# 2020 SDN API Interop Demo
# Public readout

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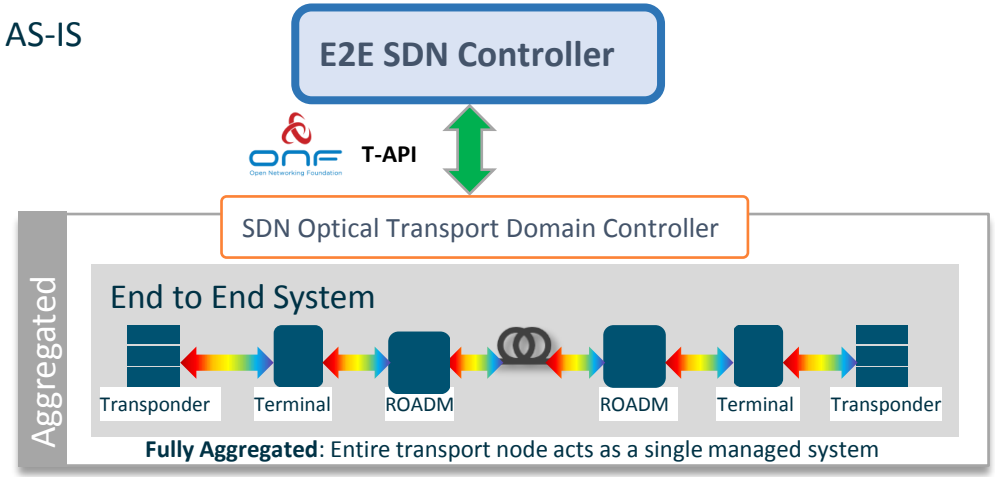
# Open Optical Networks

## Optical disaggregation will bring a flexible and modular network element architecture

Two key aspects to make **Open Optical Networks** a reality

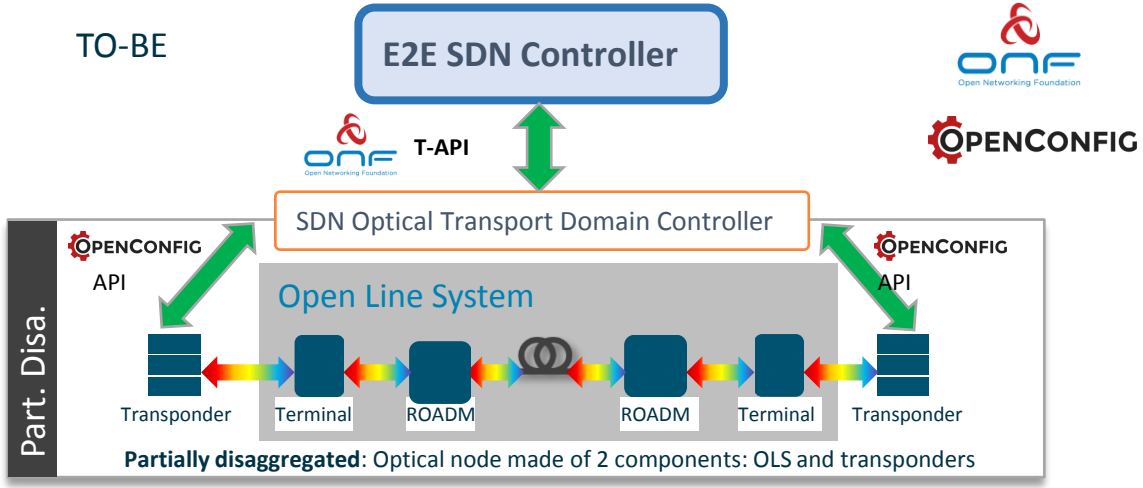
- ***Interoperability*** *through standard interfaces*
- ***SDN Control Plane*** *capabilities, based on* ***standard*** *models, to glue multivendor solutions*

AS-IS




Open Optical Networks

TO-BE




- Nowadays, network operators deploy optical nodes provided as an end-to-end closed solution
- They are being connected to SDN Domain controllers, via T-API interface, to automate provisioning, configuration and operation of a network domain.

- Within TIP, OIF and ONF, Telefonica is collaborating in operator-led initiatives to create open disaggregated optical equipment, open and common standards, and open source software
- Open Terminals (OTs) and OLS can be supplied by different vendors.
- Each component (OLS and OT) is managed independently by the SDN domain controller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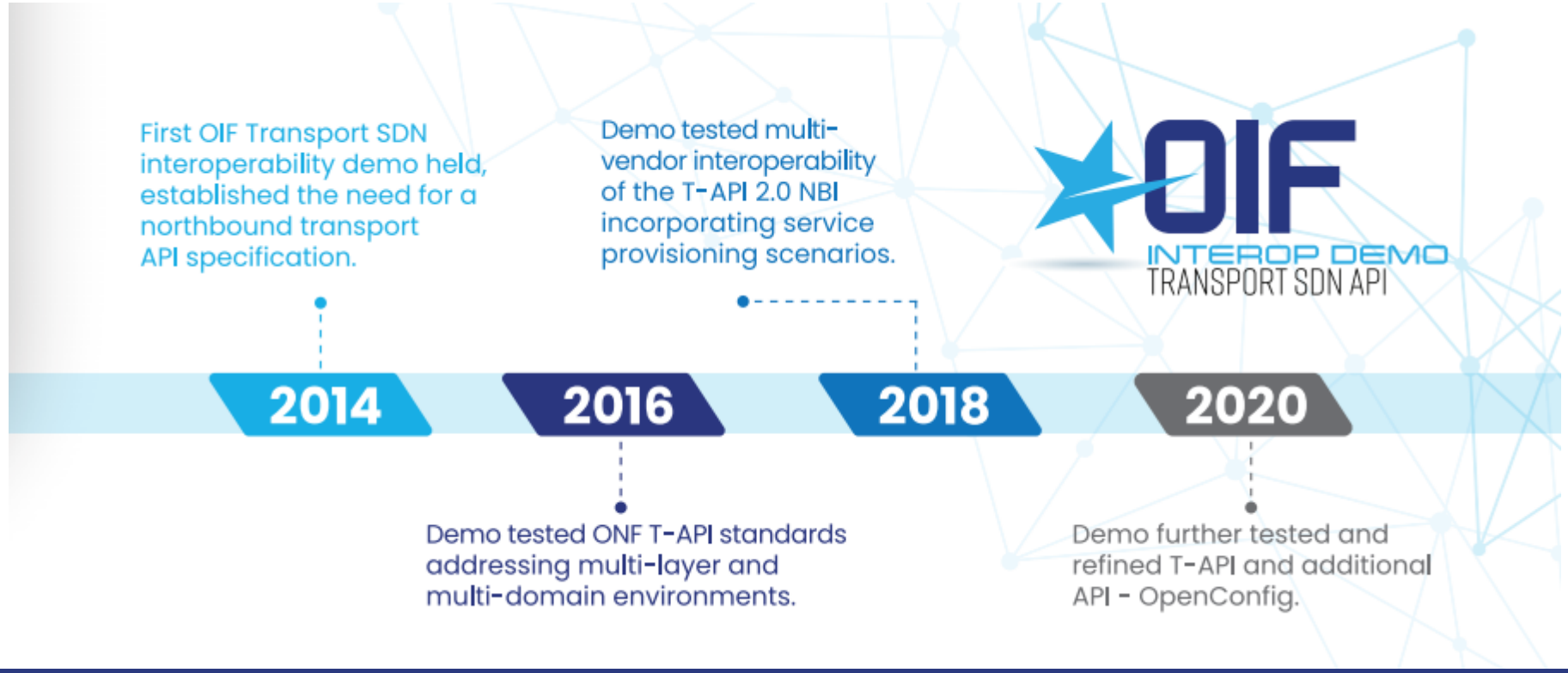
# OIF Transport SDN Interop Demo History




Helping the industry develop standard, robust, interoperable APIs for widescale adoption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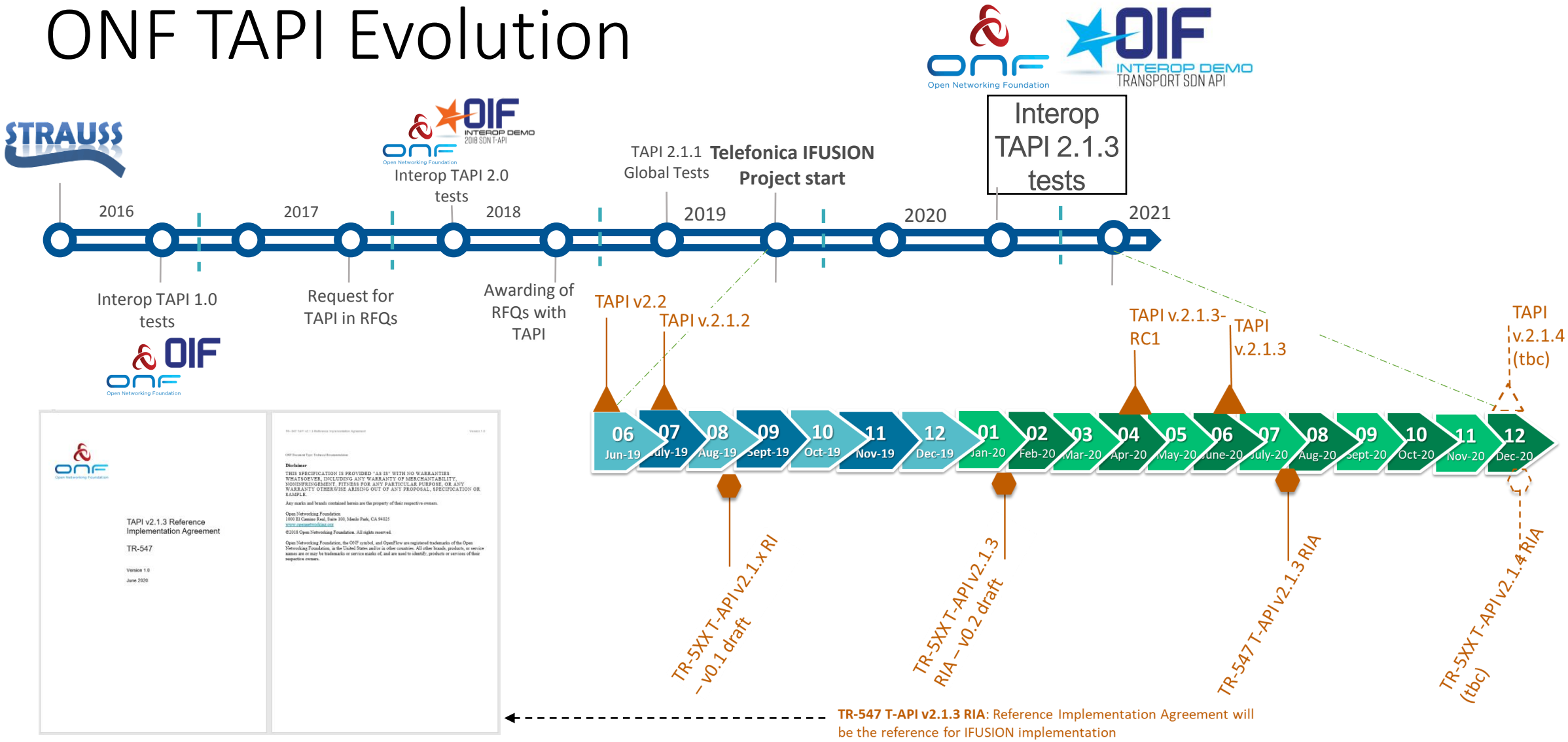
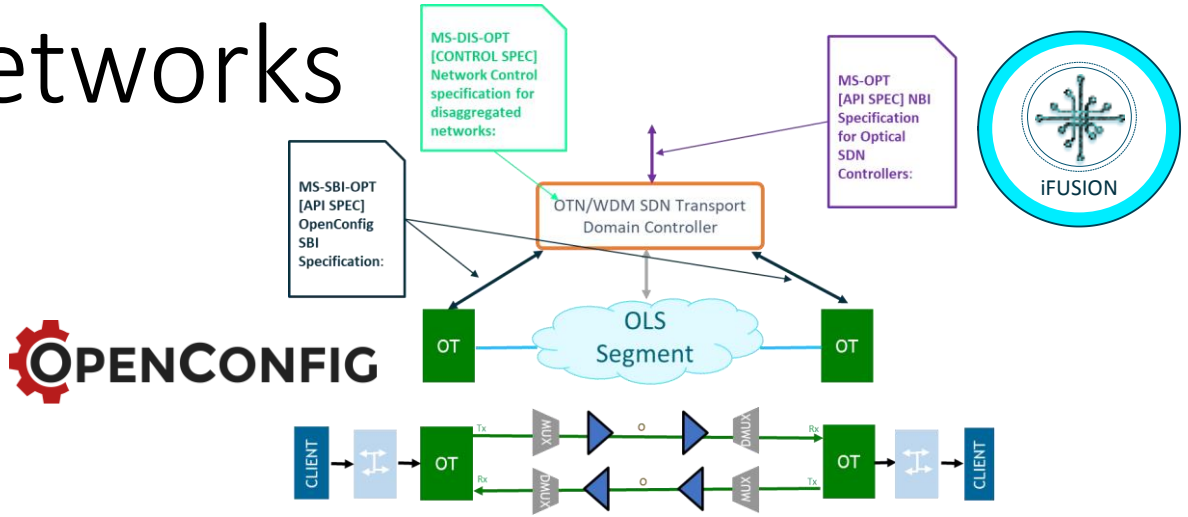
# ONF TAPI Evolution



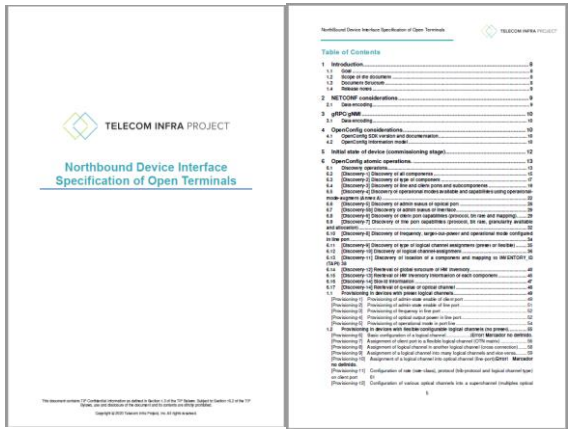
# Partially disaggregated Networks

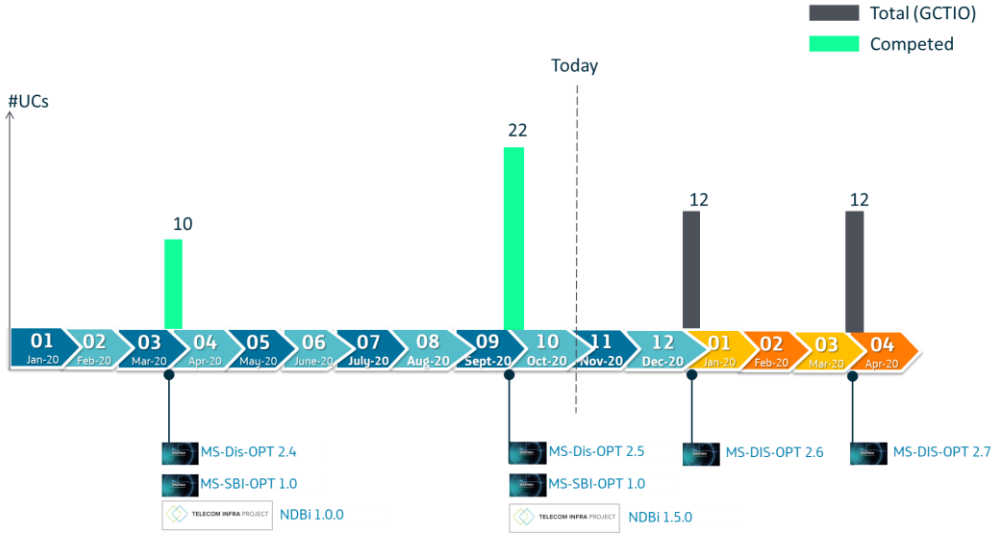
SBI specification based on OpenConfig [MS-SBI-OPT] and SDN Controller specification for Partially disaggregated Networks is being shared across the industry on several ways:

- As part of **Telefonica iFUSION project** documentation has released to all Telefonica relevant suppliers participating into this project.
- **At Telecom Infra Project (TIP) Disaggregated Optical Systems (DOS)** and **Mandatory Use case requirements for SDN for Transport (MUST)** (NDBi v0.1.5 Specification is being discussed).



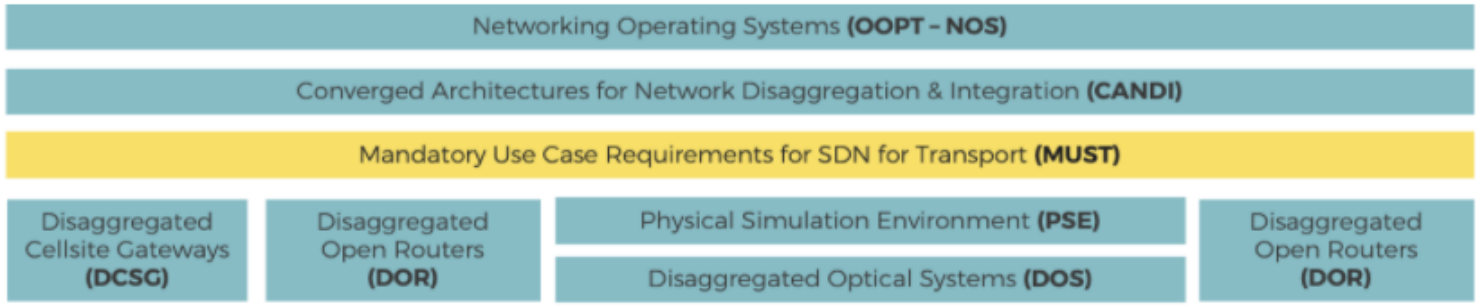

- *Telefonica iFUSION specifications map*



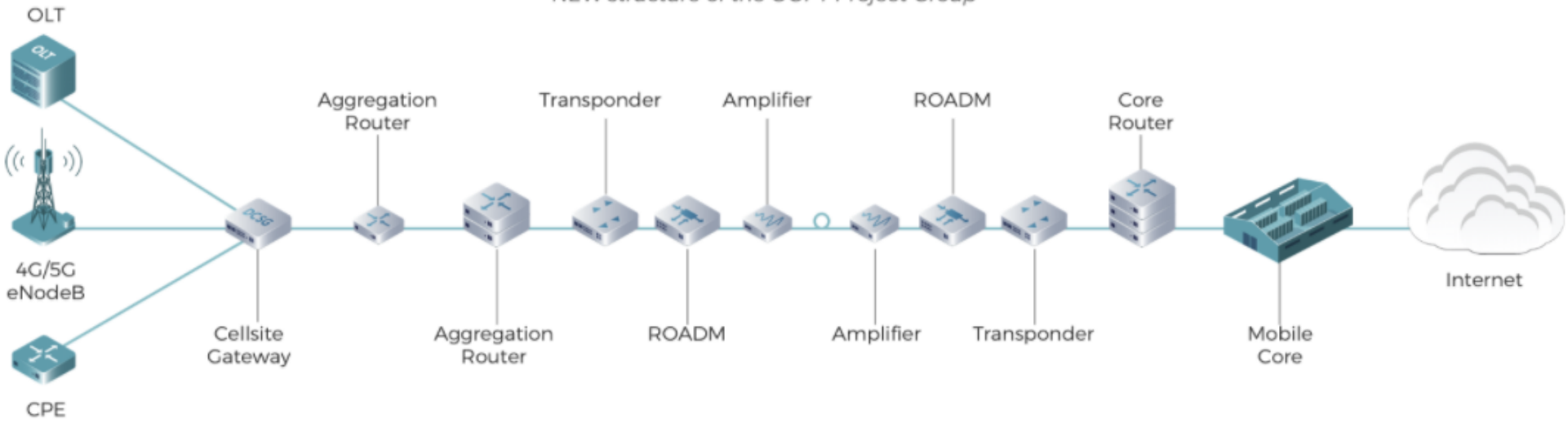




*iFUSION design progress*

# The TIP environment for Open Optical networks

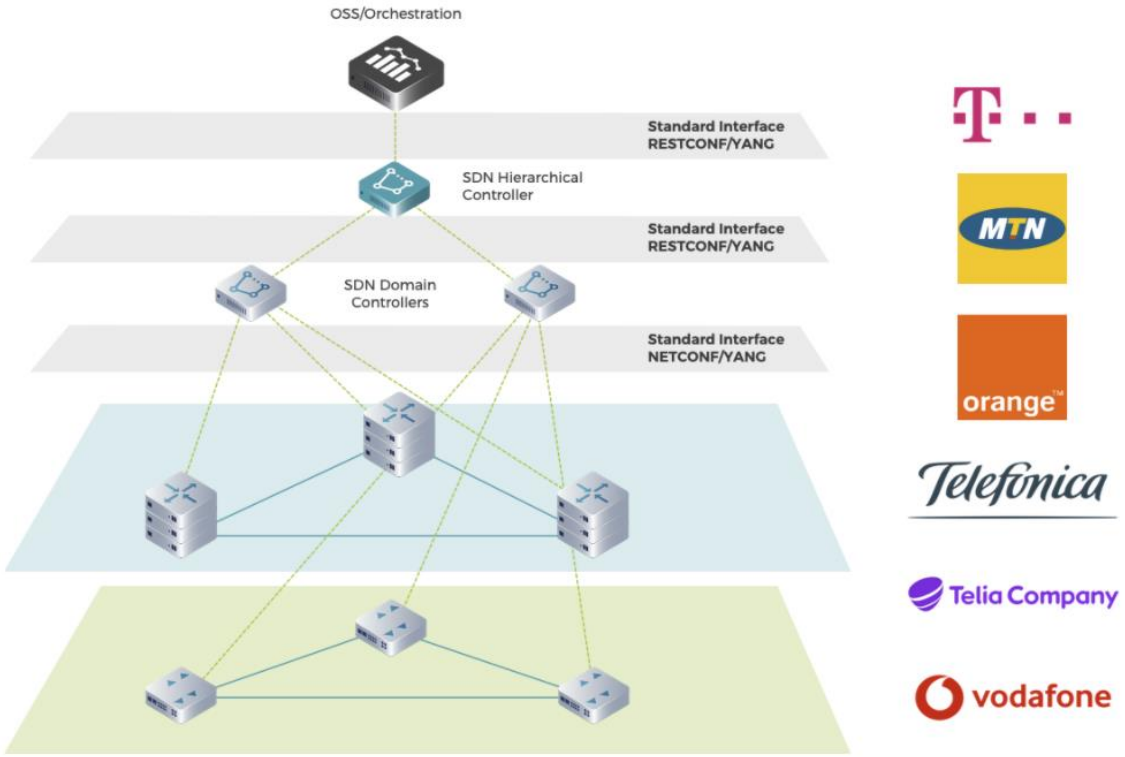



*NEW structure of the OOPT Project Group*



# MUST - Mandatory Use Case Requirements for SDN for Transport

- 6 Major Operators to Drive SDN for Transport Adoption and Acceleration Through the Telecom Infra Project
- The main objective of MUST is to accelerate and drive the adoption of SDN standards for IP/MPLS, Optical and Microwave transport technologies, through:
  - SDN common architecture
  - Agreed standard APIs
  - Commonly defined use cases
- Whitepaper available!
- TIP MUST and OIF exploring alignment and opportunities



# Testing scope and lab scenario

2020 SDN API Interop Demo

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# OIF 2020 Transport SDN Interop

- **Collaboration between OIF and ONF**
  - OIF – Optical and Transport Networks
    - API Framework
    - Prototype API experience – 2014, 2016 & 2018 Interop Demonstration events
  - ONF – SDN
    - SDN Architecture
    - Transport API Specification and Reference Implementation

# OIF 2020 Transport SDN Interop

OIF INTEROP DEMO TRANSPORT SDN API

**1**

Global host operator

Telefonica

**3**

Consulting operators

中国电信 CHINA TELECOM, TELUS, Telia

**5**

System vendors

ADVA Optical Networking, ciena, CISCO, Infinera, NOKIA

**10**

Weeks of testing
Sept – Nov 2020

**21**

Integrations
between suppliers

**29**

T-API use
cases tested

**31**

OpenConfig
operations tested


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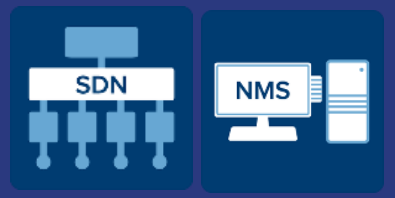
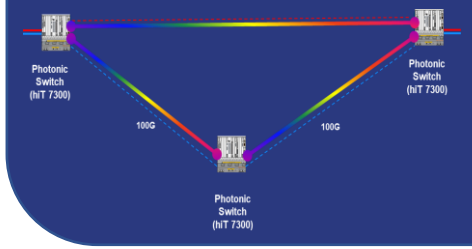
# Lab setup

## Infinera

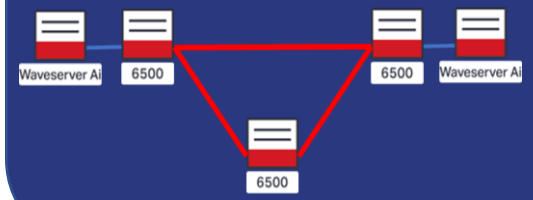



**SDN-C SW details:**
- TNMS V18.10.2.51.0
- Transport Controller R4.20.0.1388.0

**HW details:**
- 3 x nodes CD-AD, hiT7300 ONN-X96 5.40.70

## Ciena




**H-SDN-C SW details:**
- MDSO

**SDN-C SW details:**
- MCP 4.2.4

**HW details:**
- 3 x nodes 6500 S14
- 2 x Waveserver Ai OTs

## Cisco

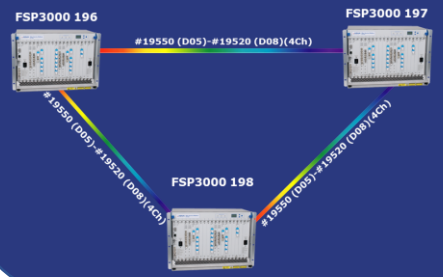
**H- SDN-C SW details:**
- Cisco Network Services Orchestrator (NSO) 5.3.2

NCS 1004

**HW details:**
- 1 x NCS 1004 EFT OT

## ADVA

FSP 3000




**SDN-C SW details:**
- Ensemble Controller version 12.3.1

**HW details:**
- 3 x nodes FSP 3000 version 18.2.2

## Nokia

CD

M&C

WS-H&A

2 x 130SCX10

**H-SDN-C SW details:**
- Cross Domain Controller

**SDN-C SW details:**
- Management & Control (NFM-T and NRC-T)
- WaveSuite Health & Analytics

**HW details:**
- 2 x 130SCX10 OTs
- WaveHub lab:
  - 3 x PSS32
  - PSS32 + PSS8x
  - PSS32 + PSS24x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# OIF 2020 Transport SDN Interop

**Evaluate current state of SDN in Transport industry**

- Validate APIs in SDN Framework
  - Useful:
    - Do the defined APIs solve operator's use cases?
  - Perform well:
    - Would a different API improve performance?
  - Can be implemented
- High level scope of the tests
  - Programmability, control, automation
  - Layer 1 and Layer 0 OTN
  - ONF T-API 2.1.3
  - OpenConfig

# OIF 2020 Transport SDN Interop

**Evaluate current state of SDN in Transport industry**

Phase I

ONF Open Networking Foundation

Transport API

Phase II

OPENCONFIG

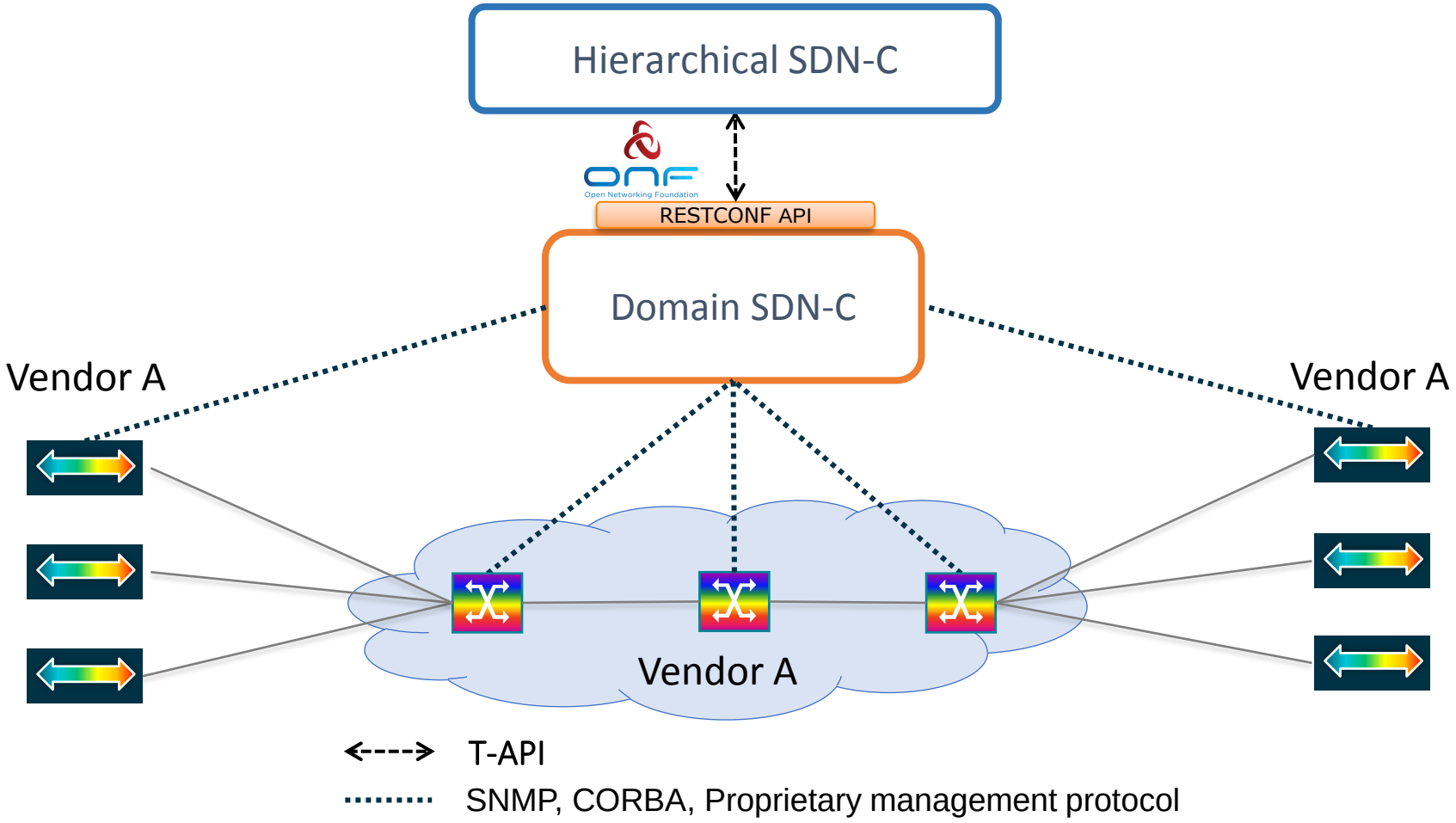
Phase III

ONF Open Networking Foundation

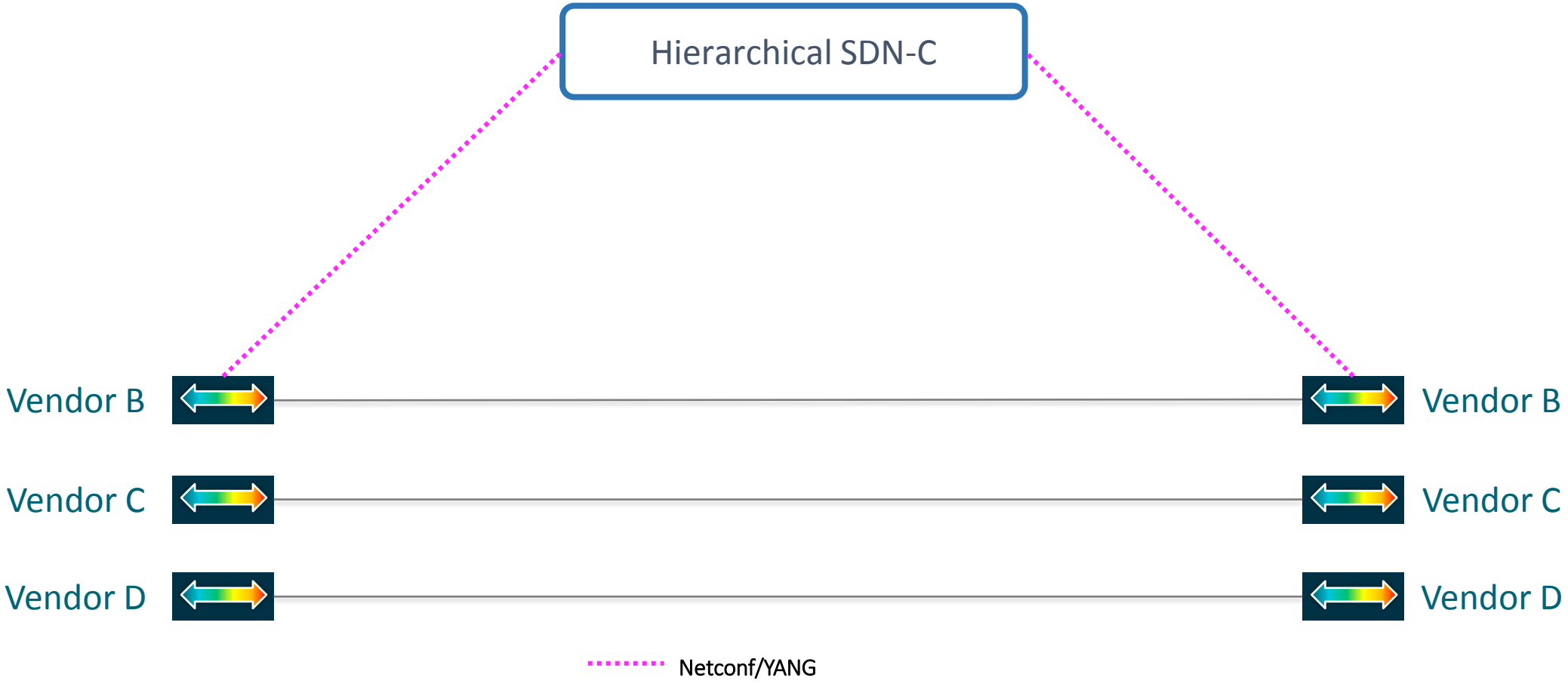
+

OPENCONFIG

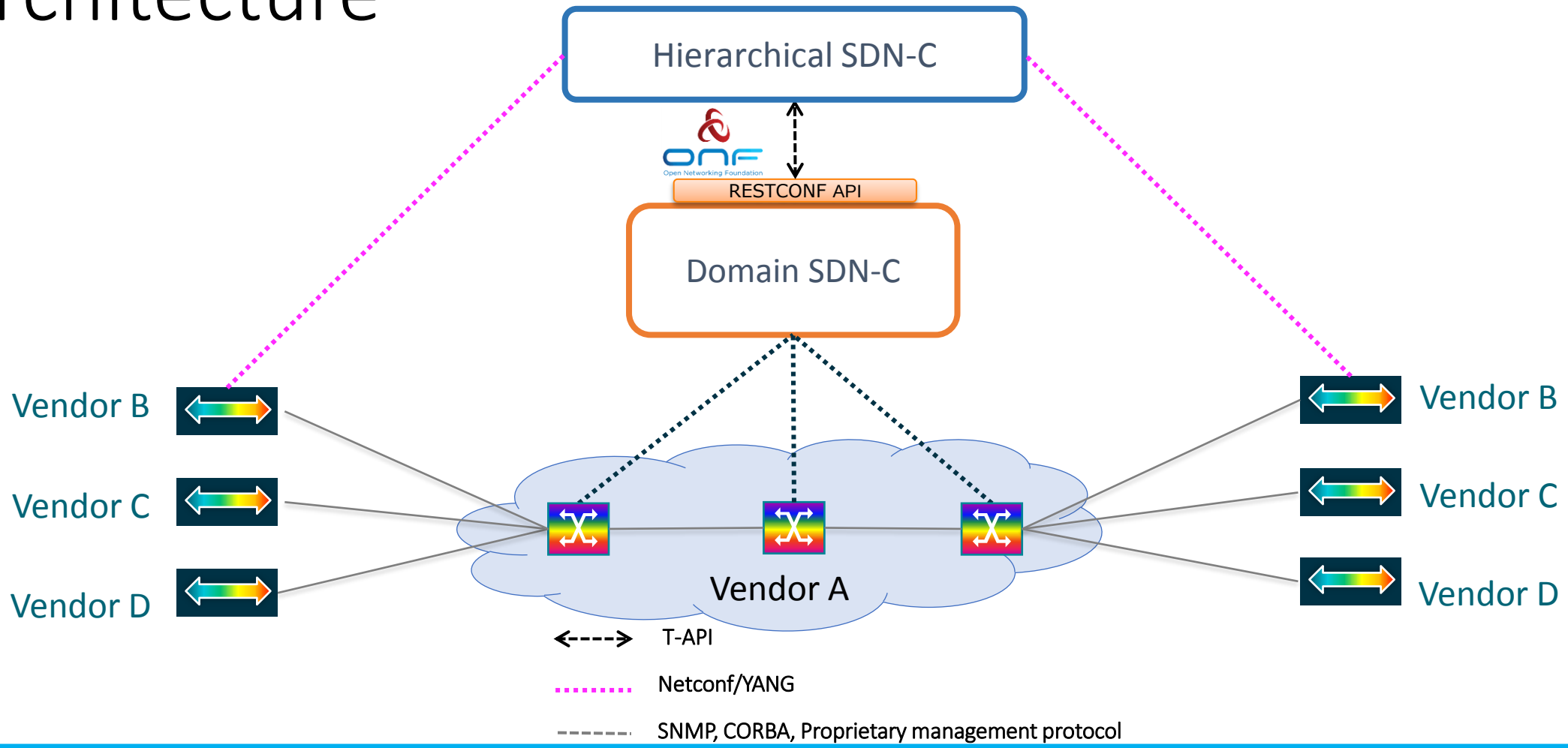
# Phase I: Aggregated SDN architecture



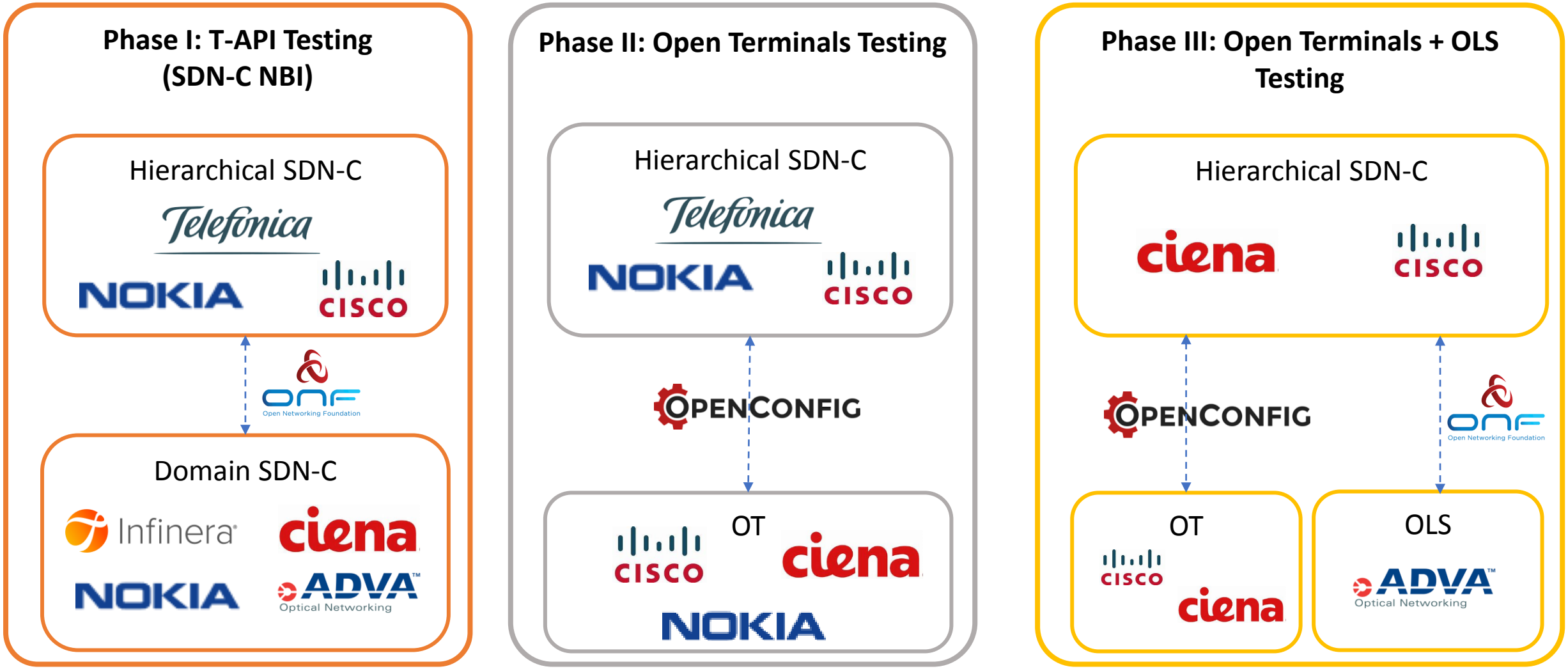
# Phase II: PtP SDN architecture



# Phase III: Partially Disaggregated SDN architecture



# Participants at Telefonica lab and roles





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# Test Tracking

| | | Supplier A - Supplier B |
|---|---|---|
| UC # | ID Test case | Result |
| Use Case 0a: Context & Service Interface Points discovery | NBI_0A_TR1 | Not Tested |
| Use Case 0a: Context & Service Interface Points discovery | NBI_0A_TR2 | Open |
| Use Case 0a: Context & Service Interface Points discovery | NBI_0A_TR3 | Completed |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR1 | Not Tested |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR2 | Open |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR3 | Completed |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR4 | Not Tested |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR5 | Open |
| Use Case 0b: Topology discovery (synchronous mode) | NBI_0B_TR6 | Completed |
| Use case 0c: Connectivity service discovery (synchronous mode) | NBI_0C_TR1 | Completed |

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# Phase I: ONF TAPI NBI testing

- Scope: ONF TAPI v2.1.3 Reference implementation agreement TR-547

- Discovery use cases (2 use cases):
  - Topology and services
- Connectivity Provisioning (8 use cases):
  - All networking layers: DSR, ODU, OTSi/OTSiA, NMC
  - Topology constrains (routing)
  - Service constrains (latency)
- Inventory (2 use cases):
  - Correlation with legacy inventory
  - All TAPI Native inventory.

| Use Cases |
|---|
| **Discovery use cases:** |
| Use case 0a: Context & Service Interface Points discovery (synchronous mode) |
| Use case 0b: Topology discovery (synchronous mode) |
| **Provisioning use cases:** |
| Use case 1a: Unconstrained DSR Service Provisioning single wavelength. |
| Use case 1b: Unconstrained DSR Service Provisioning multi wavelength. |
| Use case 1d: Unconstrained PHOTONIC_MEDIA/OTSi Service Provisioning |
| Use case 1e: Unconstrained PHOTONIC_MEDIA/OTSiA Service Provisioning |
| Use case 1f: Unconstrained PHOTONIC_MEDIA/MC Service Provisioning |
| Use case 3a: Constrained Provisioning - Include/exclude a node or group of nodes. |
| Use case 3b: Constrained Provisioning -Include/exclude a link or group of links. |
| Use case 3c: Constrained Provisioning - Include/exclude the path used by other service. |
| **Inventory use cases:** |
| Use case 4a: Introduction of references to external inventory model. |
| Use case 4b: Complete Inventory model for NBI Interface |

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# Phase I: ONF TAPI NBI testing

- Scope: ONF TAPI v2.1.3 Reference implementation agreement TR-547

- Resiliency (8 use cases):
  - 1+1 Protection (OLP, E-SNCP)
  - Restoration
  - Reversion
- Planning & Maintenance (1 use case):
  - Service deletion
- Notifications (7 use cases):
  - Asynchronous synchronization of topology and connectivity TAPI objects and Fault management use cases.

| Use Cases |
|---|
| **Resilience use cases:** |
| Use case 5a: 1+1 OLP OTS/OMS Protection |
| Use case 5b: 1+1 OLP Line Protection with Diverse Service Provisioning |
| Use case 5c: 1+1 Protection with Diverse Service Provisioning (eSNCP) |
| Use case 6a: Dynamic restoration policy for unconstrained and constrained connectivity services. |
| Use case 6b: Pre-Computed restoration policy for unconstrained and constrained connectivity services. |
| Use case 7a: Dynamic restoration and 1+1 protection of DSR/ODU unconstrained service provisioning. |
| Use case 7b: Pre-Computed restoration policy and 1+1 protection of DSR/ODU unconstrained service provisioning. |
| Use case 8a: Permanent protection 1+1 for use cases |
| **Service maintenance use cases:** |
| Use case 10a: Service deletion (applicable to all previous use cases) |
| **Alarms and Notification use cases:** |
| Use case 13a: Subscription to notification service. |
| Use case 14a: Notification of new topology element (topology, link, node, node-edge-point) inserted/removed in/from the |
| Use case 14b: Notification of new connectivity-service element inserted/removed in/from the network. |
| Use case 14c: Notification of new path-computation element inserted/removed in/from the network. |
| Use case 15a: Notification of status change on existing topology element (topology, link, node, node-edge-point) in the n |
| Use case 15b: Notification of status change on existing connectivity-service element in the network. |
| Use case 15c: Notification of status change on the switching conditions of an existing connection element in the network. |

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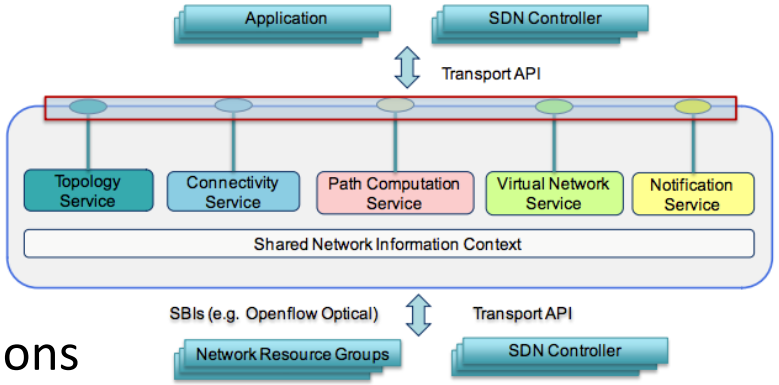
# Transport API Model

- The T-API abstracts four main functionalities:
  1. **Network Topology**
     - Export network topology information **+ Inventory**
  2. **Connectivity Requests**
     - Enable the set-up, tear down and modification of connections
  3. **Path Computation**
     - End-to-end view for the orchestrator
  4. **Network Virtualization**
     - Enable to expose a subset of the network resources to different tenants
  5. **Notification**
     - Messages that provide information about events*

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# TAPI: Retrieve Topology Details

- GET Topology Details

curl -X GET -H "Content-Type: application/json" http://127.0.0.1:8080/restconf/config/context/topology/topo-nwk/

Response:

```
{   “uuid” : “topo-nwk”,
    “name”: [
        { “value-name”: “name”,
          “value”: “NETWORK_TOPOLOGY”
        }
        ……
    ],
    “node” : [
        {……},
        ……
    ],
    “link” : [
        {……},
        ……
    ]
}
```

Every TAPI object has a name attribute that is defined as a list of name-value pairs.

Topology contains Nodes & Links (by value).

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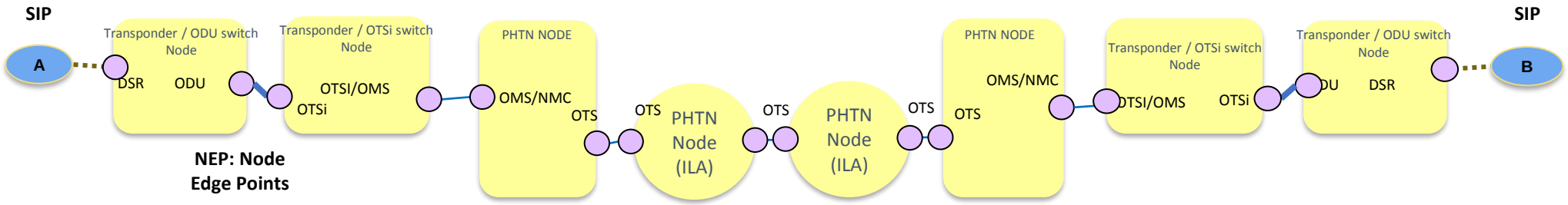
# Towards a equipment model for TAPI

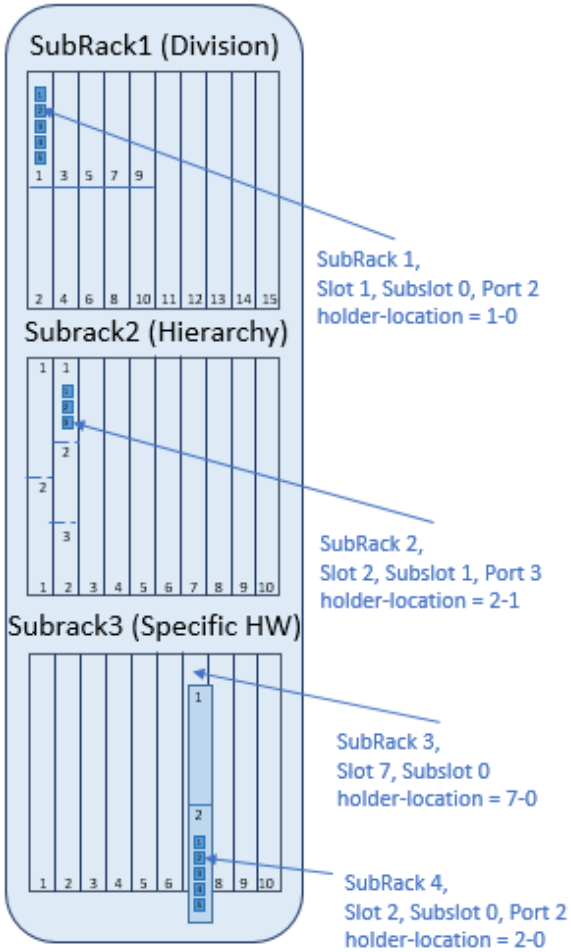
**Nodes expose OTN Hierarchy**

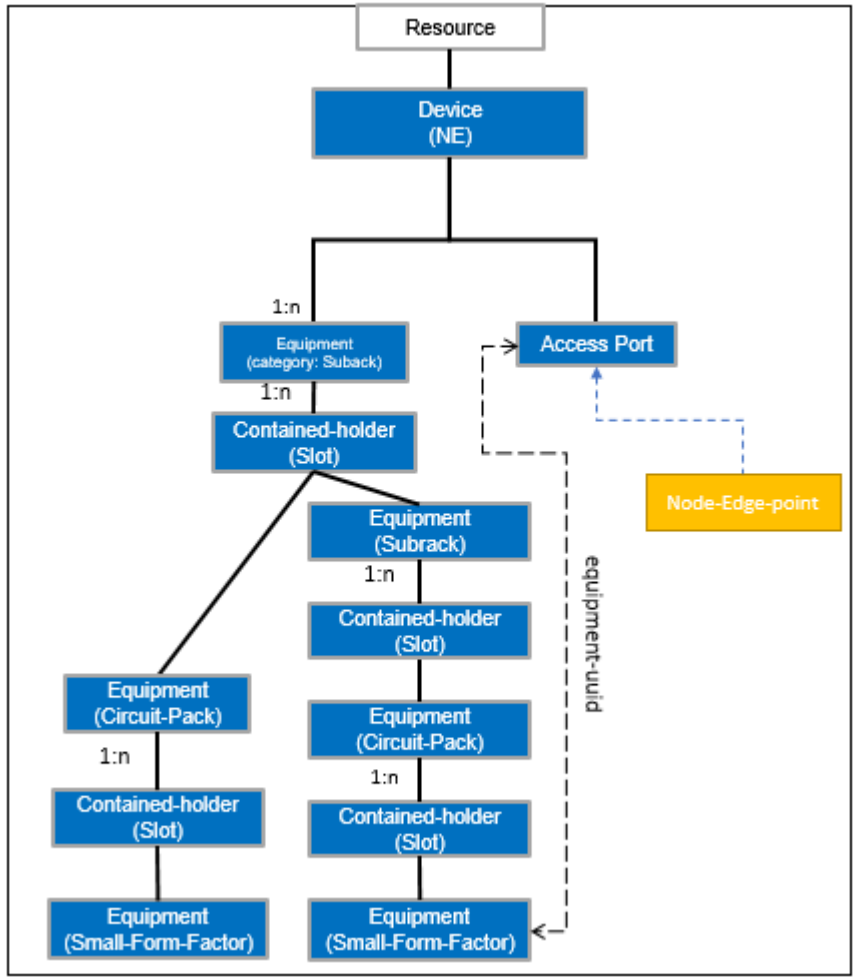



**But they do not represent the physical cards**

# HW Device representation

Basic structure device DWDM
NE (Network Element) = Device




**This is the glue between Inventory and Topological information**

# TAPI: Retrieve Inventory Information

- GET Inventory Details

curl -X GET -H "Content-Type: application/json" http://{{ip}}/restconf/data/tapi-common:context/tapi-equipment:physical-context/device=val?fields=equipment(name;uuid)

Response:


```
▼ tapi-equipment:physical-context {1}
  ▼ equipment [154]
    ▼ 0 {9}
      ▶ actual-equipment {1}
        is-expected-actual-mismatch : false
        containing-device : 53a3dfc9-d000-35b5-812a-8eed3c4d32aa
      ▶ name [1]
      ▼ expected-equipment {1}
        ▼ common-equipment-properties {6}
            equipment-type-version : REL1262Z.AG
            manufacturer-name : CIENA
            equipment-type-description : 6500 14-Slot Packet-Optical Shelf Assembly
            equipment-type-name : SHELF
            equipment-type-identifier : NTK503SA
            asset-type-identifier : NNTMRT0D59EK
        equipment-location : shelf:1
        category : shelf
        uuid : f2c436ff-00e0-32d9-b9e5-39e4fbb67e49
      ▶ containedHolder [37]
    ▶ 1 {8}
```

```
▼ 21 {4}
  ▼ occupying-fru {2}
      equipment-uuid : b422e217-c50b-381e-8287-d2412054f9a5
      device-uuid : 53a3dfc9-d000-35b5-812a-8eed3c4d32aa
  ▼ name [1]
    ▼ 0 {2}
        value-name : name
        value : XLA-1-2
  uuid : 2e328bcc-e755-3262-9b5d-30138f0138dd
  ▼ actual-holder {1}
    ▼ common-holder-properties {2}
        holder-location : shelf:1-slot:2
        holder-category : slot
```

```
▼ 77 {8}
  ▶ actual-equipment {1}
    is-expected-actual-mismatch : false
  ▼ name [1]
    ▼ 0 {2}
        value-name : name
        value : XLA-1-2
  ▼ expected-equipment {1}
    ▼ common-equipment-properties {6}
        equipment-type-version : 05
        manufacturer-name : CIENA
        equipment-type-description : XLA C-Band
        equipment-type-name : XLA
        equipment-type-identifier : NTK552KA
        asset-type-identifier : NNTMRT0G0W58
  equipment-location : shelf:1-slot:2
  category : shelf
  uuid : b422e217-c50b-381e-8287-d2412054f9a5
  ▼ containedHolder [0]
      (empty array)
```

# Phase II: Open Terminals Testing

- Discovery (16 operations):
  - Hardware inventory components state
  - Client port configuration and state
  - Line port configuration and state
  - Optical Channel configuration and state
  - Logical channels configuration and state
- Provisioning (8 operations):
  - Admin state of client and line port (Enable configuration)
  - Optical line port configuration (frequency, target-power, operational mode).
  - Logical channel (OTN multiplexing) assignment and configuration.
- Service de-activation (3 operations):
  - Admin state of client and line port (Disable configuration)
  - Logical channel assignment disable
- Streaming telemetry (4 operations)
  - gNMI path subscription and monitoring.

| OpenConfig atomic operations |
|---|
| **Discovery operations** |
| [Discovery-1] Discovery of components name |
| [Discovery-2] Discovery type of components |
| [Discovery-3] Discovery of line and client ports and subcomponents. |
| [Discovery-4] Discovery of operational modes available |
| [Discovery-5] Discovery of admin and operational status of port. |
| [Discovery-6] Discovery of index of logical channel in client side |
| [Discovery-6b] Discovery of capabilities of client logical channel |
| [Discovery-7 Discovery of line port capabilities (protocol, bit rate, granu-larity available and allocation) |
| [Discovery-8] Discovery of frequency, target-out-power and operational mode con-figured in line port |
| [Discovery-9] Discovery of type of logical channel assignment (preset or flexible) |
| [Discovery-10] Discovery of logical channel-assignment |
| [Discovery-10b] Discovery of logical channel-assignment |
| [Discovery-11] Discovery of location of a component and mapping to INVENTO-RY_ID (TAPI) |
| [Discovery-12] Retrieve of global structure of HW inventory |
| [Discovery-13] Retrieve of HW information of each component |
| [Discovery-15] Retrieval of q-value of optical channel |
| **Provisioning operations** |
| [Provisioning-1] Provisioning of admin-state enable of client port. |
| [Provisioning-2] Provisioning of admin-state enable of line port |
| [Provisioning-3] Provisioning of frequency in line port |
| [Provisioning-4] Provisioning of optical output power in line port |
| [Provisioning-5] Provisioning of operationakl mode |
| [Provisioning-6] Basic configuration of a logical channel |
| [Provisioning-8] Assignment of logical channel in another logical |
| [Provisioning-11] Configuration of rate (rate-class), protocol (trib-protocol and logical channel type) on client port |
| **Service deletion operations** |
| [Delete-1] Disable the client port |
| [Delete-2] Disable the line port |
| [Delete-3] Disable the logical channel and change assignment |
| **Streaming (gNMI)operations** |
| [gRPC-1] Subscribe for all paths with gNMI/gRPC |
| [gRPC-2] Create subscription for specific path with gNMI |
| [gRPC-3] Create subscription of a specific path with a defined SAMPLE (sample_interval) |
| [gRPC-4] Subscribe for all paths with gNMI/gRPC |

| PM COUNTERS |
|---|
| severely-errored-seconds |
| unavailable-seconds |
| fec-uncorrectable-blocks |
| fec-uncorrectable-words |
| fec-corrected-bytes |
| fec-corrected-bits |
| background-block-errors |
| **OTHER COUNTERS** |
| oc-opt-term:chromatic-dispersion |
| oc-opt-term:polarization-mode-dispersion |
| **MONITORING COUNTERS** |
| output-power |
| input-power |
| pre-fec-ber |
| post-fec-ber |
| temp |
| q-value |

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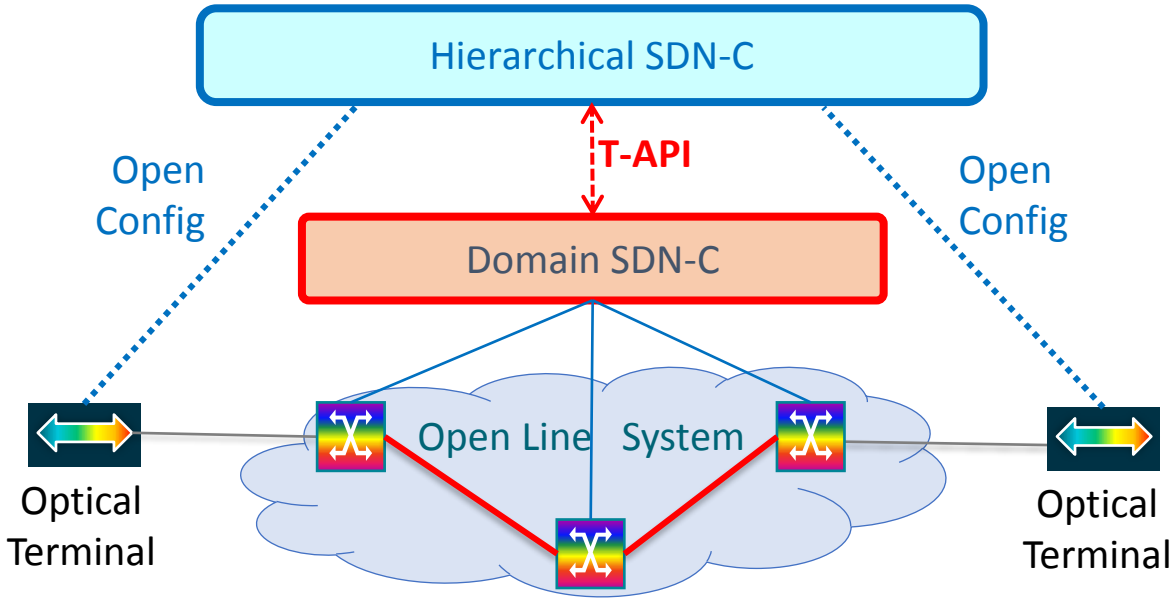
# Phase III: E2E Disaggregation demo

- Scope: Evaluation and demonstration of E2E use cases over a partially disaggregated network
- The following use cases were tested:
  1. Automatic discovery of OLS network resources
  2. Automatic discovery of OT network resources
  3. Association of OT port to OLS node/port
  4. Discovery of services on the OLS Controller (service database synchronization)
  5. Unconstrained service provisioning
  6. Unconstrained service provisioning with restoration (same frequency)
  7. Constrained service provisioning (link/node)
  8. Service deletion
  9. Visualization of complete end-to-end path across the network





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# Conclusions

2020 SDN API Interop Demo

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# Takeaways ONF TAPI Testing

- Quick adoption of ONF TR-547 reference implementation agreement.
  - RESTCONF compliant API supported on all vendors with few deviations found.
  - TAPI v2.1.3 models are implemented by all vendors
  - Notifications subscription mechanism based on tapi-notification model is widely supported.
  - SSE notification format is widespread across implementations. Websockets (as an alternative) is supported as well.
- Maturity:
  - Quite high percentage of use cases are supported across the vendor participants (64% use cases supported on average).
  - High level of mature products. Production ready products are interoperable to some extent and products implementation support exhaustive testing.
- Major interoperability issues:
  - IETF RESTCONF
    - Standard authentication for RESTCONF APIs need to be enforced.
    - API scalability for large data trees need to be addressed by RESTCONF filters or Streaming not through RESTCONF deviations.
    - RESTCONF provisioning behavior for POST operations into lists need to be clarified.
    - UUID keys provisioning by RESTCONF client must be supported.
    - Standard RESTCONF error codes must be sent if request cannot be served.
  - ONF TR-547
    - Provisioning lifecycle is still not uniform. Once the RESTCONF request is accepted, there must be a standardized lifecycle for the connectivity-service, uniform for all implementations.
    - Reduce number of API operations required when following relations between tables. T-API enhancement is desired.

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# Takeaways OpenConfig Testing

- Very good level of compliance OpenConfig models
  - Uniform HW components hierarchy relation using parent and location attributes.
  - Cross-connection logics discovery is widely implemented.
  - Optical channel configuration (Frequency, power and operational mode) 100% supported.
  - Performance indicators not fully supported yet. At least **pre-fec-ber and/or q-value** must be supported.
- NETCONF and gNMI
  - NETCONF standard is widely supported across the industry.
  - Subscription and notifications for performance streaming telemetry compliant with both, gNMI and NETCONF.
- Major interoperability issues:
  - IETF NETCONF:
    - **Standard handshake** for SSH is a must. Key exchange algorithms were different and its not fully standardized.
    - **Candidate datastore** MUST be supported and it is not fully supported across the industry.
  - OpenConfig:
    - **openconfig-transport-line-common version 0.6.0** is not widely supported a previous version is commonly adopted (0.5.2)
  - Further standardization needed for complex use cases:
    - **The commissioning and provisioning process for devices MUST be uniform**. OTN Logical channel cross-connections flexibility is hard to manage due to strong dependency on different hardware capabilities
    - **HW Dependencies does not allow some configurations**. This must be clarified for understanding configuration workflows.

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# Key Takeaways

- Manageability and flexibility of the network are critical to allow network operators to successfully deliver a range of cloud-based services, meet dynamic bandwidth demands, and to accelerate transport network transformation for the 5G era.
- Established open Transport SDN APIs can help network operators:
  - Improve network agility to adapt to dynamic service demands and traffic patterns
  - Improve service provisioning and time-to-revenue
  - Reduce maintenance and management with simplified control and automation


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# Resources

More info and infographic:
[https://www.oiforum.com/technical-work/2020-oif-transport-sdn-api-interoperability-demo/](https://www.oiforum.com/technical-work/2020-oif-transport-sdn-api-interoperability-demo/)

Press releases:
[OIF Announces Participants in 2020 Joint Network Operator, Multi-Vendor Transport SDN API Interoperability Demonstration]

[OIF Completes Successful 2020 Joint Network Operator, Multi-Vendor Transport SDN API Interoperability Demonstration]

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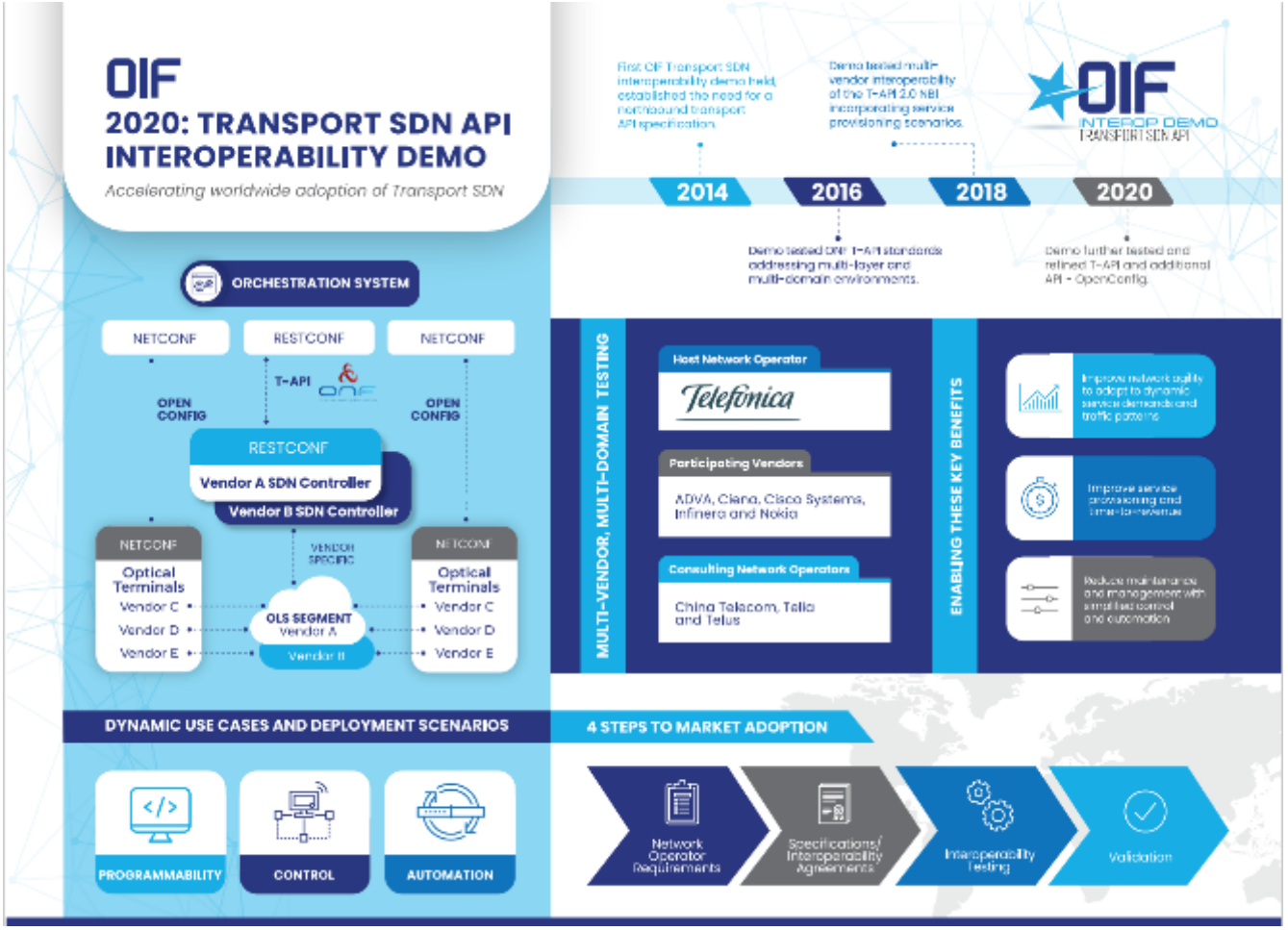

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OIF INTEROP DEMO TRANSPORT SDN API

# Thank you!

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