



GROUP REPORT

**Network Functions Virtualisation (NFV) Release 3;
Protocols and Data Models;
Report on protocol and data model solutions for
Multi-site Connectivity Services**

Reference

DGR/NFV-SOL017ed331

Keywords

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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

In the present document "**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 reports about the network connectivity protocols and data model solutions that are available in the industry (as specified by other organizations) and analyses the extent to which these solutions address the functional, interface and descriptor requirements specified in ETSI GS NFV-IFA 032 [i.2], ETSI GS NFV-IFA 010 [i.3], ETSI GS NFV-IFA 005 [i.4], ETSI GS NFV-IFA 007 [i.5], ETSI GS NFV-IFA 013 [i.6] and ETSI GS NFV-IFA 014 [i.7] for the management and support of multi-site connectivity services.

The present document concludes with a set of recommendations about the protocol and data model specification work required for addressing the gaps and requirements set specified in the above mentioned specifications.

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 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".
- [i.2] ETSI GS NFV-IFA 032: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Interface and Information Model Specification for Multi-Site Connectivity Services".
- [i.3] ETSI GS NFV-IFA 010: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Functional requirements specification".
- [i.4] ETSI GS NFV-IFA 005: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".
- [i.5] ETSI GS NFV-IFA 007: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".
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- [i.7] ETSI GS NFV-IFA 014: "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Network Service Templates Specification".
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- [i.25] IETF draft-ietf-opsawg-l2nm-01 (work in progress): "A Layer 2 VPN Network YANG Model".
- [i.26] IETF RFC 8040: "RESTCONF Protocol".
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- [i.28] IETF draft-ietf-teas-te-service-mapping-yang-05 (work in progress): "Traffic Engineering (TE) and Service Mapping Yang Model".
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- [i.30] IETF RFC 5737: "IPv4 Address Blocks Reserved for Documentation".
- [i.31] IETF RFC 7951: "JSON Encoding of Data Modeled with YANG".
- [i.32] IETF RFC 8342: "Network Management Datastore Architecture (NMDA)".
- [i.33] IETF RFC 8632: "A YANG Data Model for Alarm Management".
- [i.34] IETF RFC 8795: "YANG Data Model for Traffic Engineering (TE) Topologies".
- [i.35] IETF draft-www-opsawg-yang-vpn-service-pm-01 (work in progress): "A YANG Model for Network and VPN Service Performance Monitoring".
- [i.36] IETF draft-ietf-teas-actn-pm-telemetry-autonomics-03 (work in progress): "YANG models for VN/TE Performance Monitoring Telemetry and Scaling Intent Autonomics".
- [i.37] IETF RFC 8650: "Dynamic Subscription to YANG Events and Datastores over RESTCONF".
- [i.38] IETF RFC 8641: "Subscription to YANG Notifications for Datastore Updates".
- [i.39] IETF RFC 8639: "Subscription to YANG Notifications".
- [i.40] IETF RFC 6241: "Network Configuration Protocol (NETCONF)".
- [i.41] IETF RFC 6020: "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)".

- [i.42] IETF RFC 8407: "Guidelines for Authors and Reviewers of Documents Containing YANG Data Models".
- [i.43] ETSI GS NFV-SOL 003: "Network Functions Virtualisation (NFV) Release 3; Protocols and Data Models; RESTful protocols specification for the Or-Vnfm Reference Point".
- [i.44] IETF RFC 4364: "BGP/MPLS IP Virtual Private Networks (VPNs)".
- [i.45] ETSI GS NFV-SOL 013: "Network Functions Virtualisation (NFV) Release 3; Protocols and Data Models; Specification of common aspects for RESTful NFV MANO APIs".
- [i.46] IETF RFC 8776: "Common YANG Data Types for Traffic Engineering".
- [i.47] TAPI SDK Release 2.2.0, July 2019.

NOTE: Available at <https://github.com/OpenNetworkingFoundation/TAPI/releases/tag/v2.2.0>.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GS NFV 003 [i.1] and ETSI GS NFV-IFA 032 [i.2] apply.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI GS NFV 003 [i.1], ETSI GS NFV-IFA 032 [i.2] and the following apply:

ACTN	Abstraction and Control of Traffic Engineered Network
CE	Customer Edge
CNC	Customer Network Controller
FD	Forwarding-Domain
L2NM	L2VPN Network Model
L2SM	L2VPN Service Model
L3NM	L3VPN Network Model
L3SM	L3VPN Service Model
MDSC	Multi-Domain Service Coordinator
ONF	Open Networking Foundation
OTCC	Open Transport Configuration & Control
PE	Provider Edge
PNC	Provisioning Network Controller
SBI	South Bound Interface
TAPI	Transport API
TE	Traffic Engineering
TEAS	Traffic Engineering, Architecture and Signalling
VNS	Virtual Network Services

4 Overview of protocols and data models for network connectivity

4.1 Introduction

As specified in ETSI GS NFV-IFA 032 [i.2], a multi-site connectivity service between different NFVI-PoPs is realized by establishing connectivity between the virtual resources in different NFVI-PoPs via the WAN resources connecting these NFVI-PoP sites. Virtual resources at each NFVI-PoP are managed by a VIM and WAN resources and connectivity are managed by WAN Infrastructure Manager (WIM) and as part of end-to-end connectivity, coordination takes place between the VIMs and WIM. An overview of different network connectivity protocols and data model solutions that are available in the industry (as specified by other organizations) for supporting multi-site connectivity services and a summary of interface operations in ETSI GS NFV-IFA 032 [i.2] are listed in clause 4.

4.2 Summary of ETSI GS NFV-IFA 032

4.2.1 Overview

ETSI GS NFV-IFA 032 [i.2] specifies the following interfaces for multi-site connectivity services (MSCS), which are produced by the WAN Infrastructure Manager (WIM):

- 1) MSCS Management interface.
- 2) Capacity Management interface.
- 3) Fault Management interface.
- 4) Performance Management interface.

ETSI GS NFV-IFA 032 [i.2] further highlights the requirements applicable to these interfaces and describes the operations and information elements exchanged over them.

These interfaces are produced by the WIM to enable consumers (e.g. NFVO) to request the establishment of network connectivity between different end-points of different NFVI-PoPs. The WIM can rely on underlying network controllers to handle the fulfilment of the requested connectivity at lower level, potentially making use of different network technologies and protocols. However, such interactions between the WIM and the network controllers are not specified in the ETSI GS NFV-IFA 032 [i.2]. The WIM, via these interfaces, thus exposes/offers the consumers an abstraction of the underlying network connectivity to ease its provisioning and monitoring.

The WIM interfaces and information elements as described in ETSI GS NFV-IFA 032 [i.2] are summarized in the subsequent clauses.

4.2.2 Summary of MSCS Management interface

4.2.2.1 Overview of interface operations

This interface allows an authorized consumer to perform operations related to MSCS.

The following operations are defined for this interface in ETSI GS NFV-IFA 032 [i.2]:

- **Create MSCS operation:** This operation allows an authorized consumer to request the creation of a MSCS from the WIM.
- **Query MSCS operation:** This operation allows querying information about instantiated MSCSs from the WIM.

- **Update MSCS operation:** This operation allows updating the information of an instantiated MSCS, e.g. name and description, as well as properties of the instantiated MSCS, such as adding/removing MSCS endpoints or changing the MSCS profile.
- **Terminate MSCS operation:** This operation allows terminating one instantiated MSCS.
- **Subscribe operation:** This operation enables an authorized consumer to subscribe with a filter in order to receive notifications sent by the WIM which are related to MSCS changes or MSCS reservation changes.
- **Notify operation:** This operation distributes notifications to subscribers. It is a one-way operation issued by the WIM that cannot be invoked as an operation by the consumer. In order to receive notifications, the consumer is expected to have a subscription.
- **Query Subscription Info operation:** This operation enables the consumer to query information about subscriptions
- **Terminate Subscription operation:** This operation enables the consumer to terminate a particular subscription.
- **Create MSCS Reservation operation:** This operation allows an authorized consumer to request the reservation of MSCS from the WIM.
- **Query MSCS Reservation operation:** This operation allows querying information about reserved MSCS that the consumer has access to.
- **Update MSCS Reservation operation:** This operation allows updating MSCS reservations, such as the timing schedule (start, end and expiry time), adding/removing MSCS endpoints to the reserved set or changing the MSCS profile of the reserved MSCS.
- **Terminate MSCS Reservation:** This operation allows an authorized consumer to request the termination of MSCS reservations.

4.2.2.2 Overview of information elements

The following information elements that encapsulate information related to MSCS are specified in ETSI GS NFV-IFA 032 [i.2]:

- **MscsData:** This information element encapsulates information needed for creating or updating a MSCS.
- **MscsEndpointData:** This information element encapsulates information about the MSCS endpoint and the network configuration necessary to setup the connectivity to/from MSCS endpoint to the multi-site (WAN) network edge point.
- **MscsProfile:** This information element encapsulates information determining the connectivity constraints and requirements for the MSCS.
- **Mscs:** This information element encapsulates information about an established MSCS.
- **Msnc:** This information element encapsulates information about an established Multi-site Network Connection (MSNC) on the multi-site network, partly or fully, realizing the MSCS.
- **MsncProfile:** This information element encapsulates information about the connectivity constraints and requirements of a particular MSNC realizing the MSCS.
- **MscsEndpointInfo:** This information element encapsulates information about network configuration of the MSCS endpoint of an MSCS. The MSCS Endpoint relates a connectivity service endpoint with the MSCS.
- **MscsReservationData:** This information element encapsulates information for creating a MSCS reservation.
- **ReservedMscs:** This information element provides information about the properties of a reserved MSCS including references to the MSCS endpoints, profile, protocol layer information, etc.
- **MscsChangeNotification:** This notification informs the receiver of changes related to the MSCSs managed by the WIM.

- **MscsReservationChangeNotification:** This notification informs the receiver of changes related to the MSCS reservations managed by the WIM.

4.2.3 Summary of Capacity Management Interface

4.2.3.1 Overview of interface operations

This interface allows providing to the Consumer information about the resources capacity (e.g. bandwidth, virtual network identifiers, etc.), topology, and network edge points of the network in between different NFVI-PoPs.

The following operations are defined for Capacity Management interface in ETSI GS NFV-IFA 032 [i.2]:

- **Query Capacity operation:** This operation enables a Consumer to retrieve information about the capacity of the network in between the NFVI-PoPs.
- **Create Capacity Threshold operation:** This operation enables a Consumer to create a threshold and specify threshold levels on the capacity of the network resources managed by the WIM.
- **Delete Capacity Thresholds operation:** This operation enables a Consumer to delete one or more existing threshold(s) managed by the WIM about capacity management.
- **Query Capacity Threshold operation:** This operation enables a Consumer to query the details of one or more existing capacity thresholds on the WIM.
- **Query Topology Information operation:** This operation enables a Consumer to query information about the one or more topologies of the network in between the NFVI-PoPs.
- **Query Node Information operation:** This operation enables a Consumer to query information about a node participating in a topology of the network in between the NFVI-PoPs.
- **Query Link Information operation:** This operation enables a Consumer to query information about a link participating in a topology of the network in between the NFVI-PoPs.
- **Query Network Edge Point Information operation:** This operation enables a Consumer to query information about network edge points of the network between the NFVI-PoPs.
- **Subscribe operation:** This operation enables the Consumer to subscribe with a filter for the notifications related to capacity and topology changes sent by the WIM.
- **Notify operation:** This operation distributes notifications to subscribers. It is a one-way operation issued by the WIM and cannot be invoked as an operation by the Consumer.
- **Terminate Subscription operation:** This operation enables the Consumer to terminate a particular subscription.

Query Subscription Information operation: This operation enables the Consumer to query information about subscriptions.

4.2.3.2 Overview of information elements

The following information elements and notifications related to capacity and topology management are specified in ETSI GS NFV-IFA 032 [i.2]:

- **CapacityInfo:** This information element encapsulates information about capacity of the network in between the NFVI-PoPs (sites).
- **CapacityValueEntry:** This information element encapsulates values about a capacity metric.
- **TimePeriodInformation:** This information element specifies a time period for which capacity is queried.
- **CapacityThreshold:** This information element defines threshold for triggering capacity change notifications.

- **CapacityChangeNotification:** This notification informs the receiver of changes in the capacity of the network in between the NFVI-PoPs managed by the WIM.
- **NetworkInfo:** This information element encapsulates information about a network in between the NFVI-PoPs (sites).
- **TopologyInfo:** This information element encapsulates information about a topology of the network in between the NFVI-PoPs (sites).
- **NodeInfo:** This information element encapsulates information about a node of the network in between the NFVI-PoPs (sites).
- **LinkInfo:** This information element encapsulates information about a point to point link in between two nodes of the network in between the NFVI-PoPs (sites), or a point to point link at the edge of the network enabling the connectivity between the connectivity service endpoint of the NFVI-PoP and the WAN.
- **NetworkEdgePointInfo:** This information element encapsulates information about a network edge point of the network in between the NFVI-PoPs (sites). The network edge points represent the ingress/egress ports of the network in between the NFVI-PoPs.
- **ConnectivityServiceEndpointInfo:** This information element encapsulates information about a connectivity service endpoint of an NFVI-PoP on which a MSCS can be terminated.
- **TopologyChangeNotification:** This notification informs the receiver of changes in the network in between the NFVI-PoPs managed by the WIM in terms of topology, nodes and/or links.

4.2.4 Summary of Fault Management Interface

4.2.4.1 Overview of interface operations

This interface allows the WIM to provide alarms related to the MSCSs visible to the consumer.

The following operations are defined for Fault Management interface in ETSI GS NFV-IFA 032 [i.2]:

- **Subscribe operation:** This operation enables the consumer to subscribe with a filter for the notifications related to MSCS alarms sent by the WIM.
- **Notify operation:** This operation distributes notifications of alarms or alarm state change to subscribers.
- **Terminate Subscription operation:** This operation enables the consumer to terminate a particular subscription.
- **Query Subscription Info operation:** This operation enables the consumer to query information about subscriptions.
- **Get alarm list operation:** This operation enables the consumers to query the active alarms from the WIM.
- **Acknowledge Alarms operation:** This operation enables the consumer to acknowledge alarms at WIM.

4.2.4.2 Overview of information elements

The following information elements and notifications related to fault management are specified in ETSI GS NFV-IFA 032 [i.2]:

- **Alarm:** This information element encapsulates information about an alarm.
- **AlarmNotification:** This notification informs the receiver of alarms related to the MSCSs managed by the WIM.
- **AlarmClearedNotification:** This notification informs the receiver of the clearing of an alarm related to the MSCSs managed by the WIM.

- **AlarmListRebuiltNotification:** This notification informs the receiver that the active alarm list has been rebuilt by the WIM.

4.2.5 Summary of Performance Management Interface

4.2.5.1 Overview of interface operations

This interface allows providing of performance information (measurement results collection and notifications) related to MSCSs.

The following operations are defined for Performance Management interface in ETSI GS NFV-IFA 032 [i.2]:

- **Create PM Job operation:** This operation creates a PM job, enabling a consumer to specify a MSCS or set of MSCSs, that the WIM is managing, for which it wants to receive performance information.
- **Delete PM Jobs operation:** This operation deletes one or more PM job(s).
- **Query PM Job operation:** This operation enables the consumer to solicit from the WIM the details of one or more PM job(s). This operation does not return performance reports.
- **Create Threshold operation:** This operation allows the consumer to create a threshold and specify threshold levels on specified performance metric (for MSCS(s)) for which notifications will be generated when crossed.
- **Delete Thresholds operation:** This operation allows the consumer to delete one or more existing threshold(s).
- **Query Threshold operation:** This operation allows the consumer to query the details of an existing threshold.
- **Subscribe operation:** This operation enables the consumers to subscribe with a filter for the notifications related to performance information with the WIM.
- **Notify operation:** This operation distributes notifications to subscribers. It is a one-way operation issued by the WIM that cannot be invoked as an operation by the consumer.
- **Terminate Subscription operation:** This operation enables the consumer to terminate a particular subscription.
- **Query Subscription operation:** This operation enables the consumer to query information about subscriptions.

4.2.5.2 Overview of information elements

The following information elements and notifications related to performance management are specified in ETSI GS NFV-IFA 032 [i.2]:

- **ObjectSelection:** This information element allows specifying the MSCS or MSNC instances on which performance information will be provided.
- **PmJob:** This information element provides the details of the PM Job. The object instances for this information element are MSCS or MSNC instances.
- **Threshold:** This information element provides the details of a threshold. The object instances for this information element are MSCS or MSNC instances.
- **PerformanceReport:** This information element defines the format of a performance report provided by the producer to the consumer on a specified object instance, i.e. MSCS or MSNC instance, or a set of them.
- **PerformanceReportEntry:** This information element defines a single performance report entry. The object instances for this information element are MSCS or MSNC instances.
- **PerformanceValueEntry:** This information element defines a single performance value with its associated time stamp and measurement context.

- **PerformanceInformationAvailableNotification:** This notification informs the receiver that performance information is available. The object instances for this information element are MSCS or MSNC instances.
- **ThresholdCrossedNotification:** This notification informs the receiver that a threshold value has been crossed. The object instances for this information element are MSCS or MSNC instances.

4.3 Referenced protocol and data model standards

4.3.1 Introduction

This clause provides the overview of the relevant standards to which the interfaces and information models of the ETSI GS NFV-IFA 032 [i.2] are profiled. The overview covers the key aspects of the architecture of the respective protocols and provides a summary of the respective interfaces and data models. It also illustrates the mapping of concepts and terminology between the ETSI GS NFV-IFA 032 [i.2] and the reference standards for easy understanding of the concepts.

4.3.2 Abstraction and Control of TE Networks (ACTN)

4.3.2.1 Introduction

Based on the multi-site connectivity services and WIM interfaces requirements outlined in ETSI GS NFV-IFA 032 [i.2], there are commonalities in solutions offered by IETF ACTN connectivity models. The terminology and concepts used in IETF ACTN align with those of NFV to a certain extent and aspects of ACTN interfaces and data models that are relevant for multi-site connectivity are analysed in the present document. This clause covers an overview of ACTN system, interfaces, data models and the mapping of concepts and terminology used in IETF ACTN and ETSI GS NFV-IFA 032 [i.2].

In the context of multi-site connectivity, IETF working group on Traffic Engineering, Architecture and Signalling (TEAS) is responsible for the specification of RFCs related to the Abstraction and Control of Traffic Engineered (TE) Network (ACTN). IETF RFC 8453 [i.8] provides a framework for the ACTN and describes a set of management and control functions to support Virtual Network Services (VNS) and connectivity services.

The ACTN framework described in IETF RFC 8453 [i.8] enables:

- 1) Abstraction of the underlying network resources to higher layer applications and customers.
- 2) Virtualisation of underlying resources.
- 3) Network slicing of infrastructure based on service requirements.
- 4) Presenting an abstract view and control of the multi-domain networks as a single abstract network.
- 5) Presentation of virtual networks to customers.

4.3.2.2 Key aspects

4.3.2.2.1 Overview

The base architecture of ACTN is illustrated in figure 4.3.2.2.1-1, which is a three-tier reference model that also allows for hierarchy and recursion. It defines three controllers, and three reference points (referred to as interfaces in IETF RFC 8453 [i.8]).

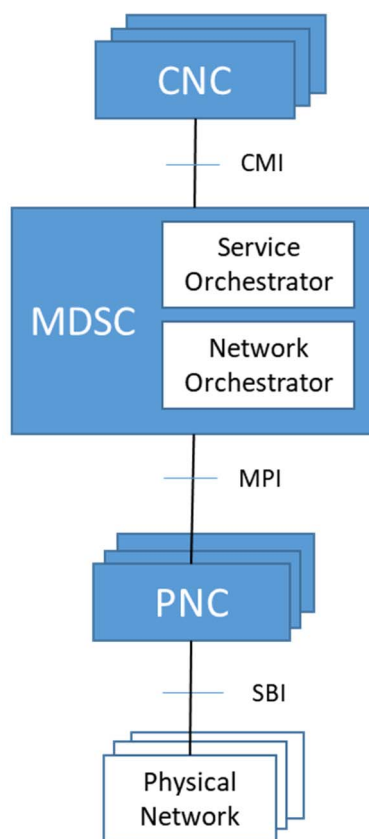


Figure 4.3.2.2.1-1: ACTN Base Architecture [i.8]

As illustrated in figure 4.3.2.2.1-1, the ACTN base architecture defines three functional elements or controller types:

- 1) CNC - Customer Network Controller.
- 2) MDSC - Multi-Domain Service Coordinator.
- 3) PNC - Provisioning Network Controller.

Figure 4.3.2.2.1-1 also shows the three reference points (referred to as interfaces) between the three controllers:

- 1) CMI - CNC-MDSC Interface.
- 2) MPI - MDSC-PNC Interface.
- 3) SBI - South Bound Interface (outside the scope of ACTN system specification).

Table 4.3.2.2.1-1 summarizes the key aspects of the ACTN system.

Table 4.3.2.2.1-1: Key aspects of ACTN's Framework

Aspect	Description
Organization	IETF
Working Group	Traffic Engineering Architecture and Signalling (TEAS)
Specifications	Framework for Abstraction and Control of TE Networks (ACTN) [i.8] Information Model for Abstraction and Control of TE Networks (ACTN) [i.9] Layer 3 VPN Service Delivery [i.13] Layer 2 VPN Service Delivery [i.12] Layer 3 VPN Network YANG Model [i.24] Layer 2 VPN Network YANG Model [i.25] YANG data model for Traffic Engineering (TE) Topologies [i.34] Traffic Engineering (TE) and Service Mapping Yang Model [i.28] YANG data model for Alarm management [i.33] YANG data model for Network and VPN Service Performance Monitoring [i.33]
Main functionalities	Abstraction of underlying network resources for use by the customer Mapping/translation of customer requests/commands into network provisioning requests. Multi-domain coordination Virtual Service (VS) coordination
Type of data models	YANG-based data models

4.3.2.2.2 Summary of the ACTN Interfaces

This summarizes the main interfaces specified in IETF RFC 8453 [i.8].

The **CNC-MDSC Interface (CMI)** is used for the conveyance of all resource related information, such as VNS type, topology, bandwidth, service constraints, between the CNC and the MDSC. The information exchanged over CMI is agnostic to the underlying topology.

The **MDSC-PNC Interface (MPI)** communicates requests for new connectivity or bandwidth changes in the underlying physical networks within a PNC domain. The MPI enables the MDSC to communicate with multiple PNC domains in a multi-domain environment. It is via MPI that the PNC presents an abstract topology of the underlying networks within its domain to the MDSC.

In the MDSC hierarchy as described in section 4 in IETF RFC 8453 [i.8], the interface between MDSC-H (higher level MDSC) and MDSC-L (lower-level MDSC) is MPI and hierarchy of MDSC can be recursive to suit different implementations of this layer.

4.3.2.2.3 Summary of the ACTN Data Models

In IETF, data models are a representation of objects that can be configured or monitored within a system. YANG [i.27] is the language of choice for documenting data models, and YANG models have been produced to allow configuration or modelling of a variety of network devices, protocol instances, and network services. Several IETF adopted Internet Drafts are developed by the TEAS WG related to YANG based data models corresponding to the ACTN architecture reference points. Based on the requirements, type and capabilities a suitable data model can be used. In this regard, the Internet Draft [i.10] shows how and to what extent the existing YANG service data models apply to the respective reference points of the ACTN architecture, and also references the specific YANG data models that are under development. Figure 4.3.2.2.3-1 shows a mapping between the ACTN architecture reference points with the relevant YANG Service Model specified in IETF RFC 8309 [i.11].

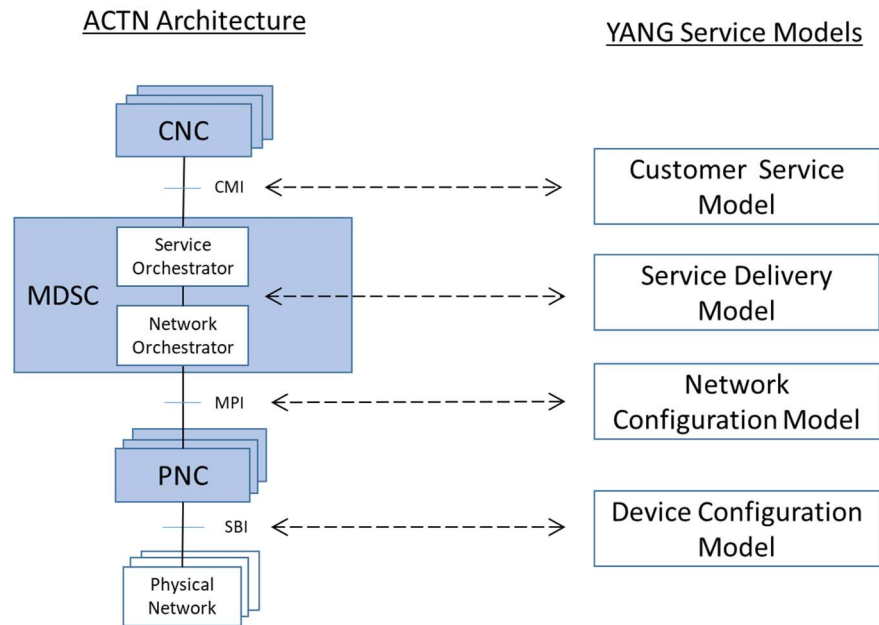


Figure 4.3.2.2.3-1: YANG Service Models corresponding to ACTN architecture reference points

With reference to figure 4.3.2.2.3-1, a summary of the service YANG data models corresponding to the ACTN architecture reference points as described in [i.10] is given below:

- 1) **Customer Service Model:** This model is used to describe services offered or delivered to a customer by a network operator. This corresponds to the CMI reference point between the CNC and the Service Orchestrator sub-component of the MDSC. The key function is the service request that includes service specific properties like service type and service requirements/constraints. The Internet Draft [i.10] gives a list of functions for the CMI and provides references to the RFCs and Internet Drafts specifying the YANG models corresponding to the CMI functions. These service YANG data models provide a customer view of the service and are focused on communication between the customers and network operators. The service models are suitable for service orchestration by providing an abstracted view of customer's requested services. For example, IETF RFC 8466 [i.12] and IETF RFC 8299 [i.13] specify L2 VPN Service YANG Model and L3 VPN Service YANG Model respectively.
- 2) **Service Delivery Model:** This model is used by the network operator to define and configure how a service is provided by the network. This corresponds to the MDSC internal reference point between the Service Orchestrator and the Network Orchestrator sub-component. The network YANG data models complement service models by providing a network-centric view of the service that is internal to a Service Provider. The network YANG data models facilitate communication between the service orchestrator (or a network operator) and the network controller/orchestrator. For example, L2NM [i.25] and L3NM [i.24] specify the Layer 2 VPN Network YANG Model and Layer 3 VPN Network YANG Model respectively and they complement the service models specified in IETF RFC 8466 [i.12] and IETF RFC 8299 [i.13]. The network YANG models can be consumed by a Service Orchestrator to request a VPN Service to a Network controller.
- 3) **Network Configuration Model:** This model is used by the network orchestrator sub-component of the MDSC to provide network-level configuration model to a controller. This corresponds to the MPI reference point between the MDSC and the PNC, and captures the parameters reflecting the network wide information, such as configuration scheduling, topology abstraction, path computation, etc. The Internet Draft [i.10] gives a list of functions for the MPI and provides references to the Internet Drafts specifying the YANG models corresponding to the MPI functions.
- 4) **Device Configuration Model:** This model is used by the controller to configure physical network elements. This corresponds to the SBI reference point between the PNC and the corresponding physical network elements. SBI is not in scope of ACTN as there are already mature protocol solutions on the device level of ACTN, such as RSVP-TE, OSPF-TE, etc.

4.3.2.3 Mapping of concepts, terminology and other

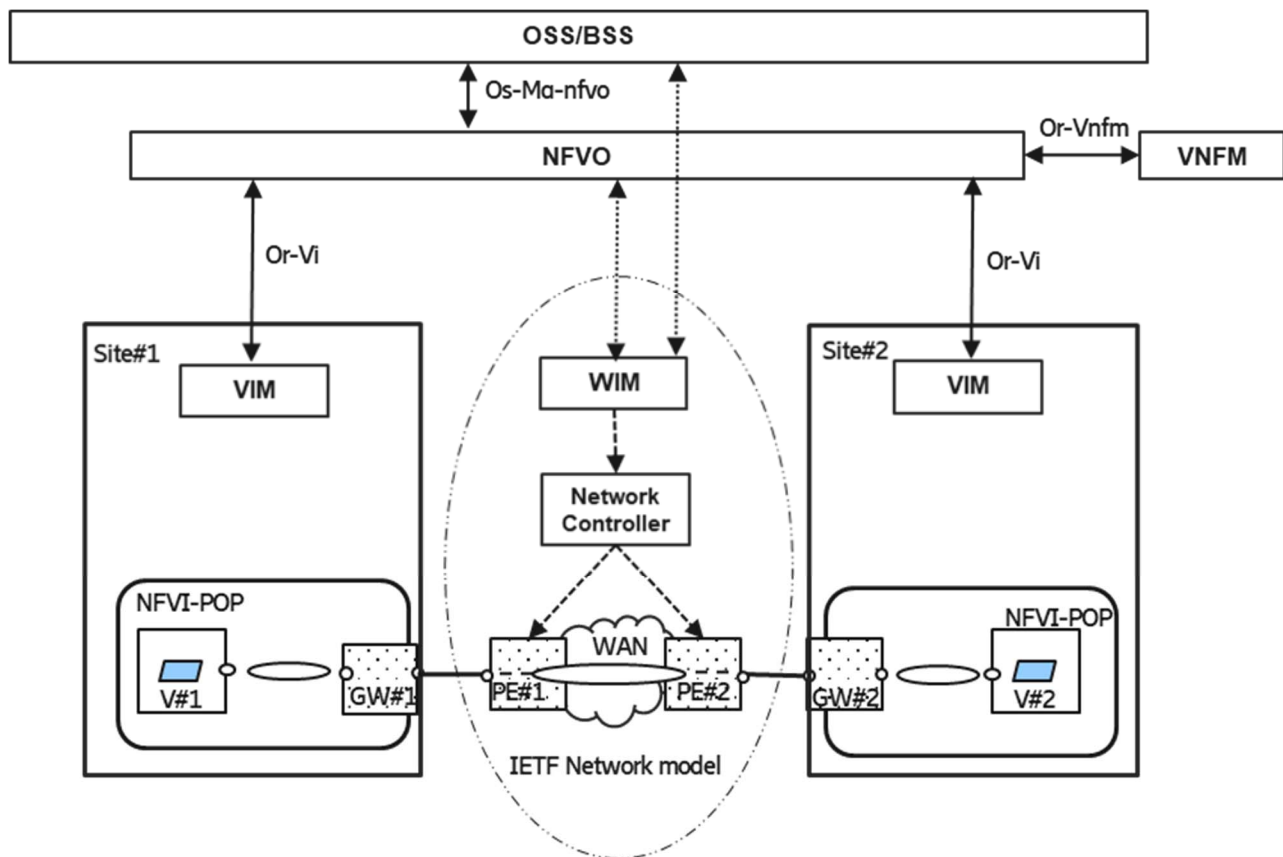


Figure 4.3.2.3-1: IETF Network YANG Models applicability for WIM interface in ETSI NFV

With reference to the multi-site connectivity, the network YANG models (L3NM and L2NM) are suitable for setting up the connectivity services as per the requirements specified in ETSI GS NFV-IFA 032 [i.2]. Figure 4.3.2.3-1 provides a mapping of the WIM interface in ETSI NFV to the IETF Network YANG models. The consumers of WIM interface are either NFVO or OSS/BSS based on the architecture options specified in clause 5.4 and Annex G of ETSI GS NFV-IFA 010 [i.3]. The network data models (L2NM and L3NM) include network-centric information and can be used by the network controllers to manage and control the VPN Service configuration in the Service Provider network.

In the intra-organization profile, VIM and WIM belong to same service provider or organization and there are no administrative restrictions in exchanging of information. WIM exposes network details to the NFVO, which can be used by the NFVO to orchestrate in between WAN and NFVI-PoP network connectivity managed by the WIM and VIM, respectively. The multi-site connectivity service end point configuration at each site is assumed to be responsibility of the VIM for the specific site. The service models of L2 and L3 VPN Network models offer interface operations to be consumed by NFVO or OSS/BSS. The interface operations toward L2NM and L3NM are supported via RESTCONF Protocol [i.26].

With reference to the multi-site connectivity requirements, the key managed objects from ETSI GS NFV-IFA 032 [i.2] are MSCS and MSNC. The MSCS object correspond to VPN-SERVICE in the L2NM and L3NM YANG models. The MSNC object correspond to the underlay network connection represented in Traffic Engineering (TE) models (e.g. the TE Tunnel). As specified in sections 3.2 and 6.2 of TE Service Mapping Model [i.28], the TE and Service mapping parameters are supported using augmentation of network models (L2NM and L3NM) for seamless control and management of their VPN services with TE tunnel support. TE Service Mapping Model is used to allow monitoring and diagnostics of the management systems to show how the service requests are mapped onto underlying network resource and TE models.

Clause A.2.2.1 of ETSI GS NFV-IFA 032 [i.2] provides a mapping of concepts between the concepts and terminology used in the ETSI GS NFV-IFA 032 [i.2] and the ACTN concepts and terminology. Table 4.3.2.3-1 illustrates the mapping between the ETSI GS NFV-IFA 032 [i.2] and ACTN for easy understanding across the concepts.

Table 4.3.2.3-1: Terminology mapping between ETSI GS NFV-IFA 032 [i.2] and IETF ACTN

ETSI GS NFV-IFA 032 [i.2]	IETF ACTN
Network edge link (LinkInfo with isNetworkEdgeLink=true)	Access link
NFVI-PoP network gateway (see note 1)	Customer Node (CE)
Network link	Link
Network node	Node
Network node (where NodeInfo has one or more networkEdgePointId)	Operator Node (PE)
Network Edge Point	Operator Node port (Port id in VPN Network Access)
Network Topology	TE Topology
MSNC	TE Tunnel
Connectivity Service Endpoint	Connection in VPN Network Access (see note 2)
MSCS	VPN Service
MSCS Endpoint	VPN Network Access (see note 3)
NOTE 1: Not specified explicitly in the ETSI GS NFV-IFA 032 [i.2], but it maps to the NFVI-PoP network gateway or CE router (see clause 4.3 in ETSI GS NFV-IFA 032 [i.2]).	
NOTE 2: Connection in VPN Network Access specifies the type of connectivity between PE and CE and the network link over which this connectivity service is available.	
NOTE 3: The VPN network access is an abstraction that represents the network interface of the Operator node for the attachment circuit towards Customer Node.	

Table 4.3.2.3-1 shows that for each one of the key concepts regarding multi-site connectivity services as specified in ETSI GS NFV-IFA 032 [i.2] there is a corresponding concept in the IETF ACTN.

4.3.3 Transport API (TAPI)

4.3.3.1 Introduction

Based on the multi-site connectivity services and WIM interfaces requirements outlined in ETSI GS NFV-IFA 032 [i.2], there are commonalities in solutions offered by Open Networking Foundation (ONF)'s Open Networking Foundation (ONF)'s (TAPI) connectivity models. The terminology and concepts used in ONF's TAPI align with those of ETSI GS NFV-IFA 032 [i.2] to a certain extent and aspects of TAPI's interfaces and data models that are relevant for multi-site connectivity are analysed in the present document. This clause covers an overview of TAPI system, interfaces, data models and the mapping of concepts and terminology used in ONF TAPI and ETSI GS NFV-IFA 032 [i.2].

TAPI is a standard defined by the ONF's Open Transport Configuration & Control (OTCC) that allows a TAPI client, such as a carrier's orchestration platform or a customer's application, to retrieve information from and control a domain of transport network equipment controlled by a TAPI server such as a Transport SDN Controller. It supports both high-level technology independent service abstraction (i.e. intent-like) and detailed technology-specific resource-related operations, depending on policy. Other industry SDOs and forums (such as MEF & OIF) have also adopted TAPI for their specific needs. Informative references [i.14] to [i.22] are to be considered during the work.

4.3.3.2 Key aspects

4.3.3.2.1 Overview

As a component of Transport SDN, TAPI enables programmatic control of the carrier's transport network to support faster and more flexible allocation of network resources to support application demands (e.g. bandwidth or latency).

Table 4.3.3.2.1-1 summarizes the key aspects of the TAPI framework.

Table 4.3.3.2.1-1: Key aspects of TAPI Framework

Aspect	Description
Organization	ONF
Working Group	Open Transport Configuration & Control (OTCC)
Specifications	TAPI SDK Release 2.2.0, July 2019 [i.47] ONF TR-547 [i.14], TAPI v2.1.3 Reference Implementation Agreement, Version 1.0, July 2020 ONF TR-527 [i.19], <i>Functional Requirements for Transport API</i> , June 2016
Main functionalities	Abstraction of underlying network resources for use by transport applications Mapping of customer requests/commands into network provisioning requests Multi-layer and Multi-domain coordination Virtual Network Service (VNS) coordination
Type of data models	YANG-based data models

4.3.3.2.2 Summary of the TAPI Interfaces

The TAPI reference architecture utilizes a functional and recursive approach without prescribing any particular deployment categorizations, domain partitioning, specific system roles or hierarchy levels. The actors involved in the information exchange over TAPI interface include transport network controllers in the role of producers (e.g. Vendor Domain Controllers, Optical Domain Controllers, Geographical Domain Controllers, Hierarchical Multi-level/domain Controllers) and the transport network application systems in the role of the consumers (e.g. Hierarchical Multi-domain/level Controllers, Orchestrators, Transport SDN Applications, etc.).

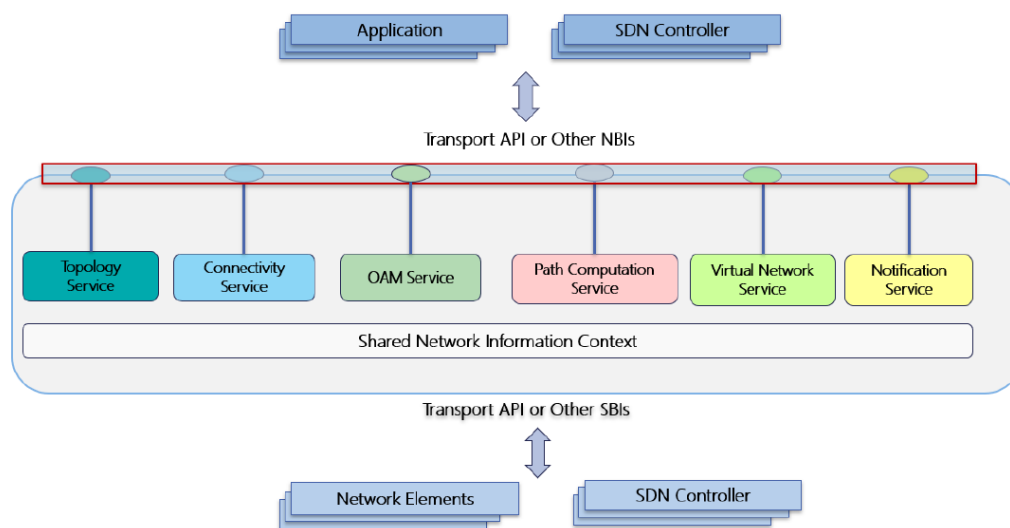


Figure 4.3.3.2.2-1: Transport API Functional Architecture [i.14]

4.3.3.2.3 Summary of TAPI Functional Interface Reference Points

TAPI provides interface solutions to Transport SDN functions identified in figure 4.3.3.2.2-1, released as OpenSource SDKs. The solution kit includes YANG data models as well as UML information models and OpenAPI schema definitions, for each of the TAPI functional interfaces.

Topology Service

The Topology Service supports retrieval of Topology information from the Controller in the form of Node, Link & Node-Edge-Point details. This information could be used for path computation, planning and analysis purposes and supports virtualisation of network resources for particular client applications.

Connectivity Service

The Connectivity Service allows the client to request new (or updates to existing) point-to-point, point-to-multipoint and multipoint-to-multipoint connectivity service across the transport network. Support for both single layer and multi-layer connectivity services is included. The TAPI server computes and provisions appropriate Connections (and routes & end-points) into the network as per the given constraints and returns these resource entities as response to the service request.

Path Computation Service

The Path Computation Service allows the client to make a request to server for computation & optimization of connectivity paths, for a given set of constraints and objective criteria. The client is expected to follow-up with a Connectivity service request to provision the computed paths.

OAM Service

The OAM service facilitates service assurance via management of maintenance entities, scheduling on-demand and proactive Jobs for monitoring and performance data collection, and management of triggers and generation of Thresholds Crossing Alerts.

Virtual Network Service

The Virtual Network Service allows the client to dynamically create (and delete) Network Topologies on request by providing a traffic matrix describing traffic requirements. The controller responds by engineering and creating a virtual Network Topology and reserving the necessary resources to support that topology.

Notification Service

The Notification Service allows the client to subscribe to and filter autonomous notifications from the server for events such as resource or service state changes, faults & failure or degradation. The service does not prescribe specific transport mechanisms for carrying the autonomous notifications (such as web-sockets).

4.3.3.2.4 Summary of TAPI Data Model Entities

TAPI Context

The TAPI context provides a scope of *control, naming and information exchange* for particular TAPI provider & client interaction using the Network Topology, Connectivity, Path Computation, Equipment Inventory and Notification Service APIs. Offline negotiation and agreement between TAPI provider & its client determines the setup of this shared context and in turn the type and degree of abstraction that is provided. A TAPI context is distinct from the TAPI provider's or TAPI client's internal context. A TAPI client assumes exclusive control over all information provided to it within its context. A TAPI context is defined by set of *Service-Interface-Points* and includes *one or more top-level Topologies* that are either statically assigned by the provider or dynamically created by the client.

Topology

A Topology is a representation of *transparent topological-aspects* of a Forwarding-Domain (FD). The underlying topological network of *Nodes* and *Links* that enable the forwarding function provided by the FD describes *Topology* of that FD.

Node

A *Node* is a representation of *opaque forwarding-aspects* of a Forwarding-Domain (FD). *Node* aggregates the edge ports of the FD (*Node-Edge-Point*) and the forwarding potential and capabilities between those edge ports.

A *Node* can encompass an *internal Topology* and be recursively decomposed into its *lower-level Nodes* and *Links*.

Link

A *Link* is a representation of the *effective adjacency* between two or more *Nodes* (specifically *Node-Edge-Points*) in a *Topology*. *Node* and *Link* express their characteristics via the *topology-pacs* that include aspects such as *Capacity*, *Risk*, *Cost*, *Latency*, *Validation*, *Transition*, etc.

Node-Edge-Point

A *Node-Edge-Point* represents the ingress/egress ports of a *Node* and exposes technology-specific characteristics for a specific *Layer-Protocol*. Hence it provides an encapsulation of addressing, mapping, termination, adaptation and OAM functions at specific transport *Layer-Protocols* (including circuit and packet forms) performed at the entry and exit points of the *Node*. Examples of supported *Layer-Protocols* include: OTSi (L0), ODU (L1) & ETH (L2).

Connectivity-Service

A *Connectivity-Service* represents an "intent-like" request for connectivity between two or more *Service-Interface-Points*. *Connectivity-Service* is a container for *connectivity request details* and is distinct from *Connection* that realizes the request. They refer to different aspects of information exchanged over T-API interface, but with-in a provider's internal context, they could be represented by the same entity instance if there is one-to-one mapping.

Connection

A *Connection* represents an *enabled (provisioned) potential* for forwarding (incl. all circuit/packet forms) between two or more *Node-Edge-Points* of a *Node*. The bounding *Node* of a *Connection* can be explicit or be conceptually *implicit*.

Connection is a container for *provisioned connectivity* that tracks the state of the allocated resources and is distinct from the *Connectivity-Service* request.

A server-layer *Connection* results in a *Link* in the client-layer. A *Connection* can also be recursively *decomposed into lower-level Connections*

Connection-End-Point

The *Connection-End-Point* encapsulate information related to a *Connection* at the ingress/egress points of every *Node* that the *Connection* traverses in a *Topology*. Thus they represent the ingress/egress port functions (including termination, encapsulation, processing, mapping, etc) of the *Connection*.

A parent *Node-Edge-Point* supports one or more *Connection-End-Points*. A *Connection-End-Point* that terminates a (server-layer) *Connection* recursively supports a *Node-Edge-Point* at the client-layer.

Route

A *Route* represents the path of a *Connection* through the *lower-level Nodes* in the *underlying Topology*. *Route* is described as a partially ordered list of *Connection-End-Points*.

Service-Interface-Points

A *Service-Interface-Point* represents the network-interface-facing aspects of the edge-port functions that access the forwarding capabilities provided by the *Node*. Hence it provides a limited, simplified view of interest to external clients (e.g. shared addressing, capacity, re-source availability, etc.), that enable the clients to request connectivity without the need to understand the provider network internals. Since *Service Interface Point* has a mapping relationship (one-to-one, one-to-many, many-to-many) to *Node-Edge-Point*; with reference to *Connectivity*, a *Service-Interface-Point* conceptually represents a pool of "potential" *Connection-End-Points* at the edge of the *Network*.

4.3.3.3 Mapping of concepts, terminology and other

Table 4.3.3.3-1 illustrates the mapping between the ETSI GS NFV-IFA 032 [i.2] and TAPI for easy understanding across the concepts. The concepts and the terms of TAPI used in table 4.3.3.3-1 are described in clause 4.3.3.2.4.

Table 4.3.3.3-1: Terminology mapping between ETSI GS NFV-IFA 032 [i.2] and ONF's TAPI [i.14] specification

ETSI GS NFV-IFA 032 [i.2]	ONF TAPI
Network edge link (LinkInfo with isNetworkEdgeLink=true)	Not explicitly represented in TAPI (represented by the "mapping" between a Service Interface Point and a Node Edge Point)
NFVI-PoP network gateway	Not explicitly represented in TAPI. A Service Interface Point acts as a proxy for such PoPs
Network link	Link
Network node	Node
Network node (where NodeInfo has one or more networkEdgePointId)	Node (where one or more Node Edge Points are "mapped" to one or more Service Interface Point)
Network Edge Point	Node Edge Point (with a "mapped" Service Interface Point)
Network Topology	Topology
MSNC	Connection
Connectivity Service Endpoint	Service Interface Point
MSCS	Connectivity Service
MSCS Endpoint	Connectivity Service End Point

Table 4.3.3.3-1 shows that for each one of the key concepts regarding multi-site connectivity services as specified in ETSI GS NFV-IFA 032 [i.2] there is a corresponding concept in the ONF's TAPI [i.14].

5 Gap analysis

5.1 Introduction

Clause 5 performs an informative profiling of the referenced protocol and data model standards specified in ONF and IETF against the requirements, interfaces and information model specified in ETSI GS NFV-IFA 032 [i.2]. The profiling work is split according to the four interfaces specified in ETSI GS NFV-IFA 032 [i.2] (refer to clause 4.2), that is:

- MSCS management interface
- Capacity management interface
- Fault management interface
- Performance management interface

The profiling of each of the interfaces identifies what interface operations, interface parameters, information elements and their attributes are fulfilled by the referred standard and the mapped operations and data model in those cases. Some elements can also, in some cases, not be fully mapped, or not be mapped at all. Overall, three categories of support are described:

- Supported: the referred interface operation, parameters, attributes of the information elements, etc. can be fully mapped as per the semantics and requirements specified in ETSI GS NFV-IFA 032 [i.2].
- Partially supported: the referred interface operation, parameters, attributes of the information elements, etc. as specified in ETSI GS NFV-IFA 032 [i.2] can be partially mapped, e.g. some sub-attribute is not supported but others are, by the profiled standard.
- Not supported: the profiled standard does not provide a matching element that fulfils the referred interface operation, parameters, attributes of the information elements, etc. as specified in ETSI GS NFV-IFA 032 [i.2].

5.2 MSCS management interface

5.2.1 Overview

Clause 5.2 provides the profiling corresponding to the MSCS management interface specified in ETSI GS NFV-IFA 032 [i.2]. The profiling with respect to ONF's TAPI standard is documented in clause 5.2.2. The profiling with respect to IETF's ACTN standards is documented in clause 5.2.3.

5.2.2 Gap analysis with respect to ONF's TAPI YANG Data Model

5.2.2.0 Introduction

The ONF has specified YANG data models for the TAPI services, which are available on GitHub [i.23]. Besides specifying the data models, these YANG models also specify the related operations, referred to as RPCs, for the respective TAPI services. Clause 5.2.2 and subclauses analyse the similarities and gaps between the MSCS management interface operations and related information elements with those of YANG model specified for TAPI's Connectivity Service. For the analysis the version 2.2.0 of the TAPI YANG [i.23] models is used.

5.2.2.1 Analysis of the MSCS Management interface operations

Table 5.2.2.1-1 maps the RPCs specified for TAPI's Connectivity service with the most relevant operations specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface.

Table 5.2.2.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] MSCS Management interface operations with TAPI's Connectivity Service RPCs

ETSI GS NFV-IFA 032 [i.2] MSCS Management Interface Operations	TAPI's Connectivity Service RPC	Comments
Create MSCS	create-connectivity-service	Supported
Create MSCS Reservation		Not supported For further details see the analysis comment 01 in clause 5.2.2.11
Query MSCS	get-connectivity-service-details	Supported
Query MSCS Reservation		Not supported For further details see the analysis comment 01 in clause 5.2.2.11
Update MSCS	update-connectivity-service	Supported
Update MSCS Reservation		Not supported For further details see the analysis comment 01 in clause 5.2.2.11
Terminate MSCS	delete-connectivity-service	Supported
Terminate MSCS Reservation		Not supported For further details see the analysis comment 01 in clause 5.2.2.11
Notify		Not supported For further details see the analysis comment 02 in clause 5.2.2.11
Subscribe	create-notification-subscription-service	Supported
Query Subscription Information	get-notification-subscription-service-details, get-notification-subscription-service-list	Supported
Terminate Subscription	delete-notification-subscription-service	Supported

This mapping shown in table 5.2.2.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation of the TAPI specification. In this case it might be needed to use multiple functions to achieve the expected result. If the analysis below suggests such a mapping for an operation it is noted in the respective analysis notes in clause 5.2.2.11.

5.2.2.2 Analysis of Create MSCS operation

5.2.2.2.1 Analysis of Create MSCS operation Input Information model

Table 5.2.2.2.1-1 provides a mapping of the information model of Create MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's create-connectivity-service RPC defined in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-connectivity-service
    >> input
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.2.1-1: Mapping of Create MSCS operations with TAPI's create-connectivity-service operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Create MSCS operation</i>	TAPI operation <i>create-connectivity-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
reservationId (Identifier)		Not Supported
mscsData (MscsData)		
> mscsName (String)	name > (value-name & name)	Partially supported For further details see the analysis comment 04 in clause 5.2.2.11
> mscsDescription (String)	name > (value-name & name)	Partially supported For further details see the analysis comment 04 in clause 5.2.2.11
> mscsEndpoint (MscsEndpointData)		
>> connectivityServiceEndpointId (Identifier)	end-point > service-interface-point > service-interface-point-uuid	Supported
>> directionality (Enum)	end-point > direction	Supported For further details see the analysis comment 05 in clause 5.2.2.11
>> networkAddressing ()		Not Supported
>> lag ()		Not Supported
> mscsProfile (MscsProfile)		
>> bandwidthIn (Number)	end-point > capacity	Partially Supported For further details see the analysis comment 06 in clause 5.2.2.11
>> bandwidthOut (Number)		
>> qosMetric ()	routing-constraint > (cost-characteristic & latency-characteristic)	Partially Supported For further details see the analysis comment 07 in clause 5.2.2.11
>> directionality (Enum)		Not Supported. For further details see the analysis comment 05 in clause 5.2.2.11
>> mtu (Number)		Not Supported
>> protectionScheme (Enum)	resilience-constraint > protection-type	Supported For further details see the analysis comment 08 in clause 5.2.2.11
>> connectivityMode (Enum)	connectivity-constraint > service-type	Supported
>> numSegment (Number)		Not Supported
>> segmentId (Identifier)		Not Supported
> mscsLayerProtocol ()	layer-protocol-name	Potentially Supported For further details see the analysis comment 09 in clause 5.2.2.11

5.2.2.2.2 Analysis of Create MSCS operation Output Information model

Table 5.2.2.2.2-1 provides a mapping of the output information model of Create MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's create-connectivity-service RPC defined in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-connectivity-service
    >> output
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.2.2-1: Mapping of Create/Query/Update MSCS operations with TAPI's create-connectivity-service/get-connectivity-service-details/update-connectivity-service operations

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Create/Query/Update MSCS operation</i>	TAPI operation <i>create-connectivity-service/get-connectivity-service-details/update-connectivity-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
mcsclId (Identifier)	service > uuid	Supported For further details see the analysis comment 03 in clause 5.2.2.11
mcsName (String)	service > name > (value-name & name)	Partially supported For further details see the analysis comment 04 in clause 5.2.2.11
mcsDescription (String)	service > name > (value-name & name)	Partially supported For further details see the analysis comment 04 in clause 5.2.2.11
mcsEndpoint (MscsEndpointInfo)		
> mcsEndpointId (Identifier)	service > end-point > local-id	Supported
> connectivityServiceEndpointId (Identifier)	service > end-point > service-interface-point > service-interface-point-uuid	Supported
> directionality (Enum)	service > end-point > direction	Supported For further details see the analysis comment 05 in clause 5.2.2.11
> networkAddressing ()		Not Supported
> lag ()		Not Supported
mcsProfile (MscsProfile)		
> bandwidthIn (Number)	service > end-point > capacity	Partially Supported For further details see the analysis comment 06 in clause 5.2.2.11
> bandwidthOut (Number)		
> qosMetric ()	service > routing-constraint > (cost-characteristic & latency-characteristic)	Partially Supported For further details see the analysis comment 07 in clause 5.2.2.11
> directionality (Enum)		Not Supported. For further details see the analysis comment 05 in clause 5.2.2.11
> mtu (Number)		Not Supported
> protectionScheme (Enum)	service > resilience-constraint > protection-type	Supported For further details see the analysis comment 08 in clause 5.2.2.11
> connectivityMode (Enum)	service > connectivity-constraint > service-type	Supported
> numSegment (Number)		Not Supported
> segmentId (Identifier)		Not Supported
msnc (MsnC)		
> msnclId (Identifier)	service > connection > connection-uuid	Supported
> msnclEndpointId (Identifier)		Not Supported For further details see the analysis comment 12 in clause 5.2.2.11

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Create/Query/Update MSCS operation</i>	TAPI operation <i>create-connectivity-service/get-connectivity-service-details/update-connectivity-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> path (Identifier)		Not Supported For further details see the analysis comment 12 in clause 5.2.2.11
> msnProfile (MsnProfile)		
>> bandwidthIn (Number)		Not Supported
>> bandwidthOut (Number)		Not Supported
>> qosMetric ()		Not Supported
>> directionality (Enum)		Not Supported For further details see the analysis comment 12 in clause 5.2.2.11
>> mtu (Number)		Not Supported
>> protectionScheme (Enum)		Not Supported For further details see the analysis comment 12 in clause 5.2.2.11
>> connectionMode (Enum)		Not Supported
> msnLayerProtocol ()	service > layer-protocol-name	Potentially Supported For further details see the analysis comment 09 in clause 5.2.2.11

5.2.2.3 Analysis of Create/Query/Update/Terminate MSCS Reservation operation

The ETSI GS NFV-IFA 032 [i.2] operations regarding the reservation of resources (i.e. Create MSCS Reservation) and the management operations on the reserved resources (i.e. Query MSCS Reservation, Update MSCS Reservation and Terminate MSCS Reservation) are supported functionally but not operationally in TAPI. In other words, the TAPI YANG model cannot be used for MSCS resource reservation in the manner specified by ETSI GS NFV-IFA 032 [i.2]. For details please see Analysis comment 13 in clause 5.2.2.11.

5.2.2.4 Analysis of Query MSCS operation

5.2.2.4.1 Analysis of Query MSCS operation Input Information model

Table 5.2.2.4.1-1 provides a mapping of the information model of Query MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's YANG model *get-connectivity-service-details* in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-connectivity-service-details
    >> input
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.4.1-1: Mapping of Query MSCS operations with TAPI's *get-connectivity-service-details* operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model: <i>Query MSCS operation</i>	TAPI operation <i>get-connectivity-service-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)		Not Supported For further details see the analysis comment 11 in clause 5.2.2.11
> attributeSelector (String)		Not Supported For further details see the analysis comment 11 in clause 5.2.2.11

5.2.2.4.2 Analysis of Query MSCS operation Output Information model

Table 5.2.2.2.2-1 provides a mapping of the output information model of Create MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's create-connectivity-service RPC defined in [i.23]. The same information model is used in the Query MSCS operations output.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-connectivity-service-details
  >> output
```

All mapped parameters are specified relative to the above path.

For the analysis please refer to clause 5.2.2.2.2 above.

5.2.2.5 Analysis of Update MSCS operation

5.2.2.5.1 Analysis of Update MSCS operation Input Information model

Table 5.2.2.5.1-1 provides a mapping of the information model of Update MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's update-connectivity-service RPC defined in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > update-connectivity-service
  >> input
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.5.1-1: Mapping of Update MSCS operations with TAPI's update-connectivity-service operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Update MSCS operation</i>	TAPI operation <i>update-connectivity-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> connectivityServiceId (Identifier)	uuid	Supported For further details see the analysis comment 03 in clause 5.2.2.11
> addMscsEndpoint (MscsEndpointData)		
>> connectivityServiceEndpointId (Identifier)	end-point > service-interface-point > service-interface-point-uuid	Supported
>> directionality (Enum)	end-point > direction	Supported For further details see the analysis comment 05 in clause 5.2.2.11
>> networkAddressing ()		Not Supported
>> lag ()		Not Supported
> removeMscsEndpoint (Identifier)	end-point > local-id	Supported
> modifyMscsEndpoint (MscsEndpointInfo)		
>> mscsEndpointId (Identifier)	end-point > local-id	Supported
>> connectivityServiceEndpointId (Identifier - Reference to ConnectivityServiceEndpointInfo)	end-point > service-interface-point > service-interface-point-uuid	Supported
>> directionality (Enum)	end-point > direction	Supported For further details see the analysis comment 05 in clause 5.2.2.11
>> networkAddressing ()		Not Supported
>> lag ()		Not Supported
> modifyMscsProfile (MscsProfile)		

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Update MSCS operation</i>	TAPI operation <i>update-connectivity-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
>> bandwidthIn (Number)	end-point > capacity	Partially Supported For further details see the analysis comment 06 in clause 5.2.2.11
>> bandwidthOut (Number)		
>> qosMetric ()	routing-constraint > (cost-characteristic & latency-characteristic)	Partially Supported For further details see the analysis comment 07 in clause 5.2.2.11
>> directionality (Enum)		Not Supported. For further details see the analysis comment 05 in clause 5.2.2.11
>> mtu (Number)		Not Supported
>> protectionScheme (Enum)	resilience-constraint > protection-type	Supported For further details see the analysis comment 08 in clause 5.2.2.11
>> connectivityMode (Enum)	connectivity-constraint > service-type	Supported
>> numSegment (Number)		Not Supported
>> segmentId (Identifier)		Not Supported
> mscsName (String)		Partially supported For further details see the analysis comment 04 in clause 5.2.2.11
> mscsDescription (String)		Partially supported For further details see the analysis comment 04 in clause 5.2.2.11

5.2.2.5.2 Analysis of Update MSCS operation Output Information model

Table 5.2.2.2.2-1 provides a mapping of the output information model of Create MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's create-connectivity-service RPC defined in [i.23]. The same information model is used in the Update MSCS operations output.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > update-connectivity-service
    >> output
```

All mapped parameters are specified relative to the above path.

For the analysis please refer to clause 5.2.2.2.2 above.

5.2.2.6 Analysis of Terminate MSCS operation

5.2.2.6.1 Analysis of Terminate MSCS operation Input Information model

Table 5.2.2.6.1-1 provides a mapping of the information model of Terminate MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's YANG model delete-connectivity-service in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > delete-connectivity-service
    >> input
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.6.1-1: Mapping of Terminate MSCS operations with TAPI's delete-connectivity-service operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model: <i>Terminate MSCS operation</i>	TAPI operation delete-connectivity-service	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> connectivityServiceId (Identifier)	uuid	Supported For further details see the analysis comment 03 in clause 5.2.2.11

5.2.2.6.2 Analysis of Terminate MSCS operation Output Information model

Table 5.2.2.6.2-1 provides a mapping of the information model of Terminate MSCS operation specified for ETSI GS NFV-IFA 032 [i.2] MSCS Management interface with the YANG model specified for TAPI v2.2.0's YANG model delete-connectivity-service in [i.23].

Table 5.2.2.6.2-1: Mapping of Terminate MSCS operations with TAPI's delete-connectivity-service operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Terminate MSCS operation</i>	TAPI operation delete-connectivity-service	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> connectivityServiceId (Identifier)		Not Supported For further details see the analysis comment 10 in clause 5.2.2.11

5.2.2.7 Analysis of Notify operation

The ETSI GS NFV-IFA 032 [i.2] specification describes a Notify operation. An equivalent operation does not exist in the TAPI YANG model. Nevertheless, the content of the notifications is specified in the TAPI YANG module *tapi-notification*. See also analysis comment 02 in clause 5.2.2.11.

The ETSI GS NFV-IFA 032 [i.2] Notify operation for MSCS Management supports the types of notification Information Elements shown in table 5.2.2.7-1.

Table 5.2.2.7-1: Mapping of ETSI GS NFV-IFA 032 [i.2] MSCS Management Notification Information Elements with TAPI's notification types

ETSI GS NFV-IFA 032 [i.2] MSCS Management Interface Notify operation information elements	TAPI's OAM Service RPC	Comments
MscsChangeNotification		Supported.
MscsReservationChangeNotification		Not Supported. For further details see the analysis comment 14 in clause 5.2.2.11

Table 5.2.2.7-2 provides the mapping of the attributes of the *MscsChangeNotification* information element to the TAPI's YANG *tapi-notification* and *tapi-oam module*. The TAPI's YANG *tapi-oam* module extends (augments) the notification type that is specified in TAPI's YANG *tapi-notification* module.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path defined in TAPI's YANG *tapi-notification* module (see [i.23]):

```
rpc
> get-notification-list
  >> output
    >>> notification
```

All mapped parameters are specified relative to the above path. Table 5.2.2.7-2 provides the mapping.

Table 5.2.2.7-2: Mapping of Notify operation IE MscsChangeNotification with TAPI's tapi-notification-service

ETSI GS NFV-IFA 032 [i.2] MSCS Management Notify operation Information Element <i>MscsChangeNotification</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
mcsId (identifier)	target-object-identifier	Supported
changedMscsProfile (Not specified)	changed-attributes	Supported For further details see the analysis comment 15 in clause 5.2.2.11
affectedComponent (Not specified)	additional-info	Supported For further details see the analysis comment 16 in clause 5.2.2.11

5.2.2.8 Analysis of Subscribe operation

5.2.2.8.1 Analysis of Subscribe operation input information model

ETSI GS NFV-IFA 032 [i.2] specifies a Filter as an input parameter for selecting notifications to subscribe to changes related to MSCS or MSCS reservation. The filter can be on *resource*, *type of notification* or *attribute of the notification*.

This is similar to the approach adopted by TAPI where a YANG model referred to as *tapi-notification* has been specified with relevant module and RPCs to support the notification service.

The ETSI GS NFV-IFA 032 [i.2] Subscribe operation maps to the TAPI's *create-notification-subscription-service* RPC. The path *create-notification-subscription-service/input/subscription-filter* have the following attributes/parameters that can serve the ETSI GS NFV-IFA 032 [i.2] Subscription operation:

- requested-notification-types* to support type of notification;
- requested-object-types* to support identifying the type of resource;
- requested-object-identifier* to support identifying the particular resource object;
- name* [value-name]* to support including notification related attributes.

5.2.2.8.2 Analysis of Subscribe operation output information model

ETSI GS NFV-IFA 032 [i.2] Subscribe operation output parameter *subscriptionId* returns identifier of the subscription realized. This is supported by the TAPI's *create-notification-subscription-service* RPC output parameter with the following path:

- *create-notification-subscription-service/output/subscription-service/notification/uuid*.

5.2.2.9 Analysis of Query Subscription operation

5.2.2.9.1 Analysis of Query Subscription Info operation input information model

ETSI GS NFV-IFA 032 [i.2] defines a *filter* as an input parameter for performing the Query Subscription Info operation. However, the content of Filter parameter is not specified, the details of which has been left for the protocol design stage.

The TAPI's *get-notification-subscription-service-details* and *get-notification-subscription-service-list* RPCs in the *tapi-notification* module operationally support the ETSI GS NFV-IFA 032 Query Subscription Info operation.

5.2.2.9.2 Analysis of Query Subscription Info operation output information model

ETSI GS NFV-IFA 032 [i.2] Query Subscription Info operation output parameter *queryResult* returns the relevant information about the queried subscription. However, the content of *queryResult* parameter is not specified, the details of which has been left for the protocol design stage.

It should be noted that TAPI operation provide a rich set of information about the queried subscriptions.

5.2.2.10 Analysis of Terminate Subscription operation

5.2.2.10.1 Analysis of Terminate Subscription operation input information model

ETSI GS NFV-IFA 032 [i.2] specifies an identifier called *subscriptionId* as the only input parameter for selecting the subscription to the notifications that should be deleted.

ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation maps to the TAPI's *delete-notification-subscription-service* RPC. The only parameter with the path *delete-notification-subscription-service/input/uuid* can be directly mapped to the *subscriptionId* parameter of the ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation.

5.2.2.10.2 Analysis of Terminate Subscription operation output information model

ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation has no output. The same is true for the mapped TAPI operation *delete-notification-subscription-service*.

5.2.2.11 Analysis Comments for MSCS Management Interface Operations

Analysis Comment 01: There is a difference in the concept of MSCS related reservation operations in ETSI GS NFV-IFA 032 [i.2] and TAPI. In ETSI GS NFV-IFA 032 [i.2], the individual parameters/attributes that reflect the reservation operations (and related information elements), can also be present in TAPI but they cannot be mapped because the concept/feature of ETSI GS NFV-IFA 032's [i.2] reservation in terms of how it is perceived to be used is not supported in TAPI.

EXAMPLE: In ETSI GS NFV-IFA 032 [i.2] a reserved MSCS instance can be available but not utilized, whereas in TAPI a reserved connectivity service instance is automatically instantiated for usage at start-time and then automatically terminated at end-time.

Analysis Comment 02: The MSCS Notify operation can be supported by the notification mechanism of the NETCONF/RESTCONF protocol implementing the TAPI YANG models. The content of the notifications that get sent are specified in the *tapi-notifications* module of the TAPI YANG model. The notifications might need some adaptation to implement the filters that the mechanisms of the NETCONF/RESTCONF protocol specifies and is expected by the ETSI GS NFV-IFA 032 [i.2] operation.

Analysis Comment 03: In ETSI GS NFV-IFA 032 [i.2] a connectivity service is uniquely identified by the **connectivityServiceId** parameter. This can be mapped to the **uuid** parameter in the **input** subtree of the RPC commands defined in the TAPI YANG schema [i.23].

Analysis Comment 04: The attributes **mcsName** and **mcsDescription** are optional and can be supported by the **name** parameter in the TAPI operation. This parameter is a list of tuples of `<value-name (type string), value (type string)>`. The **value-name** parameter of the tuple is used as key for the list and is unique. Given a **mcsName** attribute of *Connection Service 01* and a **mcsDescription** attribute of *Connecting customer A to customer B* those attributes can be mapped as tuples in the name list as follows:

```
<"mcsName", "Connection Service 01">
<"mcsDescription", "Connecting customer A to customer B">
```

Analysis Comment 05: There are 2 definitions of a directionality in ETSI GS NFV-IFA 032 [i.2]. One is defined in the *MscsEndpointData* and *MscsEndpointInfo* information elements. The other is specified in the *MscsProfile* and *MscProfile* information elements.

The **directionality** of the **MscsEndpointData** and **MscsEndpointInfo** information elements can be supported by the input parameter **direction** in the **end-point** element of TAPI's RPCs. ETSI GS NFV-IFA 032 [i.2] defined **directionality** these information elements as an enum consisting of { **INBOUND**, **OUTBOUND**, **BOTH** }. In TAPI the type is also an enum consisting of { **BIDIRECTIONAL**, **INPUT**, **OUTPUT**, **UNIDENTIFIED_OR_UNKNOWN** }. Except of the **UNIDENTIFIED_OR_UNKNOWN** value both definitions map.

The directionality in the **MscsProfile** and **MscncProfile** cannot be mapped to any input parameter in the TAPI RPCs. When returned in an output parameter set this would map to a top-level element **direction** that is defined as an enum consisting of { **BIDIRECTIONAL**, **UNIDIRECTIONAL**, **UNIDENTIFIED_OR_UNKNOWN** }. ETSI GS NFV-IFA 032 [i.2] defined **directionality** in the profile information elements as enum consisting of { **BIDIRECTIONAL**, **UNIDIRECTIONAL** }. Except of the **UNIDENTIFIED_OR_UNKNOWN** value both definitions map.

Analysis Comment 06: The TAPI model partially supports the attributes **bandwidthIn/bandwidthOut**. Whereas ETSI GS NFV-IFA 032 [i.2] defines different bandwidth parameters for incoming and outgoing traffic TAPI is not distinguishing between incoming and outgoing bandwidth. If incoming and outgoing bandwidth are considered as the same the parameters could be mapped. The detailed description of such a mapping, considering additional constraints like unit conversion and the like, is left for further specification.

Analysis Comment 07: The **qosMetric** attribute can be supported by the **cost-characteristic** and **latency-characteristic** attributes of the **routing-constraint** parameter. ETSI GS NFV-IFA 032 [i.2] does not specify the content of the **qosMetric** attribute, which makes it impossible to finally map the rather specific attributes in the TAPI framework to ETSI GS NFV-IFA 032 [i.2]. However, if the description is any indication, then ETSI GS NFV-IFA 032 [i.2] is expecting this to be modelled as a time based value for cost, delay, delay variation and latency. So if TAPI supports these time based values in **cost-characteristic** and **latency-characteristic**, that still leaves with no definition for delay, and delay variation.

Analysis Comment 08: The **protectionScheme** attribute can be mapped to the **protection-type** attribute of the **resilience-constraint** parameter in the TAPI framework. Whether or not all protection schemes defined in the ETSI GS NFV-IFA 032 [i.2] can be mapped to the TAPI framework needs to be determined.

Analysis Comment 09: Based on the interpretation of the current description of the **mscsLayerProtocol** attribute, where it implies to specify the layered protocol, it can thus be potentially mapped with the **layer-protocol-name** parameter if the mapping of a name is enough for specifying the layer protocol. Whether the protocols defined in TAPI can be mapped entirely or at least overlap with what is needed by ETSI GS NFV-IFA 032 [i.2] can be determined in a further examination. If more parameters than a name are needed to specify the **mscsLayerProtocol** there is no mapping.

Analysis Comment 10: There is no mapping for the output parameter **connectivityServiceId** of this operation because the corresponding TAPI operation has no output parameters. Still the operation as such can be supported since a similar functionality could be achieved by combining the input parameter and the return value of the NETCONF/RESTCONF operation executed by the TAPI operation. If the NETCONF/RESTCONF operation is executed successfully then the input parameter could be returned unmodified.

Analysis Comment 11: The input parameters of the Query MSCS operation defined by ETSI GS NFV-IFA 032 [i.2] are not supported by the corresponding TAPI operation. Also the operation that might augment the attributes returned by the TAPI **get-connectivity-service-details** like **get-connectivity-service-list**, **get-connection-details** and **get-connection-end-point-details** do not support those input parameters. Nevertheless, the operation can be supported by retrieving all values and do filtering and attribute selection in a second implementation step before returning the output parameters.

Analysis Comment 12: The attributes of the **Mscnc** information element cannot be returned by the mapped TAPI operation using solely the output attributes it returns. By using a second TAPI operation at least parts of the attributes specified in ETSI GS NFV-IFA 032 [i.2] could be supported as shown in table 5.2.2.11-1. When mapping **Mscnc** information element defined in ETSI GS NFV-IFA 032 [i.2] to the TAPI YANG elements below the following path is used (see [i.23]):

```
rpc
  > get-connection-details
  >> output
```

All mapped parameters are specified relative to the above path.

Table 5.2.2.11-1: Mapping of Msnc information element with TAPI's get-connection-details operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Msnc</i>	TAPI operation <i>get-connection-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
msnc (Msnc)		
> msnclId (Identifier)		The mapping in clause 5.2.2.2.2 is used as input for retrieving the information with this TAPI operation
> msnclEndpointId (Identifier)	connection > connection-end-point > connection-end-point-uuid	Supported
> path (Identifier)	connection > route > local-id	Supported
> msncProfile (MsncProfile)		
>> bandwidthIn (Number)		Not Supported
>> bandwidthOut (Number)		Not Supported
>> qosMetric ()		Not Supported
>> directionality (Enum)	connection > direction	Supported For further details see the analysis comment 05 in clause 5.2.2.11
>> mtu (Number)		Not Supported
>> protectionScheme (Enum)	get-connection-details > output > connection > switch-control > protection-type	Supported For further details see the analysis comment 08 in clause 5.2.2.11
>> connectionMode (Enum)		Not Supported
> msnclLayerProtocol ()		Potentially Supported For further details see the analysis comment 09 in clause 5.2.2.11

Analysis Comment 13: ETSI GS NFV-IFA 032 [i.2], distinctly specifies operations for reserving resources and their management of reserved resources, which can then be consumed when instantiating MSCS objects over the reserved resources at specified time. This makes the creation of an MSCS object a two-step operation. However, in the YANG model for TAPI, the resource reservation is carried out as part of the *create-connectivity-service request* without a further operation that needs to be triggered at connectivity service instantiation time. In other words it is embedded in a single operation (i.e. RPC). The same is true for the ETSI GS NFV-IFA 032 [i.2] operations for the management of the reserved resources (i.e. Query/Update/Terminate MSCS Reservation operation), which in TAPI's case are inherently part of *get-connectivity-service-details*, *update-connectivity-service* and *delete-connectivity-service* RPCs.

Analysis Comment 14: As described in clause 5.2.2.3 and analysis comment 13, the operations related to MSCS resource reservation specified for the ETSI GS NFV-IFA 032 [i.2] are not supported in TAPI, therefore the attributes of the *MscsReservationChangeNotification* information element for the MSCS Notify operation is not supported by TAPI.

Analysis Comment 15: The content of the attribute *changedMscsProfile* is not specified in ETSI GS NFV-IFA 032 [i.2]. However, the *changed-attributes* attribute, based on key-value pairs, present in the *notifications* information model defined in TAPI's *tapi-notification* module can support the inclusion of the details of the changes regarding the profile of the MSCS whenever the content of the *changedMscsProfile* attribute in ETSI GS NFV-IFA 032 [i.2] is specified.

Analysis Comment 16: The content of the attribute *affectedComponent* is not specified in ETSI GS NFV-IFA 032 [i.2]. However, the *additional-info* attribute, based on key-value pairs, present in the *notifications* information model defined in TAPI's *tapi-notification* module can support the inclusion of the details about the identification and information about components or sub-objects of the MSCS that were affected in the change, whenever the content of the *affectedComponent* attribute in ETSI GS NFV-IFA 032 [i.2] is specified.

5.2.3 Gap analysis with respect to IETF Network YANG Data models

5.2.3.0 Introduction

IETF network YANG models provide a network-centric view of the connectivity services and are suitable for service orchestration and resource orchestration. Clause 5.2.3 and subclauses analyse the similarities and gaps between the interface operations exposed by WIM and related information elements with those of the network YANG models specified by IETF.

5.2.3.1 Profiling of Information elements

5.2.3.1.1 Introduction

IETF Network data models (L2NM YANG data model [i.25] and L3NM YANG data model [i.24]) support the multi-site connectivity service and have the ability to configure the required connectivity service parameters in the transport network. This clause analyses the similarities and gaps between the information elements used in the WIM interfaces in ETSI GS NFV-IFA 032 [i.2] with those of the L2NM and L3NM YANG models. These information elements are used in the input and output parameters of different operations produced by WIM. Table 5.2.3.1.1-1 provides the references of the model and the modules used in the profiling of the information elements.

Table 5.2.3.1.1-1: Reference IETF models and modules

Name	Draft or RFC	Modules
Layer 3 VPN Network YANG Model [i.24]	draft-ietf-opsawg-l3sm-l3nm-05	ietf-l3vpn-ntw
Layer 2 VPN Network YANG Model [i.25]	draft-ietf-opsawg-l2nm-01	ietf-l2vpn-ntw
Traffic Engineering (TE) and Service Mapping Yang Model [i.28]	draft-ietf-teas-te-service-mapping-yang-03	ietf-l3sm-te-service-mapping
YANG Data Model for Traffic Engineering (TE) Topologies [i.34]	draft-ietf-teas-yang-te-topo-22	ietf-te-topology

5.2.3.1.2 MscsData Information element

Refer to clause 8.2.2.2 in ETSI GS NFV-IFA 032 [i.2]. Attributes of mscsData are provided by the customer as input while creating the service.

In the IETF network YANG models (L3NM and L2NM), VPN Site (vpn-site) refers to A VPN customer's location that is connected to the Service Provider network via a CE-PE link, which can access at least one VPN. VPN network access (vpn-network-access) is an abstraction that represents the network interfaces that are associated to a given VPN node. Traffic coming from the VPN network access belongs to the VPN. The attachment circuits (bearers) between CEs and PEs are terminated in the VPN network access. Site Bearer is augmented in network access to reference the NEs and Ports where each site Network access belongs. This helps to preserve the local and far ends from the Network controller site. The attributes of mscsData information element map to the vpn-site and vpn-network-access attributes.

In L3NM YANG model, the attributes of mscsData map to the attributes in vpn-service parent leaf and constituents of additional clauses listed in table 5.2.3.1.2-1. Refer to the snippet of L3NM YANG model in figure A.2.2-1.

Table 5.2.3.1.2-1: Profiling of the MscsData information element with L3NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis
mscsName (String)	mscsName maps to vpn-name under vpn-service leaf in L3NM model. (ietf-l3vpn-ntw/vpn-services/vpn-service/vpn-name)	Supported. See Analysis comment 01 in clause 5.2.3.1.10.
mscsDescription (String)	Maps to the vpn-description under vpn-service leaf in L3NM model (ietf-l3vpn-ntw/vpn-services/vpn-service/vpn-description)	Supported.
mscsEndpoint (List)	See clause 5.2.3.1.3	
mscsProfile	See clause 5.2.3.1.4	
mscsLayerProtocol	No attribute in the model.	Supported. See note.
NOTE: L3NM implicitly supports "BGP/MPLS IP VPN (IETF RFC 4364 [i.44])".		

In L2NM YANG model, the attributes of mscsData information element map to the attributes in vpn-service parent leaf and constituents of additional clauses listed in table 5.2.3.1.2-2. Refer to the snippet of L2NM YANG model in figure A.2.3-1.

Table 5.2.3.1.2-2: Profiling of the MscsData information element with L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L2NM YANG model	Analysis
mscsName (String)	Maps to ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-name.	Supported.
mscsDescription (String)	Maps to the vpn-description under vpn-service leaf in L2NM model (ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-description)	Supported.
mscsEndpoint (List)	See clause 5.2.3.1.3	
mscsProfile	See clause 5.2.3.1.4	
mscsLayerProtocol	Maps to ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-svc-type.	Supported. See note.
NOTE: L2 VPN service types directly match with L2VPN Service types defined in IETF RFC 8466 [i.12].		

5.2.3.1.3 MscsEndPointData Information element

Refer to clause 8.2.2.3 in ETSI GS NFV-IFA 032 [i.2]. Attributes of mscsEndPoint are provided by the customer as input while creating the service. They can be modified later with an update operation.

The attributes in mscsEndPointData information element map to site attributes in service models (L3SM & L2SM). But the network models (L3NM & L2NM) do not maintain site information.

In network models (L3NM & L2NM), the attributes in mscsEndPointData information element correlate to the configuration on PE side for the attachment circuit towards Customer network. A "vpn-network-access" includes information such as the connection on which the access is defined, the encapsulation of the traffic, policies that are applied on the access, etc.

In L3NM YANG model, these attributes correlate to the attributes in vpn-service/vpn-network-accesses/vpn-network-access parent leaf as listed in table 5.2.3.1.3-1. Refer to the snippets of L3NM YANG model in figures A.2.2-2, A.2.2-3, A.2.2-4 and A.2.2-5.

Table 5.2.3.1.3-1: Profiling of the MscsEndPointData information element with L3NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis: support status
connectivityServiceEndpointId (Identifier)	The bearer reference attribute in the vpn-network-access/connection/bearer (ietf-l3vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection/bearer/bearer-reference). See note 1.	Supported. See Analysis comment 02 in clause 5.2.3.1.10.
directionality (Enum)	Combination of vpn-services/vpn-service/vpn-service-topology and setup of "import and export profiles".	Partially supported. See Analysis comment 04 in clause 5.2.3.1.10.
networkAddressing (Not specified)	The connection and ip-connection attributes in the vpn-network-accesses/vpn-network-access identifies the networkAddressing. See note 2.	Supported
lag (Not specified)	No attribute in the model.	Not supported. See Analysis comment 05 in clause 5.2.3.1.10.
NOTE 1: The connectivityServiceEndpointId is reference of the service end point on the NFVI-PoP. To establish the CE-PE connectivity, the WIM and its consumer coordinates setting connection and ip-connection attributes using this bearer reference.		
NOTE 2: The attributes in ietf-l3vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection (e.g. encapsulation-type, cvlan-id etc) and the attributes in ietf-l3vpn-ntw/vpn-network-accesses/vpn-network-access/ip-connection (e.g. customer-address, provider-address, etc.) are configured by the WIM.		

In L2NM YANG model, these attributes correlate to the attributes in vpn-service/vpn-network-accesses/vpn-network-access parent leaf as listed in table 5.2.3.1.3-2. Refer to the snippets of L2NM YANG model in figures A.2.3-1 and A.2.3-2.

Table 5.2.3.1.3-2: Profiling of the MscsEndPointData information element with L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L2NM YANG model	Analysis: support status
connectivityServiceEndpointId (Identifier)	Maps to ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection. See note 1.	Supported. See Analysis comment 10 in clause 5.2.3.1.10.
directionality (Enum)	Can be derived from service topology. Maps to ietf-l2vpn-ntw/vpn-services/vpn-service/svc-topo.	Partially supported. See Analysis comment 11 in clause 5.2.3.1.10.
networkAddressing (Not specified)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection. See note 2.	Supported
lag (Not specified)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection/lag-interface.	Supported.
NOTE 1: The connectivityServiceEndpointId is reference of the service end point on the NFVI-PoP. To establish the CE-PE connectivity, the WIM and its consumer coordinates setting connection attributes.		
NOTE 2: The attributes in l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/connection (e.g. encapsulation-type, cvlan-id, etc.) are configured by the WIM.		

5.2.3.1.4 MscsProfile Information element

Refer to clause 8.2.2.4 in ETSI GS NFV-IFA 032 [i.2]. Attributes of mscsProfile are provided by the customer as input while creating the service. They can be modified later by update operation. The attributes specify the profile parameters for the MSCS.

The profile parameters map to the configuration on PE side for all the attachment circuits towards Customer network. There is a flexibility to create separate profiles under each vpn-node/vpn-network-access.

In L3NM YANG model, the mscsProfile parameters correlate to the attributes as listed in table 5.2.3.1.4-1. Refer to the snippet of L3NM YANG model in figure A.2.2-6.

Table 5.2.3.1.4-1: Profiling of the MscsProfile information element with L3NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis: support status
bandwidthIn (Number)	This maps to the svc-input-bandwidth attribute in vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service.	Supported. See analysis comment 06 in clause 5.2.3.1.10.
bandwidthOut (Number)	In L3NM, this maps to the svc-output-bandwidth attribute in vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service.	Supported. See analysis comment 06 in clause 5.2.3.1.10.
qosMetric (List of) (Not specified)	This maps to the qos-profile in vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service/qos.	Partially supported.
directionality (Enum)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 2.
mtu (Number)	This maps to the svc-mtu attribute in vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service.	Supported.

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis: support status
protectionScheme (Enum)	No attribute in the model. Neither access, nor WAN network diversity is supported.	Not supported.
connectivityMode (Enum)	No attribute mapping to MscsProfile.	Partially supported. See note 2.
numSegment (Number)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 3.
segmentId (List of) (Identifier)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 3.
NOTE 1: Attribute cannot be clearly profiled considering the present profiled standard. The semantics of the attribute in this information element is not clear from ETSI GS NFV-IFA 032 [i.2].		
NOTE 2: The values of the attribute from ETSI GS NFV-IFA 032 [i.2] are limited in choice of connectivity topologies. See analysis comment 11 in clause 5.2.3.1.10.		
NOTE 3: See analysis comment 03 in clause 5.2.3.1.10.		

In L2NM YANG model, the mscsProfile parameters correlate to the attributes as listed in table 5.2.3.1.4-2. Refer to the snippets of L2NM YANG model in figures A.2.3-3 and A.2.3-4.

Table 5.2.3.1.4-2: Profiling of the MscsProfile information element with L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L2NM YANG model	Analysis: support status
bandwidthIn (Number)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service/svc-input-bandwidth.	Supported. See analysis comment 06 in clause 5.2.3.1.10.
bandwidthOut (Number)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service/svc-output-bandwidth.	Supported. See analysis comment 06 in clause 5.2.3.1.10.
qosMetric (List of) (Not specified)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/service/qos/qos-profile.	Supported.
directionality (Enum)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 2.
mtu (Number)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/svc-mtu	Supported.
protectionScheme (Enum)	Maps to attributes in ietf-l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/access-diversity.	Supported.
connectivityMode (Enum)	No attribute mapping to MscsProfile.	Partially supported. See note 2.
numSegment (Number)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 3.
segmentId (List of) (Identifier)	No attribute mapping to MscsProfile.	Not supported. See notes 1 and 3.
NOTE 1: Attribute cannot be clearly profiled considering the present profiled standard. The semantics of the attribute in this information element is not clear from ETSI GS NFV-IFA 032 [i.2].		
NOTE 2: The values of the attribute from ETSI GS NFV-IFA 032 [i.2] are limited in choice of connectivity topologies. See analysis comment 11 in clause 5.2.3.1.10.		
NOTE 3: See analysis comment 03 in clause 5.2.3.1.10.		

5.2.3.1.5 Mscs Information element

Refer to clause 8.2.2.5 in ETSI GS NFV-IFA 032 [i.2]. Attributes of mscs contain the identifier for MSCS and the constituent MNCS(s).

In L3NM, there is partial mapping these attributes. These map to the attributes in vpn-service parent leaf and constituents of additional clauses listed in table 5.2.3.1.5-1. Refer to the snippet of L3NM YANG model in figure A.2.2-1.

Table 5.2.3.1.5-1: Profiling of the Mscs information element with L3NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis
mcsId (Identifier)	vpn-id maps to mcsId. mcsId can map to l3sm-vpn-id under vpn-service leaf in L3NM model.	Supported. See Analysis comment 01 in clause 5.2.3.1.10.
mcsName (String)	See in table 5.2.3.1.2-1	Supported
mcsDescription (String)	See in table 5.2.3.1.2-1	Supported
mcsEndpoint (structure)	See clause 5.2.3.1.8	
mcsProfile (structure)	See clause 5.2.3.1.4	
msnc	See clause 5.2.3.1.6	
NOTE:	If different vpns can be created to realize a customer service, the same customer-name and l3sm-vpn-id can be assigned to more vpn-ids.	

In L2NM YANG model, the attributes of MSCS correlate to the attributes in vpn-service parent leaf and constituents of additional clauses listed in table 5.2.3.1.5-2. Refer to the snippet of L2NM YANG model in figure A.2.3-1.

Table 5.2.3.1.5-2: Profiling of the Mscs information element with L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L2NM YANG model	Analysis
mcsId (Identifier)	vpn-id maps to mcsId. mcsId can map to vpn-id under vpn-service leaf in L2NM model.	Supported. See Analysis comment 01 in clause 5.2.3.1.10.
mcsName (String)	See in table 5.2.3.1.2-2	Supported
mcsDescription (String)	See in table 5.2.3.1.2-2	Supported
mcsEndpoint (structure)	See clause 5.2.3.1.3	
mcsProfile (structure)	See clause 5.2.3.1.4	
msnc	See clause 5.2.3.1.6	

5.2.3.1.6 Msnc Information element

Refer to clause 8.2.2.6 in ETSI GS NFV-IFA 032 [i.2].

IETF defined a TE Service Mapping Model [i.28] that specifies YANG data model to map customer service models to Traffic Engineering (TE) models (e.g. the TE Tunnel or the Virtual Network (VN) model). This model is applicable generically to the operator's need for seamless control and management of their VPN services with TE tunnel support. This model is principally used to allow monitoring and diagnostics of the management systems to show how the service requests are mapped onto underlying network resource and TE models.

In L3NM/L2NM with TE service mapping, the attributes map to the TE tunnel attributes and constituents of additional clauses listed in table 5.2.3.1.6-1.

The TE service mapping augmentation snippets are provided in figures A.2.4-1 and A.2.4-2.

Table 5.2.3.1.6-1: Profiling of the Msnc information element with L3NM/L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM/L2NM YANG model	Analysis
msncId (Identifier)	Maps to the "identifier" attribute of TE tunnel. For L3NM: /l3vpn-ntw/vpn-services/vpn-service/te-service-mapping/te-mapping/te/te-tunnel/identifier) For L2NM: /l2vpn-ntw/vpn-services/vpn-service/te-service-mapping/te-mapping/te/te-tunnel/identifier	Supported.
msncEndpointId (List of) (Identifier (Reference to NetworkEdgePointInfo))	Map to the resource destination or the TTPs of the TE tunnel. These endpoints are independent references compared to VPN endpoints.	Supported. See Analysis comment 07 in clause 5.2.3.1.10

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM/L2NM YANG model	Analysis
path (List of) (Identifier (Reference to NodeInfo))	YANG model supports. Mapping is depending on the technology (LSP encoding type) used.	Supported. See Analysis comment 08 in clause 5.2.3.1.10.
msncProfile (Structure)	See clause 5.2.3.1.7	
msncLayerProtocol (Not specified)	Maps to the technology (LSP encoding type) of the TE tunnel.	Supported. See Analysis comment 09 in clause 5.2.3.1.10. See note.
NOTE: The examples listed in the description of this attribute in ETSI GS NFV-IFA 032 [i.2] do not bring clarity to the semantics of this attribute.		

5.2.3.1.7 MsncProfile Information element

Refer to clause 8.2.2.7 in ETSI GS NFV-IFA 032 [i.2]. Attributes of msncProfile specify the profile parameters for the MSNC.

Table 5.2.3.1.7-1: Profiling of the MsncProfile information element with L3NM/L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM/L2NM YANG model	Analysis: support status
bandwidthIn (Number)	Maps to the ietf-te/te/tunnels/tunnel/te-bandwidth	Supported.
bandwidthOut (Number)	Maps to the ietf-te/te/tunnels/tunnel/te-bandwidth	Supported.
qosMetric (List of) (Not specified)	Maps to multiples of metric-type & upper-bound values in te/te-tunnels/tunnel/primary-paths/primary-path/path-metric-bounds/path-metric-bound	Supported.
directionality (Enum)	Can be derived from te/te-tunnels/tunnel/bidirectional. Can also use additional attributes if bidirectional flag is missing.	Supported.
mtu (Number)	No attribute mapping to MsncProfile.	Not supported. See note.
protectionScheme (Enum)	Maps to te/te-tunnels/tunnel/protection/protection-type.	Supported.
connectionMode (Enum)	This is P2P by default.	Supported.
NOTE: Attribute cannot be clearly profiled considering the present profiled standard. The semantics and need of the attribute in this information element is not clear from ETSI GS NFV-IFA 032 [i.2].		

5.2.3.1.8 MscsEndPointInfo Information element

Refer to clause 8.2.2.8 in ETSI GS NFV-IFA 032 [i.2]. Attributes of mscsEndPoint are to be fetched by the WIM to update this information.

In L3NM, these attributes specify the configuration on PE side for the attachment circuit towards Customer network. A "vpn-network-access" includes information such as the connection on which the access is defined, the encapsulation of the traffic, policies that are applied on the access, etc. These map to the attributes in vpn-service/vpn-network-accesses/vpn-network-access parent leaf.

Table 5.2.3.1.8-1: Profiling of the MscsEndPointInfo information element with L3NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L3NM YANG model	Analysis: support status
mcsEndPointId (Identifier)	Maps to l3vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/vpn-network-access/id	Supported.
connectivityServiceEndpointId (Identifier)	Refer to table 5.2.3.1.3-1.	Supported. See Analysis comment 02 in clause 5.2.3.1.10.
directionality (Enum)	Refer to table 5.2.3.1.3-1.	Partially supported. See Analysis comment 04 in clause 5.2.3.1.10.
networkAddressing (Not specified)	Refer to table 5.2.3.1.3-1.	Supported.
lag (Not specified)	Refer to table 5.2.3.1.3-1.	Not supported. See Analysis comment 05 in clause 5.2.3.1.10.

In L2NM YANG model, these attributes correlate to the attributes in vpn-service/vpn-network-accesses/vpn-network-access parent leaf as listed in table 5.2.3.1.8-2.

These map to the attributes in vpn-service/vpn-network-accesses/vpn-network-access parent leaf.

Table 5.2.3.1.8-2: Profiling of the MscsEndPointInfo information element with L2NM YANG model

ETSI GS NFV-IFA 032 [i.2] model Attribute	L2NM YANG model	Analysis: support status
mcsEndPointId (Identifier)	Maps to l2vpn-ntw/vpn-services/vpn-service/vpn-nodes/vpn-node/vpn-network-accesses/network-access-id	Supported.
connectivityServiceEndpointId (Identifier)	Refer to table 5.2.3.1.3-2.	Supported. See Analysis comment 10 in clause 5.2.3.1.10.
directionality (Enum)	Refer to table 5.2.3.1.3-2.	Partially supported. See Analysis comment 11 in clause 5.2.3.1.10.
networkAddressing (Not specified)	Refer to table 5.2.3.1.3-2.	Supported
lag (Not specified)	Refer to table 5.2.3.1.3-2.	Supported

5.2.3.1.9 MscsChangeNotification

Refer to clause 8.2.4 in ETSI GS NFV-IFA 032 [i.2]. The attributes of MscsChangeNotification are specified to inform about specific changes related to the MSCSs such as change of network path, network QoS, update the MSCS by adding new MSNCs or updating MSNCs or terminating MSNCs, etc. Table 5.2.3.1.9-1 lists the profiling of attributes in MscsChangeNotification.

Table 5.2.3.1.9-1: Profiling of MscsChangeNotification with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model (L2NM/L3NM)	Analysis: support status
mcsId (Identifier)	Maps to the vpn-id in L2NM/L3NM. See clause 5.2.3.1.5.	Supported
changedMscsProfile	See clause 5.2.3.1.4	Supported
affectedComponent	-	Not supported

5.2.3.1.10 Analysis comments for MSCS Management interface operations

Analysis comment 01: The L3SM, L2SM and L1CSM, and their augmentations have a "vpn-id", which could also be used to provide correspondence with the "mscsName". However, this would create a collision/overlapping of the "mscsName" with the "mscsId". On the other hand, the listed models also provide an attribute named "customer-name", which could be used by the interface consumer to provide the "mscsName". In the Layer 3 VPN Network YANG Model [i.24] and Layer 2 VPN Network YANG Model [i.25], attribute *vpn-name* maps to *mscsName*. Attribute *vpn-id* maps to *mscsId*.

Analysis comment 02: The connection from the site to the Service Provider network is the bearer. Every site is associated with a list of bearers. A bearer is the layer two connections with the site. In the module it is assumed that the bearer has been allocated by the Service Provider at the service orchestration step. The bearer is associated to a network element and a port. Hence, a bearer is just a bearer-reference to allow the translation between L3SM and L3NM. Refer to the snippets of L3NM YANG model in figure A.2.2-3.

Analysis comment 03: Number of segments is not supported. However, L3NM/L2NM provides a definition for providing specific values in tagged interfaces in the "connection" (see the "connection" container). It also allows for mapping multiple customer VLAN id to a VPN service. This attribute might have been misplaced in MscsProfile as in IETF, the number of resources used can be changed dynamically.

Analysis comment 04: In the L3NM, for a given connection bearer (equivalent to a connectivity service endpoint), there is no support to indicate the direction in which the data traffic can flow. However, a combination of VPN service topology and correct setting of import/export route profiles will determine the possible flow of traffic. L3NM support service topologies for: Hub-Spoke, Hub-Spoke-Disjoint, Any-to-Any, and Custom. Default is "Any-to-Any", which would be equivalent to "directionality = BOTH" in the ETSI GS NFV-IFA 032 [i.2] model.

Analysis comment 05: The L3NM latest draft (draft-ietf-opsawg-l3sm-l3nm-05 [i.24]) specifies a "lag-id" potentially to be associated to the connection bearers, but not yet shown on the tree.

Analysis comment 06: In the L3NM and L2NM, the input and output service bandwidth are assigned on a per VPN network access and involved VPN node (PE), whereas in the ETSI GS NFV-IFA 032 [i.2], a unique in and out bandwidth is set for the whole MSCS. In other words, L3NM allows to differentiate different bandwidths for each of the sites. Effectively, if all input and output service bandwidth are equal for all sites, then it maps fully to the bandwidthIn and bandwidthOut of ETSI GS NFV-IFA 032 [i.2].

Analysis comment 07: Tunnel reference id is available in the TE service mapping of L3NM or L2NM models (augmentations). Using this Tunnel reference, resource endpoints (TTPs) information can be obtained ([ietf-te/te/tunnels/tunnel/](#)).

Analysis comment 08: Tunnel reference id is available in in the TE service mapping of L3NM or L2NM models (augmentations). Using this Tunnel reference, getting the list of network nodes in the underlying network from TE tunnel model depends on the technology used in configuring the tunnel. YANG model supports the attribute.

Analysis comment 09: The LSP Encoding Type indicates the encoding type that will be used with the data associated with the LSP, i.e. the type of technology being considered. For instance, it can be SDH, SONET, Ethernet, ANSI PDH, etc. It represents the nature of the LSP, and not the nature of the links that the LSP traverses. This is used hop-by-hop by each node.

Analysis comment 10: The connection from the site to the Service Provider network is the bearer. Every site is associated with a list of bearers. A bearer is the layer two connections with the site. In L2NM, the bearer-id is specified as a string in site-bearers leaf.

Analysis comment 11: In the L2NM, for a given connection bearer (equivalent to a connectivity service endpoint), there is no support to indicate the direction in which the data traffic can flow. However, a VPN service topology ([/l2vpn-ntw/vpn-services/vpn-service/svc-topo](#)) will determine the possible flow of traffic. L2NM support service topologies for:

- Hub-Spoke;
- Hub-Spoke-Disjoint;
- Any-to-Any;
- etc.

Default is "Any-to-Any", which would be equivalent to "directionality = BOTH" in the ETSI GS NFV-IFA 032 [i.2] model.

5.2.3.2 Profiling of MSCS Management interface operations

5.2.3.2.1 Introduction

IETF L3NM YANG data model [i.24] supports the multi-site connectivity service and has the ability to configure the required connectivity service parameters in the transport network. RESTCONF protocol [i.26] RPCs support the creation, query, update and delete operations related to the YANG model. In this clause, the MSCS management interface operations produced by WIM as specified in ETSI GS NFV-IFA 032 [i.2] will be analysed with the RPCs used by L3NM YANG model. These information elements analysed in clause 5.2.3.1 will be used as a reference in the input and output parameters of different operations.

Table 5.2.3.2.1-1 describes the profiling and gap analysis corresponding to the operations of the MSCS Management interface operations specified for ETSI GS NFV-IFA 032 [i.2] with the RPCs used by IETF L3NM.

Table 5.2.3.2.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] MSCS Management interface operations with IETF L3NM model

ETSI GS NFV-IFA 032 [i.2] MSCS Management Interface Operations	RESTCONF RPCs for L3NM model	Analysis: support status
Create MSCS	PUT /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:vpn-services/vpn-service=<id>	Supported. See note 1.
Query MSCS	GET /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:vpn-services/vpn-service=<id>	Supported.
Update MSCS	PUT /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:vpn-services/vpn-service=<id>	Supported.
Terminate MSCS	DELETE /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:vpn-services/vpn-service=<id>	Supported.
Subscribe	POST /restconf/operations/subscriptions:establish-subscription	Supported.
Notify	Notifications sent according to module ietf-restconf-subscribed-notifications	Supported. See note 2.
Query Subscription Information	GET /restconf/subscriptions/<URI>	Supported.
Terminate Subscription	POST /restconf/operations/subscriptions:delete-subscription	Supported.
Create MSCS Reservation		Not supported.
Query MSCS Reservation		Not supported.
Update MSCS Reservation		Not supported.
Terminate MSCS Reservation		Not supported.
NOTE 1: A L3 VPN creation operation can also be done with a POST command on < ietf-l3vpn-ntw:vpn-services > with a vpn-id.		
NOTE 2: RESTCONF supports notification mechanism as specified in IETF RFC 8650 [i.37].		

This mapping shown in table 5.2.3.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation in L3NM YANG model. In this case it might be needed to use multiple functions to achieve the expected result.

5.2.3.2.2 Create MSCS operation

Refer to clause 6.2.2 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer to request the creation of a MSCS from the WIM.

In the IETF RPCs both the input and output parameters are part of the POST/PUT commands. Refer to the example in clause A.2.1.1 for the create MSCS operation realized with L3NM YANG model.

Table 5.2.3.2.2-1 describes the profiling and gap analysis corresponding to the input parameters of the Create MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.2-2 describes the profiling and gap analysis corresponding to the output parameters of the Create MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.2-1: Profiling of the input parameters of Create MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model Parameters & Attributes (Type)	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
reservationId (Identifier)	Not supported	Not supported
mscsData (structure inline)		
> mscsName (String)	Supported See table 5.2.3.1.2-1	Supported. See table 5.2.3.1.2-2
> mscsDescription (String)	Supported See table 5.2.3.1.2-1	Partially supported See table 5.2.3.1.2-2
> mscsEndpoint (structure inline)		
>> connectivityServiceEndpointId (Identifier)	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
>> directionality (Enum)	Partially supported See table 5.2.3.1.3-1	Partially supported See table 5.2.3.1.3-2
>> networkAddressing ()	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
>> lag ()	Not supported.	Supported See table 5.2.3.1.3-2
> mscsProfile (structure inline)		
>> bandwidthIn (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>> bandwidthOut (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>> qosMetric ()	Partially supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>> directionality (Enum)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>> mtu (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>> protectionScheme (Enum)	Not supported	Supported See table 5.2.3.1.4-2
>> connectivityMode (Enum)	Partially supported See table 5.2.3.1.4-1	Partially supported See table 5.2.3.1.4-2
>> numSegment (Number)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>> segmentId (Identifier)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
> mscsLayerProtocol ()	Supported See table 5.2.3.1.2-1	Supported See table 5.2.3.1.2-2

Table 5.2.3.2.2-2: Profiling of the output parameters of Create MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] output information model Parameters & Attributes (Type)	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
mscs (structure inline)		
>mscsId (Identifier)	Supported See table 5.2.3.1.5-1	Supported See table 5.2.3.1.5-2
>mscsName (String)	Supported See table 5.2.3.1.5-1	Supported See table 5.2.3.1.5-2
>mscsDescription (String)	Supported See table 5.2.3.1.5-1	Partially Supported See table 5.2.3.1.5-2
>mscsEndpoint (structure inline)		

ETSI GS NFV-IFA 032 [i.2] output information model Parameters & Attributes (Type)	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
>>mscsEndpointId (Identifier)	Supported See table 5.2.3.1.8-1	Supported See table 5.2.3.1.8-2
>>connectivityServiceEndpointId (Identifier)	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
>>directionality (Enum)	Partially supported See table 5.2.3.1.3-1	Partially supported See table 5.2.3.1.3-2
>>networkAddressing (Not specified)	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
>>lag (Not specified)	Not supported.	Supported See table 5.2.3.1.3-2
>mscsProfile (structure inline)		
>>bandwidthIn (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>>bandwidthOut (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>>qosMetric (List of) (Not specified)	Partially supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>>directionality (Enum)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>>mtu (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>>protectionScheme (Enum)	Not supported	Supported See table 5.2.3.1.4-2
>>connectivityMode (Enum)	Partially supported See table 5.2.3.1.4-1	Partially supported See table 5.2.3.1.4-2
>>numSegment (Number)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>>segmentId (List of) (Identifier)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>msnc (Structure inline)		
>>msncId (Identifier)	Supported See clause 5.2.3.1.6	Supported See clause 5.2.3.1.6
>>msncEndpointId (List of) (Identifier (Reference to NetworkEdgePointInfo))	Supported See clause 5.2.3.1.6	Supported See clause 5.2.3.1.6
>>path (List of) (Identifier (Reference to NodeInfo))	Supported See clause 5.2.3.1.6	Supported See clause 5.2.3.1.6
>>msncProfile (Structure inline)		
>>>bandwidthIn (Number)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>>bandwidthOut (Number)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>>qosMetric (List of) (Not specified)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>>directionality (Enum)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>>mtu (Number)	Not supported See clause 5.2.3.1.7	Not supported See clause 5.2.3.1.7
>>>protectionScheme (Enum)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>>connectionMode (Enum)	Supported See clause 5.2.3.1.7	Supported See clause 5.2.3.1.7
>>msncLayerProtocol (Not specified)	Supported See clause 5.2.3.1.6	Supported See clause 5.2.3.1.6

5.2.3.2.3 Query MSCS operation

Refer to clause 6.2.3 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer to query a MSCS from the WIM.

GET command can be used to query the attributes in L3NM YANG model. Refer to the example in clause A.2.1.2 for the query MSCS operation realized with L3NM YANG model.

Table 5.2.3.2.3-1 describes the profiling and gap analysis corresponding to the information elements of the Query MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.3-2 describes the profiling and gap analysis corresponding to the output parameters of the Query MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.3-1: Profiling of the input parameters of Query MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
filter (Filter)	Partially supported. See note 2.	Partially supported. See note 2.
attributeSelector (String)	Supported. See note 1.	Supported. See note 1.
NOTE 1: GET is flexible to retrieve a specific leaf in the model or a parent leaf. NOTE 2: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.		

Table 5.2.3.2.3-2: Profiling of the output parameters of Query MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
queryResult (mscs)	Supported. See table 5.2.3.1.5-1.	Supported. See table 5.2.3.1.5-2.

5.2.3.2.4 Update MSCS operation

Refer to clause 6.2.4 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to request update of an existing MSCS.

PUT command can be used to modify the attributes in L3NM YANG model. Refer to the example in clause A.2.1.3 for the update MSCS operation realized with L3NM YANG model.

Table 5.2.3.2.4-1 describes the profiling and gap analysis corresponding to the information elements of the Update MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.4-2 describes the profiling and gap analysis corresponding to the output parameters of the Update MSCS operation with respect to IETF L3NM and L2NM YANG models.

Table 5.2.3.2.4-1: Profiling of the input parameters of Update MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
connectivityServiceId (Identifier)	Supported Refer to mscl mapping in table 5.2.3.1.5-1	Supported Refer to mscl mapping in table 5.2.3.1.5-2
addMscsEndpoint (structure inline)		
> connectivityServiceEndpointId (Identifier)	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
> directionality (Enum)	Partially supported See table 5.2.3.1.3-1	Partially supported See table 5.2.3.1.3-2
> networkAddressing ()	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
> lag ()	Not supported.	Supported See table 5.2.3.1.3-2
removeMscsEndpoint (reference id)	Supported Refer to connectivityServiceEndpointId mapping in table 5.2.3.1.3-1	Supported Refer to connectivityServiceEndpoi ntId mapping in table 5.2.3.1.3-2
modifyMscsEndpoint (structure inline)		
>mscsEndpointId (Identifier)	Supported See table 5.2.3.1.8-1	Supported See table 5.2.3.1.8-2
>connectivityServiceEndpointId (Identifier)	Supported See table 5.2.3.1.3-1	Supported. See table 5.2.3.1.3-2 in clause 5.2.3.1.3
>directionality (Enum)	Partially supported See table 5.2.3.1.3-1	Partially supported See table 5.2.3.1.3-2
>networkAddressing (Not specified)	Supported See table 5.2.3.1.3-1	Supported See table 5.2.3.1.3-2
>lag (Not specified)	Not supported	Supported See table 5.2.3.1.3-2
modifyMscsProfile (structure inline)		
>bandwidthIn (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>bandwidthOut (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>qosMetric (List of) (Not specified)	Partially supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>directionality (Enum)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>mtu (Number)	Supported See table 5.2.3.1.4-1	Supported See table 5.2.3.1.4-2
>protectionScheme (Enum)	Not supported	Supported See table 5.2.3.1.4-2
>connectivityMode (Enum)	Partially supported See table 5.2.3.1.4-1	Partially supported. See table 5.2.3.1.4-2
>numSegment (Number)	Not supported See table 5.2.3.1.4-1	Not supported See table 5.2.3.1.4-2
>segmentId (List of) (Identifier)	Not supported See table 5.2.3.1.4-1	Not supported. See table 5.2.3.1.4-2 in clause 5.2.3.1.4
mscsName (String)	Supported See table 5.2.3.1.2-1	Supported. See table 5.2.3.1.2-2 in clause 5.2.3.1.2.
mscsDescription (String)	Supported See table 5.2.3.1.2-1	Partially supported See table 5.2.3.1.2-2

Table 5.2.3.2.4-2: Profiling of the output parameters of Update MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
mscs	Supported. See table 5.2.3.1.5-1.	Supported. See table 5.2.3.1.5-2.

5.2.3.2.5 Terminate MSCS operation

Refer to clause 6.2.5 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to terminate a MSCS.

DELETE command is be used to modify the attributes in L3NM YANG model. Refer to the example in clause A.2.1.4 for the terminate MSCS operation realized with L3NM YANG model.

Table 5.2.3.2.5-1 describes the profiling and gap analysis corresponding to the information elements of the Update MSCS operation with respect to IETF L3NM.

Table 5.2.3.2.5-1: Profiling of the input parameters of Terminate MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
connectivityServiceId (Identifier)	Supported. Refer to mscsId mapping in table 5.2.3.1.5-1.	Supported. Refer to mscsId mapping in table 5.2.3.1.5-2.

Table 5.2.3.2.5-2: Profiling of the output parameters of Terminate MSCS operation with L3NM and L2NM YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF L3NM Analysis: support status	IETF L2NM Analysis: support status
Parameters & Attributes (Type)		
connectivityServiceId (Identifier)	Supported. Refer to mscsId mapping in table 5.2.3.1.5-1.	Supported. Refer to mscsId mapping in table 5.2.3.1.5-2.

5.2.3.2.6 Subscribe operation

Refer to clause 6.2.6 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to subscribe with a filter in order to receive notifications related to MSCS changes. The input parameters of the Subscribe operation contains Input filter for selecting MSCSs and output contains subscription Id.

RESTCONF supports subscription to YANG Notifications for Datastore Updates as specified in IETF RFC 8641 [i.38]. Dynamic subscriptions are supported as specified in IETF RFC 8650 [i.37]. Tables 5.2.3.2.6-1 and 5.2.3.2.6-2 describe the profiling of parameters involved in the input and output of Subscribe operation.

Table 5.2.3.2.6-1: Profiling of the input parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Supported. See note.
NOTE: The filter details can be added as input to the "establish-subscription" as specified in IETF RFC 8639 [i.39].	

Table 5.2.3.2.6-2: Profiling of the output parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
subscriptionId (Identifier)	Supported.

5.2.3.2.7 Notify operation

Refer to clause 6.2.7 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports "push-update" and "push-change-update" notifications as specified in IETF RFC 8641 [i.38].

Profiling of the notifications as listed in table 5.2.3.2.7-1 is done in the clauses related to Information elements. See clause 5.2.3.1.9.

Table 5.2.3.2.7-1: Profiling of the Notify operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] Notifications	IETF Analysis: support status
MscsChangeNotification	Supported. See clause 5.2.3.1.9.
MscsReservationChangeNotification	Not supported.

5.2.3.2.8 Query Subscription Info operation

Refer to clause 6.2.8 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports querying subscription by specifying the subscription id in the GET operation as specified in IETF RFC 8650 [i.37]. Tables 5.2.3.2.8-1 and 5.2.3.2.8-2 describe the profiling of parameters involved in the input and output of Query Subscription Info operation.

Table 5.2.3.2.8-1: Profiling of the input parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note.
NOTE: The filter details supports a subscriptionId. Query multiple subscriptions is not supported.	

Table 5.2.3.2.8-2: Profiling of the output parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
queryResult (Not specified)	Supported.

5.2.3.2.9 Terminate Subscription operation

Refer to clause 6.2.9 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports delete-subscription operation that maps to terminate subscription operation with subscriptionId as input.

5.3 Capacity management interface

5.3.1 Overview

Clause 5.3 provides the profiling corresponding to the Capacity management interface specified in ETSI GS NFV-IFA 032 [i.2]. The profiling with respect to ONF's TAPI standard is documented in clause 5.3.2. The profiling with respect to IETF's ACTN standards is documented in clause 5.3.3.

5.3.2 Gap analysis with respect to ONF's TAPI YANG Data Model

5.3.2.0 Introduction

The ONF has specified YANG data models for the TAPI services, which are available on GitHub [i.23]. Besides specifying the data models, these YANG models also specify the related operations, referred to as RPCs, for the respective TAPI services. Clause 5.3.2 and subclauses analyse the similarities and gaps between the Capacity management interface operations and related information elements with those of the relevant YANG model specified for TAPI. For the analysis the version 2.2.0 of the TAPI YANG models is used.

5.3.2.1 Analysis of Capacity Management operations

Table 5.3.2.1-1 maps the RPCs specified for TAPI's Topology service with the most relevant operations specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface.

Table 5.3.2.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Capacity Management interface operations with TAPI's Topology Service RPCs

ETSI GS NFV-IFA 032 [i.2] Capacity Management Interface Operations	TAPI's Topology Service RPC	Comments
Query Capacity	get-topology-details get-node-details get-link-details	Partially Supported
Create Capacity Threshold		Not Supported
Delete Capacity Thresholds		Not Supported
Query Capacity Threshold		Not Supported
Query Topology Information	get-topology-details get-topology-list	Supported
Query Node Information	get-topology-details get-topology-list get-node-details	Supported
Query Link Information	get-topology-details get-topology-list get-link-details	Supported
Query Network Edge Point Information	get-topology-details get-topology-list get-node-edge-point-details	Supported
Subscribe	create-notification-subscription-service	Supported
Notify		Not Supported For further details see the analysis comment 16 in clause 5.3.2.14
Terminate Subscription	delete-notification-subscription-service	Supported
Query Subscription Info	get-notification-subscription-service-details, get-notification-subscription-service-list	Partially Supported

This mapping shown in table 5.3.2.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation of the TAPI specification. In this case it might be needed to use multiple functions to achieve the expected result. If the analysis below suggests such a mapping for an operation it is noted in the respective analysis notes in clause 5.3.2.14.

5.3.2.2 Analysis of Query Capacity operation

5.3.2.2.1 Analysis of Query Capacity operation Input Information model

Table 5.3.2.2.1-1 provides a mapping of the information model of Query Capacity operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's [i.23]. It should be noted that the RPCs of the *tapi-topology* module provisions capacity information only on active links, nodes and topologies, and not on capacity that has been reserved for the present or for the future. Also unlike ETSI GS NFV-IFA 032 [i.2], TAPI does not have the notion of "Networks" under which topologies can be grouped.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-details
    >> input
      >>> topology-id

rpc
  > get-node-details
    >> input
      >>> node-id

rpc
  > get-link-details
    >> input
      >>> link-id
```

All mapped parameters are specified relative to the above path.

Table 5.3.2.2.1-1: Mapping of Query Capacity operation input with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Capacity operation</i>	TAPI operations <i>get-topology-details</i> <i>get-node-details</i> <i>get-link-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	topology-id node-id link-id	Partially Supported. For further details see the analysis comment 1 in clause 5.3.2.14.
> attributeSelector (String)		Not Supported. For further details see the analysis comment 1 in clause 5.3.2.14.
> timePeriod (TimePeriodInformation)		Not Supported.
>> startTime (DateTime)		
>> endTime (DateTime)		

5.3.2.2.2 Analysis of Query Capacity operation Output Information model

Table 5.3.2.2.2-1 provides a mapping of the information model of Query Capacity operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's YANG model in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list
    >> output

rpc
  > get-topology-details
    >> output
rpc
  > get-node-details
    >> output
rpc
  > get-link-details
    >> output
```

Table 5.3.2.2-1: Mapping of Query Capacity operation output with TAPI

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Query Capacity operation</i>	TAPI operations <i>get-topology-list</i> <i>get-topology-details</i> <i>get-node-details</i> <i>get-link-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> capacityInfo (CapacityInfo)		
>> objectType (Enum)		Not Supported.
>> objectInstanceId (Identifier)	<ul style="list-style-type: none"> • topology-id • node-id • link-id 	Partially Supported. For further details see the analysis comment 2 in clause 5.3.2.14.
>> capacityValue (CapacityValueEntry)		
>>> capacityMetricName (String)		Not Supported.
>>> capacityValue (Value)		Partially Supported. For further details see the analysis comment 3 in clause 5.3.2.14.

5.3.2.3 Analysis of Create Capacity Threshold operation

This operation is not supported in TAPI.

5.3.2.4 Analysis of Delete Capacity Thresholds operation

This operation is not supported in TAPI.

5.3.2.5 Analysis of Query Capacity Threshold operation

This operation is not supported in TAPI.

5.3.2.6 Analysis of Query Topology Information operation

5.3.2.6.1 Analysis of Query Topology Information operation Input Information model

Table 5.3.2.6.1-1 provides a mapping of the information model of Query Topology Information operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the with the YANG model specified for the following two TAPI v2.2.0 RPC's defined in [i.23]:

- *get-topology-details*
- *get-topology-list*

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-details
    >> input
```

```
rpc
  > get-topology-list
```

It should be noted that TAPI's *get-topology-list* RPC does not define any input parameters, and thus can be used in the case where the *filter* parameter of ETSI GS NFV-IFA 032's [i.2] Query Topology Information operation is specified as a wildcard (*). Only TAPI's *get-topology-details* RPC specifies an input parameter. Therefore, table 5.3.2.6.1-1 provides the mapping of ETSI GS NFV-IFA 032's [i.2] *filter* parameter with that of TAPI's *get-topology-details* RPC.

Table 5.3.2.6.1-1: Mapping of Query Topology Information operation input with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Topology Information operation</i>	TAPI operations <i>get-topology-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	topology-id	Partially Supported. For further details see the analysis comment 4 in clause 5.3.2.14.
> attributeSelector (String)		Not Supported. For further details see the analysis comment 4 in clause 5.3.2.14.

5.3.2.6.2 Analysis of Query Topology Information operation Output Information model

Table 5.3.2.6.2-1 provides a mapping of the information model of Query Topology information operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's YANG model in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-details
    >> output
```

```
rpc
  > get-topology-list
    >> output
```

Both the above RPCs give the same output, with the difference that the RPC *get-topology-details* specifies the output for specific topology while the *get-topology-list* RPC provides the output for all active topologies.

All mapped parameters specified in table 5.3.2.6.2-1 are relative to the above paths.

Table 5.3.2.6.2-1: Mapping of Query Topology Information operation output with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Topology Information operation</i>	TAPI operations <i>get-topology-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> topologyInfo (TopologyInfo)		
>> topologyId (Identifier)	topology/uuid	Supported
>> layerProtocol (Enum)	topology/layer-protocol-name*	Supported
>> nodeId (Identifier reference to NodeInfo)	topology/node/uuid	Supported
>> linkId (Identifier reference to LinkInfo)	topology/link/uuid	Supported
>> networkEdgePointId (Identifier reference to NetworkEdgePointInfo)	topology/ boundary-node-edge-point/[topology-uuid node-uuid node-edge-point-uuid]	Supported For further details see the analysis comment 5 in clause 5.3.2.14

5.3.2.7 Analysis of Query Node Information operation

5.3.2.7.1 Analysis of Query Node Information operation Input Information model

Table 5.3.2.7.1-1 provides a mapping of the information model of Query Node operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's [i.23]. It should be noted that in TAPI, node information can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - provides node information for all the nodes in all the topologies. This RPC does not have an input parameter and is like a wild-card operation.
- 2) *get-topology-details* - provides node information for all the nodes in the queried topology. This RPC uses topology-id as an input parameter to specify the identifier of the queried topology.

- 3) *get-node-details* - provides node information for the queried node. This RPC uses node-id as an input parameter to specify the identifier of the queried node.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list

rpc
  > get-topology-details
  >> input

rpc
  > get-node-details
  >> input
```

All mapped parameters specified in table 5.3.2.7.1-1 are relative to the above path.

Table 5.3.2.7.1-1: Mapping of Query Node Information operation input with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Node Information operation</i>	TAPI operations <i>get-node-details</i> <i>get-topology-details</i> <i>get-topology-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	<ul style="list-style-type: none"> • topology-id , node-id • topology-id 	Partially Supported. For further details see the analysis comment 6 in clause 5.3.2.14.
> attributeSelector (String)		Not Supported. For further details see the analysis comment 6 in clause 5.3.2.14.

5.3.2.7.2 Analysis of Query Node Information operation Output Information model

Table 5.3.2.7.2-1 provides a mapping of the information model of Query Node information operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's YANG model in [i.23]. It should be noted that in TAPI, node information can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - the output of this RPC provides node information for all the nodes in all the topologies.
- 2) *get-topology-details* - the output of this RPC provides node information for all the nodes in the queried topology.
- 3) *get-node-details* - the output of this RPC provides node information for the queried node.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list
  >> output
  >>> topology

rpc
  > get-topology-details
  >> output
  >>> topology

rpc
  > get-node-details
  >> output
```

All mapped parameters specified in table 5.3.2.7.2-1 are relative to the above paths.

Table 5.3.2.7.2-1: Mapping of Query Node Information operation output with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Node Information operation</i>	TAPI operations <i>get-topology-list</i> <i>get-topology-details</i> <i>get-node-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> nodeInfo (NodeInfo)		
>> nodeId (Identifier)	/node/uuid	Supported.
>> layerProtocol (Enum)	node/layer-protocol-name	Supported.
>> transferCapability (Not specified)		Partially Supported. For further details see the analysis comments 7 in clause 5.3.2.14.
>> networkEdgePointId (Identifier reference to NetworkEdgePointInfo)	[get-topology-list get-topology-details]/boundary-node-edge-point/[topology-uuid node-uuid, node-edge-point-uuid]	Supported. For further details see the analysis comment 5 in clause 5.3.2.14.

5.3.2.8 Analysis of Query Link Information operation

5.3.2.8.1 Analysis of Query Link Information operation Input Information model

Table 5.3.2.8.1-1 provides a mapping of the information model of Query Link operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's [i.23]. It should be noted that in TAPI, link information can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - provides link information for all the links in all the topologies. This RPC does not have an input parameter and is like a wild-card operation.
- 2) *get-topology-details* - provides link information for all the links in the queried topology. This RPC uses topology-id as an input parameter to specify the identifier of the queried topology.
- 3) *get-link-details* - provides link information for the queried link. This RPC uses link-id as an input parameter to specify the identifier of the queried link.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list

rpc
  > get-topology-details
  >> input

rpc
  > get-link-details
  >> input
```

All mapped parameters specified in table 5.3.2.8.1-1 are relative to the above path.

Table 5.3.2.8.1-1: Mapping of Query Link Information operation input with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Link Information operation</i>	TAPI operations <i>get-link-details</i> <i>get-topology-details</i> <i>get-topology-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	<ul style="list-style-type: none"> • topology-id , link-id • topology-id • NONE 	Partially Supported. For further details see the analysis comment 6 in clause 5.3.2.14.
> attributeSelector (String)		Not Supported. For further details see the analysis comment 6 in clause 5.3.2.14.

5.3.2.8.2 Analysis of Query Link Information operation Output Information model

Table 5.3.2.8.2-1 provides a mapping of the information model of Query Link information operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's YANG model in [i.23]. It should be noted that in TAPI, link information can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - the output of this RPC provides link information for all the links in all the topologies.
- 2) *get-topology-details* - the output of this RPC provides link information for all the links in the queried topology.
- 3) *get-link-details* - the output of this RPC provides link information for the queried link.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list
    >> output
      >>> topology

rpc
  > get-topology-details
    >> output
      >>> topology

rpc
  > get-link-details
    >> output
```

All mapped parameters specified in table 5.3.2.8.2-1 are relative to the above paths.

Table 5.3.2.8.2-1: Mapping of Query Link Information operation output with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Link Information operation</i>	TAPI operations <i>get-topology-list</i> <i>get-topology-details</i> <i>get-link-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> linkInfo (LinkInfo)		
>> linkId (Identifier)	/link/uuid	Supported.
>> nodeId (Identifier reference to NodeInfo)	link/node-edge-point/node-uuid	Supported.
>> isNetworkEdgeLink (Boolean)		Not Supported. For further details see the analysis comment 8 in clause 5.3.2.14.
>> networkEdgePointId (Identifier reference to NetworkEdgePointInfo)	[get-topology-list get-topology-details]/boundary-node-edge-point/[topology-uuid node-uuid, node-edge-point-uuid]	Supported. For further details see the analysis comment 5 in clause 5.3.2.14.
>> connectivityServiceEndpointId (Identifier - reference to ConnectivityServiceEndPointInfo)		Partially Supported. For further details see the analysis comment 9 in clause 5.3.2.14.

5.3.2.9 Analysis of Query Network Edge Point Information operation

5.3.2.9.1 Analysis of Query Network Edge Point Information operation Input Information model

In ETSI GS NFV-IFA 032 [i.2], the *network edge point* is a specific ingress/egress port of a WAN network that maps to the *connectivity service endpoint*. However, TAPI's notion of a *node edge point* is more generic and can be mapped to ETSI GS NFV-IFA 032's [i.2] *network edge point* only if TAPI's *node edge point* maps to a *service interface point*, which maps to ETSI GS NFV-IFA 032's [i.2] *connectivity service end-point* (see table 4.3.3.3-1).

Table 5.3.2.9.1-1 provides a mapping of the information model of Query Network Edge Point operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's [i.23]. It should be noted that in TAPI, *node edge point* information, which maps to ETSI GS NFV-IFA 032's [i.2] network edge point information, can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - provides node edge point information for all the nodes in all the topologies. This RPC does not have an input parameter and is like a wild-card operation.
- 2) *get-topology-details* - provides node edge point information for all the nodes in the queried topology. This RPC uses topology-id as an input parameter to specify the identifier of the queried topology.
get-node-edge-point-details - provides node edge point information for the queried node. This RPC uses three inputs parameters, namely *topology-id*, *node-id* and *node-edge-point-id* as an input parameter to specify the identifier of the queried node edge point of a specific node in a specific topology.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  get-topology-list

rpc
  > get-topology-details
  >> input

rpc
  > get-node-edge-point-details
  >> input
```

All mapped parameters specified in table 5.3.2.9.1-1 are relative to the above path.

Table 5.3.2.9.1-1: Mapping of Query Network Edge Point Information operation input with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Network Edge Point Information operation</i>	TAPI operations <i>get-node-edge-point-details</i> <i>get-topology-details</i> <i>get-topology-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	<ul style="list-style-type: none"> • topology-id, node-id, node-edge-point-id • topology-id 	Partially Supported. For further details see the analysis comment 6 in clause 5.3.2.14.
> attributeSelector (String)		Not Supported. For further details see the analysis comment 6 in clause 5.3.2.14.

5.3.2.9.2 Analysis of Query Network Edge Point Information operation Output Information model

Table 5.3.2.9.2-1 provides a mapping of the information model of Query Network Edge Point information operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity management interface with the YANG's *tapi-topology* module specified for TAPI v2.2.0's YANG model in [i.23]. It should be noted that in TAPI, node information can be acquired using the following 3 RPCs:

- 1) *get-topology-list* - the output of this RPC provides node information for all the nodes in all the topologies.
- 2) *get-topology-details* - the output of this RPC provides node information for all the nodes in the queried topology.
- 3) *get-node-edge-point-details* - the output of this RPC provides node information for the queried node.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-topology-list
  >> output
  >>> node
```

```

rpc
  > get-topology-details
    >> output
      >>> topology

rpc
  > get-node-edge-point-details
    >> output

```

All mapped parameters specified in table 5.3.2.9.2-1 are relative to the above paths.

Table 5.3.2.9.2-1: Mapping of Query Network Edge Point Information operation output with TAPI

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Network Edge Point Information operation</i>	TAPI operations <i>get-topology-list get-topology-details get-node-edge-point-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> networkEdgePointInfo (NetworkEdgePointInfo)		
>> networkEdgePointId (Identifier)	/node-edge-point/uuid	Supported.
>> layerProtocol (Not Specified)	node-edge-point/layer-protocol-name	Partially Supported. For further details see the analysis comment 10 in clause 5.3.2.14.

5.3.2.10 Analysis of Subscribe operation

5.3.2.10.1 Analysis of Subscribe operation input information model

ETSI GS NFV-IFA 032 [i.2] specifies a Filter as an input parameter for selecting capacity and topology related notifications to subscribe to. It is not clear in ETSI GS NFV-IFA 032 [i.2] if the filter is specified for MSCS object, or MSNC object or both.

However, the approach of creating subscription adopted by TAPI where a YANG model for the *tapi-notification* module and relevant RPCs has been specified to support the notification service.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```

rpc
  > create-notification-subscription-service
    >> input

```

All mapped parameters specified in table 5.3.2.10.1-1 are relative to the above path.

Table 5.3.2.10.1-1: Mapping of Subscribe operation with TAPI's create-notification-subscription-service operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	subscription-filter/ [requested-object- identifier name]	Supported For further details see the analysis comment 11 in clause 5.3.2.14

5.3.2.10.2 Analysis of Subscribe operation output information model

Table 5.3.2.10.2-1 provides a mapping of the output information model of Subscribe operation specified for ETSI GS NFV-IFA 032 [i.2] Capacity Management interface with the YANG model specified for TAPI v2.2.0's YANG model *create-notification-subscription-service* in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-notification-subscription-service
    >> output
```

All mapped parameters specified in table 5.3.2.10.2-1 are relative to the above path.

Table 5.3.2.10.2-1: Mapping of Subscribe operation with TAPI's create-notification-subscription-service operation output

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> subscriptionId (Identifier)	subscription-service/uuid	Supported

5.3.2.11 Analysis of Terminate Subscription operation

5.3.2.11.1 Analysis of Terminate Subscription operation input information model

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation maps to the TAPI's *delete-notification-subscription-service* RPC.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > delete-notification-subscription-service
    >> input
```

All mapped parameters specified in table 5.3.2.11.1-1 are relative to the above path.

Table 5.3.2.11.1-1: Mapping of Terminate Subscription operation with TAPI's delete-notification-subscription-service operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Terminate Subscription operation</i>	TAPI operation <i>delete-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> subscriptionId (Identifier)	uuid	Supported

5.3.2.11.2 Analysis of Terminate Subscription operation output information model

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation has no output. The same is true for the mapped TAPI operation *delete-notification-subscription-service*.

5.3.2.12 Analysis of Query Subscription Info operation

5.3.2.12.1 Analysis of Query Subscription Info operation input information model

The ETSI GS NFV-IFA 032 [i.2] defines a *filter* as an input parameter for performing the Query Subscription Info operation. However, the content of Filter parameter is not specified, the details of which has been left for the protocol design stage.

In general, the operation can be supported by the following two TAPI's RPC:

- 1) *get-notification-subscription-service-list*
- 2) *get-notification-subscription-service-details*

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-notification-subscription-service-details
    >> input

rpc
  > get-notification-subscription-service-list
```

It should be noted that the *get-notification-subscription-service-list* RPC does not define any input parameters, and thus can be used in case the ETSI GS NFV-IFA 032 [i.2] filter parameter is specified as a wildcard (*). Only the *get-notification-subscription-service-details* RPC specifies an input parameter. Therefore, table 5.3.2.12.1-1 provides the mapping of ETSI GS NFV-IFA 032 [i.2] filter parameter with that of *get-notification-subscription-service-details* RPC.

Table 5.3.2.12.1-1: Mapping of Query Subscription Info operation with TAPI's *get-notification-subscription-service-details* and *get-notification-subscription-service-list* operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Subscription Info operation</i>	TAPI operation <i>get-notification-subscription-service-details/ get-notification-subscription-service-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	uuid	Partially Supported For further details see the analysis comment 12 in clause 5.3.2.14

5.3.2.12.2 Analysis of Query Subscription Info operation output information model

The ETSI GS NFV-IFA 032 [i.2] Query Subscription Info operation output parameter *queryResult* returns the relevant information about the queried subscription. However, the content of *queryResult* parameter is not specified, the details of which has been left for the protocol design stage. TAPI operations of *get-notification-subscription-service-details* and *get-notification-subscription-service-list*, on the other hand, provide a rich set of information about the queried subscriptions, which can potentially cover the content of ETSI GS NFV-IFA 032's [i.2] *queryResult* parameter when specified in the protocol design stage.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-notification-subscription-service-details
    >> output

rpc
  > get-notification-subscription-service-list
    >> output
```

All mapped parameters specified in table 5.3.2.12.2-1 are relative to the above path.

Table 5.3.2.12.2-1: Mapping of Query Subscription Info operation with TAPI's *get-notification-subscription-service-details* and *get-notification-subscription-service-list* operation output

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Subscription Info operation</i>	TAPI operation <i>get-notification-subscription-service-details/ get-notification-subscription-service-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> queryResult (Not specified)	See note.	Partially Supported For further details see the analysis comment 12 in clause 5.3.2.14
NOTE: As mentioned above, the content for <i>queryResult</i> is not specified, therefore it is not possible to specify a mapping to specific parameters and attributes for the above mapped TAPI RPCs. Therefore the column in table 5.3.2.12.2-1 for TAPI operation is left empty.		

5.3.2.13 Analysis of Notify operation

The ETSI GS NFV-IFA 032 [i.2] specification describes a Notify operation. An equivalent operation does not exist in the TAPI YANG model. Nevertheless, the content of the notifications is specified in the TAPI YANG modules *tapi-notifications* and *tapi-oam*. See also analysis comment 13 in clause 5.3.2.14.

The ETSI GS NFV-IFA 032 [i.2] Notify operation for Performance Management supports the types of notification Information Elements shown in table 5.3.2.13-1.

Table 5.3.2.13-1: Mapping of ETSI GS NFV-IFA 032 Capacity Management Notification Information Elements with TAPI's notification types

ETSI GS NFV-IFA 032 [i.2] Performance Management Interface Operations	TAPI's OAM Service RPC	Comments
CapacityChangeNotification		Partially Supported For further details see the analysis comment 13 in clause 5.3.2.14
TopologyChangeNotification		Partially Supported For further details see the analysis comment 13 in clause 5.3.2.14

Table 5.3.2.13-2 provides the mapping of the attributes of the *CapacityChangeNotification* information element to the TAPI's YANG *tapi-notification* and *tapi-oam* module. The TAPI's YANG *tapi-oam* module extends (augments) the notification type that is specified in TAPI's YANG *tapi-notification* module.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path defined in TAPI's YANG *tapi-notification* module (see [i.24]):

```
rpc
  > get-notification-list
    >> output
      >>> notification
```

All mapped parameters are specified relative to the above path. Table 5.3.2.13-2 provides the mapping.

Table 5.3.2.13-2: Mapping of Notify operation IE CapacityChangeNotification with TAPI's tapi-notification-service

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Notify operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
thresholdId (Identifier)		Not Supported
crossingDirection (Enum)	tca-info/threshold-parameter/[pm-parameter-above-thrs pm-parameter-below-thrs pm-parameter-clear-thrs]	Supported For further details see the analysis comment 14 in clause 5.3.2.14
objectInstanceId (Identifier)	target-object-identifier	Supported
capacityValueEntry (CapacityValueEntry)		
> capacityMetricName (String)	tca-info/threshold-parameter/pm-parameter-name	Supported
> capacityValue (Value)	tca-info/threshold-parameter/[pm-parameter-above-thrs pm-parameter-below-thrs] / [pm-parameter-int-value pm-parameter-real-value]	Supported For further details see the analysis comment 14 in clause 5.3.2.14

Table 5.3.2.13-3 provides the mapping of the attributes of the TopologyChangeNotification information element to the TAPI's YANG *tapi-notification*.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path defined in TAPI's YANG *tapi-notification* module (see [i.24]):

```
rpc
  > get-notification-list
    >> output
      >>> notification
```

All mapped parameters are specified relative to the above path. Table 5.3.2.13-3 provides the mapping.

Table 5.3.2.13-3: Mapping of Notify operation IE TopologyChangeNotification with TAPI's *tapi-notification-service*

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Notify operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
networkId (Identifier)	target-object-identifier	Partially Supported For further details see the analysis comment 15 in clause 5.3.2.14
changedInfo (Not specified)	changed-attributes/[value-name, old-value, new-value]	Partially Supported For further details see the analysis comment 15 in clause 5.3.2.14

5.3.2.14 Analysis Comments for Capacity Management Interface Operations

Analysis Comment 1: The *tapi-topology* module specifies the following 4 RPCs namely:

- 3) *get-topology-list*
- 4) *get-topology-details*
- 5) *get-node-details*
- 6) *get-link-details*

Using the above RPCs, the capacity of nodes and links in a topology can be queried.

ETSI GS NFV-IFA 032 [i.2] specifies a Filter mechanism enabling to query a full or partial set of the nodes and links in a topology. However, TAPI enables the acquisition of the capacity info of a topology, node or link based on the uuid of the respective queried entity. Moreover, TAPI does not provide details for "all network" as supported by ETSI GS NFV-IFA 032 [i.2]. This is because unlike ETSI GS NFV-IFA 032 [i.2], TAPI does not have the notion of "Networks" under which topologies can be grouped.

TAPI also does not support the querying for specified attributes as it does not support the filtering mechanism specified for ETSI GS NFV-IFA 032 [i.2]. The information about all the attributes are provided in the output of the relevant TAPIs RPCs providing details on nodes, links and topologies.

Analysis Comment 2: As mentioned in Analysis Comment 1, that TAPI does not have the notion of "Networks", therefore the parameter *objectInstanceId* cannot identify a Network or its information (i.e. NetworkInfo information element). However, TAPI supports the provisioning of information for the Node, Link and Topology.

Analysis Comment 3: ETSI GS NFV-IFA 032 [i.2] specifies a variety of capacity metrics depending on the type of queried object. However, the notion of capacity in TAPI is that of bandwidth only.

Analysis Comment 4: The **filter** parameter is only partially supported, since ETSI GS NFV-IFA 032 [i.2] expect to be able to select the topology information based on a single identifier, multiple identifiers or wildcard. TAPI on the other hand does not support the provisioning of topology information based on multiple identifiers. The mapped TAPI operation [i.23] only supports getting information for a specific topology (*get-topology-details*) or for all topologies (*get-topology-list*).

Analysis Comment 5: In ETSI GS NFV-IFA 032 [i.2], the attribute *networkEdgePointId* for *NetworkEdgePointInfo* information element is a single identifier that is used to identify the network edge point. However, in TAPI the attribute *boundary-node-edgepoint*, which is equivalent to ETSI GS NFV-IFA 032's [i.2] network edge point, is identified by a 3-tuple of identifiers namely *topology-uuid*, *node-uuid* and *node-edge-point-uuid*.

Analysis Comment 6: The **filter** parameter is only partially supported, since ETSI GS NFV-IFA 032 [i.2] expect to be able to select the node or link information based on a single identifier, multiple identifiers or wildcard. TAPI on the other hand does not support the provisioning of node, its network edge point information or link information based on *multiple identifiers*. The mapped TAPI operation [i.23] only supports getting information for a specific node (*get-node-details*), its network edge point (*get-node-edge-point-details*) or link (*get-link-details*) or for all nodes and their network edge points or links in a topology (*get-topology-details*) and for all nodes and their network edge points or links in all topologies (*get-topology-list*).

TAPI also does not support the querying for *specified attributes* of a node, its respective network edge point or link as it does not support the filtering mechanism specified for ETSI GS NFV-IFA 032 [i.2]. The information about all the attributes for a node, its respective network edge point or link are provided in the output of the relevant TAPIs RPCs providing details on nodes, their respective network edge points or links.

Analysis Comment 7: The **transferCapability** parameter is not specified in detail in ETSI GS NFV-IFA 032 [i.2]. It should contain further information of e.g. switching and routing capabilities. When using the specified TAPI RPC's to retrieve information on nodes, TAPI's information model exhibits a variety of capability parameters in several places. This means that the parameter is in principal supportable but since the details are not explicitly given it is marked as Partially Supported.

Analysis Comment 8: The *isNetworkEdgeLink* as a Boolean parameter is not explicitly specified in TAPI, hence not supported. However, in TAPI, the distinction of a link to be a Network Edge Link can be implied by the specification of attributes for the parameter *boundary-node-edge-point*.

Analysis Comment 9: The *connectivityServiceEndpointId* as defined in ETSI GS NFV-IFA 032 [i.2] cannot be mapped immediately to an attribute returned by the TAPI operations mapped to the Query Link operation information model in ETSI GS NFV-IFA 032 [i.2]. Through the knowledge of the *node-uuid* and the *node-edge-point-uuid* for a link in TAPI, ETSI GS NFV-IFA 032's *connectivityServiceEndpointId* can be mapped to the attribute *service-interface-point-uuid* found at the path *topology/node/node-edge-point/mapped-service-interface-point* of a topology in TAPI.

Analysis Comment 10: The **layerProtocol** parameter is not specified in detail in ETSI GS NFV-IFA 032 [i.2]. However, TAPI does specify the parameter *layer-protocol-name* to specify the layer protocol configured on a node-edge-point. It is thus marked as partially supported, as the extent of the content type for ETSI GS NFV IFA 032 [i.2] *layerProtocol* parameter is not yet known.

Analysis Comment 11: The following attributes/parameters can serve the ETSI GS NFV-IFA 032 [i.2] Subscription operation:

- *requested-object-identifier** to support identifying the particular resource object (e.g. which MSCS);
- *name** [*value-name**] to support including notification related attributes.

Since filtering is not defined in detail in ETSI GS NFV-IFA 032 [i.2], potentially there could be more specific filtering supported by TAPI.

Analysis Comment 12: The content of the *filter* parameter of ETSI GS NFV-IFA 032's [i.2] Query Subscription Info operation expects to be able to select a set of subscriptions. The mapped TAPI operation [i.23] only supports getting a single subscription (*get-notification-subscription-service-details*) or all subscriptions (*get-notification-subscription-service-list*). Since further details are not specified, the *filter* parameter is marked as partially supported. The *queryResult* output parameter of that operation does not specify specific attributes that should be returned. Since the output of the mapped TAPI's RPCs (*get-notification-subscription-service-details* and *get-notification-subscription-service-list*) delivers a variety of attributes the parameter is marked as partially supported.

Analysis Comment 13: The Notify operation can be supported by the notification mechanism of the NETCONF/RESTCONF protocol implementing the TAPI YANG models. The content of the notifications that get sent are specified in the *tapi-notifications*, *tapi-oam* and *tapi-topology* modules of the TAPI YANG model. The notifications might need some adaptation to implement the filters that the NETCONF/RESTCONF protocol specifies and is expected by the ETSI GS NFV-IFA 032 [i.2] operation. Some more adaptations are needed to get the full content of the notification. According to the study, TAPI only defines very basic information like the type and an identifier (uuid) of the notification. The full content is be retrieved by TAPI's *get-notification-list* RPC.

Analysis Comment 14: The *crossingDirection* attribute in ETSI GS NFV-IFA 032's [i.2] Notify operation can be acquired by the output of TAPI's *get-notification-list* RPC using the process highlighted in Analysis Comment 13. It should be noted that the *crossingDirection* attribute specifies two values namely UP and DOWN, which corresponds to the TAPI's *get-notification-list/output/notification/pm-parameter-above-thrs* and *get-notification-list/output/notification/pm-parameter-below-thrs*. It should be noted that the 2 TAPI parameters *pm-parameter-above-thrs* and *pm-parameter-below-thrs* are specified under the *tca-info* data structure which requires to be augmented to the output of the *get-notification-list* RPC. The *capacityValue* attribute of ETSI GS NFV-IFA 032's [i.2] can then be mapped to the TAPI's parameters *pm-parameter-int-value* (of type uint 64) or *pm-parameter-real-value* (of type decimal64) for the relevant threshold direction (either *pm-parameter-above-thrs* or *pm-parameter-below-thrs*).

Analysis Comment 15: The *networkId* attribute in ETSI GS NFV-IFA 032's [i.2] Notify for TopologyChangeNotification operation can be mapped to TAPI's *target-object-identifier*. However, the definition in TAPI is more general and can hold any identifier. The *changedInfo* attribute in ETSI GS NFV-IFA 032 [i.2] can be mapped to the *changed-attributes* data structure in TAPI's *get-notification-list* RPC. Since the exact content of the *changedInfo* attribute is not yet specified in ETSI GS NFV-IFA 032 [i.2], mappings to other or additional attributes and data structures defined in the *tapi-notification* module or its augmentations like those defined in the *tapi-oam* module is possible.

Analysis Comment 16: The Notify operation can be supported by the notification mechanism of the NETCONF/RESTCONF protocol implementing the TAPI YANG models. The content of the notifications that is sent are specified in the *tapi-notifications* and *tapi-oam* modules of the TAPI YANG model [i.23]. The notifications might need some adaptation to implement the filters that the NETCONF/RESTCONF protocol specifies and is expected by the ETSI GS NFV-IFA 032 [i.2] operation.

5.3.3 Gap analysis with respect to IETF's YANG Data Model

5.3.3.0 Introduction

IETF has specified YANG data model for Traffic Engineering (TE) Topologies [i.34]. The data from the YANG model can be accessed via operations specified in RESTCONF [i.26]. Clause 5.3.3 and subclauses analyse the similarities and gaps between the Capacity management interface operations and related information elements used in the input and output of these operations as specified in ETSI GS NFV-IFA 032 [i.2] with those of YANG Data model specified by IETF.

5.3.3.1 Profiling of Capacity Management interface operations

5.3.3.1.1 Introduction

IETF YANG data model for Traffic Engineering (TE) Topologies [i.34] supports the information elements involved in querying the capacity and topology information. Interface operations involved in Capacity management of multi-site connectivity services as specified in clause 6.3 of ETSI GS NFV-IFA 032 [i.2]. With the IETF YANG data model, RESTCONF protocol [i.26] RPCs supports the operations to query topology related information such as query node, query link, query network edge point information, etc. In this clause, the interface operations produced by WIM to support capacity and topology management as specified in ETSI GS NFV-IFA 032 [i.2] will be analysed with the RPCs used by IETF YANG Data model for Traffic Engineering (TE) Topologies. The information elements analysed in clause 5.3.3.2 will be used as a reference in the input and output parameters of different operations.

Table 5.3.3.1.1-1 describes the profiling and gap analysis corresponding to the operations of the Capacity Management interface operations specified for ETSI GS NFV-IFA 032 [i.2] with the RPCs used by IETF.

Table 5.3.3.1.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Capacity Management interface operations with IETF TE-Topology model

ETSI GS NFV-IFA 032 [i.2] Capacity Management Interface Operations	RESTCONF RPCs for IETF TE-Topology model	Analysis: support status
Query Capacity	No separate operation for query capacity. The capacity information will be included as part of the topology.	Supported
Create Capacity Threshold	-	Not supported
Delete Capacity Thresholds	-	Not supported
Query Capacity Threshold	-	Not supported
Query Topology Information	GET /restconf/ds/ietf-datastores:running/ietf-network:networks/ network=<topology-id>	Supported
Query Node Information	GET /restconf/ds/ietf-datastores:running/ietf-network:networks/ network=<topology-id>/node=<node-id>	Supported
Query Link Information	GET /restconf/ds/ietf-datastores:running/ietf-network:networks/ network=<topology-id>/link=<link-id>	Supported
Query Network Edge Point Information	GET /restconf/ds/ietf-datastores:running/ietf-network:networks/ network=<topology-id>/node=<node-id>/ ietf-network-topology:termination-point=<tp-id>	Supported
Subscribe	POST /restconf/operations/ietf-subscribed-notifications:establish-subscription	Supported
Notify	Notifications sent according to module ietf-restconf-subscribed-notifications	Supported See note
Terminate Subscription	POST /restconf/operations/ietf-subscribed-notifications:delete-subscription	Supported
Query Subscription Info	GET /restconf/subscriptions/<URL>	Supported
NOTE: RESTCONF supports notification mechanism as specified in IETF RFC 8650 [i.37].		

This mapping shown in table 5.3.3.1.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation in IETF YANG model. In this case it might be needed to use multiple functions to achieve the expected result.

5.3.3.1.2 Query Topology Information operation

Refer to clause 6.3.6 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to query information about topology of the network. GET command can be used to query the topology information.

Tables 5.3.3.1.2-1 and 5.3.3.1.2-2 describes the profiling and gap analysis corresponding to the input and output attributes of the Query Topology Information operation with respect to IETF YANG Data model for Traffic Engineering (TE) Topologies. Refer to the example in clause A.3.1.1 with IETF Topology YANG model.

Table 5.3.3.1.2-1: Profiling of the input parameters of Query Topology Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note 1.
attributeSelector (String)	Supported. See note 2.
NOTE 1: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.	
NOTE 2: Since the query operation with GET can contain a large amount of information, GET operation can be used in association with RESTCONF query parameters (for example for limiting the depth of the subtree). This is in line with attributeSelector in ETSI GS NFV-IFA 032 [i.2] operations.	

Table 5.3.3.1.2-2: Profiling of the output parameters of Query Topology Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
topologyInfo (TopologyInfo)	Supported. See clause 5.3.3.2.8.

5.3.3.1.3 Query Node Information operation

Refer to clause 6.3.7 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to query information about a node participating in a topology of the network. GET command can be used to query the node information.

Tables 5.3.3.1.3-1 and 5.3.3.1.3-2 describes the profiling and gap analysis corresponding to the input and output attributes of the Query Node Information operation with respect to IETF YANG Data model for Traffic Engineering (TE) Topologies. Refer to the example in clause A.3.1.2 with IETF Topology YANG model.

Table 5.3.3.1.3-1: Profiling of the input parameters of Query Node Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note 1.
attributeSelector (String)	Supported. See note 2.
NOTE 1: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.	
NOTE 2: Since the query operation with GET can contain a large amount of information, GET operation can be used in association with RESTCONF query parameters (for example for limiting the depth of the subtree). This is in line with attributeSelector in ETSI GS NFV-IFA 032 [i.2] operations.	

Table 5.3.3.1.3-2: Profiling of the output parameters of Query Node Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
nodeInfo (NodeInfo)	Supported. See clause 5.3.3.2.9.

5.3.3.1.4 Query Link Information operation

Refer to clause 6.3.8 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to query information about a link participating in a topology of the network. GET command can be used to query the link information.

Tables 5.3.3.1.4-1 and 5.3.3.1.4-2 describes the profiling and gap analysis corresponding to the input and output attributes of the Query Link Information operation with respect to IETF YANG Data model for Traffic Engineering (TE) Topologies. Refer to the example in clause A.3.1.3 with IETF Topology YANG model.

Table 5.3.3.1.4-1: Profiling of the input parameters of Query Link Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note 1.
attributeSelector (String)	Supported. See note 2.
NOTE 1: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.	
NOTE 2: Since the query operation with GET can contain a large amount of information, GET operation can be used in association with RESTCONF query parameters (for example for limiting the depth of the subtree). This is in line with attributeSelector in ETSI GS NFV-IFA 032 [i.2] operations.	

Table 5.3.3.1.4-2: Profiling of the output parameters of Query Link Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
linkInfo (LinkInfo)	Supported. See clause 5.3.3.2.10.

5.3.3.1.5 Query Network Edge point Information operation

Refer to clause 6.3.9 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to query information about network edge points of the network. GET command can be used to query the network edge point information.

Tables 5.3.3.1.5-1 and 5.3.3.1.5-2 describes the profiling and gap analysis corresponding to the input and output attributes of the Query Network Edge point Information operation with respect to IETF Topology YANG Data model. Refer to the example in clause A.3.1.4 with IETF Topology YANG model.

Table 5.3.3.1.5-1: Profiling of the input parameters of Query Network Edge point Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note 1.
attributeSelector (String)	Supported. See note 2.
<p>NOTE 1: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.</p> <p>NOTE 2: Since the query operation with GET can contain a large amount of information, GET operation can be used in association with RESTCONF query parameters (for example for limiting the depth of the subtree). This is in line with attributeSelector in ETSI GS NFV-IFA 032 [i.2] operations.</p>	

Table 5.3.3.1.5-2: Profiling of the output parameters of Query Network Edge point Information operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
networkEdgepointInfo (NetworkEdgePointInfo)	Supported. See clause 5.3.3.2.11.

5.3.3.1.6 Subscribe operation

Refer to clause 6.3.10 in ETSI GS NFV-IFA 032 [i.2]. This operation allows an authorized consumer of WIM to subscribe with a filter in order to receive notifications related to MSCS changes. The input parameters of the Subscribe operation contains Input filter for selecting MSCSs and output contains subscription Id.

RESTCONF supports subscription to YANG Notifications for Datastore Updates as specified in IETF RFC 8641 [i.38]. Dynamic subscriptions are supported as specified in IETF RFC 8650 [i.37]. Tables 5.3.3.1.6-1 and 5.3.3.1.6-2 describe the profiling of parameters involved in the input and output of Subscribe operation.

Table 5.3.3.1.6-1: Profiling of the input parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Supported. See note.
NOTE: The filter details can be added as input to the "establish-subscription" as specified in IETF RFC 8639 [i.39].	

Table 5.3.3.1.6-2: Profiling of the output parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
subscriptionId (Identifier)	Supported.

5.3.3.1.7 Notify operation

Refer to clause 6.3.11 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports "push-update" and "push-change-update" notifications as specified in IETF RFC 8641 [i.38].

Profiling of the notifications as listed in table 5.3.3.1.7-1 is done in the clauses related to Information elements. See clause 5.3.3.2.13.

Table 5.3.3.1.7-1: Profiling of the Notify operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] Notifications	IETF Analysis: support status
CapacityChangeNotification	Not supported.
TopologyChangeNotification	Supported. See clause 5.3.3.2.13.

5.3.3.1.8 Query Subscription Info operation

Refer to clause 6.3.13 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports querying subscription by specifying the subscription id in the GET operation as specified in IETF RFC 8650 [i.37]. Tables 5.3.3.1.8-1 and 5.3.3.1.8-2 describe the profiling of parameters involved in the input and output of Query Subscription Info operation.

Table 5.3.3.1.8-1: Profiling of the input parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model Parameters & Attributes (Type)	IETF Analysis: support status
filter (Filter)	Partially supported. See note.
NOTE: The filter details supports a subscriptionId. Query multiple subscriptions is not supported.	

Table 5.3.3.1.8-2: Profiling of the output parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model Parameters & Attributes (Type)	IETF Analysis: support status
queryResult (Not specified)	Supported.

5.3.3.1.9 Terminate Subscription operation

Refer to clause 6.3.12 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports delete-subscription operation that maps to terminate subscription operation with subscriptionId as input.

5.3.3.2 Profiling of Information elements

5.3.3.2.1 Introduction

This clause analyses the similarities and gaps between the information elements used in the WIM interfaces in ETSI GS NFV-IFA 032 [i.2] with those of the IETF YANG Data model for Traffic Engineering (TE) Topologies [i.34]. These information elements are used in the input and output parameters of different operations produced by WIM.

5.3.3.2.2 CapacityInfo Information element

Refer to clause 8.3.2 in ETSI GS NFV-IFA 032 [i.2]. The attributes of CapacityInfo are reported as part of topology information in the IETF YANG Data model for TE topologies. In TE topology mapping, the mapping is listed in table 5.3.3.2.2-1.

Table 5.3.3.2.2-1: Profiling of CapacityInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
objectType	The mapping is not explicit, but the capacity values specified are included with the topology. For example data for the LINK are explained in clause 5.3.3.2.3	Supported.
objectInstanceIcd	Not explicitly needed as the capacity is listed with the object	Supported
capacityValue	See clause 5.3.3.2.3	Supported

5.3.3.2.3 CapacityValueEntry Information element

Refer to clause 8.3.3 in ETSI GS NFV-IFA 032 [i.2]. The attributes of CapacityValueEntry are part of CapacityInfo. In TE topology mapping, the mapping is listed in table 5.3.3.2.3-1.

Table 5.3.3.2.3-1: Profiling of CapacityValueEntry information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
capacityMetricName	Different capacity metrics for different objects are to be investigated (example: bandwidth for the LINK).	Partially supported.
capacityValue	Different capacity metrics for a specific Metric (example: max-link-bandwidth, max-resv-link-bandwidth, unreserved-bandwidth, etc. for LINK).	Partially supported.

5.3.3.2.4 TimePeriodInformation Information element

Refer to clause 8.3.4 in ETSI GS NFV-IFA 032 [i.2]. There is no explicit reporting of attributes of TimePeriodInformation while reporting topology information in the IETF YANG Data model for TE topologies. In TE topology mapping, the mapping is listed in table 5.3.3.2.4-1.

Table 5.3.3.2.4-1: Profiling of TimePeriodInformation information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
startTime	No mapping	Not supported
endTime	No mapping	Not supported

5.3.3.2.5 CapacityThreshold Information element

Refer to clause 8.3.5 in ETSI GS NFV-IFA 032 [i.2]. The attributes of CapacityThreshold are not reported as part of topology information in the IETF YANG Data model for TE topologies. In TE topology mapping, the mapping is listed in table 5.3.3.2.5-1.

Table 5.3.3.2.5-1: Profiling of CapacityThreshold information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
thresholdId	No mapping	Not supported
objectInstanceIcd	No mapping	Not supported
thresholdType	No mapping	Not supported
thresholdDetails	No mapping	Not supported

5.3.3.2.6 NetworkCapacityChangeNotification

Refer to clause 8.3.6 in ETSI GS NFV-IFA 032 [i.2]. The attributes of NetworkCapacityChangeNotification are specified to inform about specific changes such as change in nodes, links, etc. and can be reported with Topology changes. No specific modelling is defined as part of capacity change notification in the IETF YANG Data model for TE topologies. In TE topology mapping, the mapping is listed in table 5.3.3.2.6-1.

Table 5.3.3.2.6-1: Profiling of NetworkCapacityChangeNotification with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
thresholdId	No mapping	Not supported
crossingDirection	No mapping	Not supported
objectInstancelId	Can be part of Topology change and points to the object id	Supported
capacityValueEntry	See clause 5.3.3.2.3	

5.3.3.2.7 NetworkInfo Information element

Refer to clause 8.3.7 in ETSI GS NFV-IFA 032 [i.2]. The attributes of NetworkInfo are supported as part of topology information in the IETF YANG Data model for TE topologies. In TE topology mapping, the mapping is listed in table 5.3.3.2.7-1.

Table 5.3.3.2.7-1: Profiling of NetworkInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
networkId (Identifier of network node)	Maps to network-id in the augmentation of (/nw:networks/network/network-id)	Supported
topology (TopologyInfo)	See clause 5.3.3.2.8	
node (NodeInfo)	See clause 5.3.3.2.9	
link (LinkInfo)	See clause 5.3.3.2.10	

5.3.3.2.8 TopologyInfo Information element

Refer to clause 8.3.8 in ETSI GS NFV-IFA 032 [i.2]. The attributes of TopologyInfo are supported as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.8-1.

Table 5.3.3.2.8-1: Profiling of TopologyInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
topologyId (Identifier of topology information)	Maps to te-topology-identifier (provider-id, client-id, topology-id) in the augmentation of /nw:networks/nw:network	Supported
layerProtocol	Maps to /nw:networks/nw:network/nw:network-types	Supported
nodeId (Reference to NodeInfo)	See clause 5.3.3.2.9	
linkId (Reference to LinkInfo)	See clause 5.3.3.2.10	
networkEdgePointId (Reference to NetworkEdgePointInfo)	See clause 5.3.3.2.11	

5.3.3.2.9 NodeInfo Information element

Refer to clause 8.3.9 in ETSI GS NFV-IFA 032 [i.2]. The attributes of NodeInfo are supported as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.9-1.

Table 5.3.3.2.9-1: Profiling of NodeInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
nodeId	Maps to node-id in the augmentation of /nw:networks/nw:network/nw:node/	Supported.
layerProtocol	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te/interface-switching-capability/encoding	Supported. See note 1.
transferCapability	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te/interface-switching-capability/switching-capability	Supported. See note 1.
networkEdgePointId (NetworkEdgePointInfo)	List of network edge points connected to the Node. See clause 5.3.3.2.11	Supported. See note 2.
NOTE 1: Multi-layer TE nodes can provide switching functions at multiple network layers. TE node attributes include information related to the data plane aspects of the associated node(s) (e.g. connectivity matrix), as well as configuration data (such as TE node name). Refer to clause 3.2 of IETF YANG Data model for Traffic Engineering (TE) Topologies.		
NOTE 2: TE link is connected to TE node, terminating the TE link via exactly one TE Link Termination Point (LTP).		

5.3.3.2.10 LinkInfo Information element

Refer to clause 8.3.10 in ETSI GS NFV-IFA 032 [i.2]. The attributes of LinkInfo are supported as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.10-1.

Table 5.3.3.2.10-1: Profiling of LinkInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
linkId	Unique id of the TE link. Maps to link-id in the augmentation of /nw:networks/nw:network/nw:link/	Supported. See note 1.
nodeId (Reference to NodeInfo)	Reference to the TE node (source or destination based on topology). If this is NetworkEdgeLink, only one node is mapped. Maps to the link/source/source-node & link/destination/dest-node. See clause 5.3.3.2.9	Supported. See note 2.
isNetworkEdgeLink	Can be derived based on the number of nodes identified. If only one node is mapped, this is true.	Supported.
networkEdgePointId (Reference to NetworkEdgePointInfo)	Reference to the LTP connected. Maps to the link/source/source-tp or link/destination/dest-tp See clause 5.3.3.2.11.	Supported.
connectivityServiceEndpointId (Reference to ConnectivityServiceEndpointInfo)	Reference to the connectivity service end point on NFVI-PoP. See clause 5.3.3.2.12.	Supported.
NOTE 1: A given TE node can be reached on the TE graph over one of TE links terminated by the TE node. TE link is assigned a unique ID within the TE topology scope. Refer to clause 3.3 of IETF YANG Data model for Traffic Engineering (TE) Topologies.		
NOTE 2: TE link is connected to TE node, terminating the TE link via exactly one TE Link Termination Point (LTP).		

5.3.3.2.11 NetworkEdgePointInfo Information element

Refer to clause 8.3.11 in ETSI GS NFV-IFA 032 [i.2]. The attributes of NetworkInfo are supported as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.11-1.

Table 5.3.3.2.11-1: Profiling of NetworkEdgePointInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
networkEdgePointId	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te-tp-id.	Supported.
layerProtocol	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te/interface-switching-capability/encoding	Supported.

5.3.3.2.12 ConnectivityServiceEndPointInfo Information element

Refer to clause 8.3.12 in ETSI GS NFV-IFA 032 [i.2]. The attributes of ConnectivityServiceEndPointInfo are supported as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.12-1.

Table 5.3.3.2.12-1: Profiling of ConnectivityServiceEndPointInfo information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
connectivityServiceEndpointId	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te/inter-domain-plug-id	Supported. See note.
layerProtocol	Maps to /nw:networks/nw:network/nw:node/nt:termination-point/te/interface-switching-capability/encoding.	Supported
linkId (Reference to LinkInfo)	See clause 5.3.3.2.10.	Supported
NOTE: Attribute inter-domain-plug-id maps to the bearer-id attribute in the L3NM model.		

5.3.3.2.13 TopologyChangeNotification

Refer to clause 8.3.13 in ETSI GS NFV-IFA 032 [i.2]. The attributes of TopologyChangeNotification are specified to inform about specific changes such as change in nodes, links, etc. No specific modelling is defined as part of topology information in the IETF YANG Data model for TE topologies as per the mapping listed in table 5.3.3.2.13-1.

Table 5.3.3.2.13-1: Profiling of TopologyChangeNotification with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
networkId (Reference to NetworkInfo)	See clause 5.3.3.2.7.	Supported
changedInfo	YANG model supports notifications to a specific container and change info can be defined.	Supported

5.3.3.3 Profiling of Capacity measurements referred in Capacity Management interface

5.3.3.3.1 Introduction

This clause analyses the similarities and gaps between the metrics and capacity measurements listed in clause B.2.3 of ETSI GS NFV-IFA 032 [i.2] with those of IETF YANG Data model for Network and VPN Service Performance Monitoring [i.35] and IETF YANG Data model for VN/TE Performance Monitoring Telemetry [i.36].

5.3.3.3.2 Network measurements

Refer to clause B.2.3.1 in ETSI GS NFV-IFA 032 [i.2]. In TE topology mapping, the mapping is listed in table 5.3.3.3.2-1.

Table 5.3.3.3.2-1: Profiling of Network Capacity measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Bandwidth	Capacity values related to bandwidth over the total set of links in the network. As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NetBw [total allocated reserved available]. The values can be computed from the Link bandwidth reported for each link. Refer to clause 5.3.3.3.5.	Supported.
Number of logical networks	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NetNumLogical [total allocated reserved available]	Not supported.

5.3.3.3.3 Topology measurements

Refer to clause B.2.3.2 in ETSI GS NFV-IFA 032 [i.2]. In TE topology mapping, the mapping is listed in table 5.3.3.3.3-1.

Table 5.3.3.3.3-1: Profiling of Topology Capacity measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Number of circuits (Tunnels)	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: TopoNumCircuits [total allocated reserved available] Only counter measuring "Total" can be computed from topology model.	Partially supported
Number of routing areas	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: TopoNumRoutingAreas [total allocated available] Counter measuring "Total" can be computed from topology model. In module ietf-network-vpn-pm, available routes map to augmentation of /nw:networks/nw:network/vpn-summary-statistics/ipv4/total-routes, /nw:networks/nw:network/vpn-summary-statistics/ipv4/total-active-routes Or /nw:networks/nw:network/vpn-summary-statistics/ipv6/total-routes, /nw:networks/nw:network/vpn-summary-statistics/ipv6/total-active-routes.	Partially supported.
Number of routing peers	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: TopoNumRoutingPeers [total allocated available] Only counter measuring "Total" can be computed from topology model.	Partially supported.

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Number of edge nodes per routing area	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: TopoNumEdgeNodesRoutingArea [total allocated available] Only counter measuring "Total" can be computed from topology model.	Partially supported

5.3.3.3.4 Node measurements

Refer to clause B.2.3.3 in ETSI GS NFV-IFA 032 [i.2]. In TE topology mapping, the mapping is listed in table 5.3.3.3.4-1.

Table 5.3.3.3.4-1: Profiling of Node Capacity measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Number of logical forwarding entries	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeNumLogicalForwardingEntries [total allocated available]	Not supported.
Number of routing peers of a node	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeNumRoutingPeers [total allocated available] Only counter measuring "Total" can be computed from topology model. It can also be derived from "node", "termination-point" and "link" association.	Partially supported.
Number of bidirectional forwarding detection sessions	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeNumBfdSessions [total allocated available]	Not supported.
Number of link aggregation group members	NodeNumLagMembers [total allocated available]	TBD
Forwarding Load	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeForwardingLoad [total allocated available]	Not supported. The load information can not be provided in many cases.
CPU Load	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeCpuLoad [total allocated]	Not supported. The load information can not be provided in many cases.
Memory Load	As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: NodeMemLoad [total allocated]	Not supported. The load information can not be provided in many cases.

5.3.3.3.5 Link measurements

Refer to clause B.2.3.4 in ETSI GS NFV-IFA 032 [i.2]. In TE topology mapping, the mapping is listed in table 5.3.3.3.5-1.

Table 5.3.3.3.5-1: Profiling of Link Capacity measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Bandwidth	<p>Capacity values related to bandwidth on a network link.</p> <p>As per ETSI GS NFV-IFA 032 [i.2] the measurement reads subcounters as: LinkBw [total allocated reserved available].</p> <p>Counter measuring "total" maps to Maximum Bandwidth (or link capacity) from TE topology model.</p> <p>The remaining counters can be computed from the below counters in te-telemetry/performance-metrics-one-way in the augmentation of /te:te:te:tunnels/te:tunnel: as specified in [i.36] (module ietf-te-kpi-telemetry), one-way-residual-bandwidth one-way-available-bandwidth one-way-utilized-bandwidth.</p> <p>See note 1.</p>	Supported. See note 2.
NOTE 1: As per IETF RFC 8776 [i.46], Residual bandwidth is computed by subtracting the tunnel reservations from Maximum Bandwidth (or link capacity), Available bandwidth is computed by subtracting Utilized Bandwidth from Residual bandwidth.		
NOTE 2: total = max bandwidth; allocated = utilized ; reserved = total - residual; available = residual - utilized.		

5.4 Fault management interface

5.4.1 Overview

Clause 5.4 provides the profiling corresponding to the Fault management interface specified in ETSI GS NFV-IFA 032 [i.2]. The profiling with respect to ONF's TAPI standard is documented in clause 5.4.2. The profiling with respect to IETF's ACTN standards is documented in clause 5.4.3.

5.4.2 Gap analysis with respect to ONF's TAPI YANG Data Model

5.4.2.0 Introduction

The ONF has specified YANG data models for the TAPI services, which are available on GitHub [i.23]. Besides specifying the data models, these YANG models also specify the related operations, referred to as RPCs, for the respective TAPI services. Clause 5.4.2 and subclauses analyse the similarities and gaps between the Fault management interface operations and related information elements with those of YANG model specified for TAPI's *tapi-notification* module. For the analysis the version 2.2.0 of the TAPI YANG models [i.23] is used.

5.4.2.1 Analysis of the Fault Management interface operations

Table 5.4.2.1-1 maps the RPCs specified for TAPI's *tapi-notification* module with the most relevant operations specified for ETSI GS NFV-IFA 032 [i.2] Fault Management interface. Parts of the content of notifications concerning fault management are also defined in TAPI's *tapi-oam* module.

Table 5.4.2.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Fault Management interface operations with TAPI's tapi-notification module RPCs

ETSI GS NFV-IFA 032 [i.2] Fault Management Interface Operations	TAPI's RPC for tapi-notification module	Comments
Subscribe	create-notification-subscription-service	Supported
Notify		No direct mapping For further details see the analysis comment 03 in clause 5.4.2.8
Terminate Subscription	delete-notification-subscription-service	Supported
Get Subscription Info	<ul style="list-style-type: none"> get-notification-subscription-service-details get-notification-subscription-service-list 	Supported
Get Alarm List	get-notification-list	Partially Supported
Acknowledge Alarms		Not Supported

This mapping shown in table 5.4.2.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation of the TAPI specification. In this case, it might be needed to use multiple functions to achieve the expected result. If the analysis below suggests such a mapping for an operation, it is noted in the respective analysis notes in clause 5.4.2.8.

5.4.2.2 Analysis of Subscribe operation

5.4.2.2.1 Analysis of Subscribe operation Input Information model

The ETSI GS NFV-IFA 032 [i.2] specifies *filter* as an input parameter for selecting notifications to subscribe to alarms. Its specification is left for the protocol design stage.

The ETSI GS NFV-IFA 032 [i.2] Subscribe operation maps to the TAPI's *create-notification-subscription-service* RPC.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> create-notification-subscription-service
>> input
```

All mapped parameters are specified relative to the above path. Table 5.4.2.2.1-1 provides the mapping.

Table 5.4.2.2.1-1: Mapping of Subscribe operation input with TAPI's create-notification-subscription-service input operations

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
filter	subscription-filter/requested-notification-types* subscription-filter/requested-object-types* subscription-filter/requested-object-identifier* subscription-filter/requested-layer-protocols* subscription-filter/name* [value-name]*	Supported For further details see the analysis comment 01 in clause 5.4.2.8

It should be noted that the above subscription in TAPI might return parameters that are not relevant for Fault Management interface.

5.4.2.2.2 Analysis of Subscribe operation Output Information model

The ETSI GS NFV-IFA 032 [i.2] Subscribe operation output parameter *subscriptionId* returns identifier of the subscription realized. This is supported by the TAPI's *create-notification-subscription-service* RPC output parameter with the following path:

```
rpc
> create-notification-subscription-service
>> output
```

All mapped parameters are specified relative to the above path. Table 5.4.2.2.2-1 provides the mapping.

Table 5.4.2.2.2-1: Mapping of Subscribe operations output with TAPI's create-notification-subscription-service output operations

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
subscriptionId	subscription-service/notification/uuid	Supported

5.4.2.3 Analysis of Notify operation

The ETSI GS NFV-IFA 032 [i.2] specification describes a Notify operation. An equivalent operation does not exist in the TAPI YANG model. Nevertheless, the content of the notifications is specified in the TAPI YANG module *tapi-notifications* [i.22]. See also analysis comment 03 in clause 5.4.2.8.

The ETSI GS NFV-IFA 032 Notify operation for Fault Management supports the types of notification Information Elements shown in table 5.4.2.3-1.

Table 5.4.2.3-1: Mapping of ETSI GS NFV-IFA 032 Fault Management Notification Information Elements with TAPI's notification types

ETSI GS NFV-IFA 032 [i.2] Fault Management Interface Notify opération information elements	TAPI's OAM Service RPC	Comments
AlarmNotification		Partially supported. For further details see the analysis comment 05 in clause 5.4.2.8.
AlarmClearedNotification		Partially supported. See table 5.4.2.3-2.
AlarmListRebuiltNotification		Not supported.

Table 5.4.2.3-2 provides the mapping of the attributes of the *AlarmClearedNotification* information element to the TAPI's YANG *tapi-notification* and *tapi-oam* module. The TAPI's YANG *tapi-oam* module extends (augments) the notification type that is specified in TAPI's YANG *tapi-notification* module.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path defined in TAPI's YANG *tapi-notification* module (see [i.23]):

```
rpc
> get-notification-list
>> output
>>> notification
```

All mapped parameters are specified relative to the above path. Table 5.4.2.3-2 provides the mapping.

Table 5.4.2.3-2: Mapping of Notify operation IE AlarmClearedNotification with TAPI's tapi-notification-service

ETSI GS NFV-IFA 032 [i.2] Fault Management Notify operation Information Element <i>AlarmClearedNotification</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
alarmId (Identifier)	uuid	Supported
alarmClearedTime (DateTime)		Not supported

5.4.2.4 Analysis of Terminate Subscription operation

5.4.2.4.1 Analysis of Terminate Subscription operation Input Information model

ETSI GS NFV-IFA 032 [i.2] specifies an identifier called *subscriptionId* as the only input parameter for selecting the subscription to the notifications that should be deleted.

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation maps to the TAPI's *delete-notification-subscription-service* RPC. With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > delete-notification-subscription-service
    >> input
```

All mapped parameters are specified relative to the above path. Table 5.4.2.4.1-1 provides the mapping.

Table 5.4.2.4.1-1: Mapping of Terminate Subscription operation input with TAPI's delete-notification-subscription-service operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model: <i>Terminate Subscription operation</i>	TAPI operation delete-notification-subscription-service	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
subscriptionId	uuid	Supported

5.4.2.4.2 Analysis of Terminate Subscription operation Output Information model

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation has no output. The same is true for the mapped TAPI operation *delete-notification-subscription-service*.

5.4.2.5 Analysis of Query Subscription Info operation

5.4.2.5.1 Analysis of Query Subscription Info operation Input Information model

The ETSI GS NFV-IFA 032 [i.2] Query Subscription Info operation input parameter *filter* is left for specification in the protocol design stage. In general the operation can be supported by the following two TAPI's RPC:

- *get-notification-subscription-service-list*
- *get-notification-subscription-service-details*

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-notification-subscription-service-list
```

```
rpc
  > get-notification-subscription-service-details
    >> input
```

It should be noted that the *get-notification-subscription-service-list* RPC does not define any input parameters, and thus can be used in case the ETSI GS NFV-IFA 032 [i.2] filter parameter is specified as a wildcard (*). Only the *get-notification-subscription-service-details* RPC specifies an input parameter. Therefore, table 5.4.2.5.1-1 provides the mapping of ETSI GS NFV-IFA 032 [i.2] *filter* parameter with that of *get-notification-subscription-service-details* RPC.

Table 5.4.2.5.1-1: Mapping of Query Subscription operations input with TAPI's get-notification-subscription-service-details operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Subscription Info operation</i>	TAPI operations <i>get-notification-subscription-service-details</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
filter	uuid	Partially Supported For further details see the analysis comment 02 in clause 5.4.2.8

5.4.2.5.2 Analysis of Query Subscription Info operation Output Information model

The ETSI GS NFV-IFA 032 [i.2] Query Subscription Info operation output parameter *queryResult* is left for specification in the protocol design stage. In general the operation can be supported by the outputs of the following two TAPI's RPC:

- *get-notification-subscription-service-list*
- *get-notification-subscription-service-details*

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-notification-subscription-service-list
  >>output

rpc
  > get-notification-subscription-service-details
  >> output
```

It should be noted that the mapped TAPI RPCs also return subscriptions that are not relevant for the ETSI GS NFV-IFA 032 [i.2] Fault Management interface.

5.4.2.6 Analysis of Get Alarm List operation

5.4.2.6.1 Analysis of Get Alarm List operation Input Information model

The ETSI GS NFV-IFA 032 [i.2] specifies a *filter* as an input parameter for selecting alarm notifications to return. Although the specification for the *filter* information model is left for the protocol design stage, the filter can be on *MSCS identifiers*, *severity* and *cause*. The ETSI GS NFV-IFA 032 [i.2] Get Alarm List operation maps to the TAPI's *get-notification-list* RPC.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-notification-list
  >> input
```

All mapped parameters are specified relative to the above path. Table 5.4.2.6.1-1 provides the mapping.

Table 5.4.2.6.1-1: Mapping of Get Alarm List operations input with TAPI's get-notification- list operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Get Alarm List operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
filter	subscription-id time-range/end-time time-range/start-time	Partially Supported For further details see the analysis comment 04 in clause 5.4.2.8

5.4.2.6.2 Analysis of Get Alarm List operation Output Information model

Table 5.4.2.6.2-1 provides a mapping of the output information model of Get Alarm List operation specified for ETSI GS NFV-IFA 032 [i.2] Fault Management interface with the YANG model specified for TAPI v2.2.0's *get-notification-list* RPC defined in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > get-notification-list
    >> output
```

The output of the get-notification list is also augmented by the notification related information model that is defined under the *TAPI's tapi-oam* module.

All mapped parameters are specified relative to the above path.

Table 5.4.2.6.2-1: Mapping of Get Alarm List operations output with TAPI's get-notificaion- list operation input

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Get Alarm List operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
alarm (Alarm)		
> alarmId (Identifier)	notification/uuid	Supported
> managedObjectId (Identifier)	notification/target-object-identifier	Supported
> rootCauseFaultyObject (Identifier)		Not Supported
> alarmRaisedTime (DateTime)		Not Supported
> alarmChangedTime (DateTime)		Not Supported
> alarmClearedTime (DateTime)		Not Supported
> ackState (Enum)		Not Supported
> perceivedSeverity (Enum)	notification/alarm-info/ perceived-severity	Supported
> eventTime (DateTime)	notification/event-time-stamp	Supported
> eventType (Enum)		Not Supported
> faultType (String)	notification/additional-information notification/additional-text	Supported
> probableCause (String)	notification/alarm-info/ probable-cause	Supported
> isRootCause (Boolean)		Not Supported
> correlatedAlarmId (Identifier (Reference to Alarm))		Not Supported
> faultDetails (Not Specified)	notification/additional-information notification/additional-text	Supported

5.4.2.7 Analysis of Acknowledge Alarms operation

This operation is not supported in TAPI.

5.4.2.8 Analysis Comments for Fault Management Interface Operations

Analysis Comment 01: Since the content of the *filter* parameter in ETSI GS NFV-IFA 032's [i.2] Subscribe operation is not specified, the parameters provided by the specified TAPI input operations could be used. The TAPI interface for the mapped operation *create-notification-subscription-service/subscription-filter* has the following input parameters:

- Requested-notification-types* to support type of notification.
- Requested-object-types* to support identify the type of resource.
- Requested-object-identifier* to support identify the particular resource object.
- Requested-layer-protocols* to select protocol.
- Name* [value-name]* to support including notification related attributes.

Analysis Comment 02: The *filter* parameter is only partially supported, since ETSI GS NFV-IFA 032 [i.2] expect to be able to select also a set of subscriptions. The mapped TAPI operation [i.23] only supports getting a single subscription (*get-notification-subscription-service-details*) or all subscriptions (*get-notification-subscription-service-list*).

Analysis Comment 03: The Notify operation can be supported by the notification mechanism of the NETCONF/RESTCONF protocol implementing the TAPI YANG models. The content of the notifications that get sent are specified in the *tapi-notifications* and *tapi-oam* modules of the TAPI YANG model [i.23]. The notifications might need some adaptation to implement the filters that the NETCONF/RESTCONF protocol specifies and is expected by the ETSI GS NFV-IFA 032 [i.2] operation.

Analysis Comment 04: The filter parameter cannot be supported entirely since TAPI does not support the *filter* parameters that ETSI GS NFV-IFA 032 [i.2] specifies as examples (MSCS identifiers, severity and cause). Since filter is not necessarily limited to those parameters, the general functionality is supported.

Analysis Comment 05: The attribute of the AlarmNotification notification is *alarm* the content of which is the *Alarm* information element. The *Alarm* information element is analysed in clause 5.4.2.6.2.

5.4.3 Gap analysis with respect to IETF's YANG Data Model for Alarm Management

5.4.3.0 Introduction

IETF has specified YANG data model for Alarm Management [i.33]. The data from the YANG model can be accessed via operations specified in RESTCONF [i.26]. Clause 5.4.3 and subclauses analyse the similarities and gaps between the Fault management interface operations and related information elements used in the input and output of these operations as specified in ETSI GS NFV-IFA 032 [i.2] with those of YANG Data model specified by IETF.

5.4.3.1 Profiling of Fault Management interface operations

5.4.3.1.1 Introduction

IETF YANG data model for Alarm management [i.33] supports the information elements required for the fault management of multi-site connectivity services as specified in ETSI GS NFV-IFA 032 [i.2]. RESTCONF protocol [i.26] RPCs supports the operations to get alarms, acknowledge alarms, create subscriptions and notifications, etc. In this clause, the Fault management interface operations produced by WIM as specified in ETSI GS NFV-IFA 032 [i.2] will be analysed with the RPCs used by IETF YANG Data model for Alarm management. The information elements analysed in clause 5.4.3.2 will be used as a reference in the input and output parameters of different operations.

Table 5.4.3.1.1-1 describes the profiling and gap analysis corresponding to the operations of the Fault Management interface operations specified for ETSI GS NFV-IFA 032 [i.2] with the RPCs used by IETF.

Table 5.4.3.1.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Fault Management interface operations with IETF Alarm model

ETSI GS NFV-IFA 032 [i.2] Fault Management Interface Operations	RESTCONF RPCs for IETF Alarm model	Analysis: support status
Subscribe	POST /restconf/operations/ietf-subscribed-notifications:establish-subscription	Supported
Notify	Notifications sent according to module ietf-restconf-subscribed-notifications	Supported See note 2
Terminate Subscription	POST /restconf/operations/ietf-subscribed-notifications:delete-subscription	Supported
Query Subscription Info	GET /restconf/operations/subscriptions/<URI>	Supported
Get Alarm List	GET /restconf/operations/alarms/alarm-list	Supported See note 1
Acknowledge Alarms	POST /restconf/operations/alarms/alarm-list/alarm/set-operator-state	Supported See note 1
NOTE 1: This alarm data model states that the tuple (resource, alarm-type identifier, and alarm-type qualifier) corresponds to a single alarm instance.		
NOTE 2: RESTCONF supports notification mechanism as specified in IETF RFC 8650 [i.37].		

This mapping shown in table 5.4.3.1.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation in IETF YANG model. In this case it might be needed to use multiple functions to achieve the expected result.

5.4.3.1.2 Subscribe operation

Refer to clause 6.4.2 in ETSI GS NFV-IFA 032 [i.2]. This operation enables the consumer to subscribe with a filter for the notifications related to MSCS alarms sent by the WIM. The input parameters of the Subscribe operation contains Input filter for selecting MSCSs and related alarms and output contains subscription Id. Input filter for this operation can contain the MSCS information, severity and cause of the alarm, etc.

RESTCONF supports subscription to YANG Notifications for Datastore Updates as specified in IETF RFC 8641 [i.38]. Dynamic subscriptions are supported as specified in IETF RFC 8650 [i.37]. Tables 5.4.3.1.2-1 and 5.4.3.1.2-2 describe the profiling of parameters involved in the input and output of Subscribe operation.

Table 5.4.3.1.2-1: Profiling of the input parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model Parameters & Attributes (Type)	IETF Analysis: support status
filter (Filter)	Supported. See note.
NOTE: The filter details can be added as input to the "establish-subscription" as specified in IETF RFC 8639 [i.39].	

Table 5.4.3.1.2-2: Profiling of the output parameters of Subscribe operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model Parameters & Attributes (Type)	IETF Analysis: support status
subscriptionId (Identifier)	Supported.

5.4.3.1.3 Notify operation

Refer to clause 6.4.3 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports "push-update" and "push-change-update" notifications as specified in IETF RFC 8641 [i.38].

This operation distributes notifications such as AlarmNotification, AlarmClearedNotification and AlarmListRebuiltNotification to subscribers. Profiling of the notifications as listed in table 5.4.3.1.3-1 is done in the clauses related to Information elements. See clauses 5.4.3.2.3, 5.4.3.2.4 and 5.4.3.2.5.

Table 5.4.3.1.3-1: Profiling of the Notify operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] Notifications	IETF Analysis: support status
AlarmNotification	Supported. See clause 5.4.3.2.3
AlarmClearedNotification	Supported. See clause 5.4.3.2.4
AlarmListRebuiltNotification	Not supported. See clause 5.4.3.2.5.

5.4.3.1.4 Terminate Subscription operation

Refer to clause 6.4.4 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports delete-subscription operation that maps to terminate subscription operation with subscriptionId as input.

5.4.3.1.5 Query Subscription Info operation

Refer to clause 6.4.5 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports querying subscription by specifying the subscription id in the GET operation as specified in IETF RFC 8650 [i.37]. Tables 5.4.3.1.5-1 and 5.4.3.1.5-2 describe the profiling of parameters involved in the input and output of Query Subscription Info operation.

Table 5.4.3.1.5-1: Profiling of the input parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note.
NOTE: The filter details supports a subscriptionId. Query multiple subscriptions is not supported.	

Table 5.4.3.1.5-2: Profiling of the output parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
queryResult (Not specified)	Supported.

5.4.3.1.6 Get Alarm List operation

Refer to clause 6.4.6 in ETSI GS NFV-IFA 032 [i.2]. This operation enables the consumer to query the active alarms from the WIM.

Tables 5.4.3.1.6-1 and 5.4.3.1.6-2 describes the profiling of input and output parameters of Get Alarm List operation with respect to IETF YANG model for Alarm management.

Table 5.4.3.1.6-1: Profiling of the input parameters of Get Alarm List operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note.
NOTE: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.	

Table 5.4.3.1.6-2: Profiling of the output parameters of Get Alarm List operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
List of alarms (Alarm)	Supported. See clause 5.4.3.2.2.

5.4.3.1.7 Acknowledge Alarms operation

Refer to clause 6.4.7 in ETSI GS NFV-IFA 032 [i.2]. This operation enables the consumer to acknowledge the alarms at WIM. The set-operator-state attributes in ietf-alarms/alarms/alarm-list/alarm leaf is used to acknowledge alarms. Refer to the snippet of IETF Alarm YANG model in figure A.4.1-2.

Tables 5.4.3.1.7-1 and 5.4.3.1.7-2 describes the profiling of input and output parameters of Acknowledge Alarms operation with respect to IETF YANG model for Alarm management.

Table 5.4.3.1.7-1: Profiling of the input parameters of Acknowledge Alarms operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
alarmId	Supported. See clause 5.4.3.2.2.

Table 5.4.3.1.7-2: Profiling of the output parameters of Acknowledge Alarms operation with IETF YANG model

ETSI GS NFV-IFA 032 input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
acknowledgedAlarmId (Alarm)	Supported. See clause 5.4.3.2.2.

5.4.3.2 Profiling of Information elements

5.4.3.2.1 Introduction

This clause analyses the similarities and gaps between the information elements used in the WIM interfaces in ETSI GS NFV-IFA 032 [i.2] with those of the IETF YANG Data model for Alarm management. These information elements are used in the input and output parameters of different operations produced by WIM.

5.4.3.2.2 Alarm Information element

Refer to clause 8.4.2 in ETSI GS NFV-IFA 032 [i.2]. The attributes of Alarm from the IETF YANG Data model are shown in Annex A. Refer to the snippet of IETF Alarm YANG model in figure A.4.1-1.

Table 5.4.3.2.2-1 provides the correlation of the attributes of Alarm information element to the IETF YANG Data model for Alarms in module ietf-alarms.

Table 5.4.3.2.2-1: Profiling of Alarm information element with IETF YANG Data model

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
alarmId	In IETF alarm data model, the tuple (resource, alarm-type identifier, and alarm-type qualifier) corresponds to a single alarm instance	Supported.
managedObjectId	Correlate to ietf-alarms/alarms/alarm-list/alarm/resource attribute.	Supported.
rootCauseFaultyObject	Correlates to the ietf-alarms/alarms/alarm-list/alarm/root-cause-resource attribute.	Supported.
alarmRaisedTime	Correlates to the ietf-alarms/alarms/alarm-list/alarm/last-raised attribute.	Supported.
alarmChangedTime	Correlates to the ietf-alarms/alarms/alarm-list/alarm/last-changed attribute when is-cleared is false.	Supported.
alarmClearedTime	Correlates to ietf-alarms/alarms/alarm-list/alarm/last-changed attribute when is-cleared is set to True.	Supported.
ackState	Correlates to the ietf-alarms/alarms/alarm-list/alarm/operator-status-change/state attribute. The acknowledge operation is triggered by operator and can be triggered by setting the set-operator-state.	Supported.
perceivedSeverity	Correlates to the ietf-alarms/alarms/alarm-list/alarm/perceived-severity attribute.	Supported.
eventTime	Not possible to derive this in design.	Not supported.
eventType	Supported when the system supports configurable X733 mapping from the ietf-alarms' alarm-type to X733 event-type and probable-cause.	Supported.
faultType	Can be derived from the alarm-text attribute in ietf-alarms/alarms/alarm-list/alarm leaf.	Supported.
probableCause	Supported when the system supports configurable X733 mapping from the ietf-alarms' alarm-type to X733 event-type and probable-cause.	Supported.
isRootCause	Can be derived from the resource and root-cause-resource attributes in ietf-alarms/alarms/alarm-list/alarm leaf.	Supported.
correlatedAlarmId	Correlates to the attributes under ietf-alarms/alarms/alarm-list/alarm/related-alarm	Supported.
faultDetails	Can be derived from the alt-resource, alarm-text and additional-information (reported in x733-alarm-parameters) attributes.	Supported.

5.4.3.2.3 AlarmNotification

Refer to clause 8.4.3 in ETSI GS NFV-IFA 032 [i.2] for the attributes sent in the AlarmNotification. Refer to the snippet of IETF Alarm YANG model in figure A.4.1-3. Table 5.4.3.2.3-1 describes the profiling and gap analysis corresponding to the information elements of the AlarmNotification with respect to alarm notifications supported in IETF YANG model for Alarm management.

Table 5.4.3.2.3-1 [i.2]: Profiling of Alarm Notification with IETF YANG Data model for Alarm management

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
alarm (Alarm)	Correlates to /alarms/alarm-list/alarm. Some of the key attributes are specified in /ietf-alarms/notifications/alarm-notification.	Supported. See clause 5.4.3.2.2.

5.4.3.2.4 AlarmClearedNotification

Refer to clause 8.4.4 in ETSI GS NFV-IFA 032 [i.2] for the attributes sent in the AlarmClearedNotification. Table 5.4.3.2.4-1 describes the profiling and gap analysis corresponding to the information elements of the AlarmClearedNotification with respect to IETF YANG model for Alarm management.

Table 5.4.3.2.4-1: Profiling of Alarm Cleared Notification with IETF YANG Data model for Alarm management

ETSI GS NFV-IFA 032 [i.2] model Attribute	IETF YANG model	Analysis: support status
alarmId (Identifier of Alarm)	The tuple (resource, alarm-type identifier, and alarm-type qualifier) corresponds to a single alarm instance for which notification is sent.	Supported.
alarmClearedTime	Correlates to ietf-alarms/notifications/alarm-notification/time attribute if notifications is sent for state change to clear.	Supported

5.4.3.2.5 AlarmListRebuiltNotification

Refer to clause 8.4.5 in ETSI GS NFV-IFA 032 [i.2] for AlarmListRebuiltNotification. AlarmListRebuiltNotification informs the receiver that the active alarm list has been rebuilt by the WIM. This notification has no attributes. In IETF data model, there is no special notification for Alarm List rebuilt.

5.5 Performance management interface

5.5.1 Overview

Clause 5.5 provides the profiling corresponding to the Performance management interface specified in ETSI GS NFV-IFA 032 [i.2]. The profiling with respect to ONF's TAPI standard is documented in clause 5.5.2. The profiling with respect to IETF's ACTN standards is documented in clause 5.5.3.

5.5.2 Gap analysis with respect to ONF's TAPI YANG Data Model

5.5.2.0 Introduction

The ONF has specified YANG data models for the TAPI services, which are available on GitHub [i.23]. Besides specifying the data models, these YANG models also specify the related operations, referred to as RPCs, for the respective TAPI services. Clause 5.5.2 and subclauses analyse the similarities and gaps between the Performance management interface operations and related information elements with those of the relevant YANG model specified for TAPI. For the analysis the version 2.2.0 of the TAPI YANG models is used.

5.5.2.1 Analysis of Performance Management operations

Table 5.5.2.1-1 maps the RPCs specified for TAPI's OAM Service with the most relevant operations specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface.

Table 5.5.2.1-1: Mapping of ETSI GS NFV-IFA 032 Performance Management interface operations with TAPI's OAM Service RPCs

ETSI GS NFV-IFA 032 [i.2] Performance Management Interface Operations	TAPI's OAM Service RPC	Comments
Create PM Job	create-oam-job	Supported
Delete PM Jobs	delete-oam-job	Partially Supported
Query PM Job	get-oam-job get-oam-job-list	Supported
Create Threshold	create-oam-profile	Supported
Delete Thresholds	delete-oam-profile	Partially Supported
Query Threshold	get-oam-profile	Supported
Subscribe	create-notification-subscription-service	Supported
Notify		Not Supported For further details see the analysis comment 10 in clause 5.5.2.12
Terminate Subscription	delete-notification-subscription-service	Supported
Query Subscription Info	get-notification-subscription-service- details, get-notification-subscription-service-list	Partially Supported

This mapping shown in table 5.5.2.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation of the TAPI specification. In this case it might be needed to use multiple functions to achieve the expected result. If the analysis below suggests such a mapping for an operation it is noted in the respective analysis notes in clause 5.5.2.12.

5.5.2.2 Analysis of Create PM Job operation

5.5.2.2.1 Analysis of Create PM Job operation Input Information model

Table 5.5.2.2.1-1 provides a mapping of the input information model of the Create PM Job operation of the Performance Management interface specified in ETSI GS NFV-IFA 032 [i.2] with the *create-oam-job* RPC of TAPI v2.2.0's YANG model defined in [i.23]. There is no exact one-to-one correspondence between the ETSI GS NFV-IFA 032's [i.2] Create PM Job operation and the RPCs defined by the *tapi-oam* module. The solution to set all attributes that are given by ETSI GS NFV-IFA 032's [i.2] Create PM Job operation is to use several TAPI RPCs.

The *create-oam-job* RPC of TAPI is used to create OAM jobs. It takes as input either an OAM service Id (*oam-service-id*) or an OAM service point Id (*oam-service-point-id*). In addition, an OAM profile Id (*oam-profile-id*) is needed that specifies how the monitoring is done (e.g. thresholds, granularity).

The *oam-service-id* can be obtained when creating an OAM service by invoking the *create-oam-service* RPC. An *oam-service-point-id* is created by invoking the *create-oam-service-point* RPC. Finally, the OAM profile Id *oam-profile-id* can be generated by invoking the *create-oam-profile* RPC.

The four RPCs above will create a PM Job that is comparable to a PM Job as defined in ETSI GS NFV-IFA 032 [i.2]. With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-oam-job
    >> input
```

All mapped parameters specified in table 5.5.2.2.1-1 are relative to the above path.

Table 5.5.2.2.1-1: Mapping of Create PM Job operations with TAPI's create-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Create PM Job operation</i>	TAPI operation <i>create-oam-job</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> Selector (ObjectSelection)		
>> objectType (String)		Not Supported
>> objectFilter (Filter)		Not Supported
>> objectInstanceId (identifier)	oam-service-id, oam-service-point-id	Partially supported For further details see the analysis comment 1 in clause 5.5.2.12
> performanceMetric (String)		Not Supported. For further details see the analysis comment 2 in clause 5.5.2.12
> performanceMetricGroup (String)		Not supported
> collectionPeriod (Enum)		Not Supported For further details see the analysis comment 3 in clause 5.5.2.12
> reportingPeriod (Enum)		Not Supported
> reportingBoundary (Not Specified)		Not Supported

5.5.2.2.2 Analysis of Create PM Job operation Output Information model

Table 5.5.2.2.2-1 provides a mapping of the output information model of the Create PM Job operation of the Performance Management interface specified in ETSI GS NFV-IFA 032 [i.2] with the create-oam-job of TAPI v2.2.0's YANG model specified in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-oam-job
    >> output
```

All mapped parameters specified in table 5.5.2.2.2-1 are relative to the above path.

Table 5.5.2.2.2-1: Mapping of Create PM Job operations with TAPI's create-oam-job operation

ETSI GS NFV-IFA 032 Output Information Model: <i>Create PM Job operation</i>	TAPI operation <i>create-oam-job</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> pmJobId (Identifier)	oam-job/uuid	Supported

5.5.2.3 Analysis of Delete PM Jobs operation

5.5.2.3.1 Analysis of Delete PM Jobs operation Input Information model

Table 5.5.2.3.1-1 provides a mapping of the information model of Delete PM Jobs operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's *delete-oam-job* RPC defined in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > delete-oam-job
    >> input
```

All mapped parameters in table 5.5.2.3.1-1 are specified relative to the above path.

Table 5.5.2.3.1-1: Mapping of Delete PM Jobs operations with TAPI's delete-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Delete PM Jobs operation</i>	TAPI operation <i>delete-oam-job</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
pmJobId (Identifier)	uuid	Partially Supported For further details see the analysis comment 4 in clause 5.5.2.12

5.5.2.3.2 Analysis of Delete PM Jobs operation Output Information model

Table 5.5.2.3.2-1 provides a mapping of the information model of Delete PM Jobs operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model *delete-oam-job* in [i.23].

The TAPI's *delete-oam-job* RPC does not provide any output.

Table 5.5.2.3.2-1: Mapping of Delete PM Jobs operations with TAPI's delete-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Delete PM Jobs operation</i>	TAPI operation <i>delete-oam-job</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
deletedPmJobId (Identifier)		Not Supported For further details see the analysis comment 4 in clause 5.5.2.12.

5.5.2.4 Analysis of Query PM Job operation

5.5.2.4.1 Analysis of Query PM Job operation Input Information model

Table 5.5.2.4.1-1 provides a mapping of the information model of Query PM Job operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for the following two TAPI v2.2.0 RPC's defined in [i.23]:

- *get-oam-job*
- *get-oam-job-list*

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> get-oam-job
>> input

rpc
> get-oam-job-list
```

It should be noted that TAPI's *get-oam-job-list* RPC does not define any input parameters, and thus can be used in the case where the *filter* parameter of ETSI GS NFV-IFA 032's [i.2] Query PM Job operation is specified as a wildcard (*). Only TAPI's *get-oam-job* RPC specifies an input parameter. Therefore, table 5.5.2.4.1-1 provides the mapping of ETSI GS NFV-IFA 032's [i.2] *filter* parameter with that of TAPI's *get-oam-job* RPC.

Table 5.5.2.4.1-1: Mapping of Query PM Job operation with TAPI's get-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query PM Job operation</i>	TAPI operation <i>get-oam-job</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
filter	uuid	Partially Supported For further details see the analysis comment 4 and analysis comment 5 in clause 5.5.2.12

5.5.2.4.2 Analysis of Query PM Job operation Output Information model

Table 5.5.2.4.2-1 provides a mapping of the output information model of Query PM Job operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model create-oam-job in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```

rpc
  > get-oam-job
    >> output

rpc
  > get-oam-job-list
    >> output

```

It should be noted that both *get-oam-job* and *get-oam-job-list* RPCs are similar in terms of the type of parameters that they output, differing only that the former outputs parameters for a specific PM job, whereas the latter outputs parameters for all the PM jobs.

All mapped parameters specified in table 5.5.2.4.2-1 are relative to the above path.

Table 5.5.2.4.2-1: Mapping of Query PM Job operations with TAPI's get-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Query PM Job operation</i>	TAPI operation <i>get-oam-job</i> <i>get-oam-job-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> pmJobDetails (PmJob)		
>> pmJobId (Identifier)	oam-job/uuid	Supported
>> objectSelector (ObjectSelection)		
>>> objectType		Not Supported
>>> objectFilter		Not Supported
>>> objectInstancelid	oam-job/ oam-service-point/oam-service-uuid, oam-job/ oam-service-point/oam-service-point-local-id	Partially Supported For further details see the analysis comment 1 in clause 5.5.2.12
>> performanceMetric (String)		Partially Supported For further details see the analysis comment 6 in clause 5.5.2.12
>> performanceMetricGroup (String)		Not Supported
>> collectionPeriod (Enum)		Not Supported
>> reportingPeriod (Enum)		Not Supported
>> reportingBoundary (Not Specified)		Not Supported

5.5.2.5 Analysis of Create Threshold operation

5.5.2.5.1 Analysis of Create Threshold operation Input Information model

Table 5.5.2.5.1-1 provides a mapping of the input information model of Create Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's *create-oam-profile* RPC defined in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-oam-profile
    >> input
```

All mapped parameters specified in table 5.5.2.5.1-1 are relative to the above path.

Table 5.5.2.5.1-1: Mapping of Create Threshold operations with TAPI's create-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Create Threshold operation</i>	TAPI operation <i>create-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> Selector (ObjectSelection)		
>> objectType (String)		Not Supported
>> objectFilter (Filter)		Not Supported
>> objectInstanceId (identifier)		Not Supported
> performanceMetric (String)	pm-threshold-data/ threshold-parameter/ pm-parameter-name	Supported
> thresholdType (Enum)		Not Supported
> thresholdDetails (Not Specified)	pm-threshold-data/ threshold-parameter/ [pm-parameter-above-thrs pm-parameter-below-thrs pm-parameter-clear-thrs]	Supported

5.5.2.5.2 Analysis of Create Threshold operation Output Information model

Table 5.5.2.5.2-1 provides a mapping of the output information model of Create Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model *create-oam-profile* in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-oam-profile
    >> output
```

All mapped parameters specified in table 5.5.2.5.2-1 are relative to the above path.

Table 5.5.2.5.2-1: Mapping of Create Threshold operations with TAPI's create-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Create Threshold operation</i>	TAPI operation <i>create-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> thresholdId (Identifier)	oam-profile/uuid	Supported

5.5.2.6 Analysis of Delete Threshold operation

5.5.2.6.1 Analysis of Delete Threshold operation Input Information model

Table 5.5.2.6.1-1 provides a mapping of the input information model of Delete Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's *delete-oam-profile* RPC defined in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > delete-oam-profile
    >> input
```

All mapped parameters specified in table 5.5.2.6.1-1 are relative to the above path.

Table 5.5.2.6.1-1: Mapping of Delete Threshold operations with TAPI's delete-oam-job operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Delete Threshold operation</i>	TAPI operation <i>delete-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> thresholdId (Identifier)	uuid	Partially Supported For further details see the analysis comment 4 in clause 5.5.2.12

5.5.2.6.2 Analysis of Delete Threshold operation Output Information model

Table 5.5.2.6.2-1 provides a mapping of the output information model of Delete Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model *delete-oam-profile* in [i.23].

The TAPI's *delete-oam-profile* RPC does not provide any output.

Table 5.5.2.6.2-1: Mapping of Delete Threshold operations with TAPI's delete-oam-profile operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Delete Threshold operation</i>	TAPI operation <i>delete-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> deletedThresholdId (Identifier)		Not Supported For further details see the analysis comment 4 in clause 5.5.2.12

5.5.2.7 Analysis of Query Threshold operation

5.5.2.7.1 Analysis of Query Threshold operation Input Information model

Table 5.5.2.7.1-1 provides a mapping of the input information model of Query Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's *get-oam-profile* RPC defined in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> get-oam-profile
>> input
```

All mapped parameters specified in table 5.5.2.7.1-1 are relative to the above path.

Table 5.5.2.7.1-1: Mapping of Query Threshold operations with TAPI's get-oam-profile operation

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Threshold operation</i>	TAPI operation <i>get-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	uuid	Partially Supported For further details see the analysis comment 4 in clause 5.5.2.12

5.5.2.7.2 Analysis of Query Threshold operation Output Information model

Table 5.5.2.7.2-1 provides a mapping of the output information model of Query Threshold operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model *get-oam-profile* in [i.23].

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> get-oam-profile
>> output
```

All mapped parameters specified in table 5.5.2.7.2-1 are relative to the above path.

Table 5.5.2.7.2-1: Mapping of Query Threshold operations with TAPI's get-oam-profile operation

ETSI GS NFV-IFA 032 [i.2] Output Information Model: <i>Query Threshold operation</i>	TAPI operation <i>get-oam-profile</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> thresholdDetails (Threshold)		
>> thresholdId	oam-profile/uuid	Supported
>> objectSelector (ObjectSelection)		
>>> objectType		Not Supported
>>> objectFilter		Not Supported
>>>objectInstanceId		Partially Supported. For further details see the analysis comment 1 and analysis comment 7 in clause 5.5.2.12
>>performanceMetric (String)	oam-profile/ pm-threshold- data/ pm-parameter-name	Supported
>>thresholdType (Enum)		Not Supported
>>thresholdDetails (Not Specified)	oam-profile/ pm-threshold- data/ threshold-parameter/ [pm-parameter-above-thrs pm-parameter-below-thrs pm-parameter-clear-thrs]	Supported

5.5.2.8 Analysis of Subscribe operation

5.5.2.8.1 Analysis of Subscribe operation input information model

ETSI GS NFV-IFA 032 [i.2] specifies a *Filter* as an input parameter for selecting performance management related notifications to subscribe to. The filter can be on *MSCS*, *type of notification* or *attribute of the notification*.

This is similar to the approach adopted by TAPI where a YANG model referred to as *tapi-notification* has been specified with relevant module and RPCs to support the notification service.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> create-notification-subscription-service
>> input
```

All mapped parameters specified in table 5.5.2.8.1-1 are relative to the above path.

Table 5.5.2.8.1-1: Mapping of Subscribe operation with TAPI's create-notification-subscription-service operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription- service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	subscription-filter/ [requested- notification-types requested-object-types requested-object-identifier name]	Supported For further details see the analysis comment 8 in clause 5.5.2.12

5.5.2.8.2 Analysis of Subscribe operation output information model

Table 5.5.2.8.2-1 provides a mapping of the output information model of Subscribe operation specified for ETSI GS NFV-IFA 032 [i.2] Performance Management interface with the YANG model specified for TAPI v2.2.0's YANG model *create-notification-subscription-service* in [i.23].

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
  > create-notification-subscription-service
  >> output
```

All mapped parameters specified in table 5.5.2.8.2-1 are relative to the above path.

Table 5.5.2.8.2-1: Mapping of Subscribe operation with TAPI's create-notification-subscription-service operation output

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Subscribe operation</i>	TAPI operation <i>create-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> subscriptionId (Identifier)	subscription-service/uuid	Supported

5.5.2.9 Analysis of Query Subscription Info operation

5.5.2.9.1 Analysis of Query Subscription Info operation input information model

ETSI GS NFV-IFA 032 [i.2] defines a *filter* as an input parameter for performing the Query Subscription Info operation. However, the content of Filter parameter is not specified, the details of which has been left for the protocol design stage.

In general, the operation can be supported by the following two TAPI's RPC:

- *get-notification-subscription-service-list*
- *get-notification-subscription-service-details*

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
  > get-notification-subscription-service-details
  >> input

rpc
  > get-notification-subscription-service-list
```

It should be noted that the *get-notification-subscription-service-list* RPC does not define any input parameters, and thus can be used in case the ETSI GS NFV-IFA 032 [i.2] filter parameter is specified as a wildcard (*). Only the *get-notification-subscription-service-details* RPC specifies an input parameter. Therefore, Table 5.5.2.9.1-1 provides the mapping of ETSI GS NFV-IFA 032 [i.2] *filter* parameter with that of *get-notification-subscription-service-details* RPC.

Table 5.5.2.9.1-1: Mapping of Query Subscription Info operation with TAPI's get-notification-subscription-service-details and get-notification-subscription-service-list operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Query Subscription Info operation</i>	TAPI operation <i>get-notification-subscription-service-details/ get-notification-subscription-service-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> filter (Filter)	uuid	Partially Supported For further details see the analysis comment 9 in clause 5.5.2.12

5.5.2.9.2 Analysis of Query Subscription Info operation output information model

The ETSI GS NFV-IFA 032 [i.2] Query Subscription Info operation output parameter *queryResult* returns the relevant information about the queried subscription. However, the content of *queryResult* parameter is not specified, the details of which has been left for the protocol design stage. TAPI operations of *get-notification-subscription-service-details* and *get-notification-subscription-service-list*, on the other hand, provide a rich set of information about the queried subscriptions, which can potentially cover the content of ETSI GS NFV-IFA 032's *queryResult* parameter when specified in the protocol design stage.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following paths (see [i.23]):

```
rpc
> get-notification-subscription-service-details
>> output

rpc
> get-notification-subscription-service-list
>> output
```

All mapped parameters specified in table 5.5.2.9.2-1 are relative to the above path.

Table 5.5.2.9.2-1: Mapping of Query Subscription Info operation with TAPI's get-notification-subscription-service-details and get-notification-subscription-service-list operation output

ETSI GS NFV-IFA 032 [i.2] Output Information Model <i>Query Subscription Info operation</i>	TAPI operation <i>get-notification-subscription-service-details/ get-notification-subscription-service-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> queryResult (Not specified)	See note.	Partially Supported For further details see the analysis comment 9 in clause 5.5.2.12
NOTE: As mentioned above, the content for <i>queryResult</i> is not specified, therefore it is not possible to specify a mapping to specific parameters and attributes for the above mapped TAPI RPCs. Therefore the column in table 5.5.2.9.2-1 for TAPI operation is left empty.		

5.5.2.10 Analysis of Terminate Subscription operation

5.5.2.10.1 Analysis of Terminate Subscription operation input information model

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation maps to the TAPI's *delete-notification-subscription-service* RPC.

With this mapping, the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path (see [i.23]):

```
rpc
> delete-notification-subscription-service
>> input
```

All mapped parameters specified in table 5.5.2.10.1-1 are relative to the above path.

Table 5.5.2.10.1-1: Mapping of Terminate Subscription operation with TAPI's delete-notification-subscription-service operation input

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Terminate Subscription operation</i>	TAPI operation <i>delete-notification-subscription-service</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
> subscriptionId (Identifier)	uuid	Supported

5.5.2.10.2 Analysis of Terminate Subscription operation output information model

The ETSI GS NFV-IFA 032 [i.2] Terminate Subscription operation has no output. The same is true for the mapped TAPI operation *delete-notification-subscription-service*.

5.5.2.11 Analysis of Notify operation

ETSI GS NFV-IFA 032 [i.2] describes a Notify operation. An equivalent operation does not exist in the TAPI YANG model. Nevertheless, the content of the notifications is specified in the TAPI YANG module *tapi-notifications*. See also analysis comment 10 in clause 5.5.2.12.

The ETSI GS NFV-IFA 032 [i.2] Notify operation for Performance Management supports the types of notification Information Elements shown in table 5.5.2.11-1.

Table 5.5.2.11-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Performance Management Notification Information Elements with TAPI's notification types

ETSI GS NFV-IFA 032 [i.2] Performance Management Interface Operations	TAPI's OAM Service RPC	Comments
PerformanceInformationAvailableNotification		Not Supported
ThresholdCrossedNotification		Partially Supported For further details see table 5.5.2.11-2

Table 5.5.2.11-2 provides the mapping of the attributes of the *ThresholdCrossedNotification* information element to the TAPI's YANG *tapi-notification* and *tapi-oam* module. The TAPI's YANG *tapi-oam* module extends (augments) the notification type that is specified in TAPI's YANG *tapi-notification* module.

With this mapping the information elements defined in ETSI GS NFV-IFA 032 [i.2] are compared to the TAPI YANG elements below the following path defined in TAPI's YANG *tapi-notification* module (see [i.23]):

```
rpc
> get-notification-list
  >> output
    >>> notification
```

All mapped parameters are specified relative to the above path. Table 5.5.2.11-2 provides the mapping.

Table 5.5.2.11-2: Mapping of Notify operation ThresholdCrossedNotification IE with TAPI's tapi-notification-service

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Notify operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
thresholdId (Identifier)		Not Supported
crossingDirection (Enum)	tca-info/threshold-parameter/[pm-parameter-above-thrs pm-parameter-below-thrs pm-parameter-clear-thrs]	Supported For further details see the analysis comment 11 in clause 5.5.2.12
objectInstanceId (Identifier)	target-object-identifier	Supported

ETSI GS NFV-IFA 032 [i.2] Input Information Model <i>Notify operation</i>	TAPI operation <i>get-notification-list</i>	Analysis: Support Status
Parameters & Attributes (Type)	Parameters & Attributes	
performanceMetric (String)	tca-info/threshold-parameter/pm-parameter-name	Supported
performanceValue (Value)	tca-info/threshold-parameter/[pm-parameter-above-thrs pm-parameter-below-thrs] / [pm-parameter-int-value pm-parameter-real-value]	Supported For further details see the analysis comment 11 in clause 5.5.2.12

5.5.2.12 Analysis Comments for Performance Management Interface Operations

Analysis Comment 1: In TAPI, OAM services and/or OAM service points are created by invoking *create-oam-service* or *create-oam-service-point* RPCs before those objects can be used in TAPI's *create-oam-job* RPC. The *objectInstanceId* parameter defined in ETSI GS NFV-IFA 032 [i.2] as part of ObjectSelection information element is an identifier, as well as the *oam-service-id/oam-service-point-id* parameters used in several TAPI's RPC (e.g. *create-oam-job*, *create-oam-profile*, *get-oam-job*, etc.). However, on the one hand, in the ETSI GS NFV-IFA 032 [i.2], the *objectInstanceId* is further mapped to any of the two following identifiers, *mscsId* or *msncId*, depending on whether the measured object is an MSCS or an MSNC (see clause B.1.2 of ETSI GS NFV-IFA 032 [i.2]). MSCS and MSNC measured objects have diverse types of measurements concerning specific MSCS/MSNC endpoints or more global measurements concerning the MSCS/MSNC. On the other hand, TAPI does not directly point to a connectivity service (the TAPI equivalent of an ETSI GS NFV-IFA 032 [i.2] MSCS) but to an oam service or oam service point that in turn points to a connectivity service end-point. This also means that the TAPI identifiers are limited to service end-points and thus cannot reference a whole connectivity service as described in ETSI GS NFV-IFA 032 [i.2].

Analysis Comment 2: The *performanceMetric* parameter of ETSI GS NFV-IFA 032's Create PM Job operation could be mapped to the path *input/pm-threshold-data/threshold-parameter/pm-parameter-name* of TAPI's *create-oam-profile* RPC. This means that in TAPI this input parameter is declared when specifying thresholds for the specific performance parameter for the *create-oam-profile* RPC, while in ETSI GS NFV-IFA 032 [i.2] thresholds are specified by invoking Create Threshold operation on specified performance metrics. Therefore, the *performanceMetric* parameter of ETSI GS NFV-IFA 032's [i.2] Create PM Job operation is not directly supported by TAPI's *create-oam-job* RPC.

Analysis Comment 3: The *collectionPeriod* parameter of ETSI GS NFV-IFA 032's Create PM Job operation could be mapped to the path *input/pm-threshold-data/granularity* of TAPI's *create-oam-profile* RPC. This means that in TAPI this input parameter is declared when specifying thresholds for the specific performance parameter for the *create-oam-profile* RPC, while in ETSI GS NFV-IFA 032 [i.2] thresholds are specified by invoking Create Threshold operation on specified performance metrics. Therefore, the *collectionPeriod* parameter of ETSI GS NFV-IFA 032's [i.2] Create PM Job operation is not directly supported by TAPI's *create-oam-job* RPC.

Analysis Comment 4: In several operations defined in ETSI GS NFV-IFA 032 [i.2], the cardinality of the input parameter does differ from the cardinality that the mapped TAPI operation supports. In these cases TAPI can only support a single identifier while the ETSI GS NFV-IFA 032 [i.2] operation supports a list of identifiers. Therefore, the mapping of these parameters are marked as Partially Supported. In the case of output parameters, TAPI operations that only take a single identifier as input usually return no output whereas ETSI GS NFV-IFA 032 [i.2] expects one. In such a case the output parameter is marked as Not Supported.

Analysis Comment 5: The **filter** parameter is only partially supported, since ETSI GS NFV-IFA 032 [i.2] expect to be able to select PM Jobs based on a single identifier, multiple identifiers or wildcard. TAPI on the other hand does not support the provisioning of oam jobs based on multiple identifiers. The mapped TAPI operation [i.23] only supports getting information for a specific oam job (*get-oam-job*) or for all oam-jobs (*get-oam-job-list*).

Analysis Comment 6: The output cannot be retrieved directly from the RPC *get-oam-job*. An additional query is expected to be performed to the *get-oam-profile* to find out the corresponding performance metric as associated to the OAM job. Thus getting performance metrics is a two-step approach and is partially supported.

Analysis Comment 7: The OAM profile as defined by TAPI has no parameter that links it to the OAM jobs that use this profile. The parameter *thresholdDetails* that is defined in the output of ETSI GS NFV-IFA 032's Query Threshold operation, in contrast to TAPI, links the threshold directly to instances that use this threshold by the *objectInstanceId*. To achieve the same behaviour in TAPI two operations are expected to be executed. The first operation, *get-oam-job-list*, will return all OAM jobs defined in TAPI. In a second operation, *get-oam-profile* can be invoked for each job returned by the first operation with the profile *uuid* given in the job description. A mapping that uses a single TAPI operation is not possible, thus the parameter of ETSI GS NFV-IFA 032 [i.2] is considered as partially supported.

Analysis Comment 8: The following attributes/parameters can serve the ETSI GS NFV-IFA 032 Subscription operation:

- requested-notification-types* to support type of notification
- requested-object-types* to support identifying the type of resource (e.g. MSCS)
- requested-object-identifier* to support identifying the particular resource object (e.g. which MSCS)
- name* [value-name]* to support including notification related attributes

Analysis Comment 9: The content of the *filter* parameter of ETSI GS NFV-IFA 032's [i.2] Query Subscription Info operation expects to be able to select a set of subscriptions. The mapped TAPI operation [i.23] only supports getting a single subscription (*get-notification-subscription-service-details*) or all subscriptions (*get-notification-subscription-service-list*). Since further details are not specified, the *filter* parameter is marked as partially supported. The *queryResult* output parameter of that operation does not specify specific attributes that should be returned. Since the output of the mapped TAPI's RPCs (*get-notification-subscription-service-details* and *get-notification-subscription-service-list*) delivers a variety of attributes the parameter is marked as partially supported.

Analysis Comment 10: The Notify operation can be supported by the notification mechanism of the NETCONF/RESTCONF protocol implementing the TAPI YANG models. The content of the notifications that get sent are specified in the *tapi-notifications* and *tapi-oam* modules of the TAPI YANG model. The notifications might need some adaptation to implement the filters that the NETCONF/RESTCONF protocol specifies and is expected by the ETSI GS NFV-IFA 032 [i.2] operation. Some more adaptations are needed to get the full content of the notification. According to the study TAPI only defines very basic information like the type and an identifier (*uuid*) of the notification. The full content can be retrieved by TAPI's *get-notification-list* RPC, which is augmented with notification data specified for *tca-info* that is relevant to the specified *uuid*.

Analysis Comment 11: The *crossingDirection* attribute in ETSI GS NFV-IFA 032's [i.2] Notify operation can be acquired by the output of TAPI's *get-notification-list* RPC using the process highlighted in Analysis Comment 10. It should be noted that the *crossingDirection* attribute specifies two values namely UP and DOWN, which corresponds to the TAPI's *get-notification-list/output/notification/pm-parameter-above-thrs* and *get-notification-list/output/notification/pm-parameter-below-thrs*. It should be noted that the 2 TAPI parameters *pm-parameter-above-thrs* and *pm-parameter-below-thrs* are specified under the *tca-info* data structure which requires to be augmented to the output of the *get-notification-list* RPC. The *performanceValue* attribute of ETSI GS NFV-IFA 032's [i.2] can then be mapped to the TAPI's parameters *pm-parameter-int-value* (of type uint 64) or *pm-parameter-real-value* (of type decimal64) for the relevant threshold direction (either *pm-parameter-above-thrs* or *pm-parameter-below-thrs*).

5.5.3 Gap analysis with respect to IETF's YANG Data Model for Network Performance Monitoring

5.5.3.0 Introduction

IETF has specified YANG data model for both Network Performance Monitoring and VPN Service Performance Monitoring [i.35] that can be used to monitor and manage network performance on the topology at higher layer or the service topology between VPN sites. The YANG model is designed as an augmentation to the network topology YANG model defined in IETF RFC 8345. In IETF RFC 4176, section 2.2.4 outlines performance management of Customer Service Operations and Management and section 3.2.4 outlines performance management of Provider Network Manager. Clause 5.5.3 and subclauses analyse the similarities and gaps between the Performance management interface operations and related information elements used in the input and output of these operations as specified in ETSI GS NFV-IFA 032 [i.2] with those of YANG Data model specified by IETF.

5.5.3.1 Profiling of Performance Management interface operations

5.5.3.1.1 Introduction

IETF YANG data model for Network and VPN Service Performance Monitoring [i.35] supports the performance management of multi-site connectivity services as specified in ETSI GS NFV-IFA 032 [i.2]. In this clause, the Performance management interface operations produced by WIM as specified in ETSI GS NFV-IFA 032 [i.2] will be analysed with the RPCs used by IETF YANG Data model for Network and VPN Service Performance Monitoring. The information elements analysed in clause 5.5.3.2 will be used as a reference in the input and output parameters of different operations.

Table 5.5.3.1.1-1 describes the profiling and gap analysis corresponding to the operations of the Performance Management interface operations specified for ETSI GS NFV-IFA 032 [i.2] with the RPCs used by IETF.

Table 5.5.3.1.1-1: Mapping of ETSI GS NFV-IFA 032 [i.2] Performance Management interface operations with IETF models

ETSI GS NFV-IFA 032 [i.2] Performance Management Interface Operations	RESTCONF RPCs	Analysis: support status
Create PM Job operation (Refer to clause 6.5.2 in ETSI GS NFV-IFA 032 [i.2]).	Network performance data or VPN service performance data [i.35] or TE telemetry data [i.36] in IETF models use subscription model in [i.37] to subscribe to interested data.	Partially supported. See note 1. Refer clause 5.5.3.1.2.
Delete PM Job operation (Refer to clause 6.5.3 in ETSI GS NFV-IFA 032 [i.2]).	Delete subscription is a mappable option.	Supported.
Query PM Job operation (Refer to clause 6.5.4 in ETSI GS NFV-IFA 032 [i.2]).	Query subscription is a mappable option	Supported.
Create Threshold operation (Refer to clause 6.5.5 in ETSI GS NFV-IFA 032 [i.2]).	-	Not supported. See note 2.
Delete Threshold operation (Refer to clause 6.5.6 in ETSI GS NFV-IFA 032 [i.2]).	-	Not supported.
Query Threshold operation (Refer to clause 6.5.7 in ETSI GS NFV-IFA 032 [i.2]).	-	Not supported.
Subscribe	POST /restconf/operations/ietf-subscribed- notifications:establish-subscription	Supported.
Notify	Notifications sent according to module ietf- restconf-subscribed-notifications	Supported. See note 3.
Terminate Subscription	POST /restconf/operations/ietf-subscribed- notifications:delete-subscription	Supported.
Query Subscription Info	GET /restconf/operations/subscriptions/<URI>	Supported.
NOTE 1: Refer to sections 5.1 and 5.2 of Network and VPN Service Performance Monitoring [i.35].		
NOTE 2: In IETF RFC 8776 [i.46], performance-metrics-throttle-container has attributes threshold-out and threshold-in maps to the intended behaviour in ETSI GS NFV-IFA 032 [i.2]. But currently no mapping of specifying threshold attribute in TE telemetry model or Network and VPN Service Performance Monitoring.		
NOTE 3: RESTCONF supports "push-update" and "push-change-update" notifications as specified in IETF RFC 8641 [i.38].		

This mapping shown in table 5.5.3.1.1-1 does not imply a complete overlap of the features supported by the mapped operations. Further differences between the mapped operations will be analysed at the level of information elements.

The analysis does account that parameters such as integers, enumerations, etc. might need to be converted due to the mapping being not the same e.g. in terms of units. Enumerations that can cover all values of the definition in ETSI GS NFV-IFA 032 [i.2] are considered a match.

Operations defined in ETSI GS NFV-IFA 032 [i.2] might not be able to be mapped to a single operation in IETF YANG model. In this case it might be needed to use multiple functions to achieve the expected result.

5.5.3.1.2 Create PM Job operation

Refer to clause 6.5.2 in ETSI GS NFV-IFA 032 [i.2]. This operation creates a PM job, enabling a consumer to specify an object and related performance metrics to be collected. In IETF YANG model, performance monitoring is based on YANG push notification. Performance monitoring is enabled based on the attributes added as leaf to the object and the mechanism supported is using a YANG subscription specified in [i.37].

Tables 5.5.3.1.2-1 and 5.5.3.1.2-2 describes the profiling of input and output parameters of Create PM Job operation with respect to IETF YANG models.

Table 5.5.3.1.2-1: Profiling of the input parameters of Create PM Job operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
Selector (ObjectSelection)	
➤ objectType (string)	Partially supported. See note 1.
➤ objectFilter (filter)	Partially supported. See note 1 and 2.
➤ objectInstanceId (identifier)	Supported. See note 3.
performanceMetric (String)	Supported.
performanceMetricGroup (String)	Supported. See note 4.
collectionPeriod (Not specified)	Not supported. See note 5.
reportingPeriod (Not specified)	Not supported. See note 5.
reportingBoundary (Not specified)	Not supported. See note 5.
<p>NOTE 1: In IETF YANG model, the performance monitoring is enabled based on adding relevant telemetry to the selected objects. Specifying them in subscriptions is possible.</p> <p>NOTE 2: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.</p> <p>NOTE 3: For MSCS, this identifier maps to L2 or L3 VPN Id. For MSNC, this identifier maps to the TE tunnel.</p> <p>NOTE 4: IETF YANG models support grouping of associated performance metrics into containers. But the grouping and categorization of the measurements in IETF YANG models can be different from the groups identified by ETSI GS NFV-IFA 032 [i.2].</p> <p>NOTE 5: As per section 5.1 of Network and VPN Service Performance Monitoring [i.35], the measurement interval and report interval associated with these performance data usually depends on configuration parameters. But how these attributes can be specified in TE telemetry model is not currently defined.</p>	

Table 5.5.3.1.2-2: Profiling of the output parameters of Create PM Job operation with IETF YANG model

ETSI GS NFV-IFA 032 output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
pmJobId (Identifier)	Supported. The identifier maps to the subscription-id in "ietf-restconf-subscribed-notifications" in the YANG model [i.37].

5.5.3.1.3 Delete PM Jobs operation

Refer to clause 6.5.3 in ETSI GS NFV-IFA 032 [i.2]. In IETF YANG model, performance monitoring is disabled when the attributes are deleted from the leaf to the object. Performance monitoring mechanism supported is using a YANG push model based on subscription. Delete PM Jobs operation maps to deleting of subscription created earlier. See clause 5.5.3.1.10.

5.5.3.1.4 Query PM Job operation

Refer to clause 6.5.4 in ETSI GS NFV-IFA 032 [i.2]. This operation related to querying the subscription. See clause 5.5.3.1.11.

5.5.3.1.5 Create Threshold operation

Refer to clause 6.5.5 in ETSI GS NFV-IFA 032 [i.2]. Tables 5.5.3.1.5-1 and 5.5.3.1.5-2 describes the profiling of input and output parameters of Create Threshold operation with respect to IETF YANG models.

Table 5.5.3.1.5-1: Profiling of the input parameters of Create Threshold operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
Selector (ObjectSelection)	
➤ objectType (string)	Partially supported. See note 1.
➤ objectFilter (filter)	Partially supported. See note 1 and 2.
➤ objectInstanceid (identifier)	Supported. See note 3.
performanceMetric (String)	Supported.
thresholdType (Not specified)	Not supported. See note 4.
thresholdDetails (Not specified)	Not supported. See note 4.
NOTE 1: In IETF YANG model, the performance monitoring is enabled based on adding relevant telemetry to the selected objects. Specifying them in subscriptions is possible.	
NOTE 2: RESTCONF partially supports Filter as per section 4.8.4 of IETF RFC 8040 [i.26]. SOL APIs (ETSI GS NFV-SOL 013 [i.45], clause 5.2) give possibility to include filter in the input and producer of API does the filtering. In RESTCONF, the attributes "field" and "filter" provides capability to restrict the depth of leaf and selecting specific attributes in output. In RESTCONF, additional filtering based on expressions (such as greater than, less than and range) will be responsibility of consumer by post processing the information.	
NOTE 3: For MSCS, this identifier maps to L2 or L3 VPN Id. For MSNC, this identifier maps to the TE tunnel.	
NOTE 4: IETF RFC 8776 [i.46] has threshold-in and threshold-out containers in performance-metrics-throttle-group that closely maps to the intended functionality in ETSI GS NFV-IFA 032 [i.2].	

Table 5.5.3.1.5-2: Profiling of the output parameters of Create Threshold operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
thresholdId (Identifier)	Supported. This associates to the subscription id.

With the current Network and VPN Service PM YANG model and TE telemetry model, this operation is not supported. Need to analyse the attribute if it will be supported in future versions of the models.

5.5.3.1.6 Delete Threshold operation

Refer to clause 6.5.6 in ETSI GS NFV-IFA 032 [i.2]. With the current Network and VPN Service PM YANG model and TE telemetry model, this operation is not supported.

5.5.3.1.7 Query Threshold operation

Refer to clause 6.5.7 in ETSI GS NFV-IFA 032 [i.2]. With the current Network and VPN Service PM YANG model and TE telemetry model, this operation is not supported.

5.5.3.1.8 Subscribe operation

Refer to clause 6.5.8 in ETSI GS NFV-IFA 032 [i.2]. This operation enables the consumer to subscribe with a filter for the notifications related to performance information with the WIM. The input parameters of the Subscribe operation contains Input filter for selecting MSCSs and related to notification and output contains subscription Id.

5.5.3.1.9 Notify operation

Refer to clause 6.5.9 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports "push-update" and "push-change-update" notifications as specified in IETF RFC 8641 [i.38].

Profiling of the notifications as listed in table 5.5.3.1.9-1 is done in the clauses related to Information elements.

Table 5.5.3.1.9-1: Profiling of the Notify operation with IETF YANG model

ETSI GS NFV-IFA 032 [i.2] Notifications	IETF Analysis: support status
PerformanceInformationAvailableNotification	Supported. See note.
ThresholdCrossedNotification	Not supported. Configuring thresholds are not yet supported.
NOTE: The object instance id for which the performance information is available can be MSCS id or MSNC id.	

5.5.3.1.10 Terminate Subscription operation

Refer to clause 6.5.10 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports delete-subscription operation that maps to terminate subscription operation with subscriptionId as input.

5.5.3.1.11 Query Subscription Info operation

Refer to clause 6.5.11 in ETSI GS NFV-IFA 032 [i.2]. RESTCONF supports querying subscription by specifying the subscription id in the GET operation as specified in IETF RFC 8650 [i.37]. Tables 5.5.3.1.11-1 and 5.5.3.1.11-2 describe the profiling of parameters involved in the input and output of Query Subscription Info operation.

Table 5.5.3.1.11-1: Profiling of the input parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] input information model	IETF Analysis: support status
Parameters & Attributes (Type)	
filter (Filter)	Partially supported. See note.
NOTE: The filter details supports a subscriptionId. Query multiple subscriptions is not supported.	

Table 5.5.3.1.11-2: Profiling of the output parameters of Query Subscription Info operation with IETF YANG models

ETSI GS NFV-IFA 032 [i.2] output information model	IETF Analysis: support status
Parameters & Attributes (Type)	
queryResult (Not specified)	Supported.

5.5.3.2 Profiling of Performance measurements referred in Performance Management interface

5.5.3.2.1 Introduction

This clause analyses the similarities and gaps between the performance measurements listed in clause B.1.3 of ETSI GS NFV-IFA 032 [i.2] with those of the IETF YANG Data model for Network and VPN Service Performance Monitoring and IETF YANG Data model for VN/TE Performance Monitoring Telemetry.

5.5.3.2.2 MSCS measurements

Refer to clause B.1.3.1 in ETSI GS NFV-IFA 032 [i.2]. There is partial mapping to performance measurements in IETF YANG data model for Network and VPN Service Performance Monitoring. Some of the performance measurements defined at Network level relate to VPN summary statistics and Link level and Termination Point levels statistics can be used to compute MSCS measurements listed in table 5.5.3.2.2-1. It is assumed that the API consumer can compute the corresponding MSCS measurement by collecting other related measurements from MSNC measurements.

Table 5.5.3.2.2-1: Profiling of MSCS measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032	IETF YANG model	Analysis: support status
Number of incoming packets	Inbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.
Number of outgoing packets	Outbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.
Number of incoming bytes	Inbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.
Number of outgoing bytes	Outbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.
Maximum one-way delay	Refer to clause 5.5.3.2.3. To be computed from all links in MSCS as the attribute is grouped under link-delay-statistics.	Supported.
Minimum one-way delay	Refer to clause 5.5.3.2.3. To be computed from all links in MSCS as the attribute is grouped under link-delay-statistics.	Supported.
Mean one-way delay	Refer to clause 5.5.3.2.3.	Not supported.
Maximum one-way delay variation	Refer to clause 5.5.3.2.3.	Not supported.
Minimum one-way delay variation	Refer to clause 5.5.3.2.3.	Not supported.
Mean one-way delay variation	Refer to clause 5.5.3.2.3.	Not supported.
Packet loss rate	Refer to clause 5.5.3.2.3. To be computed from all links in MSCS as the attribute is grouped under link-error-statistics.	Supported.
Packet collision rate	Refer to clause 5.5.3.2.3.	Not supported.

From ETSI GS NFV-IFA 032	IETF YANG model	Analysis: support status
Number of incoming broadcast packets	Inbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.
Number of outgoing broadcast packets	Outbound statistics related to the Network and VPN service performance. Refer to clause 5.5.3.2.3. To be computed from Termination point stats of the MSCS endpoint.	Supported.

5.5.3.2.3 MSNC measurements

Refer to clause B.1.3.2 in ETSI GS NFV-IFA 032 [i.2]. Table 5.5.3.2.3-1 list the mapping to performance measurements in IETF data model.

Table 5.5.3.2.3-1: Profiling of MSNC measurements with IETF YANG Data model

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Number of incoming packets	To be computed from leaf "inbound-unicast" and leaf "inbound-nunicast" grouped under "tp-svc-telemetry". Total packets is sum of the inbound-unicast and inbound-nunicast. See note 1.	Supported.
Number of outgoing packets	To be computed from leaf "outbound-unicast" and leaf "outbound-nunicast" grouped under "tp-svc-telemetry". Total packets is sum of the outbound-unicast and outbound-nunicast. See note 1.	Supported.
Number of incoming bytes	To be computed from "in-octets" attribute grouped under "tp-svc-telemetry". See note 1.	Supported.
Number of outgoing bytes	To be computed from "out-octets" attribute grouped under "tp-svc-telemetry". See note 1.	Supported.
Maximum one-way delay	To be computed from all links in MSNC as the attribute is grouped under link-delay-statistics. At link level this maps to leaf "max-delay-value" with direction "one-way" in container "delay-statistics" grouped under link-delay-statistics. See note 2.	Supported.
Minimum one-way delay	To be computed from all links in MSNC as the attribute is grouped under link-delay-statistics. At link level this maps to leaf "min-delay-value" with direction "one-way" in container "delay-statistics" grouped under link-delay-statistics. See note 2.	Supported.
Mean one-way delay	See notes 2 and 3.	Not supported.
Maximum one-way delay variation	See notes 2 and 3.	Not supported.
Minimum one-way delay variation	See notes 2 and 3.	Not supported.
Mean one-way delay variation	See notes 2 and 3.	Not supported.

From ETSI GS NFV-IFA 032 [i.2]	IETF YANG model	Analysis: support status
Packet loss rate	To be computed from all links in MSNC as the attribute is grouped under link-error-statistics. At link level this maps to leaf "loss-ratio" under "link-error-statistics". See note 2. "Total number of packets sent" can be derived from "loss-ratio" and "packet-loss-count"	Supported.
Packet collision rate	No mapping. See notes 2 and 4.	Not supported.
Number of incoming broadcast packets	Maps to leaf "inbound-nunicast" under "tp-svc-telemetry". See note 1.	Supported.
Number of outgoing broadcast packets	Maps to leaf "outbound-nunicast" under "tp-svc-telemetry". See note 1.	Supported.
NOTE 1: Refer to container tp-telemetry-attributes that uses tp-svc-telemetry corresponding to the Termination point (augment /nw:networks/nw:network/nw:node/nt:termination-point) in section 9 of IETF YANG model for Network and VPN Service Performance Monitoring [i.35].		
NOTE 2: Refer to container link-telemetry-attributes that uses link-delay-statistics, link-error-statistics and link-jitter-statistics corresponding to the Link (augment /nw:networks/nw:network/nt:link) in section 9 of IETF YANG model for Network and VPN Service Performance Monitoring [i.35].		
NOTE 3: At link level, link-delay-statistics specifies "min-delay-value", "max-delay-value", "low-delay-percentile", "middle-delay-percentile" and "high-delay-percentile".		
NOTE 4: At link level, link-error-statistics specifies "packets-loss-count", "loss-ratio", "packet-reorder-count", "packets-out-of-seq-count" and "packets-dup-count".		

6 Recommendations for Stage 3

6.1 Introduction

As documented in clause 5, the referred standards fulfil in different degrees the requirements specified in ETSI GS NFV-IFA 032 [i.2]. Based on such a profiling work, clause 6 provides an evaluation and comparison of the referred standards and documents a series of recommendations for developing normative protocol and data model (stage 3) solutions.

Additional details are provided in subsequent subclauses.

6.2 Evaluation of referenced protocol and data models

6.2.1 Introduction

Clause 6.2 provides a high-level assessment, comparison and evaluation of the profiled standards. It aims to derive some key indicators to help determine if there is any solution that is potentially more suitable for addressing ETSI GS NFV-IFA 032 [i.2] requirements and the specification mechanisms adopted by ETSI NFV (e.g. types of protocols, data models, etc.).

6.2.2 Evaluation

Table 6.2.2-1 provides a high-level comparison and evaluation of the profiled standards considering a set of comparison items or key indicators.

Table 6.2.2-1: High-level comparison and evaluation of the profiled standards

Comparison item (see note)	ONF TAPI	IETF ACTN
Organization	Open Networking Foundation (ONF)	Internet Engineering Task force (IETF)
Interface protocols format	NETCONF / RESTCONF	NETCONF/RESTCONF As per IETF RFC 6241 [i.40] on NETCONF and IETF RFC 8040 [i.26] on RESTCONF, IETF supports both interface protocol formats. IETF ACTN is natively NETCONF and can use RESTCONF. RESTCONF use is suggested as it is easier to use.
Data models format	YANG	YANG
Data encoding on the interface	NETCONF: XML RESTCONF: XML or JSON	NETCONF: XML RESTCONF: XML or JSON
API specification and representations	OpenAPI (OAS/Swagger) (informative)	References for creating API specifications: <ul style="list-style-type: none"> • IETF RFC 6020 [i.41]: YANG 1.0 • IETF RFC 7950 [i.27]: YANG 1.1 • IETF RFC 7951 [i.31]: JSON Encoding of Data Modeled with YANG • IETF RFC 8342 [i.32]: Network Management Datastore Architecture (NMDA) • IETF RFC 8407 [i.42]: Guidelines for Authors and Reviewers of Documents Containing YANG Data Models
Compatibility with RESTful APIs	Yes. RESTCONF is a restricted, standardized, interoperable RESTful interface and tailored for network configuration changes.	Yes. RESTCONF is a restricted, standardized, interoperable RESTful interface and tailored for network configuration changes.
Main domain/use case targets	TAPI is domain agnostic. Currently supports the management of Optical Transport (OTN, DWDM) & Packet Transport (Ethernet, MPLS-TP). Theoretically it can be extended to support L2/L3 VPN service.	ACTN is domain agnostic and used models allow to manage and to represent IP, Packet, MPLS, OTN, WSON, Microwave. The profiling focused on L2/L3 VPN service.
Extensibility	Yes. YANG definition includes the possibility to extend models providing the "augmentation" feature that can be used to extend the TAPI data models for supporting specific technology. In addition the TAPI SDK offers an informational, automated development tool offered by the ONF OpenSource SDN EAGLE project. It maps UML specifications into YANG data schema as an automated process, and similarly maps YANG into JSON Swagger specifications and Swagger into python or java code stubs.	Yes. YANG definition includes the possibility to extend models providing the "augmentation" feature. IETF standardization process is based on this feature to have generic models with basic concepts (technology agnostic models) that are "augmented" for supporting a specific technology.

Comparison item (see note)	ONF TAPI	IETF ACTN
Summary of non-supported operations or notifications per interface	<p>MSCS mgmt:</p> <ul style="list-style-type: none"> • Create MSCS Reservation • Query MSCS Reservation • Update MSCS Reservation • Terminate MSCS Reservation • Notify • MscsReservationChangeNotification <p>Capacity mgmt:</p> <ul style="list-style-type: none"> • Create Capacity Threshold • Delete Capacity Threshold • Query Capacity Threshold • Notify <p>Fault mgmt:</p> <ul style="list-style-type: none"> • Notify • Acknowledge Alarms • AlarmListRebuiltNotification <p>Performance mgmt:</p> <ul style="list-style-type: none"> • Notify • PerformanceInformationAvailableNotification 	<p>MSCS mgmt:</p> <p>All reservation specific attributes in all operations as well as below operations are not supported.</p> <ul style="list-style-type: none"> • Create MSCS Reservation • Query MSCS Reservation • Update MSCS Reservation • Terminate MSCS Reservation • MscsReservationChangeNotification <p>Capacity mgmt:</p> <p>Capacity related information is partially supported in Query operations but specific operations on capacity are not supported.</p> <ul style="list-style-type: none"> • Create Capacity Threshold • Delete Capacity Threshold • Query Capacity Threshold • CapacityChangeNotification <p>Fault mgmt:</p> <ul style="list-style-type: none"> • AlarmListRebuiltNotification <p>Performance mgmt:</p> <p>All threshold specific attributes and operations are not supported.</p> <ul style="list-style-type: none"> • Create Threshold operation • Delete Threshold operation • Query Threshold operation • ThresholdCrossedNotification
Summary of partially supported operations per interface	<p>General:</p> <ul style="list-style-type: none"> • Filter attribute used in query across all interfaces is partially supported. • Query of subscriptions is partially supported as the support for querying multiple subscriptions is not available. <p>MSCS mgmt:</p> <ul style="list-style-type: none"> • Create MSCS • Query MSCS • Update MSCS • Terminate MSCS <p>Capacity mgmt:</p> <ul style="list-style-type: none"> • Query Capacity • Query Topology Information • Query Node Information • Query Link Information • Query Network Edge Point Information • Query Subscription Info • CapacityChangeNotification • TopologyChangeNotification <p>Fault mgmt:</p> <ul style="list-style-type: none"> • Query Subscription Info • Get Alarm List • AlarmNotification • AlarmClearedNotification <p>Performance mgmt:</p> <ul style="list-style-type: none"> • Create PM Job 	<p>General:</p> <ul style="list-style-type: none"> • Filter attribute used in query across all interfaces is partially supported. • Query of subscriptions is partially supported as the support for querying multiple subscriptions is not available. <p>MSCS mgmt:</p> <ul style="list-style-type: none"> • Query MSCS • Query Subscription Info <p>Capacity mgmt:</p> <ul style="list-style-type: none"> • Query Capacity • Query Topology Information • Query Node Information • Query Link Information • Query Network Edge Point Information • Query Subscription Info <p>Fault mgmt:</p> <ul style="list-style-type: none"> • Query Subscription Info • Get Alarm List <p>Performance mgmt:</p> <p>Object selection for performance measurements is partially supported. Model support to set Collection period, reporting period, reporting boundary is currently not available.</p> <ul style="list-style-type: none"> • Create PM Job • Delete PM Job • Query PM Job

Comparison item (see note)	ONF TAPI	IETF ACTN
	<ul style="list-style-type: none"> • Delete PM Job • Query PM Job • Create Threshold • Delete Threshold • Query Threshold • Query Subscription Info • ThresholdCrossedNotificatio n 	<ul style="list-style-type: none"> • Query Subscription Info
<p>NOTE: Explanation of comparison items:</p> <ul style="list-style-type: none"> - Organization: the standards organization that produces the standard. - Interface protocols format: the protocols on which the interface/API are based. - Data models format: the data models/languages used to define the information data models. - Data encoding: how the information over the interfaces is represented. - API specification and representations: description about the guidelines and methodology for creating API specification (informative). - Compatibility with RESTful APIs: how much compatible the protocols/data models are with RESTful concepts, considering that ETSI NFV based many of its interfaces on RESTful. - Main domain/use case targets: if the standard was envisioned or had considered targeting specific domains or network layers, e.g. to understand if the standards is specifically used for multi-site connectivity use cases of certain technology or layer. - Extensibility: which mechanisms are available by the standard and/or community to extend current models, to potentially cover unaddressed requirements, if applicable. - Summary of non-supported operations per interface: to summarize, from the profiling done in clause 5, the operations that are not supported compared to the stage 2 interface definitions in ETSI GS NFV-IFA 032 [i.2]. Provide a list of operations. - Summary of partially supported operations per interface: to summarize, from the profiling done in clause 5, the operations that are partially supported compared to the stage 2 interface definitions in ETSI GS NFV-IFA 032 [i.2]. Provide a list of operations. 		

As it can be concluded from table 6.2.2-1, the two profile standards have many similarities, such as:

- support of the interface protocols formats, i.e. NETCONF and RESTCONF;
- support of the same data model format, i.e. YANG;
- support of the same protocols for data encoding on the interface, i.e. XML in the NETCONF case, and XML or JSON in the RESTCONF;
- compatibility with RESTful APIs is the same, since both support RESTCONF; and
- same extensibility, since being both based on YANG, they support the "augmentation" feature to extend the models.

In terms of requirements specified in ETSI GS NFV-IFA 032 [i.2], both profiled standards do not support operations and modelling related to MSCS reservation features. Neither support as well the operations related to capacity thresholds in the "Capacity Management" interface.

In the case of ONF TAPI, there is no support for handling notifications related to fault and performance management. On this aspect, there is a divergence with respect to how current NFV-MANO APIs (such as ETSI GS NFV-SOL 003 [i.43]) specify fault and management behaviour, which could have a bigger impact in handling of monitoring features when integrating NS, VNF and virtualised resource management with multi-site connectivity management.

Both profiled standards also maintain similar partial support of a number of features specified in ETSI GS NFV-IFA 032 [i.2], including:

- on Capacity Management and Fault Management, same list of partially supported operations of the interface; and
- on Performance Management, same list of PM Job related operations.

One major difference is on the MSCS Management, in which the ONF TAPI has just partial support for key operations such as "Create MSCS", "Query MSCS", "Update MSCS" and "Terminate MSCS". While in the case of IETF ACTN, only "Query MSCS" and "Query Subscription Info" are partially supported due to the fact of partial support of filtering attributes in query operations and query of multiple subscriptions.

6.3 Recommendations

6.3.1 Recommendations for ETSI GS NFV-IFA 032 maintenance

Based on the gap analysis detailed in clause 5, the semantics and need of some attributes in context with the related information element(s) is not clear from ETSI GS NFV-IFA 032 [i.2]. Table 6.3.1-1 lists the information elements and attributes for which maintenance in ETSI GS NFV-IFA 032 [i.2] is recommended.

Table 6.3.1-1: Maintenance recommendations to ETSI GS NFV-IFA 032 [i.2]

ETSI GS NFV-IFA 032 [i.2] Information element	ETSI GS NFV-IFA 032 [i.2] model Attribute	Reason for maintenance
MscsProfile	directionality	The semantics and need of the attribute in MscsProfile information element is not clear in ETSI GS NFV-IFA 032 [i.2]. Moreover, this attribute is also present and seems relevant in the MscsEndpointData information element, which further makes the semantics unclear of the presence of directionality in the MscsProfile.
	connectivityMode	The values of the attribute in MscsProfile information element seems to be limited in terms of the choice of connectivity topologies, and there might be other topologies to be considered in ETSI GS NFV-IFA 032 [i.2].
	numSegment	The semantics and need of the attribute in MscsProfile information element is not clear in ETSI GS NFV-IFA 032 [i.2].
	segmentId	The semantics of the attribute in MscsProfile information element is not clear in ETSI GS NFV-IFA 032 [i.2].
MsnC	msnCLayerProtocol	The examples listed in the description of the attribute do not bring clarity to the semantics of this attribute and needs correction in ETSI GS NFV-IFA 032 [i.2].
MsnCProfile	mtu	The semantics and need of the attribute in MsnCProfile information element is not obvious as it is also defined in MscsProfile information element in ETSI GS NFV-IFA 032 [i.2].
MscsData	msnCLayerProtocol	The examples listed in the description of the attribute do not bring clarity to the semantics of this attribute when analysing together with examples of the msnCLayerProtocol attribute in ETSI GS NFV-IFA 032 [i.2].
NetworkEdgePointInfo	layerProtocol	The semantics of the attribute compared to the similar attribute in the ConnectivityServiceEndpoint information element is not clear from ETSI GS NFV-IFA 032 [i.2].

6.3.2 Recommendations for stage 3 development

6.3.2.1 General

Table 6.2.2-1 provides high-level comparison and evaluation of the ONF TAPI and IETF standards for supporting Multi-Site Connectivity Services (MSCS), to establish network connectivity between different NFVI-PoPs. Based on the evaluation, the YANG models specified in ONF TAPI as well as IETF standards can be used according to relevant connectivity use cases (for e.g. L1, L2, L3 connectivity). In view of the commonalities and the differences, the following recommendation are listed to progress with stage 3 development:

- 1) Based on potential support for each connectivity standard, two normative stage 3 specifications are recommended one for each connectivity standard.

- 2) For the development of each normative specification, it is recommended to address the following aspects:
- Document applicability of the respective standard for different connectivity use cases.
 - For the supported ETSI GS NFV-IFA 032 [i.2] interface operations, endorse the respective mapped operations along with the applicable YANG model.
 - For the identified gaps that are either not supported or partially supported, create a liaison with the identified functional gaps and include for discussion with the respective standard group.
 - In case of successful liaison and support from other standard group is available, mark the support in stage 3 specification with a note that it will be addressed in the future YANG model references based on liaison response and endorse the YANG model(s) in the following ETSI NFV maintenance cycles.
 - In case of unsuccessful liaison, i.e. support from other standard group is not available, new ETSI NFV YANG model(s) are expected in the stage 3 specification extending the ONF/IETF YANG model and adding additional attributes where applicable.

6.3.2.2 ONF TAPI

This clause provides a summary of gaps of ETSI GS NFV-IFA 032 [i.2] with respect to ONF TAPI that is recommended to be addressed for stage 3 as per the approach highlighted in clause 6.3.2.1:

- Several operations defined in ETSI GS NFV-IFA 032's [i.2] include filter information elements. The attributes that describe these filter information elements defined for those operations cannot always be mapped to the TAPI YANG models. Some attributes are missing a mapping to TAPI YANG models and others do not provide exactly the same values for an attribute. In this case, an augmentation and/or alignment of the definitions in TAPI YANG modules is recommended.
- Most of the information elements defined in ETSI GS NFV-IFA 032 [i.2] for the Notify operations are supported, but some attributes in the information elements cannot always be mapped. Where some attributes are missing a mapping to TAPI YANG models or if the attributes do not provide exactly the same values for an attribute in any of these operations, an augmentation and/or alignment of the definitions in TAPI YANG modules is recommended.
- The Subscribe, Terminate Subscription, Query Subscription and Notify operations defined in all interfaces of ETSI GS NFV-IFA 032's [i.2] have only partial mappings in the TAPI YANG models. The missing functionality can be covered by the subscription and notify mechanism of the NETCONF/RESTCONF protocols that transports the implemented YANG data model messages. For some of those operations defined in ETSI GS NFV-IFA 032's [i.2] TAPI provides a direct mapping in its YANG modules but often not all attributes of the input and output information elements defined in ETSI GS NFV-IFA 032 [i.2] can be mapped. An alignment of the definitions in TAPI YANG modules is recommended.
- The reservation functionality in the MSCS interface, the management of thresholds in the Capacity and Performance Management interface and some functionality in the Fault Management interface defined in ETSI GS NFV-IFA 032's [i.2] are currently not supported in the TAPI YANG models. Thus, the operations or information elements that are defined for managing this functionality are missing completely in the TAPI YANG models. An augmentation of the TAPI YANG models to support this functionality and/or alignment of the definitions in TAPI YANG modules is recommended.
- For the partially supported operations, and even for some supported operations, in all interfaces defined in ETSI GS NFV-IFA 032 [i.2], some of the attributes of the input and output information elements cannot always be mapped. Some attributes are missing a mapping to TAPI YANG models and others do not provide exactly the same values for an attribute. In this case, an augmentation and/or alignment of the definitions in TAPI YANG modules is recommended.
- The definition of the measurement points for capacity and threshold measurement is not always exactly the same. Alignment of the definitions of these points is recommended.
- The definition of performance metric groups, collection periods, reporting periods and reporting boundaries at the time of creating a PM job in the Performance Management interface is not supported in ONF TAPI. An alignment of the definitions in TAPI YANG modules is recommended.

- The ONF TAPI YANG models does not support the provisioning of selecting objects, i.e. the MSCS or MSNC instances, on which performance information can be provided. An augmentation of the TAPI YANG models to support this functionality and/or alignment of the definitions in TAPI YANG modules is recommended.

6.3.2.3 IETF ACTN

This clause summarizes the functional gaps identified based on the detailed profiling of interface operations and information elements of ETSI GS NFV-IFA 032 [i.2] in clause 5.

Functional gaps:

- Reservation functionality is not supported in the current IETF YANG models used in multi-site connectivity service. With reservation functionality, a connectivity service is created and kept ready (reserved) to be used in the multi-site connectivity service. The reservation(s) can be used in the context of create, delete and update operations of connectivity services:
 - For this support, connectivity services (e.g. between desired end points and/or with the required connectivity profile parameters) are expected to be reserved with start`Time` (if set to 0 indicates immediate use and if set to a non-zero value, indicates the start time to use the reservation), end`Time` (if specified, indicates the end time of the reservation) and expiry`Time` (if specified, indicates the release time of reservation in case no allocation request against this reservation).
 - Notifications related to changes in reservation are expected to be supported.
- Use of capacity information for capacity and network connectivity planning is not supported in the current IETF YANG models. With the help of capacity attributes, whenever capacity thresholds are reached or breached, notifications are sent to the consumers of the network connectivity services:
 - Currently there is limited support in the YANG models to inform partial capacity information in some Topology models.
 - For the support of this functionality, different capacity parameters are expected (e.g. available, total, reserved and/or allocated capacity) to be reported at network level, network topology level, node level and link level. A time`Period` is recommended to be included with the reported capacity as reservations can be specified for a time interval and to correlate capacity at the specified time`Period`.
 - Notifications related to changes in capacity are expected to be supported.
 - Creation of thresholds based on capacity values and sending notifications based on thresholds are expected to be supported.
- In the YANG models used for performance measurements, support to set Collection period, reporting period, reporting boundary is not available. It is expected that addition of these attributes fulfils requirements related to creation of PM jobs and thresholds.

Minor observations:

- There is no unified way of identifying the name and description of VPNs in L3NM and L2NM models. The "mcsName" which indicates the human readable name for the L2 or L3 vpn-service maps to the "customer-name" under the vpn-service leaf in both L3NM and L2NM models. The "mcsDescription" which indicates the human readable description for the MSCS maps to "description" under the vpn-service leaf in L3NM model. But in the L2NM latest draft [i.25] (draft-ietf-opsawg-l2nm-00), description is not present. It is expected that "description" is included in updates of the L2NM model.
- There is no "lag" attribute in L3NM model. The L3NM latest draft [i.24] (draft-ietf-opsawg-l3sm-l3nm-03) specifies a "lag-id" potentially to be associated to the connection bearers, but not yet shown on the tree. It is expected that "lag-id" is included in updates of the L3NM model.

7 Conclusion

The present document provides a detailed profiling evaluation of the ONF TAPI and IETF ACTN standards against the functional, interface and information model requirements specified in ETSI GS NFV-IFA 032 [i.2] for supporting the management of multi-site connectivity services.

From the evaluation of the two standards, it can be concluded that neither ONF TAPI nor IETF ACTN provide full support of all the requirements specified in ETSI GS NFV-IFA 032 [i.2]. Nonetheless, the two standards offer substantial support in various areas (interfaces, operations, exchanged information) to be considered as potential candidates for development of protocols and data models supporting the management of multi-site connectivity services. In some use cases, one standard might offer advantages over the other due to better support or being more suitable to manage connectivity at certain layer (refer to clause 6.2).

The present document also provides recommendations regarding the development of protocols and data models:

- clauses 6.3.2.1 and 6.3.2.2 expose the set of recommendations to follow if further normative specification work on protocols and data models is to be developed based on ONF TAPI; and
- clauses 6.3.2.1 and 6.3.2.3 expose the set of recommendations to follow if further normative specification work on protocols and data models is to be developed based on IETF ACTN.

The consumers of the standards can choose the specific connectivity models based on the use cases which are expected to be fulfilled.

To ensure interoperability of NFV-MANO solutions regarding the management of multi-site connectivity services, it is therefore expected that further normative specification of protocols and data models will be performed.

Annex A:

Gap analysis of ETSI GS NFV-IFA0 32 Information Model with IETF's YANG models

A.1 Introduction

This annex provides a list of IETF YANG model snippets and examples referred in the Gap analysis of ETSI GS NFV-IFA 032 [i.2] (clause 5 of the present document).

A.2 MSCS management interface

A.2.1 Examples with IETF L3NM YANG model

A.2.1.0 Introduction

Clause A.2.1 provides examples of Create, Query, Update and Terminate operations of multi-site connectivity service as represented in L3NM YANG model. These examples are for reference only and the information in this clause only refer to the terminology of L3NM and do not align or compare any information elements specified in ETSI GS NFV-IFA 032 [i.2]. The high level attributes used in the example are outlined in figure A.2.1.0-1.

Key points:

- The AS Number range 65536-65551 is reserved by IETF RFC 5398 [i.29] for documentation and sample code.
- The IPv4 address blocks 192.0.2.0/24 (TEST-NET-1) and 203.0.113.0/24 (TEST-NET-3) are reserved by IETF RFC 5737 [i.30] for documentation.
- The RESTCONF protocol is defined in IETF RFC 8040 [i.26].
- The YANG 1.1 is defined in IETF RFC 7950 [i.27].
- The JSON encoding of data model with YANG is defined in IETF RFC 7951 [i.31].
- The running, intended and operational datastores are defined by NMDA in IETF RFC 8342 [i.32].

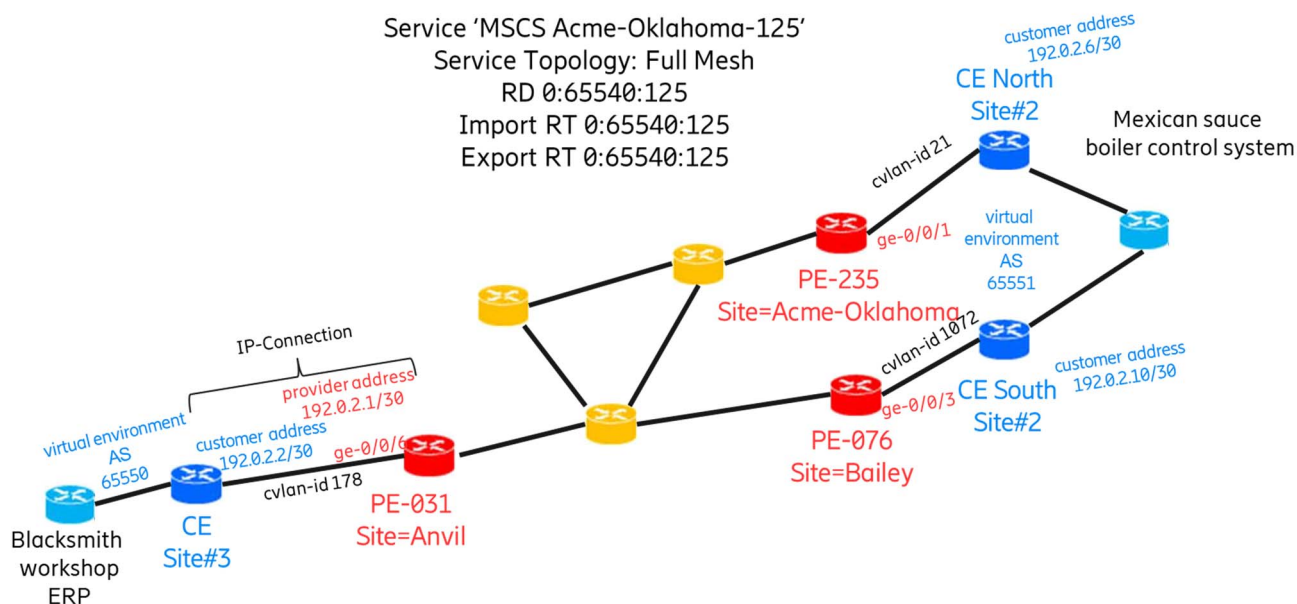


Figure A.2.1.0-1: Multi-site Connectivity Service example with L3NM YANG model

A.2.1.1 Create MSCS operation example with IETF L3NM model

The consumer of WIM interface (NFVO or the OSS/BSS) can create a service with a single operation, a copy-config in the running datastore as follow:

```
PUT /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-
service=MSCS%20Acme-Oklahoma-125 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
{
  // The During a PUT operation (copy-config or edit-config)
  // on a list item the message body does not contain the
  // "key" fields because already present in the used URL.
  // In this case the operation is on the element
  // "MSCS Acme-Oklahoma-125" of list "vpn-service"
  // This refers automatically to
  //
  // "vpn-id": "MSCS Acme-Oklahoma-125",
  //
  // A GET operation (get-config) will return it.

  "service-status": {
    "admin": {
      // The admin status can trigger the creation of
      // the service in the network on the devices.
      "status": "up"
    }
  },
  "customer-name": "1: The Acme-Oklahoma Corporation:MSCS Acme-Oklahoma",
  "vpn-service-topology": "any-to-any",
  "description": "part of MSCS for Acme-Oklahoma wearable rocket production",
  .....
  .....
}
```

The detailed input/output for PUT command for vpn-service is contained in archive gr_nfv_sol017v030301p0.zip which accompanies the present document.

In case of success, WIM respond as follows:

```
HTTP/1.1 201 Created
Date: Fri, 15 May 2020 2:57:22 GMT
Server: wim-server
Port: wim-restconf-service
Location: https://example.com/restconf/ds/ietf-datastores:running/\
```

```
ietf-l3vpn-ntw:vpn-services/vpn-service/vpn-id=MSCS%20Acme-Oklahoma-125
```

The creation of the service configuration can be performed in more than one copy-config operations or mixing them with edit-config operations changing enabling the admin status to trigger the creation of the service in the network.

The service creation can be performed with a POST operation addressed to the parent container. In this case the id of the element in the list is present in the message body that is referred to the parent container.

A.2.1.2 Query MSCS operation example with IETF L3NM model

The consumer of WIM (NFVO or OSS/BSS) can check the configuration getting it from the 'running' datastore:

```
GET /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-
service=MSCS%20Acme-Oklahoma-125 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Fri, 15 May 2020 3:10:17 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Fri, 15 May 2020 2:57:22 GMT
{
  "vpn-id": "MSCS Acme-Oklahoma-125",
  ...
  // equal to the message body of the PUT above
}
```

According to NMDA, once the WIM takes in consideration the requested configuration copied or edited in the 'running' datastore by the consumer, the WIM copies the configuration in the 'intended' datastore.

The consumer can check the configuration that will be used by the WIM in the 'intended' datastore.

```
GET /restconf/ds/ietf-datastores:intended/ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-
service=MSCS%20Acme-Oklahoma-125 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Fri, 15 May 2020 3:10:22 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Fri, 15 May 2020 2:59:11 GMT
{
  "vpn-id": "MSCS Acme-Oklahoma-125",
  ...
  // equal to the message body of the PUT above or different if not all the configurations are
  supported.
}
```

According to NMDA, once the WIM gets service provisioning confirmation from the network, the WIM reports the applied configuration in the network in the 'operational' datastore.

In the 'operational' datastore will be reported also the operational states.

The consumer can check the configuration applied by the WIM in the network as follows:

```
GET /restconf/ds/ietf-datastores:operational/ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-
service=MSCS%20Acme-Oklahoma-125 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```

HTTP/1.1 200 OK
Date: Fri, 15 May 2020 3:11:30 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Fri, 15 May 2020 3:12:49 GMT
{
  "vpn-id": "MSCS Acme-Oklahoma-125",
  ...
  // equal to the message body of the PUT above or different if not all the configurations are
  // supported by the WIM or the network devices.
  // also operational states will be included.
  ...
  "service-status": {
    ...
    // for example:
    "ops": {
      // The operational status of the service in the network on the devices.
      "status": "up"
    }
  },
  ...
}

```

A.2.1.3 Update MSCS operation example with IETF L3NM model

In case the service is already created and is present in the 'running' datastore, the same PUT command in clause A.2.1.1 is issued for changing part of the service configuration. Below is the example for Update MSCS operation.

In case of success, '204 No Content' is returned.

```

HTTP/1.1 204 No Content
Date: Fri, 15 May 2020 2:57:22 GMT
Server: wim-server
Port: wim-restconf-service
Location: https://example.com/restconf/ds/ietf-datastores:running/\
ietf-l3vpn-ntw:vpn-services/vpn-service/vpn-id=MSCS%20Acme-Oklahoma-125

```

A.2.1.4 Terminate MSCS operation example with IETF L3NM model

For deleting the service, the consumer will use DELETE operation on the 'running' datastore and then WIM will update accordingly the 'intended' and the 'operational' datastore. The operation can be performed as:

```

DELETE /restconf/ds/ietf-datastores:running/ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-
service=MSCS%20Acme-Oklahoma-125 HTTP/1.1
Host: wim-server
Port: wim-restconf-service

```

If the resource is deleted, the WIM can respond as follows:

```

HTTP/1.1 204 No Content
Date: Thu, 15 May 2020 4:15:27 GMT
Server: wim-server

```

A.2.2 Snippets from IETF L3NM YANG model used in gap analysis

Following are the list of L3NM YANG model snippets used in the gap analysis done in clause 5.


```
+--rw l3vpn-ntw
  +--rw vpn-profiles
  | ...
  +--rw vpn-services
    +--rw vpn-service* [vpn-id]
      +--rw status
      | ...
      +--rw vpn-id                vpn-common:vpn-id
      +--rw vpn-name?             string
      +--rw vpn-description?      string
      +--rw customer-name?        string
      +--rw l3sm-vpn-id?          vpn-common:vpn-id
      +--rw vpn-type?             identityref
      +--rw vpn-service-topology? identityref
      +--rw ie-profiles
      | ...
      +--rw underlay-transport
      | ...
      +--rw vpn-nodes
      | ...
      +--rw ...
```

Figure A.2.2-1: L3NM YANG model - VPN service attributes snippet

```

...
+--rw vpn-services
  +--rw vpn-service* [vpn-id]
    +--rw vpn-id          vpn-common:vpn-id
    + ...
    +--rw vpn-node* [ne-id]
      +--rw ne-id          string
      + ...
      +--rw vpn-network-accesses
        +--rw vpn-network-access* [id]
          +--rw id
            |          vpn-common:vpn-id
            ...
          +--rw connection
            +--rw encapsulation-type?  identityref
            +--rw logical-interface
            | +--rw peer-reference?  uint32
            +--rw tagged-interface
            | +--rw type?            identityref
            | +--rw dot1q-vlan-tagged
            | |          {vpn-common:dot1q}?
            | | +--rw tag-type?  identityref
            | | +--rw cvlan-id?  uint16
            | +--rw priority-tagged
            | | +--rw tag-type?  identityref
            +--rw qinq {vpn-common:qinq}?
            | +--rw tag-type?  identityref
            | +--rw svlan-id   uint16
            | +--rw cvlan-id   uint16
            +--rw qinany {vpn-common:qinany}?
            | +--rw tag-type?  identityref
            | +--rw svlan-id   uint16
            +--rw vxlan {vpn-common:vxlan}?
            | +--rw vni-id     uint32
            | +--rw peer-mode? identityref
            | +--rw peer-list* [peer-ip]
            | | +--rw peer-ip  inet:ip-address
            +--rw bearer
            ...
          ...
        ...
      ...
    ...
  ...

```

Figure A.2.2-2: L3NM YANG model - Connection subtree snippet

```

...
+--rw vpn-network-accesses
|
+--rw vpn-network-access* [id]
|
+--rw id
|
|       vpn-common:vpn-id
|
...
+--rw vpn-network-access-type?  identityref
+--rw connection
|
...
+--rw bearer
|
+--rw bearer-reference?  string
|
|       {vpn-common:bearer-reference}?
|
+--rw pseudowire
|
+--rw vcid?      uint32
|
+--rw far-end?  union
+--rw vpls
|
+--rw vcid?      union
+--rw far-end?  union
...

```

Figure A.2.2-3: L3NM YANG model - Bearer subtree snippet

```

...
+--rw vpn-services
|
+--rw vpn-service* [vpn-id]
|
+--rw vpn-id
|
|       vpn-common:vpn-id
|
+ ...
+--rw vpn-node* [ne-id]
|
+--rw ne-id
|
|       string
|
+ ...
+--rw vpn-network-accesses
|
+--rw vpn-network-access* [id]
|
+--rw id
|
|       vpn-common:vpn-id
|
+--rw port-id?
|
|       vpn-common:vpn-id
|
+--rw description?
|
|       string
|
+--rw status
|
|
|
|   +--rw admin-enabled?  boolean
|   +--ro oper-status?    operational-type
+--rw vpn-network-access-type?  identityref
+--rw connection
|
...
+--rw ip-connection
|
...
+--rw security
|
...
+--rw routing-protocols
|
...
+--rw service
|
...
...

```

Figure A.2.2-4: L3NM YANG model - Connection - IP connection snippet

```

+--rw ip-connection
  +--rw ipv4 {vpn-common:ipv4}?
    +--rw address-allocation-type?
      |   identityref
    +--rw (allocation-type)?
      +--:(provider-dhcp)
        +--rw provider-address?
          |   inet:ipv4-address
        +--rw prefix-length?
          |   uint8
        +--rw (address-assign)?
          +--:(number)
            |   +--rw number-of-dynamic-address?
              |   uint16
          +--:(explicit)
            +--rw customer-addresses
              +--rw address-group*
                [group-id]
                +--rw group-id
                  |   string
                +--rw start-address?
                  |   inet:ipv4-address
                +--rw end-address?
                  |   inet:ipv4-address
          +--:(dhcp-relay)
            +--rw dr-provider-address?
              |   inet:ipv4-address
            +--rw dr-prefix-length?
              |   uint8
            +--rw customer-dhcp-servers
              +--rw server-ip-address*
                |   inet:ipv4-address
          +--:(static-addresses)
            ...
      +--rw ipv6 {vpn-common:ipv6}?
        +--rw address-allocation-type?
          |   identityref
        +--rw (allocation-type)?
          +--:(provider-dhcp)
            +--rw (provider-dhcp)?
              +--:(provider-address)
                |   +--rw provider-address?
                  |   inet:ipv6-address
              +--:(prefix-length)
                |   +--rw prefix-length?
                  |   uint8
              +--:(address-assign)
                +--rw (address-assign)?

```

Figure A.2.2-5: L3NM YANG model - IP connection subtree snippet

```

...
+--rw vpn-network-accesses
|
+--rw vpn-network-access* [id]
|
+--rw id
|
|       vpn-common:vpn-id
|
...
+--rw service
|
+--rw svc-input-bandwidth      uint64
+--rw svc-output-bandwidth    uint64
+--rw svc-mtu                  uint16
+--rw qos {vpn-common:qos}?
|
|   +--rw qos-classification-policy
|   |
|   |   +--rw rule* [id]
|   |   |
|   |   |   +--rw id
|   |   |   |
|   |   |   |       string
|   |   |   +--rw (match-type)?
|   |   |   |   +--:(match-flow)
|   |   |   |   |
|   |   |   |   |   +--rw (13)?
|   |   |   |   |   |
|   |   |   |   |   |   +--:(ipv4)
|   |   |   |   |   |   |
|   |   |   |   |   |   |   ...
|   |   |   |   |   |   |   +--:(ipv6)
|   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   ...
|   |   |   |   |   |   +--rw (14)?
|   |   |   |   |   |   |   +--:(tcp)
|   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   +--:(udp)
|   |   |   |   |   |   |   |   |
|   |   |   |   |   |   |   |   |   ...
|   |   |   |   |   |   +--:(match-application)
|   |   |   |   |   |   |   +--rw match-application?
|   |   |   |   |   |   |   |   identityref
|   |   |   |   |   |   +--rw target-class-id?
|   |   |   |   |   |   |   string
|   |   |   +--rw qos-profile
|   |   |   |
|   |   |   |   +--rw qos-profile* [profile]
|   |   |   |   |
|   |   |   |   |   +--rw profile      leafref
|   |   |   |   |   +--rw direction?  identityref
|   |   |   +--rw carrierscarrier
|   |   |   |
|   |   |   |   {vpn-common:carrierscarrier}?
|   |   |   |   +--rw signalling-type?  enumeration
|   |   |   +--rw multicast {vpn-common:multicast}?
|   |   |   |
|   |   |   |   +--rw site-type?        enumeration
|   |   |   |   +--rw address-family?
|   |   |   |   |
|   |   |   |   |   vpn-common:address-family
|   |   |   |   +--rw protocol-type?    enumeration
|   |   |   |   +--rw remote-source?    boolean
|   |
|   ...
|
...

```

Figure A.2.2-6: L3NM YANG model - Service profile snippet

A.2.3 Snippets from IETF L2NM YANG model used in gap analysis

Following are the list of snippets from L2NM YANG model used in the gap analysis done in clause 5.

```

+--rw vpn-services
  +--rw vpn-service* [vpn-id]
    +--rw status
      | +--rw admin-status
      | | +--rw status? identityref
      | | +--rw last-updated? yang:date-and-time
      | +--ro oper-status
      | | +--ro status? identityref
      | | +--ro last-updated? yang:date-and-time
    +--rw vpn-id vpn-id
    +--rw vpn-name? string
    +--rw vpn-description? string
    +--rw customer-name? string
    +--rw l2sm-vpn-id? vpn-common:vpn-id
    +--rw vpn-svc-type? identityref
    +--rw svc-topo? identityref
    +--rw multicast-like {vpn-common:multicast}?
      | +--rw enabled? boolean
      | +--rw customer-tree-flavors
      | | +--rw tree-flavor* identityref
    +--rw extranet-vpns {vpn-common:extranet-vpn}?
      | +--rw extranet-vpn* [vpn-id]
      | | +--rw vpn-id vpn-common:vpn-id
      | | +--rw local-sites-role? identityref
    +--rw svc-mtu? uint32
    +--rw ce-vlan-preservation? boolean
    +--rw ce-vlan-cos-perservation? boolean
    +--rw underlay-transport
      | +--rw type* identityref
    +--rw vpn-nodes
      .....
  
```

Figure A.2.3-1: L2NM YANG model - VPN service attributes snippet

```

+--rw connection
+--rw encapsulation-type?  identityref
+--rw eth-inf-type*        identityref
+--rw dot1q-interface
|   +--rw l2-access-type?  identityref
|   +--rw dot1q {vpn-common:dot1q}?
|   |   +--rw physical-inf?  string
|   |   +--rw c-vlan-id?    uint32
|   +--rw qinq {vpn-common:qinq}?
|   |   +--rw s-vlan-id?    uint32
|   |   +--rw c-vlan-id?    uint32
|   +--rw qinany {vpn-common:qinany}?
|   |   +--rw s-vlan-id?    uint32
|   +--rw vxlan {vxlan}?
|   |   +--rw vni-id?      uint32
|   |   +--rw peer-mode?  identityref
|   |   +--rw peer-list* [peer-ip]
|   |   |   +--rw peer-ip  inet:ip-address
+--rw phy-interface
|   +--rw port-number?      uint32
|   +--rw port-speed?      uint32
|   +--rw mode?
|   |   +--rw vpn-common:neg-mode
|   +--rw phy-mtu?         uint32
|   +--rw flow-control?    string
|   +--rw oam-802.3ah-link {oam-3ah}?
|   |   +--rw enable?     boolean
|   +--rw uni-loop-prevention?  boolean
+--rw lag-interface
|   {vpn-common:lag-interface}?
|   +--rw lag-interface*
|   |   [lag-interface-number]
|   |   +--rw lag-interface-number  uint32
|   |   +--rw lacp

```

```

|   +--rw lacp-state?      boolean
|   +--rw lacp-mode?      boolean
|   +--rw lacp-speed?     boolean
|   +--rw mini-link?      uint32
|   +--rw system-priority?  uint16
|   +--rw member-link-list
|   |   +--rw member-link* [name]
|   |   |   +--rw name
|   |   |   |   string
|   |   |   +--rw port-speed?
|   |   |   |   uint32
|   |   |   +--rw mode?
|   |   |   |   +--rw vpn-common:neg-mode
|   |   |   +--rw link-mtu?
|   |   |   |   uint32
|   |   |   +--rw oam-802.3ah-link
|   |   |   |   {oam-3ah}?
|   |   |   |   +--rw enable?  boolean
|   |   +--rw flow-control?  string
|   |   +--rw lldp?         boolean
+--rw cvlan-id-to-svc-map* [svc-id]
|   +--rw svc-id  leafref
|   +--rw cvlan-id* [vid]
|   |   +--rw vid  uint32
+--rw split-horizon
|   +--rw group-name?  string

```

Figure A.2.3-2: L2NM YANG model - Connection subtree snippet

```

+--rw service
|
| +--rw svc-input-bandwidth
| | {vpn-common:input-bw}?
| | +--rw input-bandwidth* [type]
| | | +--rw type identityref
| | | +--rw cos-id? uint8
| | | +--rw cir? uint64
| | | +--rw cbs? uint64
| | | +--rw eir? uint64
| | | +--rw ebs? uint64
| | | +--rw pir? uint64
| | | +--rw pbs? uint64
| | +--rw svc-output-bandwidth {output-bw}?
| | +--rw output-bandwidth* [type]

```

Figure A.2.3-3: L2NM YANG model - Service profile snippet-1

```

+--rw vpn-network-accesses
+--rw vpn-network-access* [id]
| +--rw id
| | vpn-common:vpn-id
+--rw description?
| string
+--rw Interface-mtu?
| uint32
+--rw status
| +--rw admin-status
| | +--rw status? identityref
| | +--rw last-updated? yang:date-and-time
| +--ro oper-status
| | +--ro status? identityref
| | +--ro last-updated? yang:date-and-time
+--rw access-diversity
| {vpn-common:placement-diversity}?
| +--rw groups
| | +--rw fate-sharing-group-size? uint16
| | +--rw group-color? string

```

Figure A.2.3-4: L2NM YANG model - Service profile snippet-2

A.2.4 Snippets from IETF TE and Service mapping YANG model used in gap analysis

Following are the list of snippets from IETF Traffic Engineering (TE) and service mapping YANG model used in the gap analysis done in clause 5.

```

module: ietf-l3nm-te-service-mapping
  augment /l3vpn-ntw:l3vpn-ntw/l3vpn-ntw:vpn-services
    /l3vpn-ntw:vpn-service:
      +--rw te-service-mapping!
        +--rw te-mapping
          +--rw map-type?                identityref
          +--rw availability-type?       identityref
          +--rw (te)?
            +--:(vn)
              | +--rw vn-list*
              | | -> /vn:vn/vn-list/vn-id
            +--:(te-topo)
              | +--rw vn-topology-id?
              | | te-types:te-topology-id
              | +--rw abstract-node?
              | | -> /nw:networks/network/node/node-id
            +--:(te-tunnel)
              | +--rw te-tunnel-list*    te:tunnel-ref
              | +--rw sr-policy*
              | | [policy-color-ref policy-endpoint-ref]
              | | {sr-policy}?
              | | +--rw policy-color-ref  leafref
              | | +--rw policy-endpoint-ref leafref
            +--:(te-mapping-template) {template}?
              | +--rw te-mapping-template-ref? leafref
  augment /l3vpn-ntw:l3vpn-ntw/l3vpn-ntw:vpn-services
    /l3vpn-ntw:vpn-service/l3vpn-ntw:vpn-nodes
    /l3vpn-ntw:vpn-node/l3vpn-ntw:vpn-network-accesses
    /l3vpn-ntw:vpn-network-access:
      +--rw (te)?
        +--:(vn)
          | +--rw ap-list*
          | | -> /vn:ap/access-point-list/access-point-id
        +--:(te)
          +--rw ltp?      te-types:te-tp-id
  
```

Figure A.2.4-1: IETF L3NM TE Service mapping YANG model snippet

```

module: ietf-l2nm-te-service-mapping
augment /l2vpn-ntw:l2vpn-ntw/l2vpn-ntw:vpn-services
  /l2vpn-ntw:vpn-service:
  +--rw te-service-mapping!
    +--rw te-mapping
      +--rw map-type?          identityref
      +--rw availability-type? identityref
      +--rw (te)?
        +--:(vn)
          | +--rw vn-list*
          |   -> /vn:vn/vn-list/vn-id
        +--:(te-topo)
          | +--rw vn-topology-id?
          |   | te-types:te-topology-id
          | +--rw abstract-node?
          |   -> /nw:networks/network/node/node-id
        +--:(te-tunnel)
          | +--rw te-tunnel-list*      te:tunnel-ref
          | +--rw sr-policy*
          |   [policy-color-ref policy-endpoint-ref]
          |   {sr-policy}?
          |   +--rw policy-color-ref  leafref
          |   +--rw policy-endpoint-ref leafref
        +--:(te-mapping-template) {template}?
          +--rw te-mapping-template-ref? leafref
augment /l2vpn-ntw:l2vpn-ntw/l2vpn-ntw:vpn-services
  /l2vpn-ntw:vpn-service/l2vpn-ntw:vpn-nodes
  /l2vpn-ntw:vpn-node/l2vpn-ntw:vpn-network-accesses
  /l2vpn-ntw:vpn-network-access:
  +--rw (te)?
    +--:(vn)
      | +--rw ap-list*
      |   -> /vn:ap/access-point-list/access-point-id
    +--:(te)
      +--rw ltp?      te-types:te-tp-id

```

Figure A.2.4-2: IETF L2NM TE Service mapping YANG model snippet

A.3 Capacity management interface

A.3.1 Examples with IETF TE Topology YANG model

A.3.1.0 Introduction

Clause A.3.1 provides examples of Query operations related to topology, node, link and network edge points in a multi-site connectivity service. In IETF, the underlying network is represented in TE topology YANG model. These examples are for reference only and the information in this clause only refer to the terminology of TE topology and do not align or compare any information elements specified in ETSI GS NFV-IFA 032 [i.2]. The high level attributes used in the example are outlined in figure A.3.1.0-1.

Key points:

- TE router ids from 198.51.100.0/24 reserved for documentation by IETF RFC 5737 [i.30].
- Single domain network 64511 is reserved for documentation by IETF RFC 5398 [i.29].
- The RESTCONF protocol is defined in IETF RFC 8040 [i.26].

- The YANG 1.1 is defined in IETF RFC 7950 [i.27].
- The JSON encoding of data model with YANG is defined in IETF RFC 7951 [i.31].
- The running, intended and operational datastores are defined by NMDA in IETF RFC 8342 [i.32].

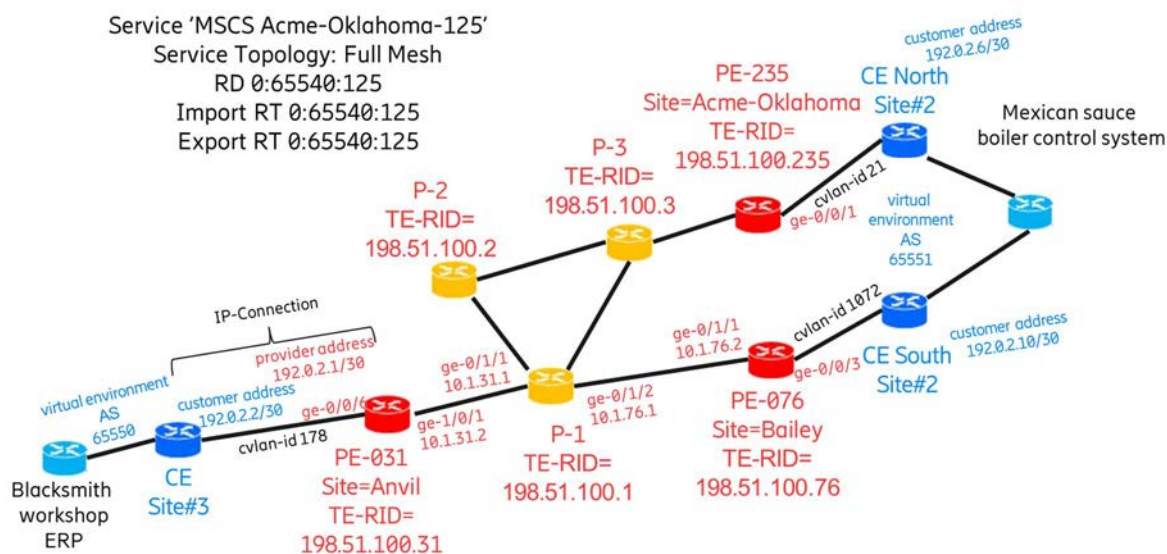


Figure A.3.1.0-1: Multi-site Connectivity Service example (with Topology details)

A.3.1.1 Query Topology Information operation example with IETF TE topology model

```
GET /restconf/ds/ietf-datastores:running/ietf-
network:networks/network=providerId%2F201%2FclientId%2F300%2FtopologyId%2Fwhite-
topology HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Tue, 7 July 2020 4:10:17 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Tue, 7 July 2020 3:57:22 GMT
{
.....
}
```

The detailed input/output for GET command for topology is contained in archive gr_nfv_sol017v030301p0.zip which accompanies the present document.

A.3.1.2 Query Node Information operation example with IETF TE topology model

```
GET /restconf/ds/ietf-datastores:running/ietf-
network:networks/network=providerId%2F201%2FclientId%2F300%2FtopologyId%2Fwhite-
topology/node=198.51.100.31 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Tue, 7 July 2020 4:10:17 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Tue, 7 July 2020 3:57:22 GMT
{
.....
}
```

The detailed input/output for GET command for node is contained in archive gr_nfv_sol017v030301p0.zip which accompanies the present document.

A.3.1.3 Query Link Information operation example with IETF TE topology model

```
GET /restconf/ds/ietf-datastores:running/ietf-
network:networks/network=providerId%2F201%2FclientId%2F300%2FtopologyId%2Fwhite-
topology/link=teNodeId%2F198.51.100.31%2FteLinkId%2F6 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Tue, 7 July 2020 4:10:17 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Tue, 7 July 2020 3:57:22 GMT
{
.....
}
```

The detailed input/output for GET command for link is contained in archive gr_nfv_sol017v030301p0.zip which accompanies the present document.

A.3.1.4 Query Network Edge Point Information operation example with IETF TE topology model

```
GET /restconf/ds/ietf-datastores:running/ietf-
network:networks/network=providerId%2F201%2FclientId%2F300%2FtopologyId%2Fwhite-
topology/node=198.51.100.31/ietf-network-topology:termination-point= 10.1.31.2 HTTP/1.1
Host: wim-server
Port: wim-restconf-service
Content Type: application/yang-data+json
```

The WIM might respond as follows:

```
HTTP/1.1 200 OK
Date: Tue, 7 July 2020 4:10:17 GMT
Server: wim-server
Port: wim-restconf-service
Content-Type: application/yang-data+json
Cache-Control: no-cache
Last-Modified: Tue, 7 July 2020 3:57:22 GMT
{
.....
}
```

The detailed input/output for GET command for termination-point is contained in archive gr_nfv_sol017v030301p0.zip which accompanies the present document.

A.4 Fault management interface

A.4.1 Snippets from IETF YANG model used in gap analysis

Following are the list of L3NM YANG model snippets used in the gap analysis done in clause 5.

```

+--ro alarm-list
|
|  +--ro number-of-alarms?  yang:gauge32
|  +--ro last-changed?     yang:date-and-time
|  +--ro alarm* [resource alarm-type-id alarm-type-qualifier]
|  |
|  |  +--ro resource          resource
|  |  +--ro alarm-type-id     alarm-type-id
|  |  +--ro alarm-type-qualifier alarm-type-qualifier
|  |  +--ro alt-resource*     resource
|  |  +--ro related-alarm* [resource alarm-type-id alarm-type-qualifier] {alarm-correlation}?
|  |  |
|  |  |  +--ro resource          -> /alarms/alarm-list/alarm/resource
|  |  |  +--ro alarm-type-id     -> /alarms/alarm-list/alarm[resource=current()/../resource]
|  |  |  +--ro alarm-type-qualifier -> /alarms/alarm-list/alarm[resource=current()/../resource]
|  |  +--ro impacted-resource* resource {service-impact-analysis}?
|  |  +--ro root-cause-resource* resource {root-cause-analysis}?
|  |  +--ro time-created       yang:date-and-time
|  |  +--ro is-cleared         boolean
|  |  +--ro last-raised        yang:date-and-time
|  |  +--ro last-changed       yang:date-and-time
|  |  +--ro perceived-severity severity
|  |  +--ro alarm-text         alarm-text
|  |  +--ro status-change* [time] {alarm-history}?
|  |  |
|  |  |  +--ro time            yang:date-and-time
|  |  |  +--ro perceived-severity severity-with-clear
|  |  |  +--ro alarm-text     alarm-text
|  |  +--ro operator-state-change* [time] {operator-actions}?
|  |  |
|  |  |  +--ro time            yang:date-and-time
|  |  |  +--ro operator       string
|  |  |  +--ro state          operator-state
|  |  |  +--ro text?         string
|  |  +---x set-operator-state {operator-actions}?
|  |  |
|  |  |  +---w input
|  |  |  |
|  |  |  |  +---w state      writable-operator-state
|  |  |  |  +---w text?    string
|  |  +---n operator-action {operator-actions}?
|  |  |
|  |  |  +-- time            yang:date-and-time
|  |  |  +-- operator       string
|  |  |  +-- state          operator-state
|  |  |  +-- text?         string
|  |
|  +---x purge-alarms

```

Figure A.4.1-1: IETF Alarm YANG model - Alarm attributes snippet

```

Operators can act upon alarms using the set-operator-state action:

+--ro alarm* [resource alarm-type-id alarm-type-qualifier]
  ...
+--ro operator-state-change* [time] {operator-actions}?
  | +--ro time          yang:date-and-time
  | +--ro operator      string
  | +--ro state         operator-state
  | +--ro text?        string
+--x set-operator-state {operator-actions}?
  +--w input
    +--w state          writable-operator-state
    +--w text?         string

```

Figure A.4.1-2: IETF Alarm YANG model - Acknowledge snippet

```

notifications:
+---n alarm-notification
  | +--ro resource          resource
  | +--ro alarm-type-id    alarm-type-id
  | +--ro alarm-type-qualifier? alarm-type-qualifier
  | +--ro alt-resource*    resource
  | +--ro related-alarm* [resource alarm-type-id alarm-type-qualifier] {alarm-correlation}?
  | | +--ro resource          -> /alarms/alarm-list/alarm/resource
  | | +--ro alarm-type-id    -> /alarms/alarm-list/alarm[resource=current()]/../resource
  | | +--ro alarm-type-qualifier -> /alarms/alarm-list/alarm[resource=current()]/../resource
  | +--ro impacted-resource* resource {service-impact-analysis}?
  | +--ro root-cause-resource* resource {root-cause-analysis}?
  | +--ro time              yang:date-and-time
  | +--ro perceived-severity severity-with-clear
  | +--ro alarm-text        alarm-text
+---n alarm-inventory-changed

```

Figure A.4.1-3: IETF Alarm YANG model - Notification snippet

Annex B: Change History

Date	Version	Information about changes
21.06.2019	0.0.1	Implements: <ol style="list-style-type: none"> NFVSOL(19)000360r1 - SOL017 - Document Structure and ToC NFVSOL(19)000361r1 - SOL017 Scope
14.09.2019	0.0.2	Implements: <ol style="list-style-type: none"> NFVSOL(19)000548r1 - SOL017 IFA032 Overview clause 4.2
01.10.2019	0.0.3	Implements: <ol style="list-style-type: none"> NFVSOL(19)000592 - SOL017 IFA032 Overview for Capacity, Performance and Fault Management interfaces for clause 4.2 NFVSOL(19)000506r3 - SOL017 Overview of ACTN Framework and Interfaces NFVSOL(19)000573 - SOL017 clause 4.3.2.3 Mapping concepts with ACTN
09.10.2019	0.0.4	Implements: <ol style="list-style-type: none"> NFVSOL(19)000605r2 - SOL017 TAPI Overview
11.12.2019	0.1.0	Implements <ol style="list-style-type: none"> NFVSOL(19)000793r2 - SOL017 Analysis ACTN and MSCS Create Operation NFVSOL(19)000818r1 - SOL017 IFA032 and TAPI Mapping NFVSOL(19)000819r1 - SOL017 Update to Overview of MSCS Information Elements
01.03.2020	0.2.0	Implements <ol style="list-style-type: none"> NFVSOL(20)000029r2 - SOL017 Analysis TAPI and MSCS Create Operation NFVSOL(20)000030r2 - SOL017 Analysis TAPI and MSCS Update Operation NFVSOL(20)000044r2 - SOL017 Analysis TAPI and MSCS Terminate Operation NFVSOL(20)000058r2 - SOL017 Analysis TAPI and MSCS Query Operation NFVSOL(20)0000103r1 - SOL017 Analysis TAPI and MSCS Create Operation Output NFVSOL(20)0000104 - SOL017 Analysis TAPI and MSCS Update Operation Output NFVSOL(20)0000105 - I SOL017 Analysis TAPI and MSCS Query Operation Output
22.04.2020	0.3.0	Implements <ol style="list-style-type: none"> NFVSOL(20)000165 - SOL017 Update of MSCS mgmt intf operation mapping to TAPI rpcs NFVSOL(20)000166 - SOL017 Analysis of create/update/query/terminate MSCS Reservation Op with TAPI NFVSOL(20)000167r1 - SOL017 Analysis of MSCS Management interface Notify Operation with TAPI NFVSOL(20)000168r1 - SOL017 Analysis of MSCS Management interface Subscribe related operation with TAPI NFVSOL(20)000201r2 - SOL017 - Mapping of FFM interfae operatins with TAPI NFVSOL(20)000202r2 - SOL017 - Analysis of FM interfae Subscribe operation with TAPI NFVSOL(20)000203r2 - SOL017 - Analysis of FM interface Query Subscription operation with TAPI NFVSOL(20)000204r1 - SOL017 - Analysis of FM interface Terminate Subscription operation with TAPI NFVSOL(20)000205 - SOL017 - Analysis of FM interface Notify operation with TAPI NFVSOL(20)000206r2 - SOL017 - Analysis of FM interface Get Alarm List and Acknowledge Alarm Ops with TAPI

Date	Version	Information about changes
18.05.2020	0.4.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000297r2 - SOL017 PM Interface Create PM Job Operation mapping to TAPI 2. NFVSOL(20)000298 - SOL017 PM Interface Delete PM Jobs Operation mapping to TAPI 3. NFVSOL(20)000299r2 - SOL017 PM Interface Query PM Jobs Operation mapping to TAPI 4. NFVSOL(20)000300 - SOL017 PM Interface Create Threshold Operation mapping to TAPI 5. NFVSOL(20)000301r1 - SOL017 PM Interface Delete Threshold Operation mapping to TAPI 6. NFVSOL(20)000303r3 - SOL017 PM Interface Query Threshold Operation mapping to TAPI 7. NFVSOL(20)000321r3 - SOL017 Analysis of Performance Management interface Subscribe related operations with TAPI 8. NFVSOL(20)000325r1 - SOL017 - Analysis of Performance Management interface Notify operation with TAPI 9. NFVSOL(20)000404r1 - SOL017 Capacity mgmt intf Create/Delete/Query Capacity Threshold operations mapping to TAPI 10. NFVSOL(20)000405r1 - SOL017 Capacity mgmt intf Query Topology Information operation mapping to TAPI 11. NFVSOL(20)000406r1 - SOL017 Capacity mgmt intf Query Capacity operation mapping to TAPI
09.06.2020	0.5.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000478 - SOL017 Capacity Management Query Topology Information output operation mapping to TAPI 2. NFVSOL(20)000518r2 - SOL017 Capacity Management Query Node Information operation mapping to TAPI 3. NFVSOL(20)000519 - SOL017 Capacity Management Query Link Information operation mapping to TAPI
17.07.2020	0.6.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000464r7 - SOL017 clause 5.2.3.x profiling Information elements in MSCS management with IETF L3NM 2. NFVSOL(20)000621r1 - SOL017 - Overview Analysis of Capacity Management interface operations 3. NFVSOL(20)000622r1 - SOL017 - Overview Analysis of Performance Management interface operations 4. NFVSOL(20)000565 - SOL017 Capacity Management Query Network Edge Point Information operation mapping to TAPI 5. NFVSOL(20)000572 - SOL017 Analysis of Capacity Management interface Subscribe related operations with TAPI 6. NFVSOL(20)000589r1 - SOL017 - Analysis of Capacity Management interface Notify operation with TAPI 7. NFVSOL(20)000161r3 - SOL017 Modifications to clause 4.3.2 8. NFVSOL(20)000501r5 - SOL017 clause 5.2.3.Y profiling operations in MSCS management with IETF L3NM 9. NFVSOL(20)000535r6 - SOL017 clause 5.2.3.x profiling Information elements in MSCS management with IETF L2NM
25.08.2020	0.7.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000629r1 - SOL017 clause 5.4.3.X profiling Fault Management interface operations with IETF YANG Data Model 2. NFVSOL(20)000632r1 - SOL017 clause 5.4.3.Y profiling information elements in Fault Management interface with IETF YANG Data Model 3. NFVSOL(20)000633r2 - SOL017 clause 5.3.3.X profiling Capacity Management interface operations with IETF YANG Data Model 4. NFVSOL(20)000634r1 - SOL017 clause 5.3.3.Y profiling information elements in Capacity Management interface with IETF YANG Data Model 5. NFVSOL(20)000654r1 - SOL017 clause 5.4.3.X minor corrections in profiling FM operations with IETF - change on top of 629 6. NFVSOL(20)000655 - SOL017 clause A.3.1 Examples with IETF TE Topology YANG model 7. NFVSOL(20)000656r1 - SOL017 filling gaps in profiling tables with IETF L2NM

Date	Version	Information about changes
20.09.2020	0.8.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000657r1 - SOL017 clause 5.3.3.Z profiling Capacity measurements referred in Capacity Management interface with IETF 2. NFVSOL(20)000658r2 - SOL017 clause 5.5.3.X profiling Performance measurements referred in Performance Management interface with IETF. 3. NFVSOL(20)000666r2 - SOL017 clause 5.5.3.Y profiling Performance Management interface operations with IETF YANG Data Model 4. NFVSOL(20)000668 - SOL017 Updating IETF references with published RFC and other latest updates 5. NFVSOL(20)000669 - SOL017 Resolve editor's note on Filter support and others related to IETF. 6. NFVSOL(20)000670r1 - SOL017 - Overview Analysis of Capacity Management interface operations - Notify 7. NFVSOL(20)000671r1 - SOL017 - Overview Analysis of Performance Management interface Notify operation 8. NFVSOL(20)000672r1 - SOL017 - Analysis of FM interface Get Alarm List output IE with TAPI 9. NFVSOL(20)000677 - SOL017 - Analysis of Fault Management interface Notify operation with TAPI 10. NFVSOL(20)000683 - SOL017 - Analysis of MSCS Management interface Notify operation IEs with TAPI
12.10.2020	0.9.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000724r1 - SOL017 clause 5.2.3.2.X profiling of subscribe and notify related operations 2. NFVSOL(20)000725r2 - SOL017 clause 5.3.3.1.X Document consistency: new subclauses for operations
09.11.202	0.10.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000742r1 - SOL017 - Modification to clause 6 structure 2. NFVSOL(20)000746 - SOL017 clause 6.2 Evaluation and comparison 3. NFVSOL(20)000750r2 - SOL017 - Resolving editor's notes and listing IFA032 maintenance items 4. NFVSOL(20)000754r1 - SOL017 clause 6.3.1 Analysis for IFA032 maintenance
19.12.2020	0.11.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(20)000770r1 - SOL017 Recommendation for stage 3 clause 6.3.2.1 General 2. NFVSOL(20)000771r1 - SOL017 clause 6.3.2.3 IETF specific recommendation 3. NFVSOL(20)000773r4 - SOL017 - Stage 3 Recommendation ONF TAPI 4. NFVSOL(20)000796 - SOL017 clause 7 Conclusion
01.03.2021	0.12.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(21)000016r1 - SOL017 - Resolving editor's notes covering IETF ACTN-part1 2. NFVSOL(21)000017r1 - SOL017 - Resolving editor's notes covering IETF ACTN-part2 3. NFVSOL(21)000023 - SOL017 - Resolving editor's notes covering IETF ACTN-part3 4. NFVSOL(21)000024 - SOL017 - Convert detailed outputs in IETF ACTN examples to text files 5. NFVSOL(21)000027 - SOL017 Clauses 5.1, 5.2.1, 5.3.1, 5.4.1, 5.5.1, 6.1 Adding content 6. NFVSOL(21)000033r1 - SOL017 - Review clause 5.2.2 7. NFVSOL(21)000035r1 - SOL017- Resolving EN in clause 4.3.3 8. NFVSOL(21)000037 - SOL017- Review clause 5.3.2 9. NFVSOL(21)000038 - SOL017- Review clause 5.4.2 10. NFVSOL(21)000078 - SOL017 - TAPI Architecture Figure 11. NFVSOL(21)000079 - SOL017 - Editing Annexes 12. NFVSOL(21)000083r1 - SOL017 - Review clause 5.5.2 13. NFVSOL(21)000085r1 - SOL017 - Clause 3 Terms Symbols Abbreviations 14. NFVSOL(21)000133 - SOL017 clause 6.3 Removing EN related to existing content 15. NFVSOL(21)000134 - SOL017 - Intro text for clause 4.3 and 4.3.1. 16. NFVSOL(21)000136 - SOL017 - Editorial fixes of references.
15.03.2021	0.13.0	Implements <ol style="list-style-type: none"> 1. NFVSOL(21)000163r1 - SOL017 - Review edits

History

Document history		
V3.3.1	May 2021	Publication