



# SDN (Software Defined Networking) control of disaggregated optical transport networks

Achim Autenrieth, ADVA Optical Networking  
DENOG10, Darmstadt, 22.11.2018

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CELTIC / BMBF and European Commission  
Horizon2020 projects SENDATE and MetroHaul



# Agenda

1

Introduction – Transport SDN Architectures

2

Optical Network Disaggregation

3

Data Models for Disaggregated Optical Transport Networks

4

Current SDN interops, field trials, and research projects

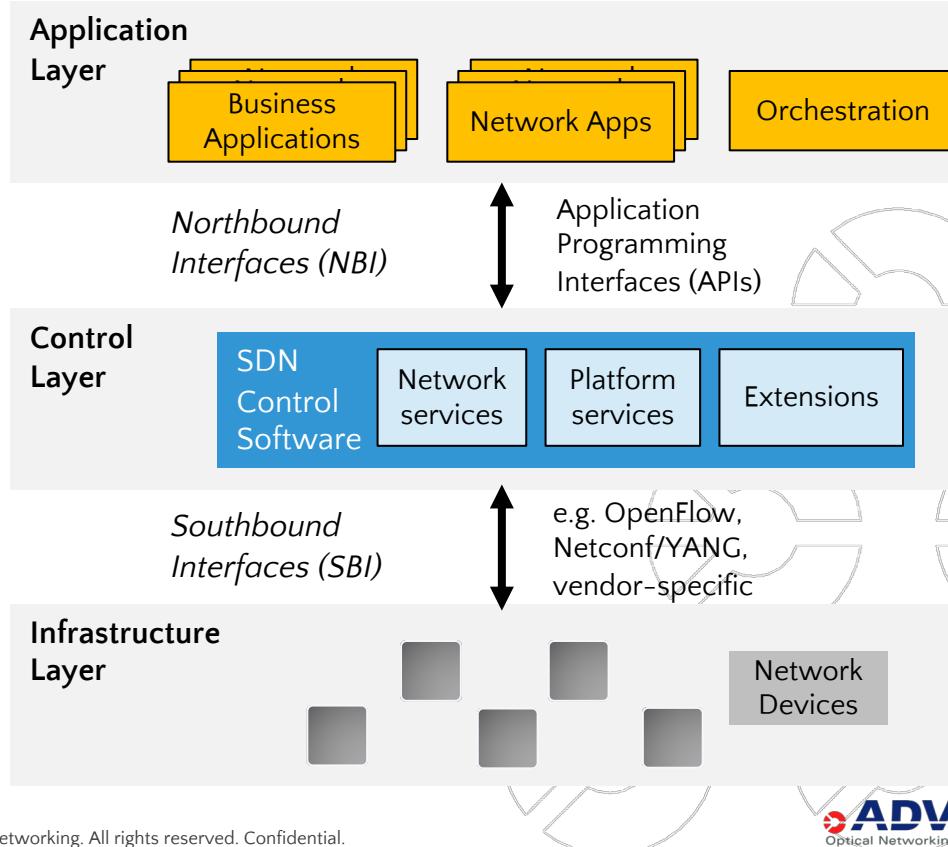
# What is Software Defined Networking (SDN)?

Software Defined Networking (SDN) is an emerging network architecture where network control is ...

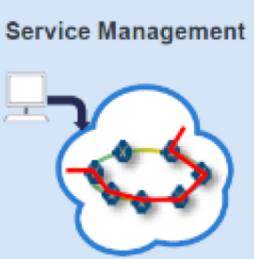
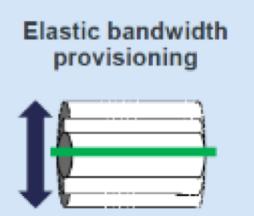
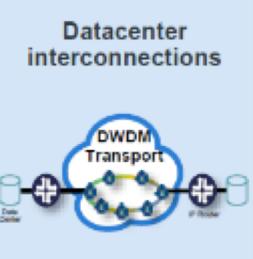
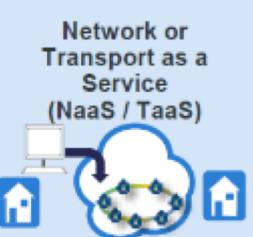
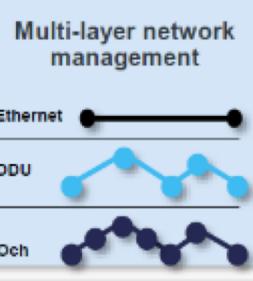
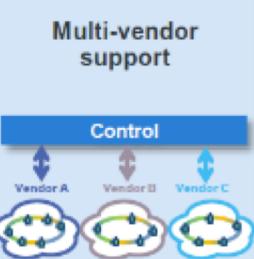
- decoupled from forwarding
- directly programmable
- logically centralized
- abstracted for applications and network services
- based on open standardized APIs



White Paper “Software-Defined Networking: The New Norm for Networks” (2012)

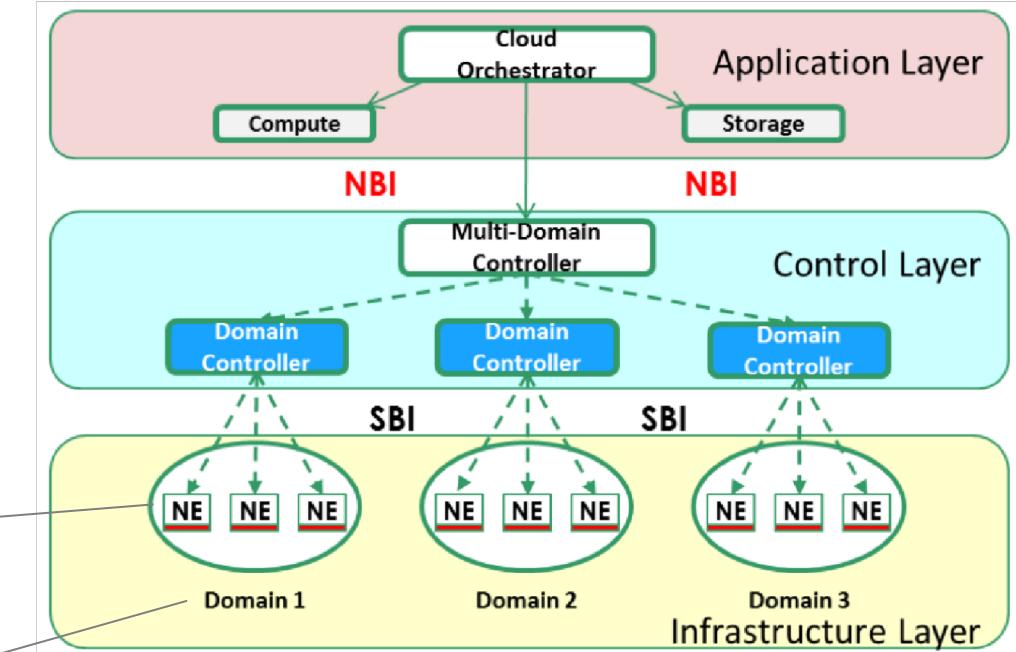


# Transport SDN use cases in ONF

| Service Management   | Elastic bandwidth provisioning   | Datacenter interconnections   | Network or Transport as a Service (NaaS / TaaS)  | Multi-layer network management  | Multi-vendor support   |
|--|--|---|--|---|--|
|   |   |    |    |    |   |
| <p><b>Automated service creation covering L0 to L3</b></p> <p>Addressing</p> <ul style="list-style-type: none"><li>▶ Time to service</li><li>▶ Ease of operation</li><li>▶ Service differentiation</li></ul> | <p><b>Creation of elastic services with automatic or “on request” changes in bandwidth</b></p> <p>Dealing with</p> <ul style="list-style-type: none"><li>▶ Statistical bandwidth sharing</li><li>▶ Dynamic data flow changes</li></ul> | <p><b>Automatic load dependent fast service creation</b></p> <p>Matching</p> <ul style="list-style-type: none"><li>▶ Hypergrowth in data volume</li><li>▶ Extremely dynamic traffic pattern</li></ul> | <p><b>Fully automate service requests incl. network planning and equipment configuration</b></p> <p>Addressing</p> <ul style="list-style-type: none"><li>▶ Non-automated Operational processes</li><li>▶ High network complexity</li></ul> | <p><b>Multilayer optimized L0-3 system with</b></p> <ul style="list-style-type: none"><li>▪ common workflows</li><li>▪ automatic routing</li><li>▪ interworking</li></ul> | <p><b>One standardized SDN control interface for easy integration of 3rd party vendors</b></p> <p>Dealing with</p> <ul style="list-style-type: none"><li>▶ Different control interfaces</li><li>▶ Missing control IF between vendors</li></ul> |

[K. Sethuraman, Transport SDN in ONF, ONS 2016]

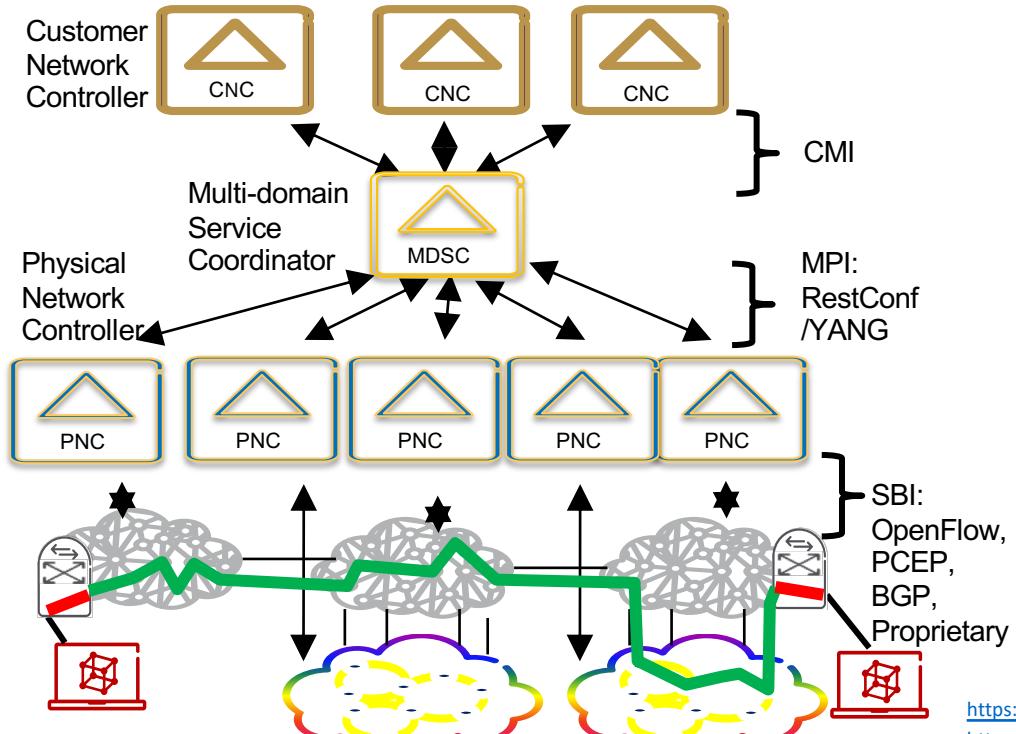
# ONF Transport SDN Architecture



- Operation Applications
- Hierarchy of Controller / Orchestrator
- Open APIs with standardized data models
- Multiple Network / Technology Domains

OIF/ONF Whitepaper, "SDN Transport API Interoperability Demonstration", August 7, 2018

# IETF SDN Architecture ACTN – Abstraction and Control of Traffic Engineered Networks



Multi-vendor multi-domain  
IP/Transport Network TE SDN  
Control

Hierarchical network resource  
abstraction and control

Standard IETF Model-based  
Northbound Interface

Hybrid legacy and green-field  
network deployment

<https://datatracker.ietf.org/doc/draft-ietf-teas-actn-framework/> (ACTN architecture)  
<https://datatracker.ietf.org/doc/draft-ietf-teas-yang-te-topo/> (TE topology YANG model)  
<https://datatracker.ietf.org/doc/draft-ietf-teas-yang-te/> (TE tunnel YANG models)

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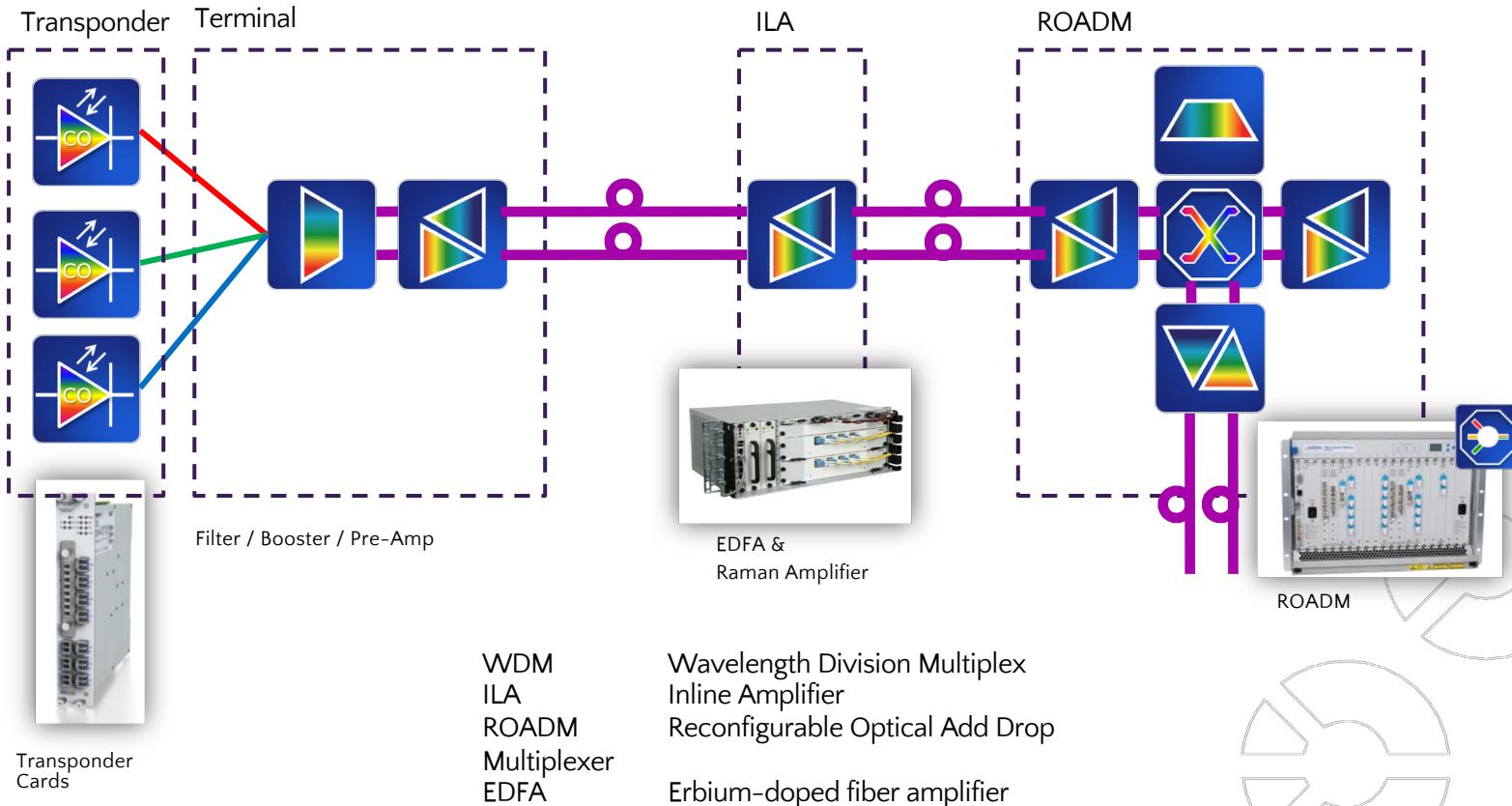
3

Data Models for Disaggregated Optical Transport Networks

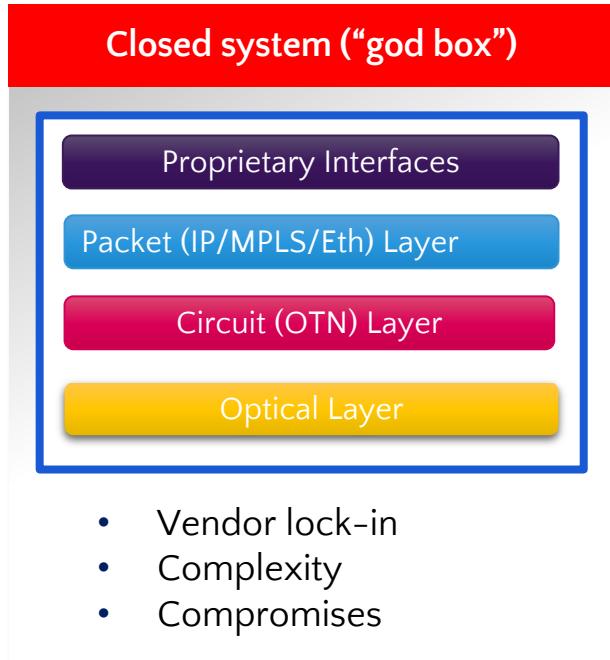
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Current SDN interops, field trials, and research projects

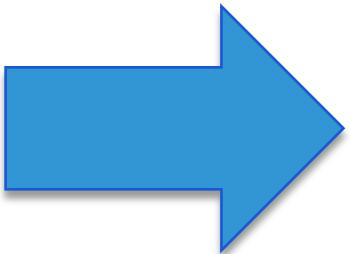
# Basic WDM System Architecture



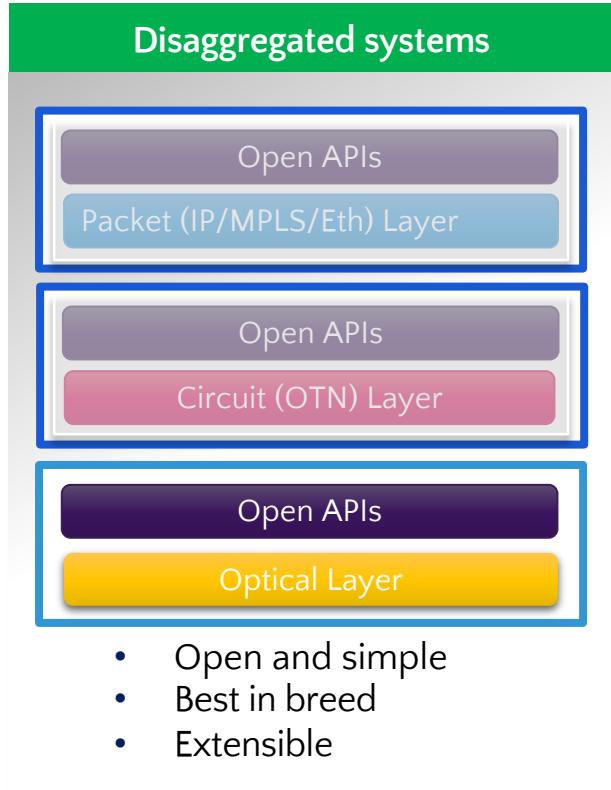
# Disaggregation – Vertical direction



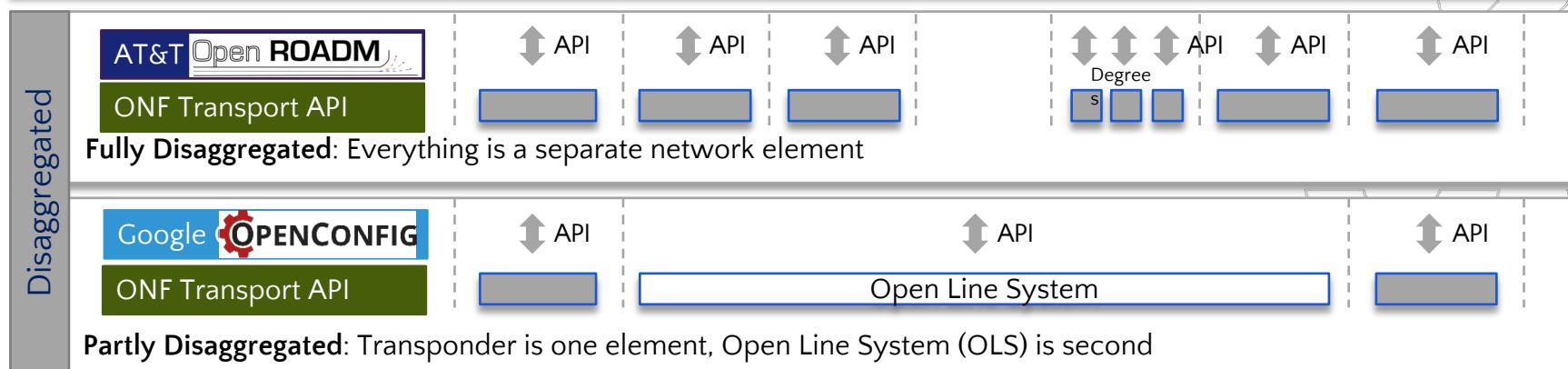
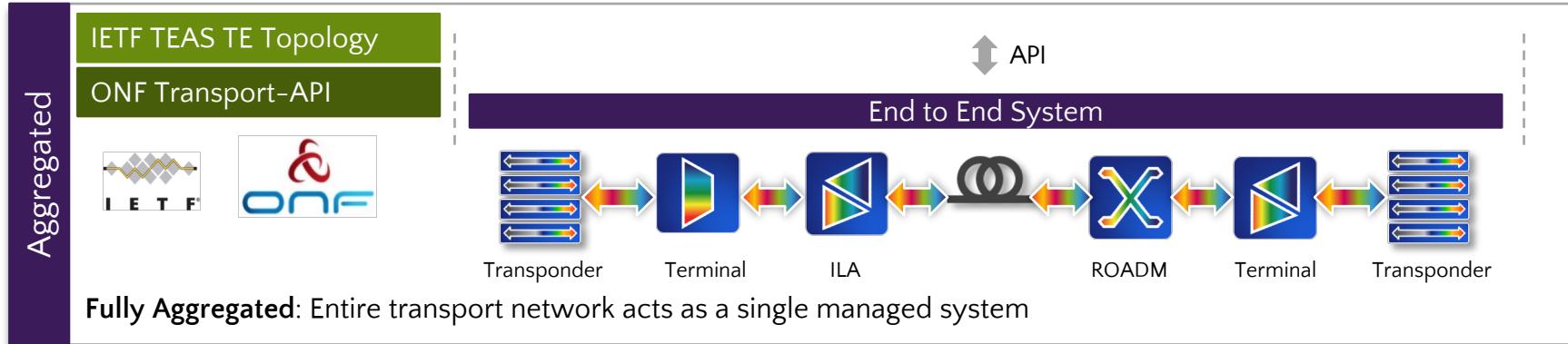
From  
Old Style



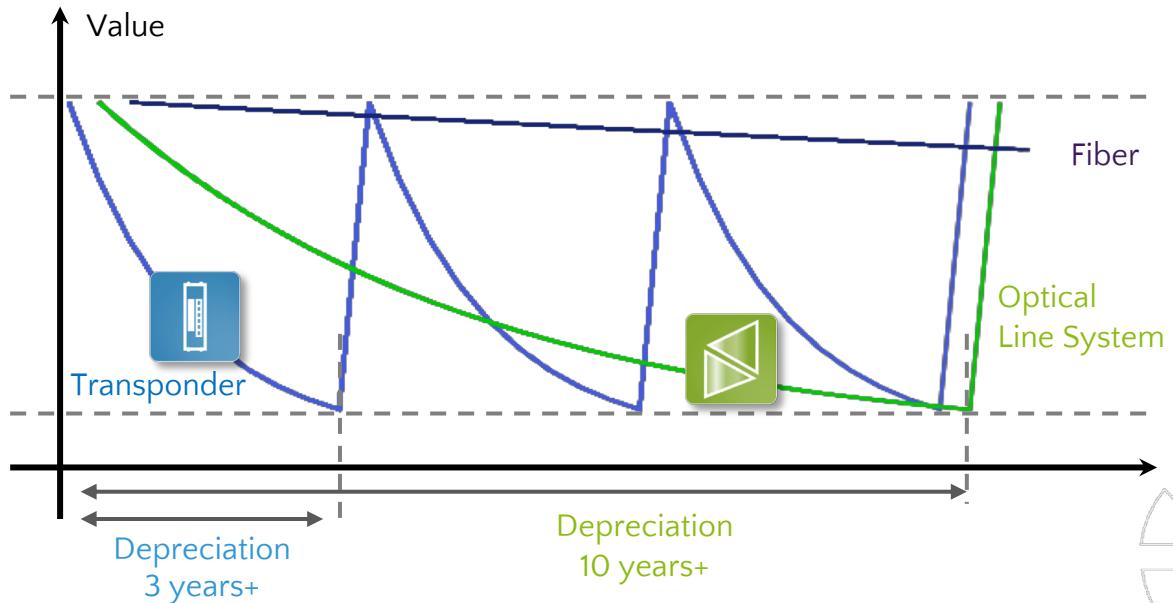
To  
New Style



# Disaggregation – Horizontal direction



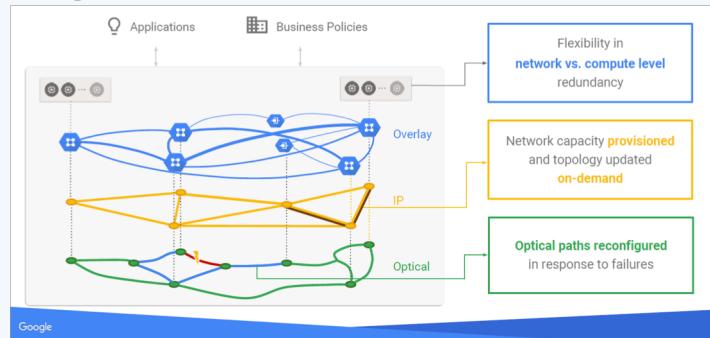
# Investment and depreciation



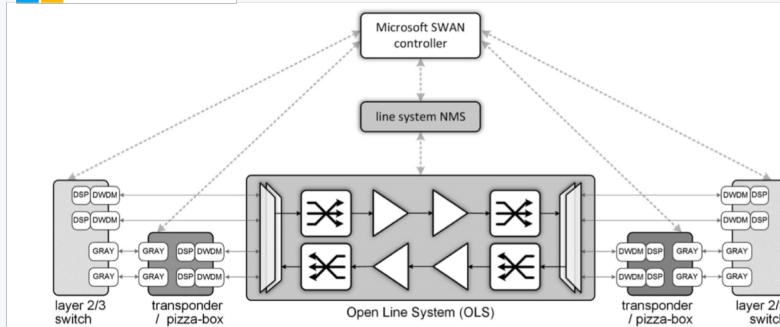
Disaggregation flexibility: Different lifecycles for line systems and terminals

# Disaggregation – Operator Concepts & Vision

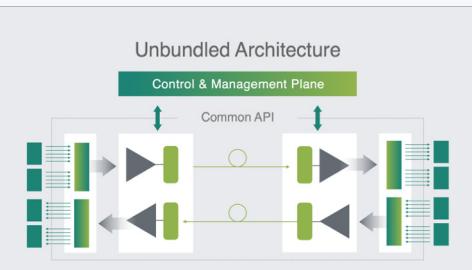
Google <https://www.youtube.com/watch?v=n9zEiGyvJA>



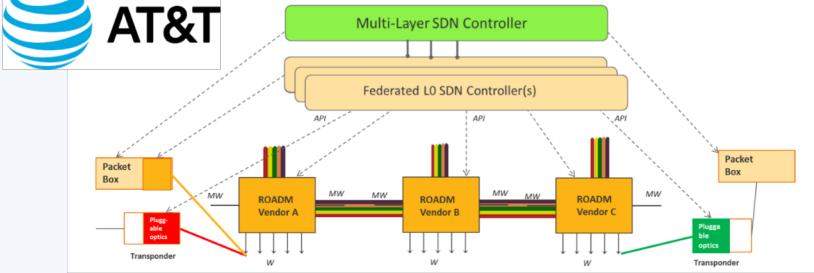
[M. Filer et al., JOCN, Vol. 8, No. 7, 2016]



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AT&T



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# Data Models for Disaggregated Transport Networks

Industry Alliances

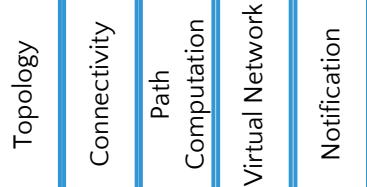
SDOs



Carrier



Transport-API



Core Model



Services



ISPs, IP over Optical

IETF TE Tunnels

IETF Network

IETF Network-  
Topology

IETF TE Topology

IETF Flexi-Grid TED

IETF Flexi-Grid  
media channel

IETF WSON  
Technology

Network



Web 2.0



Telemetry



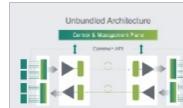
Disaggregatio



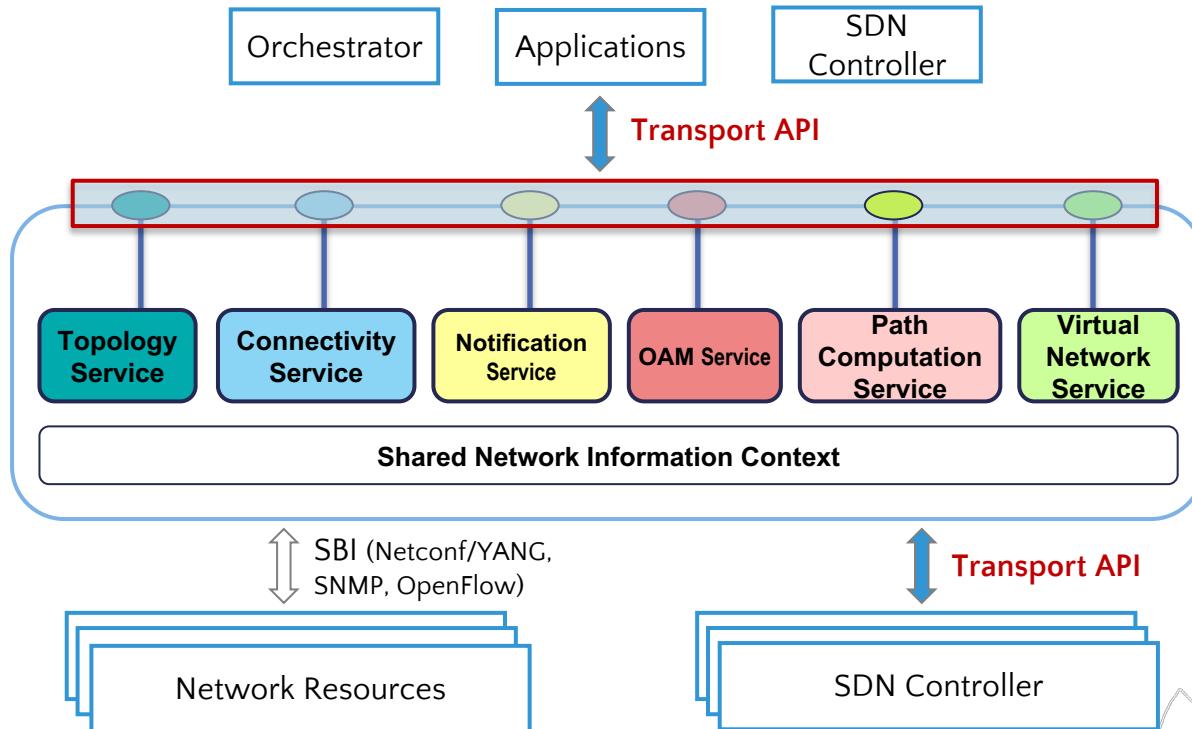
Services

Common  
Network

Device

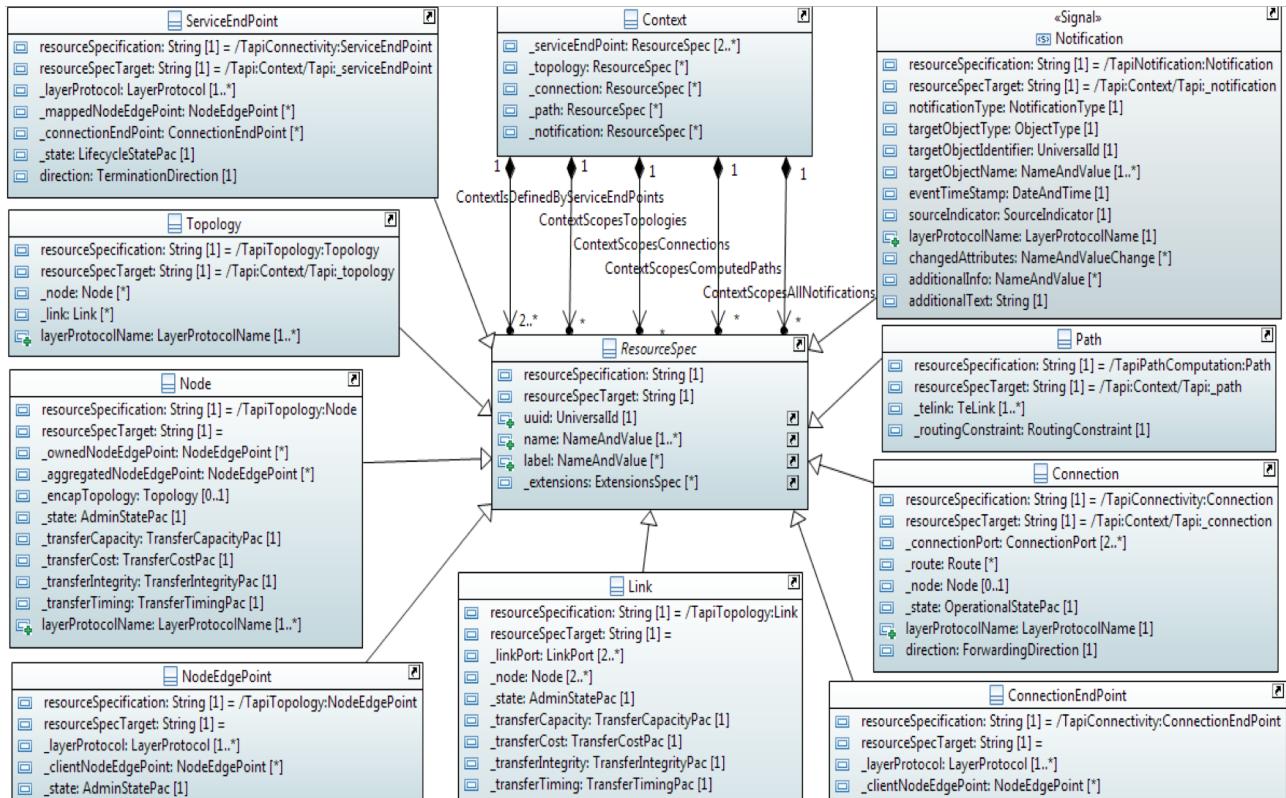


# ONF Transport-API functional architecture



# ONF TAPI

- ServiceEndPoint
- Topology
- Node
- NodeEdgePoint
- Link
- ConnectionEndPoint
- Connection
- Path
- Notification



[1] "Transport API (TAPI) 2.0 Overview", Aug 2017  
[https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport/blob/develop/DOCS/TAPI%202%20WP\\_Final.docx](https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport/blob/develop/DOCS/TAPI%202%20WP_Final.docx)

[2] <https://github.com/OpenNetworkingFoundation/Snowmass-ONFOpenTransport/tree/develop/YANG>

[3] [https://github.com/OpenNetworkingFoundation/TAPI/DOCS/presentations/onf2016.307\\_TAPI\\_SDK.01.pptx](https://github.com/OpenNetworkingFoundation/TAPI/DOCS/presentations/onf2016.307_TAPI_SDK.01.pptx)

# OpenConfig

Generic, module level API

Focus on Terminal Equipment

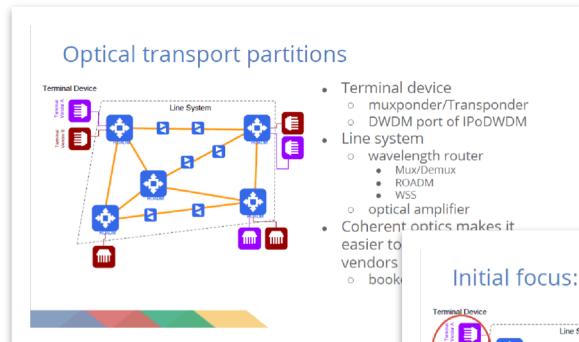
YANG models

- openconfig-transport-types.yang
- openconfig-terminal-device.yang

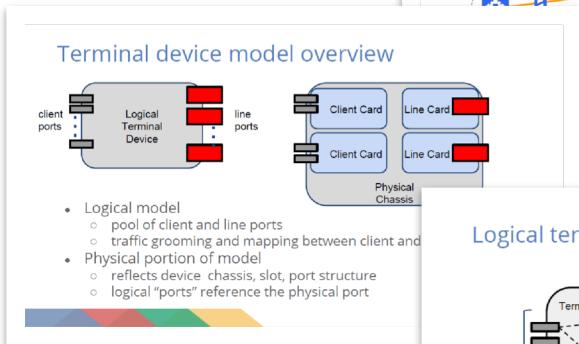
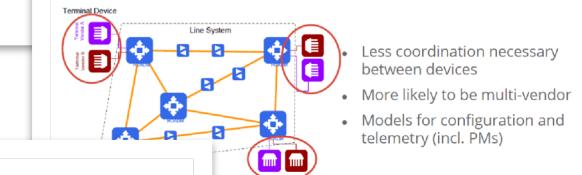
Main elements

- physical client port, physical client channel, logical channel, optical channel, physical line port
- Directionality: client to line
- Physical layout: not modeled

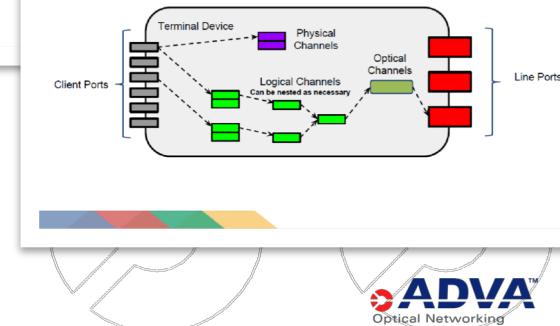
**Members:** Google, A&T, British Telecom, Microsoft, Facebook, Comcast, Verizon, Level3, Cox Communications, Yahoo!, Apple, Jive Communications, Deutsche Telekom / TeraStream, Bell Canada



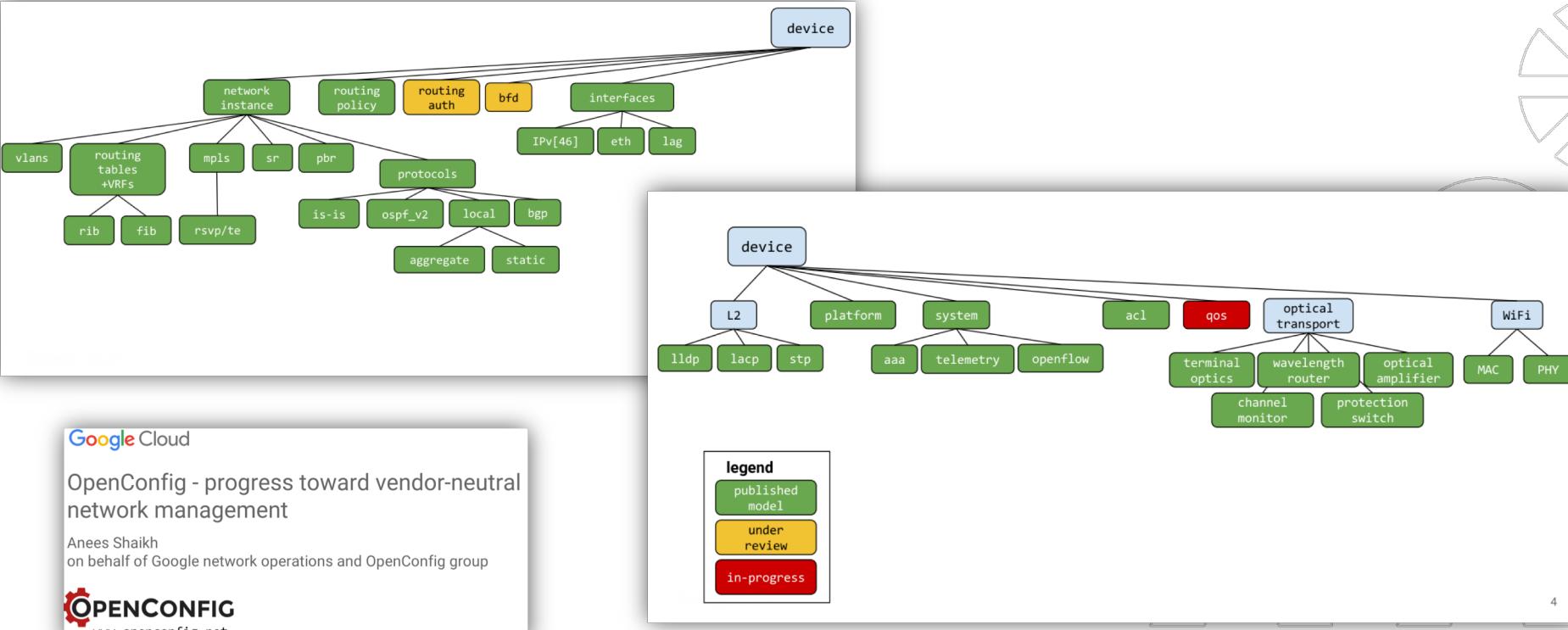
Initial focus: terminal optics device



Logical terminal device details



# OpenConfig Data Models



# OpenROADM Multi-Source Agreement (MSA)



Interoperability specifications for Reconfigurable Optical Add/Drop Multiplexers (ROADM).

ROADM switch

transponders

pluggable optics.

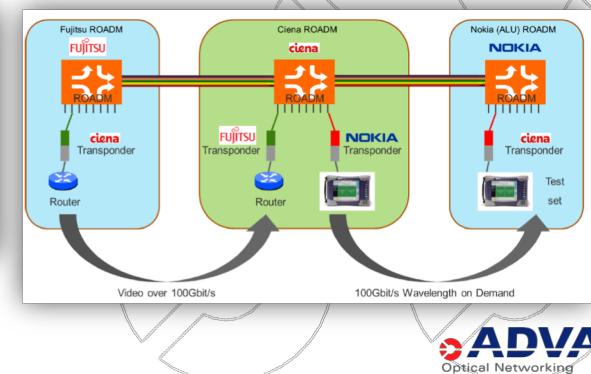
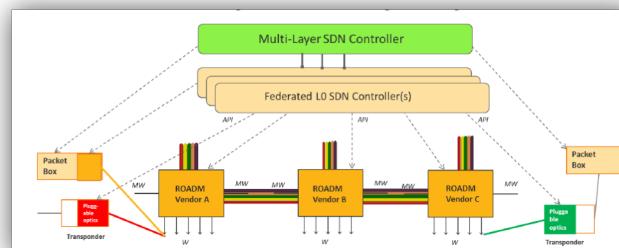
Specifications consist of both optical interoperability as well as YANG data models.

<http://openroadm.org/>

Open ROADM GitHub:

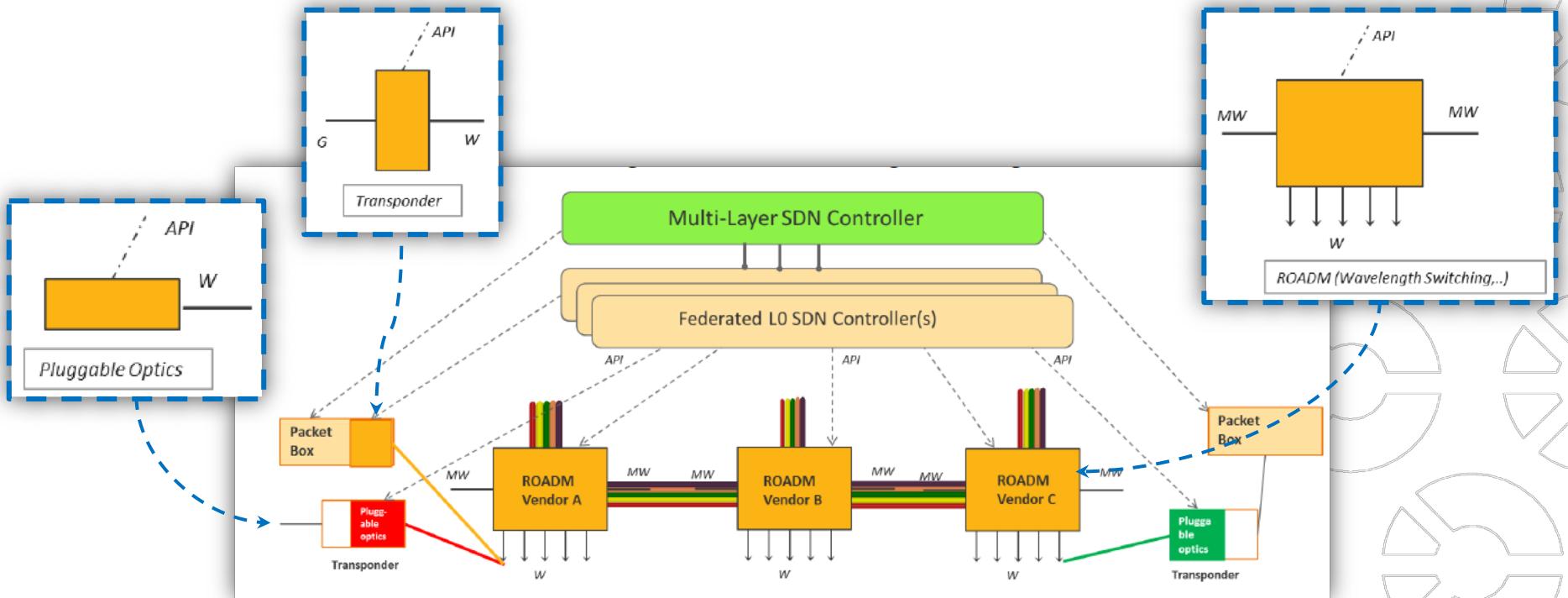
[https://github.com/OpenROADM/OpenROADM\\_MSA\\_Public](https://github.com/OpenROADM/OpenROADM_MSA_Public)

The screenshot shows the GitHub interface for the OpenROADM\_MSA\_Public repository. The repository has 7 issues and 0 pull requests. It is set to the 4.0.0 branch. The main page displays a table of releases for different components: Common, Device, Network, and Service, all at Release 4.0.0, updated 2 months ago. A note indicates the branch is 1 commit behind master. There are links for creating new files, finding files, and viewing history.



# OpenROADM Network Model and Main Objects

[https://github.com/OpenROADM/OpenROADM\\_MSA\\_Public/tree/master/mod](https://github.com/OpenROADM/OpenROADM_MSA_Public/tree/master/mod)



# Challenges

- Optical network consists of many in-homogeneous network elements
  - Amplifier, WSS, Wavelength Blocker, ...
- ROADM斯 have different levels of flexibility and internal constraints
  - Colorless, direction-less, contentionless add drop, ...
- Especially in cost-sensitive metro network environments constrained technologies are often used (filterless / fixed filters ROADM斯, non-colorless, ...)
- Data models must be **abstract** to allow future technology advances
- Number of data models should be **limited** to allow interoperability testing

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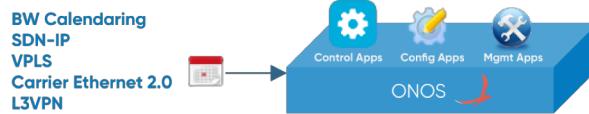
Data Models for Disaggregated Optical Transport Networks

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Current SDN interops, field trials, and research projects

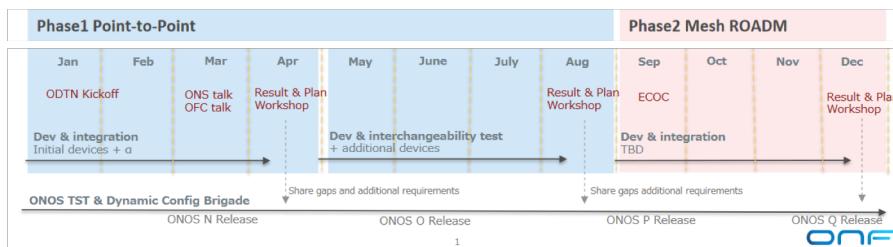
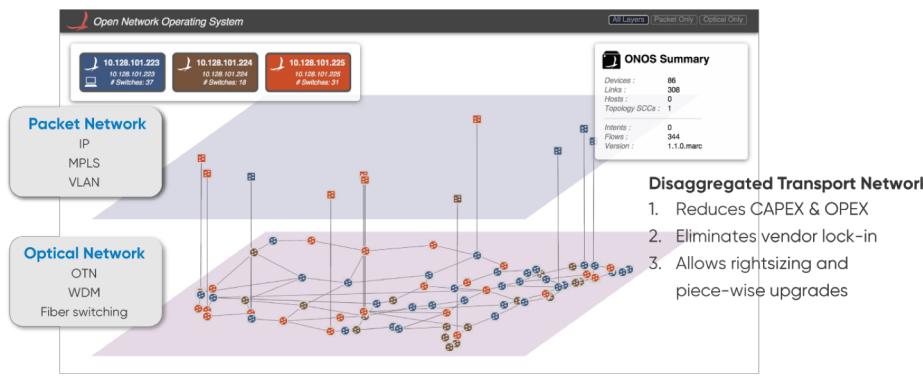
# ONF Open Disaggregated Transport Network (ODTN) (01/2018 – 12/2018)

<https://wiki.onosproject.org/display/ODTN/ODTN>



## Logically Centralized Control

1. Optimize resource usage
2. Dynamic traffic provisioning
3. Multi-layer resiliency



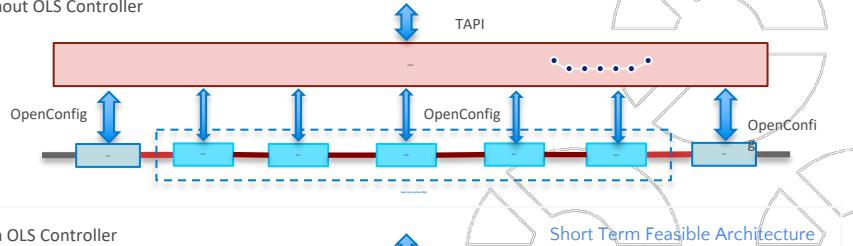
## Service Providers



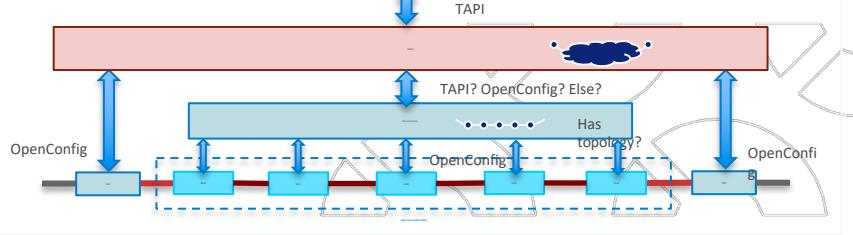
## Tier 2 Vendors



## Without OLS Controller

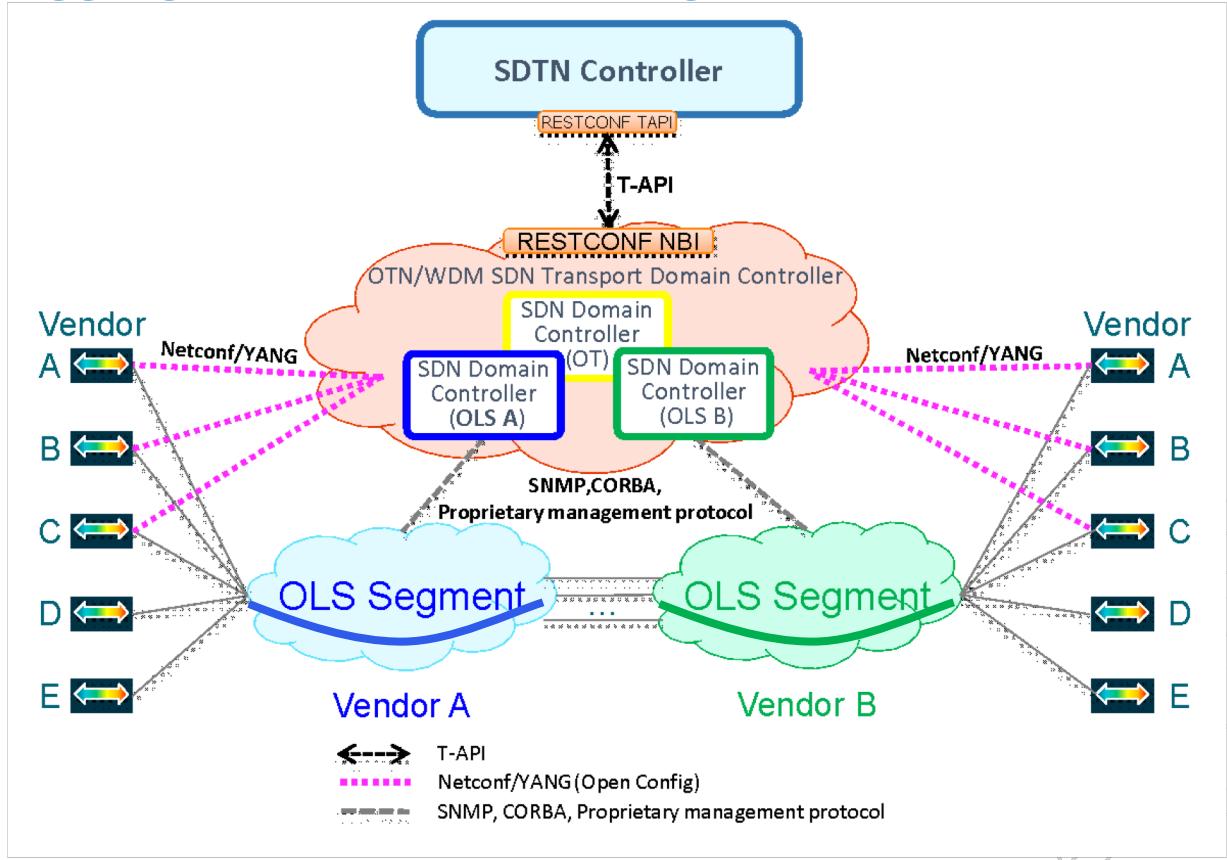


## With OLS Controller



23

# Multidomain SDN architecture for partially disaggregated network management



# SENDATE Multivendor optical SDN Trial (09/2018)



## Open Disaggregated SDN Control Architecture

- Multivendor trial including Network orchestration layer, Control and management layer and Infrastructure layer.
- Layered approach based on **ONF Transport API 2.0** with **Physical Media extensions for Optical Performance Planning**

## Network Orchestration layer

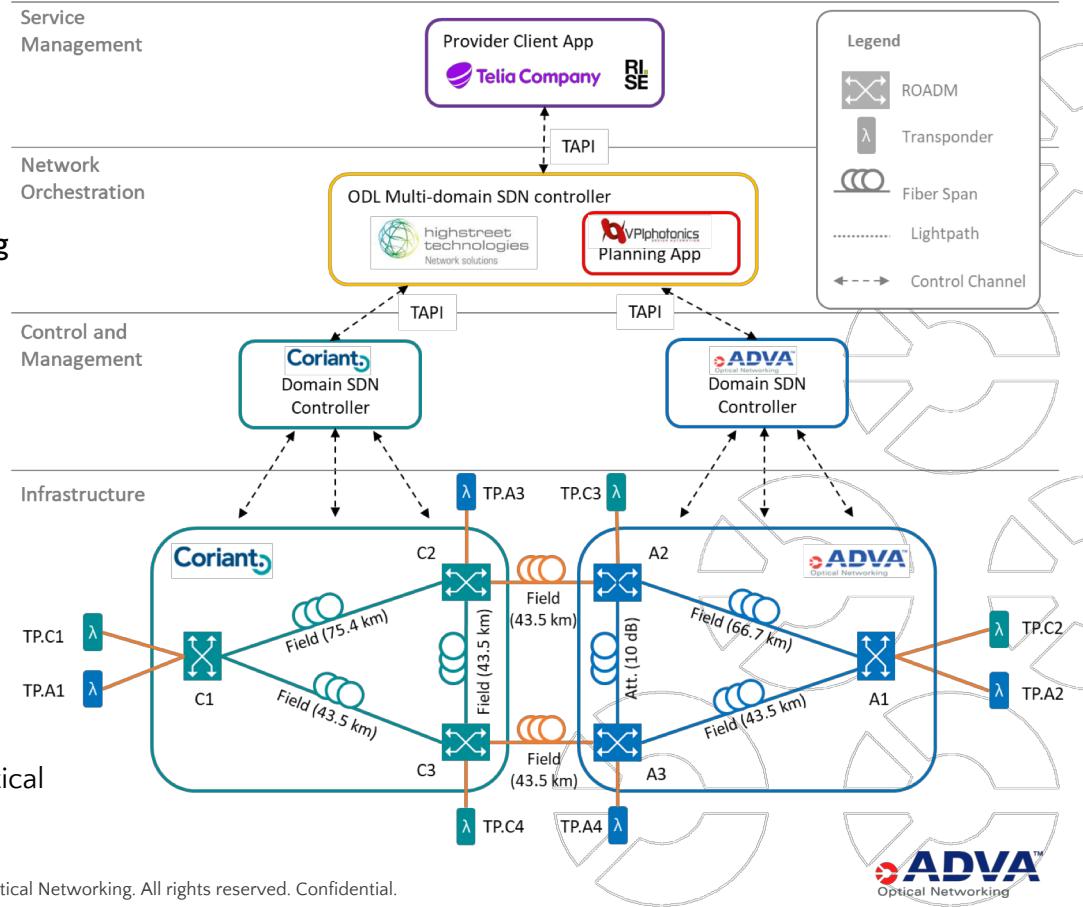
- Transport Orchestrator (highstreet technologies)
- Planning Application (VPIphotonics)  
(Bundled in Transport Orchestrator)

## Control and Management layer

- SDN Domain Controllers (ADVA and Coriant)

## Infrastructure layer

- ROADM and transponders (ADVA and Coriant)
- Transparent ROADM line port interconnect
- Alien wavelength interconnection passing both vendors optical domains

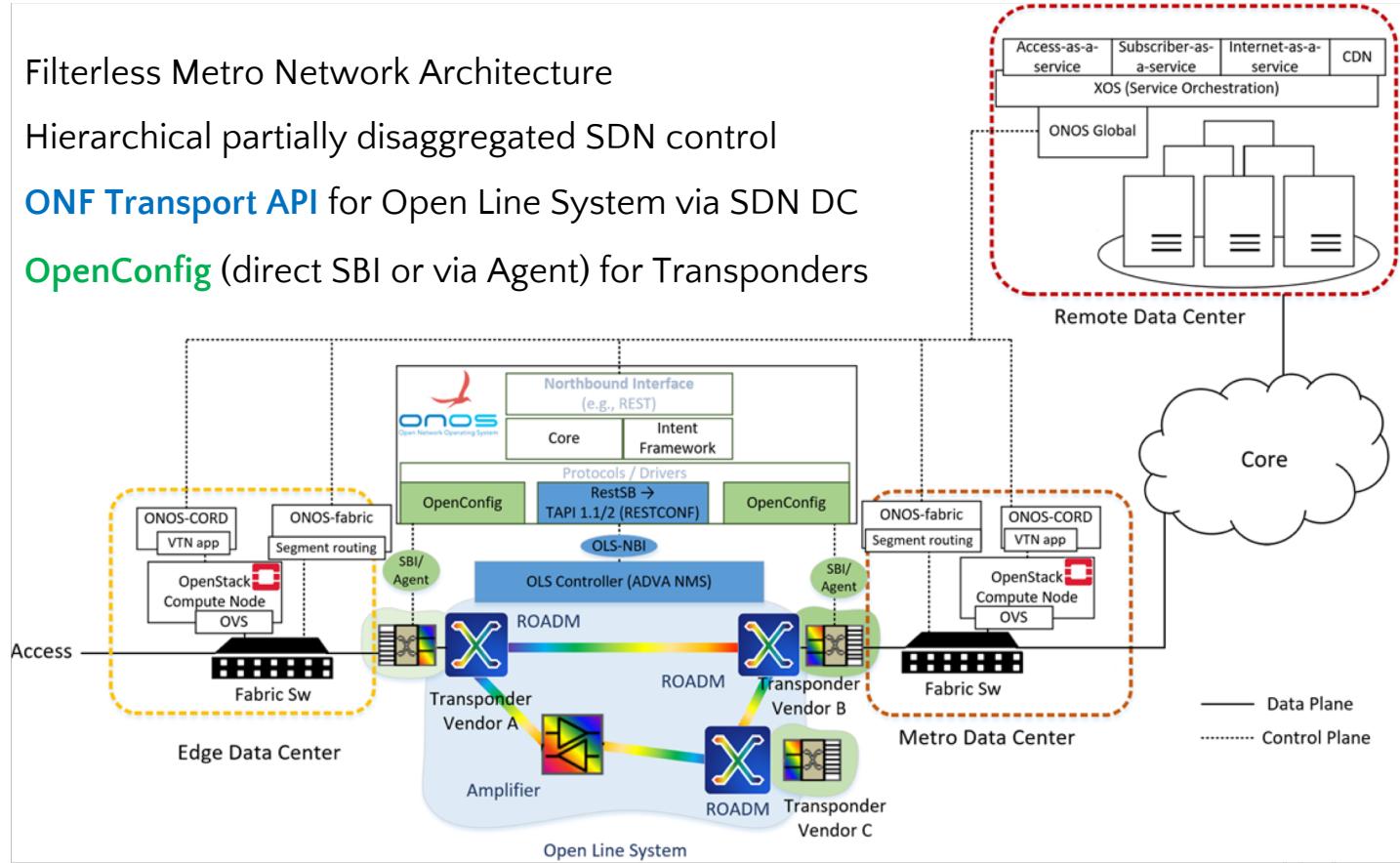


# MetroHaul Architecture (.. 2019)



<https://metro-haul.eu>

- Filterless Metro Network Architecture
- Hierarchical partially disaggregated SDN control
- **ONF Transport API** for Open Line System via SDN DC
- **OpenConfig** (direct SBI or via Agent) for Transponders



# Current status

- Commercial Transport SDN and NFV orchestration solutions with open platforms are available and being deployed
- Practical implementations and successful interop demos for (partially) disaggregated networks supporting distributed datacenters / edge clouds in metro networks
- Ongoing research activities with field trial and demonstrators (MetroHaul, SENDATE)
- Ongoing standardization effort on YANG models for (partial) disaggregation
  - ONF WTP PoC 5.0 → ONF T-API Extensions with Photonic Media (OTSi)
  - ONF ODTN (Open Disaggregated Transport Networks)
  - Telecom Infra Project (TIP)
  - OpenROADM

# Conclusions

- **Partial disaggregation** and OLS with per-device data monitoring allows a visibility down to the devices level but simplifies operation of the network
- Recent demonstrations have proven that partial disaggregation is a working approach for metro networks and data center connectivity
- High number of evolving data models delay implementation and testing and limit interoperability
- Industry (including operators) should decide on a **common data model**
- Full disaggregation of the optical layer will slow down technological progress and result in more complex (and cost-intensive) network operation



Thank you

aautenrieth@advoptical.com



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