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Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Performance Measurements Specification

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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 performance measurements and use cases for descriptors and interfaces, including Or-Vnfm reference point, Ve-Vnfm reference point, Vi-Vnfm reference point, Or-Vi reference point, and Os-Ma-nfvo reference point, based on the performance metrics collected at NFVI.

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 https://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 005: "Network Functions Virtualisation (NFV) Release 2; Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".

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

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

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

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

[6] ETSI GS NFV-SEC 004: "Network Functions Virtualisation (NFV); NFV Security; Privacy and Regulation; Report on Lawful Interception Implications".

[7] ETSI GS NFV-SEC 006: "Network Functions Virtualisation (NFV); Security Guide; Report on Security Aspects and Regulatory Concerns".

[8] ETSI GS NFV-SEC 010: "Network Functions Virtualisation (NFV); NFV Security; Report on Retained Data problem statement and requirements".

[9] ETSI GS NFV-SEC 012: "Network Functions Virtualisation (NFV) Release 3; Security; System architecture specification for execution of sensitive NFV components".

[10] ETSI GS NFV-TST 008: "Network Functions Virtualisation (NFV) Release 2; Testing; NFVI Compute and Network Metrics 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] Openstack® measurements.

NOTE: Available at https://docs.openstack.org/ceilometer/pike/admin/telemetry-measurements.html

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

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions in ETSI GS NFV 003 [i.2] and ETSI GS NFV-IFA 014 [5] apply.

NOTE: A term defined in the present document takes precedence over the definition of the same term, if any, in ETSI GS NFV 003 [i.2].

3.2 Abbreviations

For the purposes of the present document, the abbreviations in ETSI GS NFV 003 [i.2], ETSI GS NFV-IFA 014 [5] 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.2].

OM Object Mapping
SC Status Counter
TF Transparent Forwarding

4 Overview

4.1 Introduction

The present document specifies the performance measurements that are exposed on various NFV MANO reference points (e.g. Or-Vnfm, Ve-Vnfm-em, Vi-Vnfm, Or-Vi and Os-Ma-nfvo). ETSI GS NFV-TST 008 [10] specifies the Network Function Virtualisation Infrastructure (NFVI) performance metrics that will be reported to Virtualised Infrastructure Manager (VIM). VIM processes the performance metrics received from NFVI to generate performance measurements to be sent to NFV Orchestrator (NFVO) and VNF Manager (VNFM). VNFM and NFVO conduct further processing to generate performance measurements.

4.2 Use cases

4.2.1 Use case of virtual compute related measurements

Virtual compute related measurements are used to monitor the loading conditions of virtual compute resources that include memory and CPU. The measurements can be used as the triggers to the scale VNF operation (see clause 7.2.4 in ETSI GS NFV-IFA 008 [3]).

When the measurement indicated that the virtualised resources are overloaded, it can trigger the scale out operation. When the measurement indicated that the virtualised resources are underloaded, it can trigger the scale in operation.

4.2.2 Use case of network data volume related measurements

Network data volume related measurements are used to measure the data volume of networking interfaces (see clause 7.1 in ETSI GS NFV-TST 008 [10], including incoming/outgoing of IP data packets and IP data octets. These measurements provides the traffic condition of the network interfaces. When the traffic condition is too high, then it may request the application to take appropriate action.

4.3 Measurements received at VIM

Table 4.3-1 lists the measurements received at VIM to be used to define the performance measurements in clause 6. The measurements are derived from the performance metrics defined in ETSI GS NFV-TST 008 [10]).

Table 4.3-1: Measurements received at VIM

Measurements received at VIM	Description
cpu_utilization	Measure the percentage of CPU utilization in the measurement interval that can be derived from Processor Utilization metric (see clause 6.6 in ETSI GS NFV-TST 008 [10]).
memory_utilization	Measure the percentage of memory utilization in the measurement interval that can be derived from the amount of memory used, which is the sum of Memory Buffered, Memory Cached, Memory Free, Memory Slab (see clause 8.6 in ETSI GS NFV-TST 008 [10]), and the amount of memory allocated.
disk_utilization	Measure the percentage of disk utilization. See Annex A for an example of the measurement mapping from disk.usage and disk.allocation measurements. No disk metric is defined in ETSI GS NFV-TST 008 [10], since the methods of measurement for storage systems vary widely and depend on the implementation (see clause 8.9 in ETSI GS NFV-TST 008 [10]).
num_of_incoming_packets	Measure the number of incoming packets in the measurement interval that can be derived from received Packet Count metric (see clause 7.6 in ETSI GS NFV-TST 008 [10]).
num_of_outgoing_packets	Measure the number of outgoing packets in the measurement interval that can be derived from transmitted Packet Count metric (see clause 7.6 in ETSI GS NFV-TST 008 [10]).
num_of_incoming_bytes	Measure the number of incoming octets in the measurement interval that can be derived from received Octet Count metric (see clause 7.6 in ETSI GS NFV-TST 008 [10]).
num_of_outgoing_bytes	Measure the number of outgoing octets in the measurement interval that can be derived from transmitted Octet Count metric (see clause 7.6 in ETSI GS NFV-TST 008 [10]).

5 Performance measurement definition template

This clause defines the template to be used to describe the performance measurements.

a) **Description**

This clause contains the description of the performance measurement.

b) **Collection Method**

This clause contains the method in which this measurement is obtained:

- **Status Counter (SC):** The entity receives a metric at each predetermined interval. A measurement is generated from processing (e.g. arithmetic mean, peak) all of the samples received in the collection period (see clause 7.7.2.2 in ETSI GS NFV-IFA 006 [2].
- **Transparent Forwarding (TF):** The entity maintains a measurement count that stores the content of the metric that it received.
- **Object Mapping (OM):** The entity receives a metric for measured object A in the collection period and maps the received metric from measured object A to measured object B. A measurement is generated for measured object B by processing the metric(s), which may be mapped from one or more measured object(s) A to a single measured object B. It is noted that:
  - The source metric for measured object A and the target measurement for measured object B may or may not contain subcounters. How the mapping is done for the case that either of the source metric and target measurement contain subcounters is to be defined case by case in the trigger of the measurement definition.
  - Multiple source metrics for measured object A may be mapped to a single target measurement for measured object B. How the mapping is done for this case is to be defined in the trigger of the measurement definition.

c) **Trigger**

This clause contains the trigger which causes the counter to be updated.

d) **Measurement Unit**

This clause contains the unit of the measurement value.

e) **Measurement Group**

This clause contains the group to which a measurement belongs.

f) **Measured Object Type**

This clause describes the object of a measurement. See clause 6 for the measured object types defined for the performance measurements specified in the present document.

g) **Measurement Name**

This clause describes the name of a measurement:

- The measurement name is used to identify a measurement. In case the sub-counter is used, the measurement is identified by <measurement type>.<sub-counter name>.
- The measurement name is used to identify the performanceMetric in the performance report (e.g. see clause 9.7.6 of ETSI GS NFV-IFA 008 [3]).
- In the create PM Job operation, the measurement type is the content of performanceMetric to identify the type of measurement(s) to be collected (e.g. see clause 7.4.2.2 of ETSI GS NFV-IFA 008 [3]). The PM Job is applicable to the sub-counters, if the measurement contains sub-counters.
- Examples of measurement names without sub-counters are:
  - VcpuUsageMean,
  - VcpuUsagePeak.

- Examples of valid measurement names with sub-counters are:
  - VcpuUsageMeanVnf.vCompute1,

    wherein the "vCompute1" is the value of *computeId* of the *VirtualCompute* Instance (see clause 8.4.3.2.2 of ETSI GS NFV-IFA 006 [2]).
  - VcpuUsageMeanVnf.vCompute2,

    wherein the "vCompute2" is the value of *computeId* of the *VirtualCompute* Instance (see clause 8.4.3.2.2 of ETSI GS NFV-IFA 006 [2]).

h) **Measurement Context**

This clause describes the context information of a measurement at the time that the measurement is generated, see ETSI GS NFV-TST 008 [10] for more information. The measurement context provides additional information (than performance name and value) which could facilitate the measurement consumer to do the tasks that rely on more detailed information associated with the performance measurement, such as trouble shooting, VNF/VNFC scaling, etc.

The measurement context is only provided in case the measurement producer has knowledge about the context information.

Each measurement may have its specific context, so the detailed measurement context is defined in each measurement definition.

6 Measured object types

6.1 Introduction

This clause defines the measured object types for the performance measurements specified in the present document.

6.2 Measured object type definitions

6.2.1 VirtualCompute

The measured object type "VirtualCompute" is used to collect and report the performance measurements for one or more instances of the Virtualised compute resource.

The *objectType*, when used in PM job or performance report, is equal to "VirtualCompute".

The *objectInstanceId*, when used in PM job or performance report, corresponds to *computeId* (see clause 8.4.3.2.2 of ETSI GS NFV-IFA 006 [2] or clause 8.4.3.2.2 of ETSI GS NFV-IFA 005 [1]) of the measured Virtualised compute resource.

6.2.2 VNF

The measured object type "VNF" is used to collect and report the performance measurements for one or more VNF instances.

The *objectType*, when used in PM job or performance report, is equal to "VNF".

The *objectInstanceId*, when used in PM job or performance report, corresponds to *vnfInstanceId* that identifies the measured VNF instance.

6.2.3 VNFC

The measured object type "VNFC" is used to collect and report the performance measurements for one or more VNFC instances.

The *objectType*, when used in PM job or performance report, is equal to "VNFC".

The *objectInstanceId*, when used in PM job or performance report, corresponds to the combination of the *vnfcInstanceId* that identifies the measured VNFC instance and the *vnfInstanceId* of the VNF instance that contains the measured VNFC instance. The *vnfcInstanceId* and *vnfInstanceId* are connected by a comma symbol (",").

6.2.4 VirtualNetwork

The measured object type "VirtualNetwork" is used to collect and report the performance measurements for one or more instances of the virtual network.

The *objectType*, when used in PM job or performance report, is equal to "VirtualNetwork".

The *objectInstanceId*, when used in PM job or performance report, corresponds to *networkResourceId* (see clause 8.4.5.2 of ETSI GS NFV-IFA 006 [2] or clause 8.4.3.2.2 of ETSI GS NFV-IFA 005 [1]) of the measured virtual network instance.

6.2.5 VirtualStorage

The measured object type "VirtualStorage" is used to collect and report the performance measurements for one or more instances of the Virtualised storage resource.

The *objectType*, when used in PM job or performance report, is equal to "VirtualStorage".

The *objectInstanceId*, when used in PM job or performance report, corresponds to *storageId* (see clause 8.4.7.2 of ETSI GS NFV-IFA 006 [2] or clause 8.4.3.2.2 of ETSI GS NFV-IFA 005 [1]) of the measured Virtualised storage resource.

6.2.6 VnfIntCP

The measured object type "VnfIntCP" is used to collect and report the performance measurements for one or more instances of the VNF internal CP.

The *objectType*, when used in PM job or performance report, is equal to "VnfIntCP".

The *objectInstanceId*, when used in PM job or performance report, corresponds to combination of the instance Id of the VNF internal CP and *vnfInstanceId* of the VNF instance which the VNF internal CP belongs to. The instance Id of the VNF internal CP and *vnfInstanceId* are connected by a comma symbol (",").

6.2.7 VnfExtCP

The measured object type "VnfExtCP" is used to collect and report the performance measurements for one or more instances of the VNF external CP.

The *objectType*, when used in PM job or performance report, is equal to "VnfExtCP".

The *objectInstanceId*, when used in PM job or performance report, corresponds to combination of the instance Id of the VNF external CP and *vnfInstanceId* of the VNF instance that exposes the measured VNF external CP instance. The instance Id of the VNF external CP and *vnfInstanceId* are connected by a comma symbol (",").

6.2.8 SAP

The measured object type "SAP" is used to collect and report the performance measurements for one or more SAP instances of an NS instance.

The *objectType*, when used in PM job or performance report, is equal to "SAP".

The *objectInstanceId*, when used in PM job or performance report, corresponds to combination of the instance Id of the SAP and *NsInstanceId* of the NS instance that exposes the measured SAP. The instance Id of the SAP and *NsInstanceId* are connected by a comma symbol (",").

7 Performance measurements

7.1 Performance measurements produced by VIM

7.1.1 Introduction

The performance measurements defined in this clause 7.1 are applicable to the following reference points:

- Vi-Vnfm;
- Or-Vi (for indirect mode of resource allocation, in case indirect mode is supported).

7.1.2 Mean virtual CPU usage

a) **Description:** This measurement provides the mean virtual CPU usage of the Virtualised compute resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the cpu_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then takes the arithmetic mean of the virtual CPU usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VcpuUsageMean.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last cpu_utilization measurement received from NFVI in the collection period;
- **TickInterval:** Indicates the tick interval (see ETSI GS NFV-TST 008 [10]) of the last cpu_utilization measurement received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of cpu_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurements" received from NFVI in the collection period;
- **ExecutionContext:** Indicates the execution context (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurements received from NFVI in the collection period. When a single "non-Idle" VCPU Utilization is required, the sum of the utilization of all the non-Idle execution contexts should be reported as the "active" execution context.

7.1.3 Peak virtual CPU usage

a) **Description:** This measurement provides the peak virtual CPU usage of the Virtualised compute resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the cpu_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then selects the maximum metric among the virtual CPU usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VcpuUsagePeak.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurement with peak value received from NFVI in the collection period;
- **TickInterval:** Indicates the tick interval (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurement with peak value received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of cpu_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurements" received from NFVI in the collection period;
- **Execution Context:** Indicates the execution context (see ETSI GS NFV-TST 008 [10]) of the cpu_utilization measurement with peak value received from NFVI in the collection period. When a single "non-Idle" VCPU Utilization is required, the sum of the utilization of all the non-Idle execution contexts should be reported as the "active" execution context.

7.1.4 Mean memory usage

a) **Description:** This measurement provides the mean memory usage of the Virtualised compute resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the memory_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then takes the arithmetic mean of the memory usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VmemoryUsageMean.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last memory_utilization measurement received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of memory_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the memory_utilization measurements" received from NFVI in the collection period;
- **MeasurementSystemRAM:** Indicates the system RAM (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource;
- **MeasurementSystemSwapSpace:** Indicates the system SWAP space (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource.

7.1.5 Peak memory usage

a) **Description:** This measurement provides the peak memory usage of the Virtualised compute resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the memory_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then selects the maximum metric among the memory usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VmemoryUsagePeak.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the memory_utilization measurement with peak value received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of memory_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the memory_utilization measurements" received from NFVI in the collection period;
- **MeasurementSystemRAM:** Indicates the system RAM (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource;
- **MeasurementSystemSwapSpace:** Indicates the system SWAP space (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource.

7.1.6 Mean disk usage

a) **Description:** This measurement provides the mean disk usage of the Virtualised compute resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the disk_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then takes the arithmetic mean of the disk usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VdiskUsageMean.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last disk_utilization measurement received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of disk_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the disk_utilization measurements" received from NFVI in the collection period.

7.1.7 Peak disk usage

a) **Description:** This measurement provides the peak disk usage of the Virtualised Compute Resource.

b) **Collection Method:** SC.

c) **Trigger:** VIM receives the disk_utilization measurement for the virtual compute instance from NFVI at the pre-defined interval, and then selects the maximum metric among the disk usage metrics received in the collection period.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VdiskUsagePeak.

h) **Measurement Context:**

- **MeasurementEndTime:** It indicates the end time (see ETSI GS NFV-TST 008 [10]) of the disk_utilization measurement with peak value received from NFVI in the collection period;

- **MeasurementInterval:** Equals the "number of disk_utilization measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the disk_utilization measurements" received from NFVI in the collection period.

7.1.8 Number of incoming bytes on virtual compute

a) **Description:** This measurement provides the number of bytes received at the virtual compute. This measurement is split into subcounters per virtual network interface, which is the communication endpoint under an instantiated compute resource.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more num_of_incoming_bytes measurement for a virtual network interface from NFVI in the collection period, and maps the received num_of_incoming_bytes measurement(s) from the virtual network interface to the Virtual Compute instance. The VIM generates the measurement for the subject Virtual Compute instance by assigning the value of the received num_of_incoming_bytes measurement(s) to the sub-counter(s) per virtual network interface.

d) **Measurement Unit:** Each measurement is a real value.

e) **Measurement Group:** VirtualNetworkInterface.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VnetByteIncoming.*vNetItfId*, where *vNetItfId* is equal to the resourceId of the measured virtual network interface.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last num_of_incoming_bytes measurement received from NFVI for the measured virtual network interface in the collection period;

- **MeasurementInterval:** Equals the "number of num_of_incoming_bytes measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the num_of_incoming_bytes measurements" received from NFVI for the measured virtual network interface in the collection period;

- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last num_of_incoming_bytes measurement received from NFVI for the measured virtual network interface in the collection period is generated.

7.1.9 Number of outgoing bytes on virtual compute

a) **Description:** This measurement provides the number of bytes transmitted at the virtual compute. This measurement is split into subcounters per virtual network interface, which is the communication endpoint under an instantiated compute resource.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more num_of_ outgoing _bytes measurement for a virtual network interface from NFVI in the collection period, and maps the received num_of_outgoing _bytes measurement(s) from the virtual network interface to the Virtual Compute instance. The VIM generates the measurement for the subject Virtual Compute instance by assigning the value of the received num_of_ outgoing _bytes measurement(s) to the sub-counter(s) per virtual network interface.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualNetworkInterface.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VnetByteOutgoing.*vNetItfId*, where *vNetItfId* is equal to the resourceId of the measured virtual network interface.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last num_of_ outgoing _bytes measurement received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterval:** Equals the "number of num_of_outgoing _bytes measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the num_of_outgoing _bytes measurements" received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last num_of_ outgoing _bytes measurement received from NFVI for the measured virtual network interface in the collection period is generated.

7.1.10 Number of incoming packets on virtual compute

a) **Description:** This measurement provides the number of packets received at the virtual compute. This measurement is split into subcounters per virtual network interface, which is the communication endpoint under an instantiated compute resource.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more num_of_incoming_ packets measurement for a virtual network interface from NFVI in the collection period, and maps the received num_of_incoming_packets measurement(s) from the virtual network interface to the Virtual Compute instance. The VIM generates the measurement for the subject Virtual Compute instance by assigning the value of the received num_of_incoming_ packets measurement(s) to the sub-counter(s) per virtual network interface.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualNetworkInterface.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VnetPacketIncoming.*vNetItfId*, where *vNetItfId* is equal to the resourceId of the measured virtual network interface.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last num_of_incoming_ packets measurement received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterval:** Equals the "number of num_of_incoming_packets measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the num_of_incoming_packets measurements" received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last num_of_incoming_ packets measurement received from NFVI for the measured virtual network interface in the collection period is generated.

7.1.11 Number of outgoing packets on virtual compute

a) **Description:** This measurement provides the number of packets transmitted at the virtual compute. This measurement is split into subcounters per virtual network interface, which is the communication endpoint under an instantiated compute resource.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more num_of_ outgoing _ packets measurement for a virtual network interface from NFVI in the collection period, and maps the received num_of_ outgoing _packets measurement(s) from the virtual network interface to the Virtual Compute instance. The VIM generates the measurement for the subject Virtual Compute instance by assigning the value of the received num_of_ outgoing _ packets measurement(s) to the sub-counter(s) per virtual network interface.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualNetworkInterface.

f) **Measured Object Type:** VirtualCompute.

g) **Measurement Name:** VnetPacketOutgoing.*vNetItfId*, where *vNetItfId* is equal to the resourceId of the measured virtual network interface.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last num_of_ outgoing _ packets measurement received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterval:** Equals the "number of num_of_ outgoing _ packets measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of num_of_ outgoing _ packets measurements" received from NFVI for the measured virtual network interface in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last num_of_ outgoing _ packets measurement received from NFVI for the measured virtual network interface in the collection period is generated.

7.1.12 Number of incoming bytes of a virtual network

a) **Description:** This measurement provides the number of bytes received at a virtual network instance. This measurement is split into subcounters per virtual network port.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more measurements indicating the number of incoming bytes for a virtual network port of a virtual network instance from NFVI in the collection period, and maps the received measurement(s) from the virtual network port to the virtual network instance. The VIM generates the measurement for the subject virtual network instance by assigning the value, or summing up multiple values, of the received measurement(s) to the sub-counter(s) per virtual network port.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualisedNetworkResource.

f) **Measured Object Type:** VirtualNetwork.

g) **Measurement Name:** ByteIncoming.*vNPort*, where *vNPort* is equal to the *resourceId* of the measured virtual network port.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last measurement indicating the number of incoming bytes of the measured virtual network port received from NFVI in the collection period;

- **MeasurementInterval:** Equals the "number of measurements indicating the number of incoming bytes" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the number of incoming bytes received from NFVI for the measured virtual network port in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last measurement indicating the number of incoming bytes of the measured virtual network port received from NFVI in the collection period is generated.

7.1.13 Number of outgoing bytes of a virtual network

a) **Description:** This measurement provides the number of bytes transmitted at a virtual network instance. This measurement is split into subcounters per virtual network port.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more measurements indicating the number of outgoing bytes for a virtual network port of a virtual network instance from NFVI in the collection period, and maps the received measurement(s) from the virtual network port to the virtual network instance. The VIM generates the measurement for the subject virtual network instance by assigning the value, or summing up multiple values, of the received measurement(s) to the sub-counter(s) per virtual network port.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualisedNetworkResource.

f) **Measured Object Type:** VirtualNetwork.

g) **Measurement Name:** ByteOutgoing.*vNPort*, where *vNPort* is equal to the *resourceId* of the measured virtual network port.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last measurement indicating the number of outgoing bytes of the measured virtual network port received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of measurements indicating the number of outgoing bytes" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the number of outgoing bytes received from NFVI for the measured virtual network port in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last measurement indicating the number of outgoing bytes of the measured virtual network port received from NFVI in the collection period is generated.

7.1.14 Number of incoming packets of a virtual network

a) **Description:** This measurement provides the number of packets received at a virtual network instance. This measurement is split into subcounters per virtual network port.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more measurements indicating the number of incoming packets for a virtual network port of a virtual network instance from NFVI in the collection period, and maps the received measurement(s) from the virtual network port to the virtual network instance. The VIM generates the measurement for the subject virtual network instance by assigning the value, or summing up multiple values, of the received measurement(s) to the sub-counter(s) per virtual network port.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualisedNetworkResource.

f) **Measured Object Type:** VirtualNetwork.

g) **Measurement Name:** PacketIncoming.*vNPort*, where *vNPort* is equal to the *resourceId* of the measured virtual network port.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last measurement indicating the number of incoming packets of the measured virtual network port received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of measurements indicating the number of incoming packets" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the number of incoming packets received from NFVI for the measured virtual network port in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last measurement indicating the number of incoming packets of the measured virtual network port received from NFVI in the collection period is generated.

7.1.15 Number of outgoing packets of a virtual network

a) **Description:** This measurement provides the number of packets transmitted at a virtual network instance. This measurement is split into subcounters per virtual network port.

b) **Collection Method:** OM.

c) **Trigger:** VIM receives one or more measurements indicating the number of outgoing packets for a virtual network port of a virtual network instance from NFVI in the collection period, and maps the received measurement(s) from the virtual network port to the virtual network instance. The VIM generates the measurement for the subject virtual network instance by assigning the value, or summing up multiple values, of the received measurement(s) to the sub-counter(s) per virtual network port.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VirtualisedNetworkResource.

f) **Measured Object Type:** VirtualNetwork.

g) **Measurement Name:** PacketOutgoing.*vNPort*, where *vNPort* is equal to the *resourceId* of the measured virtual network port.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last measurement indicating the number of outgoing packets of the measured virtual network port received from NFVI in the collection period;
- **MeasurementInterval:** Equals the "number of measurements indicating the number of outgoing packets" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the number of outgoing packets received from NFVI for the measured virtual network port in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last measurement indicating the number of outgoing packets of the measured virtual network port received from NFVI in the collection period is generated.

7.1.16 Mean usage of Virtualised storage resource

a) **Description:** This measurement provides the mean usage of a Virtualised storage resource.

b) **Collection Method:** TF.

c) **Trigger:** VIM receives one or more measurements indicating the usage of a Virtualised storage resource from NFVI in the collection period, and generates the measurement by averaging multiple values of the received measurement(s).

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedStorageResource.

f) **Measured Object Type:** VirtualStorage.

g) **Measurement Name:** UsageMeanVStorage.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last measurement indicating the usage of the virtualised storage resource received from NFVI in the collection period;

- **MeasurementInterval:** Equals the "number of measurements indicating the usage of the Virtualised storage resource" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the usage of the Virtualised storage resource received from NFVI for the measured Virtualised storage resource in the collection period.

7.1.17 Peak usage of Virtualised storage resource

a) **Description:** This measurement provides the peak usage of a Virtualised storage resource.

b) **Collection Method:** TF.

c) **Trigger:** VIM receives one or more measurements indicating the usage of a Virtualised storage resource from NFVI in the collection period, and generates the measurement by taking the maximum of multiple values of the received measurement(s).

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedStorageResource.

f) **Measured Object Type:** VirtualStorage.

g) **Measurement Name:** UsagePeakVStorage.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the measurement indicating the usage of the virtualised storage resource received from NFVI in the collection period;

- **MeasurementInterval:** Equals the "number of measurements indicating the usage of the Virtualised storage resource" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of measurements indicating the usage of the Virtualised storage resource received from NFVI for the measured Virtualised storage resource in the collection period.

7.2 Performance measurements produced by VNFM

7.2.1 Introduction

The performance measurements defined in this clause 7.2 are applicable to the following reference points:

- Ve-Vnfm-em;
- Or-Vnfm, with one exception that the measurements are only related to VNF instance but not VNFC instance, so the measured object type "VNFC" does not apply to this reference point.

7.2.2 Mean virtual CPU usage of VNF/VNFC instance

a) **Description:** This measurement provides the mean virtual CPU usage of the underlying Virtual Compute instance(s), related to a VNF instance, or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VcpuUsageMean measurement(s) (see clause 7.1.2) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VcpuUsageMean measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value or averaging multiple values of the received VcpuUsageMean measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VcpuUsageMeanVnf.vComputeId,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VcpuUsageMean measurement received from NFVI for the measured Virtualised compute resource in the collection period;
- **TickInterval:** Indicates the tick interval (see ETSI GS NFV-TST 008 [10]) of the last VcpuUsageMean measurement received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VcpuUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VcpuUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period;
- **ExecutionContext:** Indicates the execution context (see ETSI GS NFV-TST 008 [10]) of the VcpuUsageMean measurements received from NFVI for the measured Virtualised compute resource in the collection period. When a single "non-Idle" VCPU Utilization is required, the sum of the utilization of all the non-Idle execution contexts should be reported as the "active" execution context.

7.2.3 Peak virtual CPU usage of VNF/VNFC instance

a) **Description:** This measurement provides the peak virtual CPU usage of the underlying Virtual Compute instance(s) related to a VNF instance or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VcpuUsagePeak measurement(s) (see clause 7.1.3) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VcpuUsagePeak measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value, or taking the maximum of multiple values of the received VcpuUsagePeak measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VcpuUsagePeakVnf.*vComputeId*,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VcpuUsageMean measurement received from NFVI for the measured Virtualised compute resource in the collection period;
- **TickInterval:** Indicates the tick interval (see ETSI GS NFV-TST 008 [10]) of the VcpuUsageMean measurement with peak value received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VcpuUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VcpuUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period;
- **ExecutionContext:** Indicates the execution context (see ETSI GS NFV-TST 008 [10]) of the VcpuUsageMean measurements received from NFVI for the measured Virtualised compute resource sin the collection period. When a single "non-Idle" VCPU Utilization is required, the sum of the utilization of all the non-Idle execution contexts should be reported as the "active" execution context.

7.2.4 Mean memory usage of VNF/VNFC instance

a) **Description:** This measurement provides the mean memory usage of the underlying Virtual Compute instance(s) related to a VNF instance or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VmemoryUsageMean measurement(s) (see clause 7.1.4) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VmemoryUsageMean measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value or averaging the multiple values of the received VmemoryUsageMean measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VmemoryUsageMeanVnf.*vComputeId*,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VmemoryUsageMean measurement received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VmemoryUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VmemoryUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementSystemRAM:** Indicates the system RAM (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource;
- **MeasurementSystemSwapSpace:** Indicates the system SWAP space (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource.

7.2.5 Peak memory usage of VNF/VNFC instance

a) **Description:** This measurement provides the peak memory usage of the underlying Virtual Compute instance(s) related to a VNF instance or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VmemoryUsagePeak measurement(s) (see clause 7.1.5) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VmemoryUsagePeak measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value or taking the maximum of multiple values of the received VmemoryUsagePeak measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VmemoryUsagePeakVnf.*vComputeId*,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the VmemoryUsageMean measurement with peak value received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VmemoryUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VmemoryUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementSystemRAM:** Indicates the system RAM (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource;
- **MeasurementSystemSwapSpace:** Indicates the system SWAP space (see ETSI GS NFV-TST 008 [10]) of the measured Virtualised compute resource.

7.2.6 Mean disk usage of VNF/VNFC instance

a) **Description:** This measurement provides the mean disk usage of the underlying Virtual Compute instance related to a VNF instance or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VdiskUsageMean measurement(s) (see clause 7.1.6) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VdiskUsageMean measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value, or averaging the multiple values of the received VdiskUsageMean measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VdiskUsageMeanVnf.*vComputeId*,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VdiskUsageMean measurement received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VdiskUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VdiskUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period.

7.2.7 Peak disk usage of VNF/VNFC instance

a) **Description:** This measurement provides the peak disk usage of the underlying Virtual Compute instances related to a VNF instance or to a VNFC instance in a VNF instance. This measurement is split into sub-counters per Virtual Compute instance.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VdiskUsagePeak measurement(s) (see clause 7.1.7) for the *VirtualCompute* instance(s) from the VIM in the collection period, and maps the received VdiskUsagePeak measurement(s) from the *VirtualCompute* instance to the VNF instance, or the combination of VNF instance and VNFC instance. The VNFM generates the measurement for the subject VNF/VNFC instance by assigning the value or taking the maximum of multiple values of the received VdiskUsagePeak measurement(s) to the sub-counter(s) per *VirtualCompute* instance.

d) **Measurement Unit:** Each measurement is a real value (Unit: %).

e) **Measurement Group:** VirtualisedComputeResource.

f) **Measured Object Type:** VNF, VNFC.

g) **Measurement Name:** VdiskUsagePeakVnf.*vComputeId*,
where *vComputeId* is equal to the *objectInstanceId* of the measured object of the mapped measurement.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the VdiskUsageMean measurement with peak value received from NFVI for the measured Virtualised compute resource in the collection period;
- **MeasurementInterval:** Equals the "number of VdiskUsageMean measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VdiskUsageMean measurements" received from NFVI for the measured Virtualised compute resource in the collection period.

7.2.8 Number of incoming bytes of VNF internal CP

a) **Description:** This measurement provides the number of bytes received by a VNF internal Connection Point (CP).

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VnetByteIncoming.*vNetItfId* measurement(s) (see clause 7.1.8) for the Virtual Compute instance(s) from the VIM in the collection period, and maps the received VnetByteIncoming.*vNetItfId* measurement(s) from the Virtual Compute instance to the VNF internal CP instance. The VNFM generates the measurement for the subject VNF internal CP instance by assigning the value, or summing up multiple values, of the mapped VnetByteIncoming.*vNetItfId* subcounter(s).

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfInternalCP.

f) **Measured Object Type:** VnfIntCP.

g) **Measurement Name:** ByteIncomingVnfIntCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetByteIncoming.*vNetItfId* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetByteIncoming.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetByteIncoming.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetByteIncoming.*vNetItfId* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.9 Number of outgoing bytes of VNF internal CP

a) **Description:** This measurement provides the number of bytes transmitted by a VNF internal CP.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VnetByteOutgoing.*vNetItfId* measurement(s) (see clause 7.1.9) for the Virtual Compute instances from the VIM in the collection period, and maps the received VnetByteOutgoing.*vNetItfId* measurement(s) from the Virtual Compute instance to the VNF internal CP instance. The VNFM generates the measurement for the subject VNF internal CP instance by mapping the value of *vNetItfId* to the CP of the VNFC instance, and assigning the value, or summing up multiple values, of the mapped VnetByteOutgoing.*vNetItfId* subcounter(s).

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfInternalCP.

f) **Measured Object Type:** VnfIntCP.

g) **Measurement Name:** ByteOutgoingVnfIntCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetByteOutgoing.*vNetItfId* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetByteOutgoing.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetByteOutgoing.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetByteOutgoing.*vNetItfId* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.10 Number of incoming packets of VNF internal CP

a) **Description:** This measurement provides the number of packets received by a VNF internal CP.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VnetPacketIncoming.*vNetItfId* measurement(s) (see clause 7.1.10) for the Virtual Compute instances from the VIM in the collection period, and maps the received VnetPacketIncoming.*vNetItfId* measurement(s) from the Virtual Compute instance to the VNF internal CP instance. The VNFM generates the measurement for the subject VNF internal CP instance by mapping the value of *vNetItfId* to the CP of the VNFC instance, and assigning the value, or summing up multiple values, of the mapped VnetPacketIncoming.*vNetItfId* subcounter(s).

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfInternalCP.

f) **Measured Object Type:** VnfIntCP.

g) **Measurement Name:** PacketIncomingVnfIntCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetPacketIncoming.*vNetItfId* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetPacketIncoming.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetPacketIncoming.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetPacketIncoming.*vNetItfId* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.11 Number of outgoing packets of VNF internal CP

a) **Description:** This measurement provides the number of packets transmitted by a VNF internal CP.

b) **Collection Method:** OM.

c) **Trigger:** VNFM receives one or more VnetPacketOutgoing.*vNetItfId* measurement(s) (see clause 7.1.11) for the Virtual Compute instances from the VIM in the collection period, and maps the received VnetPacketOutgoing.*vNetItfId* measurement(s) from the Virtual Compute instance to the VNF internal CP instance. The VNFM generates the measurement for the subject VNF internal CP instance by mapping the value of *vNetItfId* to the CP of the VNFC instance, and assigning the value, or summing up multiple values, of the mapped VnetPacketOutgoing.*vNetItfId* subcounter(s).

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfInternalCP.

f) **Measured Object Type:** VnfIntCP.

g) **Measurement Name:** PacketOutgoingVnfIntCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetPacketOutgoing.*vNetItfId* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetPacketOutgoing.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetPacketOutgoing.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetPacketOutgoing.*vNetItfId* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.12 Number of incoming bytes of VNF external CP

a) **Description:** This measurement provides the number of incoming bytes received by a VNF external CP.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured VNF external CP (see clause 7.1.3 of ETSI GS NFV IFA 011 [4]);
- In case the VNF external CP is mapped to a VNF internal CP:
  - The VNFM generates the measurement by mapping the performance measurement VnetByteIncomingVnf.*vnfcInstanceId.CPId* (as defined in clause 7.2.8) from VNF internal CP to VNF external CP;
- In case the VNF external CP is mapped to an internal VL:
  - The VNFM receives one or more ByteIncoming.*vNPort* measurement(s) (see clause 7.1.12) for the virtual network port(s) from VIM in the collection period, and maps the received ByteIncoming.*vNPort* subcounter(s) from the virtual network port firstly to the VNF internal VL and then to the VNF external CP (see note). The VNFM generates the measurement for the subject VNF external CP by assigning the value, or summing up multiple values, of the mapped ByteIncoming.*vNPort* subcounter(s).

NOTE: The mapping between VNF internal VL and VNF external CP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfExternalCP.

f) **Measured Object Type:** VnfExtCP.

g) **Measurement Name:** ByteIncomingVnfExtCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetByteIncoming.*vNetItfId* or ByteIncoming.*vNPort* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetByteIncoming.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetByteIncoming.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period, or the "number of ByteIncoming.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteIncoming.*vNPort* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetByteIncoming.*vNetItfId* or ByteIncoming.*vNPort* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.13 Number of outgoing bytes of VNF external CP

a) **Description:** This measurement provides the number of outgoing bytes transmitted by a VNF external CP.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured VNF external CP (see clause 7.1.3 of ETSI GS NFV IFA 011 [4]);
- In case the VNF external CP is mapped to a VNF internal CP:
  - The VNFM generates the measurement by mapping the performance measurement VnetByteOutgoingVnf.*vnfcInstanceId.CPId* (as defined in clause 7.2.9) from VNF internal CP to VNF external CP;

- In case the VNF external CP is mapped to an internal VL:
  - The VNFM receives one or more ByteOutgoing.*vNPort* measurement(s) (see clause 7.1.13) for the virtual network port(s) from VIM in the collection period, and maps the received ByteOutgoing.*vNPort* subcounter(s) from the virtual network port firstly to the VNF internal VL and then to the VNF external CP (see note). The VNFM generates the measurement for the subject VNF external CP by assigning the value, or summing up multiple values, of the mapped ByteOutgoing.*vNPort* subcounter(s).

NOTE: The mapping between VNF internal VL and VNF external CP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfExternalCP.

f) **Measured Object Type:** VnfExtCP.

g) **Measurement Name:** ByteOutgoingVnfExtCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetByteOutgoing.*vNetItfId* or ByteOutgoing.*vNPort* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetByteOutgoing.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetByteOutgoing.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period, or the "number of ByteOutgoing.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteOutgoing.*vNPort* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetByteOutgoing.*vNetItfId* or ByteOutgoing.*vNPort* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.14 Number of incoming packets of VNF external CP

a) **Description:** This measurement provides the number of incoming packets received by a VNF external CP.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured VNF external CP (see clause 7.1.3 of ETSI GS NFV IFA 011 [4]);
- In case the VNF external CP is mapped to a VNF internal CP:
  - The VNFM generates the measurement by mapping the performance measurement VnetPacketIncomingVnf.*vnfcInstanceId.CPId* (as defined in clause 7.2.10) from VNF internal CP to VNF external CP;
- In case the VNF external CP is mapped to an internal VL:
  - The VNFM receives one or more PacketIncoming.*vNPort* measurement(s) (see clause 7.1.14) from for the virtual network port(s) VIM in the collection period, and maps the received PacketIncoming.*vNPort* subcounter(s) from the virtual network port firstly to the VNF internal VL and then to the VNF external CP (see note). The VNFM generates the measurement for the subject VNF external CP by assigning the value, or summing up multiple values, of the mapped PacketIncoming.*vNPort* subcounter(s).

NOTE: The mapping between VNF internal VL and VNF external CP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfExternalCP.

f) **Measured Object Type:** VnfExtCP.

g) **Measurement Name:** PacketIncomingVnfExtCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetPacketIncoming.*vNetItfId* or PacketIncoming.*vNPort* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetPacketIncoming.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetPacketIncoming.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period, or the "number of PacketIncoming.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the PacketIncoming.*vNPort* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 GS [10]) when the last VnetPacketIncoming.*vNetItfId* or PacketIncoming.*vNPort* measurement received from NFVI for the measured CP in the collection period is generated.

7.2.15 Number of outgoing packets of VNF external CP

a) **Description:** This measurement provides the number of outgoing packets transmitted by a VNF external CP.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured VNF external CP (see clause 7.1.3 of ETSI GS NFV IFA 011 [4]);
- In case the VNF external CP is mapped to a VNF internal CP:
  - The VNFM generates the measurement by mapping the performance measurement VnetPacketOutgoingVnf.*vnfcInstanceId.CPId* (as defined in clause 7.2.11) from VNF internal CP to VNF external CP;
- In case the VNF external CP is mapped to an internal VL:
  - The VNFM receives one or more PacketOutgoing.*vNPort* measurement(s) (see clause 7.1.15) for the virtual network port(s) from VIM in the collection period, and maps the received PacketOutgoing.*vNPort* subcounter(s) from the virtual network port firstly to the VNF internal VL and then to the VNF external CP (see note). The VNFM generates the measurement for the subject VNF external CP by assigning the value, or summing up multiple values, of the mapped PacketOutgoing.*vNPort* subcounter(s).

NOTE: The mapping between VNF internal VL and VNF external CP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** VnfExternalCP.

f) **Measured Object Type:** VnfExtCP.

g) **Measurement Name:** PacketOutgoingVnfExtCP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last VnetPacketOutgoing.*vNetItfId* or PacketOutgoing.*vNPort* measurement received from NFVI for the measured CP in the collection period;
- **MeasurementInterval:** Equals the "number of VnetPacketOutgoing.*vNetItfId* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the VnetPacketOutgoing.*vNetItfId* measurements" received from NFVI for the measured CP in the collection period, or the "number of PacketOutgoing.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the PacketOutgoing.*vNPort* measurements" received from NFVI for the measured CP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last VnetPacketOutgoing.*vNetItfId* or PacketOutgoing.*vNPort* measurement received from NFVI for the measured CP in the collection period is generated.

7.3 Performance measurements produced by NFVO

7.3.1 Introduction

The performance measurements defined in this clause 7.3 are applicable to the following reference points:

- Os-Ma-Nfvo.

7.3.2 Number of incoming bytes of SAP

a) **Description:** This measurement provides the number of incoming bytes received by an SAP of an NS instance.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured SAP;
- In case the SAP is mapped to a VNF external CP:
  - The NFVO receives one or more ByteIncomingVnfExtCP measurement(s) (see clause 7.2.12) from VNFM in the collection period, and maps the received ByteIncomingVnfExtCP measurement(s) from the VNF external CP to SAP. The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped ByteIncomingVnfExtCP measurement(s);
- In case the SAP is mapped to an NS VL:
  - The NFVO receives one or more ByteIncoming.*vNPort* measurement(s) (see clause 7.1.12) for the virtual network port(s) from VIM in the collection period, and maps the received ByteIncoming.*vNPort* subcounter(s) from the virtual network port firstly to the NS VL and then to the SAP (see note). The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped ByteIncoming.*vNPort* subcounter(s).

NOTE: The mapping between NS VL and SAP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** ServiceAccessPoint.

f) **Measured Object Type:** SAP.

g) **Measurement Name:** ByteIncomingSAP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last ByteIncomingVnfExtCP or ByteIncoming.*vNPort* measurement received from NFVI for the measured SAP in the collection period;
- **MeasurementInterval:** Equals the "number of ByteIncomingVnfExtCP measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteIncomingVnfExtCP measurements" received from NFVI for the measured SAP in the collection period, or the "number of ByteIncoming.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteIncoming.*vNPort* measurements" received from NFVI for the measured SAP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last ByteIncomingVnfExtCP or ByteIncoming.*vNPort* measurement received from NFVI for the measured SAP in the collection period is generated.

7.3.3 Number of outgoing bytes of SAP

a) **Description:** This measurement provides the number of outgoing bytes transmitted by an SAP of an NS instance.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured SAP;
- In case the SAP is mapped to a VNF external CP:
  - The NFVO receives one or more ByteOutgoingVnfExtCP measurement(s) (see clause 7.2.13) from VNFM in the collection period, and maps the received ByteOutgoingVnfExtCP measurement(s) from the VNF external CP to SAP. The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped ByteOutgoingVnfExtCP measurement(s);
- In case the SAP is mapped to an NS VL:
  - The NFVO receives one or more ByteOutgoing.*vNPort* measurement(s) (see clause 7.1.13) for the virtual network port(s) from VIM in the collection period, and maps the received ByteOutgoing.*vNPort* subcounter(s) from the virtual network port firstly to the NS VL and then to the SAP (see note). The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped ByteOutgoing.*vNPort* subcounter(s).

NOTE: The mapping between NS VL and SAP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** ServiceAccessPoint.

f) **Measured Object Type:** SAP.

g) **Measurement Name:** ByteOutgoingSAP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last ByteOutgoingVnfExtCP or ByteOutgoing.*vNPort* measurement received from NFVI for the measured SAP in the collection period;
- **MeasurementInterval:** Equals the "number of ByteOutgoingVnfExtCP measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteOutgoingVnfExtCP measurements" received from NFVI for the measured SAP in the collection period, or the "number of ByteOutgoing.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteOutgoing.*vNPort* measurements" received from NFVI for the measured SAP in the collection period;

- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last ByteOutgoingVnfExtCP or ByteOutgoing.*vNPort* measurement received from NFVI for the measured SAP in the collection period is generated.

7.3.4 Number of incoming packets of SAP

a) **Description:** This measurement provides the number of incoming packets received by an SAP of an NS instance.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured SAP;
- In case the SAP is mapped to a VNF external CP:
  - The NFVO receives one or more PacketIncomingVnfExtCP measurement(s) (see clause 7.2.14) from VNFM in the collection period, and maps the received PacketIncomingVnfExtCP measurement(s) from the VNF external CP to SAP. The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped PacketIncomingVnfExtCP measurement(s);
- In case the SAP is mapped to an NS VL:
  - The NFVO receives one or more PacketIncoming.*vNPort* measurement(s) (see clause 7.1.14) for the virtual network port(s) from VIM in the collection period, and maps the received PacketIncoming.*vNPort* subcounter(s) from the virtual network port firstly to the NS VL and then to the SAP (see note). The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped PacketIncoming.*vNPort* subcounter(s).

NOTE: The mapping between NS VL and SAP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** ServiceAccessPoint.

f) **Measured Object Type:** SAP.

g) **Measurement Name:** PacketIncomingSAP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last PacketIncomingVnfExtCP or PacketIncoming.*vNPort* measurement received from NFVI for the measured SAP in the collection period;
- **MeasurementInterval:** Equals the "number of PacketIncomingVnfExtCP measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the PacketIncomingVnfExtCP measurements" received from NFVI for the measured SAP in the collection period, or the "number of PacketIncoming.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the PacketIncoming.*vNPort* measurements" received from NFVI for the measured SAP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last PacketIncomingVnfExtCP or PacketIncoming.*vNPort* measurement received from NFVI for the measured SAP in the collection period is generated.

7.3.5 Number of outgoing packets of SAP

a) **Description:** This measurement provides the number of outgoing packets transmitted by an SAP of an NS instance.

b) **Collection Method:** OM.

c) **Trigger:**

- The measurement is triggered based on the mapping of the measured SAP;
- In case the SAP is mapped to a VNF external CP:
  - The NFVO receives one or more PacketOutgoingVnfExtCP measurement(s) (see clause 7.2.15) from VNFM in the collection period, and maps the received PacketOutgoingVnfExtCP measurement(s) from the VNF external CP to SAP. The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped PacketOutgoingVnfExtCP measurement(s);
- In case the SAP is mapped to an NS VL:
  - The NFVO receives one or more ByteOutgoing.*vNPort* measurement(s) (see clause 7.1.15) for the virtual network port(s) from VIM in the collection period, and maps the received ByteOutgoing.*vNPort* subcounter(s) from the virtual network port firstly to the NS VL and then to the SAP (see note). The NFVO generates the measurement for the subject SAP by assigning the value, or summing up multiple values, of the mapped ByteOutgoing.*vNPort* subcounter(s).

NOTE: The mapping between NS VL and SAP has dependency on the connectivity modelling between them. The exact mapping is out of scope of the present document.

d) **Measurement Unit:** Each measurement is an integer value.

e) **Measurement Group:** ServiceAccessPoint.

f) **Measured Object Type:** SAP.

g) **Measurement Name:** PacketOutgoingSAP.

h) **Measurement Context:**

- **MeasurementEndTime:** Indicates the end time (see ETSI GS NFV-TST 008 [10]) of the last PacketOutgoingVnfExtCP or ByteOutgoing.*vNPort* measurement received from NFVI for the measured SAP in the collection period;
- **MeasurementInterval:** Equals the "number of PacketOutgoingVnfExtCP measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the PacketOutgoingVnfExtCP measurements" received from NFVI for the measured SAP in the collection period, or the "number of ByteOutgoing.*vNPort* measurements" * "measurement interval (see ETSI GS NFV-TST 008 [10]) of the ByteOutgoing.*vNPort* measurements" received from NFVI for the measured SAP in the collection period;
- **MeasurementInterfaceStatus:** Indicates the interface status (see ETSI GS NFV-TST 008 [10]) when the last PacketOutgoingVnfExtCP or ByteOutgoing.*vNPort* measurement received from NFVI for the measured SAP in the collection period is generated.

Annex A (informative): Mapping of TST 008 to OpenStack® measurements

Table A.1-1 provides the mapping of ETSI GS NFV-TST 008 [10] metrics to OpenStack® compute measurements in Mitaka release [i.1].

Table A.1-1: TST 008 [10] to OpenStack® measurements mapping table

NFV-TST 008 metrics	OpenStack® Telemetry measurements						
	Name	**Type**	**Unit**	**Resource**	**Origin**	**Support**	**Note**
Processor Utilization	*cpu_util*	Gauge	%	instance ID	Pollster	vSphere®	Average CPU utilization
(see note 1)	*Memory* (see note 5)	Gauge	MB	instance ID	Notification	Libvirt, Hyper-V	Volume of RAM allocated to the instance
Memory Buffered, Memory Cached, Memory Free, Memory Slab (see note 2)	*memory.usage* (see note 5)	Gauge	MB	instance ID	Pollster	vSphere®	Volume of RAM used by the instance from the amount of its allocated memory
(see note 3)	*disk.allocation* (see note 6)	Gauge	B	instance ID	Pollster	Libvirt	The amount of disk occupied by the instance on the host machine
(see note 4)	*disk.usage* (see note 6)	Gauge	B	instance ID	Pollster	Libvirt	The physical size in bytes of the image container on the host
Octet Count received	*network.incoming.bytes*	Cumulative	B	interface ID	Pollster	Libvirt, Hyper-V	Number of incoming bytes
Octet Count transmitted	*network.outgoing.bytes*	Cumulative	B	interface ID	Pollster	Libvirt, Hyper-V	Number of outgoing bytes
Packet Count received	*network.incoming.packets*	Cumulative	packet	interface ID	Pollster	Libvirt, Hyper-V	Number of incoming packets
Packet Count transmitted	*network.outgoing.packets*	Cumulative	packet	interface ID	Pollster	Libvirt, Hyper-V	Number of outgoing packets

NOTE 1: The size of the memory allocated to an instance can be derived from VirtualMemory (see clause 8.4.3.5 in ETSI GS NFV-IFA 006 [2]).
NOTE 2: The size of the memory used by an instance can be computed from the sum of Memory Buffered, Memory Cached, Memory Free, and Memory Slab.
NOTE 3: The size of the disk allocated to an instance can be derived from VirtualStorageData (see clause 8.4.6.3 in ETSI GS NFV-IFA 006 [2]).
NOTE 4: No corresponding metric is defined in ETSI GS NFV-TST 008 [10].
NOTE 5: *memory.usage* and *memory* can be used to compute memory_utilization = 100 × *memory.usage*/*memory*.
NOTE 6: *disk.usage* and *disk.allocation* can be used to compute disk_utilization = 100 × *disk.usage*/*disk.allocation*.

Annex B (informative): Security and Regulatory Concerns

B.1 Risk analysis and assessment

Table B.1-1 is the output of the Threat, Risk, and Vulnerability Analysis according to ETSI GS NFV-SEC 006 [7].

Table B.1-1: Threat, Risk, and Vulnerability Analysis

A Security Environment		
a.1	**Assumptions**	
a.1.1	A new set of management and orchestration functions in addition to existing Element Management (EM) and Operations Support Systems (OSS) functions is introduced by NFV. Such NFV-MANO functions have the role to manage the NFVI to control the collection of virtualised resources consumed by VMs.	*See clause 4.1*
a.1.2	NFV-MANO management functions include performance Management that is capable of controlling and collecting performance metrics.	*See clause 4.1*
a.1.3	An NFV-MANO service is one or more capabilities that are offered via NFV-MANO functional blocks (i.e. NFVO, VNFM, and VIM) and invoked using a defined interface.	*See clause 4.1*
a.2	**Assets**	
a.2.1	NFVO: it is responsible for processing the VNFM and VIM performance metrics to generate the NS related performance metrics to be sent to OSS/BSS.	*See clause 4.1 and 7.3*
a.2.2	VNFM: it is responsible for processing the VIM performance metrics to generate the VNF related performance measurements to be sent to EM (Element Manager) and NFVO.	*See clause 4.1 and 7.2*
a.2.3	VIM: it is responsible for processing the NFVI performance metrics to generate the Virtualised resource related performance measurements to be sent to NFVO and VNFM.	*See clause 4.1 and 7.1*
a.2.4	NFVI: it is responsible for collecting the NFVI performance metrics, and reporting them to VIM.	*See clause 4.1*
a.2.5	Performance metrics: performance information that need to be reported/acquired.	*See clause 4 and 7*
a.3	**Threat agents**	
a.3.1	Unauthorized user of assets (e.g. reports, notifications, queries, fault information, resource information)	
a.3.2	(Industrial) espionage agent	
a.3.3	Sabotage agent	
a.3.4	Internal threat agent, e.g. corrupt employee	

A Security Environment		
a.4	**Threats**	
a.4.1	Unauthorised read (viewing/copying/consuming of data and interfaces)	Refer to all threat agents a.3. Refer to all assets in a.2.
a.4.2	Unauthorized write action (Masquerade ("spoofing"), Forgery, Loss or corruption of information)	Refer to all threat agents a.3. Refer to all assets in a.2.
a.4.3	- Unauthorized access	Refer to threat agents a.3.1, a.3.2 and a.3.3. Refer to all assets in a.2.
a.4.4	Repudiation (end point and threat agents)	Refer to threat agent a.3.1, a.3.2, a.3.3, and a.3.4. Refer to all assets a.2.
a.4.5	Denial of service	Refer to threat agents a.3.1, a.3.2 and a.3.3. Refer to all assets in a.2.
B Security Objectives		
b.1 Security objectives for the asset		
b.1.1	The system should ensure that only authorized and authenticated entities can access (read or write) the provided interfaces and that data is exchanged in a confidential manner. Therefore, requirements for access controls and communications security (see clauses 8.5 and 8.6 in ETSI GS NFV-SEC 012 [9]) should be followed.	
b.1.2	The system should ensure the authenticity and integrity of all data exchanged on the interfaces. Therefore, requirements for authentications controls (see clause 8.4 in ETSI GS NFV-SEC 012 [9]) should be followed.	
b.1.3	The system should prevent replay of any data. Therefore, requirements for authentications controls (see clause 8.4 in ETSI GS NFV-SEC 012 [9]) should be followed.	
b.1.4	The system should be accountable for the data provided, that is why the system should ensure collected data (e.g. performance metrics, timestamps) is authentic.	
b.1.5	The system should ensure that interception is possible where required to support regulatory requirements (such as Lawful Interception ETSI GS NFV-SEC 004 [6] and Retained Data ETSI GS NFV-SEC 010 [8]) and not possible otherwise.	
b.1.6	The system should provide means to detect and mitigate denial of service attacks.	

Annex C (informative): Authors & contributors

The following people have contributed to the present document:

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Annex D (informative): Change History

Date	Version	Information about changes
2016-12	0.1.0	Implemented NFVIFA-F2F#43 approved contributions; NFVIFA(16)0001456r2, NFVIFA(16)0001457r1.
2017-06	0.2.0	Implemented approved contributions: NFVIFA(17)000333r1, NFVIFA(17)000335r1, NFVIFA(17)000336r1, NFVIFA(17)000384r1, NFVIFA(17)000385r2, NFVIFA(17)000386r3, NFVIFA(17)000521r1
2017-08	0.3.0	Implemented approved contributions: NFVIFA(17)000602r2, NFVIFA(17)000603r6
2017-08	0.4.0	Implemented approved contributions: NFVIFA(17)000604r5, NFVIFA(17)000605r5, NFVIFA(17)000708
2017-09	0.5.0	Implemented approved contributions: NFVIFA(17)000728r1, NFVIFA(17)000780r2, NFVIFA(17)000781r2, NFVIFA(17)000782r2
2017-09	0.5.1	Implemented the changes of the approved contributions that were not implemented in 0.5.0: NFVIFA(17)000728r1, NFVIFA(17)000781r2, NFVIFA(17)000782r2
2017-10	0.6.0	Implemented the changes of the approved contributions: NFVIFA(17)000606r7, NFVIFA(17)000857r1
2017-11	0.7.0	Implemented the changes of the approved contributions: NFVIFA(17)001023, NFVIFA(17)001024, NFVIFA(17)001042, NFVIFA(17)001045
2017-12	0.8.0	Implemented the changes of the approved contributions: NFVIFA(17)0001043r3, NFVIFA(17)0001044r3
2018-02	0.9.0	Implemented the changes of the approved contribution: NFVIFA(18)0000062r2
2018-04	0.9.1	Implemented some editorial changes, and leftover changes from NFVIFA(18)0000062r2, and the changes of the approved contributions: NFVIFA(18)000261, NFVIFA(18)000194r4, NFVIFA(18)000204r1, NFVIFA(18)000330r1

History

Document history		
V2.4.1	May 2018	Publication