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Network Functions Virtualisation (NFV); Service Quality Metrics

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Foreword

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

The present document deals with specific aspects of Service Quality Metrics in the context of Network Function Virtualisation.

Infrastructure Architecture Document		Document #
Overview		GS NFV INF 001
Illustrative Use Cases for the NFV Infrastructure		GS NFV INF 002
Architecture of the Infrastructure Domains	Compute Domain	GS NFV INF 003
	Hypervisor Domain	GS NFV INF 004
	Infrastructure Network Domain	GS NFV INF 005
Architectural Methodology	Interfaces and Abstraction	GS NFV INF 007
Service Quality Metrics		GS NFV INF 010

Modal verbs terminology

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

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Introduction

As shown in figure 1, the service quality delivered by a VNF instance to end users is dependent on the service quality of the compute, network and other resources delivered by NFV infrastructure, VIM, VNFM and NFVO to the VNF instance. Objective and quantitative metrics for the service delivered by NFV infrastructure and orchestration to NFV consumers enables:

- Better engineering of VNF user service quality.
- Efficient fault localization and mitigation.
- Faster identification of true root cause of service impairment so proper corrective actions can be taken promptly.

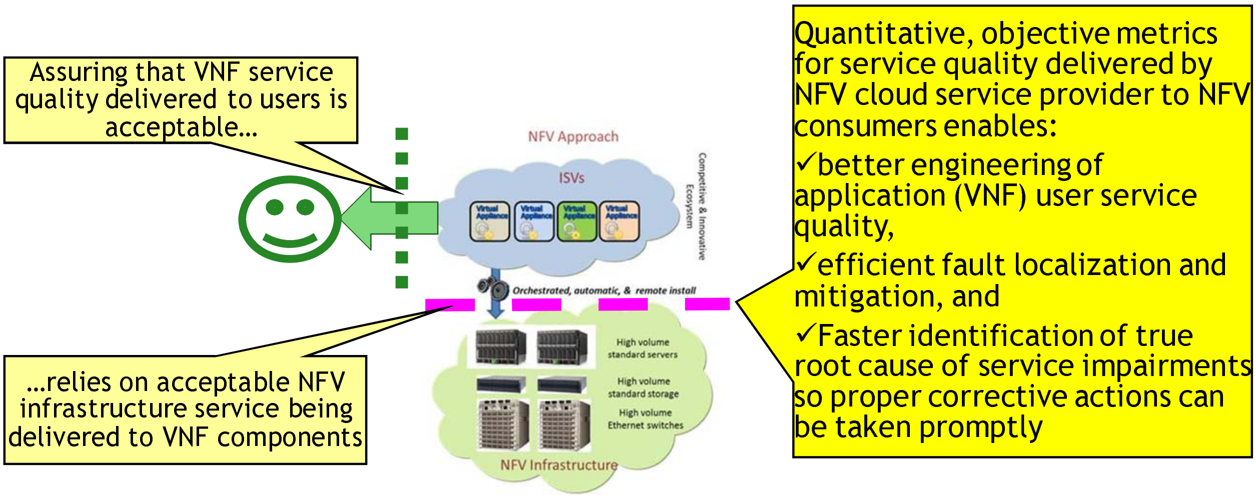

Figure 1: Purpose of NFV Service Quality Metrics

Figure 2 illustrates the service boundary characterized by these metrics between canonical NFV consumers who operate VNFs and NFVI service providers who operate NFV infrastructure and supporting systems. Objective metrics of the service quality delivered by the NFV infrastructure service provider to the NFV consumer's VNFs enable quantitative discussions and agreements for the objectives of NFV service quality to assure that the NFV consumer's VNF instances deliver acceptable service quality to end users.

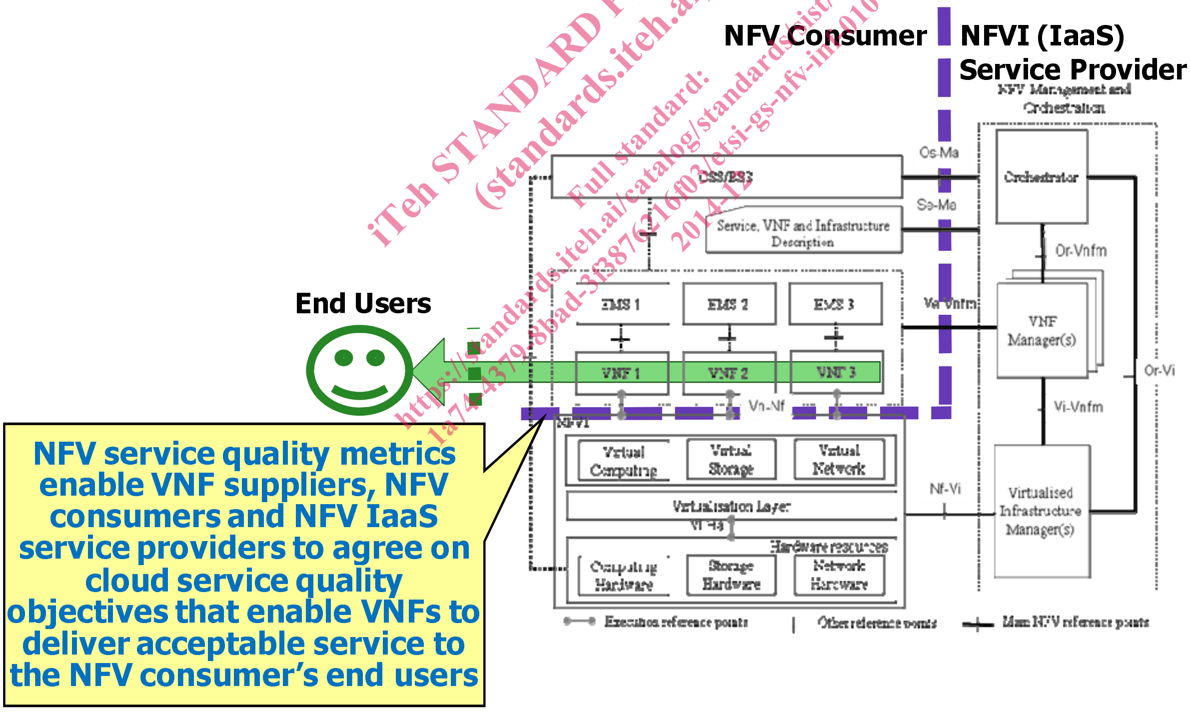

Figure 2: Service Quality Metrics in the Context of NFV Reference Architecture

Both new and familiar metrics will be needed to complete the quantification of service quality. The present document examines the properties of the virtual infrastructure and describes metrics relevant and useful to virtualised functions.

1 Scope

The present document enumerates metrics for NFV infrastructure, management and orchestration service qualities that can impact the end user service qualities delivered by VNF instances hosted on NFV infrastructure. These service quality metrics cover both direct service impairments, such as IP packets lost by NFV virtual networking which impacts end user service latency or quality of experience, and indirect service quality risks, such as NFV management and orchestration failing to continuously and rigorously enforce all anti-affinity rules which increases the risk of an infrastructure failure causing unacceptable VNF user service impact. Performance relationships exist between the metrics described in this document and in other specifications such as [i.5].

The present document does ***not*** consider:

1) Units of measurement for reporting, such as whether VM premature release rates should be expressed as hourly rate (e.g. 0,0001 premature VM release events per hour), annualized rate (e.g. 0,88 premature VM release events per year), hours between events (e.g. 10 000 hour mean time between premature release events), or events per other unit of time (e.g. 100 000 FITs, meaning 100 000 premature release events in one billion hours of operation).

2) Methods of Measurement which stipulate exactly how metrics will be measured.

3) Rigorous counting and exclusion rules, like the precise details given in the TL 9000 Measurements Handbook [i.13].

4) Metrics that do not directly or indirectly impact VNF user service quality, like power efficiency.

2 References

2.1 Normative references

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

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

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

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

[1] ETSI GS NFV-INF 001: "Network Functions Virtualisation (NFV); Infrastructure Overview".

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] NIST Special Publication 800-145 (September 2011): "The NIST Definitions of Cloud Computing", Peter Mell and Timothy Grance, US National Institute of Standards and Technology.

[i.2] IETF RFC 2330: "Framework for IP Performance Metrics".

[i.3] Wiley-IEEE Press, 2013: "Service Quality of Cloud-Based Applications," Eric Bauer and Randee Adams.

[i.4] ETSI GS NFV-MAN 01: "Network Functions Virtualisation (NFV); Management and Orchestration".

[i.5] draft-ietf-ippm-model-based-metrics-02 (work in progress) (February 2014): "Model Based Bulk Performance Metrics", M. Mathis and A. Morton.

[i.6] ETSI GS NFV-PER 001: "Network Functions Virtualisation (NFV); NFV Performance & Portability Best Practises".

[i.7] IETF RFC 6390: "Guidelines for Considering New Performance Metric Development".

[i.8] ISO/IEC 15939:2007: "Systems and software engine-ing -- Measurement process".

[i.9] NIST draft Cloud Service Metric Description v2.

[i.10] Recommendation ITU-T M.3341: "Requirements for QoS/SLA management over the TMN X-interface for IP-based services".

[i.11] Recommendation ITU-T Y.1543: "Measurements in IP networks for inter-domain performance assessment".

[i.12] Recommendation ITU-T I.356: "B-ISDN ATM layer cell transfer performance".

[i.13] TL 9000 Measurements Handbook, release 5.0, July 2012, QuestForum.

NOTE: Available at http://www.tl9000.org/handbooks/measurements_handbook.html.

3 Definitions and abbreviations

3.1 Definitions

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

derived metric: metric defined on the basis of the values produced by other Metrics

NOTE: An example from packet transfer performance is delay variation, which is based on multiple values produced from measurement of a packet delay metric. (This definition is consistent with IETF RFC 2330 [i.2] and the derived performance parameter in Recommendation ITU-T I.356 [i.12]).

measurement: set of operations having the object of determining a Measured Value or Measurement Result

NOTE: The actual instance or execution of operations leading to a Measured Value. (Based on the definition of Measurement in IETF RFC 6390 [i.7], as cited in ISO/IEC 15939 [i.8]).

measurement point: physical or logical point at which observations are made and to which the measure obtained is related, e.g. a boundary or point of demarcation between domains or functional entities (derived from NIST draft Cloud Service Metric Description v2 [i.9])

NOTE 1: When one or more measurement points are specified along with a performance metric, they define the scope of measurement and should be included with the measurement results for accurate interpretation.

NOTE 2: A point in a system possessing sufficient functionality to provide observations of reference events. (derived from Recommendation ITU-T M.3341 [i.10]) The interface between two communicating entities is often designated as a Measurement Point.

metric: standard definition of a quantity, produced in an assessment of performance and/or reliability of the network, which has an intended utility and is carefully specified to convey the exact meaning of a measured value

NOTE: This definition is consistent with that of Performance Metric in IETF RFC 2330 [i.2] and ETSI GS NFV-PER 001 [i.6].

EXAMPLE: Packet transfer performance or reliability of a network.

parameter: input factor defined as a variable in the definition of a Metric

NOTE: A numerical or other specified factor forming one of a set that fully-defines a Metric or sets the conditions of its operation. Most Parameters do not change the fundamental nature of the metric's definition, but others have substantial influence. All Parameters should be known in order to conduct measurements conforming to a Metric and interpret the results. An example Parameter includes the Measurement Point(s). (derived from IETF work in progress to design a Registry for Performance Metrics, consistent with IETF IPPM Literature)

reference event: transfer of a discrete unit of control or user information encoded in accordance with a specific protocol across a Measurement Point

NOTE: Complementary classes of reference events can sometimes be distinguished: exit and entry events, or start and stop events (derived from Recommendation ITU-T Y.1543 [i.11]).

3.2 Abbreviations

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

CCDF	Complementary Cumulative Distribution Function
CPU	Central Processing Unit
DOA	Dead on Arrival

NOTE: Also referred to as "Out-of-Box" (OOB) failures.

HW&SW	Hardware and Software
IETF	Internet Engineering Task Force
IP	Internet Protocol
MIB	Management Information Base
NFV	Network Function Virtualisation
NFVI	NEFV Infrastructure
NFVO	NFV Orchestrator
NIC	Network Interface Card
OS	Operating System
SLA	Service Level Agreement
SLO	Service Level Objective
SQM	Service Quality Metrics
TcaaS	Technology Component offered as-a-Service

NOTE: Like Database-as-a-Service.

UTC	Universal Coordinated Time
VIM	Virtual Infrastrucutre Management
VM	Virtual Machine
VN	Virtual Network
VNF	Virtualised Network Function
VNFC	Virtualised Network Function Component
VNFM	VNF Manager

4 NFV Service Quality Metrics Taxonomy

End users experience services delivered by VNF instances, which are implemented via suites of VNFCs working together. The services delivered to end users by individual VNFC instances is dependent on the service quality of the virtual machine instance that hosts the component and the virtual network service that delivers connectivity to other VNFCs. End user service quality of VNFs which use functional blocks or technology components that are offered 'as-a-Service' like Database-as-a-Service or Load-Balancing-as-a-Service are also vulnerable to service quality impairments of those technology components. NFV management and orchestration can also presents subtle risks to VNF service quality if elastic resource growth or repair is slow or faulty, or if the VNF's anti-affinity rules are not strictly and continuously enforced. Figure 3 visualizes the four suites of NFV service quality metrics:

1) Virtual machine service quality metrics.

2) Virtual network service quality metrics.

3) Technology components offered 'as-a-Service' (e.g. Database-as-a-Service) quality metrics.

4) Orchestration service quality metrics.

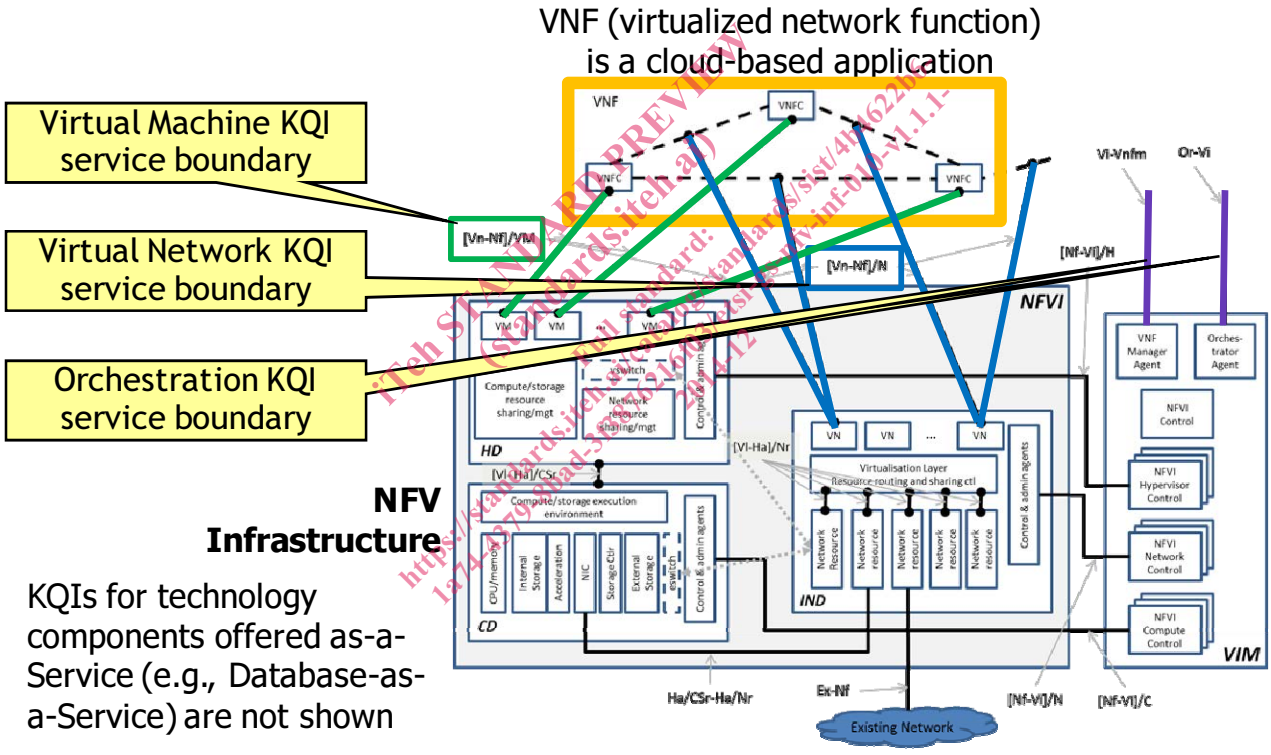

Figure 3: NFV Service Quality Metrics on High Level Overview of NFVI

When assessing performance of the NFV Infrastructure, measurement points at the [Nf-Vi]/* reference points will be critical. Measurement points at other locations in the NFV architecture will necessarily include the performance contribution of management components, such as the Vi-Vnfm and Or-Vi reference points, and these may also prove to be valuable aids in performance management.

The NFV service quality metrics are summarized in table 1. Each cell of the matrix is associated with a Service/life-cycle category (e.g. Orchestration, Operation) and a quality criterion (Speed, Accuracy, Reliability). Some intersections are critical for certain functions or resources while others may be inapplicable or contain secondary metrics. By listing each Quality Metric in its corresponding cell, it is possible to identify overlaps and gaps. The matrix may also facilitate the process to determine which Quality Metrics are the key ones and should be measured, collected, and reported. The Service Quality Metrics are applicable when the entity measured is deemed to be in the Available state (through continuous evaluation of one or more metrics). See [i.3] for consistent definitions of Availability and Reliability.

Table 1: Summary of NFV Service Quality Metrics

Service Metric Category	Speed	Accuracy	Reliability
Orchestration Step 1 (e.g. Resource Allocation, Configuration and Setup)	VM Provisioning Latency	VM Placement Policy Compliance	VM Provisioning Reliability VM Dead-on-Arrival (DOA) Ratio
VirtualMachine operation	VM Stall (event duration and frequency) VM Scheduling Latency	VM Clock Error	VM Premature Release Ratio
Virtual Network Establishment	VN Provisioning Latency	VN Diversity Compliance	VN Provisioning Reliability
Virtual Network operation	Packet Delay Packet Delay Variation (Jitter) Delivered Throughput	Packet Loss Ratio	Network Outage
Orchestration Step 2 (e.g. Resource Release)			Failed VM Release Ratio
Technology Component as-a-Service	TcaaS Service Latency	-	TcaaS Reliability (e.g.defective transaction ratio) TcaaS Outage

The impact of each NFV service quality metric of table 1 can directly or indirectly impair the VNF user service quality as follows:

- **VM provisioning latency** and **VM provisioning reliability** directly impact the time it takes to elastically grow online VNF service capacity or to restore full VNF redundancy (i.e. eliminate simplex exposure) following a failure event.
- **VM Dead on Arrival** (DOA) indirectly impacts the time to elastically grow or repair VNF capacity because a latent VM fault shall be detected and somehow mitigated before needed VNF capacity can enter user service.
- **VM premature release ratio** directly impacts the frequency that VNF service recovery actions (e.g. high availability failovers) shall be taken.
- **VM stall** characterizes disruptions in prompt and continuous execution of VNFC software which impacts the service latency and quality of service enjoyed by end users.
- **VM scheduling latency** characterizes how promptly VNFC software is executed, such as when processing isochronous bearer plane traffic, which impacts the service latency and quality of service enjoyed by end users.
- **VM clock error** characterizes the realtime inaccuracy presented to VNFC software for billing, fault and other records that rely on accurate timestamping.
- **VM placement policy compliance** characterizes how reliably the NFV infrastructure provider continuously and correctly enforces the VNF's anti-affinity rules, thereby minimizing the risk that a single infrastructure failure event will produce an unacceptable VNF user service quality impact.
- **Packet delay** characterizes the incremental user service latency introduced by communications between a VNF's VNFCs, which impacts the service latency and quality of service enjoyed by end users. A key input parameter for any packet transfer metric is the offered load during the measurement.
- **Packet delay variation (jitter)** is a derived metric that characterizes the incremental user service delay variation introduced by instability in communications latency between VNFCs within a VNF, which impacts the service latency and quality of service enjoyed by end users.
- **Delivered Throughput** is a derived metric from the offered load input parameter and other packet transfer performance metrics (loss, delay) measured at that load to characterize the actual capacity of communications between a VNF's VNFCs, and which impacts the quality of service enjoyed by end users (ETSI GS NFV-MAN 001 [i.4]).