



TELECOM INFRA PROJECT

MUST Optical SDN Controller NBI Technical Requirements Document

TIP OOPT PG - Version: 1.1



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Change Tracking

Date	Revision	Author(s)	Comment
21/01/2021	V1.0	All	Consolidated version 1
27/10/2021	V1.1	All	<p>Changed reference to ONF TAPI TR-547 v1.1 Additional requirement to support TAPI Streaming based on ONF TAPI TR-548. Addition of new use cases:</p> <ul style="list-style-type: none"> ▪ Use case 0d: Multi-domain OTN interdomain links discovery (Plug-id based on OTN TTI). ▪ Use case 1b: Unconstrained DSR Service Provisioning multi wavelength. ▪ Use case 1c: Unconstrained ODU Service Provisioning ▪ Use case 1d: Unconstrained PHOTONIC_MEDIA/OTSi Service Provisioning ▪ Use case 1f: Unconstrained PHOTONIC_MEDIA/MC Service Provisioning ▪ Use case 2a: Unconstrained service provisioning with OCh/OTSi (channel selection). ▪ Use case 2c: Unconstrained PHOTONIC_LAYER_QUALIFIER_MC / MCA service provisioning with spectrum selection ▪ Use case 4a: Introduction of references to external inventory model. ▪ Use case 6a: Dynamic restoration policy for unconstrained and constrained connectivity services. ▪ Use case 7a: Dynamic restoration and 1+1 protection of DSR/ODU unconstrained service provisioning. ▪ Use case 13b: Subscription to Notification Service for Alarm Events. ▪ Use case 13c: Subscription to Notification



			<p>Service for Threshold Crossing Alert (TCA).</p> <ul style="list-style-type: none">▪ Use case 16a: Notification of Alarm type events▪ Use case 16b: Threshold Crossing Alert (TCA) Notifications
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Introduction

The purpose of this document is to describe a set of guidelines and recommendations for a standard use of the SDN Northbound interface of the Optical SDN domain controller for the implementation of the interface between network systems in charge of the control/management of networks based on WDM/OTN technologies ...



1. Introduction

The purpose of this document is to describe a set of guidelines and recommendations for a standard use of the SDN Northbound interface of the Optical SDN domain controller for the implementation of the interface between network systems in charge of the control/management of networks based on WDM/OTN technologies.

This document aims to define the base requirements for any SDN Domain controller entity (e.g., a SDN-C) which is intended to expose the management/control capabilities of any use case such as activation/configuration, service provisioning, path-computation, fault management and monitoring over a WDM/OTN network, through the interface defined in this document.

The term management/control shall express that the scope is much wider than just configuring. The proposed common interface shall account for:

- Configuration, e.g., for automating and optimizing the network services creation and processes.
- Status, e.g., for automated configuration depending on current network status.
- Events (Alarms), e.g., for automated initiation of countermeasures.
- Current and Historical Performance Values, e.g., for perpetual network analysis.

This specification is supported by standards, protocol specifications, IETF RFCs, ITU-T recommendations and the ONF Transport API (TAPI) documentation. The appropriate references to this supplementary material are included where appropriate along the document to support the statements which conform this specification. However, this document does not intend to re-define the use cases, protocols and information models the specification consist of, but to clarify, identify missing features and trigger extensions within the appropriate SDOs in those cases where a corner case or different interpretations have been found along the mentioned standards.



1.1 Target SDN Architecture for Optical domain

Based on the current state of the art technology, the preferred target Open Transport SDN architecture within a single operator network is based on a hierarchical controller and several technology-specific SDN controllers (see **Figure 1** for the high level reference architecture). This three-tier model is aligned with the industry's main architectures, such as ONF SDN Architecture for Transport Networks [TR-522], IETF ACTN architecture [RFC8453] and IETF framework for service automation [Wu20].

Transport WDM networks from different systems vendors are deployed on a regional basis, either as a result of the legacy deployments, for technology redundancy, due to different optical performance requirements (metro vs. long-haul), or simply for commercial reasons.

In the short term, Optical SDN domain controllers are expected to provide network programmability and interoperability towards upper layers (multi-layer) and between vendors (multi-domain, multi-vendor) through the support of standard NBIs (i.e., coordination will be provided by upper layer hierarchical SDN controller).

In the Optical transport segment, a network domain is conceived as a WDM network segment controlled by a single Optical SDN Domain Controller. Each of these domains consists of an Open Optical Line System (O-OLS) (typically provided by the same supplier as the Optical SDN Domain Controller), the transponders provided by the same supplier and/or third-party Open Optical Terminals (O-OTs) transmitting "alien wavelength" over the same O-OLS. Then, there might be multiple domains in a single operator network, each exposing the management and control capabilities through a single Optical SDN Domain Controller through the standard and uniform Northbound Interface (NBI) defined in this Technical Requirement Document (TRD). For further clarity of the TIP MUST target architecture for Disaggregated Open Optical Networks, please check [MUST_OON_WHITEPAPER].

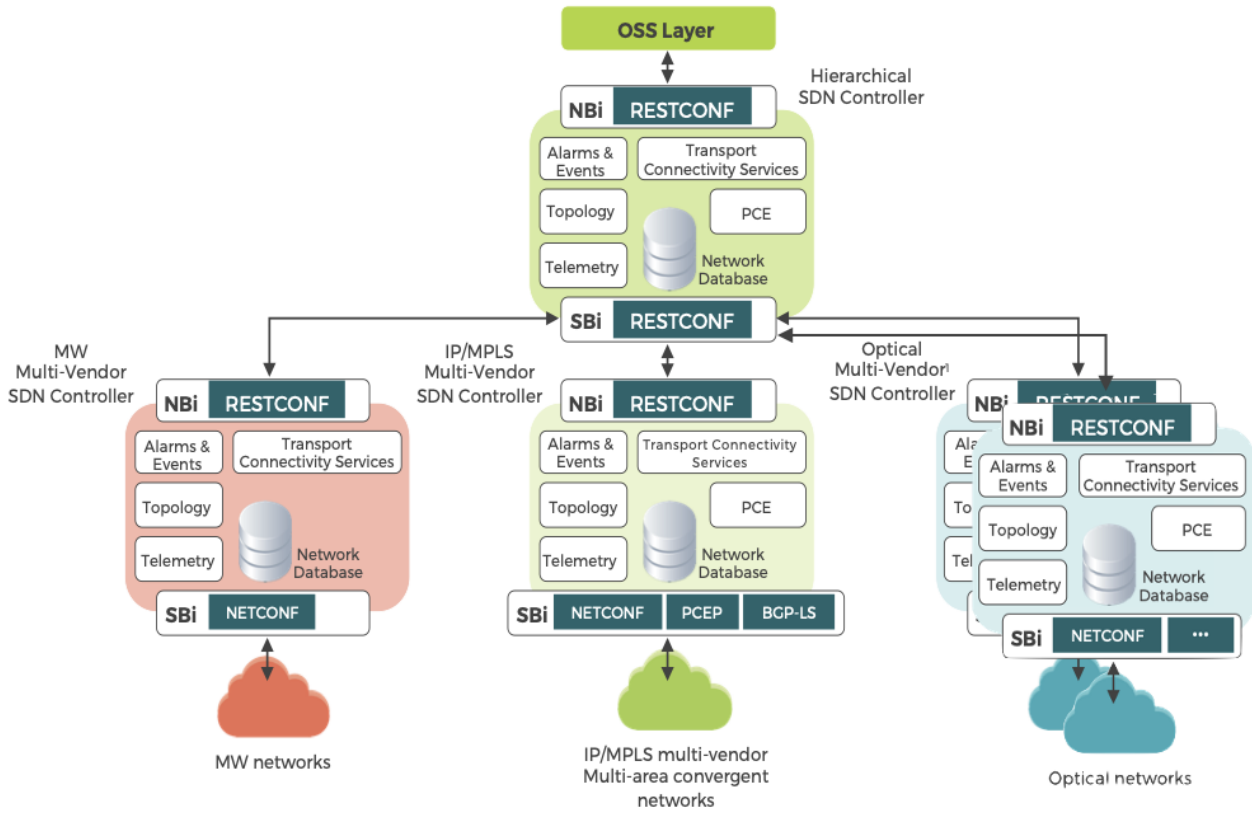


Figure 1: Open Transport SDN Target Architecture¹

¹ The architecture depicted in this TRD, includes the presence of multiple SDN Domain controllers within the optical network segment. Each SDN Domain controllers will expose the standard NBIs which may be consumed by a Hierarchical SDN Controller for end-to-end management of multiple domains.

2

NorthBound Interface (NBI)

SDN domain controllers will provide an interface for all management and control functions to be consumed by Hierarchical Controller or other Operation Support Systems (OSS) and they will expose notifications subscription for reporting about network configuration changes, performance indicators and alarms ...



2. Northbound Interface (NBI)

SDN domain controllers will provide an interface for all management and control functions to be consumed by Hierarchical Controller or other Operation Support Systems (OSS) and they will expose notifications subscription for reporting about network configuration changes, performance indicators and alarms. This Northbound Interface (NBI) of the domain controllers must be implemented following the RESTCONF standard [RFC 8040] for all specified data models considered in TIP OOPT MUST program.

Due to its maturity and availability within the industry, the ONF Transport API [T-API] is the information model considered by most of the vendors as the NBI of the optical domain controller.

The T-API models include a set of technology specification models which are intended to "augment" the previously described service models by including technology specific information from each transport layer. The transport layers covered by the T-API are:

- DSR/Ethernet
- OTN/ODU
- Photonic Media

However, for the sake of simplicity of the implementation of the target SDN architecture, we encourage that ONF Transport API and IETF ACTN [RFC8453] converge in the future in order to facilitate the interaction between technology layers. The Open Transport Group will foster initiatives towards this convergence.

This deliverable introduces a first set of use cases which are already standardized and publicly available through the [ONF TR-547] which is defining a TAPI v2.1.3 Reference Implementation Agreement for a set of use cases.

2.1 RESTCONF

RESTCONF [RFC 8040] is proposed as the transport protocol for all the defined management operations in the SDN architecture NBIs.

RESTCONF is a HTTP-based protocol that provides a programmatic interface for accessing data defined in YANG 1.0 [RFC 6020] (adoption of YANG 1.1 [RFC7950] will be driven by the adoption of new YANG models implemented in the new version, in future MUST deliverables) using the data store concepts defined in the Network Configuration Protocol (NETCONF) [RFC 6241].

The RESTCONF specification consists of the following resources:

- **{+restconf}/data (Data API):** Create/Retrieve/Update/Delete (CRUD) based API for the entire data tree defined in the TAPI information model YANG files (see section 2.2 **Error! Reference source not found.**).
- **{+restconf}/operations (Operations API):** RPC based API consisting of a small set of operations defined as RPCs in the TAPI information model YANG files.
- **{+restconf}/data/ietf-restconf-monitoring:restconf-state/streams (Notifications API):** Notifications implementation of RESTCONF protocol is defined in [Section 6.3 of \[RFC 8040\]](#)
- **{+restconf}/yang-library-version:** This mandatory leaf identifies the revision date of the "ietf-yang-library" YANG module that is implemented by this server.
- **{+restconf}/data/ietf-restconf-monitoring:restconf-state/capabilities:** leaf to report the server capability of supporting query parameters defined in [Section 9.1 of \[RFC 8040\]](#)

The Network Management Datastore Architecture (NMDA) defined in [RFC8342] is the target implementation for RESTCONF NBIs of the MUST group in all the technology domains (IP, MW, Optical transport). However, as the first deliverable is adopting the reference implementation agreement for TAPI, defined in [TR-547], its inclusion (NMDA) for the defined use cases of the Optical SDN Domain controller in this deliverable will be considered in future releases.

2.1.1 Root tree discovery

The RESTCONF API **{+restconf}** root resource can be discovered by getting the `"/.well-known/host-meta"` resource ([RFC 6415]) and using the `<Link>` element containing the `"restconf"` attribute.

The client will send the following query:

```
GET /.well-known/host-meta HTTP/1.1
Host: example.com
Accept: application/xrd+xml
```

The server might respond as follows:

```
HTTP/1.1 200 OK
Content-Type: application/xrd+xml
Content-Length: nnn

<XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'>
  <Link rel='restconf' href='/restconf'/>
</XRD>
```

2.1.2 YANG model's discovery

RESTCONF utilizes the YANG library [RFC 7895] and [RFC 8525] to allow a client to discover the YANG module conformance information for the server, in case the client wants to use it.

The mandatory `{+restconf}/yang-library-version` resource is used to clearly identify the version of the YANG library used by the server.

The server MUST implement the `"ietf-yang-library"` module, which MUST identify all the YANG modules used by the server, within the `"modules-state/module"` and `"yang-library/module-set/module"` list resource. The modules set resource is located at (both implementations are accepted so far):

- **According to [RFC 7895]: `{+restconf}/data/ietf-yang-library:modules-state`**
- **According to [RFC 8525]: `{+restconf}/data/ietf-yang-library:yang-library`**

2.1.3 Query filtering

According to RESTCONF specification, each operation allows zero or more query parameters to be present in the request URI. Specifically, query operations' parameters are described in [Section 4.8 of \[RFC 8040\]](#). Thus, the following query parameters MUST be supported by any interface compliant with this specification:

Name	Methods	Description
Content	GET, HEAD	Select config and or non-config data resources
Depth	GET, HEAD	Request limited subtree depth in the reply content
Fields	GET, HEAD	Request subset of the target resource contents
Filter	GET, HEAD	Boolean notification filter for event stream resources
With-Defaults	GET, HEAD	Control the retrieval of default values
Start-Time	GET, HEAD	Replay buffer start time for event stream resources
Stop-Time	GET, HEAD	Replay buffer stop time for event stream resources

Table 1: RESTCONF Query filters

The specific use of these query parameters will be detailed in the different Use Cases Low Level Design (LLDs) included in Section 3.

The "depth", "fields", "filter", "replay" (which applies to "start-time" and "stop-time" query parameters) and "with-defaults" query parameter URIs SHALL be listed in the "capability" leaf-list as part of the container definition in the "ietf-restconf-monitoring" module, defined in [Section 9.3 of \[RFC 8040\]](#), to advertise the server capability of

supporting these query parameters. This resource shall be located at:

- **{+restconf}/data/ietf-restconf-monitoring:restconf-state/capabilities**

2.1.4 Data encoding

JSON encoding formats MUST be supported according to [Section 3.2 of \[RFC 8040\]](#).

The solution adhering to this specification MUST support media type "application/yang-data+json" as defined in [\[RFC 7951\]](#). This MUST be advertised in the HTTP Header fields "Accept" or "Content-Type" of the corresponding HTTP Request/Response messages.

2.1.4.1 Namespaces

According to [Section 1.1.5 of \[RFC 8040\]](#), "The JSON representation is defined in "JSON Encoding of Data Modeled with YANG" [\[RFC7951\]](#) and supported with the "application/yang-data+json" media type". Thus, any implementation according to this specification MUST be compliant with the rules and definitions included in [\[RFC 7951\]](#), specifically those related to namespaces qualification included in [Section 4 of \[RFC 7951\]](#).

Example:

```
GET /restconf/data/tapi-common:context HTTP/1.1
Host: example.com
Accept: application/yang-data+json

{
  "tapi-common:context": { # Root tree object is qualified by the module name.
    "tapi-connectivity:connectivity-context": { # Any augmentation introduces a
      new qualification of the module name where the augmentation was defined.
      "connectivity-service": [
        {
          "uuid": "0b530f9f-0fc3-4d27-b6c3-5c821214db1f"
        }
      ]
    }
  }
}
```

```
    ]  
  }  
}
```

2.1.5 Notifications

The solution for the use cases included in this deliverable, must support all YANG-defined event notifications included in the information models included in Section 0 of this document.

The solution implementing the RESTCONF server must expose its supported notification streams by populating the "restconf-state/streams" container definition in the "ietf-restconf-monitoring" module defined in [Section 9.3 of \[RFC 8040\]](#). The streams resource can be found at:

- **`{+restconf}/data/ietf-restconf-monitoring:restconf-state/streams`**

The RESTCONF server MUST support, at least, the NETCONF event stream with JSON encoding format, as defined in [Section 3.2.3 of \[RFC5277\]](#) and [Section 6.2 of \[RFC 8040\]](#).

The RESTCONF server MUST support the RESTCONF Notifications subscription mechanism is defined in [Section 6.3 of \[RFC 8040\]](#).

The solution must support the "filter" Query Parameter, as defined in [Section 4.8.4 of \[RFC 8040\]](#), to indicate the target subset of the possible events being advertised by the RESTCONF server stream.

2.1.5.1 Server Sent Events – SSE





The RESTCONF standard defines the Server Sent Events (SSE) [W3C.REC] as the standard protocol for RESTCONF stream notification service. The MUST specification for RESTCONF NBI notification support is restricted only to SSE.

2.2 TAPI Data model

The ONF Transport API (TAPI) project is constantly evolving and new releases of the information models are periodically updated. All TAPI release notes can be found at: <https://github.com/OpenNetworkingFoundation/TAPI/releases>

Current proposed use cases implementation is based on TAPI v2.1.3 release defined in TAPI Reference Implementation Agreement [ONF TR-547] version 1.1.

The TAPI abstracts a common set of control plane functions such as Network Topology, Connectivity Requests, Path Computation, OAM and Network Virtualization to a set of Service interfaces. It also includes support for the following technology-specific interface profiles for Optical Transport Network (OTN) framework (L1-ODU) and Photonic Media (L0-WDM). L2 Carrier Ethernet use cases, which are complemented by [MEF Presto] models, is under evaluation and it will be included in future MUST deliverables.

The entire list of YANG models composing the TAPI information model relevant for the use cases included in the current MUST deliverable can be found in.

Model	Version	Revision (dd/mm/yyyy)
tapi-common.yang	2.1.3	23/04/2020
tapi-connectivity.yang	2.1.3	16/06/2020
tapi-equipment.yang	2.1.3	23/04/2020
tapi-eth.yang	2.1.3	23/04/2020
tapi-dsr.yang	2.1.3	23/04/2020
tapi-notification.yang	2.1.3	16/06/2020
tapi-odu.yang	2.1.3	23/04/2020
tapi-photonic-media.yang	2.1.3	16/06/2020
tapi-topology.yang	2.1.3	23/04/2020

Table 2. TAPI YANG models summary needed for MUST Optical Controller NBI

Further details about TAPI models and its usage are included in the [ONF TR-547] Section 3.

2.2.1 Topology modelling guidelines

The [ONF TR-547] specifies a concrete optical multi-layer topology arrangement for the implementation of all the use cases. Please note these topology modelling requirements are part of the definition of the use cases, thus it is a mandatory statement to support and be compliant with the guidelines included in [ONF TR-547] Section 4.

2.2.2 Connectivity modelling guidelines

The [ONF TR-547] specifies a concrete optical multi-layer connectivity model arrangement for the implementation of all the use cases. Please note these connectivity modelling requirements are part of the definition of the use cases, thus it is a mandatory statement to support and be compliant with the guidelines included in [ONF TR-547] Section 5.

2.2.3 Notifications modelling guidelines

The current TAPI information model (v2.1.3) includes a specific model, the [tapi-notification@2018-06-16.yang](#), which defines the TAPI notifications format but also a custom TAPI notification subscription procedure to enable a TAPI clients to subscribe to receive these notifications in the form of asynchronous events.

This TAPI Notification mechanism MUST be compatible with the standard RESTCONF notification subscription mechanism already described in the present document (Section 0).

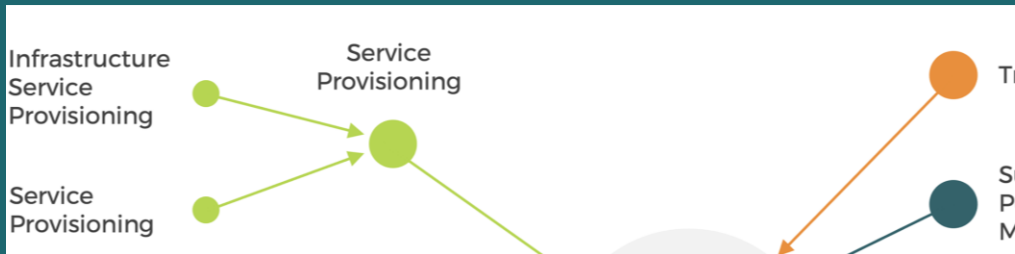
2.2.4 TAPI Streaming modelling guidelines

The TAPI Streaming model based on [ONF TR-548] is required as part of MUST Optical

3

Use cases

The use cases categories defined in MUST are depicted in





3. Use cases

The use cases categories defined in MUST are depicted in

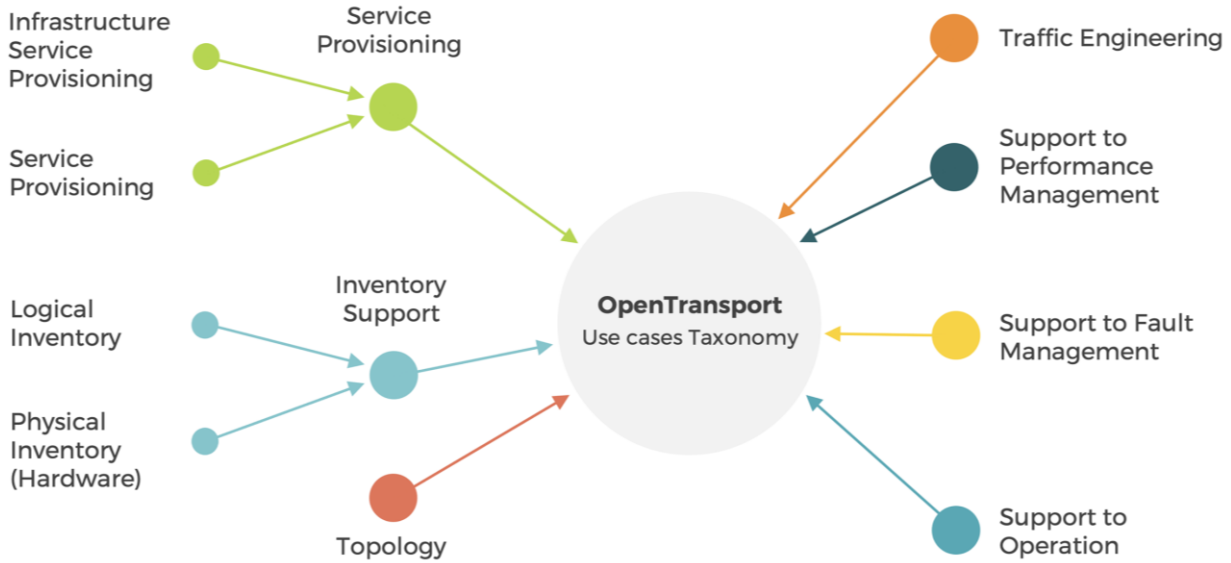


Figure 2 below. Please note the use cases numbering in the optical domain is following the TR-547 numbering.

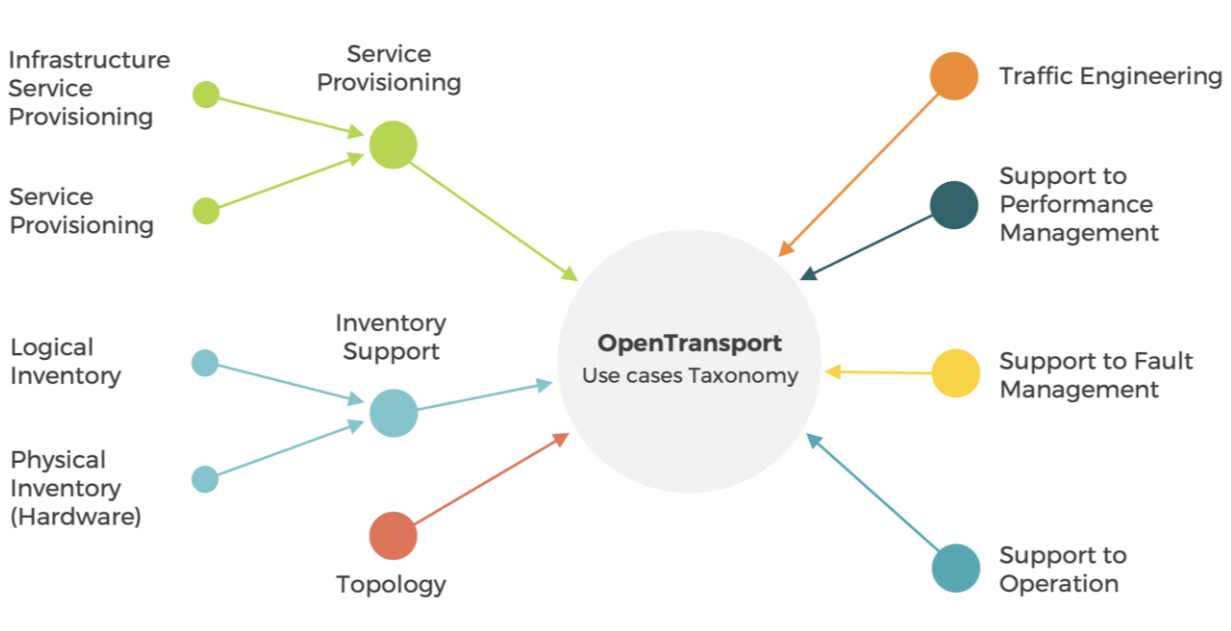




Figure 2: Uses Cases Categories

Within MUST, all member operators have agreed on a first prioritization about the different use cases already defined and available through [ONF TR-547]. The result is the selected use cases included in the following tables:

Discovery use cases:	Section TR-547 v1.1
Use case 0a: Context & Service Interface Points discovery (synchronous mode)	6.1.1
Use case 0b: Topology discovery (synchronous mode)	6.1.2
Use case 0c: Connectivity Service discovery (synchronous mode)	6.1.3
Use case 0d: Multi-domain OTN interdomain links discovery (Plug-id based on OTN TTI).	6.1.4

Table 3: Topology discovery use cases

Provisioning use cases:	Section TR-547 v1.1
Use case 1.0: Generic Unconstrained Service Provisioning	6.2.1
Use case 1a: Unconstrained DSR Service Provisioning single wavelength.	6.2.2
Use case 1b: Unconstrained DSR Service Provisioning multi wavelength.	6.2.3
Use case 1c: Unconstrained ODU Service Provisioning	6.2.4
Use case 1d: Unconstrained PHOTONIC_MEDIA/OTSi Service Provisioning	6.2.5

Use case 1f: Unconstrained PHOTONIC_MEDIA/MC Service Provisioning	6.2.7
Use case 2a: Unconstrained service provisioning with OCh/OTSi (channel selection).	6.2.10
Use case 2c: Unconstrained PHOTONIC_LAYER_QUALIFER_MC / MCA service provisioning with spectrum selection	6.2.11
Use case 3a: Constrained Provisioning - Include/exclude a node or group of nodes.	6.3.1
Use case 3b: Constrained Provisioning -Include/exclude a link or group of links.	6.3.2
Use case 3c: Constrained Provisioning - Include/exclude the path used by other service.	6.3.3

Table 4: Provisioning use cases

Inventory use cases:	Section TR-547 v.1.1
Use case 4b: Complete Inventory model for NBI Interface	6.4.2

Table 5: Inventory use cases

Resiliency use cases:	Section TR-547 v1.1
Use case 5a: 1+1 OLP OTS/OMS Protection	6.5.1
Use case 5b: 1+1 OLP Line Protection with Diverse Service Provisioning	6.5.2
Use case 5c: 1+1 Protection with Diverse Service Provisioning (eSNCP)	6.5.3
Use case 6a: Dynamic restoration policy for unconstrained and constrained connectivity services.	6.5.5

Use case 7a: Dynamic restoration and 1+1 protection of DSR/ODU unconstrained service provisioning.	6.5.7
--	-------

Table 6: Resiliency use cases

Service Maintenance use cases:	Section TR-547 v1.1
Use case 10: Service deletion (applicable to all previous use cases)	6.6.1

Table 7: Service Maintenance use cases

Alarms and notifications use cases:	Section TR-547 v1.1
Use case 13a: Subscription to notification service.	6.8.1
Use case 13b: Subscription to Notification Service for Alarm Events.	6.8.2
Use case 13c: Subscription to Notification Service for Threshold Crossing Alert (TCA).	6.8.3
Use case 14a: Notification of new topology element (topology, link, node, node-edge-point) inserted/removed in/from the network	6.8.4
Use case 14b: Notification of new connectivity-service element inserted/removed in/from the network.	6.8.5
Use case 15a: Notification of status change on existing topology element (topology, link, node, node-edge-point) in the network.	6.8.7
Use case 15b: Notification of status change on existing connectivity-service element in the network.	6.8.8
Use case 15c: Notification of status change on the switching conditions of an existing connection element in the network.	6.8.9

Use case 16a: Notification of Alarm type events	6.8.10
Use case 16b: Threshold Crossing Alert (TCA) Notifications	6.8.11

Table 8: Alarms and notifications use cases

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Glossary

API	Application Programming Interface	NMDA	Network Management Datastore Architecture
DCI	Data Center Interconnection	NOS	Network Operating System
CAPEX	Capital Expenditure	OCP	Open Compute Project
DCN	Data Communication Network	OLS	Open Line System
DWDM	Dense Wavelength Division Multiplexing	ONIE	Open Network Install Environment
EOE	Electrical-Optical-Electrical	OTN	Optical Transport Network
FEC	Forward Error Correction	ROADM	Reconfigurable Optical Add-Drop Multiplexer
GE	Gigabit Ethernet	SAN	Storage Area Network
HAL	Hardware Abstraction Layer	SDH	Synchronous Digital Hierarchy
HW	Hardware	SDN	Software Defined Network
L0/L1	Layer 0 and Layer 1	SW	Software
LAN	Local Area Network	TAI	Transponder Abstraction Interface
MAN	Metropolitan Area Networks	TRS	Technical Requirement Specification
NMS	Network Management System	WDM	Wavelength Division Multiplexing
MNO	Mobile Network Operator	ZTP	Zero Touch provisioning
MUST	Mandatory Use Case Requirements for SDN Transport		



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