ONF releases Transport API (TAPI) v2.5.0 to take a further step forward in SDN Control and OSS integration

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# Highlights

TAPI is a RESTCONF YANG interface for application between SDN controllers, orchestrators, traditional management systems and OSS solutions (see [TAPI Overview](#_TAPI_Overview_1) and also see section 8 of [TR-547 v3.1](https://github.com/OpenNetworkingFoundation/TAPI/blob/v2.5.0/TR-547-TAPI%20Reference%20Implementation%20Agreement_v3.1.pdf) (for the definitions and abbreviations)).

[TAPI v2.5.0](https://github.com/OpenNetworkingFoundation/TAPI/releases/tag/v2.5.0) (including two Reference Implementation Agreements [TR-547 v3.](https://github.com/OpenNetworkingFoundation/TAPI/blob/v2.5.0/TR-547-TAPI%20Reference%20Implementation%20Agreement_v3.1.pdf)1 and [TR-548 v3.1](https://github.com/OpenNetworkingFoundation/TAPI/blob/v2.5.0/TR-548-TAPI_ReferenceImplementationAgreement-Streaming_v3.1.pdf)) includes some new features and enhancements with respect to TAPI v2.4.0 and 2.4.1:

* [Major improvements in OAM model](#_6._Major_enhancements)
* [Link Provisioning](#_Link_Provisioning)
* [Optional Modeling the Connectivity at Media Channel Layer](#_Modeling_the_Connectivity)
* [Change-only Streaming](#_Change-only_Streaming)
* [Efficient PM streaming using gNMI and Protobuf](#_Efficient_PM_Streaming)
* [Active Problem List](#_Active_Problem_List)
* [Transceiver Provisioning](#_Transceiver_Provisioning_1)
* [Experimental Manual Switch Commands](#_Experimental_Manual_Switch)
* [Termination Point Direction](#_Termination_Point_Direction)
* [Client – Server relationship between Connectivity Services and Connections](#_Client_–_Server)
* [Other enhancements](#_Other_enhancements)

TAPI 2.5.0 is backward compatible with TAPI 2.4.1.

The combination of the above features and existing capabilities makes TAPI the right choice for Photonic, OTN and Ethernet control integration.

Read on for [Testimonial Quotes](#_Testimonial_Quotes_2) more details on [TAPI](#_TAPI_Overview_1) in general and on the [TAPI v2.5.0 features](#_TAPI_v2.5.0_Detail).

# Join the team to further advance TAPI

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# Testimonial Quotes

**TIP MUST**

“The ONF Transport API (TAPI) release 2.4 means a significant step forward into the path of openness and disaggregation of the Optical Transport Networks promoted and pursued by the Telecom Infra Project (TIP's) MUST operator’s subgroup, including Telefónica, Vodafone, Orange, MTN, Telia Company and Colt Technologies among other partners. This new TAPI release, which has been contributed by some of the MUST active operator participants, successfully accommodates several MUST-defined use cases for optical transport such as the physical Impairment data retrieval for OTSi path planning and validation," said **Oscar González de Dios**, Technical Lead at Telefónica and **Johan Hjortås**, Head of IP, Optical & Fixed Access Network strategy and architecture at Telia Company, co-chairs of the Open Optical and Packet Transport program at Telecom Infra Project.

**OIF**

“TAPI has been of significant importance to the OIF given the need for a standardized interface between SDN applications and SDN networks.  The extension supporting optical link information is especially important given the shift away from digital switching to optical switching and the advent of disaggregated systems.  And the addition of streaming notifications assists an application with learning real-time changes to the state of the network.  The OIF has enjoyed working with ONF to validate these interfaces and their applicability to service provider networks,” said **Jonathan Sadler** (Infinera), Chair, OIF Networking Interop WG.

**CTTC**

“CTTC has participated in sixteen research projects addressing packet-optical transport networks for 5G and 6G, within the framework or the European 5GPPP and SNS work programmes. CTTC has been a long-term contributor to TAPI since its inception, based on the COP protocol defined in the FP7 STRAUSS project, and we continue to develop and test TAPI as an open and standard northbound Interface for disaggregated transport networks.  Currently, we use TAPI in several research projects such as Int5Gent, TeraFlow or B5G-OPEN,” said **Raul Muñoz**, head of the Packet Optical Networks and Services Research Unit at CTTC.

**Orange**

“Network Infrastructure automation is at stake for telco to improve our operational efficiency. In this respect, open and interoperable models such as ONF Transport API (TAPI) are cornerstones. Orange is actively contributing to the standardization efforts and initiatives. Features introduced in this new release of TAPI, including impairment awareness, are an important step to support our use cases and short-term requirements. In this regard, we will continue to work on the functional and model convergence of standards, to cover the whole optical domain,” said **M. Gilles Bourdon**, Vice President, Wireline Networks and Infrastructure at Orange

**Virgin Media O2**

“As Virgin Media O2 expands its Network Automation capabilities, understanding the network topology, connectivity, and services across a multi-vendor, multi-service network would have been significantly more complex had it not been for vendor alignment to TAPI. We are looking forward to utilising the new capabilities of TAPI v2.4.0, particularly the OAM, Alarm and PM enhancements to underpin our existing developments,” said **Martin Singer**, CEng | Senior Manager, Network OSS Architecture at Virgin Media O2.

# TAPI Overview

TAPI is a RESTCONF YANG interface appropriate for use between SDN controllers and orchestrators as shown below.

A diagram of a diagram

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TAPI provides a forwarding-technology-layer neutral model with forwarding-technology-layer specific augments supporting a multi-layer solution covering L0 (photonic), L1 (OTN) and L2 (Ethernet) networks.

TAPI includes the following key focused support:

* Topology: Node, Links etc.
* Connectivity: Connectivity Services, Connections etc.
* OAM: Jobs, Records etc.
* Path Computation: Paths, Constraints etc.
* Equipment: Devices, Physical Spans etc.
* Notification: Subscriptions, Events etc.
* Streaming: Stream definitions, compacted log of events and gNMI stream of PMs etc.
* Fault Management: Alarms structure, PM structures etc.

The above allows a TAPI client to gain and maintain alignment, via an ongoing flow of state updates, with the network controlled by the TAPI provider for all relevant network properties.

[TAPI v2.5.0](https://github.com/OpenNetworkingFoundation/TAPI/releases/tag/v2.5.0) includes two Reference Implementation Agreements that specify the application of the TAPI models for various use cases:

* [TR-547-TAPI-v2.5.0-Reference-Implementation-Agreement\_v3.1](https://github.com/OpenNetworkingFoundation/TAPI/blob/v2.5.0/TR-547-TAPI%20Reference%20Implementation%20Agreement_v3.1.pdf)
* [TR-548-TAPI-v2.5.0-ReferenceImplementationAgreement-Streaming\_v3.1](https://github.com/OpenNetworkingFoundation/TAPI/blob/v2.5.0/TR-548-TAPI_ReferenceImplementationAgreement-Streaming_v3.1.pdf)

# TAPI v2.5.0 Detail

TAPI v2.5.0 builds on previous releases enhancing existing capabilities and adding new capabilities. TAPI 2.5.0 is backward compatible with TAPI 2.4.1.

## Major improvements in OAM model

The following improvements have been made:

* Full provisioning of OAM features (NCM, TCM) in both *embedded* and *independent* modes.
  + At Connectivity Service provisioning, the OAM parameters can be specified augmenting CSEPs or directly augmenting the Connectivity Service.
  + Introduced simplified generic provisioning, like *enable all available non-intrusive monitors*
* New classes *OamJobService* and *OamJobDescriptor*, replacing the deprecated *OamJob* class, to decouple *intent* model from *state* model.
* New PM data reporting model.
  + Added new composition of *HistoryData* in *OamContext*, to decouple it from the OAM job instance.
  + *CurrentData* class is deprecated, the specification of the retrieval of current PM data is left for further study, given the implications on the whole management chain till the equipment level.
* Added some FEC PM Parameters.
* Added some Photonic Media PM Parameters.
  + New draft UC 17d.2: Photonic Media Optical Power
* PM metrics enhanced with new type *MetricValueType*, where applicable, allowing the report of average/min/max etc. measured values of a metric.

Below the skeleton of OAM model:

In the figure below the *embedded* *intent* and *state* structures for the DSR UNI to OTN ENNI Service (asymmetric NCM) scenario, monitoring functions being one MEP and two MIPs composed into CEPs.



In the figure below the *independent* *intent* and *state* structures for the OTN ENNI to OTN ENNI Service scenario, monitoring functions being two TCM MEPs (level 3) for the intra-domain monitoring and other two TCM MEPs (level 4) for the inter-domain monitoring:



## Link Provisioning

Links can now be created, configured, and deleted.

* Creation/Deletion of a point to point *Link* instance between two NEPs at the lowest layer (for photonic/L0 networks this is at the OTS\_MEDIA layer) to provide a link expectation for validation and to cover the cases where there is no link discovery opportunity.
* Configuration of SRLG, provisioning risk-characteristics on *Link* objects.
* Three new draft Use Cases added to TR-547 v3.1:
  + 18a: Modify properties of a link
  + 18b: Create link
  + 18c: Delete link

## Optional Modeling of the Connectivity at Media Channel Layer

Added a new scenario where the preliminary provisioning of the MC service, described by:

* *Use case 1f: PHOTONIC\_MEDIA/Media Channel(s) (MC/MCG) Service Provisioning*

can be skipped, i.e. no mandatory MC service provisioning before OTSiMC service, specified by

* *Use case 1g: PHOTONIC\_MEDIA/OTSiMC (with optional MC) Service Provisioning*



## Change-only Streaming

In previous releases, when a change occurred, the provider had to send the whole entity. Whilst this is a reasonable approach, it is relatively costly for larger entities that have had small changes.

In TAPI 2.4.0, enhancements were made to the stream definitions to enable delta streaming, but no description was provided as to how to use those new capabilities.

In TAPI 2.5.0, TR-548 has been enhanced to explain the approach to delta streaming. Delta streaming, which works in conjunction with the compacted log mechanism enables the provider to send a record of change that includes the key identifiers and the changed properties only. This reduces the data required to be sent whilst maintaining integrity.



## Efficient PM streaming using gNMI and Protobuf

A network may produce vast volumes of performance information. As a consequence, it is vital that the controller, monitoring the performance measures, shall provide new performance data in an efficient fashion with little delay to a client where performance data, both recent and historic, will be analyzed.

In TAPI, this involved refining the definition of the structure of the performance report, to remove unnecessary data. The parameters have been defined such that the default is the most likely case. The encoding method chosen, Protobuf, allows default values to not be sent.

Protobuf defines an enumeration approach for parameter identification where the enumeration values are transferred efficiently via a binary encoding method.

The structures have been defined to allow for various cases of uncertainty including unknown and delayed measures.

The existing TAPI streaming framework is used to discover the available streams where the details on the supported streams include an opportunity to state the use of protobuf etc.

TR-548 has been updated to

* Explain the requirements that drove the solution design
* Set out key use cases
* Detail the use of the gNMI streaming method,
* Provide the definition of the efficient Protobuf structures
* Introduce a relative naming scheme to simplify data processing in the provider system
* Work through some brief example of usages
* Show the reduction in data transfer as a result of use of Protobuf encoding

The solution is expected to be used in a context where the lower controller carries out limited cleanup on the measurement data and then streams to the client for long term storage and extensive analysis.



## Active Problem List

Introduced experimental management of the Active Problem List, i.e. the list of all Alarms and TCAs which are currently active in the managed domain.

* New class *ActiveCondition*, where all active conditions are made available (see picture below).
* New Use Case added to TR-547 v3.1:
  + 17f: Retrieval of Active Conditions (Alarms and TCAs)

A diagram of a computer

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## Transceiver Provisioning

In case an adequate *TransceiverProfile* instance is not available, it is now possible to provision all or a selection of the already defined transceiver parameters directly at service creation time. This is possible by the inclusion of *CommonExplicit* and *CommonOrganizationalExplicit* packages into the OTSi CSEP, see diagram below.

A screenshot of a computer flowchart

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## Experimental Manual Switch Commands

Introduced experimental *ConnectivityProtectionService* class, to allow the provisioning of switch commands to on *SwitchControl*, *Switch* or CEP object instances.



## Termination Point Direction

TR-547 v3.1 has a new section describing various unidirectional scenarios.





## Client – Server relationship between Connectivity Services and Connections

TR-547 v3.1 has a new section clarify the relationship between:

* Connectivity Service and its Top Connection, and
* Top Connection and its server Top Connection.





## Other enhancements

1. In version 2.4.0 the Remote Procedure Calls have been deprecated. In version 2.5.0 all the RPCs have been finally removed.
2. Explicitly recommended that the *ServiceInterfacePoint* (SIP) is always referenced by the *NodeEdgePoint* (NEP) at the lowest represented layer, as shown in many scenarios of TR-547.
3. In TR-547 v3.1 added the experimental description of the Staged Provisioning of a Connectivity Service.
4. Sanitized all default values.
5. Reviewed the read/write access of all attributes.
6. Delivered a guideline regarding the workflow (tools etc.) for the development of the standard, Including a synthetic description of the necessary manual edits for the uml2yang process.
7. Delivered the Gendoc dumps of UML model into documents, improved with links facilitating the navigation.
8. Improvements to TR-548 description of Tombstone behavior along with several other wording improvements

TAPI v2.5.0 is available at <https://github.com/OpenNetworkingFoundation/TAPI/releases/tag/v2.5.0>.

# Acknowledgements

Thanks for the many contributions over the years by team members, from previous and related activities and from other bodies such as TIP and OIF.

# Further Background Details

The ONF Transport API (TAPI) project charted under the [ONF Open Transport Configuration & Control](https://opennetworking.org/open-transport/) (OTCC) is responsible for the development of this SDK as an Open Source project.

TAPI is derived from the ONF Core model [TR-512\_v1.5\_OnfCoreIm](https://opennetworking.org/wp-content/uploads/2021/11/TR-512_v1.5_OnfCoreIm-info.zip).

The TAPI project is an open community driven by contribution and collaboration between operators, vendors and other industry bodies.

TAPI features evolve from Requirements through Use Cases to Information Model then YANG. The development sequence is not strict, so Requirements are refined as the Information Model is developed etc.

TAPI is extensible to allow vendor proprietary features to be added as appropriate.

The previous widely deployed release of TAPI is [TAPI v2.1.3](https://github.com/OpenNetworkingFoundation/TAPI/releases/tag/v2.1.3) including:

* [TR-547 TAPI v2.1.3 Reference Implementation Agreement](https://opennetworking.org/wp-content/uploads/2021/12/TR-547-TAPI_ReferenceImplementationAgreement_v1.1.pdf)
* [TR-548 TAPI v2.1.3 Reference Implementation Agreement - Streaming](https://opennetworking.org/wp-content/uploads/2021/12/TR-548-TAPI_ReferenceImplementationAgreement-Streaming_v1.1.pdf)

# Bios

A person taking a selfie

Description automatically generated**Andrea Mazzini (Nokia)**

Andrea Mazzini is a senior systems and standards engineer at Nokia. He has been working in telecom network management for almost 30 years. He has contributed to ITU-T, TeleManagement Forum, MEF and ONF organizations, mainly regarding network management for SDH, ASON/GMPLS, MPLS, Ethernet, DWDM/OTN technologies, while being involved in several integration projects, internal and multi-vendor, for common management interfaces enabling end-to-end provisioning solutions.  
Contribution to TeleManagement Forum for a decade, designing MTNM and MTOSI standard management interfaces, most relevant model fragments Control Plane enhanced networks (ASON/GMPLS) and MPLS-TP networks.  
Editor of MEF 59 (Resource Model: Ethernet Connectivity), MEF 72/72.1 (Resource Model: Subscriber and Operator Layer 1 Connectivity), MEF 83 (Resource Model: Ethernet OAM), MEF 89 (Resource Model Common).  
Currently member of Technical Steering Team of Open Transport Configuration & Control Project at ONF. Editor and key contributor of ONF TAPI Information Model and Reference Implementation Agreement for the multi-layer management of Topology, Connectivity, Equipment and OAM for Ethernet, Digital OTN and Photonic Media technologies. Reviewer of ONF Core Info Model TR-512.

A person smiling for the camera

Description automatically generated with medium confidence**Nigel Davis (Ciena)**

Nigel Davis is a Systems Design Architect at Ciena and is a key innovator in multi-layer information modeling and standards. He was recognized as a Ciena Technical Fellow in 2015 for his efforts within Ciena and in the industry. Nigel has been active in the TeleManagement Forum, where he has been recognized as a Distinguished Fellow. He is now focusing on work in the Open Networking Foundation (ONF) where he co-leads the Open Information Model and Tooling (OIMT) project, is the editor of and a key contributor to the ONF Core Information Model, is an editor of and a key contributor to ONF Transport API (TAPI) specifications and is on the Technical Steering Team for the Open Networking Foundation (ONF) Open Transport Configuration and Control project. Most recently, Nigel has engaged in, and has submitted, several drafts to IETF aiming for advancements in the modeling of control solutions and for convergence of control models and architectures. Nigel has several patents in the area of management and control.

**Ramon Casellas (CTTC)**

Ramon Casellas graduated in Telecommunications Engineering in 1999 both from UPC, Barcelona and ENST Paris, where he completed a PhD degree in 2002. After working as an Associate Professor (2002-2005) he joined CTTC in 2006, where he currently is a Research Director. He has participated in several R&D projects funded by EC, Spanish National Research programmes, and industrial contracts and published over 250 conference and journal papers in the field of Optical Networking. He has served as ONDM Program/General Chair (2018, 2020), and OFC2021 Program/General Chair (2021, 2023) and as JOCN Associate Editor. He has co-authored over 10 Internet Engineering Task Force (IETF) RFCs and drafts in the TEAS, PCE and CCAMP Working Groups. He is a contributor of the Open Networking Foundation (ONF) Open Transport Configuration & Control (OTCC) and a member of the Open Disaggregated Transport Networks (ODTN) project use case and software working groups. He has been an IEEE CommSoc and OFC short course instructor on the topic of SDN for Optical Networks. His research interest areas include GMPLS/PCE architecture, Software Defined Networking (SDN), Network Function Virtualization (NFV), Traffic Engineering and Distributed control schemes, with applications to Optical and Disaggregated Transport Networks.