Transport Northbound Interface Use Cases  
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Abstract

Transport network domains, including Optical Transport Network (OTN) and Wavelength Division Multiplexing (WDM) networks, are typically deployed based on a single vendor or technology platforms. They are often managed using proprietary interfaces to dedicated Element Management Systems (EMS), Network Management Systems (NMS) and increasingly Software Defined Network (SDN) controllers.

A well-defined open interface to each domain management system or controller is required for network operators to facilitate control automation and orchestrate end-to-end services across multi-domain networks. These functions may be enabled using standardized data models (e.g. YANG), and appropriate protocol (e.g., RESTCONF).

This document describes the key use cases and requirements for transport network control and management. It reviews proposed and existing IETF transport network data models, their applicability, and highlights gaps and requirements.

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# Introduction

A common open interface to each domain controller/management system is pre-requisite for network operators to control multi-vendor and multi-domain networks and enable also service provisioning coordination/automation. This can be achieved by using standardized YANG models, used together with an appropriate protocol (e.g., RESTCONF).

This document assumes a reference architecture, including interfaces, based on the Abstraction and Control of Traffic-Engineered Networks (ACTN), defined in [ACTN-Frame].

The focus of the current version is on the MPI (interface between the Multi Domain Service Coordinator (MDSC) and a Physical Network Controller (PNC), controlling a transport network domain).

The relationship between the current IETF YANG models and the type of ACTN interfaces can be found in [ACTN-YANG].

The ONF Technical Recommendations for Functional Requirements for the transport API, may be found in [ONF TR-527].  
Furthermore, ONF transport API multi-layer examples may be found in [ONF GitHub].

This document describes use cases that could be used for analyzing the applicability of the existing models defined by the IETF for transport networks.

Considerations about the CMI (interface between the Customer Network Controller (CNC) and the MDSC) are for further study.

# Conventions used in this document

For discussion in future revisions of this document.

# Use Case 1: Single-domain with single-layer

## Reference Network

The current considerations discussed in this document are based on the following reference networks:

* + single transport domain: OTN network

It is expected that future revisions of the document will include additional reference networks.

### Single Transport Domain - OTN Network

Figure 1 shows the network physical topology composed of a single-domain transport network providing transport services to an IP network through five access links.

................................................  
 : IP domain :  
 : .............................. :  
 : : ........................ : :  
 : : : : : :  
 : : : S1 -------- S2 ------ C-R4 :  
 : : : / | : : :  
 : : : / | : : :  
 : C-R1 ------ S3 ----- S4 | : : :  
 : : : \ \ | : : :  
 : : : \ \ | : : :  
 : : : S5 \ | : : :  
 : C-R2 -----+ / \ \ | : : :  
 : : : \ / \ \ | : : :  
 : : : S6 ---- S7 ---- S8 ------ C-R5 :  
 : : : / : : :  
 : C-R3 -----+ : : :  
 : : : Transport domain : : :  
 : : : : : :  
 :........: :......................: :........:

1. Reference network for Use Case 1

The IP and transport (OTN) domains are respectively composed by five routers C-R1 to C-R5 and by eight ODU switches S1 to S8. The transport domain acts as a transit domain providing connectivity to the IP layer.

The behavior of the transport domain is the same whether the ingress/egress nodes in the IP domain, supporting an IP service, are directly attached to the transport domain or there are other routers in between the ingress/egress nodes of the IP domain and the routers directly attached to the transport network.

+-----+

| CNC |

+-----+

|

|CMI I/F

|

+-----------------------+

| MDSC |

+-----------------------+

|

|MPI I/F

|

+-------+

| PNC |

+-------+

|

-----

( )

( OTN )

( Physical )

( Network )

( )

-----

1. Controlling Hierarchy for Use Case 1

The mapping of the client IP traffic on the physical link between the routers and the transport network is made in the IP routers only and is not controlled by the transport PNC and is transparent to the transport nodes.

The control plane architecture follows the ACTN architecture and framework document [ACTN-Frame]. The Client Controller act as a client with respect to the Multi-Domain Service Coordinator (MDSC) via the Controller-MDSC Interface (CMI). The MDSC is connected to a plurality of Physical Network Controllers (PNCs), one for each domain, via a MDSC-PNC Interface (MPI). Each PNC is responsible only for the control of its domain and the MDSC is the only entity capable of multi-domain functionalities as well as of managing the inter-domain links. The key point of the whole ACTN framework is detaching the network and service control from the underlying technology and help the customer express the network as desired by business needs. Therefore, care must be taken to keep minimal dependency on the CMI (or no dependency at all) with respect to the network domain technologies. The MPI instead requires some specialization according to the domain technology.

In this section, we address the case of an IP and a Transport PNC having respectively an IP a Transport MPI. The interface within the scope of this document is the Transport MPI while the IP Network MPI is out of its scope and considerations about the CMI are for further study.

## Topology Abstractions

There are multiple methods to abstract a network topology. This document assumes the abstraction method defined in [RFC7926]:

Abstraction is the process of applying policy to the available TE information within a domain, to produce selective information that represents the potential ability to connect across the domain. Thus, abstraction does not necessarily offer all possible connectivity options, but presents a general view of potential connectivity according to the policies that determine how the domain's administrator wants to allow the domain resources to be used.

[TE-Topo] describes a YANG base model for TE topology without any technology specific parameters. Moreover, it defines how to abstract for TE-network topologies.

[ACTN-Frame] provides the context of topology abstraction in the ACTN architecture and discusses a few alternatives for the abstraction methods for both packet and optical networks. This is an important consideration since the choice of the abstraction method impacts protocol design and the information it carries. According to [ACTN-Frame], there are three types of topology:

* White topology: This is a case where the Physical Network Controller (PNC) provides the actual network topology to the Multi-domain Service Coordinator (MDSC) without any hiding or filtering. In this case, the MDSC has the full knowledge of the underlying network topology.
* Black topology: The entire domain network is abstracted as a single virtual node with the access/egress links without disclosing any node internal connectivity information.
* Grey topology: This abstraction level is between black topology and white topology from a granularity point of view. This is abstraction of TE tunnels for all pairs of border nodes. We may further differentiate from a perspective of how to abstract internal TE resources between the pairs of border nodes:
  + Grey topology type A: border nodes with a TE links between them in a full mesh fashion.
  + Grey topology type B: border nodes with some internal abstracted nodes and abstracted links.

For single-domain with single-layer use-case, the white topology may be disseminated from the PNC to the MDSC in most cases. There may be some exception to this in the case where the underlay network may have complex optical parameters, which do not warrant the distribution of such details to the MDSC. In such case, the topology disseminated from the PNC to the MDSC may not have the entire TE information but a streamlined TE information. This case would incur another action from the MDSC’s standpoint when provisioning a path. The MDSC may make a path compute request to the PNC to verify the feasibility of the estimated path before making the final provisioning request to the PNC, as outlined in [Path-Compute].

Topology abstraction for the CMI is for further study (to be addressed in future revisions of this document).

## Service Configuration

In the following use cases, the Multi Domain Service Coordinator (MDSC) needs to be capable to request service connectivity from the transport Physical Network Controller (PNC) to support IP routers connectivity. The type of services could depend of the type of physical links (e.g. OTN link, ETH link or SDH link) between the routers and transport network.

As described in section 3.1.1, the control of different adaptations inside IP routers, C-Ri (PKT -> foo) and C-Rj (foo -> PKT), are assumed to be performed by means that are not under the control of, and not visible to, transport PNC. Therefore, these mechanisms are outside the scope of this document.

### ODU Transit

This use case assumes that the physical links interconnecting the IP routers and the transport network are OTN links. The physical/optical interconnection below the ODU layer is supposed to be pre-configured and not exposed at the MPI to the MDSC.

If we consider the case of a 10Gb IP link between C-R1 to C-R3, we need to instantiate an ODU2 end-to-end data plane connection between C-R1 and C-R3, crossing transport nodes S3, S5, and S6.

The traffic flow between C-R1 and C-R3 can be summarized as:

C-R1 (PKT -> ODU2), S3 (ODU2), S5 (ODU2), S6 (ODU2),   
C-R3 (ODU2 -> PKT)

The MDSC should be capable via the MPI to request the setup of an ODU2 transit service with enough information that enable the transport PNC to instantiate and control the ODU2 data plane connection segment through nodes S3, S5, S6.

### EPL over ODU

This use case assumes that the physical links interconnecting the IP routers and the transport network are Ethernet links.

If we consider the case of a 10Gb IP link between C-R1 to C-R3, we need to instantiate an EPL service between C-R1 and C-R3 supported by an ODU2 end-to-end connection between S3 and S6, crossing transport node S5.

The traffic flow between C-R1 and C-R3 can be summarized as:

C-R1 (PKT -> ETH), S3 (ETH -> ODU2), S5 (ODU2),   
S6 (ODU2 -> ETH), C-R3 (ETH-> PKT)

The MDSC should be capable via the MPI to request the setup of an EPL service with enough information that can permit the transport PNC to instantiate and control the ODU2 end-to-end data plane connection through nodes S3, S5, S6, as well as the adaptation functions inside S3 and S6: S3&S6 (ETH -> ODU2) and S9&S6 (ODU2 -> ETH).

### Other OTN Client Services

[ITU-T G.709-2016] defines mappings of different client layers into ODU. Most of them are used to provide Private Line services over an OTN transport network supporting a variety of types of physical access links (e.g., Ethernet, SDH STM-N, Fibre Channel, InfiniBand, etc.).

This use case assumes that the physical links interconnecting the IP routers and the transport network are any one of these possible options.

If we consider the case of a 10Gb IP link between C-R1 to C-R3 using, for example SDH physical links between the IP routers and the transport network, an STM-64 Private Line service needs to be created between C-R1 and C-R3 supported by an ODU2 end-to-end data plane connection between S3 and S6, crossing transport node S5.

The traffic flow between C-R1 and C-R3 can be summarized as:

C-R1 (PKT -> STM-64), S3 (STM-64 -> ODU2), S5 (ODU2),   
S6 (ODU2 -> STM-64), C-R3 (STM-64 -> PKT)

The MDSC should be capable the MPI to request the setup of an STM-64 Private Line service with enough information that can permit the transport PNC to instantiate and control the ODU2 end-to-end connection through nodes S3, S5, S6, as well as the adaptation functions inside S3 and S6: S3&S6 (STM-64 -> ODU2) and S9&S3 (STM-64 -> PKT).

### EVPL over ODU

For future revision.

### EVPLAN and EVPTree Services

For future revision.

### Virtual Network Services

For future revision.

## Multi-functional Access Links

For future revision.

## Protection Scenarios

The MDSC needs to be capable to request the transport PNC to configure protection when requesting the setup of the connectivity services described in section 3.3.

Since in this use case it is assumed that switching within the transport network domain is performed only in one layer, also protection switching within the transport network domain can only be provided at the OTN ODU layer, for all the services defined in section 3.3.

Resiliency mechanisms on the access links are for further discussion.

### Linear Protection

It is possible to protect any service defined in section 3.3 from failures within the OTN transport domain by configuring OTN linear protection in the data plane between node S3 and node S6.

It is assumed that the OTN linear protection is configured to with 1+1 unidirectional protection switching type, as defined in [ITU-T G.808.1-2014] and [ITU-T G.873.1-2014], as well as in [RFC4427].

In these scenarios, a working transport entity and a protection transport entity, as defined in [ITU-T G.808.1-2014], (or a working LSP and a protection LSP, as defined in [RFC4427]) should be configured in the data plane, for example:

Working transport entity: S3 -> S5 -> S6

Protection transport entity: S3 -> S4 -> S6 -> S7 -> S6

The Transport PNC should be capable to report to the MDSC which is the active transport entity, as defined in [ITU-T G.808.1-2014], in the data plane.

Given the fast dynamic of protection switching operations in the data plane (50ms recovery time), this reporting is not expected to be in real-time.

It is also worth noting that with unidirectional protection switching, e.g., 1+1 unidirectional protection switching, the active transport entity may be different in the two directions.

# Use Case 2: Single-domain with multi-layer

For future revision.

# Use Case 3: Multi-domain with single-layer

## Reference Network

In this section we focus on a multi-domain reference network with homogeneous technologies:

* + multiple transport domains: OTN networks

Figure 3 shows the network physical topology composed of three transport network domains providing transport services to an IP customer network through eight access links:



1. Reference network for Use Case 3

It is worth noting that the network domain 1 is identical to the transport domain shown in Figure 1.



1. Controlling Hierarchy for Use Case 3

In this section we address the case where the CNC controls the customer IP network and requests transport connectivity among IP routers, via the CMI, to an MDSC which coordinates, via three MPIs, the control of a multi-domain transport network through three PNCs.

The interfaces within the scope of this document are the three MPIs while the interface between the CNC and the IP routers is out of its scope and considerations about the CMI are for further study.

## Topology Abstractions

Each PNC should provide the MDSC a topology abstraction of the domain’s network topology.

[ACTN-Frame] describes different types of topology abstractions. Each PNC provides topology abstraction of its own domain topology independently from each other and therefore it is possible that different PNCs provide different types of topology abstractions.

As an example, we can assume that:

* PNC1 provides a white topology abstraction (likewise use case 1 described in section 3.2)
* PNC2 provides a type A grey topology abstraction
* PNC3 provides a type B grey topology abstraction, with two abstract nodes abstracting respectively nodes S31+S32 and nodes S32+S34

The MDSC should be capable to glue together these different abstract topologies to build its own view of the multi-domain network topology.

## Service Configuration

In the following use cases, it is assumed that the CNC is capable to request service connectivity from the MDSC to support IP routers connectivity.

The same service scenarios, as described in section 3.3, are also application to this use cases with the only difference that the two IP routers to be interconnected are attached to transport nodes which belong to different PNCs domains and are under the control of the CNC.

Likewise the service scenarios in section 3.3, the type of services could depend of the type of physical links (e.g. OTN link, ETH link or SDH link) between the customer’s routers and the multi-domain transport network and the configuration of the different adaptations inside IP routers is performed by means that are outside the scope of this document because not under control of and not visible to the MDSC nor to the PNCs.

It is assumed that the CNC is capable via the CMI to request the MDSC the setup of these services with enough information that enable the MDSC to coordinate the different PNCs to instantiate and control the ODU2 data plane connection through nodes S3, S1, S2, S31, S33, S34, S15 and S18, as well as the adaptation functions inside nodes S3 and S18, when needed.

As described in section 5.2, the MDSC should have its own view of the end-to-end network topology and use it for its own path computation to understand that it needs to coordinate with PNC1, PNC2 and PNC3 the setup and control of a multi-domain ODU2 data plane connection.

### ODU Transit

In order to setup a 10Gb IP link between C-R1 and C-R5, an ODU2 end-to-end data plane connection needs be created between C-R1 and C-R5, crossing transport nodes S3, S1, S2, S31, S33, S34, S15 and S18 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

C-R1 (PKT -> ODU2), S3 (ODU2), S1 (ODU2), S2 (ODU2),  
S31 (ODU2), S33 (ODU2), S34 (ODU2),  
S15 (ODU2), S18 (ODU2), C-R5 (ODU2 -> PKT)

### EPL over ODU

In order to setup a 10Gb IP link between C-R1 and C-R5, an EPL service needs to be created between C-R1 and C-R5, supported by ODU2 end-to-end data plane connection between transport nodes S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

C-R1 (PKT -> ETH), S3 (ETH -> ODU2), S1 (ODU2), S2 (ODU2),  
S31 (ODU2), S33 (ODU2), S34 (ODU2),  
S15 (ODU2), S18 (ODU2 -> ETH), C-R5 (ETH -> PKT)

### Other OTN Client Services

In order to setup a 10Gb IP link between C-R1 and C-R5 using, for example SDH physical links between the IP routers and the transport network, an STM-64 Private Line service needs to be created between C-R1 and C-R5, supported by ODU2 end-to-end data plane connection between transport nodes S3 and S18, crossing transport nodes S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

The traffic flow between C-R1 and C-R5 can be summarized as:

C-R1 (PKT -> STM-64), S3 (STM-64 -> ODU2), S1 (ODU2), S2 (ODU2),  
S31 (ODU2), S33 (ODU2), S34 (ODU2),  
S15 (ODU2), S18 (ODU2 -> STM-64), C-R5 (STM-64 -> PKT)

## Protection Scenarios

The MDSC needs to be capable to coordinate different PNCs to configure protection switching when requesting the setup of the connectivity services described in section 5.3.

Since in this use case it is assumed that switching within the transport network domain is performed only in one layer, also protection switching within the transport network domain can only be provided at the OTN ODU layer, for all the services defined in section 5.3.

Resiliency mechanisms on the access links are for further discussion.

### Linear Protection (end-to-end)

In order to protect any service defined in section 5.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to coordinate different PNCs to configure and control OTN linear protection in the data plane between nodes S3 and node S18.

The considerations in section 3.5.1 are also applicable here with the only difference that MDSC needs to coordinate with different PNCs the setup and control of the OTN linear protection as well as of the working and protection transport entities (working and protection LSPs).

Two cases can be considered.

In one case, the working and protection transport entities pass through the same PNC domains:

Working transport entity: S3 -> S1 -> S2 ->  
 S31 -> S33 -> S34 ->  
 S15 -> S18

Protection transport entity: S3 -> S4 -> S8 ->  
 S32 ->  
 S12 -> S17 -> S18

In another case, the working and protection transport entities can pass through different PNC domains:

Working transport entity: S3 -> S5 -> S7 ->  
 S11 -> S12 -> S17 -> S18

Protection transport entity: S3 -> S1 -> S2 ->  
 S31 -> S33 -> S34 ->  
 S15 -> S18

### Segmented Protection

In order to protect any service defined in section 5.3 from failures within the OTN multi-domain transport network, the MDSC should be capable to request each PNC to configure OTN intra-domain protection when requesting the setup of the ODU2 data plane connection segment.

Resiliency mechanisms on the inter-domain links are for further discussion.

If linear protection is used within a domain, the considerations in section 3.5.1 are also applicable here only for the PNC controlling the domain where intra-domain linear protection is provided.

If PNC1 provides linear protection, the working and protection transport entities could be:

Working transport entity: S3 -> S1 -> S2

Protection transport entity: S3 -> S4 -> S8 -> S2

If PNC2 provides linear protection, the working and protection transport entities could be:

Working transport entity: S15 -> S18

Protection transport entity: S15 -> S12 -> S17 -> S18

If PNC3 provides linear protection, the working and protection transport entities could be:

Working transport entity: S31 -> S33 -> S34

Protection transport entity: S31 -> S32 -> S33

# Use Case 4: Multi-domain and multi-layer

For future revision.

# Security Considerations

For further study.

# IANA Considerations

This document requires no IANA actions.

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## Normative References

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