

**Quality Excellence for Suppliers of
Telecommunications Forum
(QuEST Forum)**

**TL 9000
Quality Management System**

**Quality Measurement of
Automated Lifecycle Management Actions
Version 1.0**

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Introduction

The on-demand self service characteristic of cloud computing means that application installation, configuration, scaling (a.k.a., growth and degrowth) and healing (a.k.a., repair) actions are automatically executed by management and orchestration systems rather than manually executed by human staff. The multi-tenancy key characteristic of cloud computing means that multiple organizations offering end-user services (e.g., IP-TV, VoLTE, EPC, etc.) are likely to share cloud infrastructure, management and orchestration deployments offered by Infrastructure-as-a-Service or Platform-as-a-Service organizations. Both the end-user services and IaaS/PaaS organizations may be part of the same larger organization with private cloud deployments or be in different corporations with public cloud deployments. Automatically executed lifecycle management actions have materially different quality and performance expectations than traditional (i.e., TL 9000 product category 7) services. For example, rather than expecting a manually executed installation or growth job to complete days after the request, an on-demand self service automated lifecycle management action is expected to complete in minutes, or perhaps even seconds. To properly measure, drive root cause analysis and corrective actions of impairments associated with automatically executed lifecycle management that are materially different than those of category 7, a new service product category focused on automated lifecycle management actions could be created. This approach allows existing TL 9000 measurement definitions to remain the same, however using the TL 9000 product category table to define normalization units and other rules associated with automated lifecycle management.

Each major section in the TL 9000 Product Category Table defines a group of products or services. For the purposes of this document and discussion, Section 10 for Automated Lifecycle Management Services houses categories that define performance measurements of mechanized automated lifecycle management services delivered by a cloud service provider to internal and external Infrastructure-as-a-Service and/or Platform-as-a-Service customers. This distinguishes and bounds the Service Providers' responsibility for deploying adequate resources, implementing competent network architectures, and applying appropriate policies.

Widespread industry use of these measurements of automated lifecycle services will enable IaaS and PaaS customers to compare suppliers against industry benchmarks. Suppliers of those services can objectively assess their performance so they can quantitatively differentiate themselves from competition.

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1 Cloud and Automated Lifecycle Management

Multi-tenancy is one of the six key characteristics of cloud computing stipulated by [ISO-IEC_17788] and is defined as:

A feature where physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from and inaccessible to one another.

Figure 1 illustrates the practical implications of multi-tenancy in NFV: multiple [ISO-IEC_17788] **Cloud Service Customer** organizations are likely to share a public or private NFV infrastructure, management and orchestration cloud which enables each cloud service customer to efficiently offer VNF-based services like VoLTE, EPC and IP-TV to their respective end users. A single public or private [ISO-IEC_17788] **Cloud Service Provider** organization offers NFV infrastructure, management and orchestration services to all of these cloud service customers.

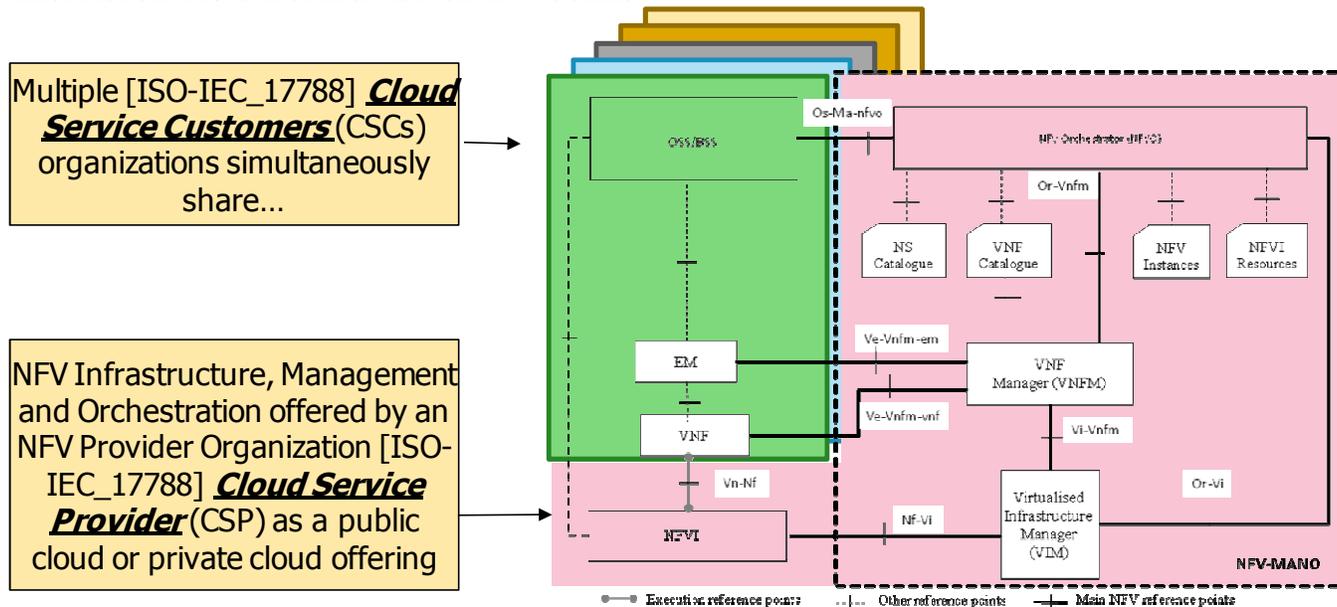


Figure 1 – Multi-tenancy in NFV¹

Another key characteristic of cloud computing stipulated by [ISO-IEC_17788] is **on-demand self-service**, defined as:

a feature where a cloud service customer can provision computing capabilities, as needed, automatically or with minimal interaction with the cloud service provider. The focus of this key characteristic is that cloud computing offers ... the user the ability to do what they need, when they need it, without requiring additional human user interactions or overhead;

The implication is that traditional, manually executed application installation, configuration, repair, capacity expansion/reduction, upgrade and retirement actions will be replaced by on-demand self-service executed via automated lifecycle management systems.

Figure 2 highlights that the primary interface for on demand self service in NFV is between the cloud service customer’s OSS/BSS and the service provider’s NFV Orchestrator via the Os-Ma-nfvo reference point. The primary self service operations requested are:

- **VNF lifecycle management actions** like *Instantiate VNF, Scale VNF, Heal VNF* and *Upgrade VNF* from [MANO]
- **Network service lifecycle management actions** like *Instantiate Network Service, Scale Network Service* and *Terminate Network Service* from [MANO]

¹ Underlay image is “Figure 5.1: The NFV-MANO architectural framework with reference points” from [MANO]

Primary NFV *On-Demand Self Service* requests flow across Os-Ma-nfvo reference point for:

1. Network Service Lifecycle Management
2. VNF Lifecycle Management

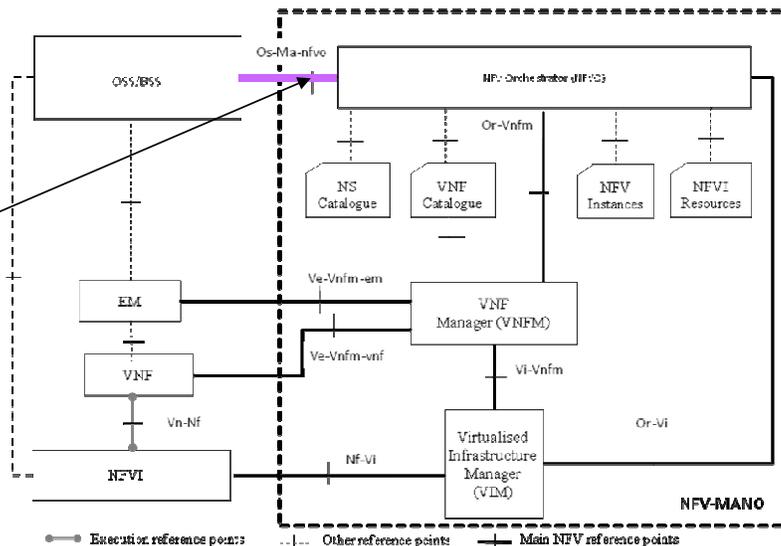


Figure 2 - On-Demand Self Service in NFV²

2 Automated Lifecycle Management Actions

Automated Lifecycle Management Actions (ALMAs) are high-level operations that a cloud service customer organization can request of a cloud service provider’s management and orchestration system, such as:

- Check VNF instantiation feasibility
- Instantiate VNF
- Update VNF software
- Upgrade VNF software
- Query VNF
- Modify VNF
- Terminate VNF
- Scale VNF
- Heal VNF

These automated actions are logically equivalent to many traditional, manually executed actions covered by TL 9000 product category 7. For example, as shown in Table 1 product category 7.1.1 **Installation** would cover instantiate VNF, update VNF software, upgrade VNF software, scale VNF and terminate VNF if those actions were executed manually.

Table 1 - TL 9000 Product Category 7.1.1 Installation

Table A-1 Product Category Definitions			
Category Code	Category Name	Definition	Examples
7.1	Network Installation and Provisioning	Contracted or internal services to install and/or provision equipment within the network or to construct network facilities.	
7.1.1	Installation	Contracted or internal services to position, configure, remove, and/or adjust a hardware/software product within the network	<ul style="list-style-type: none"> • New equipment installation • Expansion installation • Upgrade installation • Equipment removal

Measurement of most category 7 lifecycle management actions are normalized by **job**, defined by [TL_9000] as:

A job is a set of tasks, performed over one or more days, which must be carried out to achieve a defined change of operational state of some subset of the network. The completion of any single task of a job does not achieve the defined change. The job is complete only when all associated tasks have been completed.

² Underlay image is “Figure 5.1: The NFV-MANO architectural framework with reference points” from [MANO]

Where a particular organization feels this will not clearly define the total number of Jobs for a particular program of work, then the actual number of Jobs will be discussed and agreed by both parties in advance of the start of work.

While the definition of job does not preclude automated (non-human) execution of the “set of tasks,” automated execution of a lifecycle management task has materially different expectations, such as the presumption of completing the automated tasks in seconds or minutes rather than “over one or more days.” To avoid confusion by experienced quality and services practitioners with traditional, manually-executed jobs, this work will use *ALMA* for automatically-executed lifecycle management action instead of [TL_9000] *job* when referring to automatically executed lifecycle management actions.

3 Lifecycle Management Errors and Failures

A manually executed category 7.1.1 expansion installation (a.k.a., growth) is materially different from an automatically executed VNF scale action because the roles, responsibilities and accountabilities surrounding execution of the growth action are materially different. Manually executed lifecycle management actions can fail because of a range of well known procedural errors; likewise, automatically executed lifecycle management actions can fail because of a variety of error conditions. As shown in Table 3-1, many of the [TL_9000] procedural error conditions have analogous error conditions in the context of automated lifecycle management actions.

Table 3-1 – Errors in Traditional and Automated Lifecycle Management Actions

[TL_9000] Procedural Error	(Proposed) Lifecycle Management Error	Example of Elevated VNF Service Risk due to Lifecycle Management Error
An error that is the direct result of <u>human intervention or error.</u>	An error that is the direct result of <u>policy, management, or orchestration.</u>	
Contributing factors can include but are not limited to...		
a) deviations from accepted practices or documentation,	Failing to continuously enforce anti-affinity placement rules for VNFCs can lead to both primary and protecting VNFC instances appearing in a single NFV infrastructure failure group	
b) inadequate training,	<i>not generally applicable</i>	
c) unclear, incorrect, or out-of-date documentation,	faulty or out of date: automation scripts, policies; service, VNF or resource descriptors; etc	Proper execution of faulty or out of date scripts can produce faulty and higher risk (e.g., simplex) VNF configurations
d) inadequate or unclear displays, messages, or signals,	inadequate, insufficient or stale FCAPS input data	Inadequate, insufficient or stale performance information can produce faulty elastic capacity management decisions
e) inadequate or unclear hardware labeling,	<i>not generally applicable</i>	
f) miscommunication,	<i>not generally applicable</i>	
g) non-standard configurations,	Configuring non-standard third party software to monitor, manage, backup or control a VNF instance.	

h) insufficient supervision or control		Failing to diligently monitor alarms and correct unsuccessful VNF repair actions can leave impacted VNF simplex exposed
i) user characteristics such as mental attention, physical health, physical fatigue, mental health, and substance abuse.	faulty execution of policy by a management or orchestration element	Faulty execution of automation scripts can produce faulty and higher risk (e.g., simplex) VNF configurations
	tardy execution of lifecycle management action	Insufficient automated management and orchestration capacity or other causes result in late execution of VNF repair, capacity change or other lifecycle management action, thereby prolonging service risk to target VNF.
	risky operational policies	Failing to maintain sufficient spare application capacity online can yield poor user service quality when unforeseen surges in offered workload occur during capacity change lead time intervals

While a manually executed ‘expansion installation’ (a.k.a., growth) action can fail for a handful of well understood reasons like faulty MOP or procedural error, an automated grow (scale) VNF action can fail for a far more diverse range of root causes including:

1. Bug in scaling/configuration script
2. Policy restriction (e.g., virtual resource quota) prohibits requested action at this time
3. Bug in NFV orchestrator
4. Bug in VNF manager
5. Bug in Virtualized Infrastructure Manager
6. Bug in NFV Infrastructure Element
7. Bug in SDN controller
8. Insufficient virtualized infrastructure capacity available
9. Virtualized resource configuration error
10. Timing/synchronization/timeout error
11. NFV infrastructure equipment failure
12. NFV infrastructure, management or orchestration software crash

To properly measure, drive root cause analysis and corrective actions of impairments that are materially different than those of category 7, a new service product category (10) focused on automated lifecycle management actions can be created.

4 TL 9000 Measurements of Traditional Lifecycle Management Actions

Specific measurement rules for category 7 service products covering traditional lifecycle management actions:

Table A-2 Measurement Applicability Table (Normalization Units)								
Product Category								
Code	Description	Problem Reports H,S,V	Outage Frequency V	Mean Time to Restore Service V	Basic Return Rate H	Service Quality V		
						SQ		
TL 9000 Measurement Symbols (see Table A-6)		NPR	SSO	MTRS	BRR	Numerator	Denominator	Notes/Comments
7	Service Products							
7.1	Network Installation and Provisioning							
7.1.1	Installation	Job	Job	NA	NA	Non-conforming audits	Audits	Based on audits performed by the organization or on its behalf prior to customer acceptance. Defects shall include organization caused installation engineering defects and installation defects. A nonconforming audit is one that fails to satisfy specified acceptance requirements. These audits may be performed on a sample basis. NOTE: An installation audit performed by the customer is not included unless the organization requested the customer perform the audit
7.3.1	Network Maintenance	Network Elements maintained	Maintenance Actions	NA	NA	Maintenance Callbacks	Maintenance Actions	Maintenance actions or callbacks shall not be counted if it is determined that they were attributable to incorrect information supplied by the customer as mutually agreed between parties. A maintenance action is a site visit to a customer's location or remote intervention either through telephone/electronic contact with local customer personnel or through remote system access for the purpose of performing maintenance. A maintenance callback is a site visit to a customer's location or remote access for the purpose of maintenance rework.
7.3.2	Network Operations Center	Network Elements under management	Network Elements under management	Required	NA	NA		
7.3.3	Network Performance Services	Job	Job	NA	NA	NA		

Key insights about quality measurement of traditional lifecycle management services that are applicable to measurement of automated lifecycle management functions:

1. Different lifecycle management functions can be mapped into different categories, each with somewhat different measurements and normalizations
2. Number of Problem Reports (NPR) is applicable to most lifecycle management services. Per [TL_9000] section 5.1.1, the purpose of the Number of Problem Reports (NPR) measurement is:

This measurement is used to evaluate the number of customer-originated problem reports related to the product and its associated processes during its General Availability (GA) and Retirement Phases. Problem reports may have a negative impact on the organization (such as rework), on the customer (such as scheduling repeat site visits) and may jeopardize or affect the customer's business operations. Problem reports contribute to loss of end-user loyalty and customer satisfaction. This measurement is intended to stimulate continuous improvements resulting in a reduction of the number of problem reports, associated costs and potential revenue losses.

3. Fix Response Time (FRT) is applicable to most lifecycle management services. Per [TL_9000] section 5.2.2, the purpose of Fix Response Time (FRT) measurement is:

This measurement is used to quantify the responsiveness to customer-originated problem reports and to facilitate prompt fixes and closures of these problem reports. This measurement does not reflect responsiveness to service or operation restoration requests for reported incidents.

4. Overdue Problem Fix Responsiveness (OFR) is applicable to most lifecycle management services. Per [TL_9000] section 5.3.2, the purpose of Overdue Problem Fix Responsiveness (FRT) measurement is:

This measurement is used to quantify the responsiveness to overdue customer originated problem reports.

5. On Time Delivery (OTD) is applicable to most lifecycle management services. Per [TL_9000] section 5.4.2, the purpose of On Time Delivery (OTD) measurement is:

This measurement is used to evaluate the organization's on-time delivery performance to meet the customer's need for timely product delivery and to meet end-customer expectations.

6. Outage frequency (SSO) is applicable to many lifecycle management services. Per [TL_9000], the purpose of Support Service Caused Outage Measurement (SSO) is to

“provide insight into the impact of the organization's support service activities on the performance of the network. It is used to evaluate the downtime frequency delivered to the end user during product operation with a goal of reducing the frequency of these events, their associated cost, and their impact on customer satisfaction and revenue.”

Per [TL_9000] section 6.3.3:

“the Support Service Caused Outage (SSO) measurement monitors the frequency of incidents resulting in network element outages caused by organization-attributable network support service related actions and/or decisions. The SSO measurement expresses the outages per normalization unit on a monthly basis as a percentage of normalization units.”

7. Problem reports and outage frequency for lifecycle management services are normalized by one of the following:
- a. **Job,**
 - b. **Contract**
 - c. **Network Elements maintained or under management**
 - d. **Maintenance action,** where maintenance is defined by [TL_9000] as: *Any activity intended to keep a functional hardware or software unit in satisfactory working condition. The term includes tests, measurements, replacements, adjustments, changes and repairs*
8. Service quality measurements are applicable to some lifecycle management services as:
- a. **Non-conforming audits** as a fraction of audits
 - b. **Defective transactions** as a fraction of transactions
 - c. **Maintenance callbacks** as a fraction of maintenance actions

5 Context of Proposed Measurement Categories

5.1 Proposed New Service Measurement Category Definition

A subcategory will be created for each major class of NFV management and orchestration lifecycle management actions:

- VNF lifecycle management in category 10.1
- Network service lifecycle management in category 10.2

- VNF Forwarding Graph lifecycle management in category 10.3
- Virtual Link lifecycle management in category 10.4

Within each of these subcategories:

- 10.*.1 covers installation services which are likely to be applicable to all categories of cloud/NFV-based automated lifecycle management actions. Note that this subcategory is deliberately analogous to 7.1.1 Installation which covered “Contracted or internal services to position, configure, remove, and/or adjust a hardware/software product within the network.”
- 10.*.2 covers scaling services which are likely to be applicable to all categories of cloud/NFV-based automated lifecycle management actions
- 10.*.3 covers healing, when applicable

Table 2 - Proposed Automated Lifecycle Management Measurement Categories

Category Code	Category Name	Definition	Examples
10	Automated Lifecycle Management Service Products	Automated lifecycle management services provided by NFV management and orchestration deployments	
10.1	Network Element Services	Automated lifecycle management services for network elements (a.k.a., virtualized network functions)	
10.1.1	VNF Installation, Interaction and Change	Automated services to position, configure, remove, and/or adjust a VNF product within the network. <i>Analogous to 7.1.1 ‘Installation’ for PNFs</i>	<ul style="list-style-type: none"> • Check VNF instantiation feasibility • Instantiate VNF • Update VNF software • Upgrade VNF software • Query VNF • Modify VNF • Terminate VNF
10.1.2	VNF Scaling	Increase or decrease online application capacity either vertically or horizontally	<ul style="list-style-type: none"> • Scale VNF
10.1.3	VNF Healing	Automated services to maintain VNF in the field or by remote access methods. This excludes warranty and standard maintenance activities performed in support of a particular product by the product OEM. <i>Analogous to 7.3.1 ‘Network Maintenance’ for PNFs</i>	<ul style="list-style-type: none"> • Heal VNF
10.2	Network Service Services	Automated lifecycle management for service delivery chains of physical and virtualized network functions	
10.2.1	Network Service Installation, Interaction and Change	Automated services to position, configure, remove, and/or adjust a network service.	<ul style="list-style-type: none"> • Instantiate Network Service • Terminate Network Service • Update Network Service • Query Network Service

10.2.2	Network Service Scaling	Increase or decrease online network service capacity	<ul style="list-style-type: none"> Scale Network Service
10.3	Forwarding Graph Services	Automated lifecycle management for VNF Forwarding Graphs	
10.3.1	Forwarding Graph Installation, Interaction and Change	Automated services to position, configure, remove, and/or adjust a VNF forwarding graph.	<ul style="list-style-type: none"> Create VNFFG Delete VNFFG Update VNFFG Query VNFFG
10.4	Virtual Link Services	Automated lifecycle management for Virtual Links	
10.4.1	Virtual Link Installation, Interaction and Change	Automated services to position, configure, remove, and/or adjust a virtual link.	<ul style="list-style-type: none"> Create VL Delete VL Update VL Query VL

Table 3 - Proposed Automated Lifecycle Management Service Measurements

Code	Description	Problem Reports H,S,V	Outage Frequency V	Service Quality V		
				SQ		
TL 9000 Measurement Symbols (see Table A-6)		NPR	SSO	Numerator	Denominator	Notes/Comments
10	Automated Lifecycle Management Service Products					
10.1	Network Element Services					
10.1.1	VNF Installation, Interaction and Change	ALMA (automated job)	ALMA (automated job)	Faulty Actions	Transactions	[1]
10.1.2	VNF Scaling	ALMA (automated job)	ALMA (automated job)	Defective scaling transactions	Scaling requests	
10.1.3	VNF Healing	Maintenance action	NA	Defective healing actions	Healing requests	
10.2	Network Service Services					
10.2.1	Network Service Installation, Interaction and Change	ALMA (automated job)	ALMA (automated job)	Faulty Actions	Transactions	[1]
10.2.2	Network Service Scaling	ALMA (automated job)	ALMA (automated job)	Defective scaling transactions	Scaling requests	
10.3	Forwarding Graph Services					
10.3.1	Forwarding Graph Installation, Interaction and Change	ALMA (automated job)	ALMA (automated job)	Faulty Actions	Transactions	[1]
10.4	Virtual Link Services					
10.4.1	Virtual Link Installation, Interaction and Change	ALMA (automated job)	ALMA (automated job)	Faulty Actions	Transactions	[1]

Notes:

[1] - Based on audits performed by the organization or on its behalf prior to customer acceptance. Defects shall include organization caused engineering defects along with installation or construction defects. A nonconforming audit is one that fails to satisfy specified acceptance requirements. These audits may be performed on a sample basis.

NOTE: An audit performed by the customer is not included unless the organization requested the customer perform the audit

5.2 Proposed Measurement Category in the Context of NFV

Figure 3 overlays the TL 9000 services perimeters onto a canonical NFV reference architecture:

- **End User Services** - NFV is deployed to virtualize end user services, like virtualizing product category 9.1 voice, product category 9.2 wireless, product category 9.8 video broadcast services, product category 9.9 emergency service network or other services. Practically, this includes VNFs that implement network functions implementing the applicable end-user service, as well as the applicable element management systems, operations support systems and business support systems.
- **NFV Infrastructure** – NFV infrastructure equipment service virtualized compute, memory, storage and networking to VNFs across the Vn-Nf NFV reference point. NFV infrastructure service can be covered under TL 9000 product category 9.6 ‘e-Business and Content Hosting’ which includes ‘cloud computing.’
- **NFV Management and Orchestration** – NFV management and orchestration primarily offers automated lifecycle management services for end user service organizations to instantiate, configure, scale, heal, upgrade and terminate their VNFs and service chains which deliver service to end users and otherwise support those organizations’ business needs. Product category 10 measures the qualities of the automated lifecycle management services rendered by an NFV management and orchestration deployment.

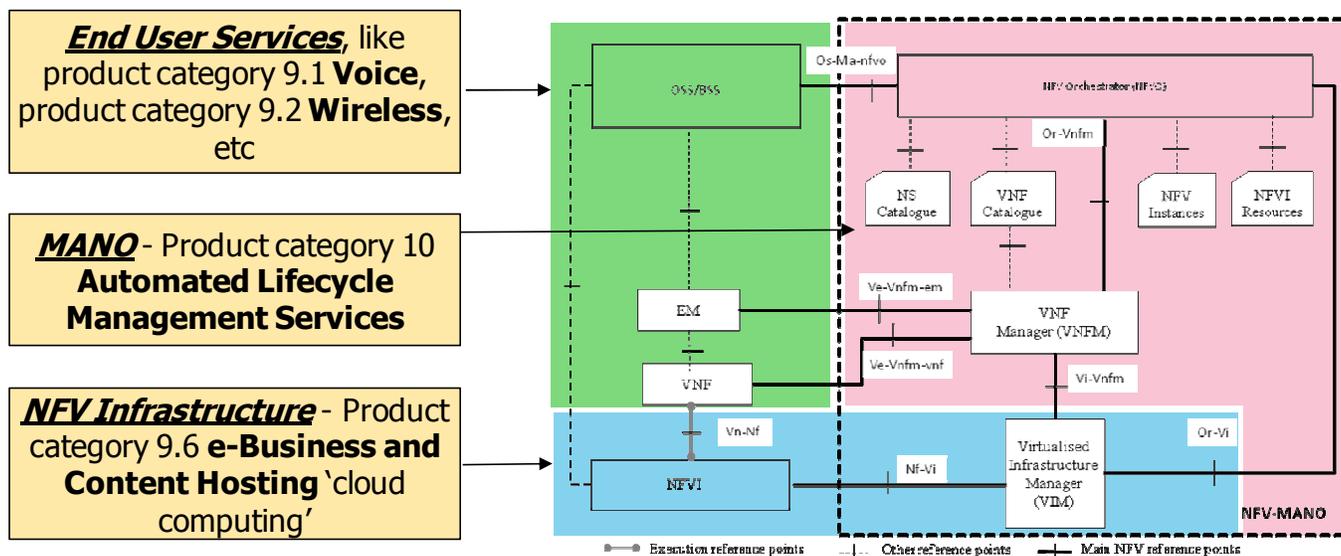


Figure 3 – TL Services Product Categories on NFV Reference Architecture³

5.3 Proposed Measurement Category in the Context of Proposed Accountability Framework

Figure 4 maps the NFV architecture into [ISO-IEC_17788], [ISO-IEC_17789] terminology in a [TMF_GB917], [TMF_TR178] model. Critical services provided by the NFV infrastructure, management and orchestration cloud service provider organization to cloud service customer organizations offering VNF-based services to end users are:

³ Underlay image is “Figure 5.1: The NFV-MANO architectural framework with reference points” from [MANO]

- Virtual machine and virtual networking services to host VNFCs across NFV's Vn-Nf reference point
- Management and orchestration services for the virtual resources, VNFs and network services hosted on the NFV infrastructure across, primarily delivered across NFV's Os-Ma-nfvo reference point

Note that while automated lifecycle management ALMAs are controlled across the Os-Ma-nfvo reference point, fulfilling the actual lifecycle management action will likely require the NFV orchestrator to interwork with VNF managers, virtualized infrastructure managers and NFV infrastructure elements, and perhaps trigger changes across the Vn-Nf reference point, like when executing *Scale VNF*. Because these automatic lifecycle management actions manifest across both management and control interfaces like Os-Ma-nfvo as well as virtual infrastructure interfaces like Vn-Nf, category 10 Automated Lifecycle Management Services cover both of those interfaces, as shown on Figure 4.

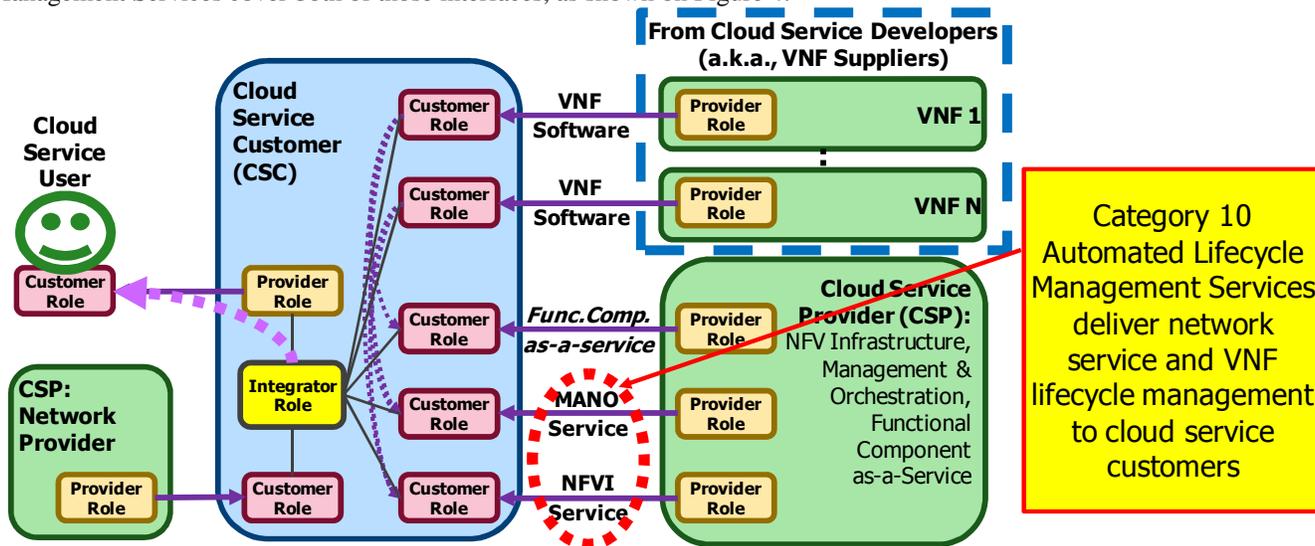


Figure 4 - On-Demand Self Service in NFV

6 Sample Use Cases

The automated lifecycle management product category is best understood via a suite of illustrative use cases. Consider the hypothetical context of Figure 5:

- Hypothetical cloud service provider is an NFV provider organization offering NFV infrastructure, management and orchestration services to multiple cloud service customers, including the VoLTE provider organization
- Hypothetical target cloud service customer is a VoLTE provider organization offering voice-over-LTE to the telco's end users. Other cloud service customers are assumed to run alongside the target cloud service customer's VNFs on the cloud service provider's NFV cloud, but details of those other customers are unimportant for this use case.
- Cloud service customers request many different types of automated lifecycle management ALMAs, but this use case considers only VNF scaling (product category 10.1.2) ALMAs
- Use case considers a single month during which 1,000 VNF scaling actions are requested by the target cloud service customer of the NFV cloud service provider, nominally half of which are growth actions and half of which are degrowth actions.
- Customer request date/time (CRD) for all VNF scaling actions is assumed to be ASAP
- For ALMAs within the NFV provider organization's terms of use, the supplier promise date/time (SPD) for all VNF scaling actions is 30 minutes from time of request.

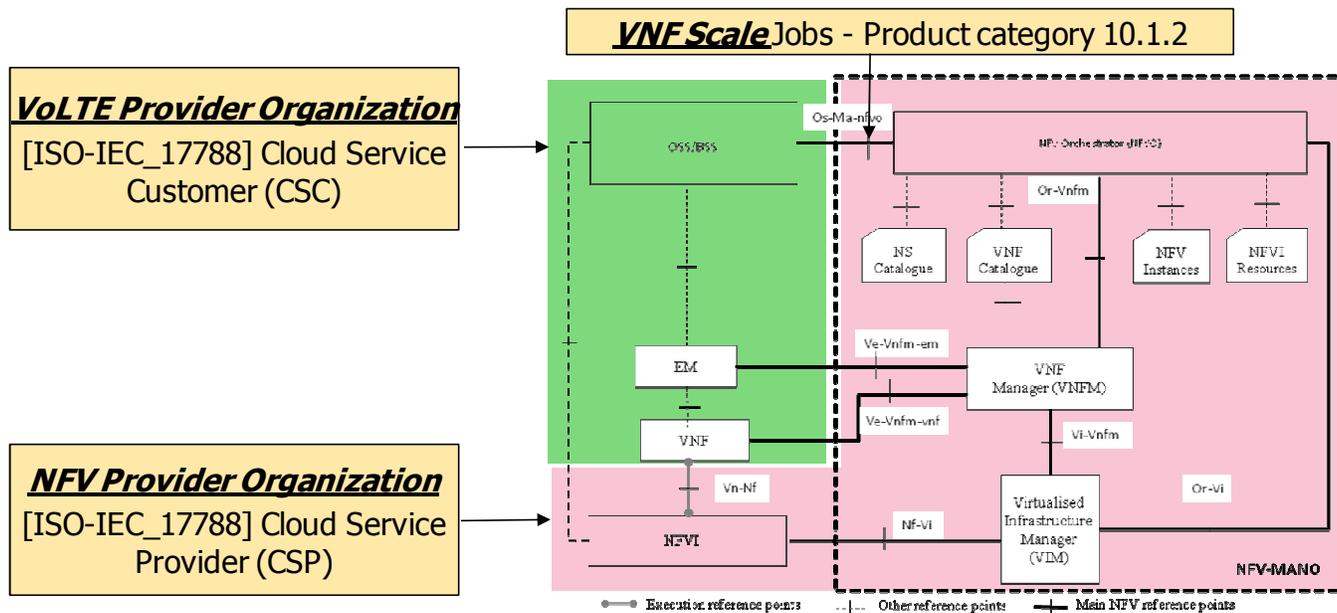


Figure 5 – Use Case Context⁴

6.1 On Time Service Delivery (OTS)

[TL_9000] On Time Delivery measurements are currently framed in days. On-demand automated lifecycle management actions will routinely complete in minutes (or perhaps even seconds) from moment of request, rather than days. Thus, on time delivery measurement of automated lifecycle management should refer to “time” instead of “date,” as in Supplier Promise Time as, say, 30 minutes from time of request rather than a traditional, fixed Supplier Promise Date, such as Friday July 10th 2015.

Over a hypothetical month, assume the VoLTE provider organization issues 1,000 VNF scale requests to the NFV provider organization. Assume 10 of those scale requests are rejected by the NFV provider organization because VNF identifiers or other input parameters are wrong; assume another 10 requests are rejected because the VoLTE organization’s rate of job submission exceeds the NFV provider organization’s limit for pending ALMAs and assume that the VoLTE provider cancels another 10 pending actions prior to completion because of changes (i.e., reductions) in patterns of user demand.

Dvd = 1000 scale requests
 - 10 rejects due to input errors
 - 10 rejects due to rate limits
 - 10 cancellations
Dvd = 970 valid ALMAs

Of the 970 valid ALMAs, assume all ALMAs completed successfully in less than the SPD of 30 minutes, except: 10 failed due to lifecycle management errors; and 10 completed successfully in longer than 30 minutes

DVa = 970 valid ALMAs
 - 10 lifecycle management errors
 - 10 exceed 30 minute SPD
DVa = 950 ALMAs

Apply the formula of [TL_9000] Table 5.4-2 OTD Measurement Identifiers and Formulas to produce On-Time Service Delivery (OTS):

$$\text{On-time service delivery (OTS)} = 100 * (\text{DVa} / \text{DVd})$$

$$\text{OTS} = 100 * (950 / 970)$$

⁴ Underlay image is “Figure 5.1: The NFV-MANO architectural framework with reference points” from [MANO]

OTS = 97.9%

Note that since promise times are likely to be expressed in minutes rather than days, TL 9000 must precisely clarify when a promised time is exceeded. For example, if an NFV service provider promises to complete a lifecycle management action in 30 minutes, then is the promise violated if the action completes at $T_{Request} + 30:00.001$? $T_{Request} + 30:01$? $T_{Request} + 30:30$? $T_{Request} + 31:00$?

6.2 Service Quality (SQ)

Considering the same hypothetical scenario of section 6.1 On Time Service Delivery (OTS):

```
SQt = Total number of service transactions opened in the month
SQt = 1000 scale requests
      - 10 rejects due to input errors
      - 10 rejects due to rate limits
SQt = 980 service transactions
```

The common definition of defective is ‘*imperfect in form or function, faulty.*’⁵ Defective service transactions consider whether the service transformation from request to final response is imperfect or faulty in some way. A transaction that is ***not*** defective is said to be **correct**; thus each transaction is either correct or defective. The general factorization of transactions as correct versus defective can be illustrated by considering SIP response codes. The following SIP response codes indicate a **correct** transaction:

- ✓ 200 OK and all other 2xx successful responses
- ✓ 3xx redirection responses – because the server is correctly processing (i.e., redirecting) a request
- ✓ 4xx client failure responses – because server is correctly detecting a syntax, semantic or policy error of a client request
- ✓ 501 Not Implemented –
- ✓ 505 Version Not Supported –
- ✓ 513 Message Too Large –
- ✓ 580 Precondition Failure –
- ✓ 600 Busy Everywhere –
- ✓ 603 Decline –
- ✓ 604 Does Not Exist Anywhere –
- ✓ 606 Not Acceptable –

The following SIP response codes indicate a **defective** transaction:

- ☛ 500 Server Internal Error -
- ☛ 502 Bad Gateway -
- ☛ 503 Service Unavailable -
- ☛ 504 Server Time-Out -

Note that since only final responses are considered by the service quality metric, all 1xx provisional responses are ignored.

```
SQd = Number of defective service transactions reported in the month
SQd = 10 lifecycle management errors - rejects due to input errors
SQd = 10 defective service transactions - rejects due to rate limits
```

Apply the formula of [TL_9000] Table 9.1-2 *SQ Measurement Identifier and Formula* to produce service quality (SQ):

```
Service Quality (SQ) = 100 * (SQd / SQt)
SQ = 100 * (10 / 980)
SQ = 1.0%
```

⁵ <http://www.merriam-webster.com/dictionary/defective> retrieved 6/23/15.

6.3 Support Service Caused Outages (SSO)

Considering the same hypothetical scenario of section 6.1 *On Time Service Delivery (OTS)*, assume that two of the 980 SQt service transactions produce outages of the target VoLTE service provider's user facing service:

1. One of the 10 lifecycle management errors leaves the target VNF's configuration in a faulty state producing a partial service capacity loss outage
2. One of the nominally successful service transactions misconfigured virtual networking so the target VNF is no longer accessible to user traffic (i.e., total service outage)

Apply the formula of [TL_9000] *Table 6.3-2 SSO Measurement Identifiers and Formulas* to produce service quality (SSO):

Nso = Number of support service caused outages in month m
Nso = 2

Ns = Normalization factor for month m
Ns = 980 service transactions

SSO = 100 * (Nso / Ns)
SSO = 100 * (2 / 980)

SSO = 0.2%

Support service caused outage (SSO) events are also charged as service outages against the target element. While VNF supplier attributable support service caused outages will be charged as SO4 against the impacted VNF, support service caused outages attributable to the following causes will be charged as SO2 (all causes outage downtime):

- a) NFV orchestrator or VNF manager bug or failure
- b) Virtualized infrastructure manager bug or failure
- c) NFV infrastructure bug or failure
- d) Incompatible or faulty operational policy by the NFV cloud service provider
- e) Incompatible or faulty integration of VNF's automated lifecycle management scripts, configurations or files with NFV cloud service provider
- f) Risky operational policies by cloud service provider, such as failing to maintain adequate infrastructure capacity online to fulfill all resource allocation requests
- g) Risky operational policies by cloud service customer, such as failing to allow enough time to detect and mitigate the user service impact of failed lifecycle management actions

6.4 Number of Problem Reports (NPR4)

Considering the same hypothetical scenario of section 6.1 *On Time Service Delivery (OTS)* and section 6.3 *Support Service Caused Outages (SSO)*, assume that the 980 SQt service transactions prompt the VoLTE service provider to file the following trouble tickets over the month with the NFV service provider organization:

1. **Critical severity** - lifecycle management errors leaves the target VNF's configuration in a faulty state causing a partial capacity loss (from section 6.3 *Support Service Caused Outages (SSO)*)
2. **Critical severity** - nominally successful service transactions misconfigured virtual networking so the target VNF is no longer accessible to user traffic (from section 6.3 *Support Service Caused Outages (SSO)*)
3. **Critical severity** – two nominally successful grow VNF scale requests returned dead-on-arrival VNFCs
4. **Major severity** – grow VNF requests failed on the 3rd, 4th, 7th, 15th and 22nd of the month because infrastructure resources were not available
5. **Minor severity** – 10 grow VNF scale requests exceeded 30 minute completion time commitment (SPD)

6. **Minor severity** – 17 failed VM release events (a.k.a., zombie VM instances) created due to improper resource release by shrink VNF scaling actions. While a failed VM release event will not impact user service, it does leak resources and may lead to overcharging resource usage.
7. **Minor severity** – 14 shrink VNF actions exceeded 30 minute completion time commitment (SPD)

Apply the formula of [TL_9000] *Table 5.1-2 NPR Measurement Identifiers and Formulas* to produce number of problem reports (NPR4):

N_{p4} = Number of problem reports in the month
 $N_{p4} = 7$

NPR_s = Normalization factor for month m
 $NPR_s = 980$ service transactions

$NPR_4 = N_{p4} / NPR_s$
 $NPR_4 = 7 / 980$

$NPR_4 = 0.0071$

6.5 Fix Response Time (FRT)

Fix response time (FRT) is measured for category 10 as it is for problem reports of any other product category.

6.6 Overdue Problem Fix Responsiveness (OFR)

Overdue problem fix responsiveness (OFR) is measured for category 10 as it is for problem reports of any other product category.

6.7 Aggregating Metrics

Undoubtedly, each of the cloud service customer organizations will want to monitor the on-time service delivery (OTS), service quality (SQ), support service caused outages (SSO), number of problem reports (NPR4), fix response time (FRT) and overdue problem fix responsiveness (OFR) qualities of their NFV cloud service provider(s) on a regular basis. If an NFV cloud service provider fails to meet expectations on some or all of the automated lifecycle management quality metrics, then impacted cloud service customer organization(s) will likely demand root cause analysis, corrective actions and get well plans from the cloud service provider.

7 Engineering Quality Measurements

Once objective and quantitative quality measurements of automated lifecycle management actions are in place, one can:

- ✓ set quantitative quality objectives,
- ✓ cascade latency, defect and other quality budgets to appropriate infrastructure, management and orchestration elements;
- ✓ methodically select and engineer orchestration, management and infrastructure elements,
- ✓ integrate and configure orchestration, management and infrastructure elements, along with operational policies, to make it feasible and likely that quality objectives will be consistently achieved, and
- ✓ manage performance to consistently fulfill those objectives.

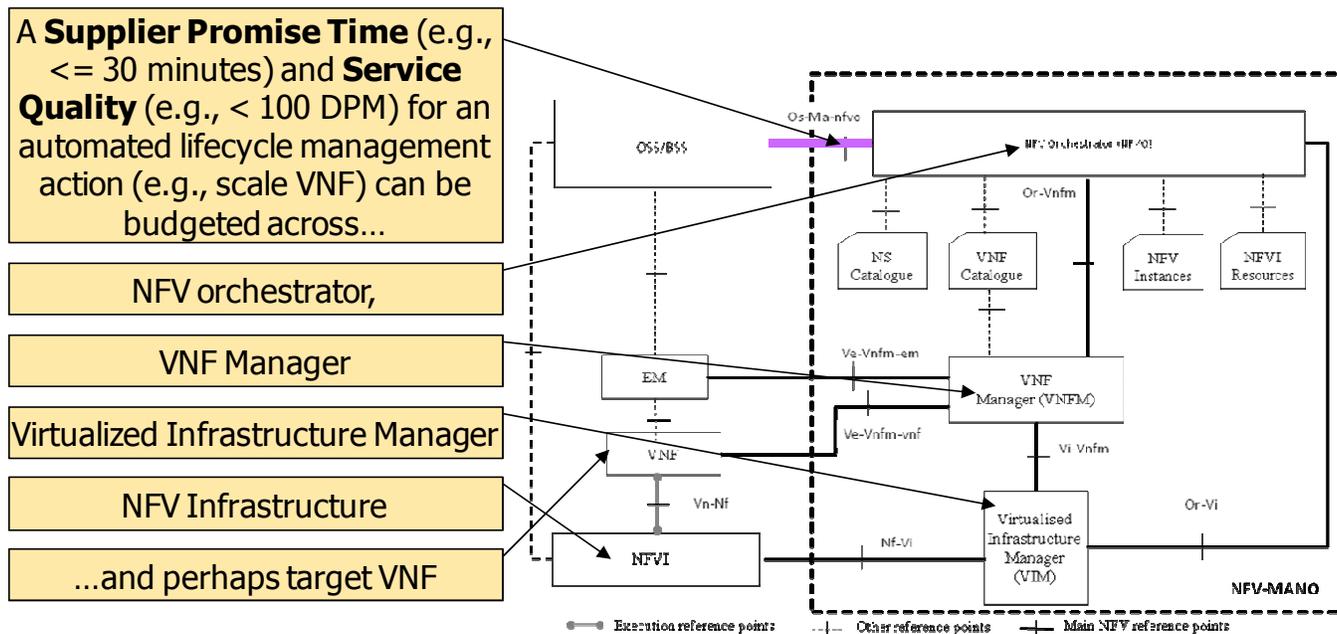


Figure 6 – Engineering Quality Measurements⁶

As shown in Figure 6, given an objective and quantitative objective like a supplier promise time of less than 15 minutes or a service quality of less than 100 defects per million (DPM) for scale VNF operations across the Os-Ma-nfvo interface, one can budget both latency and DPM across all of the elements in the VNF scaling fulfillment chain. NFV infrastructure, management and orchestration elements are selected and configured to make achievement of those latency and DPM budgets both feasible and likely. One can assure overall service quality by monitoring and managing quality of elements in the fulfillment chain, including detecting, localizing and correcting significant deviations from performance objectives.

8 References

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⁶ Underlay image is “Figure 5.1: The NFV-MANO architectural framework with reference points” from [MANO]