ETSI GR NFV-REL 013 V5.1.1 (2023-02)

Network Functions Virtualisation (NFV) Release 5; Reliability; Report on cognitive use of operations data for reliability

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Reference
DGR/NFV-REL013

Keywords
availability, NFV

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
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Foreword

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

Modal verbs terminology

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1 Scope

The present document aims at studying how operations data (KPIs, metrics, alarm notifications, event logs, debug information) can be exploited to ensure the availability and reliability of NFV-MANO and of the network services it manages using data analysis/data driven techniques. This includes, among others, the use of machine learning to find patterns for cases where detailed semantics information is unavailable (e.g. due to confidentiality) or the amount of data is overwhelming. Use cases are created describing how the information can be used offline (for example for root cause analysis and predictive maintenance resulting in, e.g. creation and/or changes of deployment flavours) and online (to identify appropriate LCM operations and policy changes in order to achieve the intended service availability objectives).

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

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

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

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GS NFV-IFA 005 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".

[i.2] ETSI GS NFV-IFA 006 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Vi-Vnfm reference point - Interface and Information Model Specification".

[i.3] ETSI GS NFV-IFA 007 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".

[i.4] ETSI GS NFV-IFA 008 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".

[i.5] ETSI GS NFV-IFA 013 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Os-Ma-Nfvo reference point - Interface and Information Model Specification".

[i.6] ETSI GS NFV-IFA 030 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Multiple Administrative Domain Aspect Interfaces Specification".

[i.7] ETSI GS NFV-IFA 031 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Requirements and interfaces specification for management of NFV-MANO".

[i.8] ETSI GS NFV-IFA 032 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Interface and Information Model Specification for Multi-Site Connectivity Services".

[i.9] ETSI GR NFV-IFA 015 (V3.4.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Report on NFV Information Model".

[i.10] ETSI GR NFV-REL 010 (V3.1.1): "Network Functions Virtualisation (NFV) Release 3; Reliability; Report on NFV Resiliency for the Support of Network Slicing".

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[i.28] D.J. Dean et al.: "UBL: Unsupervised behavior learning for predicting performance anomalies in virtualized cloud systems", 9th International Conference on Autonomic Computing (ICAC'12), September 18-20, San Jose, CA, USA.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GR NFV 003 [i.13] apply.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GR NFV 003 [i.13] and the following apply:

AAF	Availability Assurance Function
ACK	Acknowledgement
ADAM	Adaptive Moment Estimation
AFR	Average Failure Rate
ANN	Artificial Neural Network
APF	Anomaly Prediction Function
ASDD	Acceptable Service Data Disruption
ASDT	Acceptable Service Disruption Time
BA	Balanced Accuracy
BMU	Best Matching Unit
BW	Bandwidth
c/n/s	compute/network/storage
CA	Classification Accuracy
CoM	Composite Model
CpI	Checkpointing Interval
CSCF	Call Session Control Function
DLR	Distributed-Log Regression
DS	dissimilarity vector
FDLF	Fault Detection and Localization Function
FE	Functional Entity
FLM	Fault Localization Model

FN	False Negative
FP	False Positive
FPCA	Functional Principal Component Analysis
GRE	Generic Routing Encapsulation
HI	Health-Check Interval
ICMP	Internet Control Message Protocol
IPV4	Internet Protocol Version 4
IPV6	Internet Protocol Version 6
IPVLAN	Internet Protocol Virtual Local Area Network
LB	Load Balancing
LiReg	Linear Regression
LoReg	Logistic Regression
LSTM	Long Short-Term Memory
LTE	Long Term Evolution
MP	MultiPoint
MSCS	Multi-Site Connectivity Services
MTTR	Mean Time to Repair/Restore
NL	Latency
NN	Neural Network
NsDf	NS Deployment Flavour
NsQoS	Network service Quality of Service
ODU2	Optical Data Unit 2
PCA	Principal Components Analysis
PTP	Precision Time Protocol
RA	Required Availability
RAID	Redundant Array of Independent Disks
RCA	Root Cause Analysis
ReLU	Rectified Linear Unit
RF	Random Forest
SARSA	State-Action-Reward-State-Action
SB	Standby Capacity
SL2	Scale Level 2
SL3	Scale Level 3
SLAAC	Stateless Address Autoconfiguration
SLO	Service Level Objectives
SOM	Self-Organizing Map
SVM	Support Vector Machine
Tanh	Hyperbolic Tangent
TN	True Negative
TP	True Positive
UDP	User Datagram Protocol
vPE	Virtualised Provider Edge

4 Overview

Operations of communication networks produce huge amounts of data related to aspects such as characteristics, lifecycle, behavior or performance/fault monitoring.

In the context of the multi-vendor, multi-layer NFV architecture, the exploitation of such massive data with the use of cognitive approaches would ease the networks management, and could provide, in particular, the assurance of resilient runtime operations of these networks.

The present document studies how machine learning could be applied to NFV operations data for reliability and availability purposes. Clause 5 details the NFV architecture interfaces through which the field data may be collected, together with the operations which create these data.

Three families of data-driven techniques are described in clause 6: supervised, unsupervised and reinforcement learning. Used for operations control and management, they may help to build zero-touch control loops and pave the way to autonomous networking.

Three selected use cases for the use of operations data for reliability and availability are described in clause 7:

- Service availability assurance for meeting and maintaining a given network service availability.
- Root cause analysis, i.e. real-time fault localization for mitigation of incidents which underly detected anomalies.
- Anomaly prediction for anticipation of failures which could lead to outages.

A list of recommendations, some of which call for requirements specification, is finally provided in clause 8 for each use case.

5 Operations data

5.1 Nature of the data

The main input needed for cognitive approaches such as machine learning is data. Operations data of the NFV ecosystem arise from operations launched at the numerous NFV-MANO interfaces. Figure 5.1-1 shows all the interfaces through which operations data can be collected. In this figure, the interfaces are grouped, when it is possible, according to the reference points of the NFV architecture. The number following each interface refers to the clause number in Annex A of the present document elaborating on the interface. Two interfaces are common to all reference points: performance management and fault management. In addition, the policy management interface is also common with two exceptions currently. A number of interfaces exists in similar form for different resources. To improve readability, similar interfaces related to compute, network and storage are grouped through the symbol "c/n/s". Their references are also combined (e.g. A.5.2/3/4.1 meaning respectively A.5.2.1, A.5.3.1 and A.5.4.1).

The operations executed at these interfaces are of different nature:

- Lifecycle management: create, activate, associate, upload, fetch, instantiate, add, allocate, attach, build, transfer, extract/delete, stop, deactivate, disassociate, terminate, detach.
- Modification: modify, change, update, scale, migrate.
- Inquiry: query, get (alarm list, operation status, indicator value).
- Incidents: escalate severity, ACK alarms, heal, revert-to snapshot.
- Other LCM operations: grant (NS/VNF lifecycle), coordinate, operate, set (configuration).
- Subscription: initialization, termination, information query.
- Reporting: notification.

All operations found at the different interfaces are listed in Annex B.

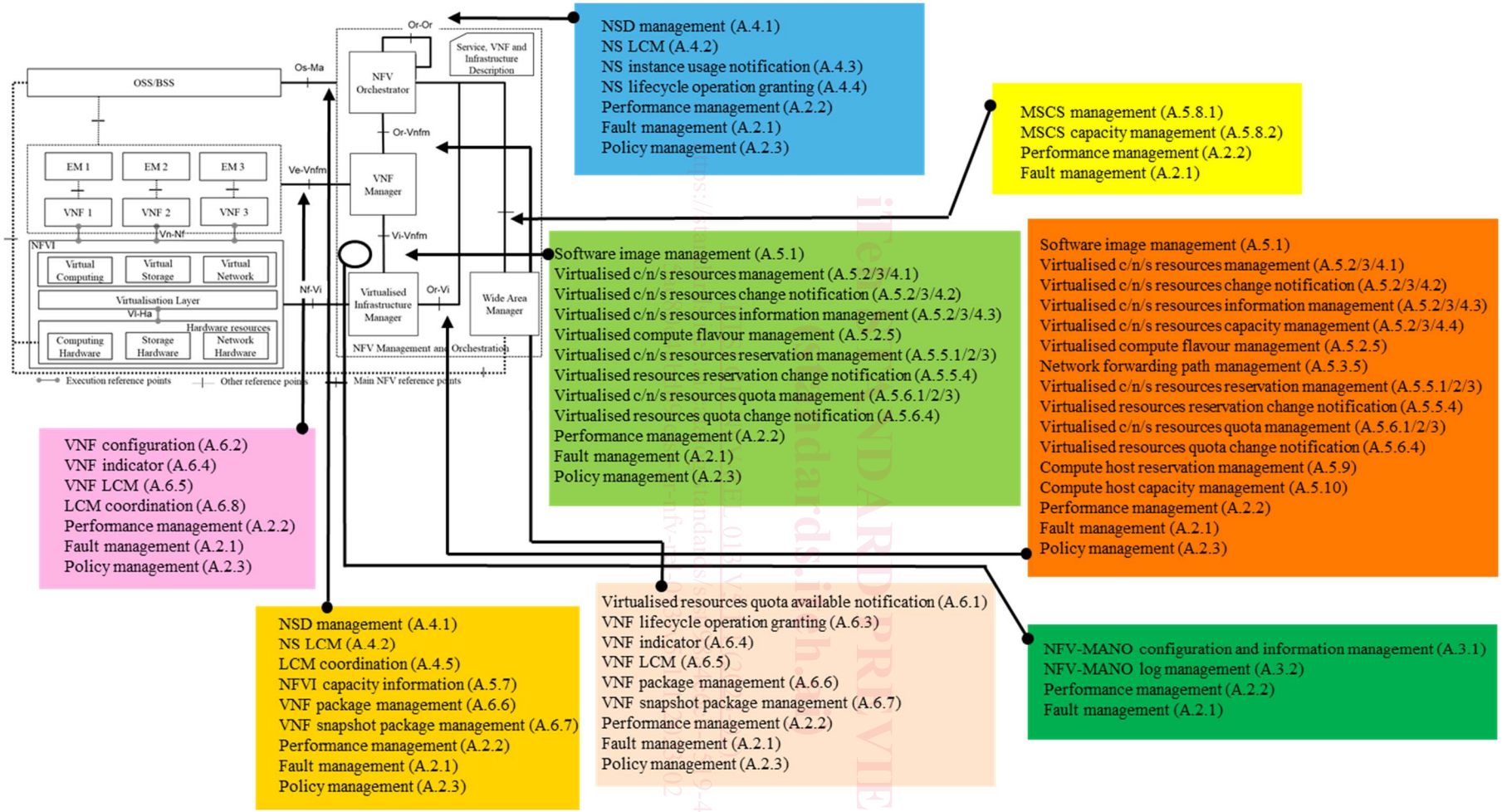

Figure 5.1-1: Interfaces of the NFV architecture

5.2 Data contents

Operations data arise from the operations shown in Annex B as the contents of their input/output parameters. These contents are composed of encapsulated information elements associated with attributes and types. Annex A shows these information. For illustration purpose, the encapsulation of fault management operations data is used below. Figure 5.2-1 lists the operations related to the fault management interface which is defined for all NFV reference points. The input/output parameters, followed by their type, are also provided for the operations. Figures 5.2-1 and 5.2-2 develop the encapsulation of the information elements in use, associated with their attributes and types. The notation applied in these figures is the following:

- 'xor' means that only one parameter:type or attribute:type can be used at a time from the list;
- regular typeset means a primitive/predefined type;
- bold typeset means a type/information element whose data structure is given in the present clause - for illustration purposes, the arrows show the encapsulation of the data structure for some particular types/information elements of an alarm;
- italic typeset means Enum whose values are listed in Table 5.2-1;
- bold+italic typeset means abstract type in place of which an appropriate specialization/child type can be used.

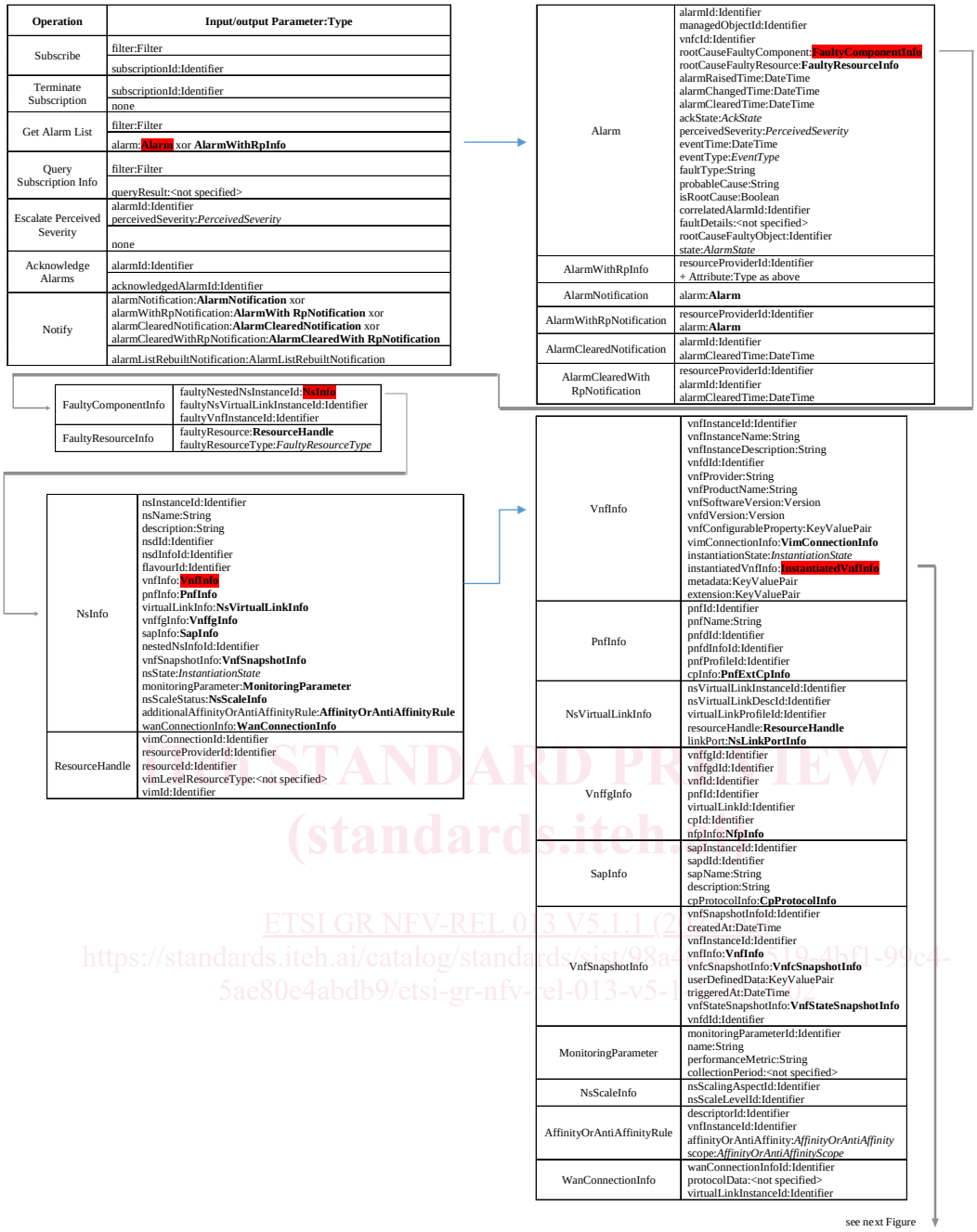

Figure 5.2-1: Operations data at the fault management interface