



GROUP SPECIFICATION

Network Functions Virtualisation (NFV); Acceleration Technologies; Network Acceleration Interface Specification; Release 3

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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 the network acceleration related interfaces supported over the Vn-Nf reference point of the NFV architectural framework [i.2] between a VNF and a dedicated switch controlled by that VNF. The present document also defines information elements exchanged over those interfaces.

The present document is built on the use of the Dynamic Optimization of Packet Flow Routing (DOPFR) mechanism (see use case described in ETSI GS NFV-IFA 001 [i.2]). Based on DOPFR, the present document aims to design a common interface allowing a Network Intensive VNF (NI-VNF) to accelerate its data plane processing on a dedicated switch.

2 References

2.1 Normative references

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

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

- [1] ETSI GS NFV-IFA 002: "Network Functions Virtualisation (NFV); Acceleration Technologies; VNF Interfaces Specification".
- [2] ETSI GS NFV-IFA 019: "Network Functions Virtualisation (NFV) Release3; Acceleration Technologies; Acceleration Resource Management Interface Specification".

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-IFA 001: "Network Functions Virtualisation (NFV); Acceleration Technologies; Report on Acceleration Technologies & Use Cases".
- [i.3] ETSI GS NFV-IFA 011: "Network Functions Virtualisation (NFV); Management and Orchestration; VNF Packaging Specification".
- [i.4] ETSI GS NFV 004: "Network Functions Virtualisation (NFV); Virtualisation Requirements".

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], ETSI GS NFV-IFA 002 [1] and the following apply:

dedicated switch: infrastructure logical switching element which is allocated to one VNF and is controlled by this VNF

NOTE: A dedicated switch can be a physical switch, a virtual switch or a switching accelerator (e.g. eSwitch embedded on a network interface card) or a partition of these elements or of a combination of them.

network acceleration interface: abstract interface used by a virtualised network function for the control and management of a switch dedicated for the acceleration purpose

network intensive VNF: VNF required to process a large number of packets and bytes per second

NOTE: Network intensive VNFs normally involve some static and relatively small CPU code, while their data plane functionalities are dynamic, such as NAT, L2/L3 forwarding and tunnelling technologies, like VxLAN.

3.2 Abbreviations

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

NOTE: An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in ETSI GS NFV 003 [i.1].

API	Application Programming Interface
UML	Unified Modelling Language

4 Overview of Network Acceleration Interface

4.1 Introduction

While a range of VNFs may work efficiently as software-only entities, some VNFs may require some form of acceleration to be provided by the NFVI to meet their performance goals. Some VNFs, referred as network-intensive VNFs (NI-VNFs) in the present document, need to process a large number of packets and bytes per second. They normally involve some static and relatively small CPU code, while their data plane functionalities are dynamic, such as NAT.

To improve the packet processing performance of a NI-VNF while decreasing the usage of server resources, the use of the Dynamic Optimization of Packet Flow Routing (DOPFR) acceleration mechanism [i.2] is recommended. With DOPFR, a NI-VNF can offload its data plane traffic to a dedicated switch in the infrastructure network while keeping its control plane being handled by the NI-VNF. It requires the NI-VNF to instruct the dedicated switch to stop forwarding the data flow to the NI-VNF and to process it directly. The data plane functionalities that can be performed by the dedicated switch include:

- L2/L3 forwarding
- Source IP/Destination IP/Source Port/Destination Port translation
- TCP sequence number adaptation
- VLAN/VXLAN/NVGRE tunnelling

As described in ETSI GS NFV-IFA 001 [i.2], the dedicated switch allocated to a NI-VNF is controlled by the NI-VNF itself via one control interface, which allows the NI-VNF to instruct the dedicated switch to process the traffic directly (fast path). Likewise, it allows the NI-VNF to retrieve the traffic from the dedicated switch (normal path). The present document refers to this control interface as the network acceleration interface (see the dashed line in figure 4.1-1).

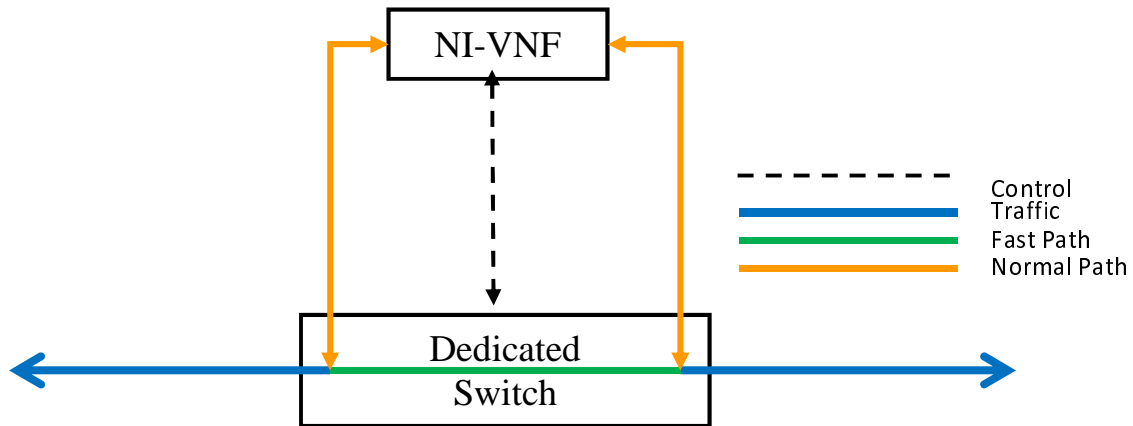


Figure 4.1-1: Network Acceleration Interface

The network acceleration interface is an abstract interface used by the NI-VNF to control/configure the dedicated switch for acceleration purposes. The dedicated switch can use this interface to report the OAM information back to the NI-VNF on the reverse direction.

4.2 Fall back and failover mechanism

ETSI GS NFV 004 [i.4] identifies virtualisation requirements in the areas of resiliency, service continuity and service assurance. These requirements imply that necessary fall-back and failover mechanisms be provided allowing a VNF instance to be recreated after a failure. Instead of considering the fall-back and failover for VNF, the present document only focuses on the link between the NI-VNF and the dedicated switch as well as dedicated switch failures and corresponding fall-back and failover mechanisms.

Detecting the abnormality is the first step towards ensuring that failures can eventually be dealt with. The failure of the dedicated switch or of the link between the NI-VNF and the dedicated switch can result in the data processing not working properly any longer. To ensure service availability and continuity, the NI-VNF is responsible for detecting a failure as soon as possible, for example, using a keep-alive detection mechanism.

Once a failure is detected, the NI-VNF has to react in order to be able to fulfil its role again, withstanding the failure. There are two kinds of recovery:

- **Proactive Recovery**

The NI-VNF pre-configures a backup network acceleration interface on the backup dedicated switch. With this type of recovery, when the NI-VNF adds one entry to the forwarding table in its dedicated switch, it will also add the corresponding backup entry on its backup dedicated switch.

Proactive recovery allows the service connection to be restored as soon as the failure has been detected. This comes however at a cost, given the links and accelerators resources required for storing the backup information.

- **Reactive Recovery**

The VIM can also be notified of the failure occurring on the dedicated switch (see the acceleration resource fault management interface in ETSI GS NFV-IFA 019 [2]). The VIM should be able to ensure that the NI-VNF be provided with enough COTS resources to meet the NI-VNF performance objectives. Then the VIM will reallocate another dedicated switch when it receives a new acceleration resource request from the NI-VNF.

4.3 Mechanisms for the network acceleration interface

As figure 4.1-1 indicates, the network acceleration interface follows the principle of separation of control and data planes. This implies that the NI-VNF can offload its data processing to diverse dedicated switches without changing its control plane code, hence motivating the dedicated switch vendors to migrate their innovative switches into NFV infrastructure easily.

In the present document, the network acceleration interface is designed as a common and extensible API to confront the increasing new features of existing network-intensive VNFs and new types of NI-VNF. The network acceleration interface treats the new features and/or types of NI-VNF as API parameters, making the network acceleration interface simple, consistent and stable. Note that the network acceleration interface is not an exclusive option and does not preclude any other API design for the NI-VNF acceleration deployment.

In the present document, the network acceleration interface uses the notion of abstract forwarding table to instruct the dedicated switch to process the packet offloading. Once a NI-VNF decides to take an acceleration procedure, it firstly adds new entries to forwarding tables with action lists and/or action sets, and then instructs the dedicated switch to execute the match-action processing via the network acceleration interface.

It should also be possible to create a forwarding graph that ensures that all traffic for the NI-VNF goes through the dedicated switch. The forwarding graph consisting of the virtual links between the forwarding tables being specified in the Virtual Link Descriptor (VLD) of ETSI GS NFV-IFA 011 [i.3] is out of scope for the present document.

5 VNF exposed Interfaces

There are no interfaces exposed by the VNF associated to the Vn-Nf reference point.

6 Dedicated switch exposed interfaces

6.1 Introduction

This clause defines the interfaces exposed by the dedicated switch towards the VNF at the Vn-Nf reference point.

NOTE: The fact that information elements and attributes are presented in tabular form does not preclude protocol designs in which these information elements and attributes are encoded in different parts of request and response messages. For example, in a RESTful interface, parts of them can be encoded in the URL, in the message header, in the message body or any combination thereof.

6.2 Forwarding Table Configuration interfaces

6.2.1 Description

This interface allows the VNF to perform operations on the entries of the forwarding tables in the dedicated switch.

The interface includes the following operations:

- Add entry
- Query entry
- Update entry
- Delete entry

6.2.2 Add Entry operation

6.2.2.1 Description

This operation allows the VNF to add a new entry to the forwarding table maintained by the dedicated switch.

Table 6.2.2.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.2.2.1-1: Add Entry operation

Message	Requirement	Direction
AddEntryRequest	Mandatory	VNF → NFVI
AddEntryResponse	Mandatory	NFVI → VNF

6.2.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.2.2.2-1.

Table 6.2.2.2-1: Add Entry operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
tableId	M	1	Identifier	Identifier of the forwarding table.
tableName	M	0..1	String	Human-readable name of the table.
entryMatch	M	1	Not specified	Element indicating the matching format of the added entry. See note.
entryAction	M	1..N	Not specified	Element describing the different actions associated to the added entry.
entryAttribute	O	1..N	Not specified	Element describing the different attributes associated to the added entry.

NOTE: The matching format can be a combination of IP address, Port, MAC address or other relevant fields depending on the packet technologies being supported by the dedicated switch.

6.2.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.2.2.3-1.

Table 6.2.2.3-1: Add Entry operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
entryInformation	M	1	EntryInformation	Information about the entry that has been added. See clause 7.2.1.

6.2.2.4 Operation results

In case of success, the entry has been added into the forwarding table maintained by the dedicated switch. In case of failure, appropriate error information is returned.

6.2.3 Query Entry operation

6.2.3.1 Description

This operation allows the VNF to query information about entries in the forwarding table maintained by the dedicated switch.

The entries for which information is queried about can be selected based on filtering criteria.

Table 6.2.3.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.2.3.1-1: Query Entry operation

Message	Requirement	Direction
QueryEntryRequest	Mandatory	VNF → NFVI
QueryEntryResponse	Mandatory	NFVI → VNF

6.2.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.2.3.2-1.

Table 6.2.3.2-1: Query Entry operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
queryEntryFilter	M	1	Filter	Query filter to select the entries about which information is queried.

6.2.3.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.2.3.3-1.

Table 6.2.3.3-1: Query Entry operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
entryInformation	M	1..N	EntryInformation	Reported information about the queried entries. See clause 7.2.1.

6.2.3.4 Operation results

In case of success, the information of the queried entries is reported. In case of failure, appropriate error information is returned.

6.2.4 Update Entry operation

6.2.4.1 Description

This operation allows the VNF to update information about an entry in the forwarding table maintained by the dedicated switch.

This operation can only update the "entryMatch", "entryAction" and "entryAttribute" of a forwarding table entry identified by matching "entryId", "tableId" and "tableName" parameters.

Table 6.2.4.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.2.4.1-1: Update Entry operation

Message	Requirement	Direction
UpdateEntryRequest	Mandatory	VNF → NFVI
UpdateEntryResponse	Mandatory	NFVI → VNF

6.2.4.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.2.4.2-1.

Table 6.2.4.2-1: Update Entry operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1	Identifier	Identifier of the entry to be updated.
tableId	M	1	Identifier	Identifier of the forwarding table to which the entry to be updated belongs.
tableName	M	0..1	String	Human-readable name of the table to which the entry to be updated belongs.
entryMatch	M	1	Not specified	The matching format of the entry to be updated.
entryAction	M	1..N	EntryAction	The action list of the entry to be updated.
entryAttribute	O	1..N	EntryAttribute	The attribute list of the entry to be updated.

6.2.4.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.2.4.3-1.

Table 6.2.4.3-1: Update Entry operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
entryInformation	M	1	EntryInformation	The reported information concerning the updated entry.

6.2.4.4 Operation results

In case of success, the entry has been updated in the forwarding table maintained by the dedicated switch. In case of failure, appropriate error information is returned.

6.2.5 Delete Entry operation

6.2.5.1 Description

This operation allows the VNF to delete one or more entries from the forwarding table maintained by the dedicated switch.

Table 6.2.5.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.2.5.1-1: Delete Entry operation

Message	Requirement	Direction
DeleteEntryRequest	Mandatory	VNF → NFVI
DeleteEntryResponse	Mandatory	NFVI → VNF

6.2.5.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.2.5.2-1.

Table 6.2.5.2-1: Delete Entry operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1..N	Identifier	The identifiers of the entries to be deleted.
tableId	M	1	Identifier	Identifier of the forwarding table to which the entry to be deleted belongs.
tableName	M	0..1	String	Human-readable name of the forwarding table.

6.2.5.3 Output parameters

None

6.2.5.4 Operation results

In case of success, the entries are deleted from the forwarding table maintained by the dedicated switch. In case of failure, appropriate error information is returned.

6.3 Performance Monitoring interface

6.3.1 Description

This interface allows providing acceleration performance information related to the VNF. The acceleration performance information on the given VNF is collected and reported by the dedicated switch of the VNF.

Collection and reporting of acceleration performance information is controlled by a performance monitoring task that groups details of acceleration performance collection and reporting information.

Besides the use of the query mechanism defined in clause 6.2.3, the VNF also uses the Performance Monitoring interface to get acceleration performance information from the dedicated switch.

The Performance Monitoring interface includes the following operations:

- Subscribe
- Terminate Subscription
- Notify
- Create Performance Monitoring Task
- Query Performance Monitoring Task
- Delete Performance Monitoring Task
- Create Threshold
- Query Threshold
- Delete Threshold

6.3.2 Subscribe operation

6.3.2.1 Description

This operation enables the VNF to subscribe with a filter for the notifications related to the acceleration performance information from the dedicated switch within the NFVI.

Table 6.3.2.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.2.1-1: Subscribe operation

Message	Requirement	Direction
SubscribeRequest	Mandatory	VNF → NFVI
SubscribeResponse	Mandatory	NFVI → VNF

6.3.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.2.2-1.

Table 6.3.2.2-1: Subscribe operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
filter	M	1	Filter	Input filter for selecting notifications to subscribe to. This filter can be on type of notification or attribute of the notification.
NOTE: Specification of the filtering mechanism is left for the protocol design stage.				

6.3.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.2.3-1.

Table 6.3.2.3-1: Subscribe operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
subscriptionId	M	1	Identifier	Identifier of the successfully created subscription.

6.3.2.4 Operation results

In case of success, the VNF is registered to receive notifications related to the acceleration performance of the dedicated switch. For a particular subscription, only notifications matching the filter will be delivered to the VNF. In case of failure, appropriate error information is returned.

6.3.3 Terminate Subscription operation

6.3.3.1 Description

This operation enables the VNF to terminate a particular subscription for notifications related to acceleration performance.

Table 6.3.3.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.3.1-1: Terminate Subscription operation

Message	Requirement	Direction
TerminateSubscriptionRequest	Mandatory	VNF → NFVI
TerminateSubscriptionResponse	Mandatory	NFVI → VNF

6.3.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.3.2-1.

Table 6.3.3.2-1: Terminate Subscription operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
subscriptionId	M	1	Identifier	Identifier of the subscription to be terminated.

6.3.3.3 Output parameters

None.

6.3.3.4 Operation results

After successful termination of a subscription, the identified subscription does not exist anymore, and the VNF will not receive notifications related to that subscription any longer. The result of the operation shall indicate if the subscription termination has been successful or not with a standard success/error result.

6.3.4 Notify operation

6.3.4.1 Description

This operation distributes notifications to subscribers. It is a one-way operation issued by the NFVI that cannot be invoked as an operation by the consumer (VNF). In order to receive notifications, the VNF shall have a subscription.

Table 6.3.4.1-1 lists the information flow exchanged between the NFVI and the VNF.

Table 6.3.4.1-1: Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVI → VNF

The following notification is sent by this operation:

- ThresholdCrossedNotification. See clause 7.3.3.

6.3.5 Create Performance Monitoring Task operation

6.3.5.1 Description

This operation enables the VNF to create a Performance Monitoring Task asking the dedicated switch to report acceleration performance information related to a single specified performance metric on one specified entry in the forwarding table.

If one VNF owns multiple entries related to multiple forwarding tables in the dedicated switch, the VNF will have to create a Performance Monitoring Task for each performance metric on each entry.

Table 6.3.5.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.5.1-1: Create Performance Monitoring Task operation

Message	Requirement	Direction
CreatePMTaskRequest	Mandatory	VNF → NFVI
CreatePMTaskResponse	Mandatory	NFVI → VNF

6.3.5.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.5.2-1.

Table 6.3.5.2-1: Create Performance Monitoring Task operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1	Identifier	The identifier of the entry for which the performance monitoring task is requested to be created.
tableId	M	1	Identifier	Identifier of the forwarding table to which the entry belongs.
tableName	M	0..1	String	Human-readable name of the forwarding table.
performanceMetric	M	1	String	The name of the performance metric on which the performance monitoring task is to be created. For example, the throughput in Layer 3 forwarding VNF.
collectionPeriod	M	1	Enum	Specifies the periodicity at which the NFVI will collect acceleration performance information on the specified performance metric. See note.
reportingPeriod	M	1	Enum	Specifies the periodicity at which the NFVI will report to the VNF acceleration performance information on the specified metric. See note.
reportingBoundary	O	0..1	Not specified	Identifies a boundary after which the performance reporting is to be stopped. The boundary shall allow a single reporting as well as periodic reporting up to the boundary.
NOTE:	At the end of each reportingPeriod, the producer (NFVI) will inform the consumer (VNF) about availability of the performance data collected for each completed collection period during this reportingPeriod. While the exact definition of the types for collectionPeriod and reportingPeriod is left for further protocol specification, it is recommended that the reportingPeriod be equal or a multiple of the collectionPeriod. In the latter case, the performance data for the collection periods within one reporting period would be reported together.			

6.3.5.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.5.3-1.

Table 6.3.5.3-1: Create Performance Monitoring Task operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
pmtId	M	1	Identifier	Identifier of the created Performance Monitoring Task.

6.3.5.4 Operation results

The result of the operation indicates if it has been successful or not with a standard success/error result. The pmtId is returned when the operation has been successful.

6.3.6 Query Performance Monitoring Task operation

6.3.6.1 Description

This operation enables the VNF to solicit from the NFVI the details of one or more Performance Monitoring Task(s).

Table 6.3.6.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.6.1-1: Query Performance Monitoring Task operation

Message	Requirement	Direction
QueryPmtRequest	Mandatory	VNF → NFVI
QueryPmtResponse	Mandatory	NFVI → VNF

6.3.6.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.6.2-1.

Table 6.3.6.2-1: Query Performance Monitoring Task operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
filter	M	1	Filter	Filter defining the Performance Monitoring Tasks on which the query applies. It can be a single identifier, multiple identifiers or a wildcard.

6.3.6.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.6.3-1.

Table 6.3.6.3-1: Query Performance Monitoring Task operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
prInfo	M	0..N	PrInfo	Details of Performance Monitoring Tasks matching the input filter. See clause 7.3.1.

6.3.6.4 Operation results

In case of success, the details of one or more Performance Monitoring Task(s) are returned. In case of failure, appropriate error information is returned.

6.3.7 Delete Performance Monitoring Task operation

6.3.7.1 Description

This operation enables the VNF to ask the NFVI to delete one or more Performance Monitoring Task(s).

Table 6.3.7.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.7.1-1: Delete Monitoring Task operation

Message	Requirement	Direction
DeletePmtRequest	Mandatory	VNF → NFVI
DeletePmtResponse	Mandatory	NFVI → VNF

6.3.7.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.7.2-1.

Table 6.3.7.2-1: Delete Performance Monitoring Task operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
pmtId	M	1..N	Identifier	Identifier of the Performance Monitoring Task(s) to be deleted.

6.3.7.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.7.3-1.

Table 6.3.7.3-1: Delete Performance Monitoring Task operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
deletedPmtId	M	1..N	Identifier	Identifiers of the Performance Monitoring Tasks successfully deleted.

6.3.7.4 Operation results

In case of success, one or more Performance Monitoring Tasks are deleted. In case of failure, appropriate error information is returned.

6.3.8 Create Threshold operation

6.3.8.1 Description

This operation enables the VNF to create a threshold to specify threshold levels on one specified performance metric for a single specified entry in the forwarding table of the dedicated switch.

If the VNF owns multiple entries in multiple forwarding tables in the dedicated switch, it needs to create one Threshold for each performance metric on each entry.

Table 6.3.8.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.8.1-1: Create Threshold operation

Message	Requirement	Direction
CreateThresholdRequest	Mandatory	VNF → NFVI
CreateThresholdResponse	Mandatory	NFVI → VNF

6.3.8.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.8.2-1.

Table 6.3.8.2-1: Create Threshold operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1	Identifier	The identifier of the entry for which the threshold is to be created.
tableId	M	1	Identifier	Identifier of the forwarding table to which the entry belongs.
tableName	M	0..1	String	Human-readable name of the table.
performanceMetric	M	1	String	The name of the performance metric on which the threshold is to be created.
thresholdType	M	1	Enum	Defines the type of threshold to be created. The list of possible values is left for the protocol design stage and might include: single/multi valued threshold, static/dynamic threshold, template based threshold, etc.
thresholdDetails	M	1	Not specified	Details of the threshold to be created: value to be crossed, and direction in which it is crossed, details on the notification to be generated, etc.

6.3.8.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.8.3-1.

Table 6.3.8.3-1: Create Threshold operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
thresholdId	M	1	Identifier	Identifier of the created threshold.

6.3.8.4 Operation results

The result of the operation indicates if it has been successful or not with a standard success/error result. The thresholdId is returned when the operation has been successful.

6.3.9 Query Threshold operation

6.3.9.1 Description

This operation enables the VNF to solicit from the NFVI the details of one or more threshold(s).

Table 6.3.9.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.9.1-1: Query Threshold operation

Message	Requirement	Direction
QueryThresholdRequest	Mandatory	VNF → NFVI
QueryThresholdResponse	Mandatory	NFVI → VNF

6.3.9.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.9.2-1.

Table 6.3.9.2-1: Query Threshold operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
filter	M	1	Filter	Filter defining the threshold(s) on which the query applies. It can be a single identifier, multiple identifiers or a wildcard.

6.3.9.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.9.3-1.

Table 6.3.9.3-1: Query Threshold operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
thresholdId	M	0..N	Threshold	Details of threshold(s) matching the input filter.

6.3.9.4 Operation results

In case of success, the details of one or more threshold (s) are returned. In case of failure, appropriate error information is returned.

6.3.10 Delete Threshold operation

6.3.10.1 Description

This operation enables the VNF to ask the NFVI to delete one or more threshold(s).

Table 6.3.10.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.3.10.1-1: Delete Threshold operation

Message	Requirement	Direction
DeleteThresholdRequest	Mandatory	VNF → NFVI
DeleteThresholdResponse	Mandatory	NFVI → VNF

6.3.10.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.3.10.2-1.

Table 6.3.10.2-1: Delete Threshold operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
thresholdId	M	1..N	Identifier	Identifier of the threshold(s) to be deleted.

6.3.10.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.3.10.3-1.

Table 6.3.10.3-1: Delete Threshold operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
deletedThresholdId	M	1..N	Identifier	Identifiers of the thresholds that have been deleted successfully.

6.3.10.4 Operation results

In case of success, one or more threshold(s) have been deleted. In case of failure, appropriate error information is returned.

6.4 Unmatched Packets Forward Notification interface

6.4.1 Description

This interface allows the VNF to subscribe to notifications sent by the NFVI which are related to events concerning unmatched packets reaching the dedicated switch.. It further allows the NFVI to provide such notifications to the subscriber.

If an ingress packet does not match any entries of a forwarding table, notifying the VNF of this table miss allows the VNF to decide how the dedicated switch should process the unmatched packet. The VNF will create a new entry in the forwarding table to process the table miss. The table-miss entry can flexibly specify how to process unmatched packets, for example, send packets to the VNF, drop packets or pass them to another table.

This clause only considers the scenario where the unmatched packets are decided to be forwarded to the VNF via the interface defined herein.

The interface includes the following operations:

- Subscribe
- Terminate Subscription
- Notify

6.4.2 Subscribe operation

6.4.2.1 Description

This operation enables the VNF to subscribe with a filter for notifications related to unmatched packets reaching the dedicated switch within the NFVI.

Table 6.4.2.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.4.2.1-1: Subscribe operation

Message	Requirement	Direction
SubscribeRequest	Mandatory	VNF → NFVI
SubscribeResponse	Mandatory	NFVI → VNF

6.4.2.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.4.2.2-1.

Table 6.4.2.2-1: Subscribe operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
filter	M	1	Filter	Input filter for selecting notifications. The filter can be on type of notification or attribute of the notification.
NOTE: Specification of filtering mechanism is left for the protocol design stage.				

6.4.2.3 Output parameters

The output parameters returned by the operation shall follow the indications provided in table 6.4.2.3-1.

Table 6.4.2.3-1: Subscribe operation output parameters

Parameter	Qualifier	Cardinality	Content	Description
subscriptionId	M	1	Identifier	Identifier of the successfully created subscription.

6.4.2.4 Operation results

As a result of this operation, the dedicated switch in the NFVI indicates to the VNF in the SubscribeResponse message whether the subscription was successful or not.

For a particular subscription, only notifications matching the filter will be delivered to the consumer (VNF).

6.4.3 Terminate Subscription operation

6.4.3.1 Description

This operation enables the VNF to terminate a particular subscription to notifications related to the unmatched packets reaching the dedicated switch within the NFVI.

Table 6.4.3.1-1 lists the information flow exchanged between the VNF and the NFVI.

Table 6.4.3.1-1: Terminate Subscription operation

Message	Requirement	Direction
TerminatesubscriptionRequest	Mandatory	VNF → NFVI
TerminatesubscriptionResponse	Mandatory	NFVI → VNF

6.4.3.2 Input parameters

The input parameters sent when invoking the operation shall follow the indications provided in table 6.4.3.2-1.

Table 6.4.3.2-1: Terminate Subscription operation input parameters

Parameter	Qualifier	Cardinality	Content	Description
subscriptionId	M	1	Identifier	Identifier of the subscription to be terminated.

6.4.3.3 Output parameters

None.

6.4.3.4 Operation results

After successful termination of a subscription, the identified subscription does not exist anymore, and the VNF will not receive notifications related that subscription any longer. The result of the operation shall indicate if the subscription termination has been successful or not with a standard success/error result.

6.4.4 Notify operation

6.4.4.1 Description

This operation distributes notifications to subscribers. It is a one-way operation issued by the NFVI that cannot be invoked as an operation by the consumer (VNF). In order to receive notifications, the VNF shall have a subscription.

Table 6.4.4.1-1 lists the information flow exchanged between the NFVI and the VNF.

Table 6.4.4.1-1: Notify operation

Message	Requirement	Direction
Notify	Mandatory	NFVI → VNF

The following notification is sent by this operation:

- UnmatchedPacketForwardNotification. See clause 7.4.

7 Information elements exchanged

7.1 Introduction

This clause defines, or references, definitions of information elements used in the interfaces defined in the present document.

The specification of the following information elements is left for the protocol design stage:

- String
- Integer
- Identifier
- Filter
- DateTime
- Value
- Version
- KeyValuePair

7.2 Information elements related to Forwarding Table

7.2.1 EntryInformation information element

7.2.1.1 Description

This information element provides information collected by the dedicated switch related to a particular entry of a forwarding table.

7.2.1.2 Attributes

The EntryInformation information element shall follow the indications provided in table 7.2.1.2-1.

Table 7.2.1.2-1: Attributes of the EntryInformation information element

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1	Identifier	Identifier of the entry. This identifier is allocated by the dedicated switch.
tableId	M	1	Identifier	Identifier of the forwarding table to which the entry belongs.
tableName	M	0..1	String	Human-readable name of the table.
entryMatch	M	1	Not specified	Element indicating the matching format of the entry. See note 1.
entryAction	M	1..N	EntryAction	Element describing the different actions associated to the entry. See note 2.
entryAttribute	O	1..N	EntryAttribute	Element describing the different attributes associated to the entry. See note 3.
entryPerformance	M	1..N	EntryPerformance	Element providing the performance metrics of the entry. See note 4.
NOTE 1: The matching format can be a combination of IP address, Port, MAC address or other relevant fields depending on the packet technologies being supported by the dedicated switch.				
NOTE 2: If there is more than one action for the entry, the order of actions is decided by the VNF.				
NOTE 3: The attribute is optional. For example, the Unicast Reverse Path Forwarding (uRPF) feature can be supported in L3 forwarding VNF.				
NOTE 4: Depending on the entry, performance metrics can include (but is not limited to) the amount of IP packets, packets density, flow duration, packet drop rate, throughput, committed information rate, peak information rate, committed burst rate, excess burst rate.				

7.2.2 EntryAction information element

7.2.2.1 Description

This information element provides the action information collected by the dedicated switch related to a particular entry in a forwarding table.

7.2.2.2 Attributes

The EntryAction information element shall follow the indications provided in table 7.2.2.2-1.

Table 7.2.2.2-1: Attributes of the EntryAction information element

Parameter	Qualifier	Cardinality	Content	Description
entryActionType	M	1	Enum	Specifies the action type for the entry. See note 1.
entryActionOperation	M	1	Not specified	Provides an operation value depending on the action type of the entry specified in the entryActionType parameter.
NOTE 1: Action types include (but not limited to) "pop"; "push"; "swap"; "forward"; "goto".				
NOTE 2: For example, if the action type is "goto", this parameter provides the table ID of the next forwarding table.				

7.2.3 EntryAttribute information element

7.2.3.1 Description

This information element provides the attribute information collected by the dedicated switch related to a particular entry in a forwarding table.

7.2.3.2 Attributes

The EntryAttribute information element shall follow the indications provided in table 7.2.3.2-1.

Table 7.2.3.2-1: Attributes of the EntryAttribute information element

Parameter	Qualifier	Cardinality	Content	Description
entryAttributeName	M	1	String	The name of the attribute for the entry.
entryAttributeValue	M	1	Not specified	The value of the attribute for the entry. See note.
NOTE: Example 1: If Unicast Reverse Path Forwarding (uRPF) is supported by a L3 forwarding VNF, the value of uRPF is "Enable" or "Disable"; Example 2: If the Maximum Transmission Units (MTU) attribute is indicated, the value specifies the number of bytes of the MTU.				

7.2.4 EntryPerformance information element

7.2.4.1 Description

This information element provides the performance information collected by the dedicated switch related to a particular entry in a forwarding table.

7.2.4.2 Attributes

The EntryPerformance information element shall follow the indications provided in table 7.2.4.2-1.

Table 7.2.4.2-1: Attributes of the EntryPerformance information element

Parameter	Qualifier	Cardinality	Content	Description
entryPerformanceMetric	M	1	String	The name of metric for the entry. For example, the throughput in Layer 3 forwarding VNF.
entryPerformanceValue	M	1..N	EntryPerformanceValueEntry	List of performance values with associated timestamp.

7.2.5 EntryPerformanceValueEntry information element

7.2.5.1 Description

This information element defines a single performance value with its associated time stamp.

7.2.5.2 Attributes

The EntryPerformanceValueEntry information element shall follow the indications provided in table 7.2.5.2-1.

Table 7.2.5.2-1: Attributes of the EntryPerformanceValueEntry information element

Parameter	Qualifier	Cardinality	Content	Description
timeStamp	M	1	Datetime	Timestamp indicating when the data was collected.
entryPerformanceValue	M	1	Value	Value of the performance metric collected.

7.3 Information elements and notifications related to VNF Performance Management

7.3.1 PrInfo information element

7.3.1.1 Description

This information element provides the details of a performance report.

7.3.1.2 Attributes

The PrInfo information element shall follow the indications provided in table 7.3.1.2-1.

Table 7.3.1.2-1: Attributes of the PrInfo information element

Parameter	Qualifier	Cardinality	Content	Description
pmtId	M	1	Identifier	Identifier of a Performance Monitoring Task.
entryId	M	1	Identifier	Identifier of the entry to which the performance metric relates.
tableId	M	1	Identifier	Identifier of the forwarding table.
tableName	M	0..1	String	Human-readable name of the table.
performanceMetric	M	1	String	The name of the performance metric. For example, the throughput in Layer 3 forwarding VNF.
collectionPeriod	M	1	Enum	Specifies the periodicity at which the NFVI will collect performance information on the specified performance metric. See note.
reportingPeriod	M	1	Enum	Specifies the periodicity at which the NFVI will report to the VNF about performance information on the specified metric. See note.
reportingBoundary	O	0..1	Not specified	Identifies a boundary after which the performance reporting is to be stopped. The boundary shall allow a single reporting as well as periodic reporting up to the boundary.
NOTE: At the end of each reporting Period, the producer (NFVI) will inform the consumer (VNF) about availability of the performance data collected for each completed collection period during this reportingPeriod. While the exact definition of the types for collectionPeriod and reportingPeriod is left for further protocol specification, it is recommended that the reportingPeriod be equal or a multiple of the collectionPeriod. In the latter case, the performance data for the collection periods within one reporting period would be reported together.				

7.3.2 Threshold information element

7.3.2.1 Description

This information element provides the details of a threshold.

7.3.2.2 Attributes

The threshold information element shall follow the indications provided in table 7.3.2.2-1.

Table 7.3.2.2-1: Attributes of the Threshold information element

Parameter	Qualifier	Cardinality	Content	Description
thresholdId	M	1	Identifier	Identifier of the threshold.
entryId	M	1	Identifier	The identifier of the entry to which the performance metric relates.
tableId	M	1	Identifier	Identifier of the forwarding table.
tableName	M	0..1	String	Human-readable name of the table.
performanceMetric	M	1	String	The name of the performance metric associated with the threshold.
thresholdType	M	1	Enum	Defines the type of threshold. The list of possible values is left for the protocol design stage and might include: single/multi valued threshold, static/dynamic threshold, template based threshold, etc.
thresholdDetails	M	1	Not specified	Details of the threshold: value to be crossed, and direction in which it is crossed, details on the notification to be generated, etc.

7.3.3 ThresholdCrossedNotification

7.3.3.1 Description

This notification informs the VNF that a threshold value has been crossed.

7.3.3.2 Trigger Condition

A Threshold has been crossed. Crossing includes both the initial triggering and the clearance of the threshold. Depending on threshold type, there might be multiple crossing values and/or different values for triggering and clearing.

7.3.3.3 Attributes

The ThresholdCrossedNotification shall follow the indications provided in table 7.3.3.3-1.

Table 7.3.3.3-1: Attributes of the ThresholdCrossedNotification

Parameter	Qualifier	Cardinality	Content	Description
thresholdId	M	1	Identifier	Identifier of the threshold which has been crossed.
crossingDirection	M	1	Enum	An indication of whether the threshold was crossed in upward or downward direction. Values: UP, DOWN.
entryId	M	1	Identifier	Identifier of the entry to which the performance metric relates.
tableId	M	1	Identifier	Identifier of the forwarding table.
tableName	M	0..1	String	Human-readable name of the table.
performanceMetric	M	1	String	The name of the performance metric associated with the threshold.
performanceValue	M	1	Value	Value of the performance metric that resulted in threshold crossing.

7.4 Information elements and notifications related to Unmatched Packets Forward

7.4.1 UnmatchedPacketForwardNotification

7.4.1.1 Description

This notification informs the VNF that unmatched packets are forwarded from the dedicated switch.

7.4.1.2 Trigger Condition

Unmatched packets arrive at the dedicated switch.

7.4.1.3 Attributes

The UnmatchedPacketForwardNotification shall follow the indications provided in table 7.4.1.3-1.

Table 7.4.1.3-1: Attributes of the UnmatchedPacketForwardNotification

Parameter	Qualifier	Cardinality	Content	Description
entryId	M	1	Identifier	Identifier of the missing entry in the forwarding table.
tableId	M	1	Identifier	Identifier of the forwarding table.
tableName	M	0..1	String	Human-readable name of the table.
unmatchedPacketData	M	1..N	Not Specified	The unmatched packets being sent to the VNF.

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