T-API contributions to ODL/TransportPCE

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NOKIA Bell Labs Core Research – Network Automation

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Animated ☺

Agenda

- CONTEXT
  - Open and Disaggregated Optical Transport Networks
  - T-API introduction

- IMPLEMENTATION
  - T-PCE initial status
  - T-PCE T-API developments

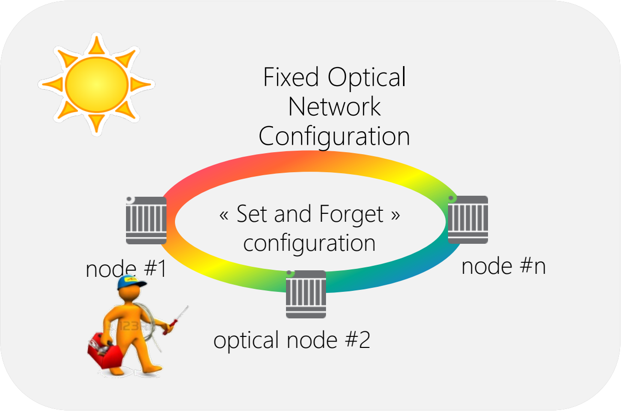
- IMPLEMENTED SCENARIO

CONTEXT

OTN/WDM Connections as Transport Connectivity Services

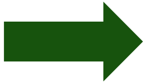
Why to Open & Disaggregate Optical Networks?

TODAY

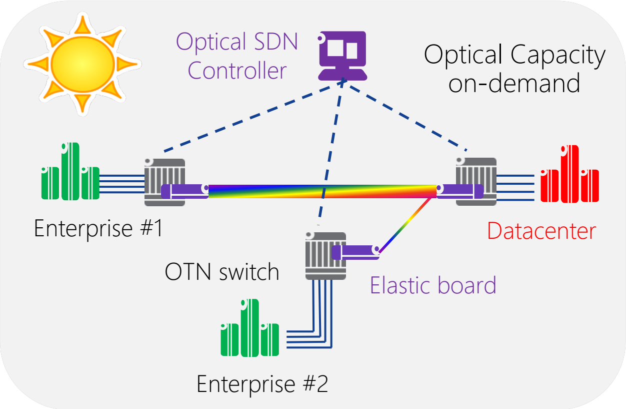

Fixed Optical Network Configuration
« Set and Forget » configuration
node #1
node #n
optical node #2

Optical Channels are fixed on siloed Transport Networks

Channels are never changed over a single domain network



FUTURE



Channels are controlled on Open Disaggregated Transport Networks

«Optical Channels as L0 Connectivity Services» Layer 0 Services must be provisioned over multiple network domains

Layer 0 Connectivity Services to realize «Transport Slices*»

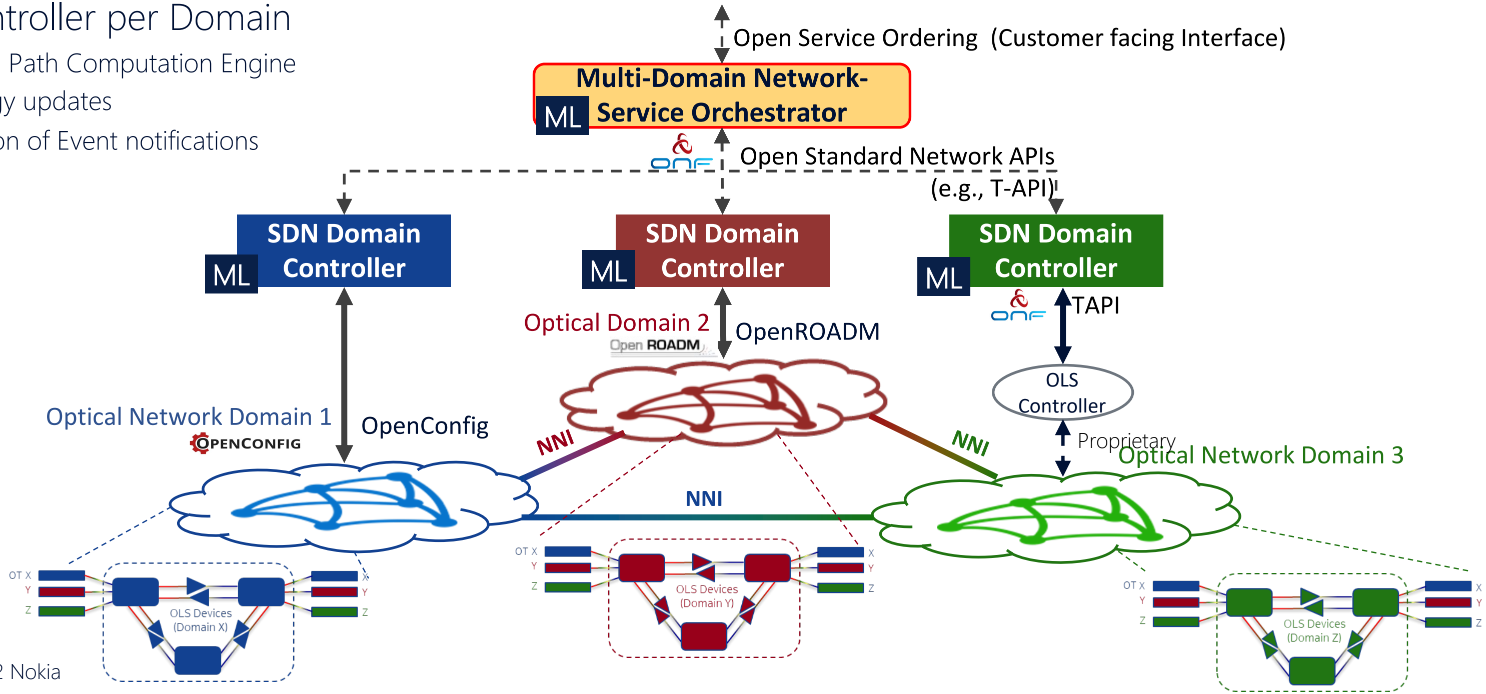
* Marina Thottan et al., "Roles of Packet/Optical Networks and SDN Control at the Edge ", F4I.1, Optical Fiber Communication Conference (OFC’2021), June 2021

Control of Multi-Domain Open Disaggregated Transport Networks

Edge-to-edge Layer 0 Connectivity Services provisioning

- Multi-Domain Network Service Orchestrator for end-to-end connectivity service provisioning.
  - ✓ End-to-end photonic connectivity service provisioning & monitoring
  - ✓ Alien wavelength use-case can be developed

- SDN Controller per Domain
  - ✓ Channel Path Computation Engine
  - ✓ Topology updates
  - ✓ Collection of Event notifications



Open Service Ordering (Customer facing Interface)

ML Multi-Domain Network-Service Orchestrator

Open Standard Network APIs (e.g., T-API)

ML SDN Domain Controller

ML SDN Domain Controller

ML SDN Domain Controller

OpenConfig

Optical Domain 2

OpenROADM

TAPI

OLS Controller

Proprietary

Optical Network Domain 1

Optical Network Domain 3

NNI

NNI

NNI

Streamlined Service Models for Transport Connectivity Services

Open Software Defined Optical Networking Platforms

- Multi-Domain Network Service Orchestrator
  - To provision end-to-end multi-domain Layer 0 Connectivity Services
  - To design L0 Connectivity Services realized by 1 or several Optical Channels
  - Through ONF/TAPI, MDSO needs to learn from its optical SDN Controllers

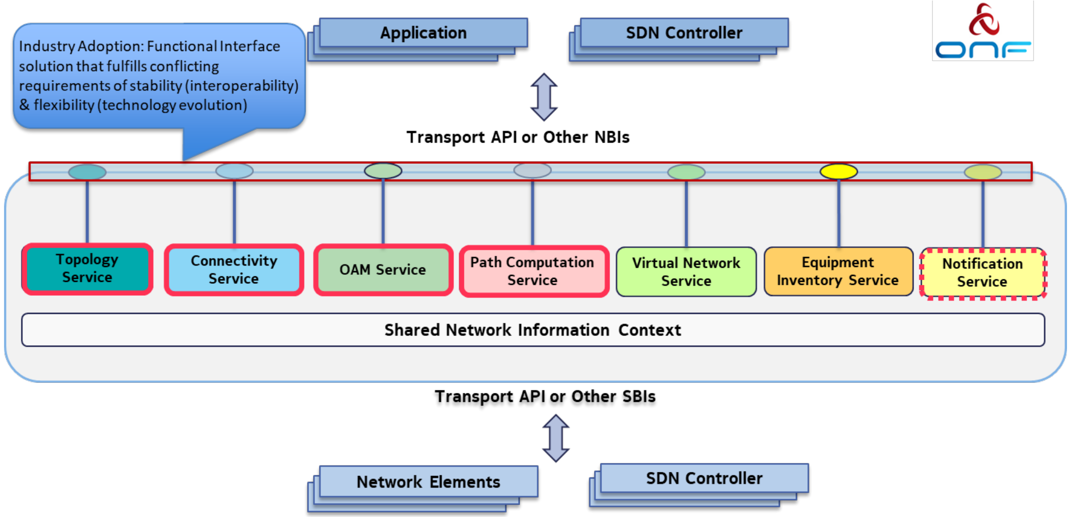
- Per Domain **Open Optical SDN Controller**
  - ODU/OTSi/Media Channel Connections between Edges (e.g., UNI/NNI’s)
  - Machine Learning-aided path computation engines with TAPI extensions
  - Contributing to ODL/TPCE project development

Open Networking Foundation - Transport API (T-API) Overview

Open Transport Network Enabler*

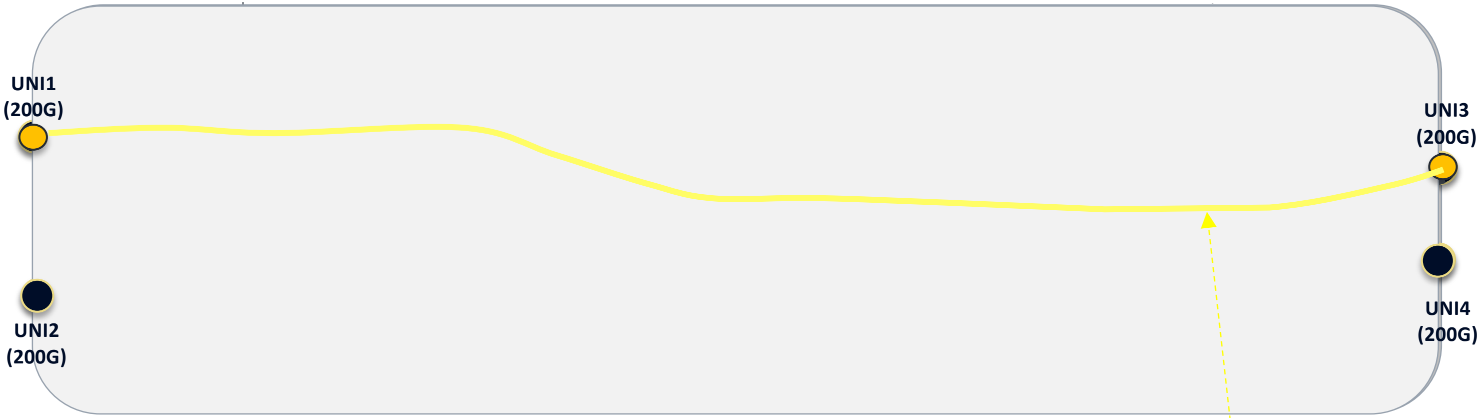
* « Multi-layer Multi-domain Network Topology Abstractions Using ONF Transport API»
Karthik Sethuraman, NEC, Sept. 2019

- TAPI project was initiated at ONF in 2014.
- T-API is typically between (Domain) *Resource Controller(s)* and a Service *Orchestrator* acting as a parent controller.
- T-API enables hierarchical recursion control pattern* which high-level SDN controller orchestrates network services across one or more lower-level SDN controllers with narrower scopes and less abstract resources
- T-API has been designed to allow network operators to deploy SDN across a multi-layer, multi-domain, multi-vendor transport infrastructure
- TAPI enables extending end-to-end network service programmability across neighbor transport network domains


Industry Adoption: Functional Interface solution that fulfills conflicting requirements of stability (interoperability) & flexibility (technology evolution)

Layer 0 Connectivity Service realized by SDN Domain Controller through TAPI

MDSO request L0 Connectivity services



L0 Connectivity Service
(MDSO view)

Abbreviations

DSR – Digital Signal Rate (Ethernet/ODU)
TPD – Transponder: MXPDR or Pluggable
RDM – ROADM Node
UNI – User-Network Interface
NNI – Network-Network Interface
OTSi – Optical Tributary Signal
OTSiA – OTSi Assembly
MC – Media Channel
MCA – Media Channel Assembly

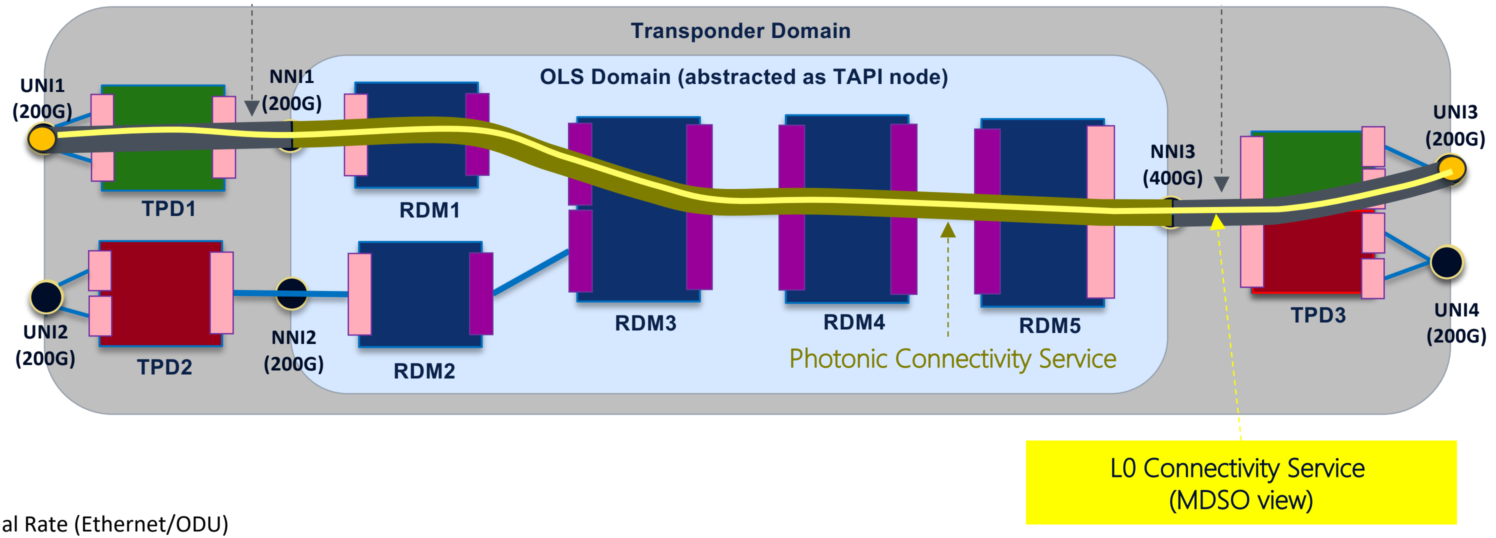
- Transport Network Infrastructure with 2 operation domains:
  - Transponder domain
  - OLS/ROADM domain (abstracted as a TAPI node)
- And with two Customers (Red and Green) connected to Transponders
- At TPD Nodes - DSRs are nested into ODU aggregated into OTSi / MC
- Only Photonic media switching assumed on ROADMs

Logical Termination Points shown

● Service Interface Point
🟥 Node Edge Point (Network Edge)
🟪 Node Edge Point (Network Internal)
● Connectivity Service End Point

Layer 0 Connectivity Service realized by SDN Domain Controller through TAPI

MDSO request L0 Connectivity services



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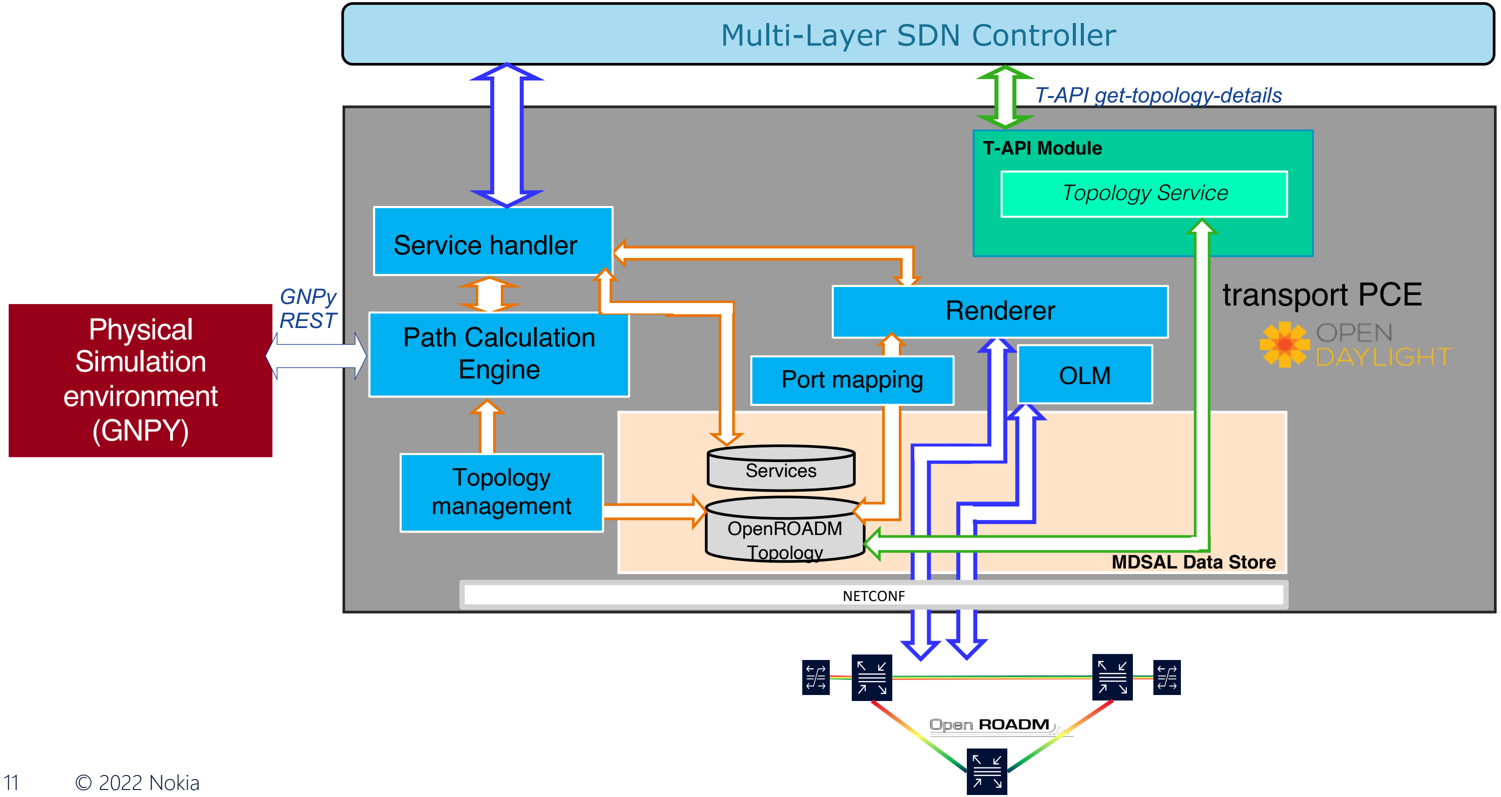
IMPLEMENTATION

TransportPCE: T-API initial status - Magnesium SR0



TransportPCE: initial status

T-API models were first introduced in Magnesium SR0 release. Need to install the corresponding Karaf feature: odl-transportpce-tapi

Limited set of RPCs implemented: get-tapi-topology-details

Non persistent data. T-API topology data was created on demand (and with 2 levels of abstraction: *T0 Multi Layer topology* & *Transponder 100GE*)

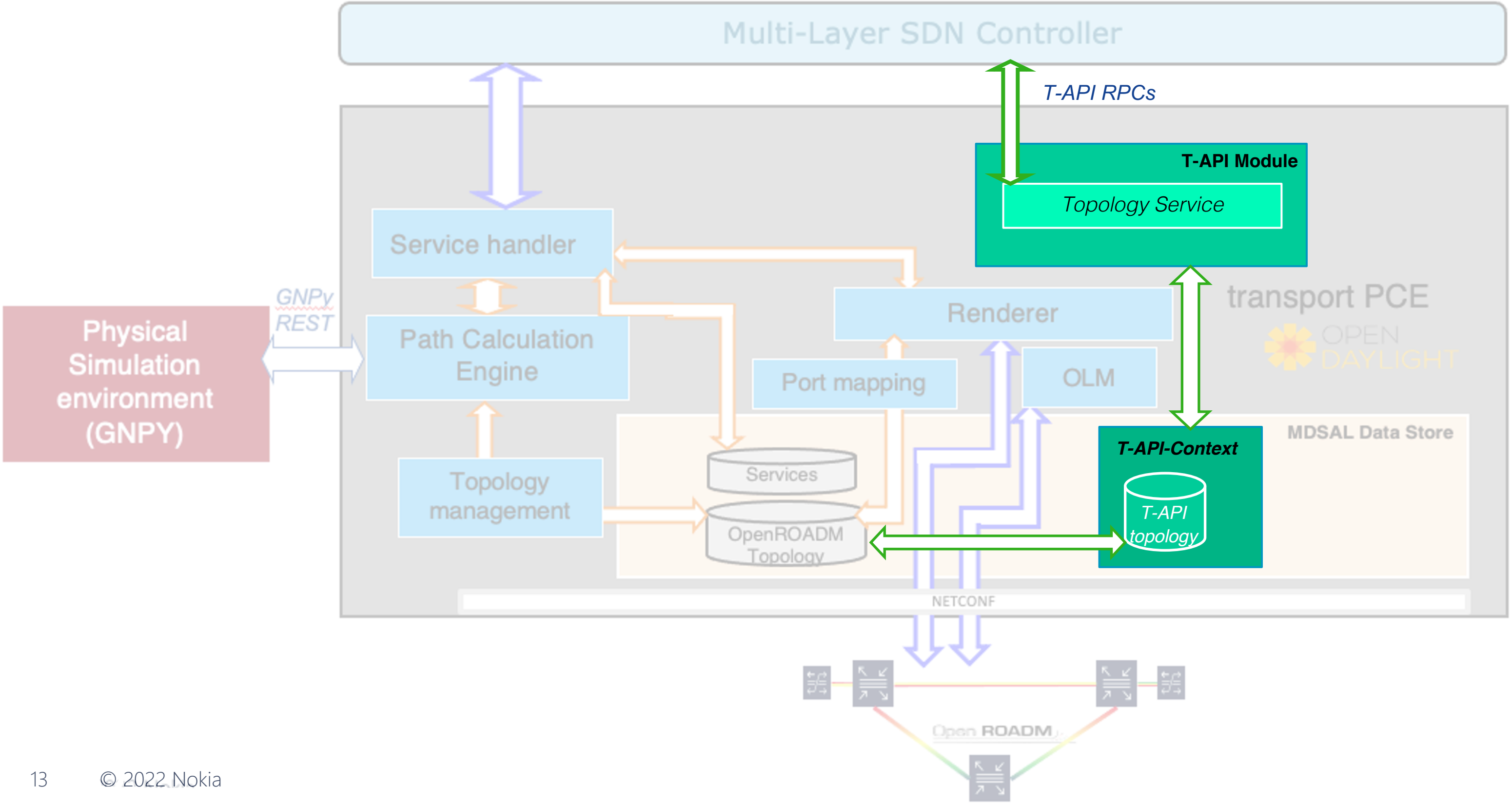
Drawbacks:

- T-API information mapped on demand. On a big transport topology, the process can take a long time
- Fully dependent on T-PCE modules & OpenROADM models

Goals:

- Enhance T-API module to support T-API services and integrate T-API related data inside MD-SAL
- Coexistence of T-API and OpenROADM models

TransportPCE: T-API Topology Service development



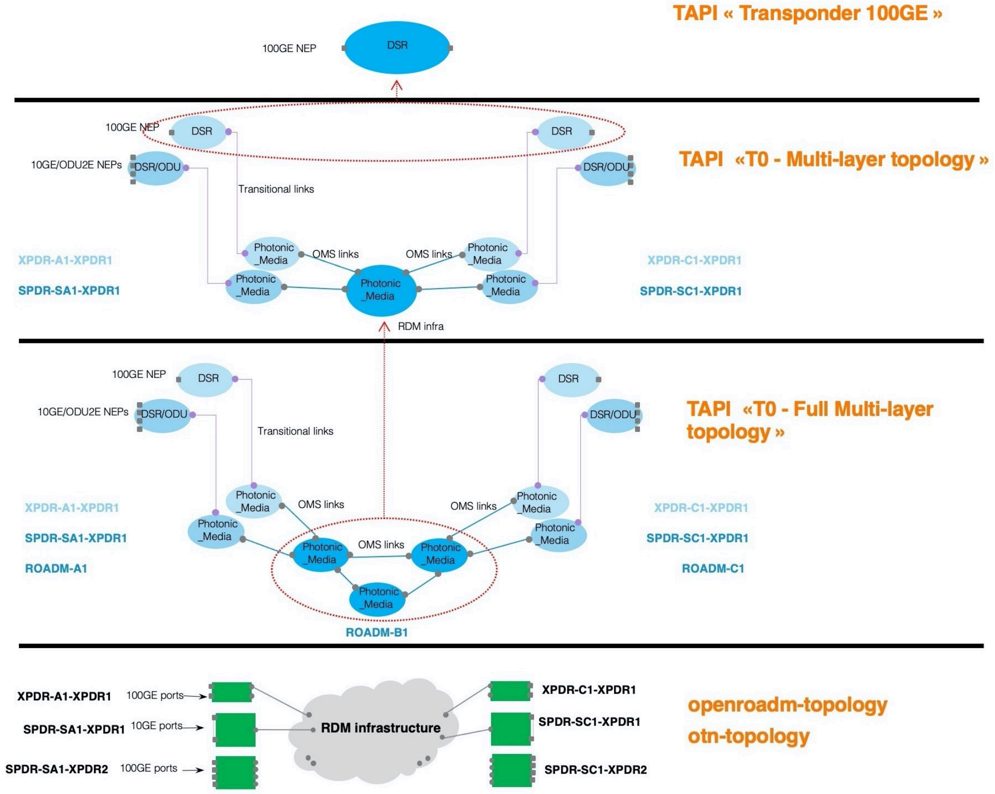
TransportPCE: T-API module development

T-API topology service

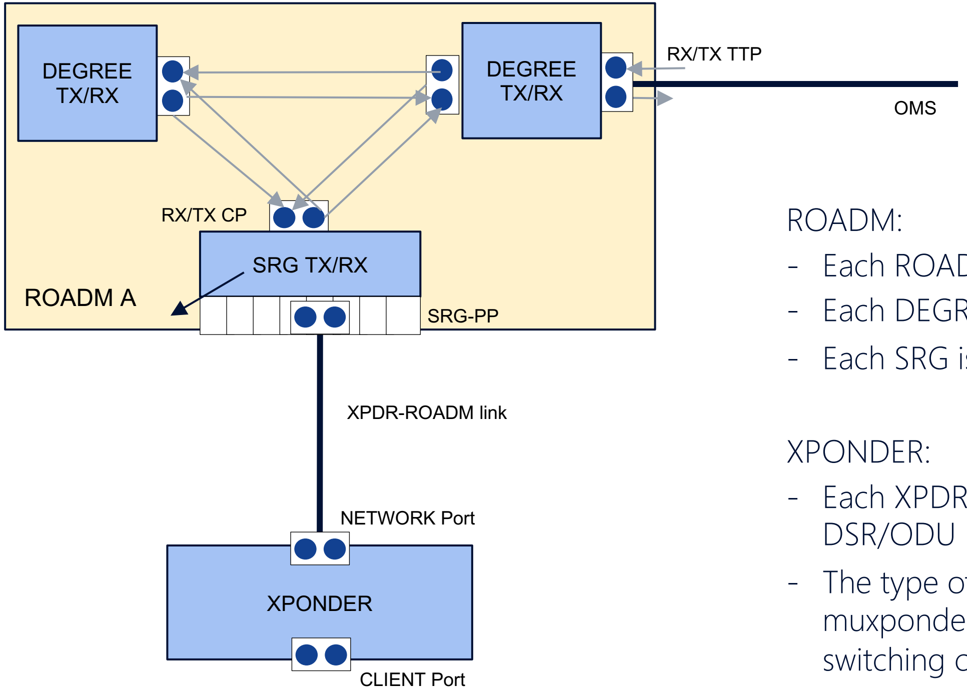
- Integration of T-API topology service in MD-SAL
- On T-API feature install:
  - OpenROADM topology data is mapped into T-API topology data and stored in the MD-SAL
- T-API topology context will be populated on connection/disconnection of a NETCONF device using the same strategy as OpenROADM topologies (through NetconfTopologyListener)
- Integrated a 3rd T-API topology: *T0 Full Multi Layer topology*. No abstraction of the OLS. Each NETCONF node is represented as a T-API node. ***Following T-API reference guide (backup slide)***
  - New mapping proposed from OpenROADM based nodes to T-API nodes
- Implementation of T-API topology service RPCs

TransportPCE: T-API module development

T-API topologies



OpenROADM view → ROADM+XPDR (simplified view)



ROADM:

- Each ROADM node is converted into 1 T-API node
- Each DEGREE is mapped into 3 NEPs
- Each SRG is mapped into 3 NEPs + 1 SIP

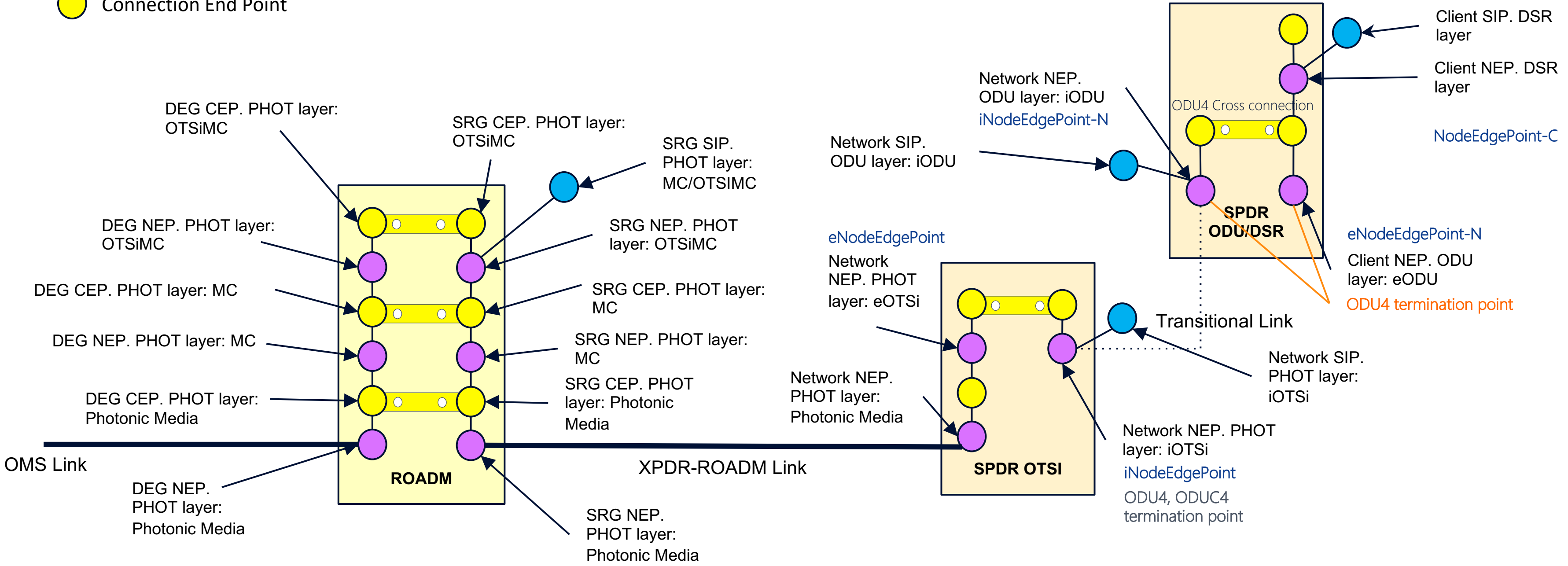
XPONDER:

- Each XPDR is converted into 2 T-API nodes: OTSi & DSR/ODU
- The type of XPDR (transponder, switchponder or muxponder) will be considered when mapping the switching capabilities

T-API view → ROADM+XPDR (T0 - Full Multi Layer topology)

Logical Termination Points shown

- ● Service Interface Point
- ● Node Edge Point
- ● Connection End Point



DEG CEP. PHOT layer: OTSiMC
SRG CEP. PHOT layer: OTSiMC
SRG SIP. PHOT layer: MC/OTSIMC
DEG NEP. PHOT layer: OTSiMC
SRG NEP. PHOT layer: OTSiMC
DEG CEP. PHOT layer: MC
SRG CEP. PHOT layer: MC
DEG NEP. PHOT layer: MC
SRG NEP. PHOT layer: MC
DEG CEP. PHOT layer: Photonic Media
SRG CEP. PHOT layer: Photonic Media
OMS Link
ROADM
DEG NEP. PHOT layer: Photonic Media
SRG NEP. PHOT layer: Photonic Media
XPDR-ROADM Link
Network SIP. ODU layer: iODU
Network NEP. ODU layer: iODU
iNodeEdgePoint-N
ODU4 Cross connection
Client SIP. DSR layer
Client NEP. DSR layer
NodeEdgePoint-C
SPDR ODU/DSR
eNodeEdgePoint-N
Client NEP. ODU layer: eODU
ODU4 termination point
eNodeEdgePoint
Network NEP. PHOT layer: eOTSi
Transitional Link
Network SIP. PHOT layer: iOTSi
Network NEP. PHOT layer: Photonic Media
SPDR OTSI
Network NEP. PHOT layer: iOTSi
iNodeEdgePoint
ODU4, ODUC4 termination point

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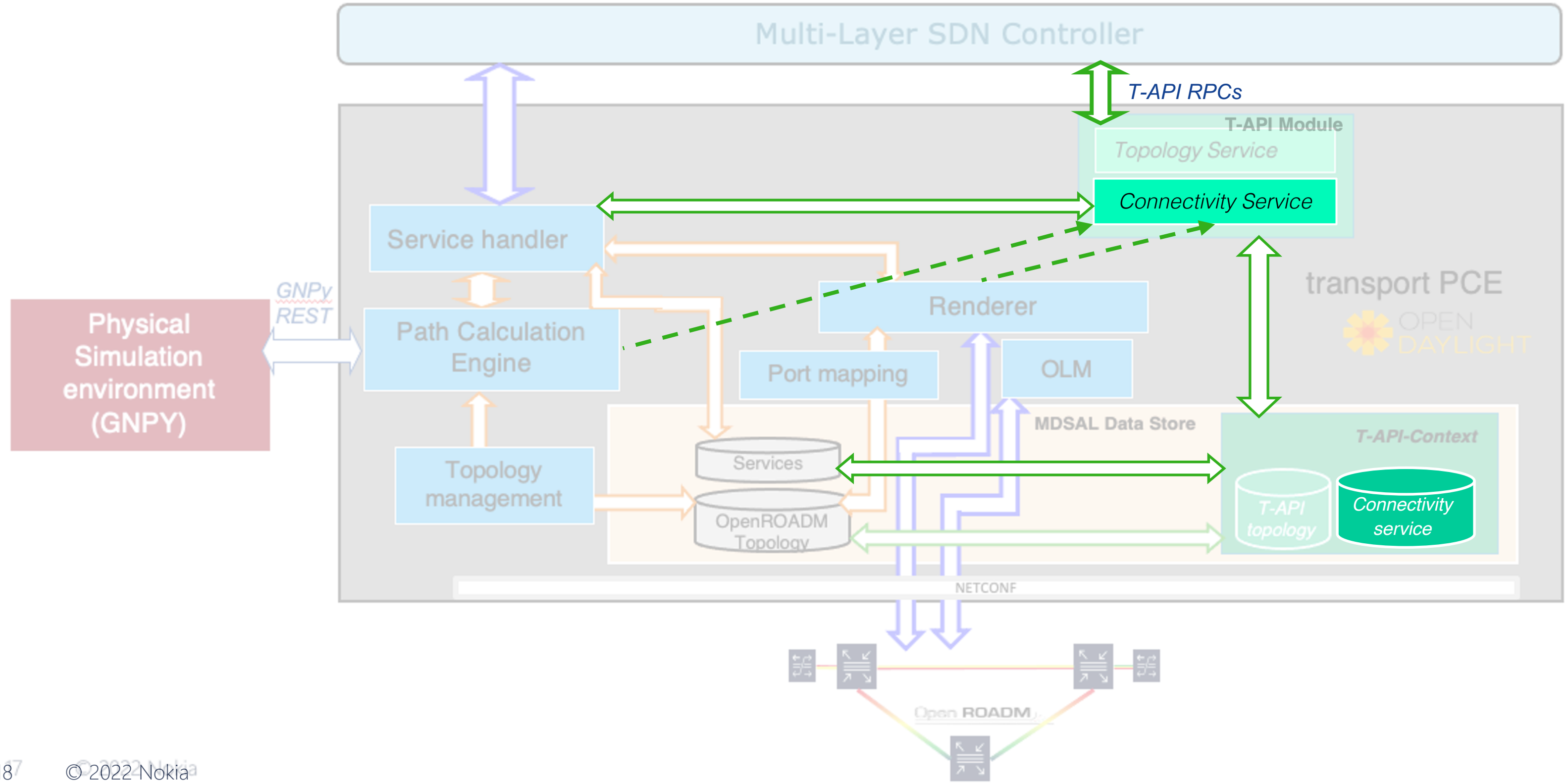
TransportPCE: T-API Connectivity Service development

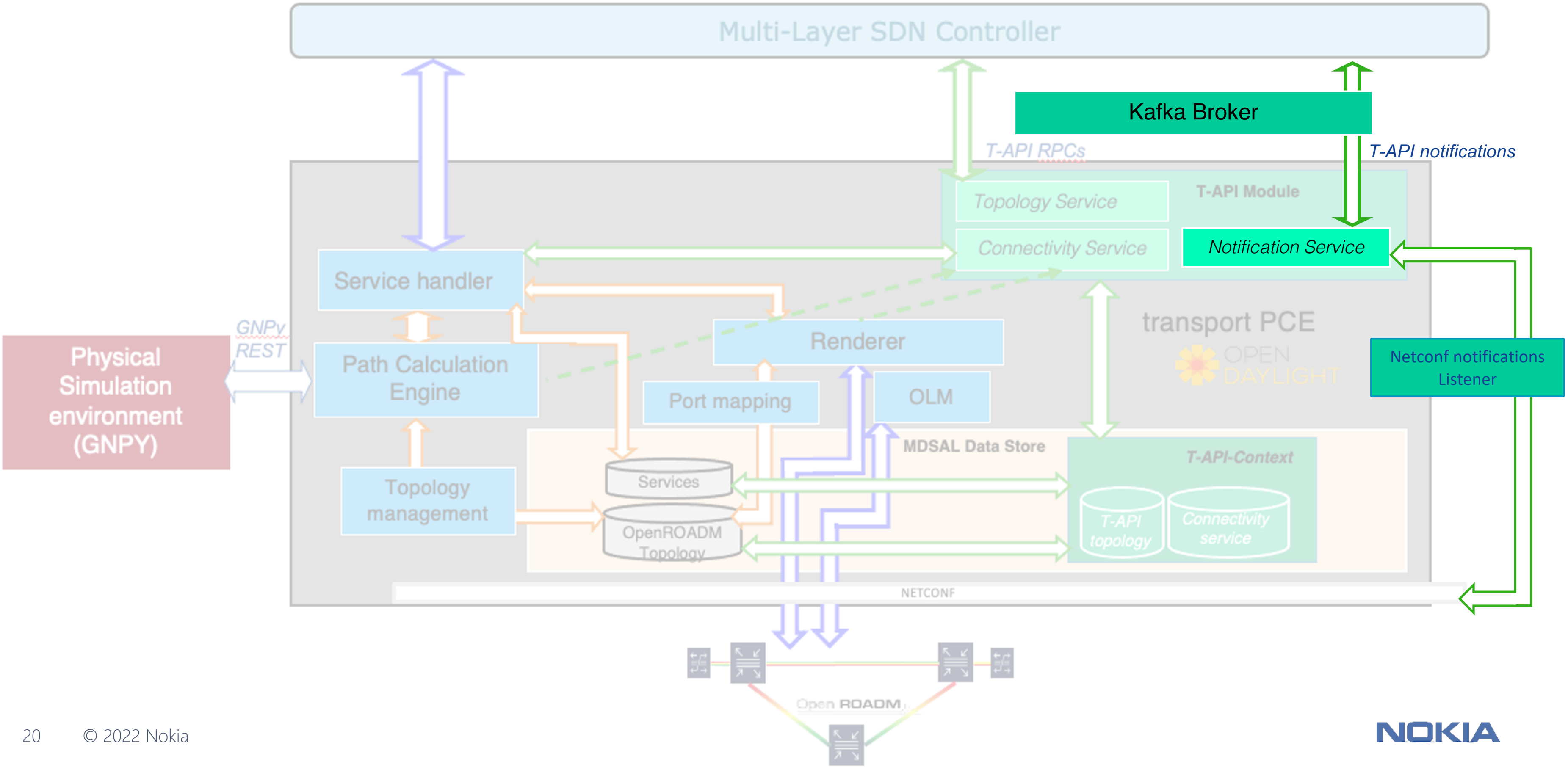


TransportPCE: T-API module development

T-API connectivity service

- Integration of T-API connectivity service in MD-SAL
- On T-API feature install:
  - OpenROADM services data is mapped into T-API connectivity service & connection data and stored in the MD-SAL
- Implementation of T-API connectivity service RPCs (except *update-connectivity-service*)
- T-API connectivity context will be populated on reception of a new connectivity service RPC request
- Mapping from T-API connectivity service request to OpenROADM service create
- Registration of listeners in T-API modules to receive notifications from the PCE & Renderer modules
  - Upon reception of a PCE notification, all necessary T-API CEPs & connections are created in the T-API context
  - Upon reception of a Renderer notification, all T-API connection and connectivity services change their state
- Support for: 100GE WDM services, OTN services

TransportPCE: T-API Notification Service development



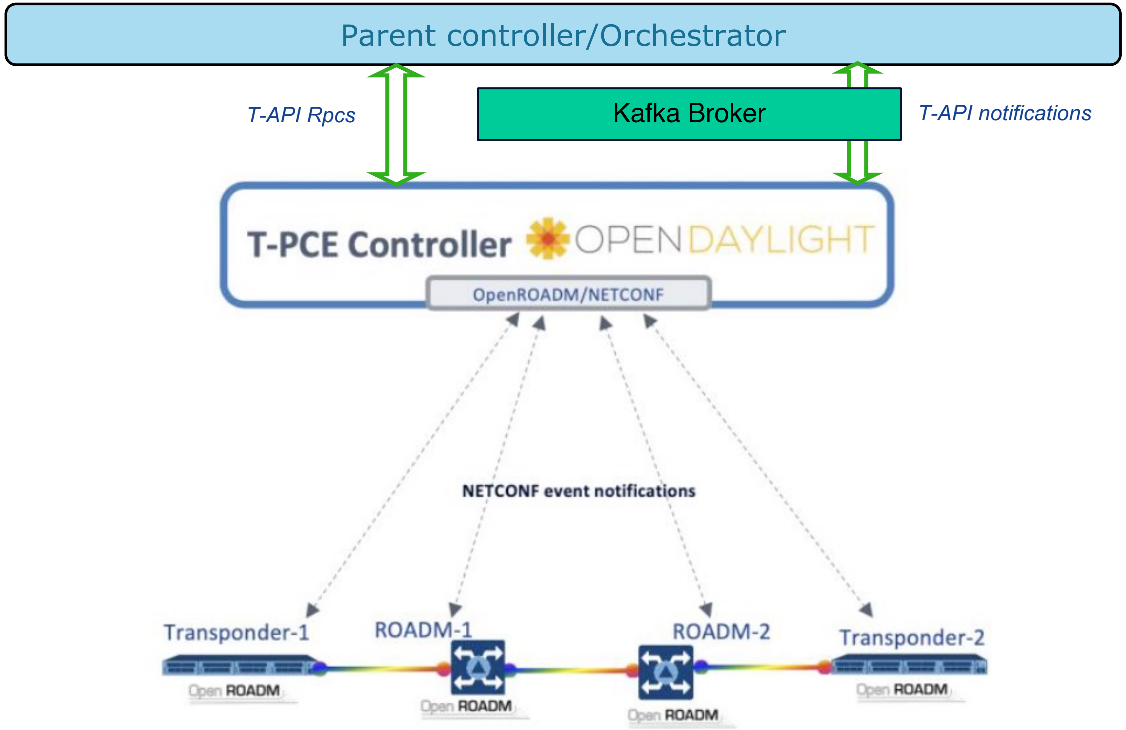
TransportPCE: T-API module development

T-API notification service

- Integration of T-API notification service in MD-SAL
- On Device configuration change (NETCONF event):
  - T-API topology update: node & link state update
  - T-API connectivity update: connection & connectivity service update
- Implementation of T-API notification RPCs (except *update-notification-subscription-service*)
- Extension of NBI-notification module to support T-API notifications:
  - Create/delete Kafka topic on demand
  - Serialize/Deserialize T-API notification based on the direction of the “stream”

IMPLEMENTED SCENARIO

Implemented Scenario



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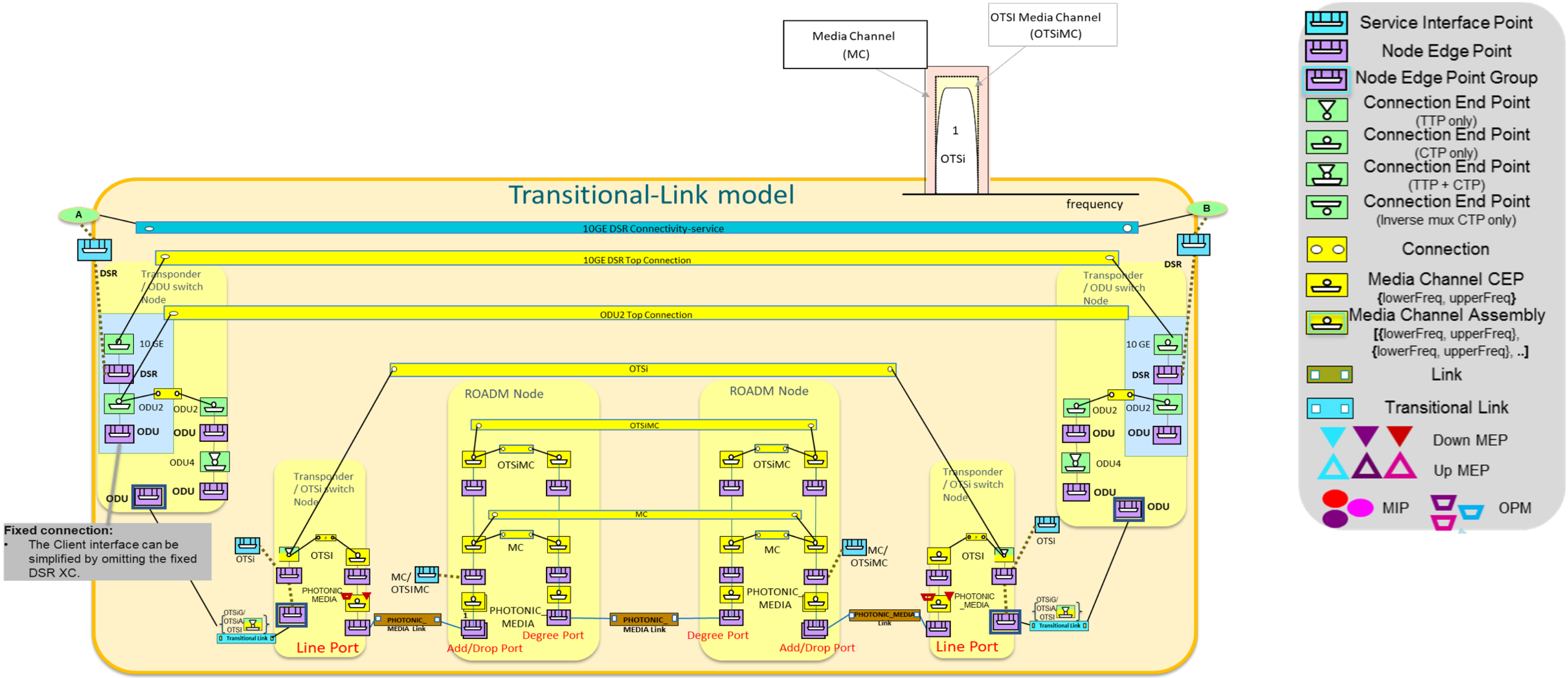
THANK YOU

Backup: T-API reference guide version 2.1.3



Fixed connection:

- The Client interface can be simplified by omitting the fixed DSR XC.