and is also available in the resource that represents the actual VNF lifecycle management operation occurrence related to this VNF LCM operation.

5.3.7 Flow of the Get Operation Status operation

This clause describes a sequence for obtaining the status of a VNF lifecycle management operation occurrence.

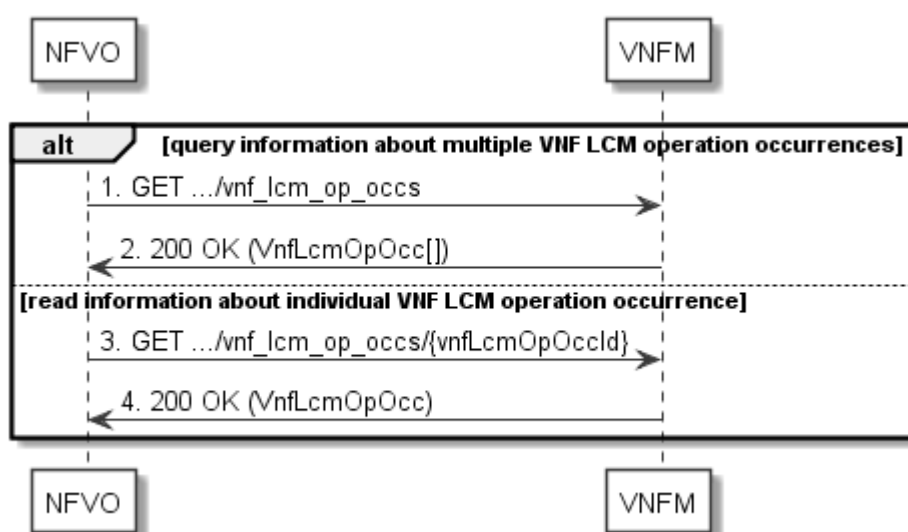


Figure 5.3.7-1: Flow of Get VNF lifecycle operation status

Obtaining the VNF lifecycle operation status, as illustrated in figure 5.3.7-1, consists of the following steps:

- 1) If the NFVO intends to query all VNF lifecycle management operation occurrences, it sends a GET request to the "VNF LCM operation occurrences" resource.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "VnfLcmOpOcc" in the payload body.
- 3) If the NFVO intends to read information about a particular VNF LCM operation occurrence, it sends a GET request to the "Individual VNF LCM operation occurrence" resource, addressed by the appropriate VNF LCM operation occurrence identifier in its resource URI.
- 4) The VNFM returns a "200 OK" response to the NFVO, and includes one data structure of type "VnfLcmOpOcc" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

5.3.8 Flow of managing subscriptions

This clause describes the procedure for creating, querying/reading and terminating subscriptions to notifications related to VNF lifecycle management.

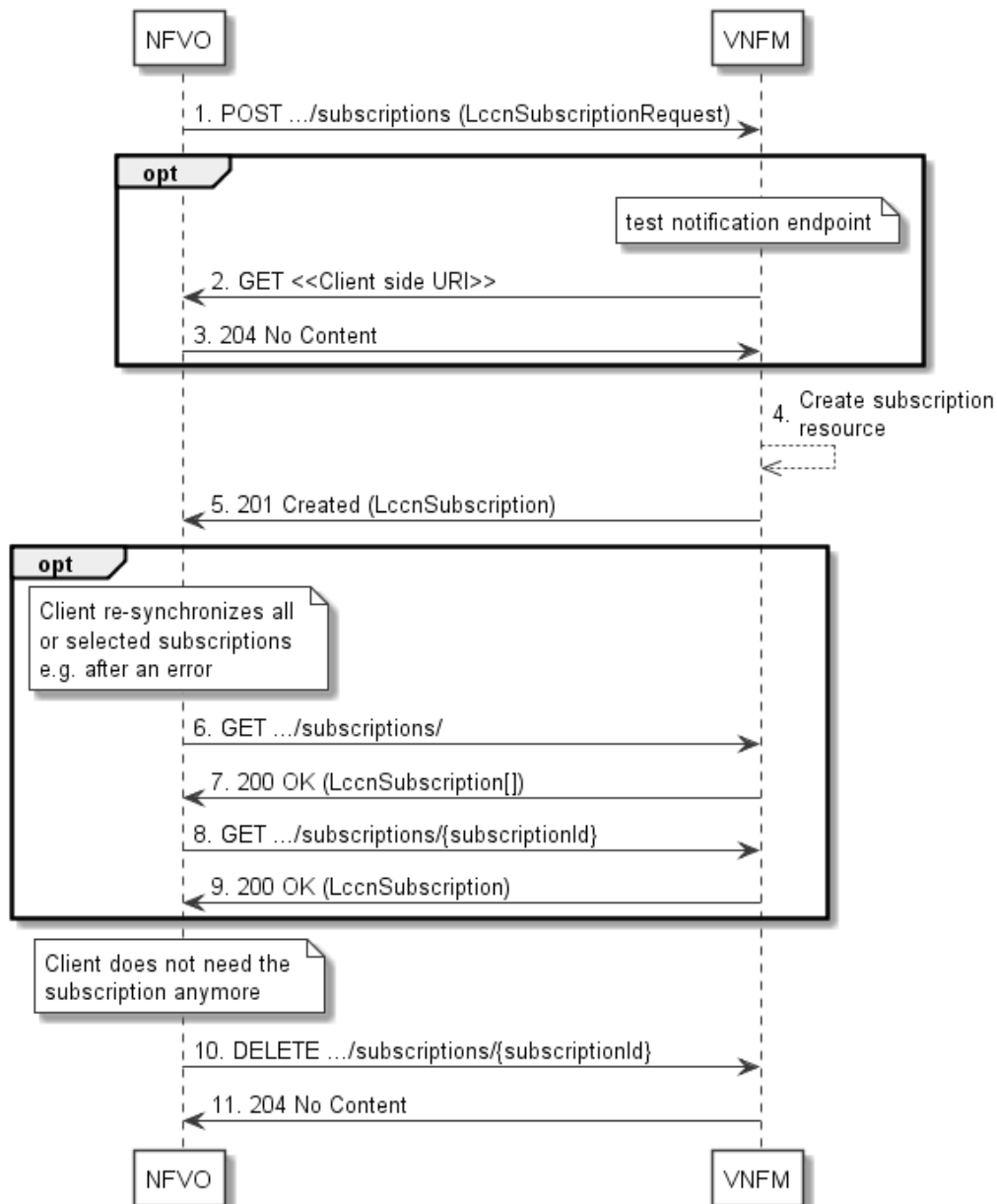


Figure 5.3.8-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 5.3.8-1:

- 1) The NFVO sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "LccnSubscriptionRequest". That data structure contains filtering criteria and a client side URI to which the VNFM will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the NFVO as part of the subscription, the VNFM sends a GET request to the notification endpoint URI.
- 3) In that case, the NFVO returns a "204 No Content" response to indicate success.
- 4) The VNFM creates a new subscription to notifications related to VNF lifecycle changes, and a resource that represents this subscription.

- 5) The VNFM returns a 201 Created response containing a data structure of type "LccnSubscription" representing the subscription resource just created by the VNFM, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) If desired, e.g. to recover from an error situation, the NFVO may query information about its subscriptions by sending a GET request to the resource representing the subscriptions.
- 7) In that case, the VNFM returns a "200 OK" response that contains zero or more representations of all existing subscriptions that were created by the NFVO.
- 8) If desired, e.g. to recover from an error situation, the NFVO may read information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the VNFM returns a "200 OK" response that contains a representation of that individual subscription.
- 10) If the NFVO does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription to remove.
- 11) The NFVO acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The VNFM rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

5.3.9 Flow of sending notifications

This clause describes the procedure for sending notifications.

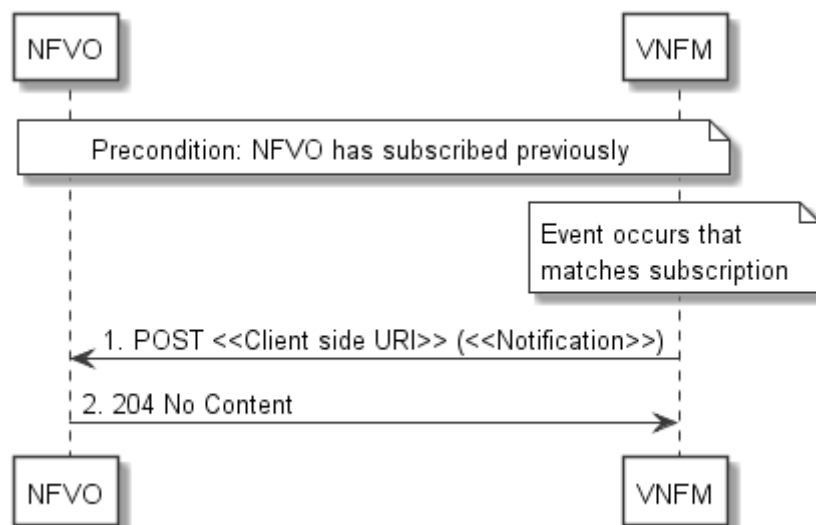


Figure 5.3.9-1: Flow of sending notifications

The procedure consists of the following steps as illustrated in figure 5.3.9-1.

Precondition: The NFVO has subscribed previously to notifications related to VNF lifecycle management.

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the VNFM generates a notification that includes information about the event, and sends it in the body of a POST request to the URI which the NFVO has registered as part of the subscription request. The variable <<Notification>> in the flow is a placeholder for the different types of notifications that can be sent by this API (see clauses 5.5.2.17 to 5.5.2.19).
- 2) The NFVO acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the VNFM does not receive the "204 No Content" response from the NFVO, it can retry sending the notification.

5.3.10 Flow of retrying a VNF lifecycle management operation

This clause describes a sequence for retrying a VNF lifecycle management operation occurrence that is represented by a "VNF LCM operation occurrence" resource. Retry is used if an operation is in FAILED_TEMP state, and there is reason to believe that the operation will eventually succeed when retried, for instance because obstacle that led to an error during the execution of the LCM operation have been removed by an automated procedure, or by manual intervention. The "retry" operation is also called "idempotent retry" because it is possible to invoke retry multiple times, without side effects.

A comprehensive description of the handling of VNF lifecycle management errors is provided in clause 5.6.

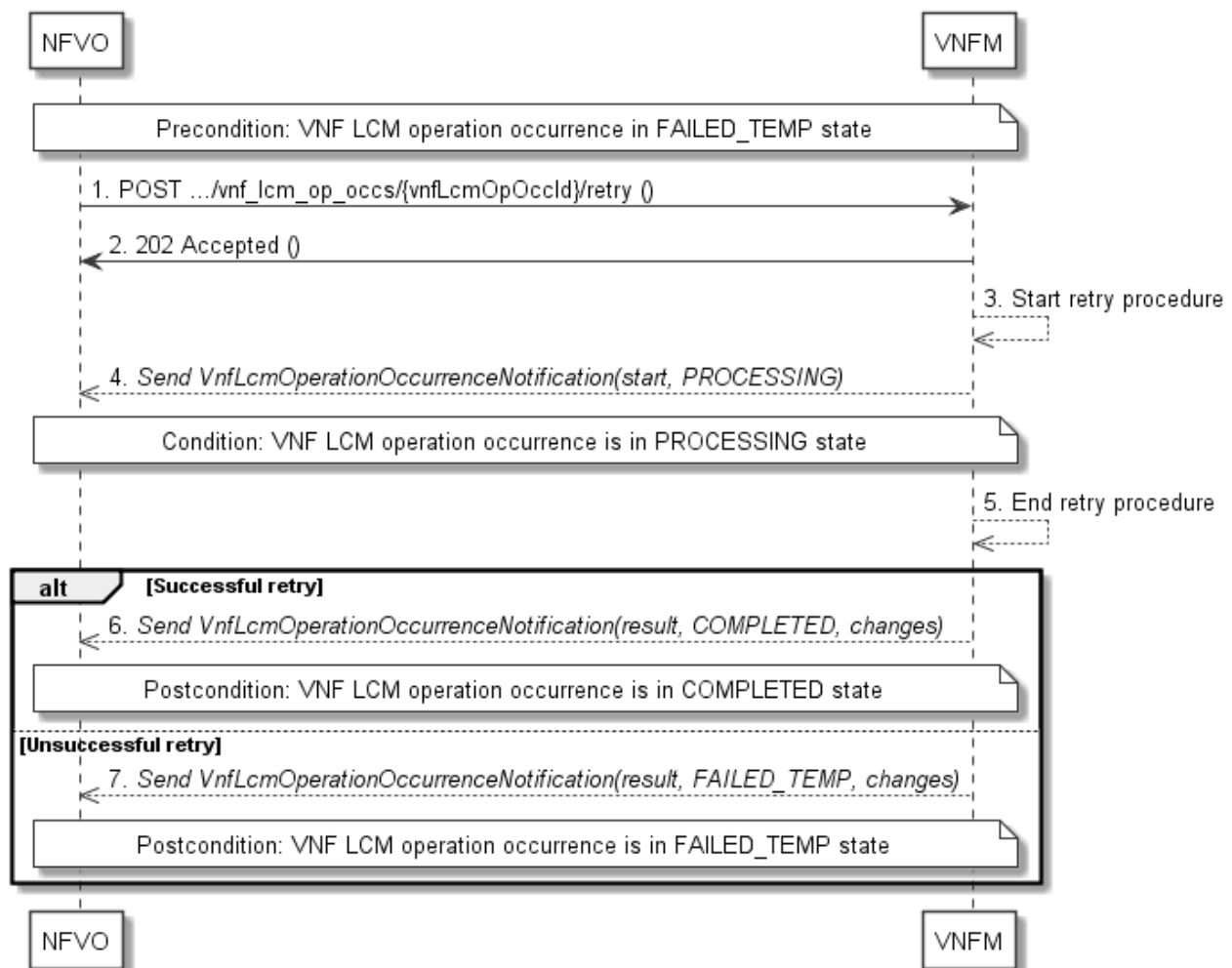


Figure 5.3.10-1: Flow of retrying a VNF lifecycle management operation

Precondition: The VNF lifecycle management operation occurrence is in FAILED_TEMP state.

Retrying a VNF lifecycle operation, as illustrated in figure 5.3.10-1, consists of the following steps:

- 1) The NFVO sends a POST request with an empty body to the "Retry operation task" resource of the VNF LCM operation occurrence that is to be retried.
- 2) The VNFM returns a "202 Accepted" response.
- 3) The VNFM starts the retry procedure.
- 4) The VNFM sends a VNF lifecycle management operation occurrence notification of type "start" to indicate that the VNF LCM operation occurrence enters the "PROCESSING" state.

- 5) The VNFM finishes the retry procedure.
- 6) On successful retry, the VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate successful completion of the operation, and inform the NFVO about the virtualised resources changes.
- 7) On unsuccessful retry, the VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate an intermediate error (retry failed) of the operation, and to inform the NFVO about the virtualised resources changes.

Postcondition: The VNF lifecycle management operation occurrence is in one of the following states: FAILED_TEMP, COMPLETED. COMPLETED is a terminal state (see clause 5.6.2.2).

Error handling: The operation is rejected in case the "VNF LCM operation occurrence" resource is in any other state than FAILED_TEMP, or in case Retry is not supported by for the particular VNF LCM operation for the particular VNF.

5.3.11 Flow of rolling back a VNF lifecycle management operation

This clause describes a sequence for rolling back a VNF lifecycle management operation occurrence that is represented by a "VNF LCM operation occurrence" resource. Rollback can be used for example if an operation is in FAILED_TEMP state, and there is no reason to believe that retrying the operation will eventually succeed.

A comprehensive description of the handling of VNF lifecycle management errors is provided in clause 5.6.

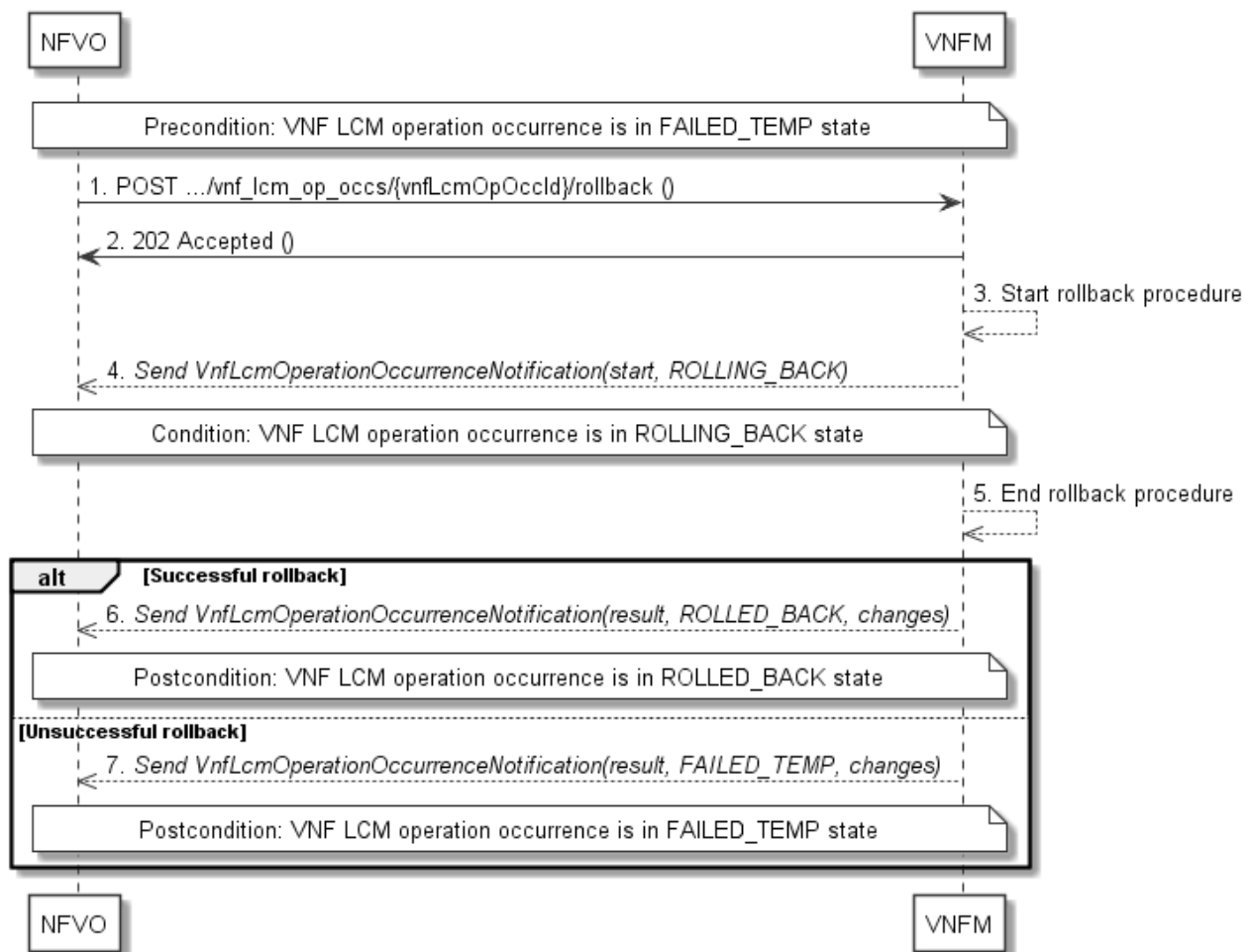


Figure 5.3.11-1: Flow of rolling back a VNF lifecycle management operation

Precondition: The VNF lifecycle management operation occurrence is in FAILED_TEMP state.

Initiating the rollback of a VNF lifecycle management operation, as illustrated in figure 5.3.11-1, consists of the following steps:

- 1) The NFVO sends a POST request with an empty body to the "Rollback operation task" resource of the VNF LCM operation occurrence that is to be rolled back.
- 2) The VNFM returns a "202 Accepted" response.
- 3) The VNFM starts the rollback procedure.
- 4) The VNFM sends a VNF lifecycle management operation occurrence notification of type "start" to indicate that the VNF LCM operation occurrence enters the "ROLLING_BACK" state.
- 5) The VNFM finishes the rollback procedure.
- 6) On successful rollback, the VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate successful completion of the operation, and inform the NFVO about the virtualised resources changes.
- 7) On unsuccessful retry, the VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate an intermediate error (rollback failed) of the operation, and to inform the NFVO about the virtualised resources changes.

Postcondition: The VNF lifecycle management operation occurrence is in one of the following states: FAILED_TEMP, ROLLED_BACK. ROLLED_BACK is a terminal state (see clause 5.6.2.2).

Error handling: The operation is rejected in case the VNF lifecycle management operation occurrence is in any other state than FAILED_TEMP, or in case Rollback is not supported for the particular VNF LCM operation for the particular VNF.

5.3.12 Flow of failing a VNF lifecycle management operation

This clause describes a sequence for declaring as "failed" a VNF lifecycle management operation occurrence that is represented by a "VNF LCM operation occurrence" resource. If there is neither an assumption that the operation can eventually succeed after further retries, nor that the operation can be successfully rolled back, the operation can be declared as "failed". This will unblock the invocation of other LCM operations, such as HealVnf, or non-graceful VNF termination, on the affected VNF instance.

A comprehensive description of the handling of VNF lifecycle management errors is provided in clause 5.6.

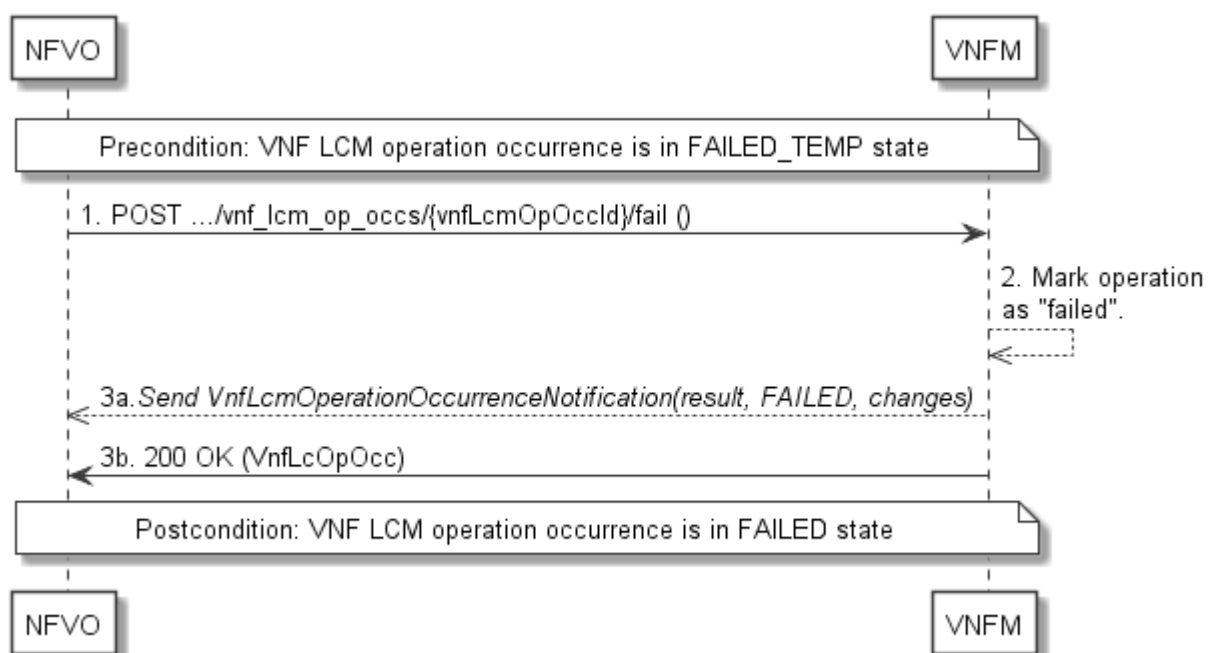


Figure 5.3.12-1: Flow of declaring a VNF lifecycle management operation as failed

Precondition: The VNF lifecycle management operation occurrence is in FAILED_TEMP state.

Declaring a VNF lifecycle management operation as failed, as illustrated in figure 5.3.12-1, consists of the following steps:

- 1) The NFVO sends a POST request with an empty body to the "Fail operation task" resource of the VNF LCM operation occurrence that is to be marked as failed.
- 2) The VNFM marks the operation as failed.
- 3) The VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate the final failure of the operation, and to inform the NFVO about the virtualised resources changes. Furthermore, it returns a "200 OK" response, and includes in the body a VnfLcmOpOcc structure. The order in which the response and the notification arrive at the NFVO is not defined.

Postcondition: The VNF lifecycle management operation occurrence is FAILED state. This is a terminal state (see clause 5.6.2.2).

Error handling: The operation is rejected in case the VNF lifecycle management operation occurrence is in any other state than FAILED_TEMP.

5.3.13 Flow of cancelling a VNF lifecycle management operation

This clause describes a sequence for cancelling an ongoing VNF LCM operation occurrence, or a rollback of a VNF LCM operation occurrence. The possibility and timing of cancellation is dependent on the implementation of the underlying lifecycle management operation.

A comprehensive description of the handling of VNF lifecycle management errors is provided in clause 5.6.

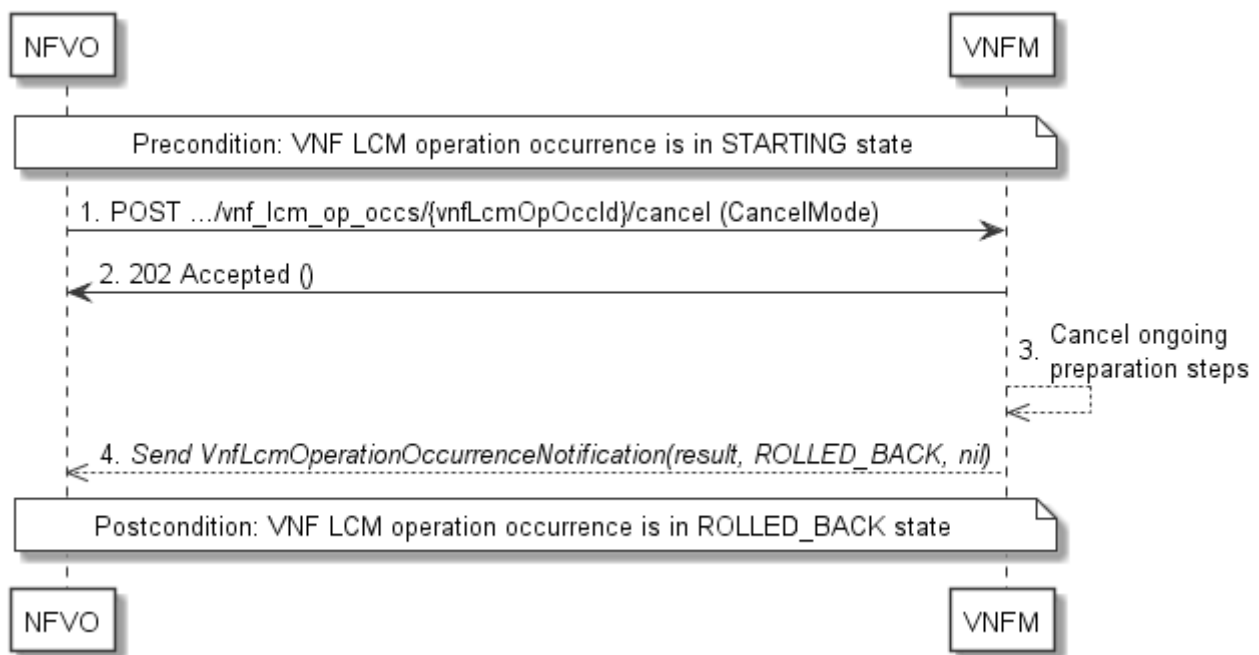


Figure 5.3.13-1: Flow of cancelling a VNF lifecycle management operation in "STARTING" state

Precondition: The VNF lifecycle management operation occurrence is in STARTING state.

Cancelling a VNF lifecycle operation when it is in STARTING state, as illustrated in figure 5.3.13-1, consists of the following steps:

- 1) The NFVO sends a POST request with "CancelMode" structure in the body to the "Cancel operation task" resource of the VNF LCM operation occurrence that is to be cancelled.
- 2) The VNFM returns a "202 Accepted" response.

- 3) The VNFM cancels the ongoing preparation operations.
- 4) The VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate an intermediate error (cancelled) of the operation, and to inform the NFVO that there were no virtualised resources changes.

Postcondition: The VNF lifecycle management operation occurrence is in ROLLED_BACK state.

Error handling: The operation is rejected in case the VNF lifecycle management operation occurrence is in any other state than STARTING.

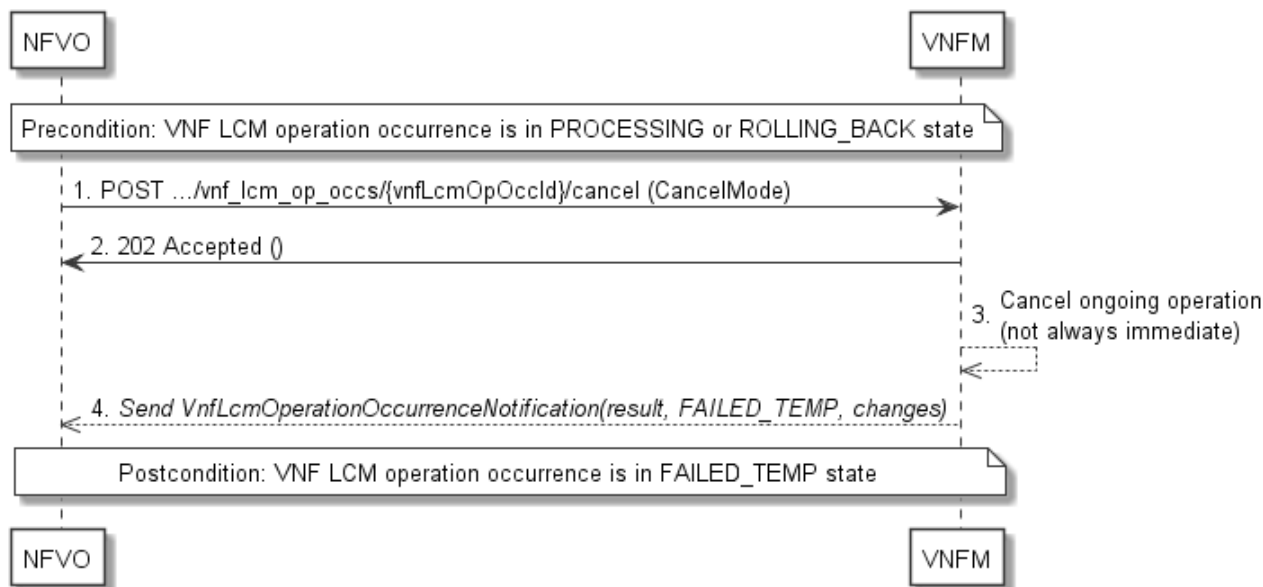


Figure 5.3.13-2: Flow of cancelling a VNF lifecycle management operation in "PROCESSING" or "ROLLING_BACK" state

Precondition: The VNF lifecycle management operation occurrence is in PROCESSING or ROLLING_BACK state.

Cancelling a VNF lifecycle management operation when it is in "PROCESSING" or "ROLLING_BACK" state, as illustrated in figure 5.3.13-2, consists of the following steps:

- 1) The NFVO sends a POST request with a "CancelMode" structure in the body to the "Cancel operation task" resource of the VNF LCM operation occurrence that is to be cancelled.
- 2) The VNFM returns a "202 Accepted" response.
- 3) The VNFM cancels the ongoing LCM operation. This can take some time.
- 4) The VNFM sends a VNF lifecycle management operation occurrence notification (see clause 5.3.9) to indicate an intermediate error (cancelled) of the operation, and to inform the NFVO about the virtualised resources changes.

Postcondition: The VNF lifecycle management operation occurrence is FAILED_TEMP state.

Error handling: The operation is rejected in case the VNF lifecycle management operation occurrence is in any other state than PROCESSING or ROLLING_BACK, or in case Cancel is not supported for the particular VNF LCM operation for the particular VNF.

5.4 Resources

5.4.1 Introduction

This clause defines all the resources and methods provided by the VNF lifecycle management interface.

5.4.2 Resource: VNF instances

5.4.2.1 Description

This resource represents VNF instances. The client can use this resource to create individual VNF instance resources, and to query VNF instances.

5.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_instances

This resource shall support the resource URI variables defined in table 5.4.2.2-1.

Table 5.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

5.4.2.3 Resource methods

5.4.2.3.1 POST

The POST method creates a new VNF instance resource.

This method shall follow the provisions specified in the tables 5.4.2.3.1-1 and 5.4.2.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.2.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.2.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	CreateVnfRequest	1	The VNF creation parameters, as defined in clause 5.5.2.3	
Response body	Data type	Cardinality	Response Codes	Description
	VnfInstance	1	201 Created	A VNF Instance identifier was created successfully. The response body shall contain a representation of the created VNF instance, as defined in clause 5.5.2.2. The HTTP response shall include a "Location" HTTP header that contains the resource URI of the created VNF instance.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.2.3.2 GET

The GET method queries information about multiple VNF instances.

This method shall follow the provisions specified in the tables 5.4.2.3.2-1 and 5.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the VnfInstance and in data types referenced from it shall be supported in attribute-based filtering parameters.
all_fields	0..1	Include all complex attributes in the response. See clause 4.3.3 for details. The VNFM shall support this parameter.
fields	0..1	Complex attributes to be included into the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude_fields	0..1	Complex attributes to be excluded from the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude_default	0..1	Indicates to exclude the following complex attributes from the response. See clause 4.3.3 for details. The VNFM shall support this parameter. The following attributes shall be excluded from the VnfInstance structure in the response body if this parameter is provided, or none of the parameters "all_fields", "fields", "exclude_fields", "exclude_default" are provided: <ul style="list-style-type: none"> - vnfConfigurableProperties - vimConnectionInfo - instantiatedVnfInfo - metadata - extensions

Table 5.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfInstance	0..N	200 OK	Information about zero or more VNF instances was queried successfully. The response body shall contain representations of zero or more VNF instances, as defined in clause 5.5.2.2.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute selector. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.2.3.3 PUT

Not supported.

5.4.2.3.4 PATCH

Not supported.

5.4.2.3.5 DELETE

Not supported.

5.4.3 Resource: Individual VNF instance

5.4.3.1 Description

This resource represents an individual VNF instance. The client can use this resource to modify and delete the underlying VNF instance, and to read information about the VNF instance.

5.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}

The base resource URI variables for this resource are defined in table 5.4.3.2-1.

Table 5.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
vnfInstanceId	Identifier of the VNF instance. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.	

5.4.3.3 Resource methods

5.4.3.3.1 POST

Not supported.

5.4.3.3.2 GET

The GET method retrieves information about a VNF instance by reading an individual VNF instance resource.

This method shall follow the provisions specified in the tables 5.4.3.3.2-1 and 5.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response codes	Description
	VnfInstance	1	200 OK	Information about an individual VNF instance was queried successfully. The response body shall contain a representation of the VNF instance, as defined in clause 5.5.2.2.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.3.3.3 PUT

Not supported.

5.4.3.3.4 PATCH

This method modifies an individual VNF instance resource.

Changes to the VNF configurable properties are applied to the configuration in the VNF instance, and are reflected in the representation of this resource. Other changes are applied to the VNF instance information managed by the VNFM, and are reflected in the representation of this resource.

This method shall follow the provisions specified in the tables 5.4.3.3.4-1 and 5.4.3.3.4-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.3.3.4-1: URI query parameters supported by the PATCH method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.3.3.4-2: Details of the PATCH request/response on this resource

Request body	Data type	Cardinality	Description	
	VnfInfoModifications	1	Parameters for the VNF modification, as defined in clause 5.5.2.12.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but the processing has not been completed. On success, the HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the VNF instance resource. Typically, this is due to the fact that another LCM operation is ongoing. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	0..1	412 Precondition failed	Error: A precondition given in an HTTP request header is not fulfilled. Typically, this is due to an ETag mismatch, indicating that the resource was modified by another entity. The response body should contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.3.3.5 DELETE

This method deletes an individual VNF instance resource.

This method shall follow the provisions specified in the tables 5.4.3.3.5-1 and 5.4.3.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.3.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.3.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The VNF instance resource and the associated VNF identifier were deleted successfully. The response body shall be empty.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the resource. Typically, this is due to the fact that the VNF instance resource is in INSTANTIATED state. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.4 Resource: Instantiate VNF task

5.4.4.1 Description

This task resource represents the "Instantiate VNF" operation. The client can use this resource to instantiate a VNF instance.

5.4.4.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}/instantiate

This resource shall support the resource URI variables defined in table 5.4.4.2-1.

Table 5.4.4.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	The identifier of the VNF instance to be instantiated. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.4.3 Resource methods

5.4.4.3.1 POST

The POST method instantiates a VNF instance.

This method shall follow the provisions specified in the tables 5.4.4.3.1-1 and 5.4.4.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.4.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.4.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	InstantiateVnfRequest	1	Parameters for the VNF instantiation, as defined in clause 5.5.2.4.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but the processing has not been completed. The response body shall be empty. The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the resource. Typically, this is due to the fact that the VNF instance resource is in INSTANTIATED state. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.4.3.2 GET

Not supported.

5.4.4.3.3 PUT

Not supported.

5.4.4.3.4 PATCH

Not supported.

5.4.4.3.5 DELETE

Not supported.

5.4.5 Resource: Scale VNF task**5.4.5.1 Description**

This task resource represents the "Scale VNF" operation. The client can use this resource to request scaling a VNF instance.

It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF.

See clause B.2 in Annex B for an explanation of VNF scaling.

5.4.5.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}/scale

This resource shall support the resource URI variables defined in table 5.4.5.2-1.

Table 5.4.5.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
vnfInstanceId	Identifier of the VNF instance to be scaled. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.5.3 Resource methods

5.4.5.3.1 POST

The POST method requests to scale a VNF instance resource incrementally.

This method shall follow the provisions specified in the tables 5.4.5.3.1-1 and 5.4.5.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.5.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.5.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	ScaleVnfRequest	1	Parameters for the scale VNF operation, as defined in clause 5.5.2.5.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	<p>The request was accepted for processing, but the processing has not been completed.</p> <p>The response body shall be empty.</p> <p>The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.</p>
	ProblemDetails	0..1	404 Not Found	<p>Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists.</p> <p>The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body.</p> <p>Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF instance represented by the parent resource, and that the task resource consequently does not exist.</p> <p>In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	1	409 Conflict	<p>Error: The operation cannot be executed currently, due to a conflict with the state of the resource.</p> <p>Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.5.3.2 GET

Not supported.

5.4.5.3.3 PUT

Not supported.

5.4.5.3.4 PATCH

Not supported.

5.4.5.3.5 DELETE

Not supported.

5.4.6 Resource: Scale VNF to Level task

5.4.6.1 Description

This task resource represents the "Scale VNF to Level" operation. The client can use this resource to request scaling of a VNF instance to a target level.

It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF.

See clause B.2 in Annex B for an explanation of VNF scaling.

5.4.6.2 Resource definition

The resource URI is:

{apiRoot}/vnfncm/v1/vnf_instances/{vnfInstanceId}/scale_to_level

This resource shall support the resource URI variables defined in table 5.4.6.2-1.

Table 5.4.6.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
vnfInstanceId	Identifier of the VNF instance to be scaled to a target level. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.6.3 Resource methods

5.4.6.3.1 POST

The POST method requests to scale a VNF instance resource to a target level.

This method shall follow the provisions specified in the tables 5.4.6.3.1-1 and 5.4.6.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.6.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.6.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	ScaleVnfToLevelRequest	1	Parameters for the scale VNF to Level operation, as defined in clause 5.5.2.6.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	<p>The request was accepted for processing, but the processing has not been completed.</p> <p>The response body shall be empty.</p> <p>The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.</p>
	ProblemDetails	0..1	404 Not Found	<p>Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists.</p> <p>The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body.</p> <p>Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF instance represented by the parent resource, and that the task resource consequently does not exist.</p> <p>In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	1	409 Conflict	<p>Error: The operation cannot be executed currently, due to a conflict with the state of the resource.</p> <p>Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.	

5.4.6.3.2 GET

Not supported.

5.4.6.3.3 PUT

Not supported.

5.4.6.3.4 PATCH

Not supported.

5.4.6.3.5 DELETE

Not supported.

5.4.7 Resource: Change VNF Flavour task

5.4.7.1 Description

This task resource represents the "Change VNF Flavour" operation. The client can use this resource to change the deployment flavour for a VNF instance.

It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF. This operation may be service-disruptive.

5.4.7.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_instances/{vnfInstanceId}/change_flavour

This resource shall support the resource URI variables defined in table 5.4.7.2-1.

Table 5.4.7.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	The identifier of the VNF instance of which the deployment flavour is requested to be changed. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.7.3 Resource methods

5.4.7.3.1 POST

The POST method changes the deployment flavour of a VNF instance.

This method shall follow the provisions specified in the tables 5.4.7.3.1-1 and 5.4.7.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.7.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.7.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	ChangeVnfFlavourRequest	1	Parameters for the Change VNF Flavour operation, as defined in clause 5.5.2.7.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	<p>The request was accepted for processing, but the processing has not been completed.</p> <p>The response body shall be empty.</p> <p>The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.</p>
	ProblemDetails	0..1	404 Not Found	<p>Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists.</p> <p>The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body.</p> <p>Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF instance represented by the parent resource, and that the task resource consequently does not exist.</p> <p>In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	1	409 Conflict	<p>Error: The operation cannot be executed currently, due to a conflict with the state of the resource.</p> <p>Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.7.3.2 GET

Not supported.

5.4.7.3.3 PUT

Not supported.

5.4.7.3.4 PATCH

Not supported.

5.4.7.3.5 DELETE

Not supported.

5.4.8 Resource: Terminate VNF task

5.4.8.1 Description

This task resource represents the "Terminate VNF" operation. The client can use this resource to terminate a VNF instance.

5.4.8.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_instances/{vnfInstanceId}/terminate

This resource shall support the resource URI variables defined in table 5.4.8.2-1.

Table 5.4.8.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	The identifier of the VNF instance to be terminated. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.8.3 Resource methods

5.4.8.3.1 POST

The POST method terminates a VNF instance.

This method shall follow the provisions specified in the tables 5.4.8.3.1-1 and 5.4.8.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.8.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.8.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	TerminateVnfRequest	1	Parameters for the VNF termination, as defined in clause 5.5.2.8.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but the processing has not been completed. The response body shall be empty. The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the resource. Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.8.3.2 GET

Not supported.

5.4.8.3.3 PUT

Not supported.

5.4.8.3.4 PATCH

Not supported.

5.4.8.3.5 DELETE

Not supported.

5.4.9 Resource: Heal VNF task

5.4.9.1 Description

This task resource represents the "Heal VNF" operation. The client can use this resource to request healing a VNF instance.

It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF.

5.4.9.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}/heal

This resource shall support the resource URI variables defined in table 5.4.9.2-1.

Table 5.4.9.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	Identifier of the VNF instance to be healed. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.9.3 Resource methods

5.4.9.3.1 POST

The POST method requests to heal a VNF instance resource.

This method shall follow the provisions specified in the tables 5.4.9.3.1-1 and 5.4.9.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.9.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.9.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	HealVnfRequest	1	Parameters for the Heal VNF operation, as defined in clause 5.5.2.9.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	<p>The request was accepted for processing, but the processing has not been completed.</p> <p>The response body shall be empty.</p> <p>The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.</p>
	ProblemDetails	0..1	404 Not Found	<p>Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists.</p> <p>The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body.</p> <p>Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF instance represented by the parent resource, and that the task resource consequently does not exist.</p> <p>In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	1	409 Conflict	<p>Error: The operation cannot be executed currently, due to a conflict with the state of the resource.</p> <p>Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	<p>In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.</p>

5.4.9.3.2 GET

Not supported.

5.4.9.3.3 PUT

Not supported.

5.4.9.3.4 PATCH

Not supported.

5.4.9.3.5 DELETE

Not supported.

5.4.10 Resource: Operate VNF task

5.4.10.1 Description

This task resource represents the "Operate VNF" operation. The client can use this resource to operate a VNF.

It depends on the VNF capabilities, and is declared in the VNFD, whether this operation is supported for a particular VNF.

The "Operate VNF" operation enables requesting to change the operational state of a VNF instance, including starting and stopping the VNF instance.

NOTE 1: These operations are complementary to instantiating and terminating a VNF.

NOTE 2: In the present document, only starting and stopping the VNF instances is supported. Extension of this operation to support other VNF state changes is left for future specification.

A VNF instance can be in the following states:

STARTED: the VNF instance is up and running.

STOPPED: the VNF instance has been shut down. A VNF instance is stopped if all its VNFC instances are also stopped.

In the state STOPPED, the virtualisation containers, where the VNFC instances of the VNF run, are shut down but not deleted. In addition, if the workflow requires a graceful stop, as part of this process the VNFM (producer of the interface) will interact with VNF/EM to gracefully stop the VNF application. Once a VNF is instantiated, i.e. all instantiation steps have been completed, the VNF instance is in the state STARTED.

5.4.10.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}/operate

This resource shall support the resource URI variables defined in table 5.4.10.2-1.

Table 5.4.10.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	Identifier of the VNF instance to be operated. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.10.3 Resource methods

5.4.10.3.1 POST

The POST method changes the operational state of a VNF instance resource.

This method shall follow the provisions specified in the tables 5.4.10.3.1-1 and 5.4.10.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.10.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.10.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	OperateVnfRequest	1	Parameters for the Operate VNF operation, as defined in clause 5.5.2.10.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	<p>The request was accepted for processing, but the processing has not been completed.</p> <p>The response body shall be empty.</p> <p>The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the operation.</p>
	ProblemDetails	0..1	404 Not Found	<p>Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists.</p> <p>The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body.</p> <p>Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF instance represented by the parent resource, and that the task resource consequently does not exist.</p> <p>In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
	ProblemDetails	1	409 Conflict	<p>Error: The operation cannot be executed currently, due to a conflict with the state of the resource.</p> <p>Typically, this is due to the fact that the VNF instance resource is in NOT_INSTANTIATED state, or that another lifecycle management operation is ongoing.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.</p>
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5		4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.10.3.2 GET

Not supported.

5.4.10.3.3 PUT

Not supported.

5.4.10.3.4 PATCH

Not supported.

5.4.10.3.5 DELETE

Not supported.

5.4.11 Resource: Change external VNF connectivity task

5.4.11.1 Description

This task resource represents the "Change external VNF connectivity" operation. The client can use this resource to change the external connectivity of a VNF instance. The types of changes that this operation supports are:

- Disconnect the external CPs that are connected to a particular external VL, and connect them to a different external VL.
- Change the connectivity parameters of the existing external CPs, including changing addresses.

NOTE: Depending on the capabilities of the underlying VIM resources, certain changes (e.g. modifying the IP address assignment) might not be supported without deleting the resource and creating another one with the modified configuration.

VNFs shall support this operation. This operation may be service-disruptive.

5.4.11.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_instances/{vnfInstanceId}/change_ext_vls

This resource shall support the resource URI variables defined in table 5.4.11.2-1.

Table 5.4.11.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	Identifier of the VNF instance of which the external connectivity is requested to be changed. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.11.3 Resource methods

5.4.11.3.1 POST

The POST method changes the external connectivity of a VNF instance.

This method shall follow the provisions specified in the tables 5.4.11.3.1-1 and 5.4.11.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.11.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.11.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
ChangeExtVnfConnectivity Request		1	Parameters for the Change external VNF connectivity operation, as defined in clause 5.5.2.11.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but the processing has not been completed. The response body shall be empty. The HTTP response shall include a "Location" HTTP header that contains the URI of the newly-created "VNF LCM operation occurrence" resource corresponding to the instantiation operation.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the resource. Typically, this is due to the fact that another lifecycle management operation is ongoing. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5		4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.11.3.2 GET

Not supported.

5.4.11.3.3 PUT

Not supported.

5.4.11.3.4 PATCH

Not supported.

5.4.11.3.5 DELETE

Not supported.

5.4.12 Resource: VNF LCM operation occurrences

5.4.12.1 Description

This resource represents VNF lifecycle management operation occurrences. The client can use this resource to query status information about multiple VNF lifecycle management operation occurrences.

5.4.12.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_lcm_op_occs

The base resource URI variables for this resource are defined in table 5.4.12.2-1.

Table 5.4.12.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

5.4.12.3 Resource methods

5.4.12.3.1 POST

Not supported.

5.4.12.3.2 GET

The client can use this method to query status information about multiple VNF lifecycle management operation occurrences.

This method shall follow the provisions specified in the tables 5.4.12.3.2-1 and 5.4.12.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.12.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the VnfLcmOpOcc and in data types referenced from it shall be supported in attribute-based filtering parameters.
all_fields	0..1	Include all complex attributes in the response. See clause 4.3.3 for details. The VNFM shall support this parameter.
fields	0..1	Complex attributes to be included into the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude_fields	0..1	Complex attributes to be excluded from the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude_default	0..1	Indicates to exclude the following complex attributes from the response. See clause 4.3.3 for details. The VNFM shall support this parameter. The following attributes shall be excluded from the VnfLcmOpOcc structure in the response body if this parameter is provided , or none of the parameters "all_fields", "fields", "exclude_fields", "exclude_default" are provided: <ul style="list-style-type: none"> - operationParams - error - resourceChanges - changedInfo changedExtVirtualLinks.

Table 5.4.12.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfLcmOpOcc	0..N	200 OK	Status information for zero or more VNF lifecycle management operation occurrences was queried successfully. The response body shall contain status information about zero or more VNF lifecycle operation occurrences, as defined in clause 5.5.2.13.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute selector. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.12.3.3 PUT

Not supported.

5.4.12.3.4 PATCH

Not supported.

5.4.12.3.5 DELETE

Not supported.

5.4.13 Resource: Individual VNF LCM operation occurrence

5.4.13.1 Description

This resource represents a VNF lifecycle management operation occurrence. The client can use this resource to read status information about an individual VNF lifecycle management operation occurrence. Further, the client can use task resources which are children of this resource to request cancellation of an operation in progress, and to request the handling of operation errors via retrying the operation, rolling back the operation, or permanently failing the operation.

5.4.13.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_lcm_op_occs/{vnfLcmOpOccId}

The base resource URI variables for this resource are defined in table 5.4.13.2-1.

Table 5.4.13.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfLcmOpOcclId	Identifier of a VNF lifecycle management operation occurrence. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a PATCH or POST request triggering a VNF LCM operation. It can also be retrieved from the "vnfLcmOpOcclId" attribute in the VnfLcmOperationOccurrenceNotification.	

5.4.13.3 Resource methods

5.4.13.3.1 POST

Not supported.

5.4.13.3.2 GET

The client can use this method to retrieve status information about a VNF lifecycle management operation occurrence by reading an individual "VNF LCM operation occurrence" resource.

This method shall follow the provisions specified in the tables 5.4.13.3.2-1 and 5.4.13.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.13.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.13.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfLcmOpOcc	1	200 OK	Information about an individual VNF instance was queried successfully. The response body shall contain status information about a VNF lifecycle management operation occurrence (see clause 5.5.2.13).
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.13.3.3 PUT

Not supported.

5.4.13.3.4 PATCH

Not supported.

5.4.13.3.5 DELETE

Not supported.

5.4.14 Resource: Retry operation task

5.4.14.1 Description

This task resource represents the "Retry operation" operation. The client can use this resource to initiate retrying a VNF lifecycle operation.

5.4.14.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_lcm_op_occs/{vnfLcmOpOccId}/retry

This resource shall support the resource URI variables defined in table 5.4.14.2-1.

Table 5.4.14.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfLcmOpOccId	Identifier of a VNF lifecycle management operation occurrence to be retried. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a PATCH or POST request triggering a VNF LCM operation. It can also be retrieved from the "vnfLcmOpOccId" attribute in the VnfLcmOperationOccurrenceNotification.	

5.4.14.3 Resource methods

5.4.14.3.1 POST

The POST method initiates retrying a VNF lifecycle operation if that operation has experienced a temporary failure, i.e. the related "VNF LCM operation occurrence" resource is in "FAILED_TEMP" state.

This method shall follow the provisions specified in the tables 5.4.14.3.1-1 and 5.4.14.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.14.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.14.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a		The POST request to this resource has an empty payload body.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but processing has not been completed. The response shall have an empty payload body.
	ProblemDetails	0..1	404 Not Found	Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists. The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body. Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF LCM operation occurrence represented by the parent resource, and that the task resource consequently does not exist. In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the VNF LCM operation occurrence resource. Typically, this is due to the fact that the VNF LCM operation occurrence is not in FAILED_TEMP state, or another error handling action is starting, such as rollback or fail. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.14.3.2 GET

Not supported.

5.4.14.3.3 PUT

Not supported.

5.4.14.3.4 PATCH

Not supported.

5.4.14.3.5 DELETE

Not supported.

5.4.15 Resource: Rollback operation task

5.4.15.1 Description

This task resource represents the "Rollback operation" operation. The client can use this resource to initiate rolling back a VNF lifecycle operation.

5.4.15.2 Resource definition

The resource URI is:

{apiRoot}/vnfcm/v1/vnf_lcm_op_occs/{vnfLcmOpOccId}/rollback

This resource shall support the resource URI variables defined in table 5.4.15.2-1.

Table 5.4.15.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfLcmOpOccId	Identifier of a VNF lifecycle management operation occurrence to be rolled back. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a PATCH or POST request triggering a VNF LCM operation. It can also be retrieved from the "vnfLcmOpOccId" attribute in the VnfLcmOperationOccurrenceNotification.	

5.4.15.3 Resource methods

5.4.15.3.1 POST

The POST method initiates rolling back a VNF lifecycle operation if that operation has experienced a temporary failure, i.e. the related "VNF LCM operation occurrence" resource is in "FAILED_TEMP" state.

This method shall follow the provisions specified in the tables 5.4.15.3.1-1 and 5.4.15.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.15.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.15.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a		The POST request to this resource has an empty payload body.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but processing has not been completed. The response shall have an empty payload body.
	ProblemDetails	0..1	404 Not Found	Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists. The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body. Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF LCM operation occurrence represented by the parent resource, and that the task resource consequently does not exist. In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the VNF LCM operation occurrence resource. Typically, this is due to the fact that the VNF LCM operation occurrence is not in FAILED_TEMP state, or another error handling action is starting, such as retry or fail. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.15.3.2 GET

Not supported.

5.4.15.3.3 PUT

Not supported.

5.4.15.3.4 PATCH

Not supported.

5.4.15.3.5 DELETE

Not supported.

5.4.16 Resource: Fail operation task

5.4.16.1 Description

This task resource represents the "Fail operation" operation. The client can use this resource to mark a VNF lifecycle management operation occurrence as "finally failed", i.e. change the state of the related VNF LCM operation occurrence resource to "FAILED", if it is not assumed that a subsequent retry or rollback will succeed. Once the operation is marked as "finally failed", it cannot be retried or rolled back anymore.

5.4.16.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/vnf_lcm_op_occs/{vnfLcmOpOccId}/fail

This resource shall support the resource URI variables defined in table 5.4.16.2-1.

Table 5.4.16.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfLcmOpOccId	Identifier of a VNF lifecycle management operation occurrence to be marked as "failed". See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a PATCH or POST request triggering a VNF LCM operation. It can also be retrieved from the "vnfLcmOpOccId" attribute in the VnfLcmOperationOccurrenceNotification.

5.4.16.3 Resource methods

5.4.16.3.1 POST

The POST method marks a VNF lifecycle management operation occurrence as "finally failed" if that operation occurrence is in "FAILED_TEMP" state.

This method shall follow the provisions specified in the tables 5.4.16.3.1-1 and 5.4.16.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.16.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.16.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			The POST request to this resource has an empty payload body.
Response body	Data type	Cardinality	Response Codes	Description
	VnfLcmOpOcc	1	200 OK	The state of the VNF lifecycle management operation occurrence was changed successfully The response shall include a representation of the VNF lifecycle operation occurrence resource.
	ProblemDetails	0..1	404 Not Found	Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists. The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body. Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF LCM operation occurrence represented by the parent resource, and that the task resource consequently does not exist. In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the VNF LCM operation occurrence resource. Typically, this is due to the fact that the VNF LCM operation occurrence is not in FAILED_TEMP state, or another error handling action is starting, such as retry or rollback. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.16.3.2 GET

Not supported.

5.4.16.3.3 PUT

Not supported.

5.4.16.3.4 PATCH

Not supported.

5.4.16.3.5 DELETE

Not supported.

5.4.17 Resource: Cancel operation task

5.4.17.1 Description

This task resource represents the "Cancel operation" operation. The client can use this resource to cancel an ongoing VNF lifecycle operation.

5.4.17.2 Resource definition

The resource URI is:

{apiRoot}/vnf_lcm/v1/vnf_lcm_op_occs/{vnfLcmOpOccId}/cancel

This resource shall support the resource URI variables defined in table 5.4.17.2-1.

Table 5.4.17.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfLcmOpOccId	Identifier of a VNF lifecycle management operation occurrence to be cancelled. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a PATCH or POST request triggering a VNF LCM operation. It can also be retrieved from the "vnfLcmOpOccId" attribute in the VnfLcmOperationOccurrenceNotification.	

5.4.17.3 Resource methods

5.4.17.3.1 POST

The POST method initiates cancelling an ongoing VNF lifecycle operation while it is being executed or rolled back, i.e. the related "VNF LCM operation occurrence" is either in "PROCESSING" or "ROLLING_BACK" state.

This method shall follow the provisions specified in the tables 5.4.17.3.1-1 and 5.4.17.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.17.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.17.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	CancelMode	1	The POST request to this resource shall include a CancelMode structure in the payload body to choose between "graceful" and "forceful" cancellation.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		202 Accepted	The request was accepted for processing, but processing has not been completed. The response shall have an empty payload body.
	ProblemDetails	0..1	404 Not Found	Error: The API producer did not find a current representation for the target resource or is not willing to disclose that one exists. The general cause for this error and its handling is specified in clause 4.3.5.4, including rules for the presence of the response body. Specifically in case of this task resource, the reason can also be that the task is not supported for the VNF LCM operation occurrence represented by the parent resource, and that the task resource consequently does not exist. In this case, the response body shall be present, and shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the VNF LCM operation occurrence resource. Typically, this is due to the fact that the operation occurrence is not in STARTING, PROCESSING or ROLLING_BACK state. The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.17.3.2 GET

Not supported.

5.4.17.3.3 PUT

Not supported.

5.4.17.3.4 PATCH

Not supported.

5.4.17.3.5 DELETE

Not supported.

5.4.18 Resource: Subscriptions

5.4.18.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to VNF lifecycle management, and to query its subscriptions.

5.4.18.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/subscriptions

This resource shall support the resource URI variables defined in table 5.4.18.2-1.

Table 5.4.18.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

5.4.18.3 Resource methods

5.4.18.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 5.4.18.3.1-1 and 5.4.18.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.18.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.18.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	LccnSubscriptionRequest	1	Details of the subscription to be created, as defined in clause 5.5.2.15.	
Response body	Data type	Cardinality	Response Codes	Description
	LccnSubscription	1	201 Created	The subscription was created successfully. The response body shall contain a representation of the created subscription resource. The HTTP response shall include a "Location" HTTP header that points to the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.18.3.2 GET

The GET method queries the list of active subscriptions of the functional block that invokes the method. It can be used e.g. for resynchronization after error situations.

This method shall follow the provisions specified in the tables 5.4.18.3.2-1 and 5.4.18.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.18.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the LccnSubscription and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 5.4.18.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	LccnSubscription	0..N	200 OK	The list of subscriptions was queried successfully. The response body shall contain the representations of all active subscriptions of the functional block that invokes the method.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.18.3.3 PUT

Not supported.

5.4.18.3.4 PATCH

Not supported.

5.4.18.3.5 DELETE

Not supported.

5.4.19 Resource: Individual subscription

5.4.19.1 Description

This resource represents an individual subscription. The client can use this resource to read and to terminate a subscription to notifications related to VNF lifecycle management.

5.4.19.2 Resource definition

The resource URI is:

{apiRoot}/vnflcm/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 5.4.19.2-1.

Table 5.4.19.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
subscriptionId	Identifier of this subscription. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.

5.4.19.3 Resource methods

5.4.19.3.1 POST

Not supported.

5.4.19.3.2 GET

The GET method retrieves information about a subscription by reading an individual subscription resource.

This method shall follow the provisions specified in the tables 5.4.19.3.2-1 and 5.4.19.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.19.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.19.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	LccnSubscription	1	200 OK	The operation has completed successfully. The response body shall contain a representation of the subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.19.3.3 PUT

Not supported.

5.4.19.3.4 PATCH

Not supported.

5.4.19.3.5 DELETE

The DELETE method terminates an individual subscription.

This method shall follow the provisions specified in the tables 5.4.19.3.5-1 and 5.4.19.3.3-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.19.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.19.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

5.4.20 Resource: Notification endpoint

5.4.20.1 Description

This resource represents a notification endpoint. The API producer can use this resource to send notifications related to VNF lifecycle changes to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

5.4.20.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 5.4.20.2-1.

Table 5.4.20.2-1: Resource URI variables for this resource

Name	Definition
n/a	

5.4.20.3 Resource methods

5.4.20.3.1 POST

The POST method delivers a notification from the server to the client.

This method shall follow the provisions specified in the tables 5.4.20.3.1-1 and 5.4.20.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.20.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Each notification request body shall include exactly one of the alternatives defined in table 5.4.20.3.1-2.

Table 5.4.20.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VnfLcmOperationOccurrenceNotification	1	A notification about lifecycle changes triggered by a VNF LCM operation occurrence.	
	VnfIdentifierCreationNotification	1	A notification about the creation of a VNF identifier and the related VNF instance resource.	
	VnfIdentifierDeletionNotification	1	A notification about the deletion of a VNF identifier and the related VNF instance resource.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned. The VNFM shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

5.4.20.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 5.4.20.3.2-1 and 5.4.20.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 5.4.20.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 5.4.20.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

5.4.20.3.3 PUT

Not supported.

5.4.20.3.4 PATCH

Not supported.

5.4.20.3.5 DELETE

Not supported.

5.5 Data model

5.5.1 Introduction

This clause defines the request and response data structures of the VNF Lifecycle management interface. If a request or response contains attributes not defined in the present specification, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

5.5.2 Resource and notification data types

5.5.2.1 Introduction

This clause defines the data structures to be used in resource representations and notifications.

5.5.2.2 Type: VnflInstance

This type represents a VNF instance. It shall comply with the provisions defined in table 5.5.2.2-1.

NOTE: Clause B.3.2 in Annex B provides examples illustrating the relationship among the different run-time information elements (CP, VL and link ports) used to represent the connectivity of a VNF.

Table 5.5.2.2-1: Definition of the VnfInstance data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of the VNF instance.
vnfInstanceName	String	0..1	Name of the VNF instance. This attribute can be modified with the PATCH method.
vnfInstanceDescription	String	0..1	Human-readable description of the VNF instance. This attribute can be modified with the PATCH method.
vnfdId	Identifier	1	Identifier of the VNFD on which the VNF instance is based.
vnfProvider	String	1	Provider of the VNF and the VNFD. The value is copied from the VNFD.
vnfProductName	String	1	Name to identify the VNF Product. The value is copied from the VNFD.
vnfSoftwareVersion	Version	1	Software version of the VNF. The value is copied from the VNFD.
vnfdVersion	Version	1	Identifies the version of the VNFD. The value is copied from the VNFD.
onboardedVnfPkgInfold	Identifier	1	Identifier of information held by the NFVO about the specific VNF package on which the VNF is based. This identifier was allocated by the NFVO. This attribute can be modified with the PATCH method. See note 1.
vnfConfigurableProperties	KeyValuePairs	0..1	Current values of the configurable properties of the VNF instance. Configurable properties referred in this attribute are declared in the VNFD (see note 2). They include those set as initial configuration, and/or those that modify a running configuration. See note 3. These configurable properties include the following standard attributes, which are declared in the VNFD if auto-scaling and/or auto-healing are supported by the VNF: <ul style="list-style-type: none"> - isAutoscaleEnabled: If present, the VNF supports auto-scaling. If set to true, auto-scaling is currently enabled. If set to false, auto-scaling is currently disabled. - isAutohealEnabled: If present, the VNF supports auto-healing. If set to true, auto-healing is currently enabled. If set to false, auto-healing is currently disabled. This attribute can be modified with the PATCH method.
vimConnectionInfo	VimConnectionInfo	0..N	Information about VIM connections to be used for managing the resources for the VNF instance. This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable. This attribute can be modified with the PATCH method.
instantiationState	Enum (inlined)	1	The instantiation state of the VNF. Permitted values: NOT_INSTANTIATED: The VNF instance is terminated or not instantiated. INSTANTIATED: The VNF instance is instantiated.
instantiatedVnfInfo	Structure (inlined)	0..1	Information specific to an instantiated VNF instance. This attribute shall be present if the instantiationState attribute value is INSTANTIATED.
>flavourId	IdentifierInVnfd	1	Identifier of the VNF deployment flavour applied to this VNF instance.

Attribute name	Data type	Cardinality	Description
>vnfState	VnfOperationalState Type	1	State of the VNF instance.
>scaleStatus	ScaleInfo	0..N	Scale status of the VNF, one entry per aspect. Represents for every scaling aspect how "big" the VNF has been scaled w.r.t. that aspect. This attribute shall be present if the VNF supports scaling. See clause B.2 in Annex B for an explanation of VNF scaling.
>extCplInfo	Structure (inlined)	1..N	Information about the external CPs exposed by the VNF instance.
>>id	IdentifierInVnf	1	Identifier of the external CP instance and the related information instance.
>>cpId	IdentifierInVnfd	1	Identifier of the external CPD, VnfExtCpd, in the VNFD.
>>addresses	NetworkAddressInfo	0..N	List of network addresses that have been configured (statically or dynamically) on the CP.
>extVirtualLinkInfo	ExtVirtualLinkInfo	0..N	Information about the external VLS the VNF instance is connected to.
>extManagedVirtualLinkInfo	ExtManagedVirtualLinkInfo	0..N	Information about the externally-managed internal VLS of the VNF instance.
>monitoringParameters	MonitoringParameter	0..N	Active monitoring parameters.
>localizationLanguage	String	0..1	Information about localization language of the VNF (includes e.g. strings in the VNFD). The localization languages supported by a VNF can be declared in the VNFD, and localization language selection can take place at instantiation time. The value shall comply with the format defined in IETF RFC 5646 [8].
>vnfcResourceInfo	VnfcResourceInfo	0..N	Information about the virtualised compute and storage resources used by the VNFCs of the VNF instance.
>vnfVirtualLinkResourceInfo	VnfVirtualLinkResourceInfo	0..N	Information about the virtualised network resources used by the VLS of the VNF instance.
>virtualStorageResourceInfo	VirtualStorageResourceInfo	0..N	Information about the virtualised storage resources used as storage for the VNF instance.
metadata	KeyValuePairs	0..1	Additional VNF-specific metadata describing the VNF instance. Metadata that are writeable are declared in the VNFD (see note 2). This attribute can be modified with the PATCH method.
extensions	KeyValuePairs	0..1	VNF-specific attributes that affect the lifecycle management of this VNF instance by the VNFM, or the lifecycle management scripts. Extensions that are writeable are declared in the VNFD (see note 2). This attribute can be modified with the PATCH method.
_links	Structure (inlined)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.
>indicators	Link	0..1	Indicators related to this VNF instance, if applicable.
>instantiate	Link	0..1	Link to the "instantiate" task resource, if the related operation is possible based on the current status of this VNF instance resource (i.e. VNF instance in NOT_INSTANTIATED state).
>terminate	Link	0..1	Link to the "terminate" task resource, if the related operation is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).

Attribute name	Data type	Cardinality	Description
>scale	Link	0..1	Link to the "scale" task resource, if the related operation is supported for this VNF instance, and is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
>scaleToLevel	Link	0..1	Link to the "scale_to_level" task resource, if the related operation is supported for this VNF instance, and is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
>changeFlavour	Link	0..1	Link to the "change_flavour" task resource, if the related operation is supported for this VNF instance, and is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
>heal	Link	0..1	Link to the "heal" task resource, if the related operation is supported for this VNF instance, and is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
>operate	Link	0..1	Link to the "operate" task resource, if the related operation is supported for this VNF instance, and is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
>changeExtConn	Link	0..1	Link to the "change_ext_conn" task resource, if the related operation is possible based on the current status of this VNF instance resource (i.e. VNF instance is in INSTANTIATED state).
<p>NOTE 1: Modifying the value of this attribute can be performed when no conflicts exist between the previous and the newly referred VNF package, i.e. when the new VNFD is not changed with respect to the previous VNFD apart from referencing to other VNF software images. In order to avoid misalignment of the VnfInstance with the current VNF's on-boarded VNF Package, the values copied from the VNFD of the on-boarded VNF package need to be kept in sync.</p> <p>NOTE 2: ETSI GS NFV-SOL 001 [i.6] specifies the structure and format of the VNFD based on TOSCA specifications.</p> <p>NOTE 3: VNF configurable properties are sometimes also referred to as configuration parameters applicable to a VNF. Some of these are set prior to instantiation and cannot be modified if the VNF is instantiated, some are set prior to instantiation (are part of initial configuration) and can be modified later, and others can be set only after instantiation. The applicability of certain configuration may depend on the VNF and the required operation of the VNF at a certain point in time.</p>			

5.5.2.3 Type: CreateVnfRequest

This type represents request parameters for the "Create VNF identifier" operation. It shall comply with the provisions defined in table 5.5.2.3-1.

Table 5.5.2.3-1: Definition of the CreateVnfRequest data type

Attribute name	Data type	Cardinality	Description
vnfdId	Identifier	1	Identifier that identifies the VNFD which defines the VNF instance to be created.
vnfInstanceName	String	0..1	Human-readable name of the VNF instance to be created.
vnfInstanceDescription	String	0..1	Human-readable description of the VNF instance to be created.

5.5.2.4 Type: InstantiateVnfRequest

This type represents request parameters for the "Instantiate VNF" operation. It shall comply with the provisions defined in table 5.5.2.4-1.

Table 5.5.2.4-1: Definition of the InstantiateVnfRequest data type

Attribute name	Data type	Cardinality	Description
flavourId	IdentifierInVnfd	1	Identifier of the VNF deployment flavour to be instantiated.
instantiationLevelId	IdentifierInVnfd	0..1	Identifier of the instantiation level of the deployment flavour to be instantiated. If not present, the default instantiation level as declared in the VNFD is instantiated.
extVirtualLinks	ExtVirtualLinkData	0..N	Information about external VLs to connect the VNF to.
extManagedVirtualLinks	ExtManagedVirtualLinkData	0..N	Information about internal VLs that are managed by other entities than the VNFM.
vimConnectionInfo	VimConnectionInfo	0..N	Information about VIM connections to be used for managing the resources for the VNF instance, or refer to external / externally-managed virtual links. This attribute shall only be supported and may be present if VNF-related resource management in direct mode is applicable.
localizationLanguage	String	0..1	Localization language of the VNF to be instantiated. The value shall comply with the format defined in IETF RFC 5646 [8].
additionalParams	KeyValuePairs	0..1	Additional input parameters for the instantiation process, specific to the VNF being instantiated, as declared in the VNFD as part of "InstantiateVnfOpConfig".

5.5.2.5 Type: ScaleVnfRequest

This type represents request parameters for the "Scale VNF" operation. It shall comply with the provisions defined in table 5.5.2.5-1. See clause B.2 in Annex B for an explanation of VNF scaling.

Table 5.5.2.5-1: Definition of the ScaleVnfRequest data type

Attribute name	Data type	Cardinality	Description
type	Enum (inlined)	1	Indicates the type of the scale operation requested. Permitted values: <ul style="list-style-type: none"> - SCALE_OUT: adding additional VNFC instances to the VNF to increase capacity - SCALE_IN: removing VNFC instances from the VNF in order to release unused capacity.
aspectId	IdentifierInVnfd	1	Identifier of the scaling aspect.
numberOfSteps	Integer	0..1	Number of scaling steps to be executed as part of this Scale VNF operation. It shall be a positive number and the default value shall be 1.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the scaling process, specific to the VNF being scaled, as declared in the VNFD as part of "ScaleVnfOpConfig".

5.5.2.6 Type: ScaleVnfToLevelRequest

This type represents request parameters for the "Scale VNF to Level" operation. It shall comply with the provisions defined in table 5.5.2.6-1. See clause B.2 in Annex B for an explanation of VNF scaling.

Table 5.5.2.6-1: Definition of the ScaleVnfToLevelRequest data type

Attribute name	Data type	Cardinality	Description
instantiationLevelId	IdentifierInVnfd	0..1	Identifier of the target instantiation level of the current deployment flavour to which the VNF is requested to be scaled. See note.
scaleInfo	ScaleInfo	0..N	For each scaling aspect of the current deployment flavour, indicates the target scale level to which the VNF is to be scaled. See note.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the scaling process, specific to the VNF being scaled, as declared in the VNFD as part of "ScaleVnfToLevelOpConfig".
NOTE: Either the instantiationLevelId attribute or the scaleInfo attribute shall be included.			

5.5.2.7 Type: ChangeVnfFlavourRequest

This type represents request parameters for the "Change VNF flavour" operation. It shall comply with the provisions defined in table 5.5.2.7-1.

Table 5.5.2.7-1: Definition of the ChangeVnfFlavourRequest data type

Attribute name	Data type	Cardinality	Description
newFlavourId	IdentifierInVnfd	1	Identifier of the VNF deployment flavour to be instantiated.
instantiationLevelId	IdentifierInVnfd	0..1	Identifier of the instantiation level of the deployment flavour to be instantiated. If not present, the default instantiation level as declared in the VNFD is instantiated.
extVirtualLinks	ExtVirtualLinkData	0..N	Information about external VLs to connect the VNF to.
extManagedVirtualLinks	ExtManagedVirtualLinkData	0..N	Information about internal VLs that are managed by other entities than the VNFM.
vimConnectionInfo	VimConnectionInfo	0..N	Information about VIM connections to be used for managing the resources for the VNF instance, or refer to external / externally-managed virtual links. This attribute shall only be supported and may be present if VNF-related resource management in direct mode is applicable.
additionalParams	KeyValuePairs	0..1	Additional input parameters for the flavour change process, specific to the VNF being modified, as declared in the VNFD as part of "ChangeVnfFlavourOpConfig".

5.5.2.8 Type: TerminateVnfRequest

This type represents request parameters for the "Terminate VNF" operation. It shall comply with the provisions defined in table 5.5.2.8-1.

Table 5.5.2.8-1: Definition of the TerminateVnfRequest data type

Attribute name	Data type	Cardinality	Description
terminationType	Enum (inlined)	1	Indicates whether forceful or graceful termination is requested. See note. Permitted values: <ul style="list-style-type: none"> - FORCEFUL: The VNFM will shut down the VNF and release the resources immediately after accepting the request. - GRACEFUL: The VNFM will first arrange to take the VNF out of service after accepting the request. Once the operation of taking the VNF out of service finishes (irrespective of whether it has succeeded or failed) or once the timer value specified in the "gracefulTerminationTimeout" attribute expires, the VNFM will shut down the VNF and release the resources.
gracefulTerminationTimeout	Integer	0..1	This attribute is only applicable in case of graceful termination. It defines the time to wait for the VNF to be taken out of service before shutting down the VNF and releasing the resources. The unit is seconds. If not given and the "terminationType" attribute is set to "GRACEFUL", it is expected that the VNFM waits for the successful taking out of service of the VNF, no matter how long it takes, before shutting down the VNF and releasing the resources.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the termination process, specific to the VNF being terminated, as declared in the VNFD as part of "TerminateVnfOpConfig".
NOTE: If the VNF is still in service, requesting forceful termination can adversely impact network service.			

5.5.2.9 Type: HealVnfRequest

This type represents request parameters for the "Heal VNF" operation. It shall comply with the provisions defined in table 5.5.2.9-1.

Table 5.5.2.9-1: Definition of the HealVnfRequest data type

Attribute name	Data type	Cardinality	Description
cause	String	0..1	Indicates the reason why a healing procedure is required.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the healing process, specific to the VNF being healed, as declared in the VNFD as part of "HealVnfOpConfig".

5.5.2.10 Type: OperateVnfRequest

This type represents request parameters for the "Operate VNF" operation. It shall comply with the provisions defined in table 5.5.2.10-1.

Table 5.5.2.10-1: Definition of the OperateVnfRequest data type

Attribute name	Data type	Cardinality	Description
changeStateTo	VnfOperationalState Type	1	The desired operational state (i.e. started or stopped) to change the VNF to.
stopType	StopType	0..1	It signals whether forceful or graceful stop is requested. Ignored if changeStateTo=STARTED.
gracefulStopTimeout	Integer	0..1	The time interval (in seconds) to wait for the VNF to be taken out of service during graceful stop, before stopping the VNF. Ignored if changeStateTo=STARTED.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the process, specific to the VNF of which the operation status is changed, as declared in the VNFD as part of "OperateVnfOpConfig".

5.5.2.11 Type: ChangeExtVnfConnectivityRequest

This type represents request parameters for the "Change external VNF connectivity" operation to modify the external connectivity of a VNF instance. It shall comply with the provisions defined in table 5.5.2.11-1.

Table 5.5.2.11-1: Definition of the ChangeExtVnfConnectivityRequest data type

Attribute name	Data type	Cardinality	Description
extVirtualLinks	ExtVirtualLinkData	1..N	Information about external VLS to change (e.g. connect the VNF to).
vimConnectionInfo	VimConnectionInfo	0..N	Information about VIM connections to be used for managing the resources for the VNF instance, or refer to external virtual links. This attribute shall only be supported and may be present if VNF-related resource management in direct mode is applicable.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO as input to the process, specific to the VNF of which the external connectivity is changed, as declared in the VNFD as part of "ChangeExtVnfConnectivityOpConfig".

The following behaviour applies for the changes that can be performed with this operation:

- To change the connection of external CP instances based on certain external CPDs from a "source" external VL to a different "target" external VL, the identifier of the "target" external VL shall be sent in the "extVirtualLinkId" attribute of the "extVirtualLinks" parameter, and the "extCps" attributes of that parameter shall refer via the "cpdId" attribute to the external CPDs of the corresponding external connection point instances that are to be reconnected to the target external VL.

NOTE: This means that all CP instances based on a given external CPD will be reconnected. See clause B.3.3 in Annex B for an illustration.

- To change the connectivity parameters of the external CPs connected to a particular external VL, including changing addresses, the identifier of that external VL shall be sent in the "extVirtualLinkId" attribute of the "extVirtualLinks" parameter, and the "extCps" attribute of that parameter shall contain at least those entries with modified parameters.

5.5.2.12 Type: VnfInfoModifications

This type represents attribute modifications for an "Individual VNF instance" resource, i.e. modifications to a resource representation based on the "VnfInstance" data type. The attributes of "VnfInstance" that can be modified according to the provisions in clause 5.5.2.2 are included in the "VnfInfoModifications" data type.

The "VnfInfoModifications" data type shall comply with the provisions defined in table 5.5.2.12-1.

Table 5.5.2.12-1: Definition of the VnfInfoModifications data type

Attribute name	Data type	Cardinality	Description
vnfInstanceName	String	0..1	New value of the "vnfInstanceName" attribute in "VnfInstance", or "null" to remove the attribute.
vnfInstanceDescription	String	0..1	New value of the "vnfInstanceDescription" attribute in "VnfInstance", or "null" to remove the attribute.
onboardedVnfPkgInfold	Identifier	0..1	New value of the "onboardedVnfPkgInfold" attribute in "VnfInstance". The value "null" is not permitted.
vnfConfigurableProperties	KeyValuePairs	0..1	Modifications of the "vnfConfigurableProperties" attribute in "VnfInstance". If present, these modifications shall be applied according to the rules of JSON Merge PATCH (see IETF RFC 7396 [17]).
metadata	KeyValuePairs	0..1	Modifications of the "metadata" attribute in "VnfInstance". If present, these modifications shall be applied according to the rules of JSON Merge PATCH (see IETF RFC 7396 [17]).
extensions	KeyValuePairs	0..1	Modifications of the "extensions" attribute in "VnfInstance". If present, these modifications shall be applied according to the rules of JSON Merge PATCH (see IETF RFC 7396 [17]).
vimConnectionInfo	VimConnectionInfo	0..N	New content of certain entries in the "vimConnectionInfo" attribute array in "VnfInstance", as defined below this table.

The following provisions shall apply when modifying an attribute that is an array of objects of type "VimConnectionInfo".

Assumptions:

- 1) "oldList" is the array to be modified and "newList" is the array that contains the changes
- 2) "oldEntry" is an entry in "oldList" and "newEntry" is an entry in "newList"
- 3) A "newEntry" has a "corresponding entry" if there exists an "oldEntry" that has the same content of "id" attribute as the "newEntry"; a "newEntry" has no corresponding entry if no such "oldEntry" exists
- 4) In any array of "VimConnectionInfo" structures, the content of "id" is unique (i.e. there are no two entries with the same content of "id")

Provisions:

- 1) For each "newEntry" in "newList" that has no corresponding entry in "oldList", the "oldList" array shall be modified by adding that "newEntry"
- 2) For each "newEntry" in "newList" that has a corresponding "oldEntry" in "oldList", the value of "oldEntry" shall be updated with the value of "newEntry" according to the rules of JSON Merge PATCH (see IETF RFC 7396 [17])

5.5.2.13 Type: VnfLcmOpOcc

This type represents a VNF lifecycle management operation occurrence. It shall comply with the provisions defined in table 5.5.2.13-1.

Table 5.5.2.13-1: Definition of the VnfLcmOpOcc data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this VNF lifecycle management operation occurrence.
operationState	LcmOperationStateType	1	The state of the LCM operation.
stateEnteredTime	DateTime	1	Date-time when the current state was entered.
startTime	DateTime	1	Date-time of the start of the operation.
vnfInstancelid	Identifier	1	Identifier of the VNF instance to which the operation applies
grantId	Identifier	0..1	Identifier of the grant related to this VNF LCM operation occurrence, if such grant exists.
operation	LcmOperationType	1	Type of the actual LCM operation represented by this VNF LCM operation occurrence.
isAutomaticInvocation	Boolean	1	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, or HealVnf triggered by auto-heal). Set to false otherwise.
operationParams	Object	1	Input parameters of the LCM operation. This attribute shall be formatted according to the request data type of the related LCM operation. The following mapping between operationType and the data type of this attribute shall apply: <ul style="list-style-type: none"> • INSTANTIATE: InstantiateVnfRequest • SCALE: ScaleVnfRequest • SCALE_TO_LEVEL: ScaleVnfToLevelRequest • CHANGE_FLAVOUR: ChangeVnfFlavourRequest • OPERATE: OperateVnfRequest • HEAL: HealVnfRequest <ul style="list-style-type: none"> – CHANGE_EXT_CONN: ChangeExtVnfConnectivityRequest • TERMINATE: TerminateVnfRequest • MODIFY_INFO: VnfInfoModifications
isCancelPending	Boolean	1	If the VNF LCM operation occurrence is in "STARTING", "PROCESSING" or "ROLLING_BACK" state and the operation is being cancelled, this attribute shall be set to true. Otherwise, it shall be set to false.
cancelMode	CancelModeType	0..1	The mode of an ongoing cancellation. Shall be present when isCancelPending=true, and shall be absent otherwise.
error	ProblemDetails	0..1	If "operationState" is "FAILED_TEMP" or "FAILED" or "operationState" is "PROCESSING" or "ROLLING_BACK" and previous value of "operationState" was "FAILED_TEMP", this attribute shall be present and contain error information, unless it has been requested to be excluded via an attribute selector.
resourceChanges	Structure (inlined)	0..1	This attribute contains information about the cumulative changes to virtualised resources that were performed so far by the LCM operation since its start, if applicable.
>affectedVnfcs	AffectedVnfc	0..N	Information about VNFC instances that were affected during the lifecycle operation. See note.
>affectedVirtualLinks	AffectedVirtualLink	0..N	Information about VL instances that were affected during the lifecycle operation. See note.
>affectedVirtualStorages	AffectedVirtualStorage	0..N	Information about virtualised storage instances that were affected during the lifecycle operation. See note.

Attribute name	Data type	Cardinality	Description
changedInfo	VnfInfoModifications	0..1	Information about the changed VNF instance information, including VNF configurable properties, if applicable. See note.
changedExtConnectivity	ExtVirtualLinkInfo	0..N	Information about changed external connectivity, if applicable. See note.
_links	Structure (inline)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.
>vnfInstance	Link	1	Link to the VNF instance that the operation applies to.
>grant	Link	0..1	Link to the grant for this operation, if one exists.
>cancel	Link	0..1	Link to the task resource that represents the "cancel" operation for this VNF LCM operation occurrence, if cancelling is currently allowed.
>retry	Link	0..1	Link to the task resource that represents the "retry" operation for this VNF LCM operation occurrence, if retrying is currently allowed.
>rollback	Link	0..1	Link to the task resource that represents the "rollback" operation for this VNF LCM operation occurrence, if rolling back is currently allowed.
>fail	Link	0..1	Link to the task resource that represents the "fail" operation for this VNF LCM operation occurrence, if declaring as failed is currently allowed.
NOTE: This allows the NFVO to obtain the information contained in the latest "result" notification if it has not received it due to an error or a wrongly configured subscription filter.			

5.5.2.14 Type: CancelMode

This type represents a parameter to select the mode of cancelling an ongoing VNF LCM operation occurrence. It shall comply with the provisions defined in table 5.5.2.14-1.

Table 5.5.2.14-1: Definition of the CancelMode data type

Attribute name	Data type	Cardinality	Description
cancelMode	CancelModeType	1	Cancellation mode to apply.

5.5.2.15 Type: LccnSubscriptionRequest

This type represents a subscription request related to notifications about VNF lifecycle changes. It shall comply with the provisions defined in table 5.5.2.15-1.

Table 5.5.2.15-1: Definition of the LccnSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	LifecycleChangeNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentication	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

5.5.2.16 Type: LccnSubscription

This type represents a subscription related to notifications about VNF lifecycle changes. It shall comply with the provisions defined in table 5.5.2.16-1.

Table 5.5.2.16-1: Definition of the LccnSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this subscription resource.
filter	LifecycleChangeNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
_links	Structure (inlined)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.

5.5.2.17 Type: VnfLcmOperationOccurrenceNotification

This type represents a VNF lifecycle management operation occurrence notification, which informs the receiver of changes in the VNF lifecycle caused by a VNF LCM operation occurrence. It shall comply with the provisions defined in table 5.5.2.17-1. The support of the notification is mandatory.

This notification is produced when there is a change in the VNF lifecycle caused by a VNF LCM operation occurrence, including:

- Instantiation of the VNF
- Scaling of the VNF instance (including auto-scaling)
- Healing of the VNF instance (including auto-healing)
- Change of the state of the VNF instance (i.e. Operate VNF)
- Change of the deployment flavour of the VNF instance
- Change of the external virtual links of the VNF instance
- Termination of the VNF instance
- Modification of VNF instance information and/or VNF configurable properties through the "PATCH" method on the "Individual VNF instance" resource

If this is the initial notification about the start of a VNF LCM operation occurrence, it is assumed that the notification is *sent* by the VNFM before any action (including sending the grant request) is taken, however, after acknowledging the LCM operation request to the consumer. Due to possible race conditions, this does not guarantee that the notification will also *arrive* at the NFVO before the grant request, and after the acknowledgement of the operation. It is not an error if the "start" notification, the grant request and the LCM operation acknowledgment arrive out of order at the NFVO, and the NFVO shall be able to handle such a situation.

If this is a notification about a final or intermediate result state of a VNF LCM operation occurrence, the notification shall be sent after all related actions of the LCM operation that led to this state have been executed.

The new state shall be set in the VnfLcmOpOcc resource before the notification about the state change is sent.

See clause 5.6.2.2 for further provisions regarding sending this notification in case of handling LCM operation errors.

Table 5.5.2.17-1: Definition of the VnfLcmOperationOccurrenceNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfLcmOperationOccurrenceNotification" for this notification type.
subscriptionId	Identifier	0..1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
notificationStatus	Enum (inlined)	1	Indicates whether this notification reports about the start of a lifecycle operation or the result of a lifecycle operation. Permitted values: - START: Informs about the start of the VNF LCM operation occurrence. - RESULT: Informs about the final or intermediate result of the VNF LCM operation occurrence.
operationState	LcmOperationStateType	1	The state of the VNF LCM operation occurrence.
vnfInstanceId	Identifier	1	The identifier of the VNF instance affected.
operation	LcmOperationType	1	The lifecycle management operation.
isAutomaticInvocation	Boolean	1	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, or HealVnf triggered by auto-heal). Set to false otherwise.
vnfLcmOpOcclId	Identifier	1	The identifier of the VNF lifecycle management operation occurrence associated to the notification.
affectedVnfcs	AffectedVnfc	0..N	Information about VNFC instances that were affected during the lifecycle operation. See note.
affectedVirtualLinks	AffectedVirtualLink	0..N	Information about VL instances that were affected during the lifecycle operation. See note.
affectedVirtualStorages	AffectedVirtualStorage	0..N	Information about virtualised storage instances that were affected during the lifecycle operation. See note.
changedInfo	VnfInfoModifications	0..1	Information about the changed VNF instance information, including changed VNF configurable properties. Shall be present if the "notificationStatus" is set to "RESULT" and the operation has performed any changes to VNF instance information, including VNF configurable properties. Shall be absent otherwise.
changedExtConnectivity	ExtVirtualLinkInfo	0..N	Information about changed external connectivity, if this notification represents the result of a lifecycle operation occurrence. Shall be present if the "notificationStatus" is set to "RESULT" and the "operation" is set to "CHANGE_EXT_CONN". Shall be absent otherwise.
error	ProblemDetails	0..1	Details of the latest error, if one has occurred during executing the LCM operation (see clause 4.3.5). Shall be present if the "operationState" attribute is "FAILED_TEMP" or "FAILED", and shall be absent otherwise.
_links	LccnLinks	1	Links to resources related to this notification.
NOTE:	Shall be present if the "notificationStatus" is set to "RESULT" and the operation has performed any resource modification. Shall be absent otherwise. This attribute contains information about the cumulative changes to virtualised resources that were performed so far by the VNF LCM operation occurrence and by any of the error handling procedures for that operation occurrence.		

5.5.2.18 Type: VnfIdentifierCreationNotification

This type represents a VNF identifier creation notification, which informs the receiver of the creation of a new VNF instance resource and the associated VNF instance identifier. It shall comply with the provisions defined in table 5.5.2.18-1. The support of the notification is mandatory.

This notification is triggered by the creation of a VNF instance resource and the associated VNF instance identifier.

Table 5.5.2.18-1: Definition of the VnfIdentifierCreationNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfIdentifierCreationNotification" for this notification type.
subscriptionId	Identifier	0..1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
vnfInstancelId	Identifier	1	The created VNF instance identifier.
_links	LccnLinks	1	Links to resources related to this notification.

5.5.2.19 Type: VnfIdentifierDeletionNotification

This type represents a VNF identifier deletion notification, which informs the receiver of the deletion of a new VNF instance resource and the associated VNF instance identifier. It shall comply with the provisions defined in table 5.5.2.19-1. The support of the notification is mandatory.

This notification is triggered by the deletion of a VNF instance resource and the associated VNF instance identifier.

Table 5.5.2.19-1: Definition of the VnfIdentifierDeletionNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfIdentifierDeletionNotification" for this notification type.
subscriptionId	Identifier	0..1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
vnfInstancelId	Identifier	1	The deleted VNF instance identifier.
_links	LccnLinks	1	Links to resources related to this notification.

5.5.3 Referenced structured data types

5.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but can neither be resource representations nor bound to any subscribe/notify mechanism.

5.5.3.2 Type: ExtVirtualLinkInfo

This type represents information about an external VL. It shall comply with the provisions defined in table 5.5.3.2-1.

Table 5.5.3.2-1: Definition of the ExtVirtualLinkInfo data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of the external VL and the related external VL information instance.
resourceHandle	ResourceHandle	1	Reference to the resource realizing this VL.
linkPorts	ExtLinkPort	0..N	Link ports of this VL.

5.5.3.3 Type: ExtManagedVirtualLinkInfo

This type provides information about an externally-managed virtual link. It shall comply with the provisions defined in table 5.5.3.3-1.

Table 5.5.3.3-1: Definition of the ExtManagedVirtualLinkInfo data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of the externally-managed internal VL and the related externally-managed VL information instance.
vnfVirtualLinkDescId	IdentifierInVnfd	1	Identifier of the VNF Virtual Link Descriptor (VLD) in the VNFD.
networkResource	ResourceHandle	1	Reference to the VirtualNetwork resource.
vnfLinkPorts	VnfLinkPort	0..N	Link ports of this VL.

5.5.3.4 Type: ScaleInfo

This type represents the scale level of a VNF instance related to a scaling aspect. It shall comply with the provisions defined in table 5.5.3.4-1.

Table 5.5.3.4-1: Definition of the ScaleInfo data type

Attribute name	Data type	Cardinality	Description
aspectId	IdentifierInVnfd	1	Identifier of the scaling aspect.
scaleLevel	Integer	1	Indicates the scale level. The minimum value shall be 0 and the maximum value shall be \leq maxScaleLevel as described in the VNFD.

5.5.3.5 Type: VnfcResourceInfo

This type represents the information on virtualised compute and storage resources used by a VNFC in a VNF instance. It shall comply with the provisions defined in table 5.5.3.5-1.

Table 5.5.3.5-1: Definition of the VnfcResourceInfo data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of this VnfcResourceInfo instance.
vduld	IdentifierInVnfd	1	Reference to the applicable VDU in the VNFD. See note.
computeResource	ResourceHandle	1	Reference to the VirtualCompute resource.
storageResourceIds	IdentifierInVnf	0..N	References to the VirtualStorage resources. The value refers to a VirtualStorageResourceInfo item in the VnfInstance.
reservationId	Identifier	0..1	The reservation identifier applicable to the resource. It shall be present when an applicable reservation exists.
vnfcCpInfo	Structure (inlined)	0..N	CPs of the VNFC instance. Shall be present when that particular CP of the VNFC instance is associated to an external CP of the VNF instance. May be present otherwise.
>id	IdentifierInVnf	1	Identifier of this VNFC CP instance and the associated array entry.
>cpId	IdentifierInVnfd	1	Identifier of the VDU CPD, cpId, in the VNFD. See note.
>vnfExtCpId	IdentifierInVnf	0..1	When the VNFC CP is exposed as external CP of the VNF, the identifier of this external VNF CP.
>addresses	NetworkAddressInfo	0..N	List of network addresses that have been configured (statically or dynamically) on the CP.
metadata	KeyValuePairs	0..1	Metadata about this resource.

NOTE: ETSI GS NFV-SOL 001 [i.6] specifies the structure and format of the VNFD based on TOSCA specifications.

5.5.3.6 Type: VnfVirtualLinkResourceInfo

This type represents the information that allows addressing a virtualised resource that is used by an internal VL instance in a VNF instance. It shall comply with the provisions defined in table 5.5.3.6-1.

Table 5.5.3.6-1: Definition of the VnfVirtualLinkResourceInfo data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of this VnfVirtualLinkResourceInfo instance.
virtualLinkDescId	IdentifierInVnfd	1	Identifier of the VNF Virtual Link Descriptor (VLD) in the VNFD.
networkResource	ResourceHandle	1	Reference to the VirtualNetwork resource.
reservationId	Identifier	0..1	The reservation identifier applicable to the resource. It shall be present when an applicable reservation exists.
vnfLinkPorts	VnfLinkPort	0..N	Links ports of this VL. Shall be present when the linkPort is used for external connectivity by the VNF (refer to VnfLinkPort). May be present otherwise.
metadata	KeyValuePairs	0..1	Metadata about this resource.

5.5.3.7 Type: VirtualStorageResourceInfo

This type represents the information that allows addressing a virtualised resource that is used by a VNF instance. It shall comply with the provisions defined in table 5.5.3.7-1.

Table 5.5.3.7-1: Definition of the VirtualStorageResourceInfo data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of this VirtualStorageResourceInfo instance.
virtualStorageDescId	IdentifierInVnfd	1	Identifier of the VirtualStorageDesc in the VNFD.
storageResource	ResourceHandle	1	Reference to the VirtualStorage resource.
reservationId	Identifier	0..1	The reservation identifier applicable to the resource. It shall be present when an applicable reservation exists.
metadata	KeyValuePairs	0..1	Metadata about this resource.

5.5.3.8 Type: VnfLinkPort

This type represents a link port of an internal VL of a VNF. It shall comply with the provisions defined in table 5.5.3.8-1.

Table 5.5.3.8-1: Definition of the VnfLinkPort data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of this link port as provided by the entity that has created the link port.
resourceHandle	ResourceHandle	1	Reference to the virtualised network resource realizing this link port.
cpInstanceId	IdentifierInVnf	0..1	<p>Identifier of the external CP of the VNF to be connected to this link port.</p> <p>Shall be present when the link port is used for external connectivity by the VNF.</p> <p>May be present if used to reference a VNFC CP instance.</p> <p>There shall be at most one link port associated with any external connection point instance or internal connection point (i.e. VNFC CP) instance.</p> <p>The value refers to an "extCplInfo" item in the VnfInstance or a "vnfcCplInfo" item of a "vnfcResourceInfo" item in the VnfInstance.</p>

5.5.3.9 Type: ExtLinkPort

This type represents a link port of an external VL, i.e. a port providing connectivity for the VNF to an NS VL. It shall comply with the provisions defined in table 5.5.3.9-1.

Table 5.5.3.9-1: Definition of the ExtLinkPort data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this link port as provided by the entity that has created the link port.
resourceHandle	ResourceHandle	1	Reference to the virtualised network resource realizing this link port.
cpInstanceid	IdentifierInVnf	0..1	Identifier of the external CP of the VNF to be connected to this link port. There shall be at most one link port associated with any external connection point instance. The value refers to an "extCpInfo" item in the VnfInstance.

5.5.3.10 Type: NetworkAddressInfo

This type represents information about a network address that has been assigned. It shall comply with the provisions defined in table 5.5.3.10-1.

Table 5.5.3.10-1: Definition of the NetworkAddressInfo data type

Attribute name	Data type	Cardinality	Description
macAddress	MacAddress	1	Assigned MAC address.
ipAddress	IpAddress	0..1	IP address. Present if an IP address was assigned.
subnetIpRanges	Structure	0..N	IP address ranges defining the subnet in which the IP address was assigned. May be present if the "ipAddress" attribute is present, and shall be absent if the "ipAddress" attribute is not present.
>minIpAddress	IpAddress	1	Lowest IP address belonging to the range.
>maxIpAddress	IpAddress	1	Highest IP address belonging to the range.

5.5.3.11 Type: MonitoringParameter

This type represents a monitoring parameter that is tracked by the VNFM, e.g. for auto-scaling purposes. It shall comply with the provisions defined in table 5.5.3.11-1.

Valid monitoring parameters of a VNF are defined in the VNFD.

NOTE: ETSI GS NFV-SOL 001 [i.6] specifies the structure and format of the VNFD based on TOSCA specifications.

Table 5.5.3.11-1: Definition of the MonitoringParameter data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnfd	1	Identifier of the monitoring parameter defined in the VNFD.
name	String	0..1	Human readable name of the monitoring parameter, as defined in the VNFD.
value	(any type)	1	Value of the monitoring parameter known to the VNFM (e.g. obtained for autoscaling purposes). See note.
timeStamp	DateTime	1	Represents the point in time when the measurement has been performed, as known to the VNFM.
NOTE: The type of the "value" attribute (i.e. scalar, structure (Object in JSON), or array (of scalars, arrays or structures/Objects)) is assumed to be defined in an external measurement specification outside the scope of the present document.			

5.5.3.12 Type: LifecycleChangeNotificationsFilter

This type represents a subscription filter related to notifications about VNF lifecycle changes. It shall comply with the provisions defined in table 5.5.3.12-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 5.5.3.12-1: Definition of the LifecycleChangeNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
vnfInstanceSubscriptionFilter	VnfInstanceSubscriptionFilter	0..1	Filter criteria to select VNF instances about which to notify.
notificationTypes	Enum (inlined)	0..N	Match particular notification types. Permitted values: - VnfLcmOperationOccurrenceNotification - VnfIdentifierCreationNotification - VnfIdentifierDeletionNotification See note.
operationTypes	LcmOperationType	0..N	Match particular VNF lifecycle operation types for the notification of type VnfLcmOperationOccurrenceNotification. May be present if the "notificationTypes" attribute contains the value "VnfLcmOperationOccurrenceNotification", and shall be absent otherwise.
operationStates	LcmOperationStateType	0..N	Match particular LCM operation state values as reported in notifications of type VnfLcmOperationOccurrenceNotification. May be present if the "notificationTypes" attribute contains the value "VnfLcmOperationOccurrenceNotification", and shall be absent otherwise.
NOTE: The permitted values of the "notificationTypes" attribute are spelled exactly as the names of the notification types to facilitate automated code generation systems.			

5.5.3.13 Type: AffectedVnfc

This type provides information about added, deleted, modified and temporary VNFCs. It shall comply with the provisions in table 5.5.3.13-1.

Table 5.5.3.13-1: Definition of the AffectedVnfc data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of the Vnfc instance, identifying the applicable "vnfcResourceInfo" entry in the "VnfInstance" data type (see clause 5.5.2.2).
vduld	IdentifierInVnfd	1	Identifier of the related VDU in the VNFD.
changeType	Enum (inlined)	1	Signals the type of change Permitted values: <ul style="list-style-type: none"> - ADDED - REMOVED - MODIFIED - TEMPORARY For a temporary resource, an AffectedVnfc structure exists as long as the temporary resource exists.
computeResource	ResourceHandle	1	Reference to the VirtualCompute resource. Detailed information is (for new and modified resources) or has been (for removed resources) available from the VIM.
addedStorageResourceIds	IdentifierInVnf	0..N	References to VirtualStorage resources that have been added. Each value refers to a VirtualStorageResourceInfo item in the VnfInstance that was added to the VNFC. It shall be provided if at least one storage resource was added to the VNFC.
removedStorageResourceIds	IdentifierInVnf	0..N	References to VirtualStorage resources 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. It shall be provided if at least one storage resource was removed from the VNFC.

5.5.3.14 Type: AffectedVirtualLink

This type provides information about added, deleted, modified and temporary VLs. It shall comply with the provisions in table 5.5.3.14-1.

Table 5.5.3.14-1: Definition of the AffectedVirtualLink data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of the virtual link instance, identifying the applicable "vnfVirtualLinkResourceInfo" entry in the "VnfInstance" data type (see clause 5.5.2.2).
virtualLinkDescId	IdentifierInVnfd	1	Identifier of the related VLD in the VNFD.
changeType	Enum (inlined)	1	Signals the type of change. Permitted values: <ul style="list-style-type: none"> - ADDED - REMOVED - MODIFIED - TEMPORARY - LINK_PORT_ADDED - LINK_PORT_REMOVED For a temporary resource, an AffectedVirtualStorage structure exists as long as the temporary resource exists.
networkResource	ResourceHandle	1	Reference to the VirtualNetwork resource. Detailed information is (for new and modified resources) or has been (for removed resources) available from the VIM.

5.5.3.15 Type: AffectedVirtualStorage

This type provides information about added, deleted, modified and temporary virtual storage resources. It shall comply with the provisions in table 5.5.3.15-1.

Table 5.5.3.15-1: Definition of the AffectedVirtualStorage data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnf	1	Identifier of the storage instance, identifying the applicable "virtualStorageResourceInfo" entry in the "VnfInstance" data type (see clause 5.5.2.2).
virtualStorageDescId	IdentifierInVnfd	1	Identifier of the related VirtualStorage descriptor in the VNFD.
changeType	Enum (inlined)	1	Signals the type of change. Permitted values: <ul style="list-style-type: none"> - ADDED - REMOVED - MODIFIED - TEMPORARY For a temporary resource, an AffectedVirtualStorage structure exists as long as the temporary resource exists.
storageResource	ResourceHandle	1	Reference to the VirtualStorage resource. Detailed information is (for new and modified resources) or has been (for removed resources) available from the VIM.

5.5.3.16 Type: LccnLinks

This type represents the links to resources that a notification can contain. It shall comply with the provisions defined in table 5.5.3.16-1.

Table 5.5.3.16-1: Definition of the LccnLinks data type

Attribute name	Data type	Cardinality	Description
vnfInstance	Link	1	Link to the resource representing the VNF instance to which the notified change applies.
subscription	Link	1	Link to the related subscription.
vnfLcmOpOcc	Link	0..1	Link to the VNF lifecycle management operation occurrence that this notification is related to. Shall be present if there is a related lifecycle operation occurrence.

5.5.4 Referenced simple data types and enumerations

5.5.4.1 Introduction

This clause defines simple data types and enumerations that can be referenced from data structures defined in the previous clauses.

5.5.4.2 Simple data types

No particular simple data types are defined for this interface, in addition to those defined in clause 4.4.

5.5.4.3 Enumeration: VnfOperationalStateType

The enumeration VnfOperationalStateType shall comply with the provisions defined in table 5.5.4.3-1.

Table 5.5.4.3-1: Enumeration VnfOperationalStateType

Enumeration value	Description
STARTED	The VNF instance is up and running.
STOPPED	The VNF instance has been shut down.

5.5.4.4 Enumeration: StopType

The enumeration StopType shall comply with the provisions defined in table 5.5.4.4-1.

Table 5.5.4.4-1: Enumeration StopType

Enumeration value	Description
FORCEFUL	The VNFM will stop the VNF immediately after accepting the request.
GRACEFUL	The VNFM will first arrange to take the VNF out of service after accepting the request. Once that operation is successful or once the timer value specified in the "gracefulStopTimeout" attribute expires, the VNFM will stop the VNF.

5.5.4.5 Enumeration: LcmOperationStateType

The enumeration LcmOperationStateType shall comply with the provisions defined in table 5.5.4.5-1. More information of the meaning of the states can be found in clause 5.6.2.2.

Table 5.5.4.5-1: Enumeration LcmOperationStateType

Enumeration value	Description
STARTING	The LCM operation is starting.
PROCESSING	The LCM operation is currently in execution.
COMPLETED	The LCM operation has been completed successfully.
FAILED_TEMP	The LCM operation has failed and execution has stopped, but the execution of the operation is not considered to be closed.
FAILED	The LCM operation has failed and it cannot be retried or rolled back, as it is determined that such action won't succeed.
ROLLING_BACK	The LCM operation is currently being rolled back.
ROLLED_BACK	The LCM operation has been successfully rolled back, i.e. The state of the VNF prior to the original operation invocation has been restored as closely as possible.

5.5.4.6 Enumeration: CancelModeType

The enumeration CancelModeType defines the valid modes of cancelling a VNF LCM operation occurrence. It shall comply with the provisions defined in table 5.5.4.6-1.

Table 5.5.4.6-1: Enumeration CancelModeType

Enumeration value	Description
GRACEFUL	The VNFM shall not start any new resource management operation and shall wait for the ongoing resource management operations in the underlying system, typically the VIM, to finish execution or to time out. After that, the VNFM shall put the operation occurrence into the FAILED_TEMP state.
FORCEFUL	The VNFM shall not start any new resource management operation, shall cancel the ongoing resource management operations in the underlying system, typically the VIM, and shall wait for the cancellation to finish or to time out. After that, the VNFM shall put the operation occurrence into the FAILED_TEMP state.

5.6 Handling of errors during VNF lifecycle management operations

5.6.1 Basic concepts (informative)

5.6.1.1 Motivation

VNF lifecycle management operation occurrences can fail. Failure can be caused by multiple reasons, which generally fall into the following categories:

- Transient errors which don't require intervention from a human operator or a higher-layer management entity for resolution, e.g. momentary network outage.
- "Permanent" errors which require such intervention.

It is unreasonable to expect that all errors can be resolved automatically, therefore the possibility of intervention has to be incorporated in the system design as acknowledged means of error resolution.

5.6.1.2 Failure resolution strategies: Retry and Rollback

Most transient errors are handled best with a retry mechanism. Retry might happen automatically at the point of failure within the same LCM workflow (where it makes sense to limit the number of automatic retries). It is important to strive for designing retry operations that have no unintended side effects from the original invocation of the operation. This is called *idempotent retry*. Idempotent retry can also be used as an on-demand error resolution mechanism (see below) if the original operation failed because of a condition that has been resolved manually by the human operator or by a higher-level management entity, so idempotent retry is suitable for general error resolution in most cases.

However, even if a system is designed with idempotent retry capabilities, eventual success of the operation cannot be guaranteed. In this case, the resolution of the inconsistent state can be attempted by requesting to roll back the changes made by the operation. Therefore, rollback as an error handling strategy is also desired to be allowed in the system design.

In many cases, idempotent retry can resolve transient errors and lead to success eventually. Depending on the situation, rollback followed by a repetition of the operation could take longer than a successful retry, as rollback first removes allocated resources and then the repetition of the operation allocates them again, which costs time.

Therefore, it often makes sense to perform first idempotent retry, which is followed by rollback if the retry has failed. Idempotent retry is meaningful and useful for all operation types, but for some operations rollback is better suited and has a better chance of success. In general, rollback is well-suited for additive operations such as *InstantiateVnf* or *scale out*, while ill-suited for subtractive ones such as *scale in* or *TerminateVnf*, or for *HealVnf*.

Both rollback and idempotent retry can fail. In that case, the system can be left in an inconsistent state after a failed operation, which requires resolution by a higher-level entity such as NFVO or human operator.

5.6.1.3 Error handling at VNFM and NFVO

If the VNFM executes an LCM workflow and encounters a problem, the following options are possible:

- Stop on first error
 - Once the VNFM encounters an error, the normal execution of the LCM workflow is interrupted, and an error handling procedure is triggered (automatic retry, automatic rollback, automatic fail, escalate). See the paragraphs below for description of error handling procedures.
 - It is assumed that all VNFs and all VNFMs support "stop on first error".

EXAMPLE 1: NFVO is attempting to instantiate a VNF with 100 VNFCs. The first 97 VNFCs are instantiated successfully, however, an error occurs when attempting to instantiate VNFC #98. The VNFM stops execution and chooses which of the error handling options it invokes (note that it even could try multiple options after each other).

- Best Effort
 - Each time the VNFM encounters an error, it is decided whether the execution of a part or all of the remaining steps of the LCM workflow is performed, or whether the execution is interrupted and an error handling procedure is triggered (automatic retry, automatic rollback, automatic fail, escalate). See the paragraphs below for description of error handling procedures.
 - Support of "best effort" requires a suitable workflow design.
 - It is therefore assumed that not all VNFs and not all VNFMs support "best effort".

EXAMPLE 2: Same example as above. After the error occurs attempting to instantiate VNFC #98, the VNFM continues by creating #99 and #100, and then chooses which error handling options it invokes.

The VNFM has the following error handling procedures to react to errors (see clause 5.6.1.2 for general elaboration regarding retry and rollback):

- Automatic Retry: The VNFM retries (once or more) to continue the execution of the workflow without involving an external entity. Automatic retry of failed parts of the workflow might even be built into the workflow itself. Retry can eventually succeed or fail. Successful retry leads to the LCM operation to be reported as successful. Failed retry is typically escalated.

- **Automatic Rollback:** The VNFM rolls back the VNF to the state prior to starting the LCM operation without involving an external entity. Rollback can eventually succeed or can fail, preventing the VNF from reaching that previous state. Successful rollback leads to the LCM operation to be reported as rolled back. Failed rollback is typically escalated.
- **Escalate:** After failed automatic retry/retries, automatic rollback is typically not the first option in most situations, but the error is preferably reported to the NFVO for further resolution. The same applies if no automatic error resolution was attempted by the VNFM, or if automated rollback has failed. This is done by sending a VNF LCM operation occurrence notification.
- **Unresolvable Error:** The VNFM determines that the operation has failed and definitely cannot be recovered (e.g. if no retry and no rollback is possible), and that escalating the error to the NFVO will have no chance to lead to a resolution either. In this case, the VNFM would report that the operation has terminally failed. After that, other means of resolution can be attempted, such as the invocation of HealVnf, or manual procedures using the GUI of the VNFM or VIM to release stranded resources.

The NFVO has the following error handling procedures to react to error reports from the VNFM:

- **On-demand retry:** After the VNFM has reported the error to the NFVO, the NFVO or the human operator takes steps to resolve the situation that has led to the occurrence of the error. Subsequently, the retry of the operation is triggered towards the VNFM by the NFVO via the VNF LCM interface.
- **On-demand rollback:** After the VNFM has reported the error to the NFVO, and after the NFVO or the human operator has decided to roll back the operation, the rollback of the operation is triggered towards the VNFM by the NFVO via the VNF LCM interface.
- **Fail:** After the VNFM has reported the error to the NFVO, and after the NFVO or the human operator has determined that neither on-demand retry nor on-demand rollback will fix the error, the LCM operation can be declared as terminally failed towards the VNFM by the NFVO via the VNF LCM interface. After that, other means of resolution can be attempted, such as the invocation of HealVnf, or manual procedures using the GUI of the VNFM or VIM to release stranded resources.

5.6.2 States and state transitions of a VNF lifecycle management operation occurrence

5.6.2.1 General

A VNF lifecycle management operation occurrence supports a number of states and error handling operations. The states and state transitions that shall be supported are shown in figure 5.6.2.1-1. Transitions labelled with underlined text represent error handling operations; other transitions represent conditions.

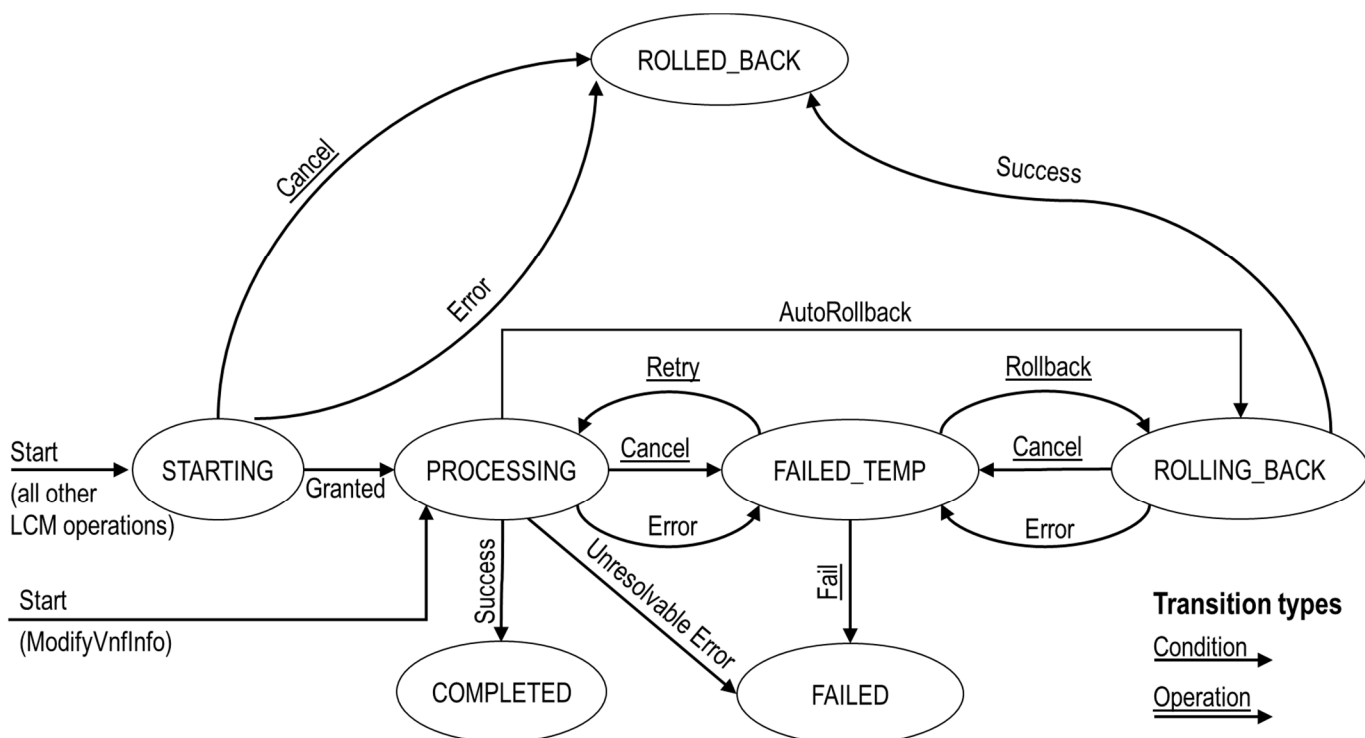


Figure 5.6.2.1-1: States of a VNF lifecycle management operation occurrence

5.6.2.2 States of a VNF lifecycle management operation occurrence

At each time, a VNF lifecycle management operation occurrence is in one of the following states. There are transitional states (states from which a different state can be reached) and terminal states (states from which no other state can be reached; i.e. the state of a VNF lifecycle management operation occurrence in a terminal state cannot change anymore).

STARTING: The operation is starting. This state represents the preparation phase of the operation, including invoking Grant Lifecycle Operation. This state has the following characteristics:

- This is the initial state for any LCM operation except ModifyVnfInformation.
- This is a transient state.
- This state may block other LCM operations from being executed on the same VNF instance (up to VNF and VNFM implementation).
- In this state, the VNF lifecycle management operation occurrence does not perform any changes to the VNF instance or to resources.
- Once the VNF lifecycle operation has been granted, the VNF lifecycle management operation occurrence transits into the PROCESSING state.
- If the LCM operation is cancelled in the "STARTING" state, the VNF lifecycle management operation occurrence shall transit to the "ROLLED_BACK" state. The NFVO shall be prepared to receive the notification about the cancellation of the operation before and after having provided the grant. This is necessary to address possible race conditions.
- If an error occurs before the VNFM receives the grant response, or the grant is rejected, as no changes to the underlying VNF or resources were done, the VNF lifecycle management operation occurrence shall transit into the "ROLLED_BACK" state.

COMPLETED: The operation has completed successfully. This is a terminal state.

FAILED_TEMP: The operation has failed and execution has stopped, but the execution of the operation is not considered to be closed. This state has the following characteristics:

- This is a transient state.
- The grant received for the operation is still valid, and the granted resource changes are still foreseen for the VNF.
- This state may block other LCM operations from being executed on the same VNF instance (enforced by the VNFM, and up to VNF and VNFM capabilities).
- Retry and / or rollback may be invoked for the operation.
- If the VNF LCM operation is retried, the VNF lifecycle management operation occurrence shall transit into the "PROCESSING" state.
- If the VNF LCM operation is rolled back, the VNF lifecycle management operation occurrence shall transit into the "ROLLING_BACK" state.
- If the VNF LCM operation is marked as "failed", the VNF lifecycle management operation occurrence shall transit into the "FAILED" state.
- Operation cancellation and failure to roll back should result in FAILED_TEMP.

FAILED: The operation has failed and it cannot be retried or rolled back, as it is determined that such action won't succeed. This state has the following characteristics:

- This is a terminal state.
- Such an operation state is typically the result of a decision of a higher layer management entity (NFVO) or its human operator that an operation in "FAILED_TEMP" state cannot be retried or rolled back ("Fail").
- Such an operation state can also be reached immediately in case of failure of an operation in "PROCESSING" state that can neither be retried nor rolled back ("Unresolvable Error").
- The result of the LCM operation (the actual resource changes) can show an inconsistent state of the VNF, and can reflect partial resource changes compared to the granted changes. Nevertheless, these changes shall be synchronized between the VNFM and NFVO (by reporting them in the LCCN, and by allowing the NFVO to obtain them on request) in order for other VNF LCM operations (e.g. Heal, Terminate) to be guaranteed to work on resources that are known to the NFVO.
- The fact that a LCM operation is in "FAILED" state shall not block other operations from execution on the VNF instance by the VNFM. However, the VNF instance may itself be in a state that disallows certain operations.

ROLLED_BACK: The state of the VNF prior to the original operation invocation has been restored as closely as possible. This state has the following characteristics:

- This is a terminal state.
- This may involve recreating some resources that have been deleted by the operation, the recreated resources should be as similar as possible to the deleted ones. Differences between original resources and re-created ones may include a different resource identity, but also different dynamic attributes such as an IP address.

PROCESSING: The LCM operation is currently in execution. This state has the following characteristics:

- This is the initial state for the ModifyVnfInformation operation.
- This is a transient state.
- This state may block other LCM operations from being executed on the same VNF instance (up to VNF and VNFM implementation).
- The operations "Retry" and "Rollback" shall not be permitted to be invoked for an operation that is in this state.

- All failures of procedures executed by the VNFM as part of the LCM operation while in "PROCESSING" state should result by default in transiting to FAILED_TEMP, with the following two alternative options:
 - If a failure occurs in the "PROCESSING" state from which the VNFM knows that the VNF instance can be brought into a consistent state by immediately rolling back the operation, the VNF lifecycle management operation occurrence may transit directly into the "ROLLING_BACK" state ("Autorollback"). For the ModifyVnfInformation operation, Autorollback is the typical error handling method.
 - If a failure occurs in the "PROCESSING" state from which the VNFM knows that it can neither be fixed by retrying nor be rolled back, the VNF lifecycle management operation occurrence may transit directly into the "FAILED" state ("Unresolvable Error").
- If a "cancel" request was issued during the operation is in "PROCESSING" state, processing will be cancelled but this might not be immediate. This is represented by a flag in the data model that indicates there is a pending "cancel" request for this state. Upon successful cancellation, the VNF lifecycle management operation occurrence shall transit into the "FAILED_TEMP" state.

ROLLING_BACK: The LCM operation is currently being rolled back. This state has the following characteristics:

- This is a transient state.
- This state may block other LCM operations from being executed on the same VNF instance (up to VNF and VNFM implementation).
- The operations "Retry" and "Rollback" shall not be permitted to be invoked for an operation that is in this state.
- If a "Cancel" request was issued during the operation is in "ROLLING_BACK" state, rolling back will be cancelled but this might not be immediate. This is represented by a flag in the data model that indicates there is a pending "Cancel" request for this state. Upon successful cancellation, the VNF lifecycle management operation occurrence shall transit into the "FAILED_TEMP" state.
- If a failure occurs during rolling back, the operation should transition to the "FAILED_TEMP" state.
- Upon successful rollback, the VNF lifecycle management operation occurrence shall transit into the "ROLLED_BACK" state.

In addition, the following provisions apply to VNF lifecycle management operation occurrence notifications:

- The "start" notification (i.e. notificationStatus="START") shall be sent when the operation enters one of states "STARTING", "PROCESSING" and "ROLLING_BACK" from another state, indicating the state entered.
- The "result" notification (i.e. notificationStatus="RESULT") shall be sent when the VNF LCM operation occurrence enters one of the error states "FAILED_TEMP", "FAILED", "ROLLED_BACK", indicating the state entered, the error cause and the changes to the VNF's resources since the operation was initially started.
- The "result" notification (i.e. notificationStatus="RESULT") shall be sent when the operation enters the success state "COMPLETED", indicating the state entered and the changes to the VNF's resources.

Such a notification scheme allows the NFVO to keep in sync with changes to the VNF's resources by an ongoing LCM operation. If the notification relates to a transient state, further changes can be expected. If the notification relates to a terminal state, no further changes to the VNF's resources will be performed by the related VNF lifecycle management operation occurrence, and the NFVO can use the information in the notification to synchronize its internal state with the result of the LCM operation. In case of loss of notifications, a the NFVO can read the resource that represents the VNF lifecycle management operation occurrence to obtain the same information.

5.6.2.3 Error handling operations that change the state of a VNF lifecycle management operation occurrence

Retry: This operation retries a VNF lifecycle operation. It has the following characteristics:

- Execution of "Retry" for an actual LCM operation on a particular VNF may be supported, depending on characteristics of the VNF and the LCM operation.

- "Retry" shall operate within the bounds of the Grant for the LCM operation.
- The operation may be invoked via an interface, or the VNFM may invoke the operation per its own decision.

Rollback: This operation rolls back a VNF lifecycle operation. It has the following characteristics:

- Execution of "Rollback" for an actual LCM operation on a particular VNF may be supported, depending on characteristics of the VNF and the LCM operation.
- "Rollback" shall operate within the bounds of the Grant for the LCM operation, an additionally may execute the inverse of granted LCM operations (e.g. if a resource deletion was granted, rollback might re-create the deleted resource or a similar resource).
- The operation may be invoked via an interface, or the VNFM may invoke the operation per its own decision.

Fail: This operation transits the VNF lifecycle management operation occurrence into the terminal "FAILED" state. It has the following characteristics:

- Execution of "Fail" shall be supported for an LCM operation on a particular VNF if at least one of Retry, Rollback, Cancel is supported for this operation.
- The operation may be invoked via an interface, or the VNFM may invoke the operation per its own decision.

Cancel: This operation cancels an ongoing VNF lifecycle management operation, its Retry or Rollback. It has the following characteristics:

- Execution of Cancel for an actual LCM operation on a particular VNF may be supported, depending on characteristics of the VNF and the LCM operation.
- The "Cancel" operation need not have immediate effect, depending on the capabilities of the underlying systems, and the currently executed resource management operation.
- Two modes of cancellation are supported: graceful and forceful.
 - When executing the *graceful* "Cancel" operation, the VNFM will not initiate any new operation towards the underlying systems, will wait until the currently executed operations finish or time out, and will then put the VNF lifecycle management operation occurrence into the "FAILED_TEMP" state.
 - When executing the *forceful* "Cancel" operation, the VNFM will cancel all ongoing operations in the underlying systems for which cancellation is supported, will not initiate any new operation towards the underlying systems, will wait for the requested cancellations to finish or time out, and will the put the VNF lifecycle management operation occurrence into the "FAILED_TEMP" state.
 - In "STARTING" state, there is no difference between the graceful and the forceful cancellation mode.
- Executing "Cancel" can lead to inconsistencies between the information that the VNFM has about the state of the resources of the VNF, and their actual state. The probability of such inconsistencies is bigger when using the *forceful* cancellation mode.

5.6.3 Detailed flows

5.6.3.1 Immediate failure

If the VNF LCM operation fails immediately, i.e. it returns an HTTP error, then the operation has not started, and no "VNF LCM operation occurrence" resource has been created. Also, neither a "start" VNF lifecycle management operation occurrence notification nor a Grant request has been sent. The operation cannot be retried, but the same operation may be invoked again from the API. The VNF instance is not changed by a synchronous failure, so no special error handling is required.

Figure 5.6.3.1-1 illustrates the flow.

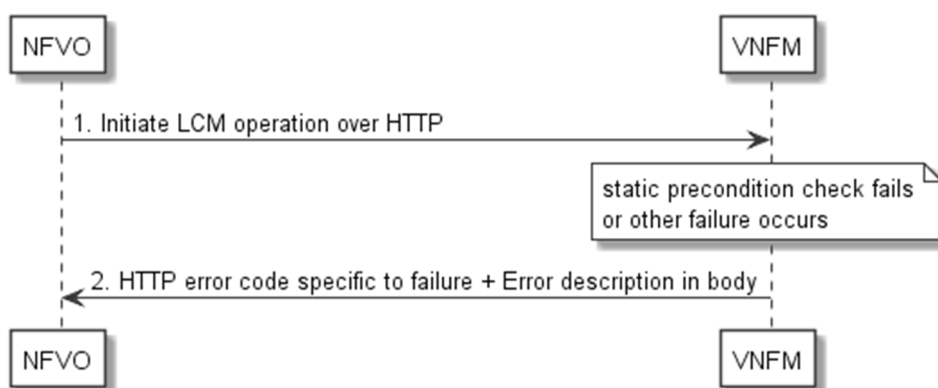


Figure 5.6.3.1-1: Immediate failure of a VNF LCM operation

5.6.3.2 Failure in "STARTING" state

This error scenario assumes that the "VNF LCM operation occurrence" resource has been created and the "start" VNF lifecycle management operation occurrence notification has been sent.

If the operation fails before the VNFM receives the Grant response, or the Grant is rejected, persistent change to the state of the VNF cannot have happened. Therefore, it is assumed that this operation enters the ROLLED_BACK state immediately. Figure 5.6.3.2-1 illustrates the flow.

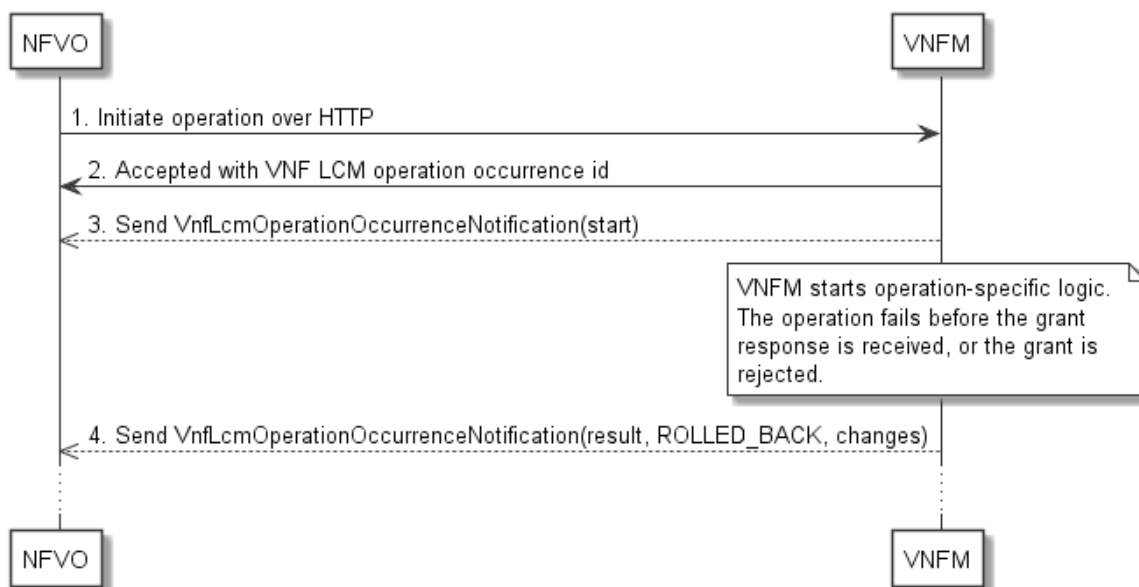


Figure 5.6.3.2-1: Failure of a VNF LCM operation before applying any change to the VNF instance

5.6.3.3 Failure during actual LCM operation execution

After a failed resource management operation, automatic retry can be invoked by the VNFM itself. These invocations are not visible outside of the VNFM, as the VNF LCM operation occurrence stays in "PROCESSING" state during these automatic retries. If these do not resolve the issue, intervention (typically by a human operator) is necessary. For that purpose, the LCM operation is set into a temporary failure state, and the NFVO is notified. The human operator performs a root cause analysis and eventually resolves the obstacle. Subsequently, and if supported, the operation can be retried, rolled-back or determined as permanently failed. Figure 5.6.3.3-1 illustrates the possible options.

NOTE 1: Excluding automated rollback which is seen as a rare option.

NOTE 2: Excluding "start" notifications (i.e. notificationStatus="START") for simplification purposes.

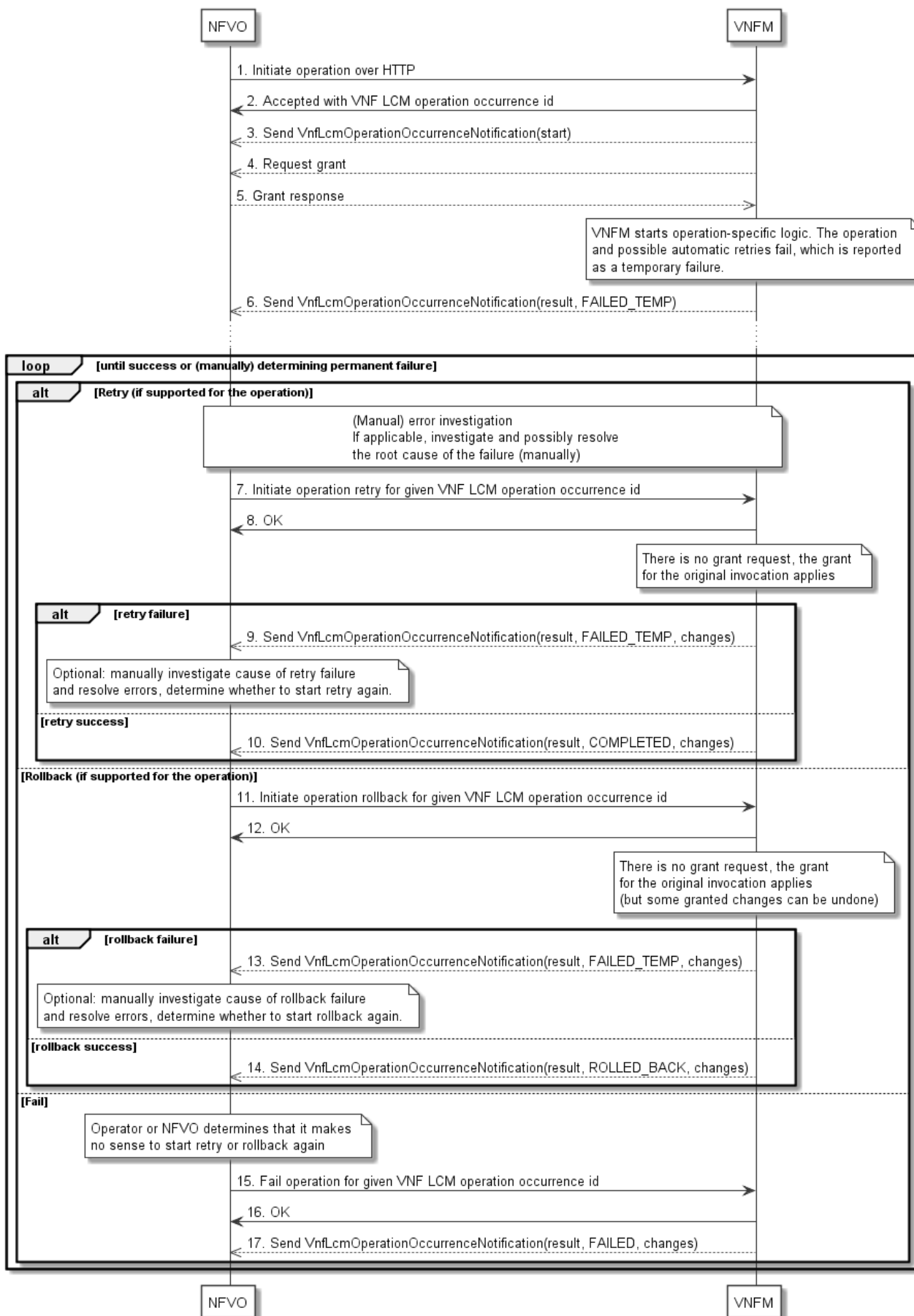


Figure 5.6.3.3-1: Handling failures during the actual execution of a VNF LCM operation

5.6.3.4 LCM operation cancellation

The cancellation of an LCM operation that is in PROCESSING or ROLLING_BACK state is handled like any other error that leads to stopping the execution of the VNF LCM workflow before it can be successfully completed. The VNF LCM operation transits into the FAILED_TEMP state which allows root cause analysis, possible fixing of the root cause, followed by retrying, rolling back, or finally failing of the operation.

The cancellation of an operation in STARTING state (i.e. until the Grant is received) transits the operation into the ROLLED_BACK state, as no changes to the resources or VNF instance have been performed.

6 VNF Performance Management interface

6.1 Description

This interface allows providing performance management (measurement results collection and notifications) related to VNFs. Performance information on a given VNF instance results from performance information of the virtualised resources that is collected from the VIM and mapped to this VNF instance. Collection and reporting of performance information is controlled by a PM job that groups details of performance collection and reporting information.

When new performance information is available, the consumer is notified using the notification PerformanceInformationAvailableNotification.

The operations provided through this interface are:

- Create PM Job
- Query PM Job
- Delete PM Job
- Create Threshold
- Query Threshold
- Delete Threshold
- Subscribe
- Query Subscription Information
- Terminate Subscription
- Notify

6.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2.

The string "vnfpm" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present specification. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 6.2-1 shows the overall resource URI structure defined for the performance management API.

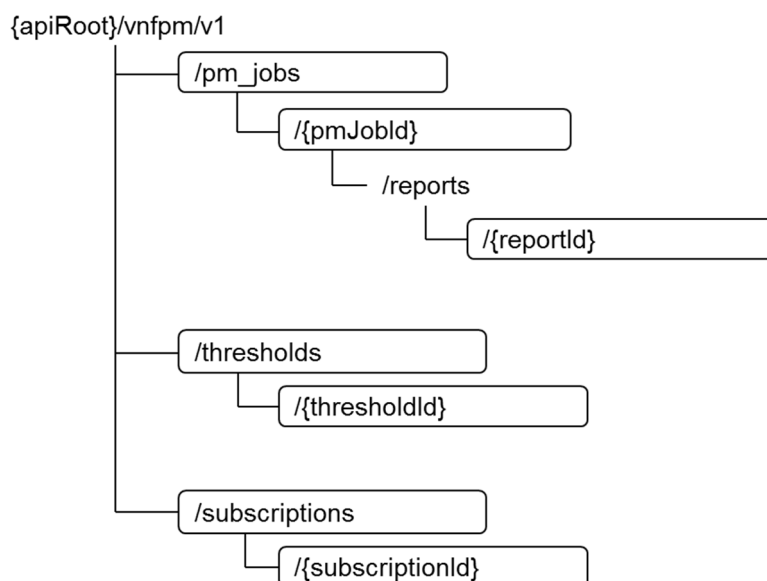


Figure 6.2-1: Resource URI structure of the VNF Performance Management interface

Table 6.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 6.2-1: Resources and methods overview of the VNF Performance Management interface

Resource name	Resource URI	HTTP Method	Meaning
PM jobs	/pm_jobs	POST	Create a PM job
		GET	Query PM jobs
Individual PM job	/pm_jobs/{pmJobId}	GET	Read a single PM job
		DELETE	Delete a PM job
Individual performance report	/pm_jobs/{pmJobId}/reports/{reportId}	GET	Read an individual performance report
Thresholds	/thresholds	POST	Create a threshold
		GET	Query thresholds
Individual threshold	/thresholds/{thresholdId}	GET	Query a single threshold
		DELETE	Delete a threshold
Subscriptions	/subscriptions	POST	Subscribe to PM notifications
		GET	Query PM related subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Query a single PM related subscription
		DELETE	Terminate a subscription
Notification endpoint	(client-defined)	POST	Notify about PM related events
		GET	Test the notification endpoint

6.3 Sequence diagrams (informative)

6.3.1 Flow of creating a PM job

This clause describes a sequence for creating a performance management jobs.

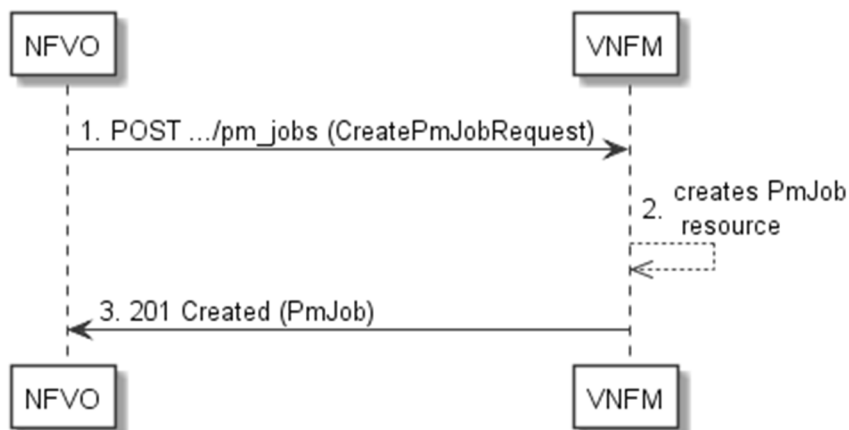


Figure 6.3.1-1: Flow of PM job creation

PM job creation, as illustrated in figure 6.3.1-1, consists of the following steps:

- 1) If the NFVO intends to create a PM job, it sends a POST request to the "PM jobs" resource, including one data structure of type "CreatePmJobRequest" in the payload body.
- 2) The VNFM creates a PM job instance.
- 3) The VNFM returns a "201 Created" response to the NFVO, and includes in the payload body a representation of the PM job just created.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.2 Flow of querying/reading PM jobs

This clause describes a sequence for querying/reading performance management jobs.

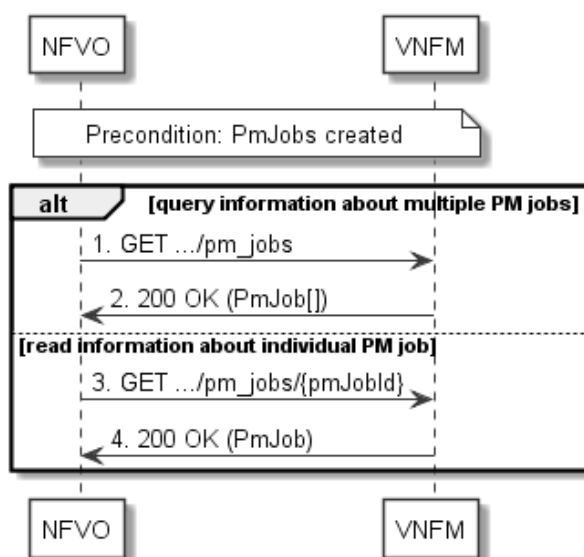


Figure 6.3.2-1: Flow of PM jobs query/read

PM jobs query/read, as illustrated in figure 6.3.2-1, consists of the following steps:

- 1) If the NFVO intends to query all PM jobs, it sends a GET request to the "PM jobs" resource.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "PmJob" in the payload body.
- 3) If the NFVO intends to read information about a particular PM job, it sends a GET request to the "Individual PM job" resource, addressed by the appropriate PM job identifier in its resource URI.
- 4) The VNFM returns a "200 OK" response to the NFVO, and includes one data structure of type "PmJob" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.3 Flow of deleting a PM job

This clause describes a sequence for deleting a performance management jobs.

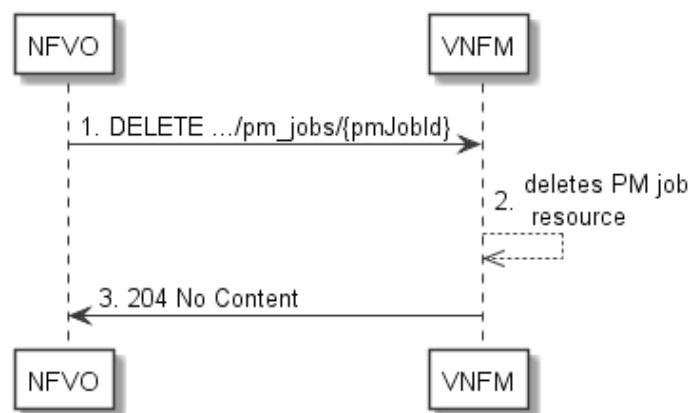


Figure 6.3.3-1: Flow of PM job deletion

PM job deletion, as illustrated in figure 6.3.3-1, consists of the following steps:

- 1) If the NFVO intends to delete a PM job, it sends a DELETE request to the "Individual PM job" resource, addressed by the appropriate PM job identifier in its resource URI.
- 2) The VNFM returns a response with a "204 No Content" response code and an empty payload body to the NFVO.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.4 Flow of obtaining performance reports

This clause describes a sequence for obtaining performance reports.

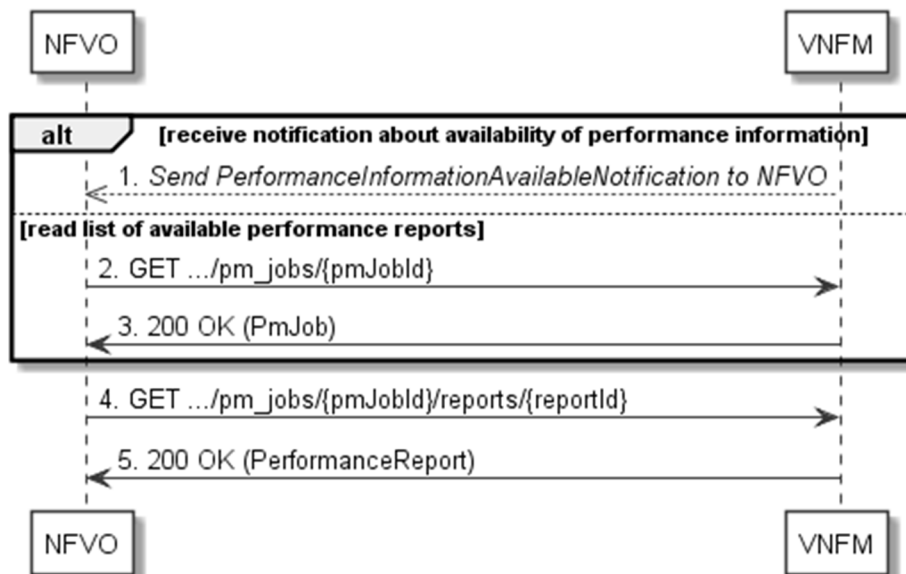


Figure 6.3.4-1: Flow of obtaining performance reports

Obtaining a performance report, as illustrated in figure 6.3.4-1, consists of the following steps:

- 1) The VNFM sends to the NFVO a *PerformanceInformationAvailableNotification* (see clause 6.3.9) that indicates the availability of a new performance report, including a link from which the report can be obtained.
- 2) Alternatively, the NFVO sends a GET request to the "Individual PM job" resource, to obtain a representation of the PM job resource including information about performance reports that are available for this PM job, including their URIs.
- 3) In that case, the VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "PmJob" in the payload body.
- 4) The NFVO sends to the VNFM a GET request to the URI obtained either in step (1) or step (3), in order to read a performance report resource.
- 5) The VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "PerformanceReport" in the payload body.

6.3.5 Flow of creating a threshold

This clause describes a sequence for creating a performance management threshold.

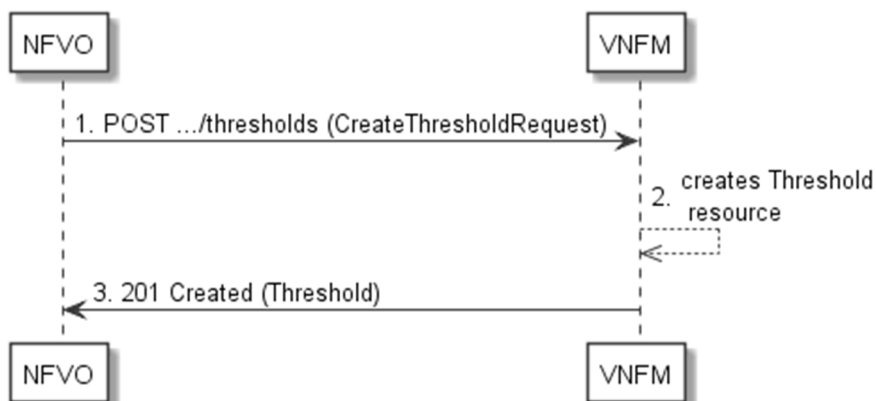


Figure 6.3.5-1: Flow of threshold creation

Threshold creation, as illustrated in figure 6.3.5-1, consists of the following steps:

- 1) If the NFVO intends to create a threshold, it sends a POST request to the "Thresholds" resource, including a data structure of type "CreateThresholdRequest" in the payload body.
- 2) The VNFM creates a threshold instance.
- 3) The VNFM returns a "201 Created" response to the NFVO, and includes in the payload body a representation of the threshold just created.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.6 Flow of querying/reading thresholds

This clause describes a sequence for querying/reading performance management thresholds.

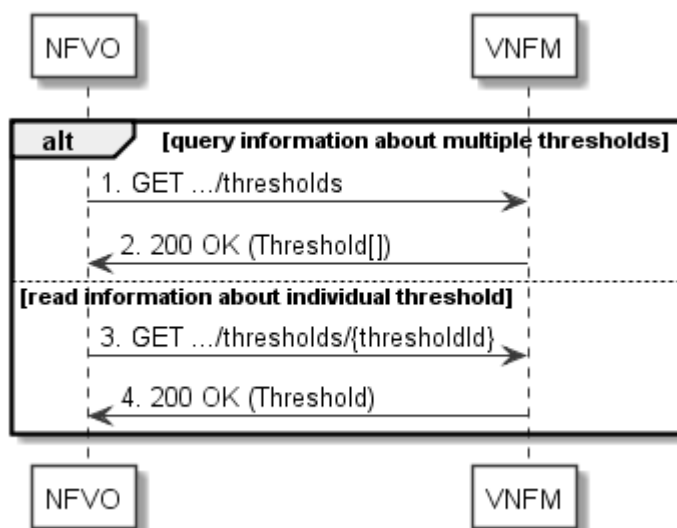


Figure 6.3.6-1: Flow of thresholds query/read

Threshold query/read, as illustrated in figure 6.3.6-1, consists of the following steps:

- 1) If the NFVO intends to query all thresholds, it sends a GET request to the "Thresholds" resource.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "Threshold" in the payload body.
- 3) If the NFVO intends to read information about a particular threshold, it sends a GET request to the "Individual threshold" resource with the appropriate threshold identifier in its resource URI.
- 4) The VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "Threshold" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.7 Flow of deleting thresholds

This clause describes a sequence for deleting performance management thresholds.

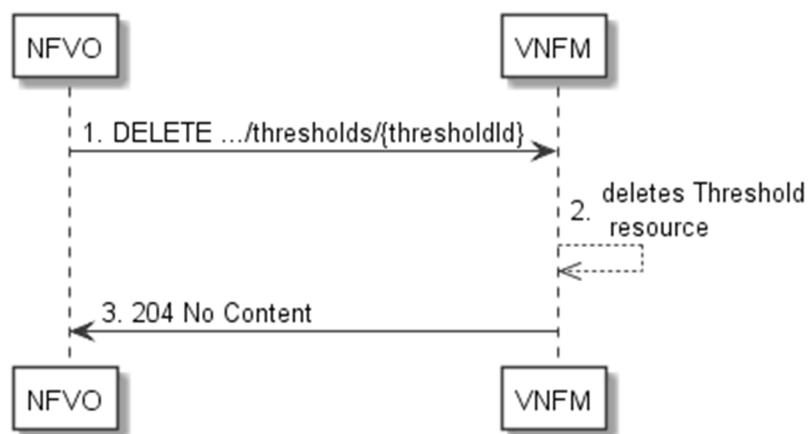


Figure 6.3.7-1: Flow of threshold deletion

Threshold deletion, as illustrated in figure 6.3.7-1, consists of the following steps:

- 1) If the NFVO intends to delete a particular threshold, it sends a DELETE request to the "Individual threshold" resource, addressed by the appropriate threshold identifier in its resource URI.
- 2) The VNFM returns a "204 No Content" response code to the NFVO. The response body shall be empty.

Error handling: In case of failure, appropriate error information is provided in the response.

6.3.8 Flow of managing subscriptions

This clause describes the procedure for creating, reading and terminating subscriptions to notifications related to VNF performance management.

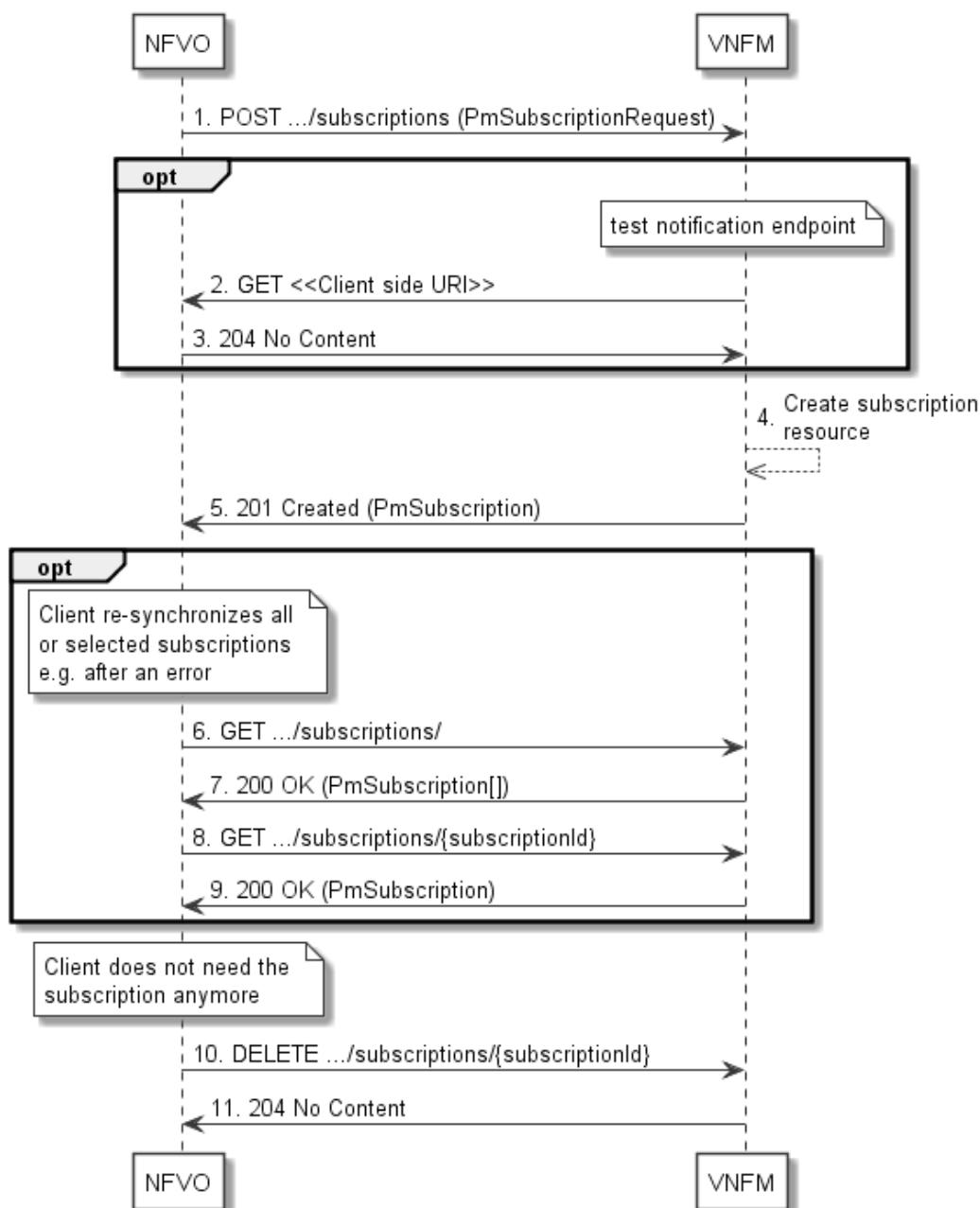


Figure 6.3.8-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 6.3.8-1:

- 1) The NFVO sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "PmSubscriptionRequest". This data structure contains filtering criteria and a client side URI to which the VNFM will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the NFVO as part of the subscription, the VNFM sends a GET request to the notification endpoint URI.
- 3) In that case, the NFVO returns a "204 No Content" response to indicate success.

- 4) The VNFM creates a new subscription to notifications related to VNF performance management, and a resource that represents this subscription.
- 5) The VNFM returns a "201 Created" response containing a data structure of type "PmSubscription," representing the subscription resource just created by the VNFM, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) Optionally, for example when trying to recover from an error situation, the NFVO may query information about its subscriptions by sending a GET request to the "Subscriptions" resource.
- 7) In that case, the VNFM returns a "200 OK" response that contains the list of representations of all existing subscriptions that were created by the NFVO.
- 8) Optionally, for example when trying to recover from an error situation, the NFVO may read information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the VNFM returns a "200 OK" response that contains a representation of that individual subscription.
- 10) When the NFVO does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription.
- 11) The VNFM acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The VNFM rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

6.3.9 Flow of sending notifications

This clause describes the procedure for sending notifications related to VNF performance management.

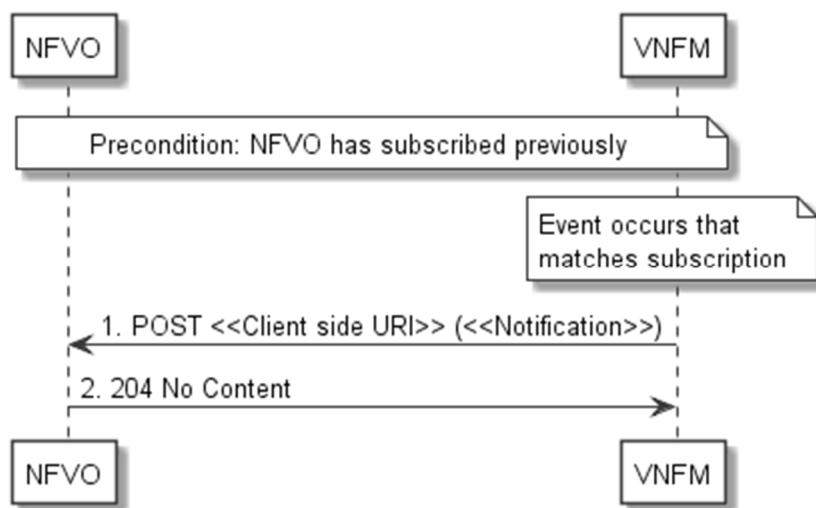


Figure 6.3.9-1: Flow of sending notifications

Precondition: The NFVO has subscribed previously for notifications related to VNF performance management.

The procedure consists of the following steps as illustrated in figure 6.3.9-1:

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the VNFM generates a notification that includes information about the event, and sends it in the body of a POST request to the URI which the NFVO has registered as part of the subscription request. The variable <<Notification>> in the flow is a placeholder for the different types of notifications that can be sent by this API.
- 2) The NFVO acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the VNFM does not receive the "204 No Content" response from the NVFO, it can retry sending the notification.

6.4 Resources

6.4.1 Introduction

This clause defines all the resources and methods provided by the performance management API.

6.4.2 Resource: PM jobs

6.4.2.1 Description

This resource represents PM jobs. The client can use this resource to create and query PM jobs.

6.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/pm_jobs

This resource shall support the resource URI variables defined in table 6.4.2.2-1.

Table 6.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

6.4.2.3 Resource methods

6.4.2.3.1 POST

The POST method creates a PM job.

This method shall follow the provisions specified in the tables 6.4.2.3.1-1 and 6.4.2.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.2.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.2.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	CreatePmJobRequest	1	PM job creation request	
Response body	Data type	Cardinality	Response Codes	Description
	PmJob	1	201 Created	The PM job was created successfully. The response body shall contain a representation of the created PM job resource, as defined in clause 6.5.2.7. The HTTP response shall include a "Location" HTTP header that points to the created PM job resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.2.3.2 GET

The client can use this method to retrieve information about PM jobs.

This method shall follow the provisions specified in the tables 6.4.2.3.2-1 and 6.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the PmJob and in data types referenced from it shall be supported in attribute-based filtering parameters.
all_fields	0..1	Include all complex attributes in the response. See clause 4.3.3 for details. The VNFM shall support this parameter.
fields	0..1	Complex attributes to be included into the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude_fields	0..1	Complex attributes to be excluded from the response. See clause 4.3.3 for details. The VNFM should support this parameter.
exclude-default	0..1	Indicates to exclude the following complex attributes from the response. See clause 4.3.3 for details. The VNFM shall support this parameter. The following attributes shall be excluded from the PmJob structure in the response body if this parameter is provided, or none of the parameters "all_fields", "fields", "exclude_fields", "exclude_default" are provided: - reports

Table 6.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PmJob	0..N	200 OK	Information about zero or more PM jobs was queried successfully. The response body shall contain representations of zero or more PM jobs, as defined in clause 6.5.2.7.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute selector. In the returned ProblemDetails structure, the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.2.3.3 PUT

Not supported.

6.4.2.3.4 PATCH

Not supported.

6.4.2.3.5 DELETE

Not supported.

6.4.3 Resource: Individual PM job

6.4.3.1 Description

This resource represents an individual PM job. The client can use this resource to delete and read the underlying PM job.

6.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/pm_jobs/{pmJobId}

This resource shall support the resource URI variables defined in table 6.4.3.2-1.

Table 6.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
pmJobId	Identifier of the PM job. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new PM job resource. It can also be retrieved from the "id" attribute in the payload body of that response.	

6.4.3.3 Resource methods

6.4.3.3.1 POST

Not supported.

6.4.3.3.2 GET

The client can use this method for reading an individual PM job.

This method shall follow the provisions specified in the tables 6.4.3.3.2-1 and 6.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PmJob	1	200 OK	Information about an individual PM job was queried successfully. The response body shall contain a representation of the PM job resource, as defined in clause 6.5.2.7.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.3.3.3 PUT

Not supported.

6.4.3.3.4 PATCH

Not supported.

6.4.3.3.5 DELETE

This method terminates an individual PM job.

This method shall follow the provisions specified in the tables 6.4.3.3.5-1 and 6.4.3.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.3.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.3.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The PM job was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.4 Resource: Individual performance report

6.4.4.1 Description

This resource represents an individual performance report that was collected by a PM job. The client can use this resource to read the performance report. The URI of this report can be obtained from a PerformanceInformationAvailableNotification (see clause 6.5.2.5) or from the representation of the "Individual PM job" resource.

It is determined by means outside the scope of the present document, such as configuration or policy, how long an individual performance report is available.

6.4.4.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/pm_jobs/{pmJobId}/reports/{reportId}

This resource shall support the resource URI variables defined in table 6.4.4.2-1.

Table 6.4.4.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
pmJobId	Identifier of the PM job.
reportId	Identifier of the performance report.

6.4.4.3 Resource methods

6.4.4.3.1 POST

Not supported.

6.4.4.3.2 GET

The client can use this method for reading an individual performance report.

This method shall follow the provisions specified in the tables 6.4.4.3.2-1 and 6.4.4.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.4.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.4.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PerformanceReport	1	200 OK	Information of an individual performance report was read successfully. The response body shall contain a representation of the performance report resource, as defined in clause 6.5.2.10.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

6.4.4.3.3 PUT

Not supported.

6.4.4.3.4 PATCH

Not supported.

6.4.4.3.5 DELETE

Not supported.

6.4.5 Resource: Thresholds

6.4.5.1 Description

This resource represents thresholds. The client can use this resource to create and query thresholds.

6.4.5.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/thresholds

This resource shall support the resource URI variables defined in table 6.4.5.2-1.

Table 6.4.5.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

6.4.5.3 Resource methods

6.4.5.3.1 POST

The POST method can be used by the client to create a threshold.

This method shall follow the provisions specified in the tables 6.4.5.3.1-1 and 6.4.5.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.5.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.5.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	CreateThresholdRequest	1	Request parameters to create a threshold resource.	
Response body	Data type	Cardinality	Response Codes	Description
	Threshold	1	201 Created	A threshold was created successfully. The response body shall contain a representation of the created threshold resource, as defined in clause 6.5.2.9. The HTTP response shall include a "Location" HTTP header that contains the resource URI of the created threshold resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.5.3.2 GET

The client can use this method to query information about thresholds.

This method shall follow the provisions specified in the tables 6.4.5.3.2-1 and 6.4.5.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.5.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the Thresholds data type and in data types referenced from it shall be supported in attribute-based filtering parameters.
NOTE: There are no attribute selectors defined for this resource as the threshold attributes with cardinality 0..1 or 0..N are not structurally complex in nature.		

Table 6.4.5.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	Threshold	0..N	200 OK	Information about zero or more thresholds was queried successfully. The response body shall contain representations of zero or more thresholds, as defined in clause 6.5.2.9.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.5.3.3 PUT

Not supported.

6.4.5.3.4 PATCH

Not supported.

6.4.5.3.5 DELETE

Not supported.

6.4.6 Resource: Individual threshold**6.4.6.1 Description**

This resource represents an individual threshold.

6.4.6.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/thresholds/{thresholdId}

This resource shall support the resource URI variables defined in table 6.4.6.2-1.

Table 6.4.6.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
thresholdId	Identifier of the threshold. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new threshold resource. It can also be retrieved from the "id" attribute in the payload body of that response.	

6.4.6.3 Resource methods

6.4.6.3.1 POST

Not supported.

6.4.6.3.2 GET

The client can use this method for reading an individual threshold

This method shall follow the provisions specified in the tables 6.4.6.3.2-1 and 6.4.6.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.6.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.6.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	Threshold	1	200 OK	Information about an individual threshold was queried successfully. The response body shall contain a representation of the threshold, as defined in clause 6.5.2.9.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.6.3.3 PUT

Not supported.

6.4.6.3.4 PATCH

Not supported.

6.4.6.3.5 DELETE

This method allows to delete a threshold.

This method shall follow the provisions specified in the tables 6.4.6.3.5-1, and 6.4.6.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.6.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.6.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The threshold was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.7 Resource: Subscriptions

6.4.7.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to VNF performance management and to query its subscriptions.

6.4.7.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/subscriptions

This resource shall support the resource URI variables defined in table 6.4.7.2-1.

Table 6.4.7.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

6.4.7.3 Resource methods

6.4.7.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 6.4.7.3.1-1 and 6.4.7.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.7.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.7.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	PmSubscriptionRequest	1	Details of the subscription to be created.	
Response body	Data type	Cardinality	Response Codes	Description
	PmSubscription	1	201 Created	The subscription was created successfully. A representation of the created subscription resource shall be returned in the response body, as defined in clause 6.5.2.3. The HTTP response shall include a "Location" HTTP header that contains the resource URI of the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.7.3.2 GET

The client can use this method to query the list of active subscriptions to Performance management notifications subscribed by the client.

This method shall follow the provisions specified in the tables 6.4.7.3.2-1 and 6.4.7.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.7.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the PmSubscription and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 6.4.7.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PmSubscription	0..N	200 OK	The list of subscriptions was queried successfully. The response body shall contain the representations of all active subscriptions of the functional block that invokes the method, as defined in clause 6.5.2.3.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.7.3.3 PUT

Not supported.

6.4.7.3.4 PATCH

Not supported.

6.4.7.3.5 DELETE

Not supported.

6.4.8 Resource: Individual subscription

6.4.8.1 Description

This resource represents an individual subscription for notifications about performance management related events.

The client can use this resource to read and to terminate a subscription to notifications related to VNF performance management.

6.4.8.2 Resource definition

The resource URI is:

{apiRoot}/vnfpm/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 6.4.8.2-1.

Table 6.4.8.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
subscriptionId	Identifier of the subscription. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.

6.4.8.3 Resource methods

6.4.8.3.1 POST

Not supported.

6.4.8.3.2 GET

The client can use this method for reading an individual subscription about Performance management notifications subscribed by the client.

This method shall follow the provisions specified in the tables 6.4.8.3.2-1 and 6.4.8.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.8.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.8.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PmSubscription	1	200 OK	The subscription was read successfully. The response body shall contain a representation of the subscription resource, as defined in clause 6.5.2.3.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.8.3.3 PUT

Not supported.

6.4.8.3.4 PATCH

Not supported.

6.4.8.3.5 DELETE

This method terminates an individual subscription.

This method shall follow the provisions specified in the tables 6.4.8.3.5-1 and 6.4.8.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.8.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.8.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

6.4.9 Resource: Notification endpoint

6.4.9.1 Description

This resource represents a notification endpoint for VNF performance management.

The API producer can use this resource to send notifications related to performance management events to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

6.4.9.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 6.4.9.2-1.

Table 6.4.9.2-1: Resource URI variables for this resource

Name	Definition
n/a	

6.4.9.3 Resource methods

6.4.9.3.1 POST

The POST method delivers a notification regarding a performance management event from the server to the client.

This method shall follow the provisions specified in the tables 6.4.9.3.1-1 and 6.4.9.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.9.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.9.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	PerformanceInformationAvailableNotification	1	Notification about performance information availability	
ThresholdCrossedNotification	1	Notification about threshold crossing		
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned. The VNFM shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

6.4.9.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 6.4.9.3.2-1 and 6.4.9.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 6.4.9.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 6.4.9.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

6.4.9.3.3 PUT

Not supported.

6.4.9.3.4 PATCH

Not supported.

6.4.9.3.5 DELETE

Not supported.

6.5 Data Model

6.5.1 Introduction

This clause defines the request and response data structures of the VNF Performance Management interface. If a request or response contains attributes not defined in the present specification, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

6.5.2 Resource and notification data types

6.5.2.1 Introduction

This clause defines the data structures to be used in resource representations and notifications.

6.5.2.2 Type: PmSubscriptionRequest

This type represents a subscription request. It shall comply with the provisions defined in table 6.5.2.2-1.

Table 6.5.2.2-1: Definition of the PmSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	PmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentification	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

6.5.2.3 Type: PmSubscription

This type represents a subscription. It shall comply with the provisions defined in table 6.5.2.3-1.

Table 6.5.2.3-1: Definition of the PmSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier that identifies the subscription
filter	PmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter
callbackUri	Uri	1	The URI of the endpoint to send the notification to
_links	Structure (inlined)	1	Links to resources related to this resource
>self	Link	1	URI of this resource

6.5.2.4 Type: ThresholdCrossedNotification

This type represents a notification that is sent when a threshold has been crossed. It shall comply with the provisions defined in table 6.5.2.4-1.

Table 6.5.2.4-1: Definition of the ThresholdCrossedNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "ThresholdCrossedNotification " for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date and time of the generation of the notification.
thresholdId	Identifier	1	Identifier of the threshold which has been crossed.
crossingDirection	CrossingDirectionType	1	An indication of whether the threshold was crossed in upward or downward direction.
objectInstanceId	Identifier	1	Identifier that identifies a VNF instance.
performanceMetric	String	1	Performance metric associated with the threshold.
performanceValue	(any type)	1	Value of the metric that resulted in threshold crossing. See note.
_links	Structure (inlined)	1	Links to resources related to this notification
>subscription	Link	1	Link to the related subscription.
>objectInstance	Link	0..1	Link to the resource representing the VNF instance to which the notified change applies. Shall be present if the VNF instance information is accessible as a resource.
>threshold	Link	1	Link to the resource that represents the threshold that was crossed.
NOTE:	The type of the "performanceValue" attribute (i.e. scalar, structure (Object in JSON), or array (of scalars, arrays or structures / Objects)) is assumed to be defined in an external measurement specification outside the scope of the present document.		

6.5.2.5 Type: PerformanceInformationAvailableNotification

This notification informs the receiver that performance information is available. It shall comply with the provisions defined in table 6.5.2.5-1.

NOTE: The timing of sending this notification is determined by the capability of the producing entity to evaluate the threshold crossing condition.

Table 6.5.2.5-1: Definition of the PerformanceInformationAvailableNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "PerformanceInformationAvailableNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date and time of the generation of the notification.
objectInstanceId	Identifier	1	Identifier that identifies a VNF instance.
_links	Structure (inlined)	1	Links to resources related to this notification.
>subscription	Link	1	Link to the related subscription.
>objectInstance	Link	0..1	Link to the resource representing the VNF instance to which the notified change applies. Shall be present if the VNF instance information is accessible as a resource.
>pmJob	Link	1	Link to the resource that represents the PM job for which performance information is available.
>performanceReport	Link	1	Link from which the available performance information of data type "PerformanceReport" (see clause 6.5.2.10) can be obtained. This link should point to an "Individual performance report" resource as defined in clause 6.4.4.

6.5.2.6 Type: CreatePmJobRequest

This type represents a request to create a PM job. It shall comply with the provisions defined in table 6.5.2.6-1.

Table 6.5.2.6-1: Definition of the CreatePmJobRequest data type

Attribute name	Data type	Cardinality	Description
objectInstanceIds	Identifier	1..N	Identifiers of the VNF instances for which performance information is requested to be collected.
criteria	PmJobCriteria	1	Criteria of the collection of performance information.

6.5.2.7 Type: PmJob

This type represents a PM job. It shall comply with the provisions defined in table 6.5.2.7-1.

Table 6.5.2.7-1: Definition of the PmJob data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this PM job.
objectInstanceIds	Identifier	1..N	Identifiers of the VNF instances for which performance information is collected.
criteria	PmJobCriteria	1	Criteria of the collection of performance information.
reports	Structure (inlined)	0..N	Information about available reports collected by this PM job.
>href	Uri	1	The Uri where the report can be obtained.
>readyTime	DateTime	1	The time when the report was made available.
>expiryTime	DateTime	0..1	The time when the report will expire.
>fileSize	UnsignedInt	0..1	The size of the report file in bytes, if known.
_links	Structure (inlined)	1	Links for this resource.
>self	Link	1	URI of this resource.
>objects	Link	0..N	Links to resources representing the VNF instances for which performance information is collected. Shall be present if the VNF instance information is accessible as a resource.

6.5.2.8 Type: CreateThresholdRequest

This type represents a request to create a threshold. It shall comply with the provisions defined in table 6.5.2.8-1.

Table 6.5.2.8-1: Definition of the CreateThresholdRequest data type

Attribute name	Data type	Cardinality	Description
objectInstanceid	Identifier	1	Identifier of the VNF instance associated with this threshold.
criteria	ThresholdCriteria	1	Criteria that define this threshold.

6.5.2.9 Type: Threshold

This type represents a threshold. It shall comply with the provisions defined in table 6.5.2.9-1.

Table 6.5.2.9-1: Definition of the Threshold data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this threshold resource.
objectInstanceid	Identifier	1	Identifier of the VNF instance associated with the threshold.
criteria	ThresholdCriteria	1	Criteria that define this threshold.
_links	Structure (inlined)	1	Links for this resource.
>self	Link	1	URI of this resource.
>object	Link	0..1	Link to a resource representing the VNF instance for which performance information is collected. Shall be present if the VNF instance information is accessible as a resource.

6.5.2.10 Type: PerformanceReport

This type defines the format of a performance report provided by the VNFM to the NFVO as a result of collecting performance information as part of a PM job. The type shall comply with the provisions defined in table 6.5.2.10-1.

Table 6.5.2.10-1: Definition of the PerformanceReport data type

Attribute name	Data type	Cardinality	Description
entries	Structure (inlined)	1..N	List of performance information entries. Each performance report entry is for a given metric of a given object (i.e. VNF instance), but can include multiple collected values.
>objectType	String	1	Defines the object type for which performance information is reported (i.e. VNF type). The string value shall be set to the vnfdId of the VNF instance to which the performance information relates.
>objectInstanceid	Identifier	1	The object instance for which the performance metric is reported. The object instances for this information element will be VNF instances.
>performanceMetric	String	1	Name of the metric collected.
>performanceValue	Structure (inlined)	1..N	List of performance values with associated timestamp.
>>timeStamp	DateTime	1	Time stamp indicating when the data was collected.
>>performanceValue	(any type)	1	Value of the metric collected. See note.
NOTE: The type of the "performanceValue" attribute (i.e. scalar, structure (Object in JSON), or array (of scalars, arrays or structures / Objects)) is assumed to be defined in an external measurement specification outside the scope of the present document.			

6.5.3 Referenced structured data types

6.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but can neither be resource representations nor bound to any subscribe/notify mechanism.

6.5.3.2 Type: PmNotificationsFilter

This type represents a filter that can be used to subscribe for notifications related to performance management events. It shall comply with the provisions defined in table 6.5.3.2-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 6.5.3.2-1: Definition of the PmNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
vnfInstanceSubscriptionFilter	VnfInstanceSubscriptionFilter	0..1	Filter criteria to select VNF instances about which to notify.
notificationTypes	Enum (inlined)	0..N	Match particular notification types. Permitted values: - ThresholdCrossedNotification - PerformanceInformationAvailableNotification See note.
NOTE: The permitted values of the "notificationTypes" attribute are spelled exactly as the names of the notification types to facilitate automated code generation systems.			

6.5.3.3 Type: PmJobCriteria

This type represents collection criteria for PM jobs. It shall comply with the provisions defined in table 6.5.3.3-1.

Table 6.5.3.3-1: Definition of the PmJobCriteria data type

Attribute name	Data type	Cardinality	Description
performanceMetric	String	0..N	This defines the types of performance metrics for the specified object instances. At least one of the two attributes (performance metric or group) shall be present.
performanceMetricGroup	String	0..N	Group of performance metrics. A metric group is a pre-defined list of metrics, known to the producer that it can decompose to individual metrics. At least one of the two attributes (performance metric or group) shall be present.
collectionPeriod	UnsignedInt	1	Specifies the periodicity at which the producer will collect performance information. The unit shall be seconds. See note 1 and note 2.
reportingPeriod	UnsignedInt	1	Specifies the periodicity at which the producer will report to the consumer about performance information. The unit shall be seconds. See note 1 and note 2.
reportingBoundary	DateTime	0..1	Identifies a time boundary after which the reporting will stop. The boundary shall allow a single reporting as well as periodic reporting up to the boundary.
<p>NOTE 1: At the end of each reportingPeriod, the producer will inform the consumer about availability of the performance data collected for each completed collection period during this reportingPeriod. The reportingPeriod should be equal to or a multiple of the collectionPeriod. In the latter case, the performance data for the collection periods within one reporting period are reported together.</p> <p>NOTE 2: In particular when choosing short collection and reporting periods, the number of PM jobs that can be supported depends on the capability of the producing entity.</p>			

6.5.3.4 Type: ThresholdCriteria

This type represents criteria that define a threshold. It shall comply with the provisions defined in table 6.5.3.4-1.

Table 6.5.3.4-1: Definition of the ThresholdCriteria data type

Attribute name	Data type	Cardinality	Description
performanceMetric	String	1	Defines the performance metric associated with the threshold.
thresholdType	Enum (inlined)	1	Type of threshold. This attribute determines which other attributes are present in the data structure. Permitted values: - SIMPLE: Single-valued static threshold See note 1.
simpleThresholdDetails	Structure (inlined)	0..1	Details of a simple threshold. Shall be present if thresholdType="SIMPLE".
>thresholdValue	Number	1	The threshold value. Shall be represented as a floating point number.
>hysteresis	Number	1	The hysteresis of the threshold. Shall be represented as a non-negative floating point number. A notification with crossing direction "UP" will be generated if the measured value reaches or exceeds "thresholdValue" + "hysteresis". A notification with crossing direction "DOWN" will be generated if the measured value reaches or undercuts "thresholdValue" - "hysteresis". See note 2.
NOTE 1: In the present document, simple thresholds are defined. The definition of additional threshold types is left for future specification.			
NOTE 2: The hysteresis is defined to prevent storms of threshold crossing notifications. When processing a request to create a threshold, implementations should enforce a suitable minimum value for this attribute (e.g. override the value or reject the request).			

6.5.4 Referenced simple data types and enumerations

6.5.4.1 Introduction

This clause defines simple data types and enumerations that can be referenced from data structures defined in the previous clauses.

6.5.4.2 Simple data types

No particular simple data types are defined for this interface, in addition to those defined in clause 4.4.

6.5.4.3 Enumeration: CrossingDirectionType

The enumeration CrossingDirectionType shall comply with the provisions defined in table 6.5.4.3-1.

Table 6.5.4.3-1: Enumeration CrossingDirectionType

Enumeration value	Description
UP	The threshold was crossed in upward direction.
DOWN	The threshold was crossed in downward direction.

7 VNF Fault Management interface

7.1 Description

This interface allows the NFVO to subscribe to notifications regarding VNF alarms provided by the VNFM. The operations provided through this interface are:

- Get Alarm List
- Acknowledge Alarm
- Subscribe
- Query Subscription Information
- Terminate Subscription
- Notify

7.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "vnffm" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present specification. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 7.2-1 shows the overall resource URI structure defined for the VNF fault management interface.

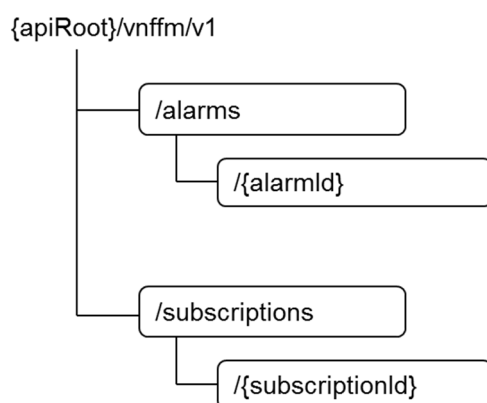


Figure 7.2-1: Resource URI structure of the VNF Fault Management interface

Table 7.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 7.2-1: Resources and methods overview of the VNF Fault Management interface

Resource name	Resource URI	HTTP Method	Meaning
Alarms	/alarms	GET	Query alarms related to VNF instances
Individual alarm	/alarms/{alarmId}	GET	Read individual alarm
		PATCH	Acknowledge individual alarm
Subscriptions	/subscriptions	POST	Subscribe to VNF alarms
		GET	Query multiple subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Read an individual subscription
		DELETE	Terminate a subscription
Notification endpoint	(client-provided)	POST	Notify about VNF alarms
		GET	Test the notification endpoint

7.3 Sequence diagrams (informative)

7.3.1 Flow of the Get Alarm List operation

This clause describes a sequence flow for querying one or multiple alarms.

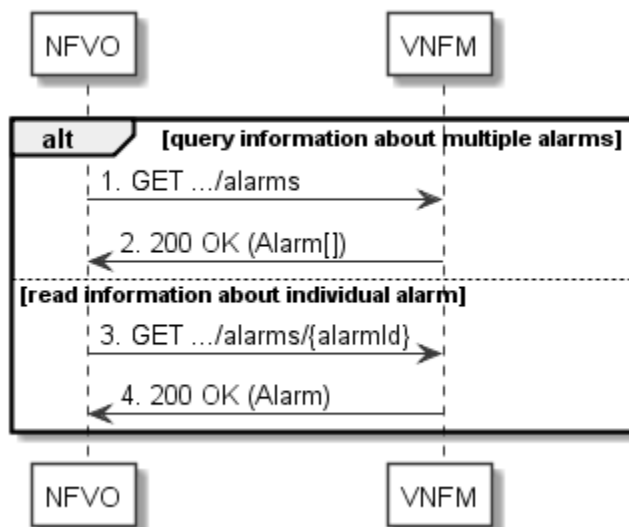


Figure 7.3.1-1: Flow of alarm query/read

Alarm query, as illustrated in figure 7.3.1-1, consists of the following steps:

- 1) If the NFVO intends to query all alarms, it sends a GET request to the "Alarms " resource.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "Alarm" in the payload body.
- 3) If the NFVO intends to read a particular alarm, it sends a GET request to the "Individual alarm" resource, addressed by the appropriate alarm identifier in its resource URI.
- 4) The VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "Alarm" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

7.3.2 Flow of acknowledging alarm

This clause describes the procedure to acknowledge an individual alarm.

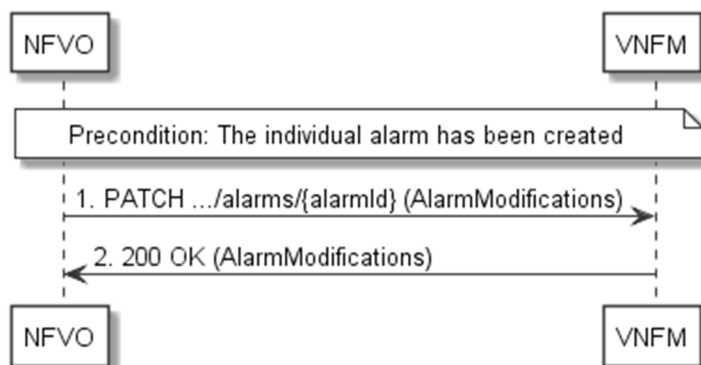


Figure 7.3.2-1: Flow of acknowledging alarm

Precondition: The resource representing the individual alarm has been created.

Acknowledge alarm, as illustrated in figure 7.3.2-1, consists of the following steps:

- 1) The NFVO sends a PATCH request to the individual alarm.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "AlarmModifications" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

7.3.3 Flow of managing subscriptions

This clause describes the procedure for creating, reading and terminating subscriptions to notifications related to VNF fault management.

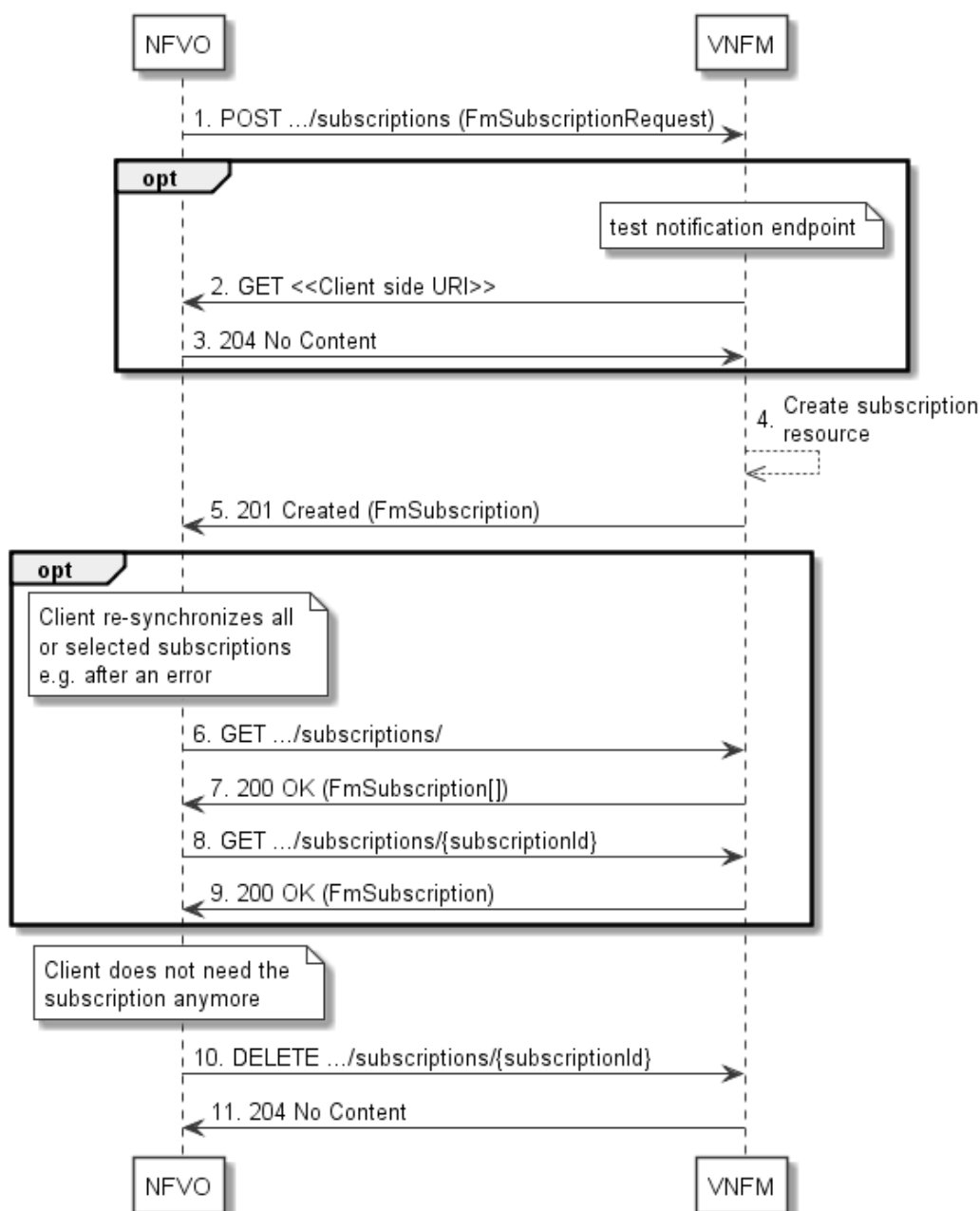


Figure 7.3.3-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 7.3.3-1:

- 1) The NFVO sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "FmSubscriptionRequest". This data structure contains filtering criteria and a client side URI to which the VNFM will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the NFVO as part of the subscription, the VNFM sends a GET request to the notification endpoint URI.
- 3) In that case, the NFVO returns a "204 No Content" response to indicate success.
- 4) The VNFM creates a new subscription for notifications related to VNF fault management, and a resource that represents this subscription.
- 5) The VNFM returns a "201 Created" response containing a data structure of type "FmSubscription," representing the subscription resource just created by the VNFM, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) Optionally, for example when trying to recover from an error situation, the NFVO may query information about its subscriptions by sending a GET request to the "Subscriptions" resource.
- 7) In that case, the VNFM returns a "200 OK" response that contains the list of representations of all existing subscriptions that were created by the NFVO.
- 8) Optionally, for example when trying to recover from an error situation, the NFVO may read information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the VNFM returns a "200 OK" response that contains a representation of that individual subscription.
- 10) When the NFVO does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription.
- 11) The VNFM acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The VNFM rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

7.3.4 Flow of sending notifications

This clause describes the procedure for sending notifications related to VNF fault management.

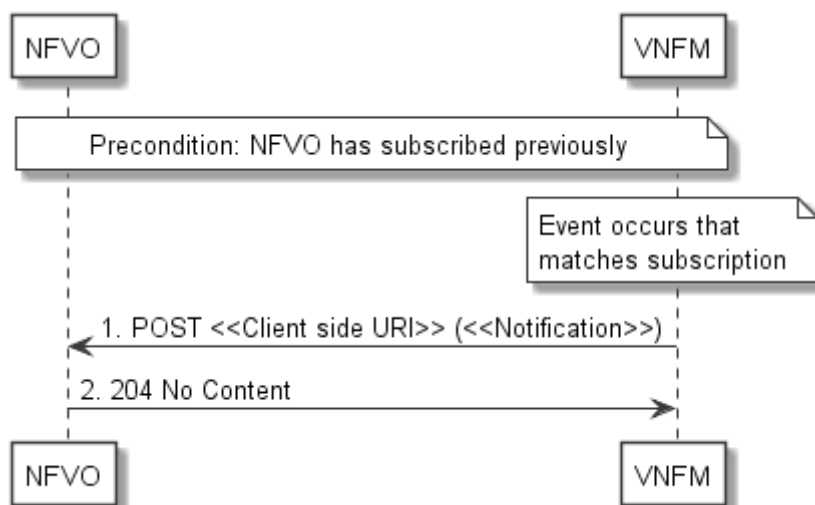


Figure 7.3.4-1: Flow of sending notifications

Precondition: The NFVO has subscribed previously for notifications related to VNF fault management.

The procedure consists of the following steps as illustrated in figure 7.3.4-1:

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the VNFM generates a notification that includes information about the event, and sends it in the body of a POST request to the URI which the NFVO has registered as part of the subscription request. The variable <<Notification>> in the flow is a placeholder for the different types of notifications that can be sent by this API (see clauses 7.5.2.5, 7.5.2.6 and 7.5.2.7).
- 2) The NFVO acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the VNFM does not receive the "204 No Content" response from the NFVO, it can retry sending the notification.

7.4 Resources

7.4.1 Introduction

This clause defines all the resources and methods provided by the VNF fault management interface.

7.4.2 Resource: Alarms

7.4.2.1 Description

This resource represents a list of alarms related to VNF instances.

7.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vnffm/v1/alarms

This resource shall support the resource URI variables defined in table 7.4.2.2-1.

Table 7.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

7.4.2.3 Resource methods

7.4.2.3.1 POST

Not supported.

7.4.2.3.2 GET

The client can use this method to retrieve information about the alarm list.

This method shall follow the provisions specified in the tables 7.4.2.3.2-1 and 7.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	<p>Attribute-based filtering parameters according to clause 4.3.2.</p> <p>The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters.</p> <p>The following attribute names shall be supported in attribute-based filtering parameters: id, vnfInstanceId, rootCauseFaultyResource.faultyResourceType, eventType, perceivedSeverity, probableCause.</p>

NOTE: There are no attribute selectors defined for this resource as the Alarm attributes with cardinality 0..1 or 0..N are not structurally complex in nature.

Table 7.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	Alarm	0..N	200 OK	<p>The request has succeeded.</p> <p>The response body shall contain the list of related alarms.</p>
	ProblemDetails	1	400 Bad Request	<p>Error: Invalid attribute-based filtering parameters.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	<p>In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.</p>

7.4.2.3.3 PUT

Not supported.

7.4.2.3.4 PATCH

Not supported.

7.4.2.3.5 DELETE

Not supported.

7.4.3 Resource: Individual alarm

7.4.3.1 Description

This resource represents an individual alarm.

7.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vnffm/v1/alarms/{alarmId}

This resource shall support the resource URI variables defined in table 7.4.3.2-1.

Table 7.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
alarmId	Identifier of the alarm. See note.
NOTE:	This identifier can be retrieved from the "id" attribute of the "alarm" attribute in the AlarmNotification or AlarmClearedNotification. It can also be retrieved from the "id" attribute of the applicable array element in the payload body of the response to a GET request to the "Alarms" resource.

7.4.3.3 Resource methods

7.4.3.3.1 POST

Not supported.

7.4.3.3.2 GET

The client can use this method to read an individual alarm.

This method shall follow the provisions specified in the tables 7.4.3.3.2-1 and 7.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 7.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	Alarm	1	200	Information about an individual alarm was read successfully. The response body shall contain a representation of the individual alarm.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

7.4.3.3.3 PUT

Not supported.

7.4.3.3.4 PATCH

This method modifies an individual alarm resource.

This method shall follow the provisions specified in the tables 7.4.3.3.4-1 and 7.4.3.3.4-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.3.3.4-1: URI query parameters supported by the PATCH method on this resource

Name	Cardinality	Description
none supported		

Table 7.4.3.3.4-2: Details of the PATCH request/response on this resource

Request body	Data type	Cardinality	Description	
	AlarmModifications	1	The parameter for the alarm modification, as defined in clause 7.5.2.8.	
Response body	Data type	Cardinality	Response Codes	Description
	AlarmModifications	1	200 OK	The request was accepted and completed. The response body shall contain attribute modifications for an 'Individual alarm' resource (see clause 7.5.2.4).
	ProblemDetails	0..1	409 Conflict	Error: The operation cannot be executed currently, due to a conflict with the state of the "Individual alarm" resource. Typically, this is due to the fact that the alarm is already in the state that is requested to be set (such as trying to acknowledge an already-acknowledged alarm). The response body shall contain a ProblemDetails structure, in which the "detail" attribute shall convey more information about the error.
	ProblemDetails	0..1	412 Precondition failed	Error: A precondition given in an HTTP request header is not fulfilled. Typically, this is due to an ETag mismatch, indicating that the resource was modified by another entity. The response body should contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.	

7.4.3.3.5 DELETE

Not supported.

7.4.4 Resource: Subscriptions

7.4.4.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to VNF alarms and to query its subscriptions

7.4.4.2 Resource definition

The resource URI is:

{apiRoot}/vnffm/v1/subscriptions

This resource shall support the resource URI variables defined in table 7.4.4.2-1.

Table 7.4.4.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

7.4.4.3 Resource methods

7.4.4.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 7.4.4.3.1-1 and 7.4.4.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.4.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Remarks
none supported		

Table 7.4.4.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	FmSubscriptionRequest	1	Details of the subscription to be created, as defined in clause 7.5.2.2.	
Response body	Data type	Cardinality	Response Codes	Description
	FmSubscription	1	201 Created	The subscription was created successfully. The response body shall contain a representation of the created subscription resource. The HTTP response shall include a "Location:" HTTP header that points to the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

7.4.4.3.2 GET

The client can use this method to retrieve the list of active subscriptions for VNF alarms subscribed by the client. It can be used e.g. for resynchronization after error situations.

This method shall follow the provisions specified in the tables 7.4.4.3.2-1 and 7.4.4.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.4.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Remarks
(filter)	0..1	<p>Attribute-based filtering parameters according to clause 4.3.2.</p> <p>The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters.</p> <p>All attribute names that appear in the FmSubscription and in data types referenced from it shall be supported in attribute-based filtering parameters.</p>

Table 7.4.4.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	FmSubscription	0..N	200 OK	<p>The list of subscriptions was queried successfully.</p> <p>The response body shall contain the representations of all active subscriptions of the functional block that invokes the method.</p>
	ProblemDetails	1	400 Bad Request	<p>Error: Invalid attribute-based filtering parameters.</p> <p>The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

7.4.4.3.3 PUT

Not supported.

7.4.4.3.4 PATCH

Not supported.

7.4.4.3.5 DELETE

Not supported.

7.4.5 Resource: Individual subscription

7.4.5.1 Description

This resource represents an individual subscription for VNF alarms. The client can use this resource to read and to terminate a subscription to notifications related to VNF fault management.

7.4.5.2 Resource definition

The resource URI is:

{apiRoot}/vnffm/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 7.4.5.2-1.

Table 7.4.5.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
subscriptionId	Identifier of this subscription. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.

7.4.5.3 Resource methods

7.4.5.3.1 POST

Not supported.

7.4.5.3.2 GET

The client can use this method for reading an individual subscription for VNF alarms subscribed by the client.

This method shall follow the provisions specified in the tables 7.4.5.3.2-1 and 7.4.5.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.5.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 7.4.5.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	FmSubscription	1	200 OK	The operation has completed successfully. The response body shall contain a representation of the subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

7.4.5.3.3 PUT

Not supported.

7.4.5.3.4 PATCH

Not supported.

7.4.5.3.5 DELETE

This method terminates an individual subscription.

This method shall follow the provisions specified in the tables 7.4.5.3.5-1 and 7.4.5.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.5.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 7.4.5.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

7.4.6 Resource: Notification endpoint

7.4.6.1 Description

This resource represents a notification endpoint for VNF alarms.

The API producer can use this resource to send notifications related to VNF alarms or about a rebuilt alarm list to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

7.4.6.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 7.4.6.2-1.

Table 7.4.6.2-1: Resource URI variables for this resource

Name	Definition
n/a	

7.4.6.3 Resource methods

7.4.6.3.1 POST

The POST method notifies a VNF alarm or that the alarm list has been rebuilt.

This method shall follow the provisions specified in the tables 7.4.6.3.1-1 and 7.4.6.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.6.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Each notification request body shall include exactly one of the alternatives defined in table 7.4.6.3.1-2.

Table 7.4.6.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	AlarmNotification	1	Information of a VNF alarm	
	AlarmClearedNotification	1	Information of the clearance of a VNF alarm	
	AlarmListRebuiltNotification	1	Information that the alarm list has been rebuilt by the VNFM	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5 may be returned. The VNFM shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

7.4.6.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 7.4.6.3.2-1 and 7.4.6.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 7.4.6.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 7.4.6.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

7.4.6.3.3 PUT

Not supported.

7.4.6.3.4 PATCH

Not supported.

7.4.6.3.5 DELETE

Not supported.

7.5 Data Model

7.5.1 Introduction

This clause defines the request and response data structures of the VNF fault management interface. If a request or response contains attributes not defined in the present document, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

7.5.2 Resource and notification data types

7.5.2.1 Introduction

This clause defines the data structures to be used in the resource representations and notifications for the VNF fault management interface.

7.5.2.2 Type: FmSubscriptionRequest

This type represents a subscription request related to notifications about VNF faults. It shall comply with the provisions defined in table 7.5.2.2-1.

Table 7.5.2.2-1: Definition of the FmSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	FmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentification	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

7.5.2.3 Type: FmSubscription

This type represents a subscription related to notifications about VNF faults. It shall comply with the provisions defined in table 7.5.2.3-1.

Table 7.5.2.3-1: Definition of the FmSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this subscription resource.
filter	FmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
_links	Structure (inlined)	1	Links for this resource.
>self	Link	1	URI of this resource.

7.5.2.4 Type: Alarm

The alarm data type encapsulates information about an alarm. It shall comply with the provisions defined in table 7.5.2.4-1.

Table 7.5.2.4-1: Definition of the Alarm data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this Alarm information element.
managedObjectId	Identifier	1	Identifier of the affected VNF instance.
rootCauseFaultyResource	FaultyResourceInfo	1	The virtualised resources that are causing the VNF fault.
alarmRaisedTime	DateTime	1	Time stamp indicating when the alarm is raised by the managed object.
alarmChangedTime	DateTime	0..1	Time stamp indicating when the alarm was last changed. It shall be present if the alarm has been updated.
alarmClearedTime	DateTime	0..1	Time stamp indicating when the alarm was cleared. It shall be present if the alarm has been cleared.
ackState	Enum (inlined)	1	Acknowledgement state of the alarm. Permitted values: - UNACKNOWLEDGED - ACKNOWLEDGED.
perceivedSeverity	PerceivedSeverityType	1	Perceived severity of the managed object failure.
eventTime	DateTime	1	Time stamp indicating when the fault was observed.
eventType	EventType	1	Type of event.
faultType	String	0..1	Additional information to clarify the type of the fault.
probableCause	String	1	Information about the probable cause of the fault.
isRootCause	Boolean	1	Attribute indicating if this fault is the root for other correlated alarms. If TRUE, then the alarms listed in the attribute CorrelatedAlarmId are caused by this fault.
correlatedAlarmIds	Identifier	0..N	List of identifiers of other alarms correlated to this fault.
faultDetails	String	0..N	Provides additional information about the fault.
_links	Structure (inlined)	1	Links for this resource.
>self	Link	1	URI of this resource.
>objectInstance	Link	0..1	Link to the resource representing the VNF instance to which the notified alarm is correlated. Shall be present if the VNF instance information is accessible as a resource.

7.5.2.5 Type: AlarmNotification

This type represents an alarm notification about VNF faults. It shall comply with the provisions defined in table 7.5.2.5-1.

Table 7.5.2.5-1: Definition of the AlarmNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "AlarmNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
alarm	Alarm	1	Information about an alarm including AlarmId, affected VNF identifier, and FaultDetails.
_links	Structure (inlined)	1	Links to resources related to this notification.
>subscription	Link	1	Link to the related subscription.

7.5.2.6 Type: AlarmClearedNotification

This type represents an alarm cleared notification about VNF faults. It shall comply with the provisions defined in table 7.5.2.6-1.

Table 7.5.2.6-1: Definition of the AlarmClearedNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "AlarmClearedNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
alarmId	Identifier	1	Alarm identifier.
alarmClearedTime	DateTime	1	The time stamp indicating when the alarm was cleared.
_links	Structure (inlined)	1	Links to resources related to this notification.
>subscription	Link	1	Link to the related subscription.
>alarm	Link	1	Link to the resource that represents the related alarm.

7.5.2.7 Type: AlarmListRebuiltNotification

This type represents a notification that the alarm list has been rebuilt, e.g. if the VNFM detects its storage holding the alarm list is corrupted. It shall comply with the provisions defined in table 7.5.2.7-1.

Table 7.5.2.7-1: Definition of the AlarmListRebuiltNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "AlarmListRebuiltNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
_links	Structure (inlined)	1	Links to resources related to this notification.
>subscription	Link	1	Link to the related subscription.
>alarms	Link	1	Link to the alarm list, i.e. the "Alarms" resource.

7.5.2.8 Type: AlarmModifications

This type represents attribute modifications for an "Individual alarm" resource, i.e. modifications to a resource representation based on the "Alarm" data type. The attributes of "Alarm" that can be modified according to the provisions in clause 7.5.2.4 are included in the "AlarmModifications" data type.

The "AlarmModifications" data type shall comply with the provisions defined in table 7.5.2.8-1.

Table 7.5.2.8-1: Definition of the AlarmModifications data type

Attribute name	Data type	Cardinality	Description
ackState	Enum (inlined)	1	New value of the "ackState" attribute in "Alarm". Permitted values: - ACKNOWLEDGED

7.5.3 Referenced structured data types

7.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but can neither be resource representations nor bound to any subscribe/notify mechanism.

7.5.3.2 Type: FmNotificationsFilter

This type represents a subscription filter related to notifications about VNF faults. It shall comply with the provisions defined in table 7.5.3.2-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 7.5.3.2-1: Definition of the FmNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
vnfInstanceSubscriptionFilter	VnfInstanceSubscriptionFilter	0..1	Filter criteria to select VNF instances about which to notify.
notificationTypes	Enum (inlined)	0..N	Match particular notification types. Permitted values: - AlarmNotification - AlarmClearedNotification - AlarmListRebuiltNotification See note.
faultyResourceTypes	FaultyResourceType	0..N	Match VNF alarms with a faulty resource type listed in this attribute.
perceivedSeverities	PerceivedSeverityType	0..N	Match VNF alarms with a perceived severity listed in this attribute.
eventTypes	EventType	0..N	Match VNF alarms with an event type listed in this attribute.
probableCauses	String	0..N	Match VNF alarms with a probable cause listed in this attribute.
NOTE: The permitted values of the "notificationTypes" attribute are spelled exactly as the names of the notification types to facilitate automated code generation systems.			

7.5.3.3 Type: FaultyResourceInfo

This type represents the faulty virtual resources that have a negative impact on a VNF. It shall comply with the provisions defined in table 7.5.3.3-1.

Table 7.5.3.3-1: Definition of the FaultyResourceInfo data type

Attribute name	Data type	Cardinality	Description
faultyResource	ResourceHandle	1	Information that identifies the faulty resource instance and its managing entity.
faultyResourceType	FaultyResourceType	1	Type of the faulty resource.

7.5.4 Referenced simple data types and enumerations

7.5.4.1 Introduction

This clause defines simple data types and enumerations that can be referenced from data structures defined in the previous clauses.

7.5.4.2 Simple data types

No particular simple data types are defined for this interface, in addition to those defined in clause 4.4.

7.5.4.3 Enumeration: PerceivedSeverityType

The enumeration PerceivedSeverityType shall comply with the provisions defined in table 7.5.4.3-1. It indicates the relative level of urgency for operator attention.

Table 7.5.4.3-1: Enumeration PerceivedSeverityType

Enumeration value	Description
CRITICAL	The Critical severity level indicates that a service affecting condition has occurred and an immediate corrective action is required. Such a severity can be reported, for example, when a managed object becomes totally out of service and its capability needs to be restored (ITU-T Recommendation X.733 [20]).
MAJOR	The Major severity level indicates that a service affecting condition has developed and an urgent corrective action is required. Such a severity can be reported, for example, when there is a severe degradation in the capability of the managed object and its full capability needs to be restored (ITU-T Recommendation X.733 [20]).
MINOR	The Minor severity level indicates the existence of a non-service affecting fault condition and that corrective action should be taken in order to prevent a more serious (for example, service affecting) fault. Such a severity can be reported, for example, when the detected alarm condition is not currently degrading the capacity of the managed object (ITU-T Recommendation X.733 [20]).
WARNING	The Warning severity level indicates the detection of a potential or impending service affecting fault, before any significant effects have been felt. Action should be taken to further diagnose (if necessary) and correct the problem in order to prevent it from becoming a more serious service affecting fault (ITU-T Recommendation X.733 [20]).
INDETERMINATE	The Indeterminate severity level indicates that the severity level cannot be determined (ITU-T Recommendation X.733 [20]).
CLEARED	The Cleared severity level indicates the clearing of one or more previously reported alarms. This alarm clears all alarms for this managed object that have the same Alarm type, Probable cause and Specific problems (if given) (ITU-T Recommendation X.733 [20]).

7.5.4.4 Enumeration: EventType

The enumeration EventType represents those types of events that trigger an alarm. It shall comply with the provisions defined in table 7.5.4.4-1.

Table 7.5.4.4-1: Enumeration EventType

Enumeration value	Description
COMMUNICATIONS_ALARM	An alarm of this type is associated with the procedure and/or process required conveying information from one point to another (ITU-T Recommendation X.733 [20]).
PROCESSING_ERROR_ALARM	An alarm of this type is associated with a software or processing fault (ITU-T Recommendation X.733 [20]).
ENVIRONMENTAL_ALARM	An alarm of this type is associated with a condition related to an enclosure in which the equipment resides (ITU-T Recommendation X.733 [20]).
QOS_ALARM	An alarm of this type is associated with degradation in the quality of a service (ITU-T Recommendation X.733 [20]).
EQUIPMENT_ALARM	An alarm of this type is associated with an equipment fault (ITU-T Recommendation X.733 [20]).

7.5.4.5 Enumeration: FaultyResourceType

The enumeration FaultyResourceType represents those types of faulty resource. It shall comply with the provisions defined in table 7.5.4.5-1.

Table 7.5.4.5-1: Enumeration FaultyResourceType

Enumeration value	Description
COMPUTE	Virtual compute resource
STORAGE	Virtual storage resource
NETWORK	Virtual network resource

8 VNF Indicator interface

8.1 Description

This interface allows the VNFM to provide information on value changes of VNF related indicators. VNF related indicators are declared in the VNFD. This interface is originally produced by the EM and/or VNF on the Ve-Vnfm-em and/or Ve-Vnfm-vnf reference point respectively (see ETSI GS NFV-SOL 002 [i.2]) and is re-exposed by the VNFM towards the NFVO.

The operations provided through this interface are:

- Get Indicator Value
- Subscribe
- Query Subscription Information
- Terminate Subscription
- Notify

8.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "vnfind" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present specification. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 8.2-1 shows the overall resource URI structure defined for the VNF Indicator interface.

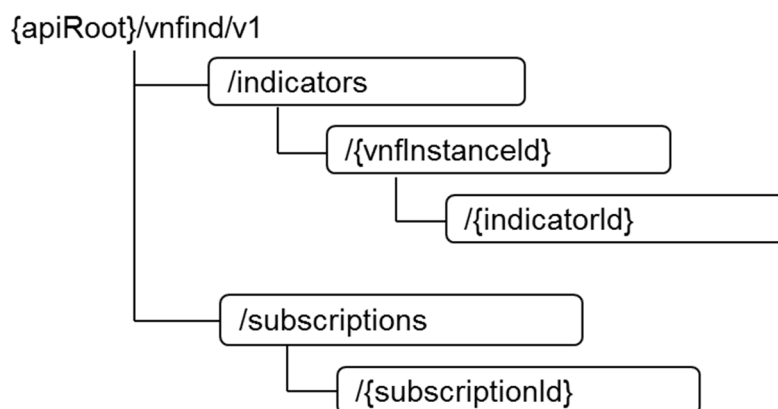


Figure 8.2-1: Resource URI structure of the VNF Indicator Interface

Table 8.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 8.2-1: Resources and methods overview of the VNF Indicator interface

Resource name	Resource URI	HTTP Method	Meaning
VNF indicators	/indicators	GET	Query multiple VNF indicators. See note
VNF indicators related to a VNF instance	/indicators/{vnfInstanceId}	GET	Query multiple VNF indicators related to one VNF instance
Individual VNF indicator	/indicators/{vnfInstanceId}/{indicatorId}	GET	Read an individual VNF indicator
Subscriptions	/subscriptions	POST	Subscribe to VNF indicator change notifications
		GET	Query subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Read an individual subscription
		DELETE	Terminate a subscription
Notification endpoint	(client-provided)	POST	Notify about VNF indicator change
		GET	Test the notification endpoint

NOTE: This resource allows to query all VNF indicators that are known to the VNFM.

8.3 Sequence diagrams (informative)

8.3.1 Flow of querying VNF indicators

This clause describes a sequence for querying VNF indicators.

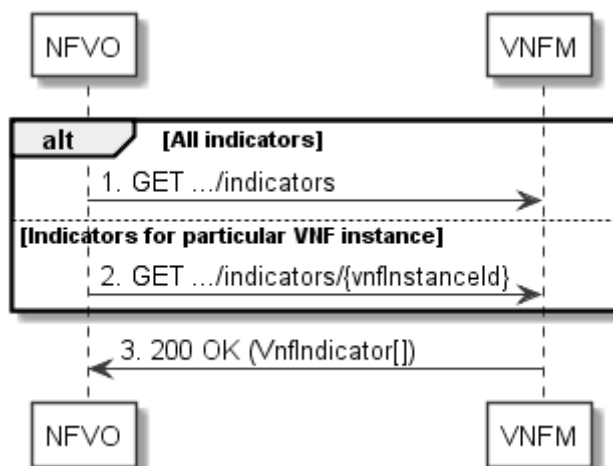


Figure 8.3.1-1: Flow of querying VNF indicators

VNF indicator query, as illustrated in figure 8.3.1-1, consists of the following steps:

- 1) If the NFVO intends to query all VNF indicators, it sends a GET request to the "VNF indicators" resource.
- 2) If the NFVO intends to query the VNF indicators of a particular VNF instance, it sends a GET request to the "VNF indicators related to a VNF instance" resource.
- 3) The VNFM returns a "200 OK" response to the NFVO, and includes zero or more data structures of type "VnfIndicator" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

8.3.2 Flow of reading a VNF indicator

This clause describes a sequence for reading a VNF indicator, i.e. for getting the indicator value.

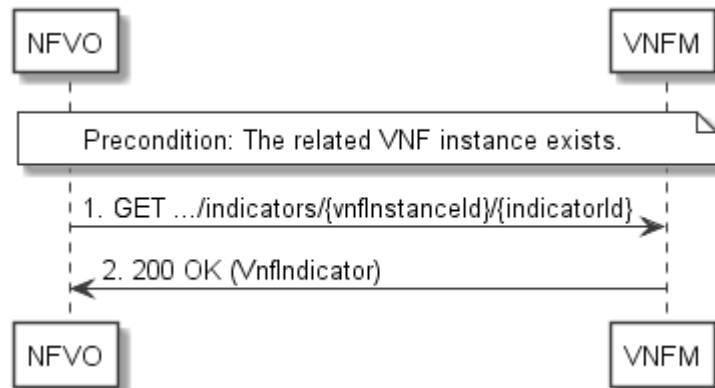


Figure 8.3.2-1: Flow of reading a VNF indicator

Precondition: The related VNF instance exists.

Reading a VNF indicator, as illustrated in figure 8.3.2-1, consists of the following steps:

- 1) The NFVO sends a GET request to the "Individual VNF indicator" resource that is to be read.
- 2) The VNFM returns a "200 OK" response to the NFVO, and includes a data structure of type "VnfIndicator" in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

8.3.3 Flow of managing subscriptions

This clause describes the procedure for creating, querying/reading and terminating subscriptions to notifications related to VNF indicator value changes.

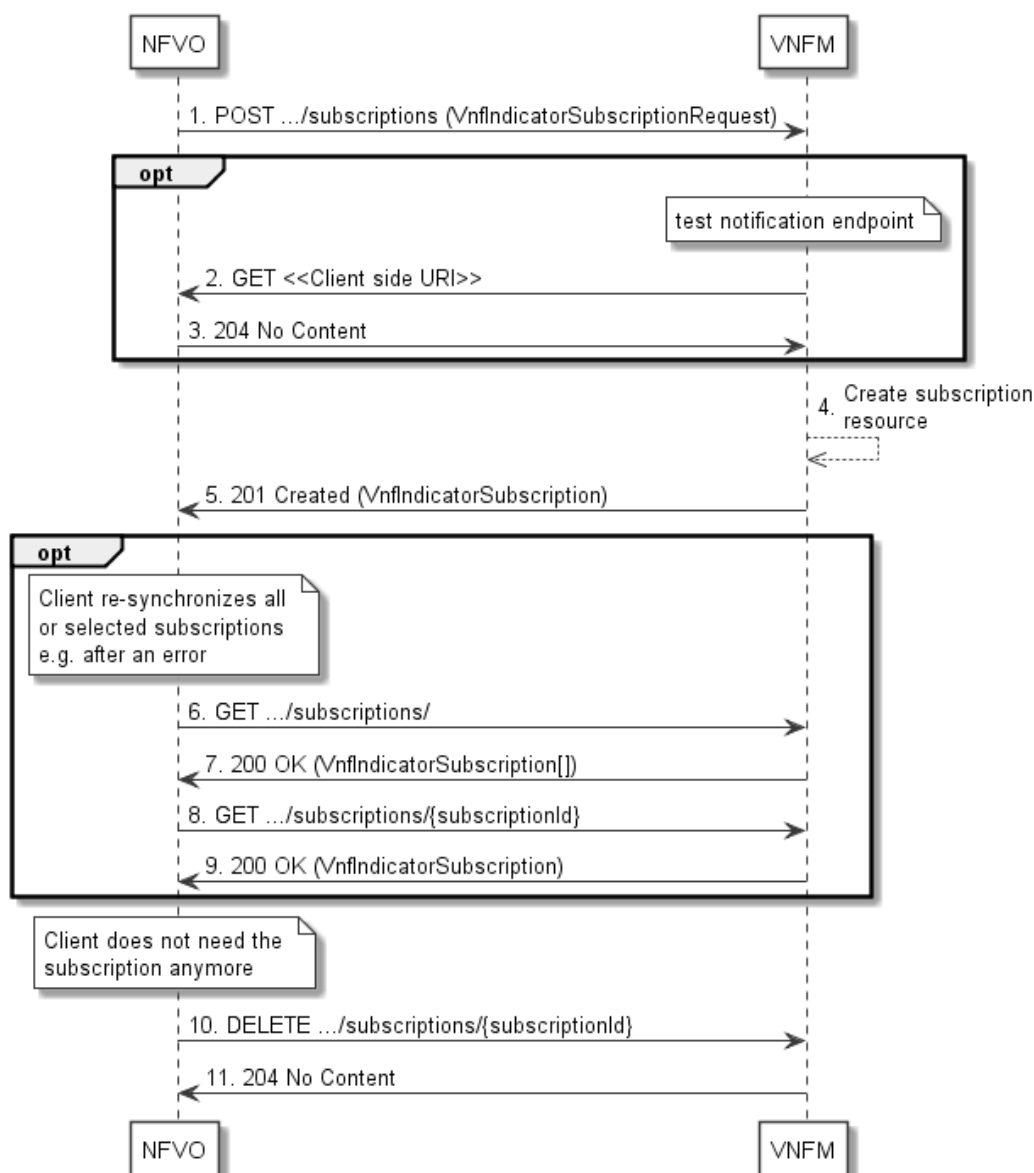


Figure 8.3.3-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 8.3.3-1:

- 1) The NFVO sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "VnfIndicatorSubscriptionRequest". That data structure contains filtering criteria and a client side URI to which the VNFM will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the NFVO as part of the subscription, the VNFM sends a GET request to the notification endpoint URI.
- 3) In that case, the NFVO returns a "204 No Content" response to indicate success.
- 4) The VNFM creates a new subscription to notifications related to VNF indicator value changes, and a resource that represents this subscription.
- 5) The VNFM returns a 201 Created response containing a data structure of type "VnfIndicatorSubscription" representing the subscription resource just created by the VNFM, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) If desired, e.g. to recover from an error situation, the NFVO may query information about its subscriptions by sending a GET request to the resource representing the subscriptions.

- 7) In that case, the VNFM returns a "200 OK" response that contains the list of representations of all existing subscriptions that were created by the NFVO.
- 8) If desired, e.g. to recover from an error situation, the NFVO may read information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the VNFM returns a "200 OK" response that contains a representation of that individual subscription.
- 10) If the NFVO does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription to remove.
- 11) The NFVO acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The VNFM rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

8.3.4 Flow of sending notifications

This clause describes the procedure for sending notifications.

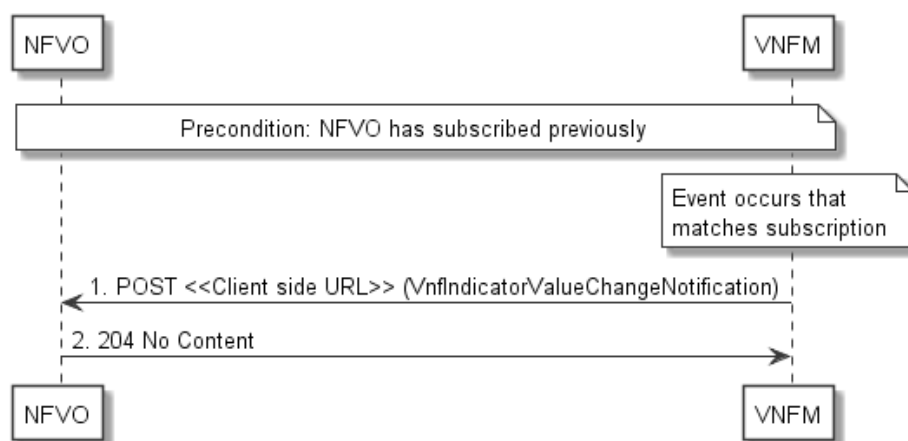


Figure 8.3.4-1: Flow of sending notifications

The procedure consists of the following steps as illustrated in figure 8.3.4-1.

Precondition: The NFVO has subscribed previously to notifications related to VNF indicator value changes.

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the VNFM generates an `VnfIndicatorValueChangeNotification` that includes information about the event, and sends it in the body of a POST request to the client side URI which the NFVO has registered as part of the subscription request.
- 2) The NFVO acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the VNFM does not receive the "204 No Content" response from the NFVO, it can retry sending the notification.

8.4 Resources

8.4.1 Introduction

This clause defines all the resources and methods provided by the VNF Indicator interface.

8.4.2 Resource: VNF indicators

8.4.2.1 Description

This resource represents VNF indicators. The client can use this resource to query multiple VNF indicators.

8.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vnfind/v1/indicators

This resource shall support the resource URI variables defined in table 8.4.2.2-1.

Table 8.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

8.4.2.3 Resource methods

8.4.2.3.1 POST

Not supported.

8.4.2.3.2 GET

The GET method queries multiple VNF indicators.

This method shall follow the provisions specified in the tables 8.4.2.3.2-1 and 8.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	<p>Attribute-based filtering parameters according to clause 4.3.2.</p> <p>The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters.</p> <p>All attribute names that appear in the VnfIndicator data type and in data types referenced from it shall be supported in attribute-based filtering parameters.</p>

Table 8.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicator	0..N	200 OK	The list of VNF indicators was queried successfully. The response body shall contain the representations of all VNF indicators that match the attribute filter.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.2.3.3 PUT

Not supported.

8.4.2.3.4 PATCH

Not supported.

8.4.2.3.5 DELETE

Not supported.

8.4.3 Resource: VNF indicators related to a VNF instance

8.4.3.1 Description

This resource represents VNF indicators related to a VNF instance. The client can use this resource to query multiple VNF indicators that are related to a particular VNF instance.

8.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vnfind/v1/indicators/{vnfInstanceId}

This resource shall support the resource URI variables defined in table 8.4.3.2-1.

Table 8.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	Identifier of the VNF instance to which the VNF indicator applies. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.

8.4.3.3 Resource methods

8.4.3.3.1 POST

Not supported.

8.4.3.3.2 GET

The GET method queries multiple VNF indicators related to a VNF instance.

This method shall follow the provisions specified in the tables 8.4.3.3.2-1 and 8.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the VnfIndicator data type and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 8.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicator	0..N	200 OK	The list of VNF indicators was queried successfully. The response body shall contain the representations of all VNF indicators that are related to the particular VNF instance and that match the attribute filter.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.3.3.3 PUT

Not supported.

8.4.3.3.4 PATCH

Not supported.

8.4.3.3.5 DELETE

Not supported.

8.4.4 Resource: Individual VNF indicator

8.4.4.1 Description

This resource represents an individual VNF indicator. The client can use this resource to read an individual VNF indicator.

8.4.4.2 Resource definition

The resource URI is:

{apiRoot}/vnf/v1/indicators/{vnfInstanceId}/{indicatorId}

This resource shall support the resource URI variables defined in table 8.4.4.2-1.

Table 8.4.4.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
vnfInstanceId	Identifier of the VNF instance to which the VNF indicator applies. See note 1.
indicatorId	Identifier of the VNF indicator. See note 2.
NOTE 1: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new VNF instance resource. It can also be retrieved from the "id" attribute in the payload body of that response.	
NOTE 2: This identifier can be retrieved from the resource referenced by the payload body in the response to a POST request creating a new VNF instance resource.	

8.4.4.3 Resource methods

8.4.4.3.1 POST

Not supported.

8.4.4.3.2 GET

The GET method reads a VNF indicator.

This method shall follow the provisions specified in the tables 8.4.4.3.2-1 and 8.4.4.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.4.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 8.4.4.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicator	1	200 OK	The VNF indicator was read successfully. The response body shall contain the representation of the VNF indicator.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.4.3.3 PUT

Not supported.

8.4.4.3.4 PATCH

Not supported.

8.4.4.3.5 DELETE

Not supported.

8.4.5 Resource: Subscriptions

8.4.5.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to VNF indicator value changes, and to query its subscriptions.

8.4.5.2 Resource definition

The resource URI is:

{apiRoot}/vnfind/v1/subscriptions

This resource shall support the resource URI variables defined in table 8.4.5.2-1.

Table 8.4.5.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

8.4.5.3 Resource methods

8.4.5.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 8.4.5.3.1-1 and 8.4.5.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.5.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 8.4.5.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VnfIndicatorSubscriptionRequest	1	Details of the subscription to be created.	
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicatorSubscription	1	201 Created	The subscription was created successfully. The response body shall contain a representation of the created subscription resource. The HTTP response shall include a "Location" HTTP header that points to the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.5.3.2 GET

The GET method queries the list of active subscriptions of the functional block that invokes the method. It can be used e.g. for resynchronization after error situations.

This method shall follow the provisions specified in the tables 8.4.5.3.2-1 and 8.4.5.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.5.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The VNFM shall support receiving filtering parameters as part of the URI query string. The NFVO may supply filtering parameters. All attribute names that appear in the VnfIndicatorSubscription data type and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 8.4.5.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicatorSubscription	0..N	200 OK	The list of subscriptions was queried successfully. The response body shall contain the representations of all active subscriptions of the functional block that invokes the method which match the attribute filter.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.5.3.3 PUT

Not supported.

8.4.5.3.4 PATCH

Not supported.

8.4.5.3.5 DELETE

Not supported.

8.4.6 Resource: Individual subscription

8.4.6.1 Description

This resource represents an individual subscription. The client can use this resource to read and to terminate a subscription to notifications related to VNF indicator value changes.

8.4.6.2 Resource definition

The resource URI is:

{apiRoot}/vnfind/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 8.4.6.2-1.

Table 8.4.6.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
subscriptionId	Identifier of this subscription. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.

8.4.6.3 Resource methods

8.4.6.3.1 POST

Not supported.

8.4.6.3.2 GET

The GET method reads an individual subscription.

This method shall follow the provisions specified in the tables 8.4.6.3.2-1 and 8.4.6.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.6.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 8.4.6.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VnfIndicatorSubscription	1	200 OK	The operation has completed successfully. The response body shall contain a representation of the subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.6.3.3 PUT

Not supported.

8.4.6.3.4 PATCH

Not supported.

8.4.6.3.5 DELETE

The DELETE method terminates an individual subscription.

This method shall follow the provisions specified in the tables 8.4.6.3.5-1 and 8.4.6.3.3-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.6.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 8.4.6.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

8.4.7 Resource: Notification endpoint

8.4.7.1 Description

This resource represents a notification endpoint.

The API producer can use this resource to send notifications related to VNF indicator value changes to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

8.4.7.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 8.4.7.2-1.

Table 8.4.7.2-1: Resource URI variables for this resource

Name	Definition
n/a	

8.4.7.3 Resource methods

8.4.7.3.1 POST

The POST method delivers a notification from the server to the client.

This method shall follow the provisions specified in the tables 8.4.7.3.1-1 and 8.4.7.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.7.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Each notification request body shall include exactly one instance of the VnfIndicatorValueChangeNotification structure.

Table 8.4.7.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VnfIndicatorValueChangeNotification	1	A notification about VNF indicator value changes.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned. The VNFM shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

8.4.7.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 8.4.7.3.2-1 and 8.4.7.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 8.4.7.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 8.4.7.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

8.4.7.3.3 PUT

Not supported.

8.4.7.3.4 PATCH

Not supported.

8.4.7.3.5 DELETE

Not supported.

8.5 Data model

8.5.1 Introduction

This clause defines the request and response data structures of the VNF Indicator interface. If a request or response contains attributes not defined in the present document, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

8.5.2 Resource and notification data types

8.5.2.1 Introduction

This clause defines the data structures to be used in resource representations and notifications.

8.5.2.2 Type: VnfIndicator

This type represents a VNF indicator value. It shall comply with the provisions defined in table 8.5.2.2-1.

Table 8.5.2.2-1: Definition of the VnfIndicator data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnfd	1	Identifier of this VNF indicator.
name	String	0..1	Human readable name of the indicator. Shall be present if defined in the VNFD.
value	Object	1	Provides the value of the indicator. The value format is defined in the VNFD. See note.
vnfInstanceid	Identifier	1	Identifier of the VNF instance which provides the indicator value.
_links	Structure (inlined)	1	Links for this resource.
>self	Link	1	URI of this resource.
>vnfInstance	Link	1	Link to the related VNF instance resource.
NOTE: ETSI GS NFV-SOL 001 [i.6] specifies the structure and format of the VNFD based on TOSCA specifications.			

8.5.2.3 Type: VnfIndicatorSubscriptionRequest

This type represents a subscription request related to VNF indicator value change notifications. It shall comply with the provisions defined in table 8.5.2.3-1.

Table 8.5.2.3-1: Definition of the VnfIndicatorSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	VnfIndicatorNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentication	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

8.5.2.4 Type: VnfIndicatorSubscription

This type represents a subscription related to notifications about VNF indicator value changes. It shall comply with the provisions defined in table 8.5.2.4-1.

Table 8.5.2.4-1: Definition of the VnfIndicatorSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this subscription resource
filter	VnfIndicatorNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
_links	Structure (inlined)	1	Links for this resource
>self	Link	1	URI of this resource

8.5.2.5 Type: VnfIndicatorValueChangeNotification

This type represents a VNF indicator value change notification. It shall comply with the provisions defined in table 8.5.2.5-1.

Table 8.5.2.5-1: Definition of the VnfIndicatorValueChangeNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfIndicatorValueChangeNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
vnfIndicatorId	IdentifierInVnfd	1	Identifier of the VNF indicator whose value has changed.
name	String	0..1	Human readable name of the VNF indicator. Shall be present if defined in the VNFD.
value	Object	1	Provides the value of the VNF indicator. The value format is defined in the VNFD. See note.
vnfInstanceId	Identifier	1	Identifier of the VNF instance which provides the indicator value.
_links	Structure (inlined)	1	Links for this resource.
>vnfInstance	Link	1	Link to the related VNF instance resource.
>subscription	Link	1	Link to the related subscription.

NOTE: ETSI GS NFV-SOL 001 [i.6] specifies the structure and format of the VNFD based on TOSCA specifications.

8.5.3 Referenced structured data types

8.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but can neither be resource representations nor bound to any subscribe/notify mechanism.

8.5.3.2 Type: VnfIndicatorNotificationsFilter

This type represents a subscription filter related to notifications about VNF indicator value changes. It shall comply with the provisions defined in table 8.5.3.2-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 8.5.3.2-1: Definition of the VnfIndicatorNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
vnfInstanceSubscriptionFilter	VnfInstanceSubscriptionFilter	0..1	Filter criteria to select VNF instances about which to notify.
indicatorIds	IdentifierInVnfd	0..N	Match particular VNF indicator identifiers.

8.5.4 Referenced simple data types and enumerations

No particular simple data types and enumerations are defined for this interface, in addition to those defined in clause 4.4.

9 VNF Lifecycle Operation Granting interface

9.1 Description

This interface allows the VNFM to obtain from the NFVO permission and configuration parameters for a VNF lifecycle operation. The operation provided through this interface is:

- Grant Lifecycle Operation

9.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "grant" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present specification. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 9.2-1 shows the overall resource URI structure defined for the VNF Lifecycle Operation Granting interface.

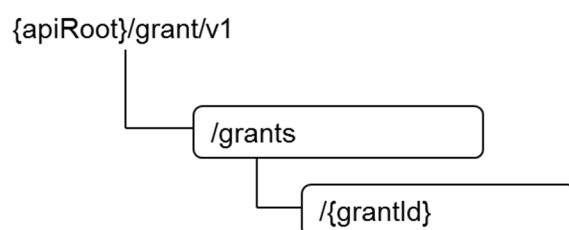


Figure 9.2-1: Resource URI structure of the VNF Lifecycle Operation Granting Interface

Table 9.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 9.2-1: Resources and methods overview of the VNF Lifecycle Operation Granting interface

Resource name	Resource URI	HTTP Method	Meaning
Grants	/grants	POST	Request a grant
Individual grant	/grants/{grantId}	GET	Read a grant

9.3 Sequence diagrams (informative)

9.3.1 Flow of grant request with synchronous response

This clause describes a sequence for a grant request with synchronous (i.e. immediate) response. If the NFVO can decide immediately what to respond to a grant request, it returns the response immediately.

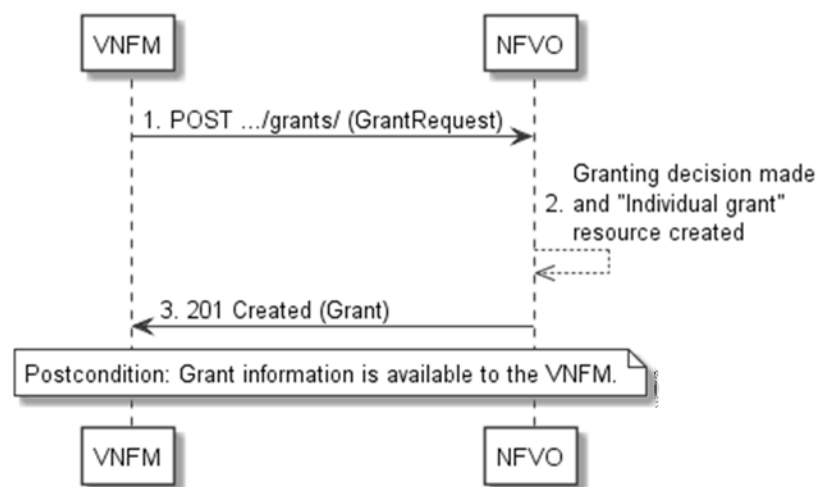


Figure 9.3.1-1: Flow of granting with synchronous response

Granting with synchronous response, as illustrated in figure 9.3.1-1, consists of the following steps:

- 1) The VNFM sends a POST request to the "Grants" resource with a "GrantRequest" data structure in the body.
- 2) The NFVO makes the granting decision, and creates a new "Individual grant" resource.
- 3) The NFVO returns to the VNFM a "201 Created" response with a "Grant" data structure in the body and a "Location" HTTP header that points to the new "Individual grant" resource.

Postcondition: The grant information is available to the VNFM.

9.3.2 Flow of grant request with asynchronous response

This clause describes a sequence for a grant request with asynchronous (i.e. delayed) response. If the NFVO can't decide immediately what to respond to a grant request, and therefore runs the risk of a timeout of the http connection while waiting for the completion of the decision, it returns the response in an asynchronous (delayed) fashion.

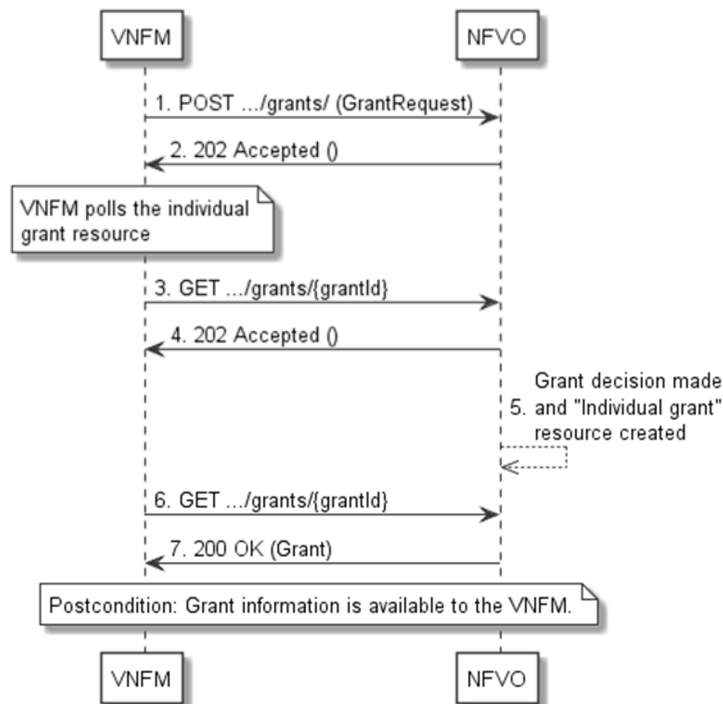


Figure 9.3.2-1: Flow of granting with asynchronous response

Granting with asynchronous response, as illustrated in figure 9.3.2-1, consists of the following steps:

- 1) The VNFM sends a POST request to the "Grants" resource with a "GrantRequest" data structure in the body.
- 2) The NFVO returns to the VNFM a "202 Accepted" response with an empty body and a "Location" HTTP header that indicates the URI of the "Individual grant" resource that will be created once the granting decision will have been made.
- 3) The VNFM tries to obtain the grant by sending a GET request to the NFVO, using the URI that was returned in step (2) in the "Location" header.
- 4) As there is no result of the granting decision available yet and consequently the "Individual grant" resource is still in the process of being created, the NFVO returns a "202 Accepted" response with an empty body.
- 5) The NFVO finalizes the granting decision and creates the "Individual grant" that contains the grant.
- 6) The VNFM tries to obtain the grant by sending a GET request to the NFVO, using the URI that was returned in step (2) in the "Location" header.
- 7) This time, the grant is available, and the NFVO returns a "200 OK" response with a "Grant" data structure in the body.

Postcondition: The grant information is available to the VNFM.

9.4 Resources

9.4.1 Introduction

This clause defines all the resources and methods provided by the VNF lifecycle operation granting interface.

9.4.2 Resource: Grants

9.4.2.1 Description

This resource represents grants. The client can use this resource to obtain permission from the NFVO to perform a particular VNF lifecycle operation.

9.4.2.2 Resource definition

The resource URI is:

{apiRoot}/grant/v1/grants

This resource shall support the resource URI variables defined in table 9.4.2.2-1.

Table 9.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

9.4.2.3 Resource methods

9.4.2.3.1 POST

The POST method requests a grant for a particular VNF lifecycle operation.

This method shall follow the provisions specified in the tables 9.4.2.3.1-1 and 9.4.2.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 9.4.2.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 9.4.2.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	GrantRequest	1		
Response body	Data type	Cardinality	Response Codes	Description
	Grant	1	201 Created	The grant was created successfully (synchronous mode). A representation of the created "Individual grant" resource shall be returned in the response body. The HTTP response shall include a "Location" HTTP header that indicates the URI of the "Individual grant" resource just created.
	n/a		202 Accepted	The request was accepted for processing, but the processing has not been completed. It is expected to take some time to create the grant (asynchronous mode). The response body shall be empty. The HTTP response shall include a "Location" HTTP header that indicates the URI of the "Individual grant" resource that will be created once the granting decision has been made.
	ProblemDetails	1	403 Forbidden	The grant was rejected. A ProblemDetails structure shall be included in the response to provide more details about the rejection in the "details" attribute.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

9.4.2.3.2 GET

Not supported.

9.4.2.3.3 PUT

Not supported.

9.4.2.3.4 PATCH

Not supported.

9.4.2.3.5 DELETE

Not supported.

9.4.3 Resource: Individual grant

9.4.3.1 Description

This resource represents an individual grant. The client can use this resource to read the grant.

It is determined by means outside the scope of the present document, such as configuration or policy, how long an individual grant is available.

9.4.3.2 Resource definition

The resource URI is:

{apiRoot}/grant/v1/grants/{grantId}

This resource shall support the resource URI variables defined in table 9.4.3.2-1.

Table 9.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2
grantId	Identifier of the grant. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request granting a new VNF lifecycle operation. It can also be retrieved from the "id" attribute in the payload body of that response.	

9.4.3.3 Resource methods

9.4.3.3.1 POST

Not supported.

9.4.3.3.2 GET

The GET method reads a grant.

This method shall follow the provisions specified in the tables 9.4.3.3.2-1 and 9.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 9.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 9.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	Grant	1	200 OK	The grant was read successfully. A representation of the "individual grant" resource shall be returned in the response body.
	n/a		202 Accepted	The process of creating the grant is ongoing, no grant is available yet. The response body shall be empty.
	ProblemDetails	1	403 Forbidden	The grant was rejected. A ProblemDetails structure shall be included in the response to provide more details about the rejection in the "details" attribute.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

9.4.3.3.3 PUT

Not supported.

9.4.3.3.4 PATCH

Not supported.

9.4.3.3.5 DELETE

Not supported.

9.5 Data model

9.5.1 Introduction

This clause defines the request and response data structures of the VNF Lifecycle Operation Granting interface. If a request or response contains attributes not defined in the present document, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

9.5.2 Resource and notification data types

9.5.2.1 Introduction

This clause defines data structures to be used in resource representations and notifications.

9.5.2.2 Type: GrantRequest

This type represents a grant request. It shall comply with the provisions defined in table 9.5.2.2-1.

Table 9.5.2.2-1: Definition of the GrantRequest data type

Attribute name	Data type	Cardinality	Description
vnfInstanceid	Identifier	1	Identifier of the VNF instance which this grant request is related to. Shall also be provided for VNFs that not yet exist but are planned to exist in the future, i.e. if the grant is requested for InstantiateVNF.
vnfLcmOpOcclid	Identifier	1	The identifier of the VNF lifecycle management operation occurrence associated to the GrantRequest.
vnfdid	Identifier	1	Identifier of the VNFD that defines the VNF for which the LCM operation is to be granted.
flavourid	Identifier	0..1	Identifier of the VNF deployment flavour of the VNFD that defines the VNF for which the LCM operation is to be granted. Shall be provided when instantiating the VNF or changing the deployment flavour of the VNF instance.
operation	LcmOperationType	1	The lifecycle management operation for which granting is requested. See note 1.
isAutomaticInvocation	Boolean	1	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, or HealVnf triggered by auto-heal). Set to false otherwise.
instantiationLevelid	Identifier	0..1	If operation=INSTANTIATE, the identifier of the instantiation level may be provided as an alternative way to define the resources to be added. This attribute shall only be used if operation=INSTANTIATE. See note 2.
addResources	ResourceDefinition	0..N	List of resource definitions in the VNFD for resources to be added by the LCM operation which is related to this grant request, with one entry per resource. See note 2.
tempResources	ResourceDefinition	0..N	List of resource definitions in the VNFD for resources to be temporarily instantiated during the runtime of the LCM operation which is related to this grant request, with one entry per resource. See note 3.

Attribute name	Data type	Cardinality	Description
removeResources	ResourceDefinition	0..N	Provides the definitions of resources to be removed by the LCM operation which is related to this grant request, with one entry per resource.
updateResources	ResourceDefinition	0..N	Provides the definitions of resources to be modified by the LCM operation which is related to this grant request, with one entry per resource.
placementConstraints	PlacementConstraint	0..N	Placement constraints that the VNFM may send to the NFVO in order to influence the resource placement decision. If sent, the NFVO shall take the constraints into consideration when making resource placement decisions, and shall reject the grant if they cannot be honoured. See note 4 and note 5.
vimConstraints	VimConstraint	0..N	Used by the VNFM to require that multiple resources are managed through the same VIM connection. If sent, the NFVO shall take the constraints into consideration when making VIM selection decisions, and shall reject the grant if they cannot be honoured. This attribute shall be supported if VNF-related Resource Management in direct mode is applicable. The applicability and further details of this attribute for indirect mode are left for future specification.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the VNFM, specific to the VNF and the LCM operation.
_links	Structure (inlined)	1	Links to resources related to this request.
>vnfLcmOpOcc	Link	1	Related lifecycle management operation occurrence.
>vnfInstance	Link	1	Related VNF instance.
<p>NOTE 1: The VNF LCM operations CreateVnfIdentifier, DeleteVnfIdentifier, QueryVnf and ModifyVnfInformation can be executed by the VNFM without requesting granting.</p> <p>NOTE 2: If the granting request is for InstantiateVNF, either instantiationLevel or addResources shall be present.</p> <p>NOTE 3: The NFVO will assume that the VNFM will be responsible to both allocate and release the temporary resource during the runtime of the LCM operation. This means, the resource can be allocated and consumed after the "start" notification for the LCM operation is sent by the VNFM, and the resource will be-released before the "result" notification of the VNF LCM operation is sent by the VNFM.</p> <p>NOTE 4: The affinity/anti-affinity rules defined in the VNFD , and the placement constraints in the GrantVnfLifecycleOperation as defined in this clause should be conflict-free. In case of conflicts, the placement constraints in the GrantVnfLifecycleOperation shall take precedence.</p> <p>NOTE 5: Passing constraints allows the VNFM or the lifecycle management scripts to influence resource placement decisions by the NFVO to ensure VNF properties such as performance or fault tolerance.</p>			

9.5.2.3 Type: Grant

This type represents a grant. It shall comply with the provisions defined in table 9.5.2.3-1.

Table 9.5.2.3-1: Definition of the Grant data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of the grant.
vnfInstancelid	Identifier	1	Identifier of the related VNF instance.
vnfLcmOpOcclid	Identifier	1	Identifier of the related VNF lifecycle management operation occurrence.

Attribute name	Data type	Cardinality	Description
vimConnections	VimConnectionInfo	0..N	<p>Provides information regarding VIM connections that are approved to be used by the VNFM to allocate resources, and provides parameters of these VIM connections.</p> <p>The VNFM shall update the " vimConnectionInfo" attribute of the "VnfInstance" structure by adding unknown entries received in this attribute.</p> <p>This attribute is not intended for the modification of VimConnection entries passed earlier; for that, the VnfInfoModifications structure shall be used.</p> <p>This attribute shall only be supported when VNF-related Resource Management in direct mode is applicable. In direct mode, this parameter shall be absent if the VIM information was configured to the VNFM in another way, present otherwise. See note 1.</p>
zones	ZoneInfo	0..N	Identifies resource zones where the resources are approved to be allocated by the VNFM.
zoneGroups	ZoneGroupInfo	0..N	<p>Information about groups of resource zones that are related and that the NFVO has chosen to fulfil a zoneGroup constraint in the GrantVnfLifecycleOperation request.</p> <p>This information confirms that the NFVO has honoured the zoneGroup constraints that were passed as part of "placementConstraints" in the GrantRequest.</p>
computeReservati onId	IdentifierInVim	0..1	Information that identifies a reservation applicable to the compute resource requirements of the corresponding grant request. See note 2.
networkReservati onId	IdentifierInVim	0..1	Information that identifies a reservation applicable to the network resource requirements of the corresponding grant request. See note 2.
storageReservati onId	IdentifierInVim	0..1	Information that identifies a reservation applicable to the storage resource requirements of the corresponding grant request. See note 2.
addResources	GrantInfo	0..N	List of resources that are approved to be added, with one entry per resource.
tempResources	GrantInfo	0..N	List of resources that are approved to be temporarily instantiated during the runtime of the lifecycle operation, with one entry per resource.
removeResources	GrantInfo	0..N	List of resources that are approved to be removed, with one entry per resource.
updateResources	GrantInfo	0..N	List of resources that are approved to be modified, with one entry per resource.
vimAssets	Structure (inlined)	0..1	<p>Information about assets for the VNF that are managed by the NFVO in the VIM, such as software images and virtualised compute resource flavours.</p> <p>This attribute is not intended for the modification of vimAssets entries passed earlier. See note 3.</p>
>computeResourc eFlavours	VimComputeReso urceFlavour	0..N	Mappings between virtual compute descriptors defined in the VNFD and compute resource flavours managed in the VIM.
>softwareImages	VimSoftwareImage	0..N	Mappings between software images defined in the VNFD and software images managed in the VIM.

Attribute name	Data type	Cardinality	Description
extVirtualLinks	ExtVirtualLinkData	0..N	Information about external VLs to connect the VNF to. See note 5.
extManagedVirtualLinks	ExtManagedVirtualLinkData	0..N	Information about internal VLs that are managed by other entities than the VNFM. See note 4 and note 5.
additionalParams	KeyValuePairs	0..1	Additional parameters passed by the NFVO, specific to the VNF and the LCM operation.
_links	Structure (inlined)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.
>vnfLcmOpOcc	Link	1	Related VNF lifecycle management operation occurrence.
>vnfInstance	Link	1	Related VNF instance.
<p>NOTE 1: This interface allows to signal the use of multiple VIMs per VNF. However, due to the partial support of this feature in the present release, it is recommended in the present document that the number of entries in the "vims" attribute in the Grant is not greater than 1.</p> <p>NOTE 2: At least one of (computeReservationId, networkReservationId, storageReservationId) shall be present when policy is GRANT_RESERVE_SINGLE and an applicable reservation exists. None of these shall be present otherwise.</p> <p>NOTE 3: Modification of VIM assets during the lifetime of a VNF instance is not necessary, since it is expected that all applicable assets have been on boarded into the VIM before the VNF is instantiated.</p> <p>NOTE 4: The indication of externally-managed internal VLs is needed in case networks have been pre-configured for use with certain VNFs, for instance to ensure that these networks have certain properties such as security or acceleration features, or to address particular network topologies.</p> <p>NOTE 5: External and/or externally-managed internal VLs can be passed in VNF lifecycle management operation requests such as InstantiateVnf or ChangeVnfFlavor, and/or in the grant response. The NFVO may choose to override in the grant response external and/or externally-managed VL instances that have been passed previously in the associated VNF lifecycle management request, if the lifecycle management request has originated from the NFVO itself.</p>			

9.5.3 Referenced structured data types

9.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but are not resource representations.

9.5.3.2 Type: ResourceDefinition

This type provides information of an existing or proposed resource used by the VNF. It shall comply with the provisions defined in table 9.5.3.2-1.

Table 9.5.3.2-1: Definition of the ResourceDefinition data type

Attribute name	Data type	Cardinality	Description
id	IdentifierLocal	1	Identifier of this "ResourceDefinition" structure, unique at least within the scope of the "GrantRequest" structure.
type	Enum (inlined)	1	Type of the resource definition referenced. Permitted values: - COMPUTE - VL - STORAGE - LINKPORT
vduld	IdentifierInVnfd	0..1	Reference to the related VDU in the VNFD applicable to this resource. Shall only be present if a VDU is applicable to this resource.

Attribute name	Data type	Cardinality	Description
resourceTemplateId	IdentifierInVnfd	0..1	Reference to a resource template (VnfVirtualLinkDesc, VirtualComputeDesc, VnfExtCpd, VirtualStorageDesc) in the VNFD. Shall be present for the planned creation of new resources, including temporary resources, and for the modification of existing resources. Shall be absent otherwise.
resource	ResourceHandle	0..1	Resource information for an existing resource. Shall be present for resources that are planned to be deleted or modified. Shall be absent otherwise.

9.5.3.3 Type: GrantInfo

This type contains information about a Compute, storage or network resource whose addition/update/deletion was granted. It shall comply with the provisions defined in table 9.5.3.3-1.

Table 9.5.3.3-1: Definition of the GrantInfo data type

Attribute name	Data type	Cardinality	Description
resourceDefinitionId	IdentifierLocal	1	Identifier of the related "ResourceDefinition" structure from the related "GrantRequest" structure.
reservationId	Identifier	0..1	The reservation identifier applicable to the VNFC/VirtualLink/VirtualStorage. It shall be present for new resources when policy is GRANT_RESERVE_MULTI and an applicable reservation exists; shall not be present otherwise.
vimConnectionId	Identifier	0..1	Identifier of the VIM connection to be used to manage this resource. Shall be present for new resources, and shall be absent for resources that have already been allocated. The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnfInstance" structure. This attribute shall only be supported when VNF-related Resource Management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifies the entity responsible for the management of the virtualised resource. Shall be present for new resources, and shall be absent for resources that have already been allocated. This attribute shall only be supported when VNF-related Resource Management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
zoneId	IdentifierLocal	0..1	Reference to the identifier of the "ZoneInfo" structure in the "Grant" structure defining the resource zone into which this resource is to be placed. Shall be present for new resources if the zones concept is applicable to them (typically, Compute resources), and shall be absent for resources that have already been allocated.

Attribute name	Data type	Cardinality	Description
resourceGroupId	IdentifierInVim	0..1	<p>Identifier of the "infrastructure resource group", logical grouping of virtual resources assigned to a tenant within an Infrastructure Domain, to be provided when allocating the resource.</p> <p>If the VIM connection referenced by "vimConnectionId" applies to multiple infrastructure resource groups, this attribute shall be present for new resources.</p> <p>If the VIM connection referenced by "vimConnectionId" applies to a single infrastructure resource group, this attribute may be present for new resources.</p> <p>This attribute shall be absent for resources that have already been allocated.</p>

9.5.3.4 Type: ZoneInfo

This type provides information regarding a resource zone. It shall comply with the provisions defined in table 9.5.3.4-1.

Table 9.5.3.4-1: Definition of the ZoneInfo data type

Attribute name	Data type	Cardinality	Description
id	IdentifierLocal	1	The identifier of this ZoneInfo instance, for the purpose of referencing it from other structures in the "Grant" structure.
zoneId	Identifier	1	The identifier of the resource zone, as managed by the resource management layer (typically, the VIM).
vimConnectionId	Identifier	0..1	<p>Identifier of the connection to the VIM that manages the resource zone.</p> <p>The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnInstance" structure.</p> <p>This attribute shall only be supported and present when VNF-related Resource Management in direct mode is applicable.</p>
resourceProviderId	Identifier	0..1	<p>Identifies the entity responsible for the management the resource zone.</p> <p>This attribute shall only be supported and present when VNF-related Resource Management in indirect mode is applicable. The identification scheme is outside the scope of the present document.</p>

9.5.3.5 Type: ZoneGroupInfo

This type provides information regarding a resource zone group. A resource zone group is a group of one or more related resource zones which can be used in resource placement constraints. To fulfil such constraint, the NFVO may decide to place a resource into any zone that belongs to a particular group.

NOTE: A resource zone group can be used to support overflow from one resource zone into another, in case a particular deployment supports only non-elastic resource zones.

The ZoneGroupInfo type shall comply with the provisions defined in table 9.5.3.5-1.

Table 9.5.3.5-1: Definition of the ZoneGroupInfo data type

Attribute name	Data type	Cardinality	Description
zonelId	IdentifierLocal	1..N	References of identifiers of "ZoneInfo" structures, each of which provides information about a resource zone that belongs to this group.

9.5.3.6 Type: PlacementConstraint

This type provides information regarding a resource placement constraint. A set of such constraints may be sent by the VNFM to the NFVO to influence the resource placement decisions made by the NFVO as part of the granting process. A placement constraint defines a condition to the placement of new resources, considering other new resources as well as existing resources.

EXAMPLE: The following rules influence the placement of a set of resources such that they are placed in the same Network Function Virtualisation Infrastructure Point of Presence (NFVI-PoP) but in different resource zones:

```
{type="affinity"; scope="NFVI_POP"; {resource1,resource2}}
{type="anti-affinity"; scope="ZONE"; {resource1,resource2}}
```

The PlacementConstraint type shall comply with the provisions defined in table 9.5.3.6-1.

Table 9.5.3.6-1: Definition of the PlacementConstraint data type

Attribute name	Data type	Cardinality	Description
affinityOrAntiAffinity	Enum (inlined)	1	The type of the constraint. Permitted values: - AFFINITY - ANTI_AFFINITY
scope	Enum (inlined)	1	The scope of the placement constraint indicating the category of the "place" where the constraint applies. Permitted values: - NFVI_POP - ZONE - ZONE_GROUP - NFVI_NODE
resource	ConstraintResourceRef	1..N	References to resources in the constraint rule.

9.5.3.7 Type: VimConstraint

This type provides information regarding a VIM selection constraint. A set of such constraints may be sent by the VNFM to the NFVO to influence the VIM selection decisions made by the NFVO as part of the granting process.

The VimConstraint type shall comply with the provisions defined in table 9.5.3.7-1.

Table 9.5.3.7-1: Definition of the VimConstraint data type

Attribute name	Data type	Cardinality	Description
sameResourceGroup	Boolean	0..1	If present and set to true, this signals that the constraint applies not only to the same VIM connection, but also to the same infrastructure resource group.
resource	ConstraintResourceRef	1..N	References to resources in the constraint rule. The NFVO shall ensure that all resources in this list are managed through the same VIM connection. If "sameResourceGroup" is set to true, the NFVO shall further ensure that all resources in this list are part of the same infrastructure resource group in that VIM connection.

9.5.3.8 Type: ConstraintResourceRef

This type references a resource either by its VIM-level identifier for existing resources, or by the identifier of a "ResourceDefinition" structure in the "GrantRequest" structure for new resources.

The ConstraintResourceRef type shall comply with the provisions defined in table 9.5.3.8-1.

Table 9.5.3.8-1: Definition of the ConstraintResourceRef data type

Attribute name	Data type	Cardinality	Description
idType	Enum (inlined)	1	The type of the identifier. Permitted values: <ul style="list-style-type: none"> - RES_MGMT: Resource-management-level identifier; this identifier is managed by the VIM in the direct mode of VNF-related resource management, and is managed by the NFVO in the indirect mode) - GRANT: Reference to the identifier of a "ResourceDefinition" structure in the "GrantRequest" structure.
resourceId	IdentifierInVim	1	An actual resource-management-level identifier (idType=RES_MGMT), or an identifier that references a "ResourceDefinition" structure in the related "GrantRequest" structure (idType=GRANT).
vimConnectionId	Identifier	0..1	Identifier of the VIM connection for managing the resource. It shall only be present when idType = RES_MGMT. The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnfInstance" structure. This attribute shall only be supported when VNF-related resource management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifier of the resource provider. It shall only be present when idType = RES_MGMT. This attribute shall only be supported when VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.

9.5.3.9 Type: VimComputeResourceFlavour

If the VIM requires the use of virtual compute resource flavours during compute resource instantiation, it is assumed that such flavours are selected or created by the NFVO based on the information in the virtual compute descriptor defined in the VNFD.

This type defines the mapping between a virtual compute descriptor in the VNFD and the corresponding compute resource flavour managed by the NFVO in the VIM. It shall comply with the provisions defined in table 9.5.3.9-1.

Table 9.5.3.9-1: Definition of the VimComputeResourceFlavour data type

Attribute name	Data type	Cardinality	Description
vimConnectionId	Identifier	0..1	Identifier of the VIM connection to access the flavour referenced in this structure. The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnfInstance" structure. This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifies the entity responsible for the management of the virtualised resource. This attribute shall only be supported and present if VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
vnfdVirtualComputeDescId	IdentifierInVnfd	1	Identifier which references the virtual compute descriptor in the VNFD that maps to this flavour.
vimFlavourId	IdentifierInVim	1	Identifier of the compute resource flavour in the resource management layer (i.e. VIM).

9.5.3.10 Type: VimSoftwareImage

This type contains a mapping between a software image definition the VNFD and the corresponding software image managed by the NFVO in the VIM which is needed during compute resource instantiation. It shall comply with the provisions defined in table 9.5.3.10-1.

Table 9.5.3.10-1: Definition of the VimSoftwareImage data type

Attribute name	Data type	Cardinality	Description
vimConnectionId	Identifier	0..1	<p>Identifier of the VIM connection to access the software image referenced in this structure.</p> <p>The applicable "VimConnectionInfo" structure, which is referenced by vimConnectionId, can be obtained from the "vimConnectionInfo" attribute of the "VnflInstance" structure.</p> <p>This attribute shall only be supported and present if VNF-related resource management in direct mode is applicable.</p>
resourceProviderId	Identifier	0..1	<p>Identifies the entity responsible for the management of the virtualised resource.</p> <p>This attribute shall only be supported and present if VNF-related resource management in indirect mode is applicable. The identification scheme is outside the scope of the present document.</p>
vnfdSoftwareImageId	IdentifierInVnfd	1	Identifier which references the software image descriptor in the VNFD.
vimSoftwareImageId	IdentifierInVim	1	Identifier of the software image in the resource management layer (i.e. VIM).

9.5.4 Referenced simple data types and enumerations

No particular simple data types and enumerations are defined for this interface, in addition to those defined in clause 4.4.

10 VNF Package Management interface

10.1 Description

This interface allows the VNFM to obtain VNF package information from the NFVO. The operations provided through this interface are:

- Query On-boarded VNF Package Information, including obtaining the VNFD
- Fetch On-boarded VNF Package
- Fetch On-boarded VNF Package Artifacts
- Subscribe
- Query Subscription Info
- Terminate Subscription
- Notify

10.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "vnfpkgm" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present document. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 10.2-1 shows the overall resource URI structure defined for the VNF Package Management interface.

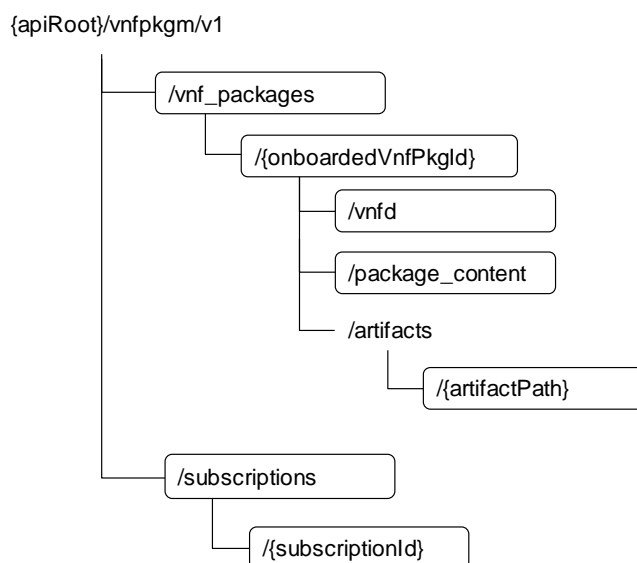


Figure 10.2-1: Resource URI structure of the VNF Package Management Interface

Table 10.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 10.2-1: Resources and methods overview of the VNF Package Management interface

Resource name	Resource URI	HTTP METHOD	Meaning
VNF packages	/vnf_packages	GET	Query on-boarded VNF packages
Individual on-boarded VNF package	/vnf_packages/{onboardedVnfPkgId}	GET	Read information about an individual on-boarded VNF package
VNFD of an individual on-boarded VNF package	/vnf_packages/{onboardedVnfPkgId}/vnfd	GET	Read VNFD of an on-boarded VNF package
On-boarded VNF package content	/vnf_packages/{onboardedVnfPkgId}/package_content	GET	Fetch an on-boarded VNF package
Individual on-boarded VNF package artifact	/vnf_packages/{onboardedVnfPkgId}/artifacts/{artifactPath}	GET	Fetch individual VNF package artifact
Subscriptions	/subscriptions	POST	Subscribe to VNF package change notifications
		GET	Query subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Read an individual subscription
		DELETE	Terminate a subscription
Notification endpoint	(client-provided)	POST	Notify about VNF package change
		GET	Test the notification endpoint

10.3 Sequence diagrams (informative)

10.3.1 Flow of querying/reading on-boarded VNF package information

This clause describes a sequence for querying information about one or multiple on-boarded VNF packages.

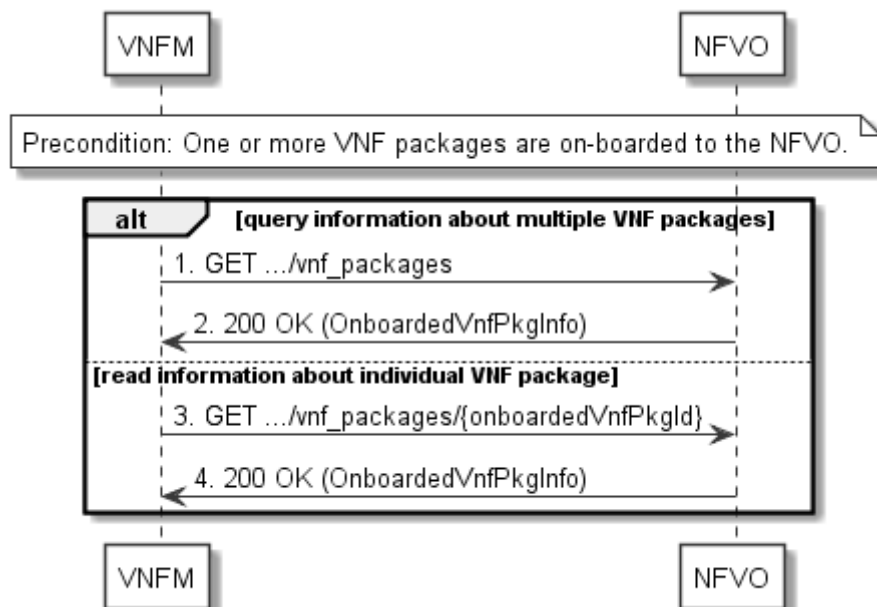


Figure 10.3.1-1: Flow of querying/reading on-boarded VNF package information

Precondition: One or more VNF packages are on-boarded to the NFVO.

On-boarded VNF package information query, as illustrated in figure 10.3.1-1, consists of the following steps:

- 1) If the VNFM intends to query information about multiple VNF packages, it sends a GET request to the "VNF packages" resource.
- 2) The NFVO returns a "200 OK" response, and includes in the payload body zero or more data structures of type "OnboardedVnfPkgInfo".
- 3) If the VNFM intends to read information about a particular VNF package, the VNFM sends a GET request to the "Individual on-boarded VNF package" resource, addressed by the appropriate VNF package identifier in its resource URI.
- 4) The NFVO returns a "200 OK" response, and includes in the payload body a data structure of type "OnboardedVnfPkgInfo".

Postcondition: Upon successful completion, the VNFM gets the information of the VNF packages or the VNF package.

Error handling: In case of failure, appropriate error information is provided in the response.

10.3.2 Flow of reading the VNFD of an on-boarded VNF package

This clause describes the procedure for reading the VNFD of an on-boarded VNF package.

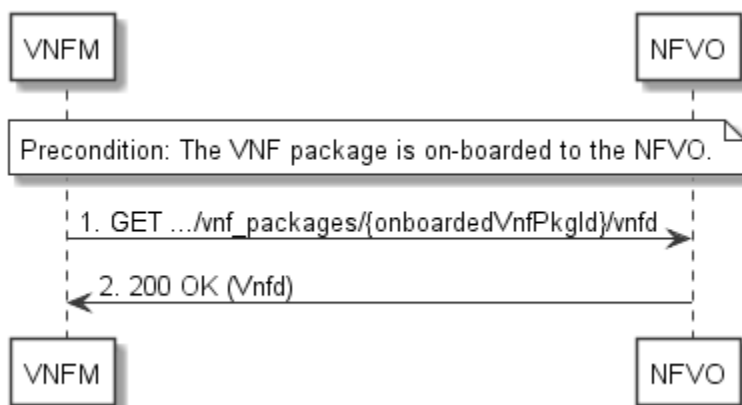


Figure 10.3.2-1: Flow of reading VNFD

Precondition: The VNF package is on-boarded to the NFVO.

The procedure consists of the following steps as illustrated in figure 10.3.2-1:

- 1) The VNFM sends a GET request to the "VNFD in an individual on-boarded VNF package" resource.
- 2) The NFVO returns a "200 OK" response, and includes a copy of the VNFD from the VNF package in the payload body.

10.3.3 Flow of fetching an on-boarded VNF package

This clause describes a sequence for fetching the content of an on-boarded VNF package.

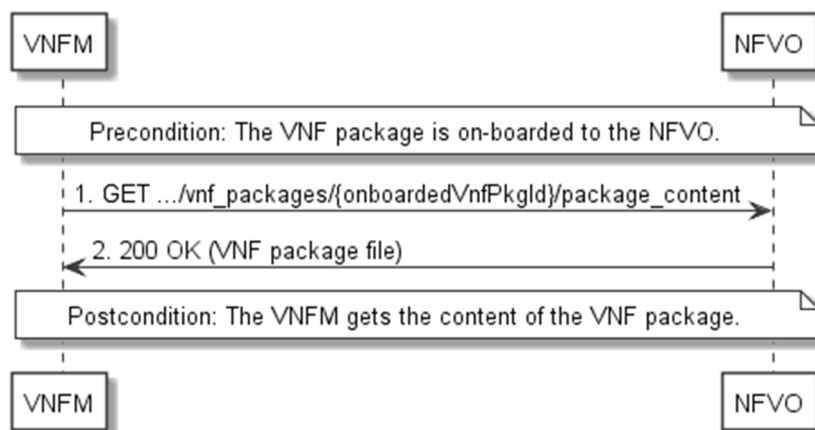


Figure 10.3.3-1: Flow of fetching an on-boarded VNF package

Precondition: The VNF package is on-boarded to the NFVO.

Fetching an on-boarded VNF package, as illustrated in figure 10.3.3-1, consists of the following steps:

- 1) The VNFM sends a GET request to the "On-boarded VNF package content" resource.
- 2) The NFVO returns a "200 OK" response, and includes a copy of the VNF package file in the payload body.

Postcondition: Upon successful completion, the VNFM gets the content of the VNF package.

Error handling: In case of failure, appropriate error information is provided in the response.

10.3.4 Flow of fetching a VNF package artifact

This clause describes a sequence for fetching an individual artifact contained in an on-boarded VNF package.

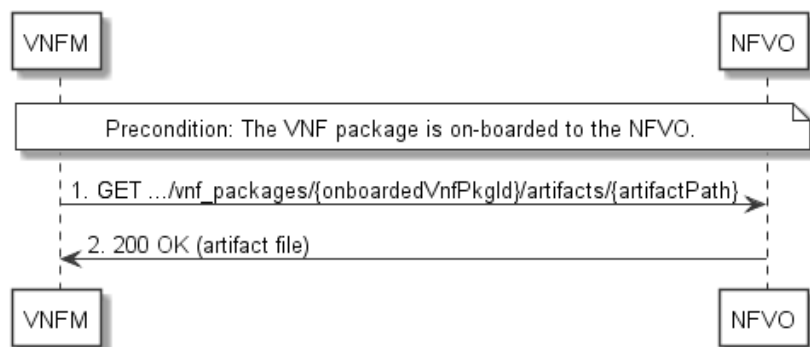


Figure 10.3.4-1: Flow of fetching a VNF package artifact

Precondition: The VNF package is on-boarded to the NFVO.

Fetching an individual artifact contained in an on-boarded VNF package, as illustrated in figure 10.3.4-1, consists of the following steps:

- 1) The VNFM sends a GET request to the "Individual on-boarded VNF package artifact" resource.
- 2) The NFVO returns a "200 OK" response, and includes a copy of the applicable artifact file from the VNF package in the payload body.

Error handling: In case of failure, appropriate error information is provided in the response.

10.3.5 Flow of managing subscriptions

This clause describes the procedure for creating, reading and terminating subscriptions to notifications related to VNF package management.

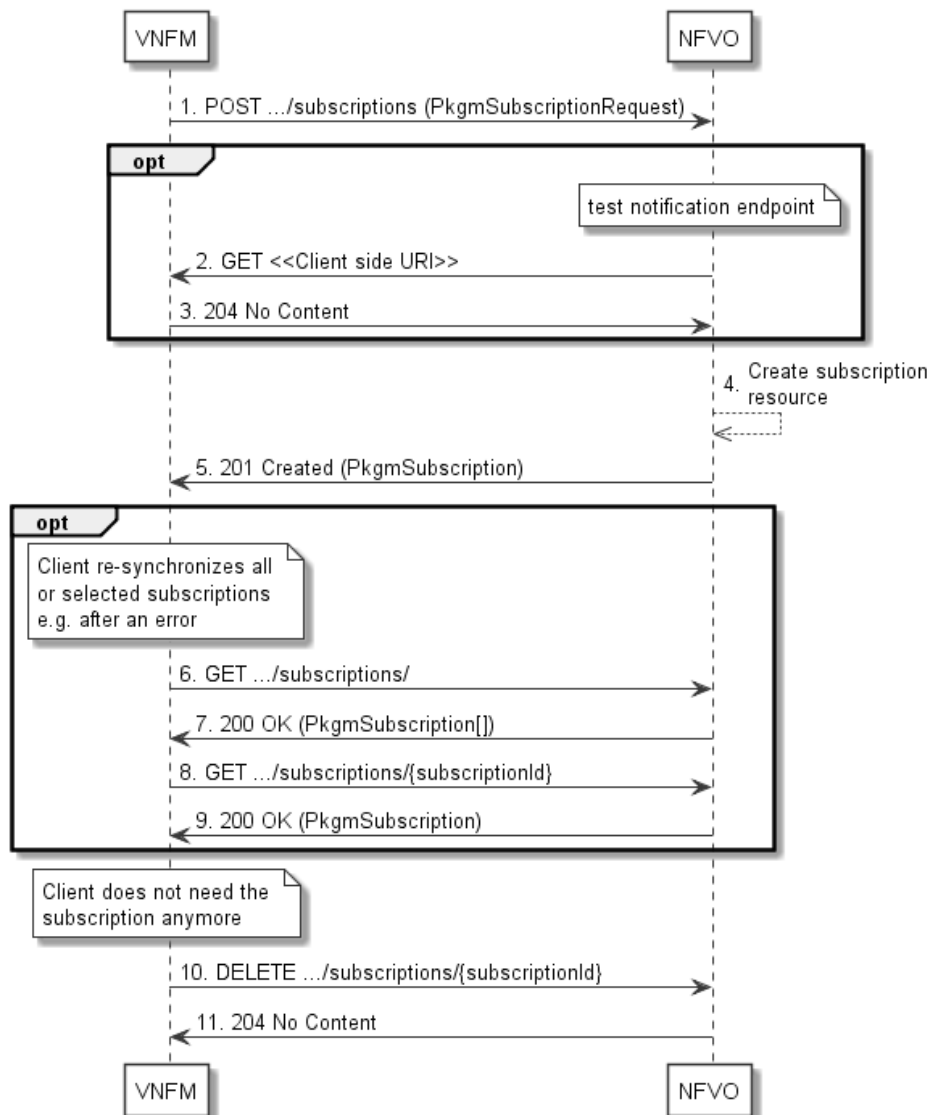


Figure 10.3.5-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 10.3.5-1:

- 1) The VNF sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "PkgmSubscriptionRequest". That data structure contains filtering criteria and a client side URI to which the VNF will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the VNF as part of the subscription, the NFVO sends a GET request to the notification endpoint URI.
- 3) In that case, the VNF returns a "204 No Content" response to indicate success.
- 4) The NFVO creates a new subscription to notifications related to VNF package on-boarding or changes, and a resource that represents this subscription.
- 5) The NFVO returns a "201 Created" response containing a data structure of type "PkgmSubscription" representing the subscription resource just created by the NFVO, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) If desired, e.g. to recover from an error situation, the VNF may obtain information about its subscriptions by sending a GET request to the resource representing the subscriptions.
- 7) In that case, the NFVO returns a "200 OK" response that contains the list of representations of all existing subscriptions that were created by the VNF.

- 8) If desired, e.g. to recover from an error situation, the VNFM may obtain information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the NFVO returns a "200 OK" response that contains a representation of that individual subscription.
- 10) If the VNFM does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription to remove.
- 11) The NFVO acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The NFVO rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

10.3.6 Flow of sending notifications

This clause describes the procedure for sending notifications related to VNF package management.

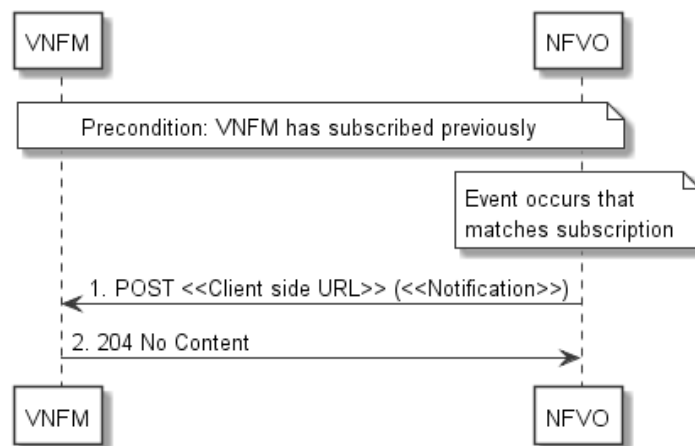


Figure 10.3.6-1: Flow of sending notifications

Precondition: The VNFM has subscribed previously for notifications related to VNF package management.

The procedure consists of the following steps as illustrated in figure 10.3.6-1:

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the NFVO generates a notification that includes information about the event, and sends it in the body of a POST request to the URI which the VNFM has registered as part of the subscription request. The variable <<Notification>> in the flow is a placeholder for the different types of notifications that can be sent by this API (see clauses 10.5.2.5 and 10.5.2.6).
- 2) The VNFM acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the NFVO does not receive the "204 No Content" response from the VNFM, it can retry sending the notification.

10.4 Resources

10.4.1 Introduction

This clause defines all the resources and methods provided by the VNF package management interface.

10.4.2 Resource: VNF packages

10.4.2.1 Description

This resource represents VNF packages that have been on-boarded to the NFVO. The client can use this resource to query information of the on-boarded VNF packages.

10.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/vnf_packages

This resource shall support the resource URI variables defined in table 10.4.2.2-1.

Table 10.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

10.4.2.3 Resource methods

10.4.2.3.1 POST

Not supported.

10.4.2.3.2 GET

The GET method queries the information of the on-boarded VNF packages matching the filter.

This method shall follow the provisions specified in the tables 10.4.2.3.2-1 and 10.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The NFVO shall support receiving filtering parameters as part of the URI query string. The VNFM may supply filtering parameters. All attribute names that appear in the OnboardedVnfPkgInfo and in data types referenced from it shall be supported in attribute-based filtering parameters.
all_fields	0..1	Include all complex attributes in the response. See clause 4.3.3 for details. The VNFM shall support this parameter.
fields	0..1	Complex attributes to be included into the response. See clause 4.3.3 for details. The NFVO should support this parameter.
exclude_fields	0..1	Complex attributes to be excluded from the response. See clause 4.3.3 for details. The NFVO should support this parameter.
exclude_default	0..1	Indicates to exclude the following complex attributes from the response. See clause 4.3.3 for details. The NFVO shall support this parameter. The following attributes shall be excluded from the OnboardedVnfPkgInfo structure in the response body if this parameter is provided, or none of the parameters "all_fields", "fields", "exclude_fields", "exclude_default" are provided: <ul style="list-style-type: none"> - softwareImages - additionalArtifacts - userDefinedData.

Table 10.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	OnboardedVnfPkgInfo	0..N	200 OK	Information of the selected VNF packages.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. In the returned ProblemDetails structure, the "detail" attribute should convey more information about the error.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute selector. In the returned ProblemDetails structure, the "detail" attribute should convey more information about the error.
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx		In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.2.3.3 PUT

Not supported.

10.4.2.3.4 PATCH

Not supported.

10.4.2.3.5 DELETE

Not supported.

10.4.3 Resource: Individual on-boarded VNF package

10.4.3.1 Description

This resource represents an individual VNF package that has been on-boarded to the NFVO. The client can use this resource to read information of the individual on-boarded VNF package.

10.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}

This resource shall support the resource URI variables defined in table 10.4.3.2-1.

Table 10.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
onboardedVnfPkgId	Identifier of the on-boarded VNF package. The identifier is allocated by the NFVO. See note.
NOTE: This identifier can be retrieved from the "onboardedVnfPkgId" attribute in the VnfPackageOnboardingNotification or VnfPackageChangeNotification.	

10.4.3.3 Resource methods

10.4.3.3.1 POST

Not supported.

10.4.3.3.2 GET

The GET method reads the information of an individual VNF package.

This method shall follow the provisions specified in the tables 10.4.3.3.2-1 and 10.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	OnboardedVnfPkgInfo	1	200 OK	Information of the VNF package.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.3.3.3 PUT

Not supported.

10.4.3.3.4 PATCH

Not supported.

10.4.3.3.5 DELETE

Not supported.

10.4.4 Resource: VNFD in an individual on-boarded VNF package

10.4.4.1 Description

This resource represents the VNFD contained in an on-boarded VNF package. The client can use this resource to obtain the content of the VNFD.

10.4.4.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/vnfd

This resource shall support the resource URI variables defined in table 10.4.4.2-1.

Table 10.4.4.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
onboardedVnfPkgId	Identifier of the on-boarded VNF package. The identifier is allocated by the NFVO. See note.
NOTE:	This identifier can be retrieved from the "onboardedVnfPkgId" attribute in the VnfPackageOnboardingNotification or VnfPackageChangeNotification.

10.4.4.3 Resource methods

10.4.4.3.1 POST

Not supported.

10.4.4.3.2 GET

The GET method reads the content of the VNFD within a VNF package.

The VNFD can be implemented as a single file or as a collection of multiple files. If the VNFD is implemented in the form of multiple files, a ZIP file embedding these files shall be returned. If the VNFD is implemented as a single file, either that file or a ZIP file embedding that file shall be returned.

The selection of the format is controlled by the "Accept" HTTP header passed in the GET request.

- If the "Accept" header contains only "text/plain" and the VNFD is implemented as a single file, the file shall be returned; otherwise, an error message shall be returned.
- If the "Accept" header contains only "application/zip", the single file or the multiple files that make up the VNFD shall be returned embedded in a ZIP file.
- If the "Accept" header contains both "text/plain" and "application/zip", it is up to the NFVO to choose the format to return for a single-file VNFD; for a multi-file VNFD, a ZIP file shall be returned.

The default format of the ZIP file shall be the one specified in ETSI GS NFV-SOL 004 [2] where only the YAML files representing the VNFD, and information needed to navigate the ZIP file and to identify the file that is the entry point for parsing the VNFD (such as TOSCA-meta or manifest files or naming conventions) are included.

This method shall follow the provisions specified in the tables 10.4.4.3.2-1 and 10.4.4.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.4.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.4.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a		The request shall contain the appropriate entries in the "Accept" HTTP header as defined above.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a	1	200 OK	On success, the content of the VNFD is returned. The payload body shall contain a copy of the file representing the VNFD or a ZIP file that contains the file or multiple files representing the VNFD, as specified above. The "Content-Type" HTTP header shall be set according to the format of the returned file, i.e. to "text/plain" for a YAML file or to "application/zip" for a ZIP file.
	ProblemDetails	0..1	406 Not Acceptable	If the "Accept" header does not contain at least one name of a content type for which the NFVO can provide a representation of the VNFD, the NFVO shall respond with this response code. The "ProblemDetails" structure may be included with the "detail" attribute providing more information about the error.
ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.	

10.4.4.3.3 PUT

Not supported.

10.4.4.3.4 PATCH

Not supported.

10.4.4.3.5 DELETE

Not supported.

10.4.5 Resource: On-boarded VNF package content

10.4.5.1 Description

This resource represents a VNF package identified by the VNF package identifier allocated by the NFVO. The client can use this resource to fetch the content of the VNF package.

10.4.5.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/package_content

This resource shall support the resource URI variables defined in table 10.4.5.2-1.

Table 10.4.5.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
onboardedVnfPkgId	Identifier of the on-boarded VNF package. The identifier is allocated by the NFVO. See note.
NOTE:	This identifier can be retrieved from the "onboardedVnfPkgId" attribute in the VnfPackageOnboardingNotification or VnfPackageChangeNotification.

10.4.5.3 Resource methods

10.4.5.3.1 POST

Not supported.

10.4.5.3.2 GET

The GET method fetches the content of a VNF package identified by the VNF package identifier allocated by the NFVO.

This method shall follow the provisions specified in the tables 10.4.5.3.2-1 and 10.4.5.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.5.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.5.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			<p>The request may contain a "Range" HTTP header to obtain single range of bytes from the VNF package file. This can be used to continue an aborted transmission.</p> <p>If the NFVO does not support range requests, it should return the whole file with a 200 OK response instead.</p>
Response body	Data type	Cardinality	Response Codes	Description
	n/a	1	200 OK	<p>On success, a copy of the VNF package file is returned.</p> <p>The response body shall include a copy of the VNF package file.</p> <p>The "Content-Type HTTP" header shall be set according to the type of the file, i.e. to "application/zip" for a VNF Package as defined in ETSI GS NFV-SOL 004 [2].</p>
	n/a	1	206 Partial Content	<p>On success, if the NFVO supports range requests, a single consecutive byte range from the content of the VNF package file is returned.</p> <p>The response body shall contain the requested part of the VNF package file.</p> <p>The "Content-Range" HTTP header shall be provided according to IETF RFC 7233 [15].</p> <p>The "Content-Type" HTTP header shall be set as defined above for the "200 OK" response.</p>
	ProblemDetails	0..1	416 Range Not Satisfiable	<p>The byte range passed in the "Range" header did not match any available byte range in the VNF package file (e.g. "access after end of file").</p> <p>The response body may contain a ProblemDetails structure.</p>
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.5.3.3 PUT

Not supported.

10.4.5.3.4 PATCH

Not supported.

10.4.5.3.5 DELETE

Not supported.

10.4.6 Resource: Individual on-boarded VNF package artifact

10.4.6.1 Description

This resource represents an individual artifact contained in a VNF package. The client can use this resource to fetch the content of the artifact.

10.4.6.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/artifacts/{artifactPath}

This resource shall support the resource URI variables defined in table 10.4.6.2-1.

Table 10.4.6.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
onboardedVnfPkgId	Identifier of the on-boarded VNF package. The identifier is allocated by the NFVO. See note 1.
artifactPath	Path of the artifact within the VNF package. See note 2.
NOTE 1: This identifier can be retrieved from the "onboardedVnfPkgId" attribute in the VnfPackageOnboardingNotification or VnfPackageChangeNotification.	
NOTE 2: This identifier can be retrieved from the "artifactPath" attribute of the applicable "additionalArtifacts" entry in the body of the response to a GET request querying the "Individual VNF package" or the "On-boarded VNF packages" resource.	

10.4.6.3 Resource methods

10.4.6.3.1 POST

Not supported.

10.4.6.3.2 GET

The GET method fetches the content of an artifact within a VNF package.

This method shall follow the provisions specified in the tables 10.4.6.3.2-1 and 10.4.6.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.6.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.6.3.2-2: Details of the GET request/response on this resource

	Data type	Cardinality	Description
Request body	n/a		The request may contain a "Range" HTTP header to obtain single range of bytes from an artifact file. This can be used to continue an aborted transmission.
			If the NFVO does not support range requests, it should return the whole file with a 200 OK response instead.

	Data type	Cardinality	Response Codes	Description
Response body	n/a	1	200 OK	On success, the content of the artifact is returned. The payload body shall contain a copy of the artifact file from the VNF package, as defined by ETSI GS NFV-SOL 004 [2]. The "Content-Type" HTTP header shall be set according to the content type of the artifact file. If the content type cannot be determined, the header shall be set to the value "application/octet-stream".
	n/a	1	206 Partial Content	A single consecutive byte range from the content of the artifact file, if the NFVO supports range requests. The response body shall contain the requested part of the artifact file from the VNF package, as defined by ETSI GS NFV-SOL 004 [2]. The "Content-Type" HTTP header shall be set according to the content type of the artifact file. If the content type cannot be determined, the header shall be set to the value "application/octet-stream". The "Content-Range" HTTP header shall be provided according to IETF RFC 7233 [15].
	ProblemDetails	0..1	416 Range Not Satisfiable	The byte range passed in the "Range" header did not match any available byte range in the artifact file (e.g. "access after end of file"). The response body may contain a ProblemDetails structure.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.6.3.3 PUT

Not supported.

10.4.6.3.4 PATCH

Not supported.

10.4.6.3.5 DELETE

Not supported.

10.4.7 Resource: Subscriptions

10.4.7.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to the VNF package management, and to query its subscriptions.

10.4.7.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/subscriptions

This resource shall support the resource URI variables defined in table 10.4.7.2-1.

Table 10.4.7.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

10.4.7.3 Resource methods

10.4.7.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 10.4.7.3.1-1 and 10.4.7.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.7.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.7.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	PkgmSubscriptionRequest	1	Details of the subscription to be created.	
Response body	Data type	Cardinality	Response Codes	Description
	PkgmSubscription	1	201 Created	Representation of the created subscription resource. The HTTP response shall include a "Location" HTTP header that points to the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.7.3.2 GET

The GET method queries the list of active subscriptions of the functional block that invokes the method. It can be used e.g. for resynchronization after error situations.

This method shall follow the provisions specified in the tables 10.4.7.3.2-1 and 10.4.7.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.7.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The NFVO shall support receiving filtering parameters as part of the URI query string. The VNFM may supply filtering parameters. All attribute names that appear in the PkgmSubscription and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 10.4.7.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PkgmSubscription	0..N	200 OK	Active subscriptions of the functional block that invokes the method.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.7.3.3 PUT

Not supported.

10.4.7.3.4 PATCH

Not supported.

10.4.7.3.5 DELETE

Not supported.

10.4.8 Resource: Individual subscription

10.4.8.1 Description

This resource represents an individual subscription. The client can use this resource to read and to terminate a subscription to notifications related to the VNF package management.

10.4.8.2 Resource definition

The resource URI is:

{apiRoot}/vnfpkgm/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 10.4.8.2-1.

Table 10.4.8.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
subscriptionId	Identifier of this subscription. See note.
NOTE:	This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.

10.4.8.3 Resource methods

10.4.8.3.1 POST

Not supported.

10.4.8.3.2 GET

The GET method reads an individual subscription.

This method shall follow the provisions specified in the tables 10.4.8.3.2-1 and 10.4.8.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.8.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.8.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	PkgmSubscription	1	200 OK	Representation of the subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.8.3.3 PUT

Not supported.

10.4.8.3.4 PATCH

Not supported.

10.4.8.3.5 DELETE

The DELETE method terminates an individual subscription.

This method shall follow the provisions specified in the tables 10.4.8.3.5-1 and 10.4.8.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.8.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.8.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

10.4.9 Resource: Notification endpoint

10.4.9.1 Description

This resource represents a notification endpoint.

The API producer can use this resource to send notifications related to VNF package management events to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

10.4.9.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 10.4.9.2-1.

Table 10.4.9.2-1: Resource URI variables for this resource

Name	Definition
n/a	

10.4.9.3 Resource methods

10.4.9.3.1 POST

The POST method delivers a notification from the server to the client.

This method shall follow the provisions specified in the tables 10.4.9.3.1-1 and 10.4.9.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.9.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Each notification request body shall include exactly one of the alternatives defined in table 10.4.9.3.1-2.

Table 10.4.9.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VnfPackageOnboardingNotification	1	A notification about on-boarding of a VNF package.	
VnfPackageChangeNotification	1	A notification about changes of status in a VNF package.		
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned. The NFVO shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

10.4.9.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 10.4.9.3.2-1 and 10.4.9.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 10.4.9.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 10.4.9.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

10.4.9.3.3 PUT

Not supported.

10.4.9.3.4 PATCH

Not supported.

10.4.9.3.5 DELETE

Not supported.

10.5 Data model

10.5.1 Introduction

This clause defines the request and response data structures of the VNF package management interface. If a request or response contains attributes not defined in the present document, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

10.5.2 Resource and notification data types

10.5.2.1 Introduction

This clause defines data structures to be used in resource representations and notifications.

10.5.2.2 Type: OnboardedVnfPkgInfo

This type represents the information of an on-boarded VNF package. It shall comply with the provisions defined in table 10.5.2.2-1.

Table 10.5.2.2-1: Definition of the OnboardedVnfPkgInfo data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of the on-boarded VNF package. This identifier is allocated by the NFVO.
vnfdId	Identifier	1	This identifier, which is managed by the VNF provider, identifies the VNF package and the VNFD in a globally unique way. It's copied from the VNFD of the on-boarded VNF package.
vnfProvider	String	1	Provider of the VNF package and the VNFD. This information is copied from the VNFD.
vnfProductName	String	1	Name to identify the VNF product. Invariant for the VNF product lifetime. This information is copied from the VNFD.
vnfSoftwareVersion	Version	1	Software version of the VNF. This is changed when there is any change to the software included in the VNF package. This information is copied from the VNFD.
vnfdVersion	Version	1	The version of the VNFD. This information is copied from the VNFD.
checksum	Checksum	1	Checksum of the on-boarded VNF package.
softwareImages	VnfPackageSoftwareImageInfo	0..N	Information about VNF package artifacts that are software images. This attribute shall be present unless it has been requested to be excluded per attribute selector.

Attribute name	Data type	Cardinality	Description
additionalArtifacts	VnfPackageArtifactInfo	0..N	Information about VNF package artifacts contained in the VNF package that are not software images.
operationalState	PackageOperationalStateType	1	Operational state of the on-boarded instance of the VNF package.
usageState	PackageUsageStateType	1	Usage state of the on-boarded instance of the VNF package.
deletionPending	Boolean	1	The value "true" indicates that deletion of this instance of the VNF package has been requested but the VNF package is still being used by created VNFs. This instance of the VNF package will be deleted once all VNFs instantiated from this package are deleted.
userDefinedData	KeyValuePairs	0..1	User defined data for the VNF package.
_links	Structure (inlined)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.
>vnfd	Link	1	Link to the VNFD resource.
>packageContent	Link	1	Link to the "On-boarded VNF package content" resource.

10.5.2.3 Type: PkgmSubscriptionRequest

This type represents a subscription request related to VNF package management notifications about VNF package on-boarding or changes. It shall comply with the provisions defined in table 10.5.2.3-1.

Table 10.5.2.3-1: Definition of the PkgmSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	PkgmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentication	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

10.5.2.4 Type: PkgmSubscription

This type represents a subscription related to notifications about VNF package management. It shall comply with the provisions defined in table 10.5.2.4-1.

Table 10.5.2.4-1: Definition of the PkgmSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this subscription resource.
filter	PkgmNotificationsFilter	0..1	Filter settings for this subscription, to define the subset of all notifications this subscription relates to. A particular notification is sent to the subscriber if the filter matches, or if there is no filter.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
_links	Structure (inlined)	1	Links to resources related to this resource.
>self	Link	1	URI of this resource.

10.5.2.5 Type: VnfPackageOnboardingNotification

This type represents a VNF package management notification, which informs the receiver of the on-boarding of a VNF package. It shall comply with the provisions defined in table 10.5.2.5-1. The support of this notification is mandatory.

The notification is triggered when a new VNF package is on-boarded.

Table 10.5.2.5-1: Definition of the VnfPackageOnboardingNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfPackageOnboardingNotification" for this notification type.
subscriptionId	Identifier	0..1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
onboardedVnfPkgId	Identifier	1	Identifier of the on-boarded VNF package. This identifier is allocated by the NFVO.
vnfdId	Identifier	1	This identifier, which is managed by the VNF provider, identifies the VNF package and the VNFD in a globally unique way. It's copied from the VNFD of the on-boarded VNF package.
_links	PkgmLinks	1	Links to resources related to this notification.

10.5.2.6 Type: VnfPackageChangeNotification

This type represents a VNF package management notification, which informs the receiver of a change of the status in a VNF package. Only changes in operationalState and/or deletionPending attributes will be reported. Change in usageState attribute is not reported. The notification shall comply with the provisions defined in table 10.5.2.6-1. The support of this notification is mandatory.

The notification is triggered when there is a change in the status of a VNF package, including:

- Change of states (operationalState and/or deletionPending) of an on-boarded VNF package.
- Deletion of an on-boarded VNF package.

Table 10.5.2.6-1: Definition of the VnfPackageChangeNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VnfPackageChangeNotification" for this notification type.
subscriptionId	Identifier	0..1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
onboardedVnfPkgId	Identifier	1	Identifier of the on-boarded VNF package. This identifier is allocated by the NFVO.
vnfdId	Identifier	1	Identifier of the VNFD contained in the VNF package, which also identifies the VNF package. This identifier is allocated by the VNF provider and copied from the VNFD.
changeType	PackageChangeType	1	The type of change of the VNF package.

Attribute name	Data type	Cardinality	Description
operationalState	PackageOperationalStateType	0..1	New operational state of the VNF package. Only present when changeType is OP_STATE_CHANGE.
deletionPending	Boolean	0..1	The value "true" indicates that the deletion instance of the VNF package has been requested but the VNF package is still being used by instantiated VNFs. Only present when changeType is DELETE_PEND_CHANGE.
_links	PkgmLinks	1	Links to resources related to this notification.

10.5.3 Referenced structured data types

10.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but are not resource representations.

10.5.3.2 Type: VnfPackageSoftwareImageInfo

This type represents an artifact contained in a VNF package which represents a software image. It shall comply with provisions defined in table 10.5.3.2-1.

Table 10.5.3.2-1: Definition of the VnfPackageSoftwareImageInfo data type

Attribute name	Data type	Cardinality	Description
id	IdentifierInVnfd	1	Identifier of the software image.
name	String	1	Name of the software image.
provider	String	1	Provider of the software image.
version	Version	1	Version of the software image.
checksum	Checksum	1	Checksum of the software image file.
containerFormat	Enum (inlined)	1	<p>Container format indicates whether the software image is in a file format that also contains metadata about the actual software.</p> <p>Permitted values:</p> <ul style="list-style-type: none"> - AKI: a kernel image format - AMI: a machine image format - ARI: a ramdisk image format - BARE: the image does not have a container or metadata envelope - DOCKER: docker container format - OVA: OVF package in a tarfile - OVF: OVF container format <p>See note 1.</p>

Attribute name	Data type	Cardinality	Description
diskFormat	Enum (inlined)	1	Disk format of a software image is the format of the underlying disk image. Permitted values: <ul style="list-style-type: none"> - AKI: a kernel image format - AMI: a machine image format - ARI: a ramdisk image format - ISO: an archive format for the data contents of an optical disc, such as CD-ROM - QCOW2: a common disk image format, which can expand dynamically and supports copy on write - RAW: an unstructured disk image format - VDI: a common disk image format - VHD: a common disk image format - VHDX: enhanced version of VHD format - VMDK: a common disk image format See note 2.
createdAt	DateTime	1	Time when this software image was created.
minDisk	UnsignedInt	1	The minimal disk for this software image in bytes.
minRam	UnsignedInt	1	The minimal RAM for this software image in bytes.
size	UnsignedInt	1	Size of this software image in bytes.
userMetadata	KeyValuePairs	0..1	User-defined data.
imagePath	String	1	Path in the VNF package, which identifies the image artifact and also allows to access a copy of the image artifact.
NOTE 1: The list of permitted values was taken from "Container formats" in [i.7].			
NOTE 2: The list of permitted values was adapted from "Disk formats" in [i.7].			

10.5.3.3 Type: VnfPackageArtifactInfo

This type represents an artifact other than a software image which is contained in a VNF package. It shall comply with provisions defined in table 10.5.3.3-1.

Table 10.5.3.3-1: Definition of the VnfPackageArtifactInfo data type

Attribute name	Data type	Cardinality	Description
artifactPath	String	1	Path in the VNF package, which identifies the artifact and also allows to access a copy of the artifact.
checksum	Checksum	1	Checksum of the artifact file.
metadata	KeyValuePairs	0..1	The metadata of the artifact that are available in the VNF package, such as Content type, size, creation date, etc.

10.5.3.4 Type: PkgmNotificationsFilter

This type represents a subscription filter related to notifications related to VNF package management. It shall comply with the provisions defined in table 10.5.3.4-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 10.5.3.4-1: Definition of the PkgmNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
notificationTypes	Enum (inlined)	0..N	Match particular notification types. Permitted values: - VnfPackageOnboardingNotification - VnfPackageChangeNotification See note 1.
vnfProvider	String	0..N	Match VNF packages from a provider that is listed as part of this attribute.
vnfProductInfo	Structure (inlined)	0..N	Match particular VNF products.
>vnfProductName	String	1	Match VNF products with a particular name.
>vnfSoftwareVersion	Version	0..N	Match VNF products with one of the software versions listed as part of this attribute. See note 2.
>vnfdVersion	Version	0..N	Match VNF products with one of the VNFD versions listed as part of this attribute. See note 2.
vnfdId	Identifier	0..N	Match VNF packages with a VNFD identifier listed in the attribute. See note 3.
onboardedVnfPkgId	Identifier	0..N	Match VNF packages with a package identifier listed in the attribute. May be present if the "notificationTypes" attribute contains the value "VnfPackageChangeNotification", and shall be absent otherwise. See note 3.
operationalState	PackageOperationalStateType	0..N	Match particular operational state of the on-boarded VNF package. May be present if the "notificationTypes" attribute contains the value "VnfPackageChangeNotification", and shall be absent otherwise.
usageState	PackageUsageStateType	0..N	Match particular usage state of the on-boarded VNF package. May be present if the "notificationTypes" attribute contains the value "VnfPackageChangeNotification", and shall be absent otherwise.
<p>NOTE 1: The permitted values of the "notificationTypes" attribute are spelled exactly as the names of the notification types to facilitate automated code generation systems.</p> <p>NOTE 2: As "vnfSoftwareVersion" and "vnfdVersion" can change independently from each other, care should be taken when specifying both at the same time.</p> <p>NOTE 3: On-boarded VNF package identifiers and VNFD identifiers are alternatives to reference to particular VNF packages in a filter. They should not be used both in the same filter instance, but one alternative should be chosen.</p>			

10.5.3.5 Type: PkgmLinks

This type represents the links to resources that a VNF package management notification can contain. It shall comply with the provisions defined in table 10.5.3.5-1.

Table 10.5.3.5-1: Definition of the PkgmLinks data type

Attribute name	Data type	Cardinality	Description
vnfPackage	Link	1	Link to the resource representing the VNF package to which the notified change applies, i.e. the individual on-boarded VNF package resource that represents the VNF package.
subscription	Link	1	Link to the related subscription.

10.5.3.6 Type: Checksum

This type represents the checksum of a VNF package or an artifact file. It shall comply with the provisions defined in table 10.5.3.6-1.

Table 10.5.3.6-1: Definition of the Checksum data type

Attribute name	Data type	Cardinality	Description
algorithm	String	1	Name of the algorithm used to generate the checksum, as defined in ETSI GS NFV-SOL 004 [2]. For example, SHA-256, SHA-512.
hash	String	1	The hexadecimal value of the checksum.

10.5.4 Referenced simple data types and enumerations

10.5.4.1 Introduction

This clause defines simple data types and enumerations that can be referenced from data structures defined in the previous clauses.

10.5.4.2 Simple data types

No particular simple data types are defined for this interface, in addition to those defined in clause 4.4.

10.5.4.3 Enumeration: PackageOperationalStateType

The enumeration PackageOperationalStateType shall comply with the provisions defined in table 10.5.4.3-1.

Table 10.5.4.3-1: Enumeration PackageOperationalStateType

Enumeration value	Description
ENABLED	The VNF package is enabled, i.e. it can be used for instantiation of new VNF instances.
DISABLED	The VNF package is disabled, i.e. it cannot be used for further VNF instantiation requests (unless and until the VNF package is re-enabled).

10.5.4.4 Enumeration: PackageUsageStateType

The enumeration PackageUsageStateType shall comply with the provisions defined in table 10.5.4.4-1.

Table 10.5.4.4-1: Enumeration PackageUsageStateType

Enumeration value	Description
IN_USE	VNF instances instantiated from this VNF package exist.
NOT_IN_USE	No existing VNF instance is instantiated from this VNF package.

10.5.4.5 Enumeration: PackageChangeType

The enumeration PackageChangeType shall comply with the provisions defined in table 10.5.4.5-1.

Table 10.5.4.5-1: Enumeration PackageChangeType

Enumeration value	Description
OP_STATE_CHANGE	The "operationalState" attribute has been changed.
DELETE_PEND_CHANGE	The "deletionPending" attribute has been changed.
PKG_DELETE	The VNF package has been deleted.

11 Virtualised Resources Quota Available Notification interface

11.1 Description

This interface allows the VNFM to subscribe to notifications on the availability of the virtualised resources quotas, and allows the NFVO to provide such notification to the subscriber.

Support for this interface is optional.

The operations provided through this interface are:

- Subscribe
- Query Subscription Information
- Terminate Subscription
- Notify

11.2 Resource structure and methods

All resource URIs of the API shall use the base URI specification defined in clause 4.2. The string "vrqan" shall be used to represent {apiName}. The {apiVersion} shall be set to "v1" for the present document. All resource URIs in the sub-clauses below are defined relative to the above base URI.

Figure 11.2-1 shows the overall resource URI structure defined for the Virtualised Resources Quota Available Notification interface.

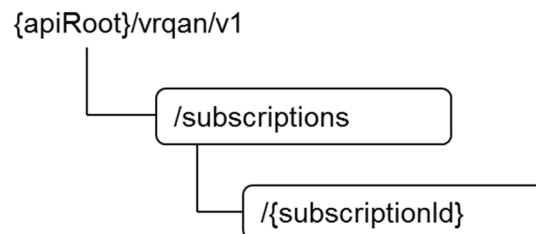


Figure 11.2-1: Resource URI structure of Virtualised Resources Quota Available Notification Interface

Table 11.2-1 lists the individual resources defined, and the applicable HTTP methods.

Table 11.2-1: Resources and methods overview of the Virtualised Resources Quota Available Notification interface

Resource name	Resource URI	HTTP Method	Meaning
Subscriptions	/subscriptions	POST	Subscribe to the notifications related to the availability of the virtualised resources quotas
		GET	Query subscriptions
Individual subscription	/subscriptions/{subscriptionId}	GET	Read individual subscription
		DELETE	Terminate subscription
Notification endpoint	(client-provided)	POST	Notify about the availability of the virtualised resources quota
		GET	Test the notification endpoint

11.3 Sequence diagrams (informative)

11.3.1 Flow of managing subscriptions

This clause describes the procedure for creating, reading and terminating subscriptions to notifications related to the availability of the virtualised resources quotas.

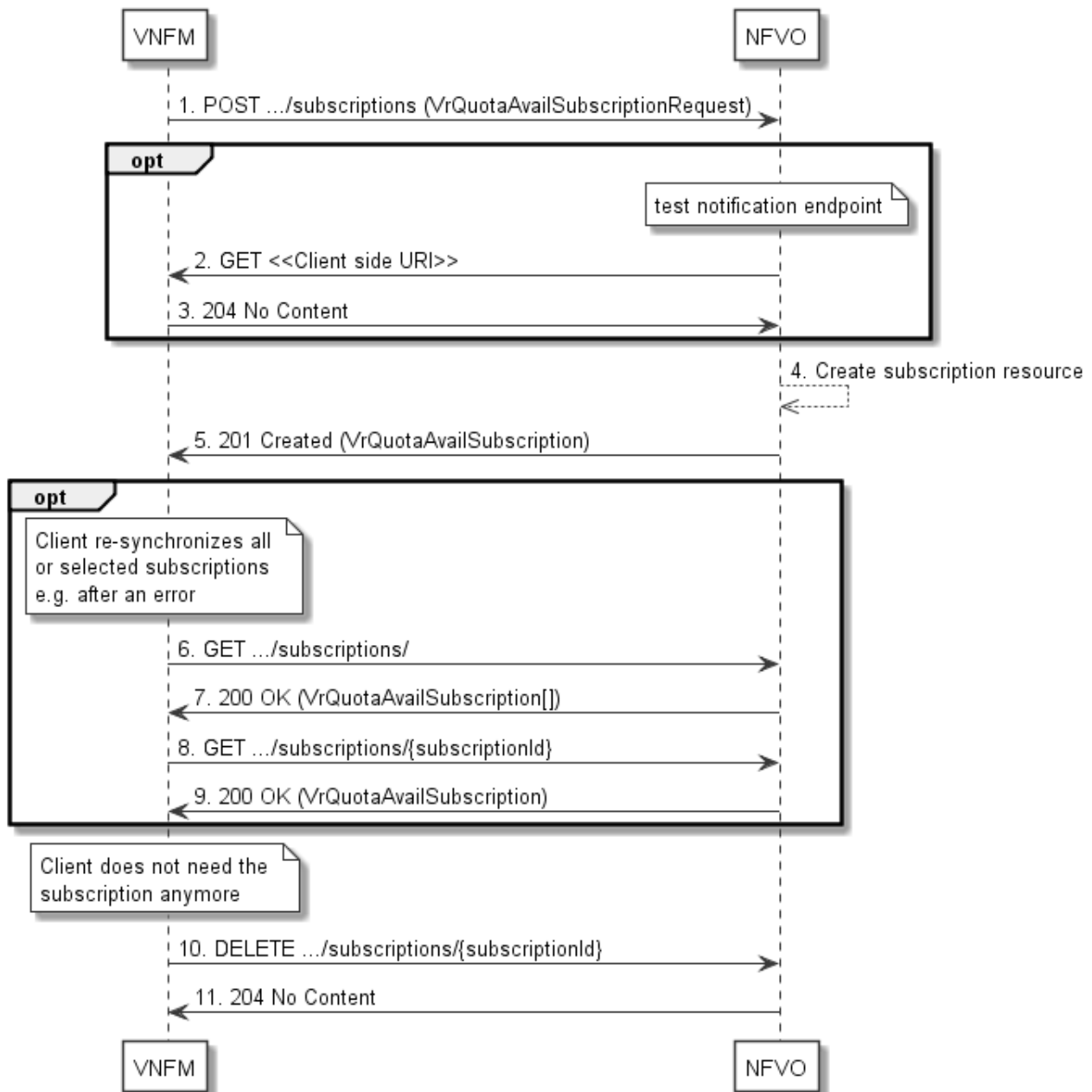


Figure 11.3.1-1: Flow of managing subscriptions

The procedure consists of the following steps as illustrated in figure 11.3.1-1:

- 1) The VNFM sends a POST request to the "Subscriptions" resource including in the payload body a data structure of type "VrQuotaAvailSubscriptionRequest". That data structure contains filtering criteria and a client side URI to which the NFVO will subsequently send notifications about events that match the filter.
- 2) Optionally, to test the notification endpoint that was registered by the VNFM as part of the subscription, the NFVO sends a GET request to the notification endpoint URI.
- 3) In that case, the VNFM returns a "204 No Content" response to indicate success.

- 4) The NFVO creates a new subscription to notifications related to the availability of the virtualised resources quotas, and a resource that represents this subscription.
- 5) The NFVO returns a "201 Created" response containing a data structure of type "VrQuotaAvailSubscription" representing the subscription resource just created by the NFVO, and provides the URI of the newly-created resource in the "Location" HTTP header.
- 6) If desired, e.g. to recover from an error situation, the VNFM may obtain information about its subscriptions by sending a GET request to the resource representing the subscriptions.
- 7) In that case, the NFVO returns a "200 OK" response that contains the list of representations of all existing subscriptions that were created by the VNFM.
- 8) If desired, the VNFM may obtain information about a particular subscription by sending a GET request to the resource representing that individual subscription.
- 9) In that case, the NFVO returns a "200 OK" response that contains a representation of that individual subscription.
- 10) If the VNFM does not need the subscription anymore, it terminates the subscription by sending a DELETE request to the resource that represents the individual subscription to remove.
- 11) The NFVO acknowledges the successful termination of the subscription by returning a "204 No Content" response.

Error handling: The NFVO rejects a subscription if the subscription information is not valid: endpoint cannot be reached, subscription information is malformed, etc.

11.3.2 Flow of sending notifications

This clause describes the procedure of sending notifications related to the availability of virtualised resources quota.

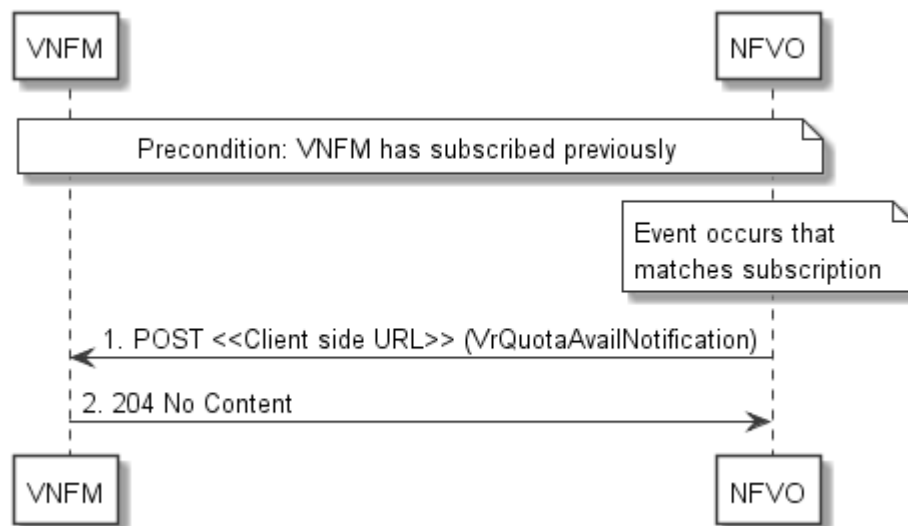


Figure 11.3.2-1: Flow of sending notifications

The procedure consists of the following steps as illustrated in figure 11.3.2-1:

Precondition: The VNFM has subscribed previously to notifications related to the availability of virtualised resources quotas.

- 1) If an event occurs that matches the filtering criteria which are part of the subscription, the NFVO generates a VrQuotaAvailNotification that includes information about the event, and sends it in the body of a POST request to the URI which the VNFM has registered as part of the subscription request.
- 2) The VNFM acknowledges the successful delivery of the notification by returning a "204 No Content" response.

Error handling: If the NFVO does not receive the "204 No Content" response from the VNFM, it can retry sending the notification.

11.4 Resources

11.4.1 Introduction

This clause defines all the resources and methods provided by the Virtualised Resources Quota Available Notification interface.

11.4.2 Resource: Subscriptions

11.4.2.1 Description

This resource represents subscriptions. The client can use this resource to subscribe to notifications related to the availability of the virtualised resources quotas, and to query its subscriptions.

11.4.2.2 Resource definition

The resource URI is:

{apiRoot}/vrqan/v1/subscriptions

This resource shall support the resource URI variables defined in table 11.4.2.2-1.

Table 11.4.2.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2

11.4.2.3 Resource methods

11.4.2.3.1 POST

The POST method creates a new subscription.

This method shall follow the provisions specified in the tables 11.4.2.3.1-1 and 11.4.2.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.2.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 11.4.2.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VrQuotaAvailSubscriptionRequest		1	Details of the subscription to be created.
Response body	Data type	Cardinality	Response Codes	Description
	VrQuotaAvailSubscription	1	201 Created	Representation of the created subscription resource. The HTTP response shall include a "Location" HTTP header that points to the created subscription resource.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

11.4.2.3.2 GET

The GET method queries the list of active subscriptions of the functional block that invokes the method. It can be used e.g. for resynchronization after error situations.

This method shall follow the provisions specified in the tables 11.4.2.3.2-1 and 11.4.2.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.2.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
(filter)	0..1	Attribute-based filtering parameters according to clause 4.3.2. The NFVO shall support receiving filtering parameters as part of the URI query string. The VNFM may supply filtering parameters. All attribute names that appear in the VrQuotaAvailSubscription and in data types referenced from it shall be supported in attribute-based filtering parameters.

Table 11.4.2.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VrQuotaAvailSubscription	0..N	200 OK	Active subscriptions of the functional block that invokes the method.
	ProblemDetails	1	400 Bad Request	Error: Invalid attribute-based filtering parameters. The response body shall contain a ProblemDetails structure, in which the "detail" attribute should convey more information about the error.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

11.4.2.3.3 PUT

Not supported.

11.4.2.3.4 PATCH

Not supported.

11.4.2.3.5 DELETE

Not supported.

11.4.3 Resource: Individual subscription

11.4.3.1 Description

This resource represents an individual subscription. The client can use this resource to read and to terminate a subscription to notifications related to the availability of the virtualised resources quotas.

11.4.3.2 Resource definition

The resource URI is:

{apiRoot}/vrqan/v1/subscriptions/{subscriptionId}

This resource shall support the resource URI variables defined in table 11.4.3.2-1.

Table 11.4.3.2-1: Resource URI variables for this resource

Name	Definition
apiRoot	See clause 4.2.
subscriptionId	Identifier of this subscription. See note.
NOTE: This identifier can be retrieved from the resource referenced by the "Location" HTTP header in the response to a POST request creating a new subscription resource. It can also be retrieved from the "id" attribute in the payload body of that response.	

11.4.3.3 Resource methods

11.4.3.3.1 POST

Not supported.

11.4.3.3.2 GET

The GET method reads an individual subscription.

This method shall follow the provisions specified in the tables 11.4.3.3.2-1 and 11.4.3.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.3.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 11.4.3.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	VrQuotaAvailSubscription	1	200 OK	Representation of the subscription resource
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

11.4.3.3.3 PUT

Not supported.

11.4.3.3.4 PATCH

Not supported.

11.4.3.3.5 DELETE

The DELETE method terminates an individual subscription.

This method shall follow the provisions specified in the tables 11.4.3.3.5-1 and 11.4.3.3.5-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.3.3.5-1: URI query parameters supported by the DELETE method on this resource

Name	Cardinality	Description
none supported		

Table 11.4.3.3.5-2: Details of the DELETE request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The subscription resource was deleted successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned.

11.4.4 Resource: Notification endpoint**11.4.4.1 Description**

This resource represents a notification endpoint.

The API producer can use this resource to send notifications related to virtualised resources quota availability to a subscribed API consumer, which has provided the URI of this resource during the subscription process.

11.4.4.2 Resource definition

The resource URI is provided by the client when creating the subscription.

This resource shall support the resource URI variables defined in table 11.4.4.2-1.

Table 11.4.4.2-1: Resource URI variables for this resource

Name	Definition
n/a	

11.4.4.3 Resource methods

11.4.4.3.1 POST

The POST method delivers a notification from the server to the client.

This method shall follow the provisions specified in the tables 11.4.4.3.1-1 and 11.4.4.3.1-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.4.3.1-1: URI query parameters supported by the POST method on this resource

Name	Cardinality	Description
none supported		

Table 11.4.4.3.1-2: Details of the POST request/response on this resource

Request body	Data type	Cardinality	Description	
	VrQuotaAvailNotification	1	A notification related to the availability of the virtualised resources quota.	
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification was delivered successfully.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in clause 4.3.5.5, may be returned. The NFVO shall not retry sending the notification if a 4xx/5xx error code other than 401 is received.

11.4.4.3.2 GET

The GET method allows the server to test the notification endpoint that is provided by the client, e.g. during subscription.

This method shall follow the provisions specified in the tables 11.4.4.3.2-1 and 11.4.4.3.2-2 for URI query parameters, request and response data structures, and response codes.

Table 11.4.4.3.2-1: URI query parameters supported by the GET method on this resource

Name	Cardinality	Description
none supported		

Table 11.4.4.3.2-2: Details of the GET request/response on this resource

Request body	Data type	Cardinality	Description	
	n/a			
Response body	Data type	Cardinality	Response Codes	Description
	n/a		204 No Content	The notification endpoint was tested successfully. The response body shall be empty.
	ProblemDetails	See clauses 4.3.5.4 / 4.3.5.5	4xx/5xx	In addition to the response codes defined above, any common error response code as defined in clause 4.3.5.4, and any other valid HTTP error response as defined in 4.3.5.5, may be returned.

11.4.4.3.3 PUT

Not supported.

11.4.4.3.4 PATCH

Not supported.

11.4.4.3.5 DELETE

Not supported.

11.5 Data model

11.5.1 Introduction

This clause defines the request and response data structures of the Virtualised Resources Quota Available Notification interface. If a request or response contains attributes not defined in the present document, a receiving functional block that does not understand these attributes shall not treat their presence as an error, and may choose to ignore them.

11.5.2 Resource and notification data types

11.5.2.1 Introduction

This clause defines data structures to be used in resource representations and notifications.

11.5.2.2 Type: VrQuotaAvailSubscriptionRequest

This type represents a subscription request related to notifications related to the availability of the virtualised resources quotas. It shall comply with the provisions defined in table 11.5.2.2-1.

Table 11.5.2.2-1: Definition of the VrQuotaAvailSubscriptionRequest data type

Attribute name	Data type	Cardinality	Description
filter	VrQuotaAvailNotificationsFilter	0..1	Input filter for selecting notifications to subscribe to. This filter can contain information about specific attributes of the virtualised resources quota.
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
authentication	SubscriptionAuthentication	0..1	Authentication parameters to configure the use of Authorization when sending notifications corresponding to this subscription, as defined in clause 4.5.3.4. This attribute shall only be present if the subscriber requires authorization of notifications.

11.5.2.3 Type: VrQuotaAvailSubscription

This type represents a subscription related to notifications related to the availability of the virtualised resources quotas. It shall comply with the provisions defined in table 11.5.2.3-1.

Table 11.5.2.3-1: Definition of the VrQuotaAvailSubscription data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this subscription resource
filter	VrQuotaAvailNotificationsFilter	0..1	Input filter for selecting notifications to subscribe to. This filter can contain information about specific attributes of the virtualised resources quota
callbackUri	Uri	1	The URI of the endpoint to send the notification to.
_links	Structure (inlined)	1	Links for this resource
>self	Link	1	URI of this resource

11.5.2.4 Type: VrQuotaAvailNotification

This type represents a notification which indicates the availability of a quota applicable to the consumer. It shall comply with the provisions defined in table 11.5.2.4-1. Support of this notification is mandatory if the Virtualised Resources Quota Available Notification interface is supported.

Table 11.5.2.4-1: Definition of the VrQuotaAvailNotification data type

Attribute name	Data type	Cardinality	Description
id	Identifier	1	Identifier of this notification. If a notification is sent multiple times due to multiple subscriptions, the "id" attribute of all these notifications shall have the same value.
notificationType	String	1	Discriminator for the different notification types. Shall be set to "VrQuotaAvailNotification" for this notification type.
subscriptionId	Identifier	1	Identifier of the subscription that this notification relates to.
timeStamp	DateTime	1	Date-time of the generation of the notification.
resourceGroupId	IdentifierInVim	1	Identifier of the "infrastructure resource group", logical grouping of virtual resources assigned to a tenant within an Infrastructure Domain.
vimConnectionInfo	VimConnectionInfo	0..1	Information about the VIM connection to manage the virtualised resources quota. This attribute shall only be supported and present when VNF-related Resource Management in direct mode is applicable.
resourceProviderId	Identifier	0..1	Identifies the entity responsible for the management of the virtualised resources quota.

Attribute name	Data type	Cardinality	Description
			This attribute shall only be supported and present when VNF-related Resource Management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
_links	QuotaAvailLinks	1	Links to resources related to this notification.

11.5.3 Referenced structured data types

11.5.3.1 Introduction

This clause defines data structures that can be referenced from data structures defined in the previous clauses, but can neither be resource representations nor bound to any subscribe/notify mechanism.

11.5.3.2 Type: VrQuotaAvailNotificationsFilter

This type represents a subscription filter related to notifications about the availability of the virtualised resources quotas. It shall comply with the provisions defined in table 11.5.3.2-1.

At a particular nesting level in the filter structure, the following applies: All attributes shall match in order for the filter to match (logical "and" between different filter attributes). If an attribute is an array, the attribute shall match if at least one of the values in the array matches (logical "or" between the values of one filter attribute).

Table 11.5.3.2-1: Definition of the VrQuotaAvailNotificationsFilter data type

Attribute name	Data type	Cardinality	Description
vimIds	Identifier	0..N	Match VIMs that were created the quota for a consumer of the virtualised resources. This attribute shall only be supported when VNF-related Resource Management in direct mode is applicable.
resourceProviderIds	Identifier	0..N	Match the entities responsible for the management of the virtualised resources that were allocated by the NFVO. This attribute shall only be supported when VNF-related Resource Management in indirect mode is applicable. The identification scheme is outside the scope of the present document.
resourceTypes	Enum (inlined)	0..N	Match particular resource types. Permitted values: - COMPUTE - STORAGE - NETWORK
resourceGroupIds	IdentifierInVim	0..N	Match the "infrastructure resource groups" that are logical groupings of the virtualised resources assigned to a tenant within an infrastructure Domain.

11.5.3.3 Type: QuotaAvailLinks

This type represents the links to resources that a notification of type "VrQuotaAvailNotification" can contain. It shall comply with the provisions defined in table 11.5.3.3-1.

Table 11.5.3.3-1: Definition of the QuotaAvailLinks data type

Attribute name	Data type	Cardinality	Description
subscription	Link	1	Link to the related subscription.

Annex A (informative): Mapping operations to protocol elements

A.1 Overview

This annex provides the mapping between operations as defined in ETSI GS NFV-IFA 007 [1] and the corresponding resources and HTTP methods defined in the present document.

A.2 VNF Package Management interface

Table A.2-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Query Onboarded VNF Package Info	GET	vnfpkgm/v1/vnf_packages	VNFM → NFVO
	GET	vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}	VNFM → NFVO
	GET	vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/vnfd	VNFM → NFVO
Fetch Onboarded VNF Package	GET	vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/package_content	VNFM → NFVO
Fetch Onboarded VNF Package Artifacts	GET	vnfpkgm/v1/vnf_packages/{onboardedVnfPkgId}/artifacts/{artifactPath}	VNFM → NFVO
Subscribe	POST	vnfpkgm/v1/subscriptions	VNFM → NFVO
Query Subscription Information	GET	vnfpkgm/v1/subscriptions	VNFM → NFVO
	GET	vnfpkgm/v1/subscriptions/{subscriptionId}	VNFM → NFVO
Terminate subscription	DELETE	vnfpkgm/v1/subscriptions/{subscriptionId}	VNFM → NFVO
Notify	POST	(client-provided)	NFVO → VNFM

A.3 VNF Lifecycle Operation Granting interface

Table A.3-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Grant Lifecycle Operation	POST	grant/v1/grants	VNFM → NFVO
	GET	grant/v1/grants/{grantId}	VNFM → NFVO

A.4 Virtualised Resources Management interfaces in indirect mode

This group of interfaces is outside the scope of the present document.

A.5 Virtualised Resources Quota Available Notification interface

Table A.5-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Subscribe	POST	vrqan/v1/subscriptions	VNFM → NFVO
Query Subscription Information	GET	vrqan/v1/subscriptions	NFVO → VNFM
	GET	vrqan/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Terminate subscription	DELETE	vrqan/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Notify	POST	(client-provided)	NFVO → VNFM

A.6 VNF Lifecycle Management interface

Table A.6-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Create VNF Identifier	POST	vnflcm/v1/vnf_instances	NFVO → VNFM
Instantiate VNF	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/instantiate	NFVO → VNFM
Scale VNF	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/scale	NFVO → VNFM
Scale VNF to Level	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/scale_to_level	NFVO → VNFM
Change VNF Flavour	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/change_flavour	NFVO → VNFM
Terminate VNF	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/terminate	NFVO → VNFM
Delete VNF Identifier	DELETE	vnflcm/v1/vnf_instances/{vnfInstanceId}	NFVO → VNFM
Query VNF	GET	vnflcm/v1/vnf_instances/{vnfInstanceId}	NFVO → VNFM
	GET	vnflcm/v1/vnf_instances	NFVO → VNFM
Heal VNF	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/heal	NFVO → VNFM
Operate VNF	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/operate	NFVO → VNFM
Change External VNF Connectivity	POST	vnflcm/v1/vnf_instances/{vnfInstanceId}/change_ext_conn	NFVO → VNFM
Modify VNF Information	PATCH	vnflcm/v1/vnf_instances/{vnfInstanceId}	NFVO → VNFM
Get Operation Status	GET	vnflcm/v1/vnf_lcm_op_occs	NFVO → VNFM
	GET	vnflcm/v1/vnf_lcm_op_occs/{vnfLcmOpOcclId}	NFVO → VNFM
Subscribe	POST	vnflcm/v1/subscriptions	NFVO → VNFM
Query Subscription Information	GET	vnflcm/v1/subscriptions	NFVO → VNFM
	GET	vnflcm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Terminate Subscription	DELETE	vnflcm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Notify	POST	(client-provided)	VNFM → NFVO

A.7 VNF Performance Management interface

Table A.7-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Create PM Job	POST	vnfpm/v1/pm_jobs	NFVO → VNFM
Delete PM Job	DELETE	vnfpm/v1/pm_jobs/{pmJobId}	NFVO → VNFM
Query PM Job	GET	vnfpm/v1/pm_jobs	NFVO → VNFM
	GET	vnfpm/v1/pm_jobs/{pmJobId}	NFVO → VNFM
Create Threshold	POST	vnfpm/v1/thresholds	NFVO → VNFM
Delete Threshold	DELETE	vnfpm/v1/thresholds/{thresholdId}	NFVO → VNFM
Query Threshold	GET	vnfpm/v1/thresholds	NFVO → VNFM
	GET	vnfpm/v1/thresholds/{thresholdId}	NFVO → VNFM
Subscribe	POST	vnfpm/v1/subscriptions	NFVO → VNFM
Query Subscription Information	GET	vnfpm/v1/subscriptions	NFVO → VNFM
	GET	vnfpm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Terminate Subscription	DELETE	vnfpm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Notify	POST	(client-provided)	VNFM → NFVO

A.8 VNF Fault Management interface

Table A.8-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Get Alarm List	GET	vnffm/v1/alarms	NFVO → VNFM
Acknowledge Alarm	PATCH	vnffm/v1/alarms/{alarmId}	NFVO → VNFM
Subscribe	POST	vnffm/v1/subscriptions	NFVO → VNFM
Query Subscription Information	GET	vnffm/v1/subscriptions	NFVO → VNFM
	GET	vnffm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Terminate Subscription	DELETE	vnffm/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Notify	POST	(client-provided)	VNFM → NFVO

A.9 VNF Indicator interface

Table A.9-1

ETSI GS NFV-IFA 007 operation	HTTP method	Resource	Direction
Get Indicator Value	GET	vnfind/v1/indicators	NFVO → VNFM
	GET	vnfind/v1/indicators/{vnfInstanceId}	NFVO → VNFM
	GET	vnfind/v1/indicators/{vnfInstanceId}/{indicatorId}	NFVO → VNFM
Subscribe	POST	vnfind/v1/subscriptions	NFVO → VNFM
Query Subscription Information	GET	vnfind/v1/subscriptions	NFVO → VNFM
	GET	vnfind/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Terminate Subscription	DELETE	vnfind/v1/subscriptions/{subscriptionId}	NFVO → VNFM
Notify	POST	(client-provided)	VNFM → NFVO

Annex B (informative): Explanations

B.1 Introduction

This annex provides explanations of certain concepts introduced in the present document.

In clause B.2, the underlying concepts of scaling a VNF instance are explained.

In clause B.3, examples of VNF connectivity patterns, and change of VNF external connectivity, are provided.

B.2 Scaling of a VNF instance

A VNF instance can be scaled in the following ways:

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

This mechanism is called "horizontal scaling".

NOTE: Besides that, there is also "vertical scaling" which is not supported in the present document, and which includes scale up (adding further resources to existing VNFC instances) and scale down (removing resources from existing VNFC instances).

Potentially, different *aspects* of a VNF can be scaled independently. For example, a VNF could be designed to provide static capacity such as database nodes and dynamic capacity such as query processing nodes. Such a VNF might be scaled w.r.t. two separate aspects: the 'static capacity' aspect can be scaled by adding VNFCs from VNF Deployment Units (VDUs) defining database nodes, and the 'dynamic capacity' aspect can be scaled by adding VNFCs from VDUs defining query processing nodes. In complex VNF designs, scaling a VNF often requires adding/removing a number of related VNFC instances of several different types, possibly based on multiple VDUs. For example, in a high availability configuration, it might be required to add in each scaling step a pair of VNFC instances, one in active and one in standby configuration. The scaling aspects valid for a particular VNF are declared in the VNFD.

Each scaling aspect can only be scaled in discrete steps, the so-called "*scaling steps*". Each scaling step corresponds to adding or removing an *increment* (set of VNFCs based on one or more VDUs, and the related virtualised storage / virtualised network resources) to or from the VNF instance, and (re)configuring the virtualised resources. Per increment, the VNFM will figure out the necessary set of VNFCs and the related set of resources based on VNF-specific rules, for instance using the lifecycle management script associated to the Scale VNF or Scale VNF to Level event.

When scaling a VNF for a particular aspect, the number of scaling steps to apply to that aspect can be provided as a parameter. A scaling step is the smallest unit by which a particular aspect of a VNF can be scaled, and is mapped by the VNFM to the addition (or removal) of a certain set of resources. For each scaling aspect, the minimum scale level is assumed as zero, and the maximum scale level is defined in the VNFD. The maximum scale level corresponds to the maximum number of scaling steps that can be performed for this aspect, starting from the minimum scale level (i.e. zero). The maximum scale level represents the maximum configuration of that aspect of the VNF in a given deployment flavour. The minimum scale level represents the minimum configuration of that aspect of the VNF in a given deployment flavour. It usually corresponds to some deployed resources, but it is also possible to define in the VNFD that certain VDUs may not always have a corresponding VNFC instance, i.e. for certain aspects the minimum configuration may indeed be empty.

At each point in time between the completed VNF instantiation and the VNF termination, the current "size" of a particular scaling aspect of the VNF can be expressed by the current scale level w.r.t. that aspect. When the VNF is instantiated, the current scale level is initialized with values that are defined as part of the instantiation level in the VNFD for the associated aspect. Figure B.2-1 illustrates the concepts described above.

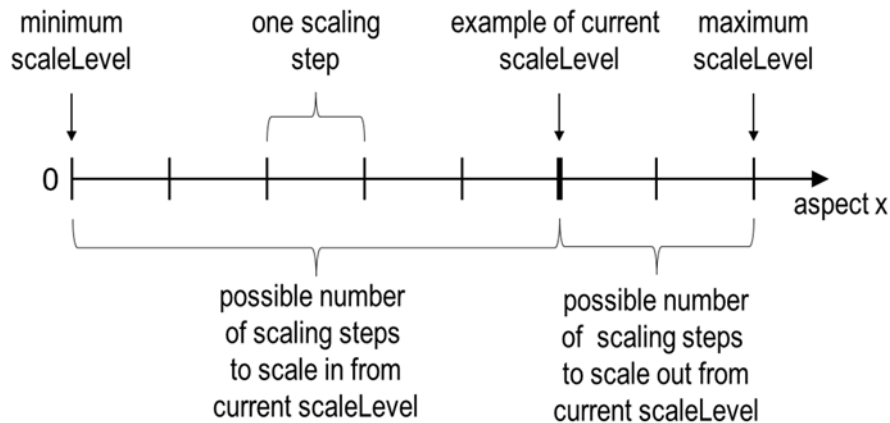


Figure B.2-1: Illustrating the concepts of scale level and scaling steps for a particular scaling aspect

As indicated above, a VNF can have one or more scaling aspects. Each individual aspect has a current scale level. All pairs of (aspect, scaleLevel) together are called the *scale status* of the VNF instance and can be obtained from the "scaleStatus" attribute of the VnfInstance structure which is returned when reading the "Individual VNF instance" resource or when querying the "VNF instances" resource. Example 1 illustrates a possible scale status.

EXAMPLE 1:

```
"scaleStatus": [
  {"aspectId": "processing", "scaleLevel": "2"},
  {"aspectId": "database", "scaleLevel": "3"}
]
```

When requesting scaling of a VNF instance, there are two methods: Scale VNF (see clause 5.4.5) and Scale VNF to Level (see clause 5.4.6). When using "Scale VNF", the scaling request defines how many increments (scaling steps) are requested to be added to or removed from the current "size" (scale level) *for a single aspect*. Depending on the VNF capabilities, single-step scaling or multiple-step scaling can be supported in a single scale request. When using "Scale VNF to Level", the scale request defines a target size of the VNF instance by defining the requested target size *for all aspects at once*, independent from the current scale status (current size) of the VNF instance. The target size can be expressed by referencing pre-defined sizes (called *instantiation levels*) declared in the VNFD, or by explicitly providing the target scale level for each scaling aspect, as illustrated in example 2.

EXAMPLE 2:

```
"scaleInfo": [
  {"aspectId": "processing", "scaleLevel": "4"},
  {"aspectId": "database", "scaleLevel": "2"}
]
```

These combinations allow four sub-modes of scaling:

- Scale VNF with a single step.
- Scale VNF with multiple steps.
- Scale VNF to Level based on pre-defined sizes (instantiation levels) only.
- Scale VNF to Level with arbitrary sizes.

B.3 Examples of VNF connectivity patterns

B.3.1 Overview

Clause B.3.3 illustrates examples of possible connectivity patterns for a VNF. The purpose is to illustrate the relationship among the different information elements specified in clause 8.5 that are used to describe the connectivity of and within a VNF instance.

NOTE: The information related to connectivity as shown in the clause B.3.2 is to be understood in the context of the present document, i.e. availability of certain information on the Or-Vnfm reference point follows the conditions that are detailed in the respective attribute descriptions and notes in the present document.

This clause also illustrates the use of the "Change external VNF connectivity" task resource to re-connect external CPs of a VNF instance to a different external VL.

B.3.2 Example of a VNF instance with two different types of external connections points

The present example shows a regular connectivity pattern of a VNF where the two external CPs of the VNF use different connectivity patterns. Figure B.3.2-1 illustrates the example, from which it is highlighted the following:

- An external CP of the VNF instance (see VnfExtCp #1) that maps to an internal CP, i.e. a CP of a specific VNFC.
- An external CP of the VNF instance (see VnfExtCp #2) that refers to a link port of an internal VL of the VNF (see VnfLinkPort #2.2).
- An internal VL of the VNF instance (see VnfVirtualLink #1) that is only used for connectivity of VNFCs within the VNF,
- An internal VL of the VNF instance (see VnfVirtualLink #2) that is used as provider of a link port for connectivity of external CPs of the VNF.
- Link ports of internal VLs of the VNF instance (see VnfLinkPort #1.1 to #1.3 and VnfLinkPort #2.1) that are optionally exposed on Or-Vnfm reference point.
- Internal CPs, i.e. CPs of specific VNFCs (see grey VNFC CPs) that are optionally exposed on the Or-Vnfm reference point.

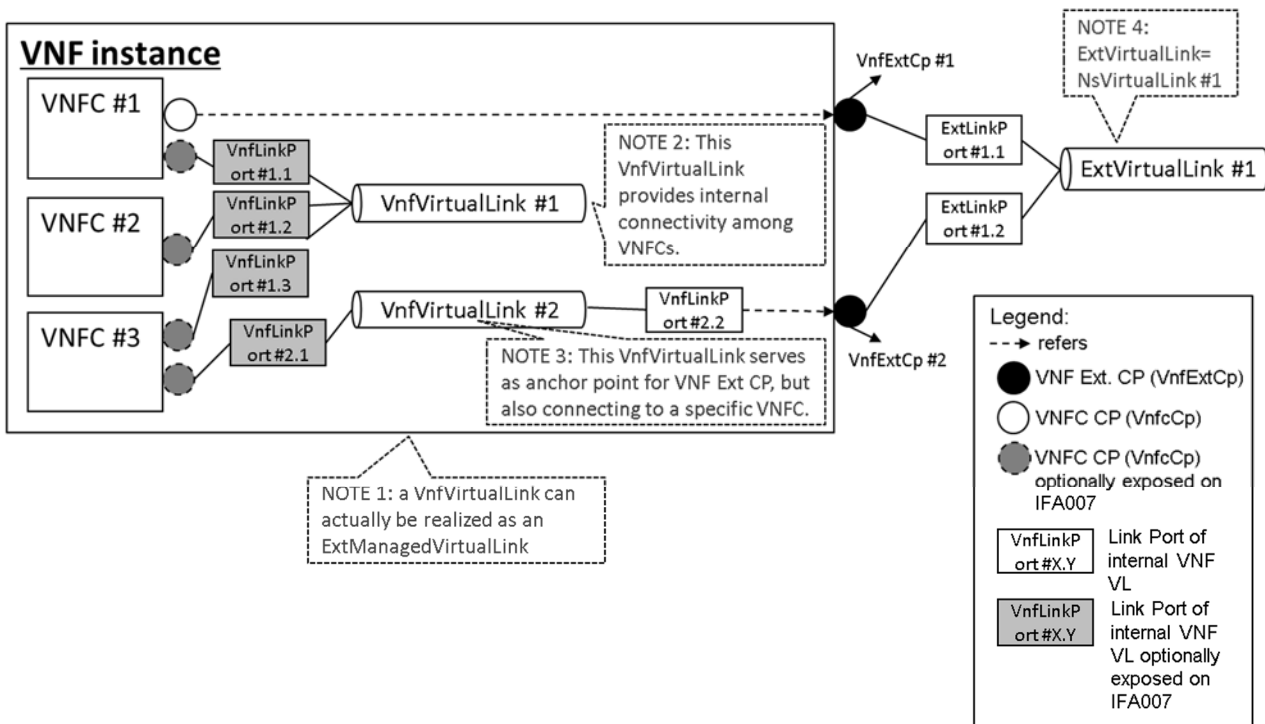


Figure B.3.2-1: Example of a VNF instance with two different types of external connections points

B.3.3 Example of changing VNF connectivity

This example illustrates changing the external connectivity of a VNF instance using the "Change external VNF connectivity" task resource (clause 5.4.11). The scenario depicted disconnects from a "source" external VL all those external CP instances that were created based on a particular CPD, and connects them to a "target" external VL.

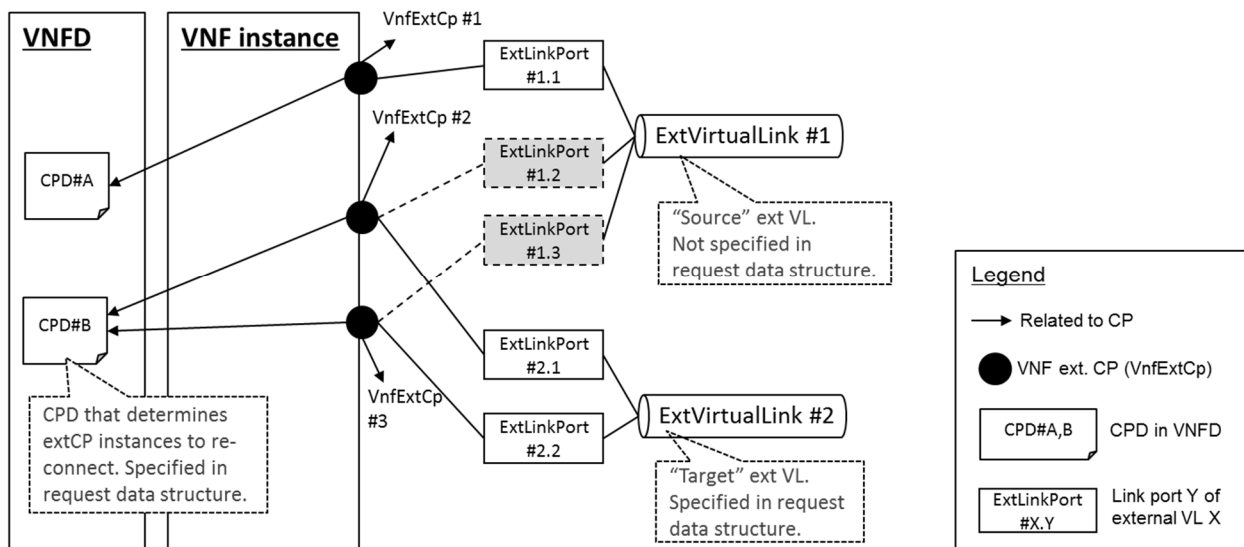


Figure B.3.3-1: Illustration of disconnecting external CPs from one external VL and connecting them to another external VL

Annex C (informative): VimConnectionInfo Registry

C.1 Purpose

This annex defines the basic structure of the entries of a registry for VimConnectionInfo parameters. The registry contains a reference to the present document to indicate where the structure of the VimConnectionInfo data type is defined.

C.2 Registry content

The primary elements of the registry are:

Registered identifier

- vimType: Identifier of a set of VimConnectionInfo parameters (mandatory)

NOTE 1: The registration authority is required to ensure global uniqueness of registered identifiers.

Registered interface information for a particular vimType

- interfaceInfo: Interface information as a list of key names with data type, permissible values and description (mandatory)
- accessInfo: Access information as a list of key names with data type, permissible values and description (mandatory)
- extra: Additional specific information as a list of key names with data type, permissible values and description (optional)

Registrant information

- Registrant Name: Name of the company or organization registering the vimType (mandatory)
- Previous Registrant Name(s): Name or names of the company or organization to whom the registered identifier has belonged previously, e.g. due to buyout, merger, acquisition (optional)

NOTE 2: It is assumed that the registration authority will manage further information related to the identity of the registrant (e.g. contact information).

Additional information

- Solution Name: Name of the VIM for which the VimConnectionInfo parameter set is being registered (e.g. "OpenStack Release xyz with Keystone") (mandatory)
- Description: General description of the VIM for which the VimConnectionInfo parameter set is being registered (e.g. "ETSI-registered VIM Connection Info to enable the use of Openstack rel xyz with SOL003. Interface is using keystone as the gateway. Valid for releases starting from xyz"). (mandatory)
- Specification URI: Publically reachable URI of the specification that defines further details of the particular VIM Connection Info registered. Needs to be long-lived. (recommended)
- Registration Date: Date of the registration (mandatory)

Annex D (informative): Authors & contributors

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Annex E (informative): Change History

Date	Version	Information about changes
May 2016	0.0.1	Initial version based on <ul style="list-style-type: none"> - NFVSOL(16)000008r1 SOL003 ToC Proposal - NFVSOL(16)000009 SOL003 basic skeleton
September 2016	0.1.0	Contributions incorporated <ul style="list-style-type: none"> - NFVSOL(16)000092 SOL003 structure update - NFVSOL(16)000085r2 SOL003 InstantiateVnf_flow - NFVSOL(16)000076r2 SOL002 SOL003 - 4_2 Specification Methodology - NFVSOL(16)000081r3 SOL003 - Interface design for CreateVNFIId Editorials <ul style="list-style-type: none"> - Removed the old clause 5 and 6 structure as this is not in line anymore with the template - Added reference to RFC7159 as instructed in the Editor's note in document 76r2, removed the Editor's note, and changed the style of the reference to comply with EDR. - Added applicable abbreviations - Added changes of GS title page requested by TSC (NFVTSC(16)000052) - Added editorials requested by Ericsson
October 2016	0.1.5	Contributions incorporated that were agreed at SOL#11 call <ul style="list-style-type: none"> - NFVSOL(16)000105r1 SOL003 align GS with template changes in 104 - NFVSOL(16)000096 SOL003 4_2 RFC3986 - NFVSOL(16)000101 SOL003 Removal of Editor's Note in Section 5_2_1 Creation - NFVSOL(16)000107r1 SOL003 Scope
November 2016	0.2.0	Contributions incorporated that were agreed at SOL#12 meeting in Bundang <ul style="list-style-type: none"> - NFVSOL(16)000097r3 SOL003 4_2 Normative status of https - NFVSOL(16)000100r3 SOL003 Add JSON schema Annex skeleton - NFVSOL(16)000102r3 SOL003 VNF Lifecycle Management interface Terminate VNF fl - NFVSOL(16)000108r1 SOL003 Interface overview annex - NFVSOL(16)000109 SOL003 operations mapping annex - NFVSOL(16)000110r3 SOL002 SOL003 Delete VNF Identifier Interface - NFVSOL(16)000113r3 SOL003 ScaleVnf_flow - NFVSOL(16)000115r2 SOL003 QueryVnf_flow - NFVSOL(16)000116r3 SOL003 GetOperationStatus_flow - NFVSOL(16)000118r2 SOL002 SOL003 instantiate VNF resource description - NFVSOL(16)000119r3 SOL002 SOL003 terminate VNF resource description - NFVSOL(16)000120r4 SOL003 LCM-Operate Interface - NFVSOL(16)000122r1 SOL003 data type of CreateVnfRequest - NFVSOL(16)000128 SOL003 small change - NFVSOL(16)000129r2 SOL003 Instantiate_flow changes - NFVSOL(16)000132r1 SOL003 LCCN notification interface resources and methods - NFVSOL(16)000134r1 SOL003 Resource of VNF lifecycle operation occurrences - NFVSOL(16)000137 SOL003 Apply convention change from document 136
November 2016	0.3.0	Contributions incorporated that were agreed at SOL#13 and SOL#14 <ul style="list-style-type: none"> - NFVSOL(16)000145r2 Conventions simplifying the table - NFVSOL(16)000131r2 SOL003 Granting interface resources and methods - NFVSOL(16)000140R1 SOL003 Create Delete VNF Identifier -_make consistent with REST - NFVSOL(16)000156R1 Change Flavour Interface

Date	Version	Information about changes
December 2016	0.4.0	<p>Contributions incorporated that were agreed in SOL#15 call and at SOL#16Shenzhen F2F</p> <ul style="list-style-type: none"> - NFVSOL(16)000144r3_SOL003_refactoring_the_LCM_flows (aligned style of headlines of flows afterwards as an editorial action, and moved the Delete VNF Instance clause to a more appropriate place) - NFVSOL(16)000159R1_SOL003_LCCN_interface_flows - NFVSOL(16)000160r2_SOL003_LCCN_interface_subscriptions - NFVSOL(16)000161r1_SOL003_LCCN_interface_notification_resources - NFVSOL(16)000167_SOL003_Editors_note_on_granting_OperateVnf - NFVSOL(16)000172r1_SOL003_Attribute_filters (added clause "4.3.1 Introduction" as an editorial action on top of the text introduced by this contribution in order to improve the reading flow). - NFVSOL(16)000174r2_SOL003_LCM_error_handling - NFVSOL(16)000179r3_SOL003_Heal_VNF_Interface - NFVSOL(16)000180r2_SOL003_Scale_VNF_task - NFVSOL(16)000181r2_SOL003_Scale_VNF_to_Level_task - NFVSOL(16)000191r3_SOL003_VNF_Pkg_resources - NFVSOL(16)000193r2_SOL003_QueryVnfPackage_flow - NFVSOL(16)000196r1_SOL003_Query_VNF_resource_description - NFVSOL(16)000197r2_SOL003_General_Aspects_HTTP_headers - NFVSOL(16)000200r1_SOL003_align_resource_description_clauses - NFVSOL(16)000201r2_SOL003_Modify_VNF_Information_Interface - NFVSOL(16)000202r3_SOL003_VNF_Fault_Management_interface - NFVSOL(16)000208_SOL003_nicer_tables (aligned the table in the FM clause as an editorial action) <p>Editorials:</p> <ul style="list-style-type: none"> - Aligned the format of the references in clause 2.1 - Fixed a copy&paste error in the Granting interface (VNF lifecycle management interface → VNF lifecycle operation granting interface) - Added "Release 2" to title
January 2017	0.5.0	<p>Contributions incorporated that were agreed in NFVSOL#17 call:</p> <ul style="list-style-type: none"> - NFVSOL(17)000001r1_SOL003_merging_LCM_and_LCCN_interfaces - NFVSOL(16)000173r3_SOL003_Attribute_selectors - NFVSOL(16)000194r4_SOL003_FetchVnfPackage_flow <p>Editorials:</p> <ul style="list-style-type: none"> - Added "Draft" to page header
January 2017	0.6.0	<p>Contributions incorporated that were agreed at NFVSOL#18 F2F in Munich:</p> <ul style="list-style-type: none"> - NFVSOL(16)000139r1_SOL003_error_codes_to_signal_application_errors - NFVSOL(16)000195r4_SOL003_FetchVnfPackageArtifacts_flow - NFVSOL(16)000203r2_SOL003_LCCN_interface_notification_data_types (Rapporteur's addition when implementing this contribution: Removed the inline definitions of DateTime as this is now defined as a global type.) - NFVSOL(17)000005r3_SOL003_VnfLcOpOcc_data_structure - NFVSOL(17)000006r1_SOL003_LCM_error_handling_resources - NFVSOL(17)000007r2_SOL003_Indicator_interface_structure - NFVSOL(17)000008_SOL003_Replace_URL_by_URI - NFVSOL(17)000022r1_SOL003_ModifyVnfInformatin_flow - NFVSOL(17)000023r1_SOL003_VR_Quota_Available_resources - NFVSOL(17)000024r1_SOL003_VR_Quota_Available_notification_flow - NFVSOL(17)000026_SOL003_VNF_Pkgm_structure_update - NFVSOL(17)000027r1_SOL003_VnfConfig_implementing_IFA_verdict_part_1_-_PATCH - NFVSOL(17)000028r2_SOL003_VnfConfig_implementing_IFA_verdict_part_2_-_Change_ex - NFVSOL(17)000032r4_SOL003_Granting_resources - NFVSOL(17)000033r2_SOL003_Granting_data_types - NFVSOL(17)000035r1_SOL003_LCM_flow_update - NFVSOL(17)000046_SOL003__Change_to_the_Resource_Representation_of_an_Individu <p>Editorials:</p> <ul style="list-style-type: none"> - Fixed some typos - s/DF/deployment flavour/ - removed the mentioning of boldfaced text in the text referring to figure 5.5.2.1-1 - s/encodeddata/encoded data/

Date	Version	Information about changes
		<ul style="list-style-type: none"> - s/and includes in the entity body binary-encoded data/and includes binary-encoded data in the entity body/ - Fixed leftovers of "information element" in Granting interface (copy&paste error from IFA007)
February 2017	0.7.0	<p>Contributions incorporated that were agreed at NFVSOL#19 call and NFV#20 in Bilbao:</p> <ul style="list-style-type: none"> - NFVSOL(17)000038r2_SOL003_Add_resource_and_enumeration_for_alarm - NFVSOL(17)000047r1_SOL003_PATCH_entity_body - NFVSOL(17)000079r1_SOL003_General_Data_types - NFVSOL(17)000048r2_SOL003_Indirect_RM - NFVSOL(17)000049_SOL003_Error_handling_Granteeing_interface - NFVSOL(17)000056r1_SOL003_PM_interface_structure (as agreed in Bilbao, clauses related to subscription resources have been moved to the end of the resources clauses to align with other APIs) - NFVSOL(17)000059_SOL003_Adding_criterion_to_LccnSubscriptionFilter - NFVSOL(17)000064r1_SOL002_SOL003_and_SOL005_Labelling_of_API_Names - NFVSOL(17)000066r2_SOL003_VimInfo_fixes_plus_InterfaceInfo_and_AccessInfo_defin - NFVSOL(17)000074_SOL003_VNF_package_management_notification_flows - NFVSOL(17)000080r1_SOL003_VNF_package_management_resources - NFVSOL(17)000083_SOL003_Error_handling_LCM_interface (with the following modification by the rapporteur: replaced multiple occurrences of the copy-paste error "corresponding to the instantiation operation" by "corresponding to the operation") - NFVSOL(17)000085r1_SOL003_Flows_for_Indicator_interface - NFVSOL(17)000086r1_SOL003_Resources_of_Indicator_interface - NFVSOL(17)000087r1_SOL003_Filters_and_Selectors_for_the_LCM_interface - NFVSOL(17)000090r2_SOL003_Links_for_LCM_and_Granteeing_interfaces - NFVSOL(17)000091_SOL003_LifecycleChangeNotification_terminology (with the following modifications by the rapporteur: (1) use lowercase in "lifecycle management operation occurrence" if it appears in flowing text. (2) change "represented by a VNF Lifecycle Operation Occurrence" → "represented by a VNF Lifecycle Operation Occurrence resource") - NFVSOL(17)000092r2_SOL003_VNF_Fault_Management_interface_data_model (with the following modifications by the rapporteur: as the contribution proposes two alternatives for the request body, added the sentence " Each notification request body shall include exactly one of the alternatives defined in table 7.3.6.3.1-2." that we use in other occurrences of this pattern. - NFVSOL(17)000096_SOL003_VNF_fault_management_subscription_and_notification_fl - NFVSOL(17)000097r2_SOL003_VNF_package_management_data_models - NFVSOL(17)000098r2_SOL003_notification_and_filter_design_for_vr_quota_avail_not - NFVSOL(17)000099r1_SOL003_error_codes_design_for_vr_quota_avail_notification_in - NFVSOL(17)000100r1_SOL003_Data_structures_of_the_Indicator_interface - Aligned Annex A with Conventions change in - NFVSOL(17)000106_Conventions_Document_NFVSOL_17_000050_Swagger_Representatio - NFVSOL(17)000111_SOL003_Conventions_move_Resource_structure_up_in_the_TOC <p>Editorials:</p> <ul style="list-style-type: none"> - Sorted the references. Removed the two informative references to JSON schema as they are not referenced any longer. - Various typo and numbering corrections - In FM interface, moved subscriptions resources to the end of the resources clauses to align with the structure of the other APIs - Applied those changes in NFVSOL(17)000084r1_Template_changes_for_error_handling that are editorial (note that technical changes regarding error handling etc. require a contribution) - In a number of NOTES, replaced "softwareVersion" by "vnfSoftwareVersion". In the table, the name of the attribute to which the note refers was changed to "vnfSoftwarVersion" but that was forgotten in the NOTE. - Moved the datatype definition for VnfLcOpOcc in front of the subscription data types in order to align with the sequence of the resources

March 2017	0.8.0	<p>Stable Draft, with a small number of noted gaps as defined in contribution NFVSOL(17)000009r9.</p> <p>Contributions incorporated that were agreed at NFVSOL#21 call and NFV#22 in Piscataway:</p> <ul style="list-style-type: none"> - NFVSOL(17)000078r3_SOL002_SOL003_VimId_fixes (Additionally, rapporteur deleted one related editor's note in table 9.5.3.3-1 that was forgotten to be deleted by contribution 78r3) - NFVSOL(17)000118r1_SOL003_VNF_performance_management_pmJobs_flows - NFVSOL(17)000119r3_SOL003_VNF_performance_management_thresholds_flows - NFVSOL(17)000120_SOL003_VNF_performance_management_subscription_and_notification - NFVSOL(17)000124r1_SOL003_Authorization - NFVSOL(17)000125r1_SOL002_SOL003_MonitoringParameters_data_structure - NFVSOL(17)000126r1_SOL002_SOL003_NetworkAddress_data_structure - NFVSOL(17)000127r2_SOL003_Fixes_related_to_IFA_decisions_in_Bilbao_and_beyond (Additional change was performed by the rapporteur to Annex B.2 to align with the removal of "Fetch VNF Package" which corresponds to the spirit of this contribution but was forgotten) - NFVSOL(17)000128r2_SOL002_SOL003_Addressing_Rapporteur_s_and_Editor_s_notes_bat - NFVSOL(17)000139_SOL003_apply_conventions_to_vr_quota_avail_notification_flow - NFVSOL(17)000141_SOL002_SOL003_Rename_ind_to_vnfind - NFVSOL(17)000147r1_SOL002_SOL003_Definitions_symbols_and_abbreviations - NFVSOL(17)000148r1_SOL003-Clause_4_1_Overview - NFVSOL(17)000149_SOL002_SOL003_LCM_ed_note_error_handling_bugfix - NFVSOL(17)000150r1_SOL002_SOL003_Adding_description_of_rollback_retry_cancel_fa - NFVSOL(17)000151r1_SOL003_SOL002_clause_5_6_1_Basic_concepts_for_LCM_errors - NFVSOL(17)000152_SOL003_Move_LcmOpType_to_global_types_list - NFVSOL(17)000153r2_SOL003_PM_ThresholdCriteria - NFVSOL(17)000154r2_SOL003_PM_interface_data_model - NFVSOL(17)000155r1_SOL003_SOL002_resolve_Auto-X_editor_s_note - NFVSOL(17)000157_SOL003_SOL002_5_2_1_Fixing_Vnf_Instance_Creation_flow - NFVSOL(17)000169_SOL003_Adding_VNFD_resource_in_VNF_package_management_interf - NFVSOL(17)000170r1_SOL003_Read_VNFD_flow - NFVSOL(17)000171r1_SOL003_Add_selectors_for_VNF_package_management_interface - NFVSOL(17)000172_SOL003_Add_filters_for_VNF_package_management_interface - NFVSOL(17)000173_SOL003_Add_filters_for_vr_quota_available_notification_inter - NFVSOL(17)000174r1_SOL003_modify_data_type_of_the_artifacts - NFVSOL(17)000175r1_SOL003_define_checksum_data_type_for_the_VNF_package_managem - NFVSOL(17)000176r1_SOL003_Add_alarm_resource_to_FM_and_fix_links - NFVSOL(17)000177r2_SOL003_VNF_fault_management_related_data_types - NFVSOL(17)000178_SOL003_Correction_of_vnfdld_Data_Type_in_Vnflnstance_Claus - NFVSOL(17)000180r2_SOL003_VNF_Fault_Management_Get_Alarm_List_sequence_flow - NFVSOL(17)000181r3_SOL003_Update_FM_Resources - NFVSOL(17)000182_SOL002_SOL003_Indicators clean up - NFVSOL(17)000187r1_SOL002_SOL003_Conventions_global_fix_for_normative_statement - NFVSOL(17)000188_SOL002_SOL003_Notification_id - NFVSOL(17)000189r1_SOL002_SOL003_VnflInstanceSubscriptionFilter_general_data_typ - NFVSOL(17)000190_SOL002_SOL003_VnflLcOpOcc_fixes_for_ModifyVnflInfo
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Date	Version	Information about changes
		<ul style="list-style-type: none"> - NFVSOL(17)000191r1_SOL002_SOL003_state_change_timestamp_and_affected_resources (but "attributeChanges was not added to the exclude-default for VnfLcOpOcc in the last change, as this attribute has been removed from the contribution in r1, but removal from that particular change was missed) - NFVSOL(17)000192_SOL002_SOL003_Remove_editor_s_note_in_5_4_3_3_4 - NFVSOL(17)000193r1_SOL003_Resume_partial_download_of_artifacts_and_VNF_package (and applied the change we agreed in another document for the 200 OK response for fetching a VNF package artifact also to the 206 response) - NFVSOL(17)000199_SOL002_SOL003_Renaming_attribute_selectors - NFVSOL(17)000200_SOL002_SOL003_Attribute_filter_equality - NFVSOL(17)000201_SOL003_FM_align_fault_type_and_event_type_with_IFA_contribut - NFVSOL(17)000202r1_SOL003_Annex_B_Mapping - NFVSOL(17)000203_SOL003_VNF_FM_Interface_Terminology_Clean-Ups - NFVSOL(17)000204_SOL003_error_handling_filters_and_selectors_for_VNF_perform <p>Editorials:</p> <ul style="list-style-type: none"> - A number of small typos fixed - Removed ":" after "Location" when the "Location" HTTP header is mentioned. - Reworded two awkwardly-formulated sentences about the NFVO trying to recover from an error situation, in the subscription management flows of FM and PM i/fs) - Aligned the intro text of the clauses "Referenced simple types and enumerations", and replaced empty "Referenced simple types and enumerations" clauses by references to clause 4.4. - Captions of tables that define an enumeration have been aligned with the template - Changed name of the "Remarks" column to "Description" globally - Removed template leftovers from the front matter.
April 2017	V 0.8.1	Editorial changes to prepare for clean-up by editHelp!
April 2017	V 0.8.2	Clean-up done by editHelp!

May 2017	V 0.9.0	<p>Contributions incorporated that were agreed at NFVSOL#23 and NFVSOL#25 calls and in EA round #1:</p> <ul style="list-style-type: none"> - NFVSOL(17)000209r1_SOL002_SOL003_SOL005_all_fields_and_defaults_for_selectors - NFVSOL(17)000225r2_SOL003_clause_6_Fetching_of_Performance_reports - NFVSOL(17)000226r1_SOL003_global_Harmonize_Query_vs_Read - NFVSOL(17)000237r1_SOL003_6_5_2_4_EN_add_id_to_ThresholdCrossed_Notification - NFVSOL(17)000238_SOL003_6_5_2_5_EN_add_id_to_PerformanceInformationAvailable - NFVSOL(17)000242_SOL003_10_4_5_3_2_and_10_4_6_3_2_EN_Non-support_of_range_req - NFVSOL(17)000245r2_SOL002_SOL003_5_x_harmonization_of_VnfLcOpOcc_related_identifiers - NFVSOL(17)000247_SOL003_B_7_small_bugfix - NFVSOL(17)000258r1_SOL003_5_6_Better_name_for_unresolvable_fail - NFVSOL(17)000257_SOL003_5_3_vnfInstanceId_in_LCM_flow_diagrams (applies to ModifyVnfInfo) - NFVSOL(17)000260r4_SOL003_global_editorial_and_minor_technical_changes - NFVSOL(17)000294_SOL003_4_5_2_3_Clarification_of_two_access_token_usage (Rapporteur: and added "#2" in the text in a few additional places to align with the figure) - NFVSOL(17)000295_SOL003_4_5_2_3_flow_and_step_consistency - NFVSOL(17)000297_SOL003_5_3_12_Missing_error_handling_description - NFVSOL(17)000304_SOL003_removing_status_from_SoftwareImageInformation - NFVSOL(17)000305_SOL003_4_1_Overview_Consistency_Fix - NFVSOL(17)000309_SOL003_4_5_2_Authorization_flow_description_inconsistency - NFVSOL(17)000315_SOL003_4_5_2_fixing_HTTP_method_in_OAuth_2_0_flows - NFVSOL(17)000317_SOL003_5_5_2_13_operationType_in_VnfLcOpOcc (Rapporteur: In table 5.5.2.13-1, it was missed to delete "Type" from "operationType"; all other occurrences use "operation" not "operationType") - NFVSOL(17)000321_SOL003_9_5_2_3_Change_VimInfo_data_type_to_VimConnectionInfo - NFVSOL(17)000323_SOL003_Clause_7_5_4_3_Change_the_description_of_PerceivedSev - NFVSOL(17)000329_SOL003_global_ignore_unknown_attributes - NFVSOL(17)000336r1_SOL003_many_Fixing_some_conditions (Rapporteur: and aligned the new text with 245r2, i.e. "VNF LCM operation occurrence" instead of "operation") <p>Contributions incorporated that were agreed at NFVSOL#26 and NFVSOL#27 calls, in EA rounds #2 and #3, and in SOL#28 F2F:</p> <ul style="list-style-type: none"> - NFVSOL(17)000217r4_SOL003_VNF_FM_Acknowledge_Alarm_operation - NFVSOL(17)000218r1 - NFVSOL(17)000227r1_SOL003_4_3_2_2_EN_Attribute_filters_point_in_time - NFVSOL(17)000228r1_SOL003_4_4_1_3_EN_for_KeyValuePair_Object - NFVSOL(17)000229r1_SOL003_10_5_3_2_VnfPackageSoftwareImageInfos_fixes - NFVSOL(17)000230r3_SOL003_global_Apply_conventions_for_identifiers - NFVSOL(17)000231r1_SOL003_5_5_3_5_ENs_VimConnectionInfo_registry - NFVSOL(17)000232_SOL003_5_5_3_7_rapp_note_information_element - NFVSOL(17)000233r2_SOL003_5_5_3_7_to_5_5_3_9_resource_metadata - NFVSOL(17)000234r2_SOL003_5_6_2_3_EN_regarding_forceful_vs_graceful_cancel - NFVSOL(17)000235_SOL003_6_3_3_rapporteur_s_notes_regarding_PM_flow - NFVSOL(17)000236_SOL003_6_3_6_rapporteur_s_note_regarding_PM_flow_bugs - NFVSOL(17)000240_SOL003_9_5_3_3_EN_in_table_for_GrantInfo - NFVSOL(17)000241_SOL003_9_5_2_2_and_9_5_2_3_EN_and_rapporteurs_note - NFVSOL(17)000244_SOL003_5_x_Problem_with_Error_handling_ModifyVnfInfo - NFVSOL(17)000246r1_SOL003_5_4_16_Making_the_Fail_operation_synchronous
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Date	Version	Information about changes
		<ul style="list-style-type: none"> - NFVSOL(17)000374_SOL003_SOL002_Notification_Authorization_future_proo - NFVSOL(17)000375r1_SOL003_SOL002_Explanation_of_OperateVnf - NFVSOL(17)000384_SOL003_SOL002_Refactoring_VNF_Instance_link_in_Al - NFVSOL(17)000389r2_SOL003_10_4_4_Fetch_the_VNFD - NFVSOL(17)000393_SOL002_SOL003_Move_VimConnectionInfo_to_the_corr - NFVSOL(17)000394_SOL002_SOL003_address_comments_from_Procera_N - NFVSOL(17)000396r2_SOL002_SOL003_6_4_7_4_8_4_9_4_10_4_11_4_Ad - NFVSOL(17)000397_SOL002_SOL003_5_3_3_Clarification_of_notification_flo - NFVSOL(17)000399_SOL003_SOL002_changedExtVLS_in_LcmOpOccNotif <p>Editorials:</p> <ul style="list-style-type: none"> - Put "Notify" always as last row in the tables in all clauses of Annex B - Enforced naming convention of using plural for attributes of cardinality 0..N
June 2017	V 0.10.0	<p>Contributions incorporated that were approved at NFVSOL#29 call:</p> <ul style="list-style-type: none"> - NFVSOL(17)000337r1_SOL003_5_5_2_x_additionalParameters_missing_from - NFVSOL(17)000387r2_SOL003_SOL002_EN_Scaling_explanation - NFVSOL(17)000403r3_SOL003_ExtCP_ExtVL_fixes_related_to_IFA_discussion - NFVSOL(17)000405r2_SOL003_SOL002_one_change_pulled_out_from_349r - NFVSOL(17)000408r3_SOL003_rapporteur_s_cleanup_of_V_0_9_0 - NFVSOL(17)000414r3_SOL003_issue_resourceGroupld_in_Grant_interface - NFVSOL(17)000416_SOL003_Remove_Swagger_Annex_A - NFVSOL(17)000417_SOL003_SOL002_copying_over_a_note_from_IFA007 <p>Editorials:</p> <ul style="list-style-type: none"> - Fixing awkward "(s)" plural where applicable: (1) use plural where appropriate e.g. for arrays resource(s) → resources, (2) use singular where appropriate, e.g. if there's only a single entry such as notification about quota(s) → quota, (3) use alternatives where there are two distinct possibilities, e.g. VIM interface or VIM interfaces - Removed editor's notes not addressed by contributions, apart from the one in the registry
July 2017	V 0.10.1	<ul style="list-style-type: none"> - Editorial changes - Fixing the implementation of document NFVSOL(17)000199_SOL002_SOL003_Renaming_attribute_selectors

History

Document history		
V2.3.1	July 2017	Publication