TELECOM INFRA PROJECT

MUST Optical SDN Controller NBI Technical Requirements Document

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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	Changed reference to ONF TAPI TR-547 v1.1 Additional requirement to support TAPI Streaming based on ONF TAPI TR-548 and new use cases.
24/04/2024	V2.0	All	Updated version based on ONF [TR-547] T-APIv2.5.0[1] RIA v3.1 and [TR-548] T-APIv2.5.0[2] RIA Streaming v3.1 and new use cases
28/02/2025	V2.1	All	Minor update to include dual version support of TAPI 2.1.3 and 2.5.0

[1] or any minor posterior release T-APIv2.5.x RIA v3.x required for bug fixes
[2] or any minor posterior release T-APIv2.5.x RIA Streaming v3.x required for bug fixes

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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.

The technical requirements defined in this document are supported by standards, protocol specifications, IETF RFCs, ITU-T recommendations and the ONF[3] Transport API (TAPI) documentation. The references to this supplementary material are included where appropriate along the document. However, this document does not intend to re-define the use cases, protocols and information models the specification consists 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.

[3] https://opennetworking.org

1.1 Target SDN Architecture for Optical domain

Based on the current state of the art, 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 network and service automation [RFC8969].

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].

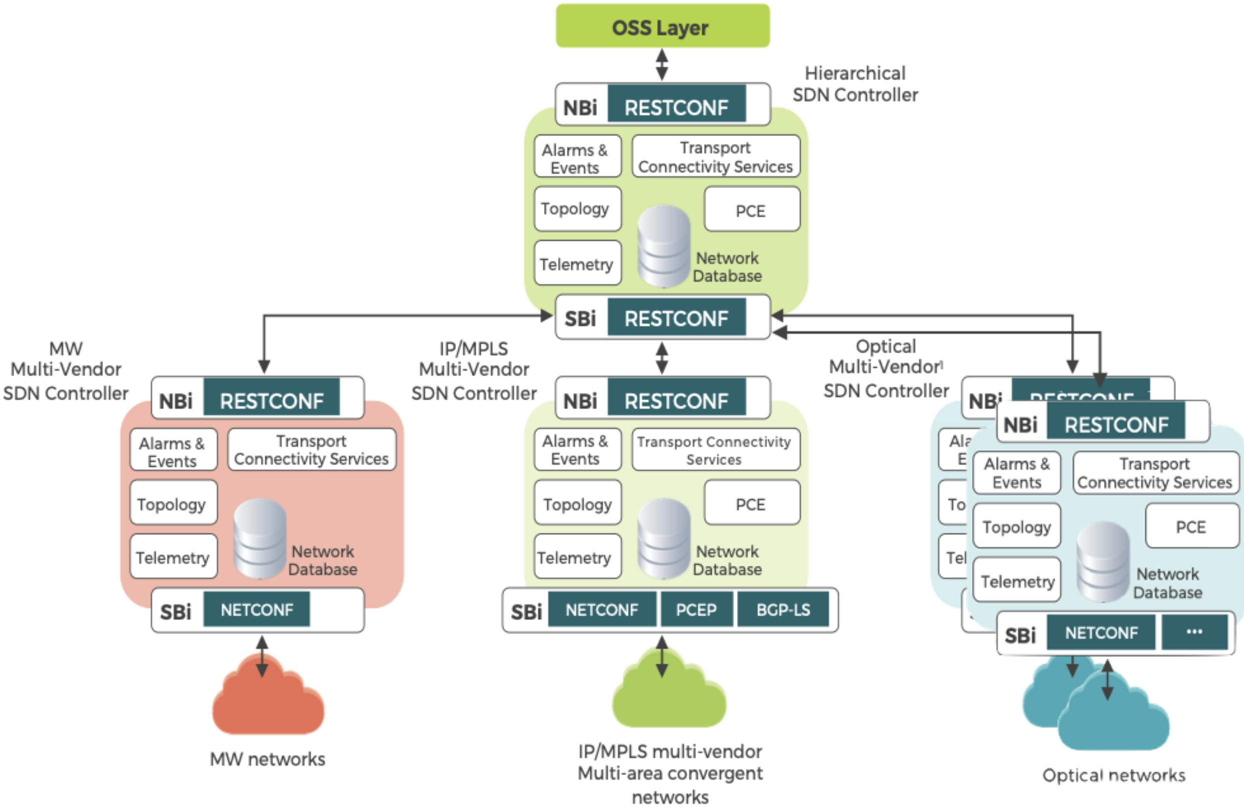

Figure 1: Open Transport SDN Target Architecture[4]

1.2 Target O-OLS partial disaggregation architectures

T-API RESTCONF based interface is needed in both recommended TIP MUST O-OLS partial disaggregation architectures.

In TIP MUST OLS partial disaggregation Solution 1 architecture, it is used for North Bound Interface of the Optical/O-OLS SDN Controller towards OSS or Hierarchical SDN controller as shown in the figure below:

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

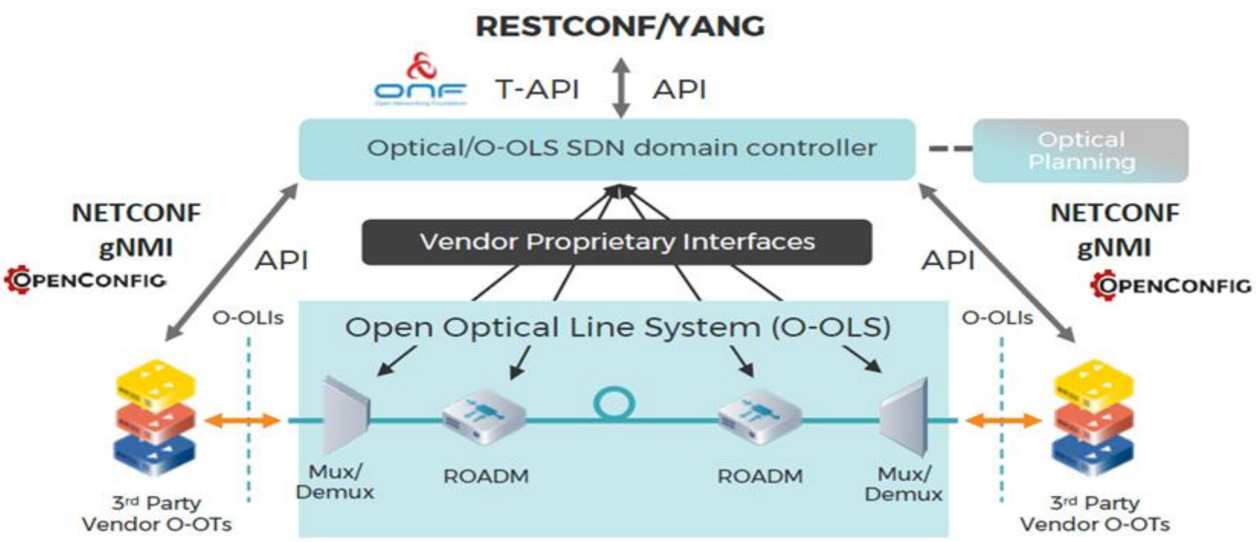

Figure 2: Combined Optical/O-OLS SDN domain controller

while in TIP MUST OLS partial disaggregation Solution 2 architecture, it is used both for South Bound Interface of the Optical SDN Controller towards O-OLS SDN Controller(s) and in North Bound Interface of the Optical SDN Controller towards OSS or Hierarchical SDN controller as shown in the figure below:

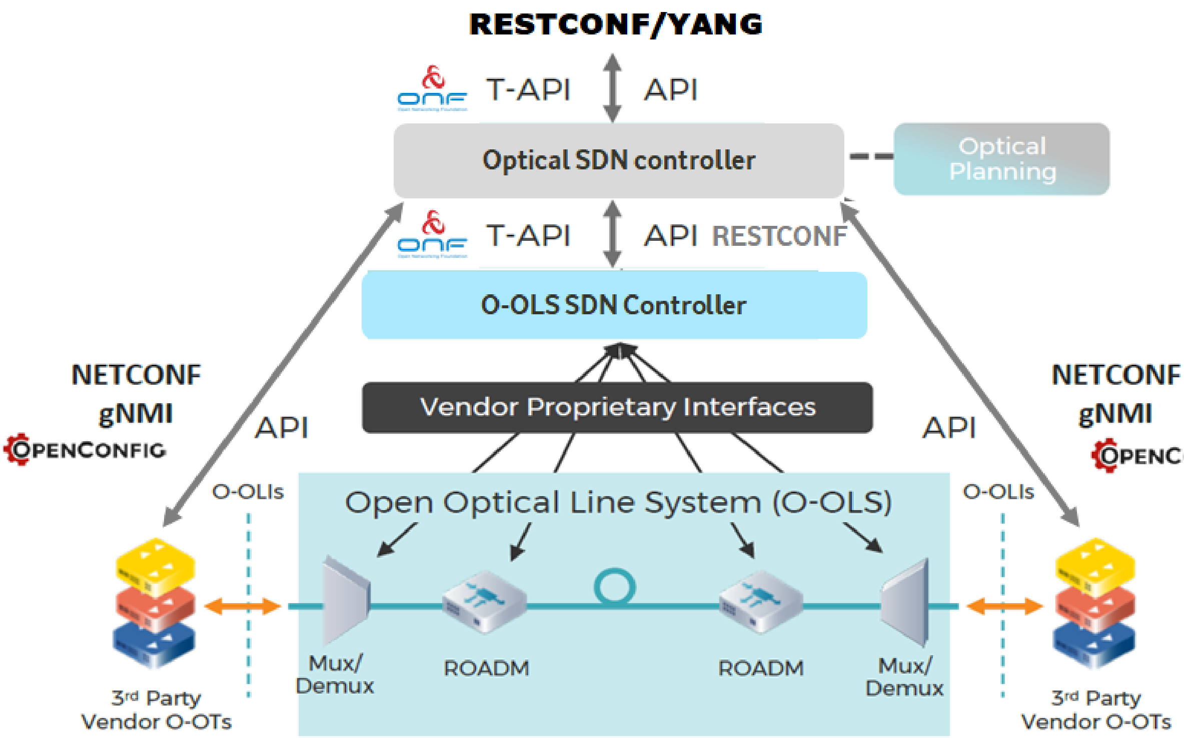

Figure 3: Split Optical SDN Controller and O-OLS SDN controller

Note: the scope of this Technical Requirement Document (TRD) is T-API North Bound Interface only. T-API South Bound Interface requirements will be covered in the future in a separate document.

1.3 Adoption of TAPI 2.5.0 and Dual Implementation Approach

The evolution of the target Northbound Interface (NBI) technical requirements in version 2.0 of this document primarily introduces the adoption of TAPI 2.5.0 as the model set for implementing the designated use cases. This transition aligns with industry advancements and ensures enhanced capabilities for Optical SDN Controllers (SDN-C).

1.3.1 Compatibility with Previous Versions

To ensure backward compatibility and facilitate a smooth transition, target implementations shall support a dual implementation approach. This approach enables the selection and activation of either TAPI v2.1.3 or TAPI v2.5.0, thereby accommodating different deployment scenarios and minimizing disruption.

1.3.2 Dual Implementation Requirement

Any product implementing an Optical SDN-C NBI 2.0-compliant interface MUST adhere to the following requirements:

Support for Two API Implementations:

- MUST provide an Optical SDN-C NBI 1.0-compliant solution based on TAPI v2.1.3 models.
- MUST provide an Optical SDN-C NBI 2.0-compliant solution based on TAPI v2.5.0 models.

General Availability and Activation Constraints:

- Both APIs MUST be commercial-grade, fully supported, and generally available within the same product software version.
- It MUST be possible to activate either of the two APIs within the product, but not simultaneously.

This dual implementation ensures flexibility in network deployments while maintaining a structured path for transitioning to newer TAPI versions.

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 or service 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[5] Transport API [ONF TR-547] 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 [RFC 8453] 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 an updated set of use cases which are already standardized and publicly available through the [ONF TR-547] which is defining a TAPI v2.5.0 Reference Implementation Agreement.

[5] While writing this document it was announced on December, 14th 2023 that the ONF market leading portfolio of open source networking projects were merging into the Linux Foundation and a new Open Network Models and Interfaces (ONMI) project was hosting ONF's network modelling and interface projects including T-API: onf-merges-market-leading-portfolio-of-networking-projects-into-linux-foundation

2.1 High-level recommendations (RESTCONF and notifications)

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

Vendors T-API implementations shall be RESTCONF compliant with the section 2 RESTCONF/YANG Protocol considerations of T-APIv2.5.0 RIA v3.1 [ONF TR-547].

From TIP MUST Optical subgroup operators's point of view, in order to simplify in the future T-API v2.5.0 Vendors' implementations interoperability, following recommendations are made:

- Server Sent Events (SSE) {W3C.REC] is defined by RESTCONF RFC8040 as the standard protocol for RESTCONF stream notifications service as should be the target implementation supported by all Vendors. However, it is recognized that some current Vendors' implementations are based instead on Websockets [RFC6455] which is considered valid by TIP MUST subgroup.

- T-API Streaming as defined in TR-548 T-API v2.5.0 RIA v3.1 is considered by TIP MUST Optical subgroup as the target implementation for all information exchange between T-API servers (Optical SDN Controller or O-OLS SDN Controller) and T-API clients (OSS /Hierarchical SDN Controller or Optical SDN Controller) for achieving scalability of T-API interface(s) for big networks and also for flow integrity and information consistency in case of recovery and re-synchronization. As mentioned in [TR-548 RIA v3.1] different streams and log strategies will apply to different types of information. The target is to use T-API v2.5.0 Streaming mechanism for all T-API notifications, PMs and alarm reporting over T-API.

    - As described in section 3.8.1.1 [ONF TR-548] COMPACTED log-storage-strategy MUST be supported for notifications, alarm reporting and TCAs enabling the client to achieve and maintain eventual consistency without the need to get current state. Recommended log-record-strategy shall be WHOLE_ENTITY to be used in association with COMPACTED log-storage strategy.

- As described in section 3.8.1.2 [ONF TR-548] TRUNCATED log-storage-strategy MUST be supported for PM reporting. Truncation will occur as a result of volume of records, age of records or some other criteria, so limiting either by log size or by content age. This log-storage-strategy does not allow the client to achieve eventual consistency without getting the current state. Recommended log-record-strategy supported shall be both WHOLE_ENTITY and CHANGE_ONLY for PM reporting.

- In the particular case of PM reporting stream the use of gNMI streaming with protobuf encoding as defined in [TR-548 RIA v3.1] is considered optional and not mandatory as it may depend on the deployment scenario in each operator. As a target gNMI must support also standard subscription mechanism so that Client systems can define which parameters they are interested in getting from the Optical SDN controller.
- As a consequence it is recommended to have T-API Streaming capability to be used to stream live measurements on a parameter-by-parameter basis in case gNMI is not used. This shall be done through the combination support of log-storage-strategy, log-record-strategy and record-trigger. As suggested by the T-API Streaming RIA, for live measurements reporting, following shall be supported:

  - COMPACTED, WHOLE_ENTITY, PERIODIC for values related to measurements which may tend to dither around a value or tend to increase (or decrease) on an ongoing basis.

  - COMPACTED, WHOLE_ENTITY, ON_CHANGE for values related to measurements which tend to change rarely.

- Current T-API Streaming implementation must soon become more flexible to enable to subscribe/filter only to specific attributes/parameters from specific objects in a given context, in particular for PM and near real-time streaming/reporting of live measurements. Target goal is to keep more scalable and flexible implementations of the T-API Streaming client systems without overloading them with unnecessary information.

- For interoperability reasons it is requested to Optical SDN controller to support both T-API notifications and T-API Streaming in South Bound towards the O-OLS SDN controllers while T-API Streaming in North Bound of Optical SDN controller shall be the only solution.

- The Network Management Datastore Architecture (NMDA) defined in [RFC8342] mentioned as the target implementation for RESTCONF NBIs of the MUST group in all the technology domains (IP, MW, Optical transport). While NMDA is mandatory for IP SDN controllers TIP MUST Optical subgroup noticed that NMDA compliance is not yet addressed even in T-APIv2.5.0 RIA v3.1. So NMDA is only considered as a valid point to be considered for future in Optical SDN controllers.

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 v2.5.0 release defined in TAPI Reference Implementation Agreement version 3.1 [ONF TR-547] or any posterior TAPIv2.5.x RIA v3.x released for bug fixes

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).

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

Model	Version	Revision (dd/mm/yyyy)
tapi-common.yang	2.5.0	10/10/2023
tapi-connectivity.yang	2.5.0	10/10/2023
tapi-equipment.yang	2.5.0	10/10/2023
tapi-fm.yang	2.5.0	10/10/2023
tapi-dsr.yang	2.5.0	10/10/2023
tapi-notification.yang	2.5.0	10/10/2023
tapi-digital-otn.yang	2.5.0	10/10/2023
tapi-oam.yang	2.5.0	10/10/2023
tapi-photonic-media.yang	2.5.0	10/10/2023
tapi-streaming.yang	2.5.0	10/10/2023 (covered by [ONF TR-548])
tapi-topology.yang	2.5.0	10/10/2023

Table 1: 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] [ONF TR-548] Section 3.

2.2.1 Network 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 service 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.

3

Use cases

The use cases categories defined in MUST are depicted in

3. Use cases

3.1 TR-547 Use cases

The use cases categories defined in MUST are depicted in figure below. Please note the use cases numbering in the optical domain is following the TR-547 numbering.

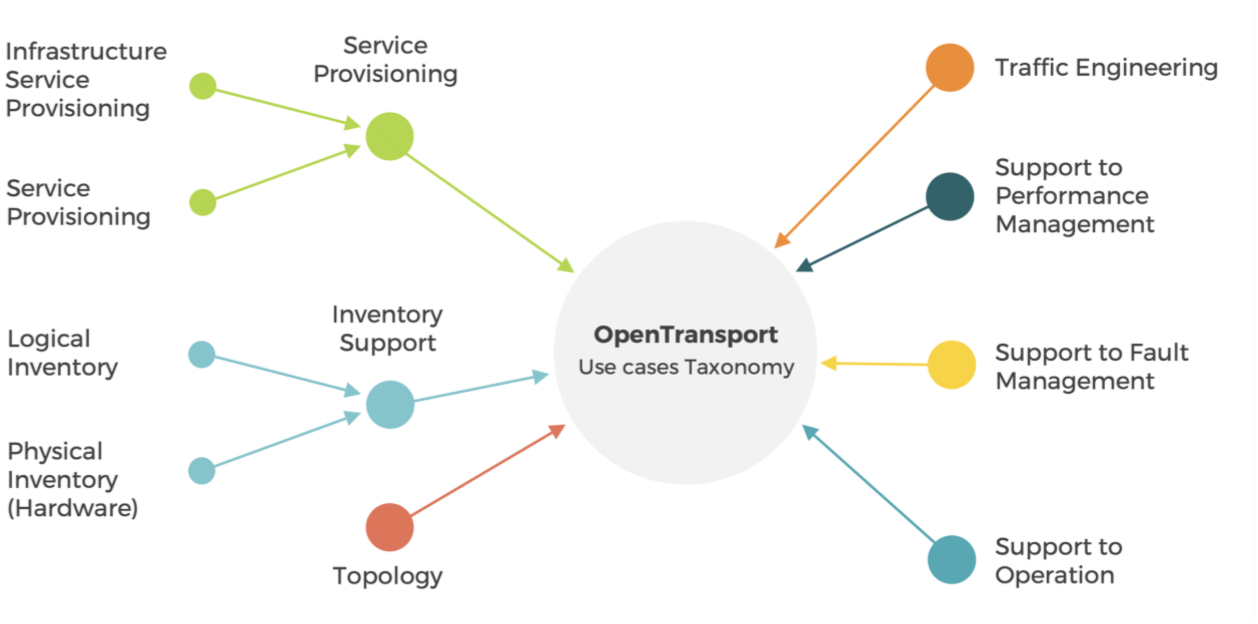

Figure Uses Cases Categories

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 set of use cases included in the following tables:

Discovery use cases:	**Section TR-547 v3.1**
Use case 0a: Context & Service Interface Points discovery	6.1.1
Use case 0b: Topology discovery	6.1.2
Use case 0c: Connectivity Service and Connection discovery	6.1.3
Use case 0c-1: Mapping Connections to Physical Route	6.1.4
Use case 0d: Multi-domain OTN interdomain links discovery (Plug-id based on OTN TTI).	6.1.5

Table 2: Topology & services discovery use cases

Provisioning use cases:	**Section TR-547 v3.1**
Use case 1.0: Generic Unconstrained Service Provisioning	6.2.3
Use case 1a: Unconstrained DSR Service Provisioning (=<100G)	6.2.4
Use case 1b: Unconstrained DSR Service Provisioning multi wavelength (beyond 100G)	6.2.5
Use case 1c: DSR over ODU Service Provisioning	6.2.6
Use case 1d: DIGITAL_OTN with PHOTONIC_MEDIA/OTSi Service Provisioning	6.2.7
Use case 1e: DIGITAL_OTN with PHOTONIC_MEDIA/OTSiA Service Provisioning	6.2.8
Use case 1f: PHOTONIC_MEDIA/Media Channel(s) (MC/MCG) Service Provisioning	6.2.10

Use case 1g: PHOTONIC_MEDIA/OTSiMC (with optional MC) Service Provisioning	6.2.11
Use case 1h: Asymmetric DSR Service Provisioning, DSR UNI to OTUk E-NNI grey interface.	6.2.12
Use case 2a: DIGITAL_OTN with PHOTONIC_MEDIA/OTSiA Service Provisioning with channel selection	6.2.13
Use case 2b: DSR service provisioning with ODU channel selection	6.2.14
Use case 2c: PHOTONIC_MEDIA/Media Channel(s) (MC/MCG) service provisioning with spectrum selection	6.2.15
Use case 3a: Include/ex1clude one or more nodes	6.2.16
Use case 3b: Include/exclude a link or group of links.	6.2.17
Use case 3c: Include/exclude the route used by another service.	6.2.18
Use case 3d: Diverse Routing in SRG failure	6.2.19
Use case 3e: Provisioning based on min hops policy	6.2.20
Use case 3f: Provisioning based on min latency policy	6.2.21

Table 3: Provisioning use cases

Inventory use cases:	**Section TR-547 v3.1**
Use case 4a: Introduction of references to external inventory model	6.3.1
Use case 4b: Complete Inventory model for NBI Interface	6.3.2

Table 4: Inventory use cases

Resiliency use cases:	**Section TR-547 v3.1**
Use case 5a: OLP OMS/OTS_MEDIA Protection Discovery	6.4.2
Use case 5b: 1+1 OLP-based Transponder to Transponder with Diverse Service Provisioning	6.4.3
Use case 5c: 1+1 protection DSR/ODU with Diverse Service Provisioning (eSNCP)	6.4.4
Use case 5d: 1+1 DSR/ODU protection with Diverse Service Provisioning (eSNCP) in Asymmetric scenarios	6.4.5
Use case 6a: Dynamic restoration policy for connectivity services.	6.4.6
Use case 6b: Pre-computed restoration policy for connectivity services	6.4.7
Use case 7a: Dynamic restoration and 1+1 protection of DSR/ODU unconstrained service provisioning	6.4.8
Use case 7b: Pre-Computed restoration policy and 1+1 protection for connectivity services	6.4.9
Use case 8: Permanent protection 1+1 for use cases	6.4.10
Use case 9: Reverted protection	6.4.11

Table 5: Resiliency use cases

Service Maintenance use cases:	**Section TR-547 v3.1**
Use case 10: Service deletion (applicable to all previous use cases)	6.5.1
Use case 11a: Modification of service path	6.5.2

Table 6: Service Maintenance use cases

Planning use cases:	Section TR-547 v3.1
Use case 12a: Path Computation	6.6.1
Use case 12d: Physical Impairment Data retrieval for OTSi path planning and validation	6.6.4

Table 2: Planning use cases

Notifications and alarms use cases:	Section TR-547 v3.1
Use case 13a: Subscription to notification service.	6.7.1
Use case 13b: Subscription to Notification Service for Alarm Events.	6.7.2
Use case 13c: Subscription to Notification Service for Threshold Crossing Alert (TCA).	6.7.3
Use case 14a: Subscription and Notification of insertion and removal of Topology Objects	6.7.4
Use case 14b: Subscription and Notification of insertion and removal of Connectivity Objects	6.7.5
Use case 14c: Subscription and Notification of insertion and removal of Path Computation Objects	6.7.6
Use case 14d: Subscription and Notification of Creation/Deletion of OAM data	6.7.7
Use case 15a: Notification of status change on existing topology objects	6.7.8
Use case 15b: Notification of status change on existing Connectivity Objects .	6.7.9

Use case 15c: Notification of status change on the switching conditions of an existing connection	6.7.10
Use case 15d: Notification of status change on OAM data	6.7.11
Use case 16a: Notification of Alarm events	6.7.12
Use case 16b: Notification of Threshold Crossing Alert (TCA) events	6.7.13

Table 3: Alarms and notifications use cases

Performance and OAM use cases:	**Section TR-547 v3.1**
Use case 17a: OAM Profile and Context discovery	6.8.3
Use case 17b: OAM Provisioning using the embedded provisioning scenario	6.8.4
Use case 17c: Configuration of an OAM profile	[Missing section number in TR-547]
Use case 17d: Provisioning of an OAM Job service	6.8.5
Use case 17e: OAM Provisioning using the independent provisioning scenario	6.8.6
Use case 17f: Retrieval of Active Conditions (Alarms and TCAs)	6.8.7

Table 9: Performance and OAM use cases

3.2 TR-548 Streaming Use cases

Streaming infrastructure use cases	**Section TR-548 v3.1**
Use case ST-0.1: Get Auth Token	7.2.1
Use case ST-0.2: Discover supported and available streams, then select available streams	7.2.2

Use case ST-0.3: Connect to Stream and align – new client	7.2.3
Use case ST-0.4: Client maintains idle connection	7.2.4
Use case ST-0.5: Provider delivers event storm (or slow client) – bad day	7.2.5
Use case ST-0.6: Provider delivers extreme event storm (or very slow client)	7.2.6
Use case ST- 0.7: Short loss of communication	7.2.7
Use case ST-0.8: Long loss of communication	7.2.8
Use case ST-0.9: Client requires realignment	7.2.9

Table 10: Streaming infrastructure use cases

Building and operating a stream on a provider	**Section TR-548 v3.1**
Use case ST- 1.1 Provider initializes and operates a stream	7.3.1
Use case ST- 1.2 Provider recovers a stream after internal loss	7.3.2

Table 11: Building and operating a stream on a provider use cases

4 References

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[RFC8453] Framework for Abstraction and Control of TE Networks (ACTN). IETF. August 2018.

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[ONF TR-548] TAPI v2.5.0 Reference Implementation Agreement, Streaming, Version 3.1, October 2023
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Server Sent Events (new link)

Glossary

ACTN	Abstraction and Control of Traffic Engineering Networks
API	Application Programming Interface
IETF	Internet Engineering Task Force
L0/L1	Layer 0 (Photonic layer) and Layer 1 (OTN layer)
LF	Linux Foundation
MC	Media Channel
MCG	Media Channel Group
MUST	Mandatory Use Case Requirements for SDN Transport
MW	Microwave
NMDA	Network Management Datastore Architecture
OAM	Operations and Maintenance
ODU	Optical Data Unit
OLP	Optical Line Protection
OLS	Open Line System
OMS	Optical Multiplex Section
ONF	Open Network Foundation
OSS	Operations Support Systems
OTN	Optical Transport Network
OTS	Optical Transmission Section
OTSi	Optical Tributary Signal

OTSiA	Optical Tributary Signal Assembly
OTSiMC	Optical Tributary Signal Media Channel
PM	Performance Monitoring
RIA	Reference Implementation Agreement
SDN	Software Defined Network
SNCP	SubNetwork Connection Protection
SRG	Shared Risk Group
TCA	Threshold Crossing Alert
T-API	Transport API
WDM	Wavelength Division Multiplexing

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