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Transport Northbound Interface Applicability Statement and 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 to be

used as the basis for applicability statements analyzing how IETF

data models can be used for transport network control and

management.

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1. Introduction

Transport of packet services are critical for a wide-range of

applications and services, including: data center and LAN

interconnects, Internet service backhauling, mobile backhaul and

enterprise Carrier Ethernet Services. These services are typically

setup using stovepipe NMS and EMS platforms, often requiring

propriety management platforms and legacy management interfaces. A

clear goal of operators will be to automate setup of transport

services across multiple transport technology domains.

A common open interface (API) to each domain controller and or

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 describes key use cases for analyzing the

applicability of the models defined by the IETF for transport

networks. The intention of this document is to provide the base

reference scenarios for applicability statements that will describe

in details how IETF transport models are applied to solve the

described use cases and requirements.

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1.1. Scope of this document

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 this document 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 in [ONF TR-527] and the ONF transport API multi-

layer examples in [ONF GitHub] have been considered as an input for

this work.

Considerations about the CMI (interface between the Customer Network

Controller (CNC) and the MDSC) are outside the scope of this

document.

2. Terminology

Domain : is considered to be any collection of network elements within a common realm of address space or path computation responsibility [RFC5151]

E-LINE: Ethernet Line

EPL: Ethernet Private Line

EVPL: Ethernet Virtual Private Line

OTH: Optical Network Hierarchy

OTN: Optical Transport Network

Service: [RFC8309] A service in the context of this document can be considered as some form of connectivity between customer sites across the network operator’s network

Service Model: As described in [RFC8309] it describes a service and the parameters of the service in a portable way that can be used uniformly and independent of the equipment and operating environment.

UNI: User Network Interface

MDSC : Multi-Domain Service Coordinator

CNC : Customer Network Controller

PNC: Provisioning Network Controller

MAC bridging: Virtual LANs (VLANs) on IEEE 802.3 Ethernet network

3. Conventions used in this document

3.1. Topology and traffic flow processing

The traffic flow between different nodes is specified as an ordered

list of nodes, separated with commas, indicating within the brackets

the processing within each node:

<node> (<processing>) {, <node> (<processing>)}

The order represents the order of traffic flow being forwarded

through the network.

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The processing can be either an adaptation of a client layer into a

server layer "(client -> server)" or switching at a given layer

"([switching])". Multi-layer switching is indicated by two layer

switching with client/server adaptation: "([client] -> [server])".

For example, the following traffic flow:

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

C-R3 (ODU2 -> [PKT])

Node C-R1 is switching at the packet (PKT) layer and mapping packets

into a ODU2 before transmission to node S3. Nodes S3, S5 and S6 are

switching at the ODU2 layer: S3 sends the ODU2 traffic to S5 which

then sends it to S6 which finally sends to C-R3. Node C-R3

terminates the ODU2 from S6 before switching at the packet (PKT)

layer.

The paths of working and protection transport entities are specified

as an ordered list of nodes, separated with commas:

<node> {, <node>}

The order represents the order of traffic flow being forwarded

through the network in the forward direction. In case of

bidirectional paths, the forward and backward directions are

selected arbitrarily, but the convention is consistent between

working/protection path pairs as well as across multiple domains.

4. Use Case 1: Single-domain with single-layer

4.1. Reference Network

The current considerations discussed in this document are based on

the following reference networks:

- single transport domain: OTN network

4.1.1. Single Transport Domain - OTN Network

As shown in Figure 1 the network physical topology composed of a

single-domain transport network providing transport services to an

IP network through five access links.

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................................................

: IP domain :

: .............................. :

: : ........................ : :

: : : : : :

: : : S1 -------- S2 ------ C-R4 :

: : : / | : : :

: : : / | : : :

: C-R1 ------ S3 ----- S4 | : : :

: : : \ \ | : : :

: : : \ \ | : : :

: : : S5 \ | : : :

: C-R2 -----+ / \ \ | : : :

: : : \ / \ \ | : : :

: : : S6 ---- S7 ---- S8 ------ C-R5 :

: : : / : : :

: C-R3 -----+ : : :

: : : Transport domain : : :

: : : : : :

:........: :......................: :........:

Figure 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 network providing connectivity

for IP layer services.

The behavior of the transport domain is the same whether the

ingress or egress service nodes in the IP domain are only attached

to the transport domain, or if there are other routers in between

the ingress or egress nodes of the IP domain not also attached to

the transport domain. In other words, the behavior of the transport

network does not depend on whether C-R1, C-R2, ..., C-R5 are PE or P

routers for the IP services.

The transport domain control plane architecture follows the ACTN

architecture and framework document [ACTN-Frame], and functional

components:

o Customer Network Controller (CNC) act as a client with respect to

the Multi-Domain Service Coordinator (MDSC) via the CNC-MDSC

Interface (CMI);

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o MDSC is connected to a plurality of PNCs Physical Network Controller

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 ACTN framework facilitates the detachment of 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.

+-----+

| CNC |

+-----+

|

|CMI I/F

|

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

| MDSC |

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

|

|MPI I/F

|

+-------+

| PNC |

+-------+

|

-----

( )

( OTN )

( Physical )

( Network )

( )

-----

Figure 2 Controlling Hierarchy for Use Case 1

Once the service request is processed by the MDSC the mapping of the

client IP traffic between the routers (across the transport network)

is made in the IP routers only and is not controlled by the

transport PNC, and therefore transparent to the transport nodes.

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4.2. Topology Abstractions

Abstraction provides a selective method for representing

connectivity information within a domain. 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:

o 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;

o 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;

o 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;

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- 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).

4.3. 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 4.1.1, 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.

4.3.1. 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.

To setup a 10Gb IP link between C-R1 to C-R3, an ODU2 end-to-end

data plane connection needs to be created 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:

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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.

4.3.2. EPL over ODU

This use case assumes that the physical links interconnecting the IP

routers and the transport network are Ethernet links.

In order to setup a 10Gb IP link between C-R1 to C-R3, an EPL

service needs to be created 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).

4.3.3. 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.

In order to setup a 10Gb IP link between C-R1 to C-R3 using, for

example STM-64 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.

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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 via 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).

4.3.4. EVPL over ODU

This use case assumes that the physical links interconnecting the IP

routers and the transport network are Ethernet links and that

different Ethernet services (e.g, EVPL) can share the same physical

link using different VLANs.

In order to setup two 1Gb IP links between C-R1 to C-R3 and between

C-R1 and C-R4, two EVPL services need to be created, supported by

two ODU0 end-to-end connections respectively between S3 and S6,

crossing transport node S5, and between S3 and S2, crossing

transport node S1.

Since the two EVPL services are sharing the same Ethernet physical

link between C-R1 and S3, different VLAN IDs are associated with

different EVPL services: for example VLAN IDs 10 and 20

respectively.

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

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [ODU0]), S5 ([ODU0]),

S6 ([ODU0] -> VLAN), C-R3 (VLAN -> [PKT])

The traffic flow between C-R1 and C-R4 can be summarized as:

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [ODU0]), S1 ([ODU0]),

S2 ([ODU0] -> VLAN), C-R4 (VLAN -> [PKT])

The MDSC should be capable via the MPI to request the setup of these

EVPL services with enough information that can permit the transport

PNC to instantiate and control the ODU0 end-to-end data plane

connections as well as the adaptation functions on the boundary

nodes: S3&S2&S6 (VLAN -> ODU0) and S3&S2&S6 (ODU0 -> VLAN).

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4.3.5. EVPLAN and EVPTree Services

This use case assumes that the physical links interconnecting the IP

routers and the transport network are Ethernet links and that

different Ethernet services (e.g., EVPL, EVPLAN and EVPTree) can

share the same physical link using different VLANs.

Note - it is assumed that EPLAN and EPTree services can be supported

by configuring EVPLAN and EVPTree with port mapping.

In order to setup an IP subnet between C-R1, C-R2, C-R3 and C-R4, an

EVPLAN/EVPTree service needs to be created, supported by two ODUflex

end-to-end connections respectively between S3 and S6, crossing

transport node S5, and between S3 and S2, crossing transport node

S1.

In order to support this EVPLAN/EVPTree service, some Ethernet

Bridging capabilities are required on some nodes at the edge of the

transport network: for example Ethernet Bridging capabilities can be

configured in nodes S3 and S6 but not in node S2.

Since this EVPLAN/EVPTree service can share the same Ethernet

physical links between IP routers and transport nodes (e.g., with

the EVPL services described in section 4.3.4), a different VLAN ID

(e.g., 30) can be associated with this EVPLAN/EVPTree service.

In order to support an EVPTree service instead of an EVPLAN,

additional configuration of the Ethernet Bridging capabilities on

the nodes at the edge of the transport network is required.

The MAC bridging function in node S3 is needed to select, based on

the MAC Destination Address, whether the Ethernet frames form C-R1

should be sent to the ODUflex terminating on node S6 or to the other

ODUflex terminating on node S2.

The MAC bridging function in node S6 is needed to select, based on

the MAC Destination Address, whether the Ethernet frames received

from the ODUflex should be set to C-R2 or C-R3, as well as whether

the Ethernet frames received from C-R2 (or C-R3) should be sent to

C-R3 (or C-R2) or to the ODUflex.

For example, the traffic flow between C-R1 and C-R3 can be

summarized as:

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [MAC] -> [ODUflex]),

S5 ([ODUflex]), S6 ([ODUflex] -> [MAC] -> VLAN),

C-R3 (VLAN -> [PKT])

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The MAC bridging function in node S3 is also needed to select, based

on the MAC Destination Address, whether the Ethernet frames one

ODUflex should be sent to C-R1 or to the other ODUflex.

For example, the traffic flow between C-R3 and C-R4 can be

summarized as:

C-R3 ([PKT] -> VLAN), S6 (VLAN -> [MAC] -> [ODUflex]),

S5 ([ODUflex]), S3 ([ODUflex] -> [MAC] -> [ODUflex]),

S1 ([ODUflex]), S2 ([ODUflex] -> VLAN), C-R4 (VLAN -> [PKT])

In node S2 there is no need for any MAC bridging function since all

the Ethernet frames received from C-R4 should be sent to the ODUflex

toward S3 and viceversa.

The traffic flow between C-R1 and C-R4 can be summarized as:

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [MAC] -> [ODUflex]),

S1 ([ODUflex]), S2 ([ODUflex] -> VLAN), C-R4 (VLAN -> [PKT])

The MDSC should be capable via the MPI to request the setup of this

EVPLAN/EVPTree services with enough information that can permit the

transport PNC to instantiate and control the ODUflex end-to-end data

plane connections as well as the Ethernet Bridging and adaptation

functions on the boundary nodes: S3&S6 (VLAN -> MAC -> ODU2), S3&S6

(ODU2 -> ETH -> VLAN), S2 (VLAN -> ODU2) and S2 (ODU2 -> VLAN).

4.4. Multi-functional Access Links

This use case assumes that some physical links interconnecting the

IP routers and the transport network can be configured in different

modes, e.g., as OTU2 or STM-64 or 10GE.

This configuration can be done a-priori by means outside the scope

of this document. In this case, these links will appear at the MPI

either as an ODU Link or as an STM-64 Link or as a 10GE Link

(depending on the a-priori configuration) and will be controlled at

the MPI as discussed in section 4.3.

It is also possible not to configure these links a-priori and give

the control to the MPI to decide, based on the service

configuration, how to configure it.

For example, if the physical link between C-R1 and S3 is a multi-

functional access link while the physical links between C-R3 and S6

and between C-R4 and S2 are STM-64 and 10GE physical links

respectively, it is possible at the MPI to configure either an STM-

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64 Private Line service between C-R1 and C-R3 or an EPL service

between C-R1 and C-R4.

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 traffic flow between C-R1 and C-R4 can be summarized as:

C-R1 ([PKT] -> ETH), S3 (ETH -> [ODU2]), S1 ([ODU2]),

S2 ([ODU2] -> ETH), C-R4 (ETH-> [PKT])

The MDSC should be capable via the MPI to request the setup of

either service with enough information that can permit the transport

PNC to instantiate and control the ODU2 end-to-end data plane

connection as well as the adaptation functions inside S3 and S2 or

S6.

4.5. Protection Requirements

Protection switching provides a pre-allocated survivability

mechanism, typically provided via linear protection methods and

would be configured to operate as 1+1 unidirectional (the most

common OTN protection method), 1+1 bidirectional or 1:n

bidirectional. This ensures fast and simple service survivability.

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 4.3.

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 4.3.

It may be necessary to consider not only protection, but also

restoration functions in the future. Restoration methods would

provide capability to reroute and restore connectivity traffic

around network faults, without the network penalty imposed with

dedicated 1+1 protection schemes.

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4.5.1. Linear Protection

It is possible to protect any service defined in section 4.3 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, S8, 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.

5. Use Case 2: Single-domain with multi-layer

5.1. Reference Network

The current considerations discussed in this document are based on

the following reference network:

- single transport domain: OTN and OCh multi-layer network

In this use case, the same reference network shown in Figure 1 is

considered. The only difference is that all the transport nodes are

capable to switch in the ODU as well as in the OCh layer.

All the physical links within the transport network are therefore

assumed to be OCh links. Therefore, with the exception of the access

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links, no ODU internal link exists before an OCh end-to-end data

plane connection is created within the network.

The controlling hierarchy is the same as described in Figure 2.

The interface within the scope of this document is the Transport MPI

which should be capable to control both the OTN and OCh layers.

5.2. Topology Abstractions

A grey topology type B abstraction is assumed: abstract nodes and

links exposed at the MPI corresponds 1:1 with the physical nodes and

links controlled by the PNC but the PNC abstracts/hides at least

some optical parameters to be used within the OCh layer.

5.3. Service Configuration

The same service scenarios, as described in section 4.3, are also

applicable to these use cases with the only difference that end-to-

end OCh data plane connections will need to be setup before ODU data

plane connections.

6. Use Case 3: Multi-domain with single-layer

6.1. 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:

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........................

.......... : :

: : : Network domain 1 : .............

:Customer: : : : :

:domain 1: : S1 -------+ : : Network :

: : : / \ : : domain 3 : ..........

: C-R1 ------- S3 ----- S4 \ : : : : :

: : : \ \ S2 --------+ : :Customer:

: : : \ \ | : : \ : :domain 3:

: : : S5 \ | : : \ : : :

: C-R2 ------+ / \ \ | : : S31 --------- C-R7 :

: : : \ / \ \ | : : / \ : : :

: : : S6 ---- S7 ---- S8 ------ S32 S33 ------ C-R8 :

: : : / | | : : / \ / : :........:

: C-R3 ------+ | | : :/ S34 :

: : :..........|.......|...: / / :

:........: | | /:.../.......:

| | / /

...........|.......|..../..../...

: | | / / : ..........

: Network | | / / : : :

: domain 2 | | / / : :Customer:

: S11 ---- S12 / : :domain 2:

: / | \ / : : :

: S13 S14 | S15 ------------- C-R4 :

: | \ / \ | \ : : :

: | S16 \ | \ : : :

: | / S17 -- S18 --------- C-R5 :

: | / \ / : : :

: S19 ---- S20 ---- S21 ------------ C-R6 :

: : : :

:...............................: :........:

Figure 3 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.

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| Client |

| Controller |

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|

....................|.......................

|

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| |

| MDSC |

| |

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/ | \

/ | \

............../.....|......\................

/ | \

/ ---------- \

/ | PNC2 | \

/ ---------- \

---------- | \

| PNC1 | ----- \

---------- ( ) ----------

| ( ) | PNC3 |

----- ( Network ) ----------

( ) ( Domain 2 ) |

( ) ( ) -----

( Network ) ( ) ( )

( Domain 1 ) ----- ( )

( ) ( Network )

( ) ( Domain 3 )

----- ( )

( )

-----

Figure 4 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 outside the scope of this

document.

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6.2. Topology Abstractions

Each PNC should provide the MDSC a topology abstraction of the

domain's network topology.

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:

o PNC1 provides a white topology abstraction (likewise use case 1

described in section 4.2)

o PNC2 provides a type A grey topology abstraction

o PNC3 provides a type B grey topology abstraction, with two

abstract nodes (AN31 and AN32). They abstract respectively nodes

S31+S33 and nodes S32+S34. At the MPI, only the abstract nodes

should be reported: the mapping between the abstract nodes (AN31

and AN32) and the physical nodes (S31, S32, S33 and S34) should

be done internally by the PNC.

The MDSC should be capable to glue together these different abstract

topologies to build its own view of the multi-domain network

topology. This might require proper administrative configuration or

other mechanisms (to be defined/analysed).

6.3. 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 4.3, 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 4.3, 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 to

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request the proper configuration of the different adaptation

functions inside the customer's IP routers, by means which are

outside the scope of this document.

It is also 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 6.2, 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.

6.3.1. 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])

6.3.2. 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 an

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])

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6.3.3. 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])

6.3.4. EVPL over ODU

In order to setup two 1Gb IP links between C-R1 to C-R3 and between

C-R1 and C-R5, two EVPL services need to be created, supported by

two ODU0 end-to-end connections respectively between S3 and S6,

crossing transport node S5, and between S3 and S18, crossing

transport nodes S1, S2, S31, S33, S34 and S15 which belong to

different PNC domains.

The VLAN configuration on the access links is the same as described

in section 4.3.4.

The traffic flow between C-R1 and C-R3 is the same as described in

section 4.3.4.

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

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [ODU2]), S1 ([ODU2]),

S2 ([ODU2]), S31 ([ODU2]), S33 ([ODU2]), S34 ([ODU2]),

S15 ([ODU2]), S18 ([ODU2] -> VLAN), C-R5 (VLAN -> [PKT])

6.3.5. EVPLAN and EVPTree Services

In order to setup an IP subnet between C-R1, C-R2, C-R3 and C-R7, an

EVPLAN/EVPTree service needs to be created, supported by two ODUflex

end-to-end connections respectively between S3 and S6, crossing

transport node S5, and between S3 and S18, crossing transport nodes

S1, S2, S31, S33, S34 and S15 which belong to different PNC domains.

The VLAN configuration on the access links is the same as described

in section 4.3.5.

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The configuration of the Ethernet Bridging capabilities on nodes S3

and S6 is the same as described in section 4.3.5 while the

configuration on node S18 similar to the configuration of node S2

described in section 4.3.5.

The traffic flow between C-R1 and C-R3 is the same as described in

section 4.3.5.

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

C-R1 ([PKT] -> VLAN), S3 (VLAN -> [MAC] -> [ODUflex]),

S1 ([ODUflex]), S2 ([ODUflex]), S31 ([ODUflex]),

S33 ([ODUflex]), S34 ([ODUflex]),

S15 ([ODUflex]), S18 ([ODUflex] -> VLAN), C-R5 (VLAN -> [PKT])

6.4. Multi-functional Access Links

The same considerations of section 4.4 apply with the only

difference that the ODU data plane connections could be setup across

multiple PNC domains.

For example, if the physical link between C-R1 and S3 is a multi-

functional access link while the physical links between C-R7 and S31

and between C-R5 and S18 are STM-64 and 10GE physical links

respectively, it is possible to configure either an STM-64 Private

Line service between C-R1 and C-R7 or an EPL service between C-R1

and C-R5.

The traffic flow between C-R1 and C-R7 can be summarized as:

C-R1 ([PKT] -> STM-64), S3 (STM-64 -> [ODU2]), S1 ([ODU2]),

S2 ([ODU2]), S31 ([ODU2] -> STM-64), C-R3 (STM-64 -> [PKT])

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])

6.5. 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 6.3.

Since in this use case it is assumed that switching within the

transport network domain is performed only in one layer, also

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protection switching within the transport network domain can only be

provided at the OTN ODU layer, for all the services defined in

section 6.3.

6.5.1. Linear Protection (end-to-end)

In order to protect any service defined in section 6.3 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 4.5.1 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

6.5.2. Segmented Protection

In order to protect any service defined in section 6.3 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.

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If linear protection is used within a domain, the considerations in

section 4.5.1 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, S34

7. Use Case 4: Multi-domain and multi-layer

7.1. Reference Network

The current considerations discussed in this document are based on

the following reference network:

- multiple transport domains: OTN and OCh multi-layer networks

In this use case, the reference network shown in Figure 3 is used.

The only difference is that all the transport nodes are capable to

switch either in the ODU or in the OCh layer.

All the physical links within each transport network domain are

therefore assumed to be OCh links, while the inter-domain links are

assumed to be ODU links as described in section 6.1 (multi-domain

with single layer - OTN network).

Therefore, with the exception of the access and inter-domain links,

no ODU link exists within each domain before an OCh single-domain

end-to-end data plane connection is created within the network.

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The controlling hierarchy is the same as described in Figure 4.

The interfaces within the scope of this document are the three MPIs

which should be capable to control both the OTN and OCh layers

within each PNC domain.

7.2. Topology Abstractions

Each PNC should provide the MDSC a topology abstraction of its own

network topology as described in section 5.2.

As an example, it is assumed that:

o PNC1 provides a type A grey topology abstraction (likewise in use

case 2 described in section 5.2)

o PNC2 provides a type B grey topology abstraction (likewise in use

case 3 described in section 6.2)

o PNC3 provides a type B grey topology abstraction with two

abstract nodes, likewise in use case 3 described in section 6.2,

and hiding at least some optical parameters to be used within the

OCh layer, likewise in use case 2 described in section 5.2.

7.3. Service Configuration

The same service scenarios, as described in section 6.3, are also

applicable to these use cases with the only difference that single-

domain end-to-end OCh data plane connections needs to be setup

before ODU data plane connections.

8. Security Considerations

Typically, OTN networks ensure a high level of security and data

privacy through hard partitioning of traffic onto isolated circuits.

There may be additional security considerations applied to specific

use cases, but common security considerations do exist and these

must be considered for controlling underlying infrastructure to

deliver transport services:

o use of RESCONF and the need to reuse security between RESTCONF

components;

o use of authentication and policy to govern which transport

services may be requested by the user or application;

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o how secure and isolated connectivity may also be requested as an

element of a service and mapped down to the OTN level.

9. IANA Considerations

This document requires no IANA actions.

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