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

Part of this research is funded by
CELTIC / BMBF and European Commission
Horizon2020 projects SENDATE and MetroHaul

Achim Autenrieth, ADVA Optical Networking
DENOG10, Darmstadt, 22.11.2018

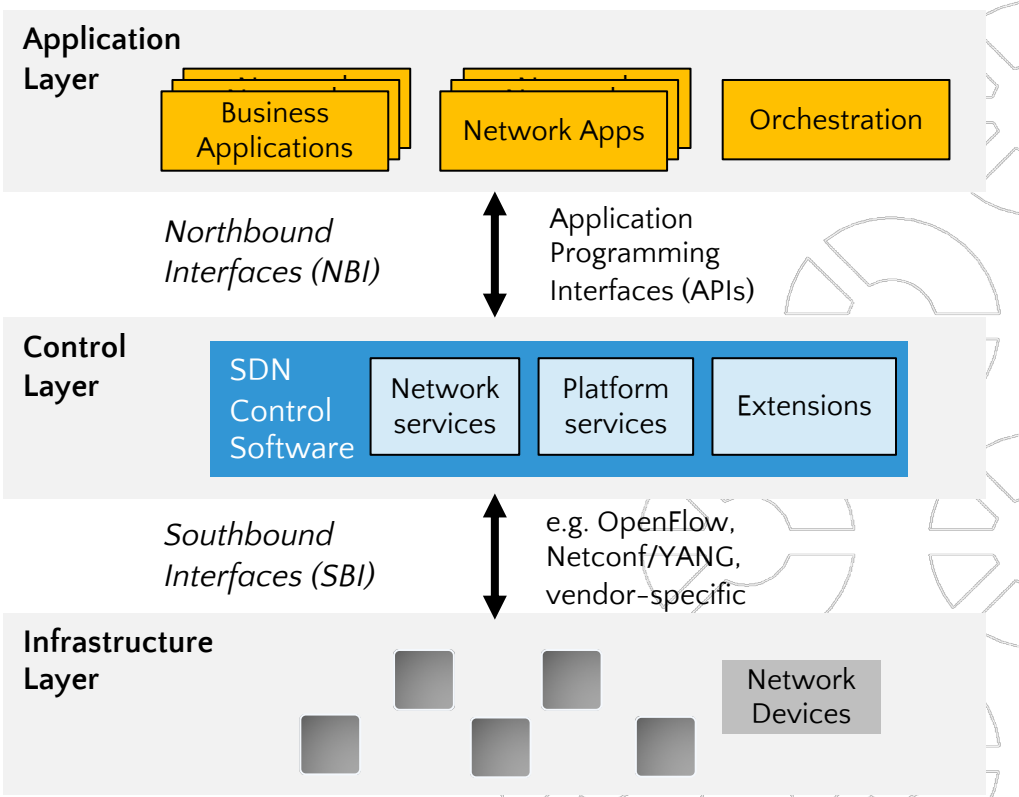
Agenda

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)?

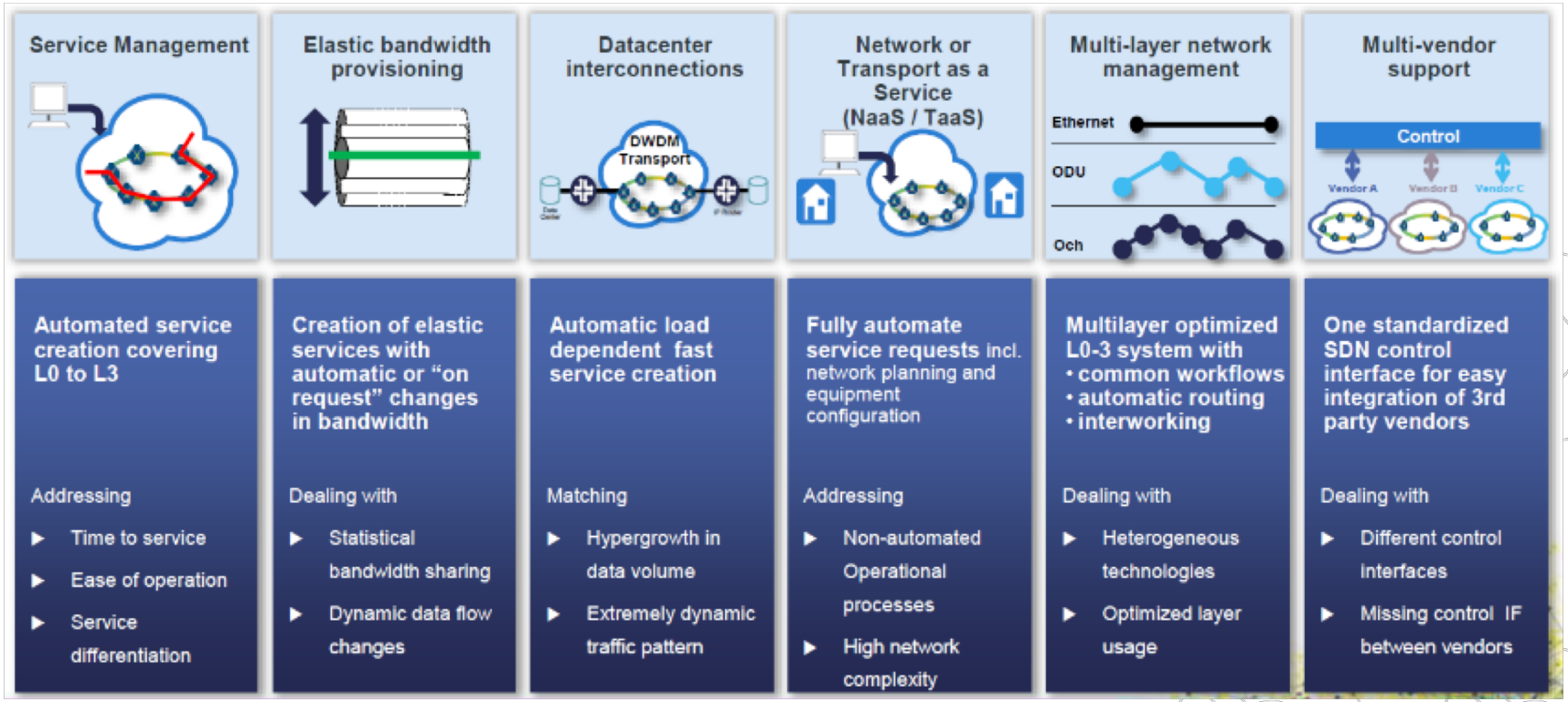
Software Defined Networking (SDN) is an emerging network architecture where network control is …

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



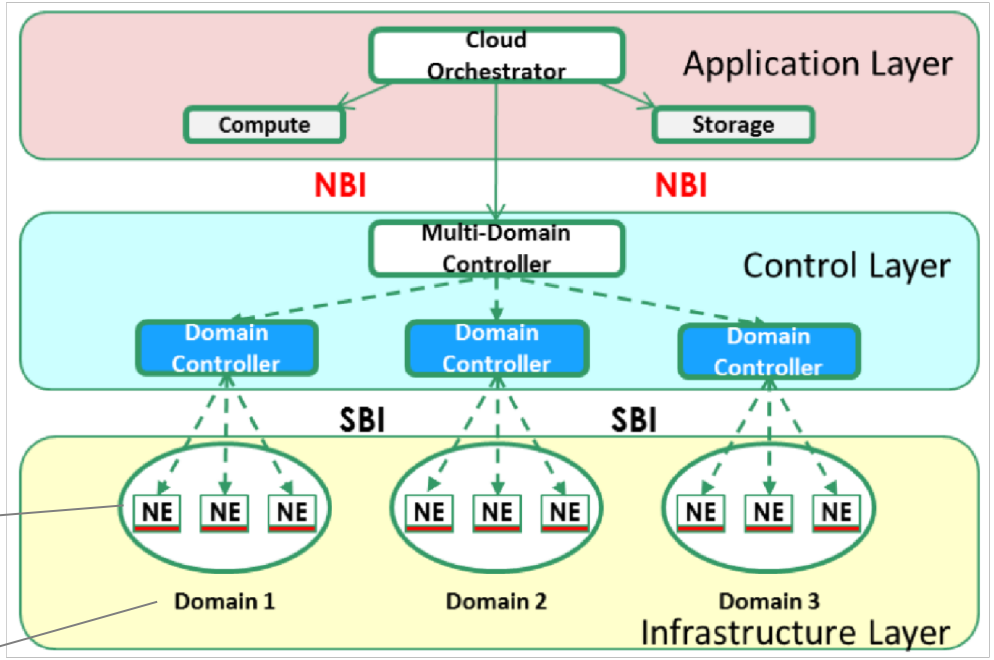
White Paper "Software-Defined Networking: The New Norm for Networks" (2012)

Transport SDN use cases in ONF



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

ONF Transport SDN Architecture



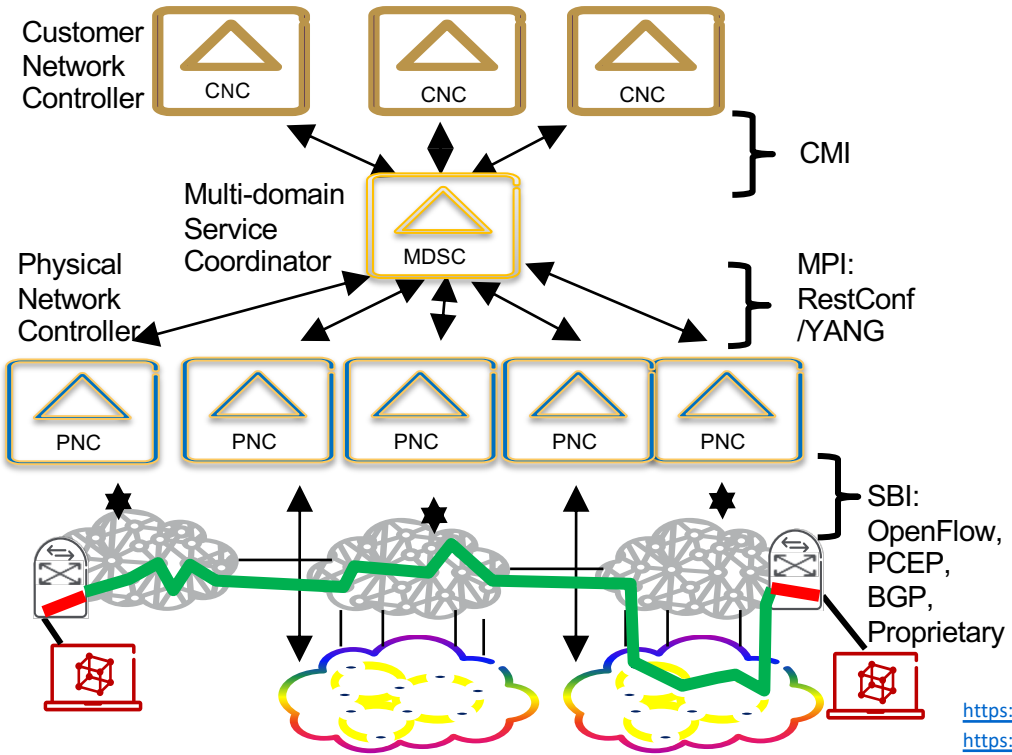
L3 IP Routers
L2 Ethernet Switches
L0/L1 Optical ROADMs

Vendor / Technology Domains
- IP / Ethernet / Optical
- Juniper / Cisco / ADVA / Ciena …
- Access / Metro / Core

- 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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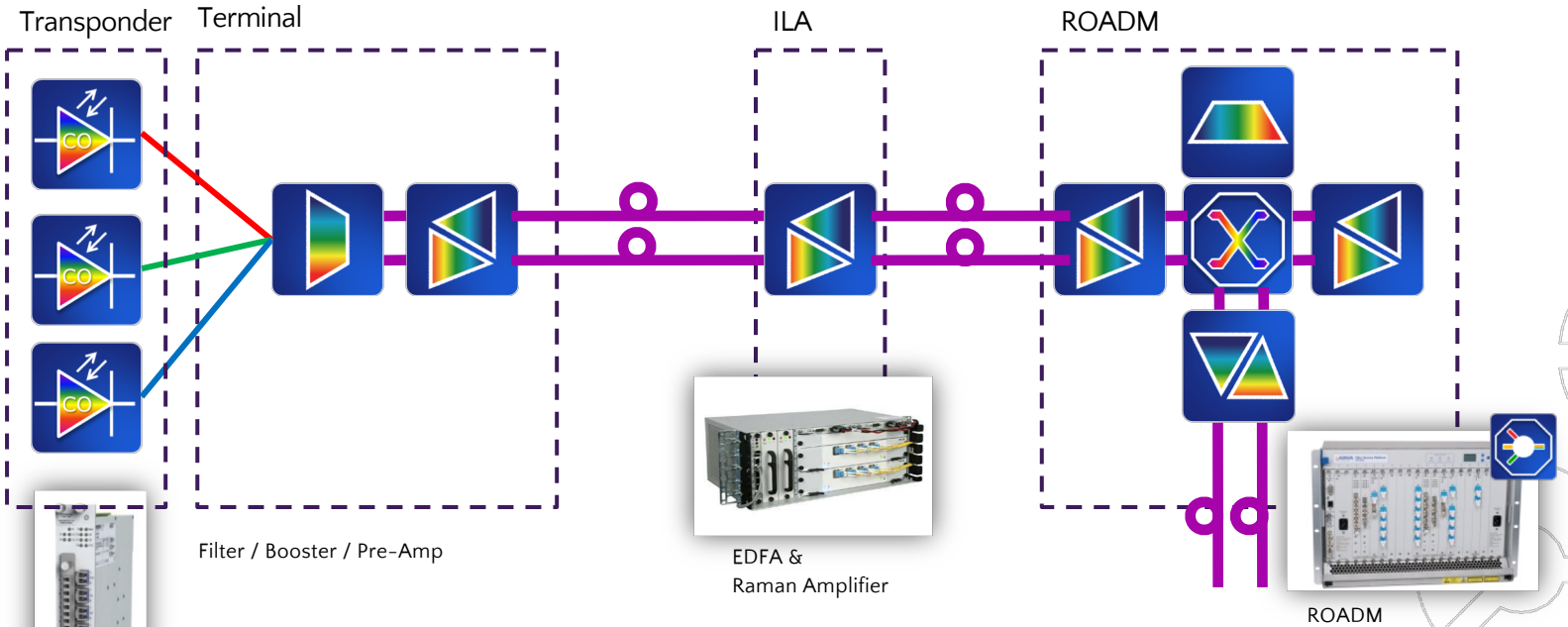
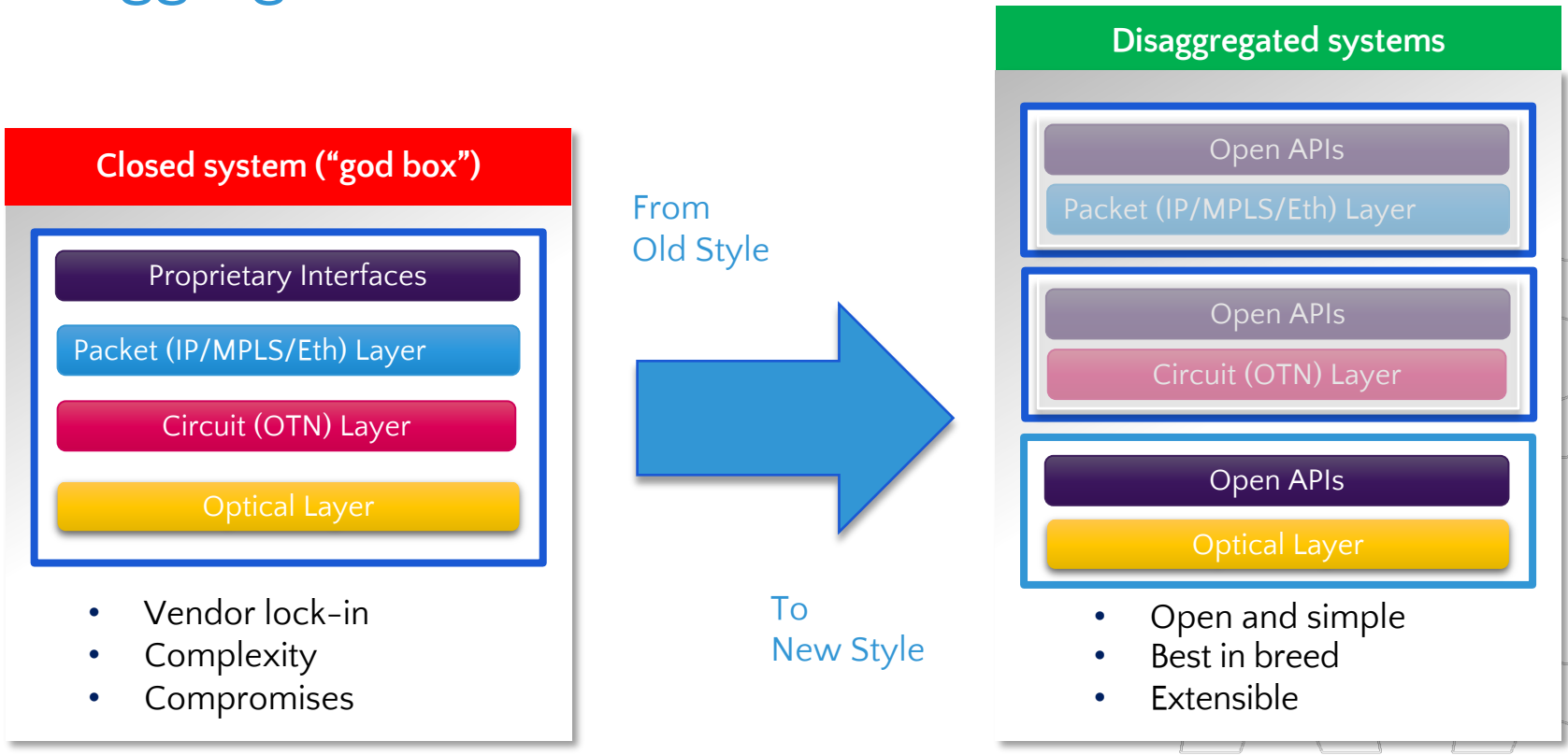
Basic WDM System Architecture

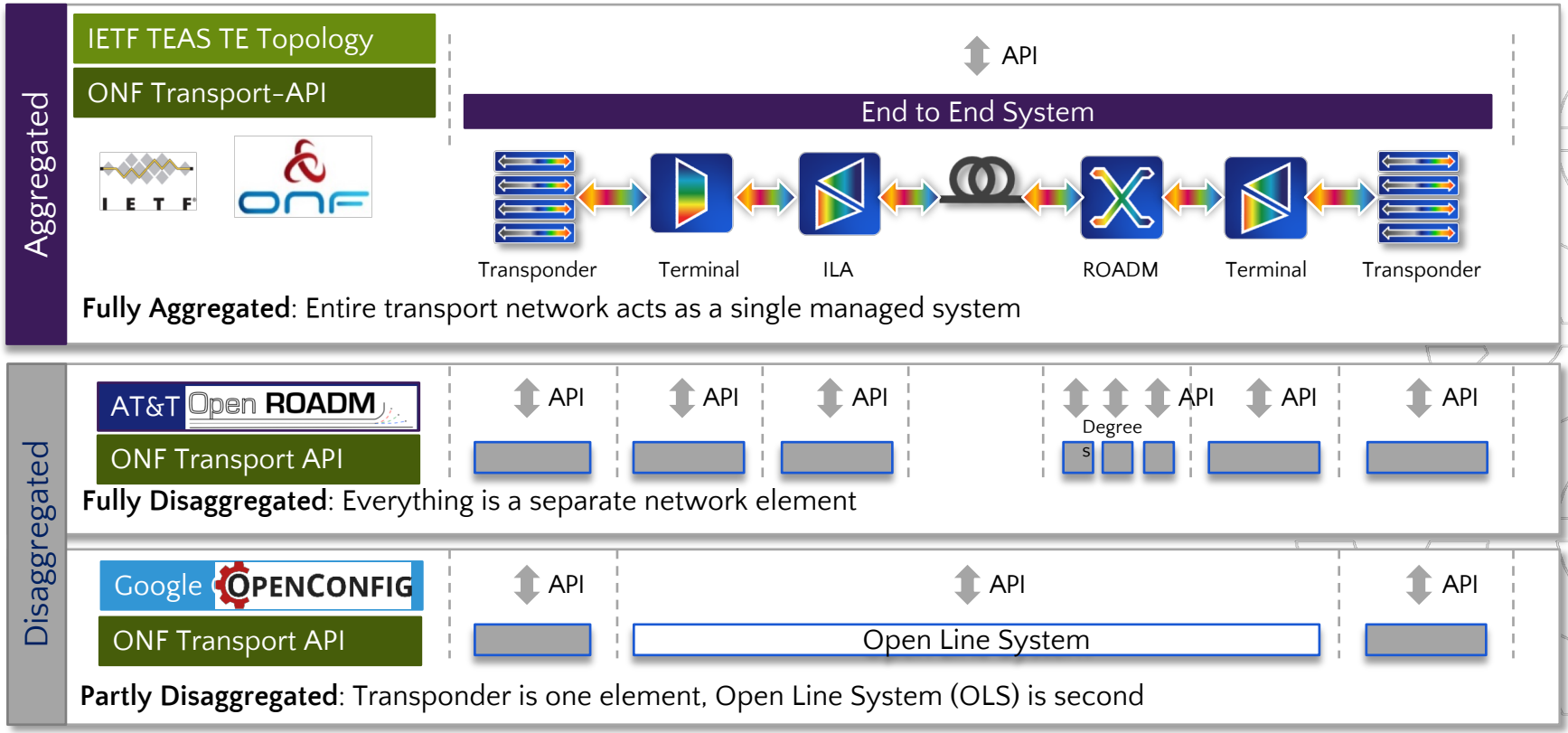


WDM	Wavelength Division Multiplex
ILA	Inline Amplifier
ROADM	Reconfigurable Optical Add Drop Multiplexer
EDFA	Erbium-doped fiber amplifier

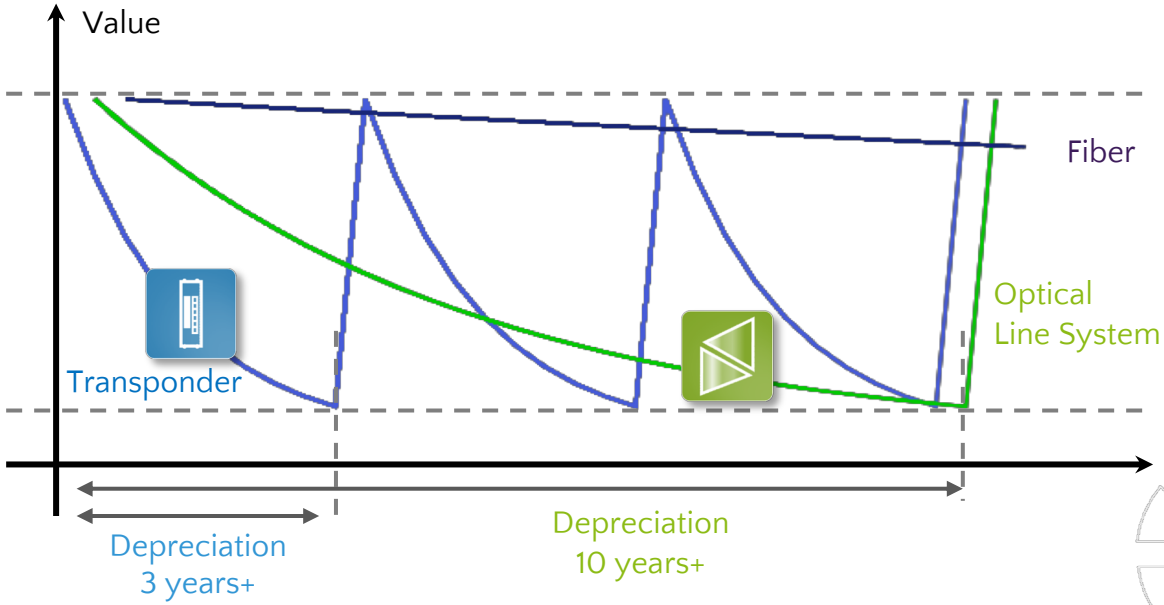
Disaggregation – Vertical direction



Disaggregation – Horizontal direction



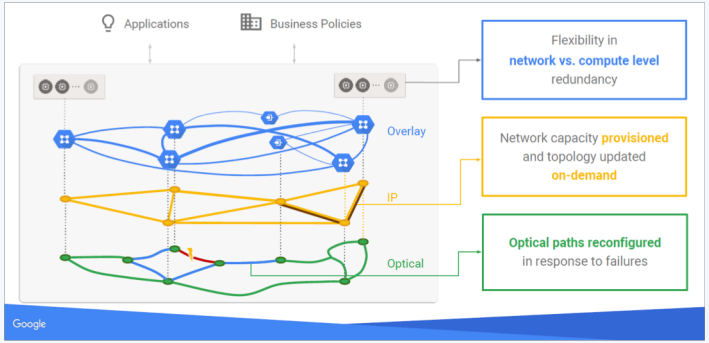
Investment and depreciation



Disaggregation flexibility: Different lifecycles for line systems and terminals

Disaggregation – Operator Concepts & Vision

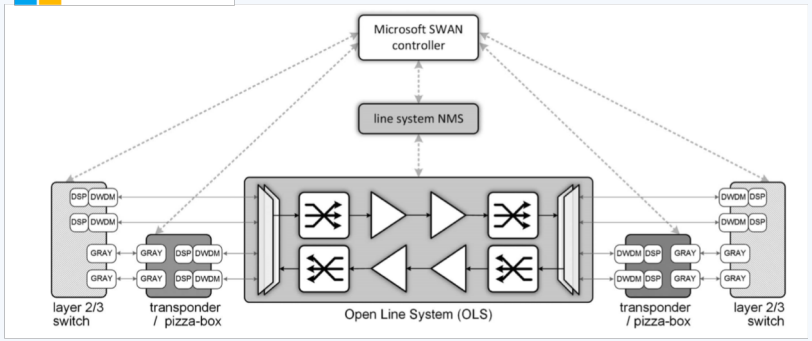
Google https://www.youtube.com/watch?v=n9zEiGyvJ-A



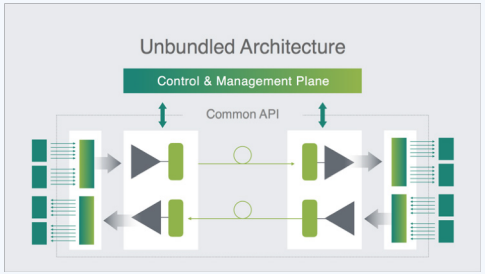
[U. Hölzle, Plenary Talk, OFC 2017]

Microsoft

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

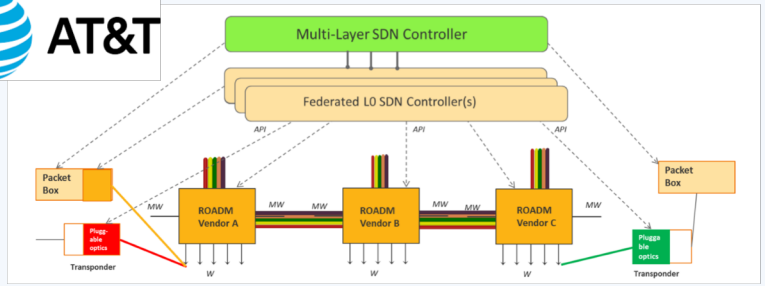


facebook



TELECOM INFRA PROJECT

AT&T



https://0201.nccdn.net/1_2/000/000/098/a85/Open-ROADM-whitepaper-v1-0.pdf

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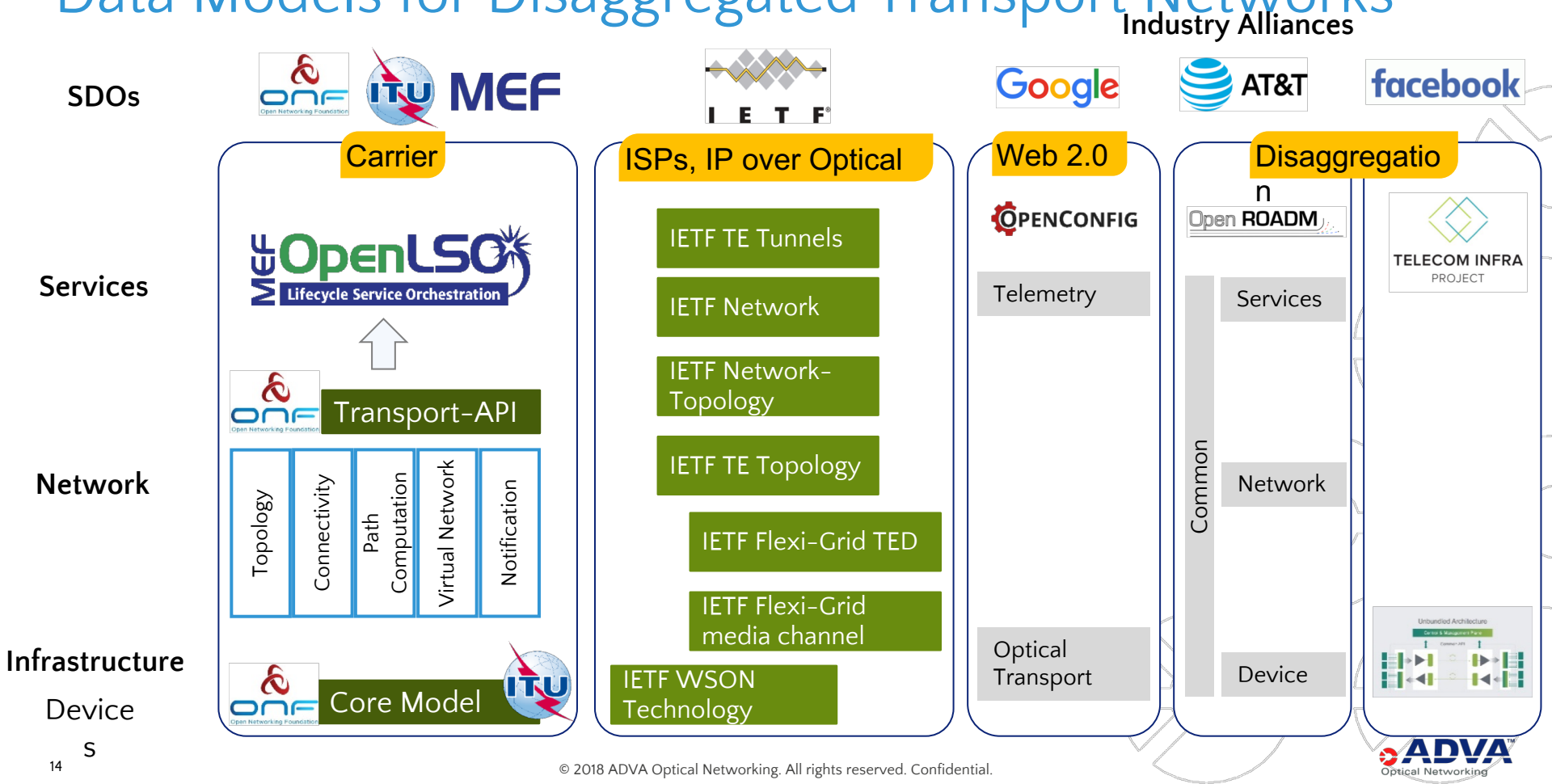
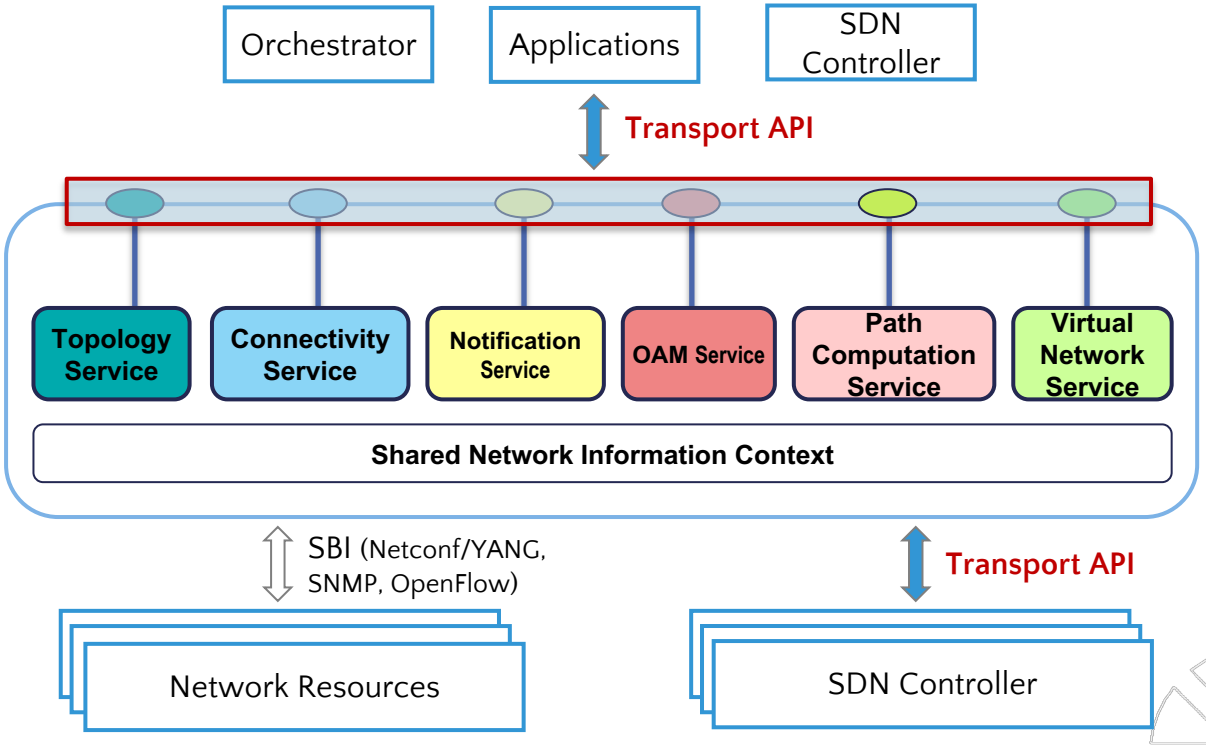
Data Models for Disaggregated Transport Networks

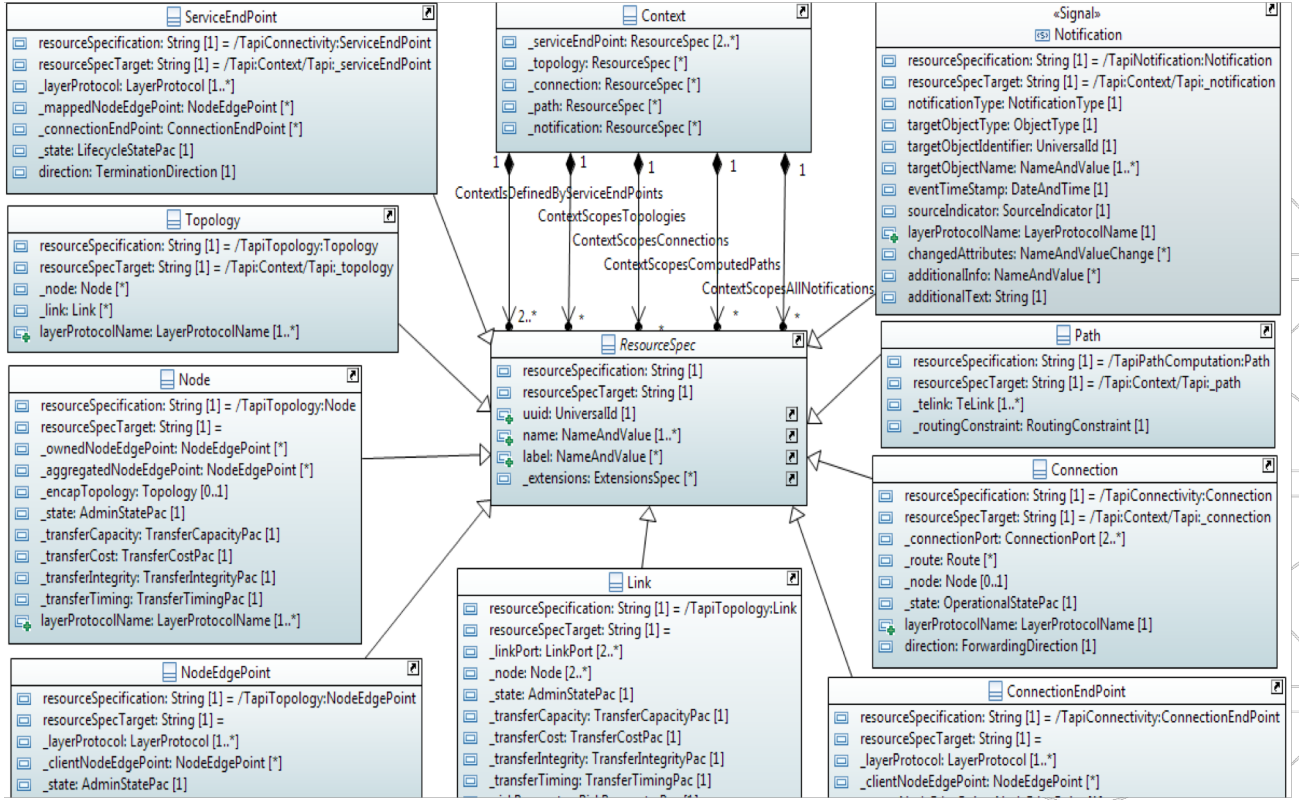


ONF Transport–API functional architecture



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)

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

[3] https://github.com/OpenNetworkingFoundation/TAPI/DOCS/presentations/onf2016.307_TAPI_SDK.01.pptx

OpenConfig

Generic, module level API

Focus on Terminal Equipment

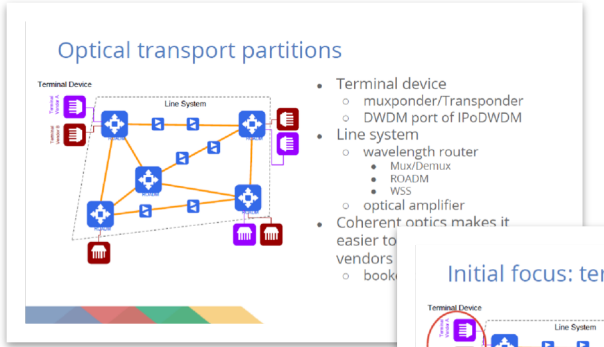
YANG models

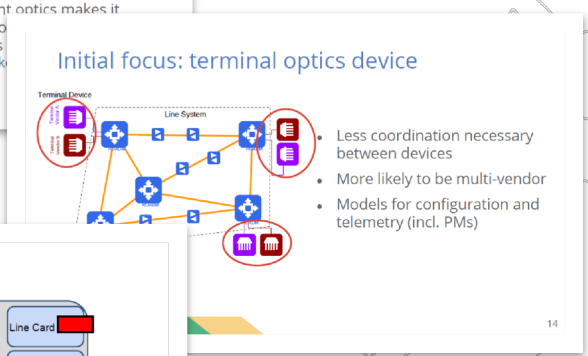
- openconfig-transport-types.yang
- openconfig-terminal-device.yang

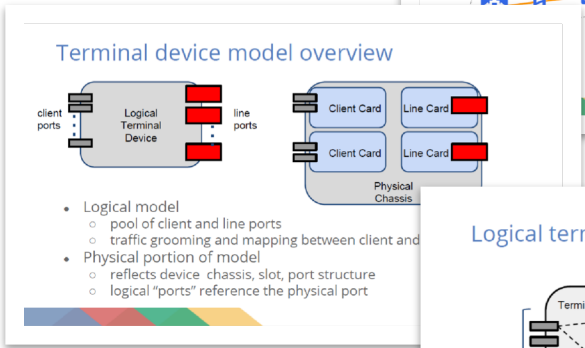
Main elements

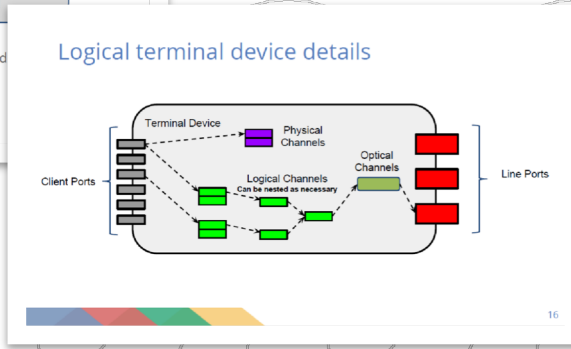
- physical client port, physical client channel, logical channel, optical channel, physical line port
- Directionality: client to line
- Physical layout: not modeled

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

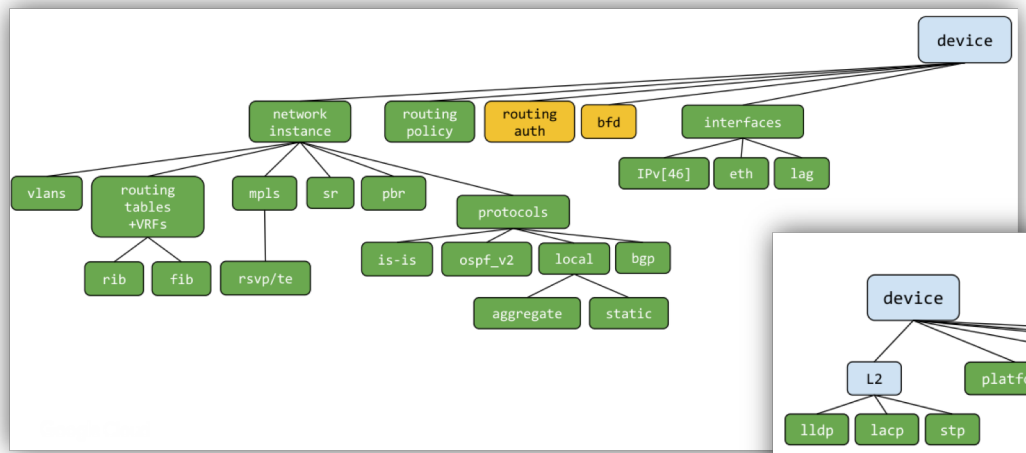


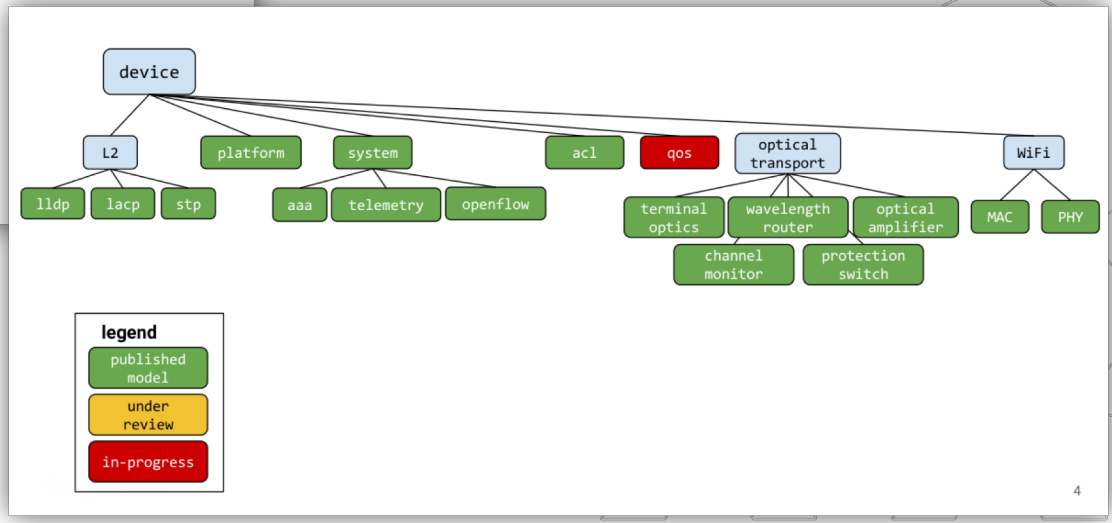






OpenConfig Data Models





Google Cloud

OpenConfig - progress toward vendor-neutral network management

Anees Shaikh
on behalf of Google network operations and OpenConfig group

OPENCONFIG
www.openconfig.net

OpenROADM Multi-Source Agreement (MSA)

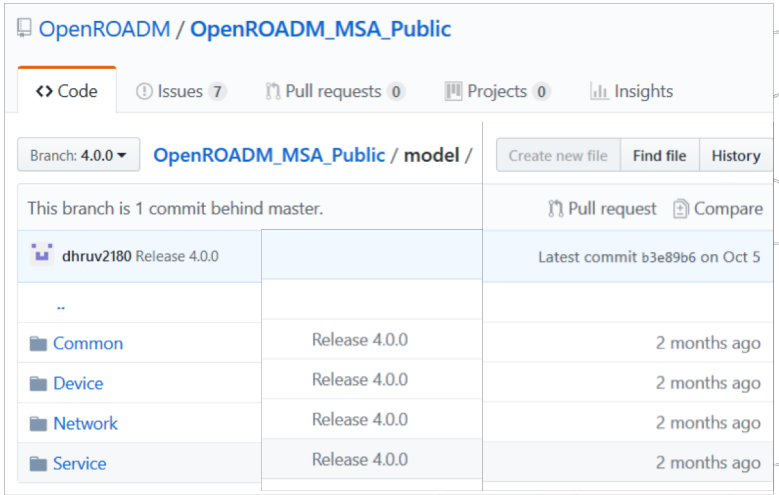
Interoperability specifications for Reconfigurable Optical Add/Drop Multiplexers (ROADM).

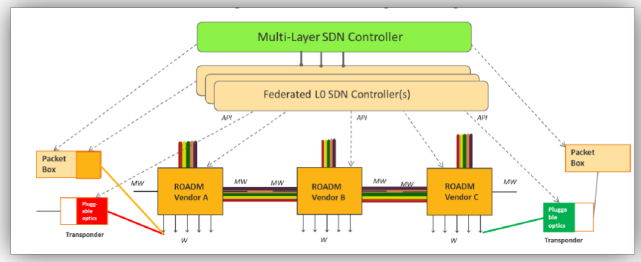
ROADM switch

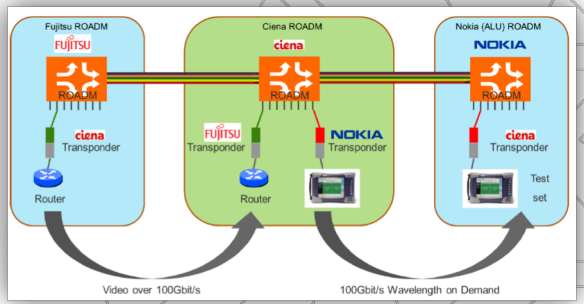
transponders

pluggable optics.

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







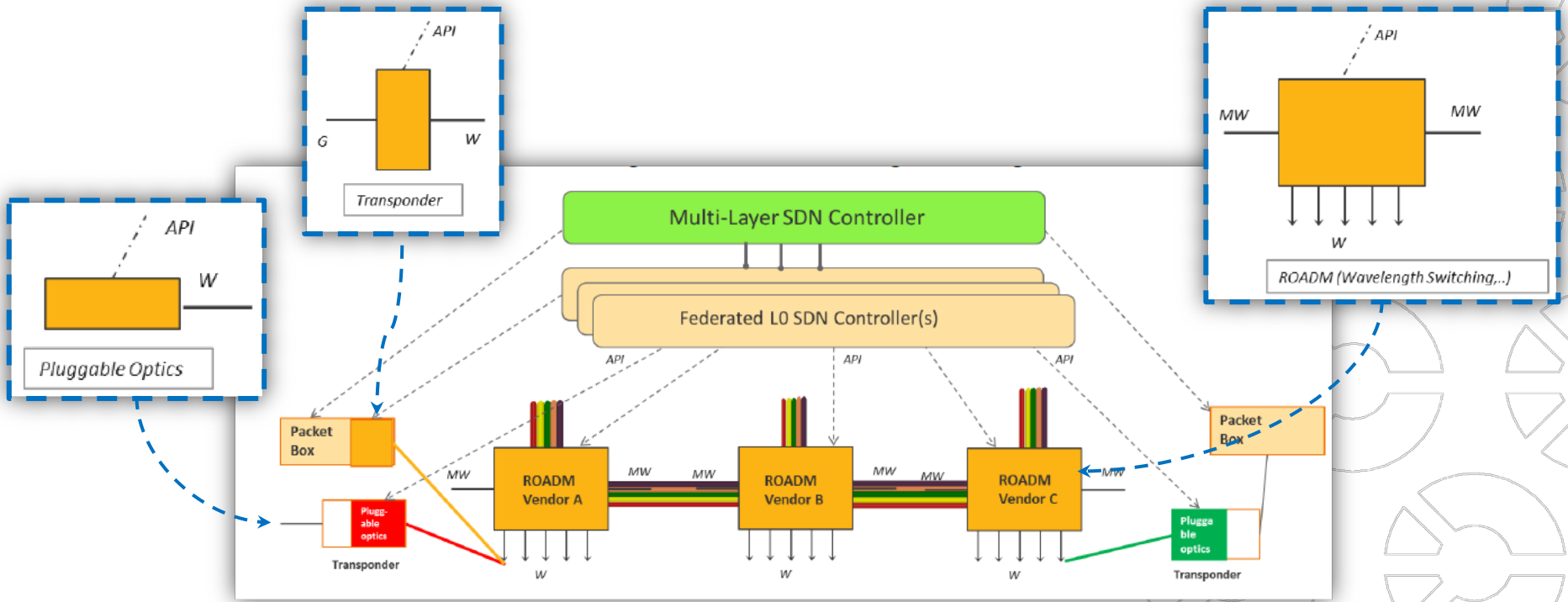
http://openroadm.org/

Open ROADM GitHub:

https://github.com/OpenROADM/OpenROADM_MSA_Public

OpenROADM Network Model and Main Objects

https://github.com/OpenROADM/OpenROADM_MSA_Public/tree/master/mod



Challenges

- Optical network consists of many in-homogeneous network elements
  - Amplifier, WSS, Wavelength Blocker, …
- ROADMs 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 ROADMs, 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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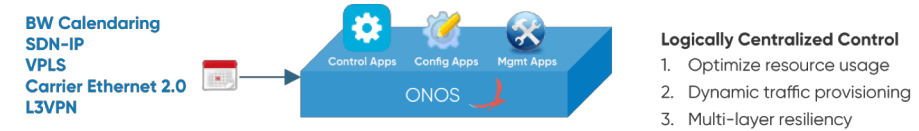
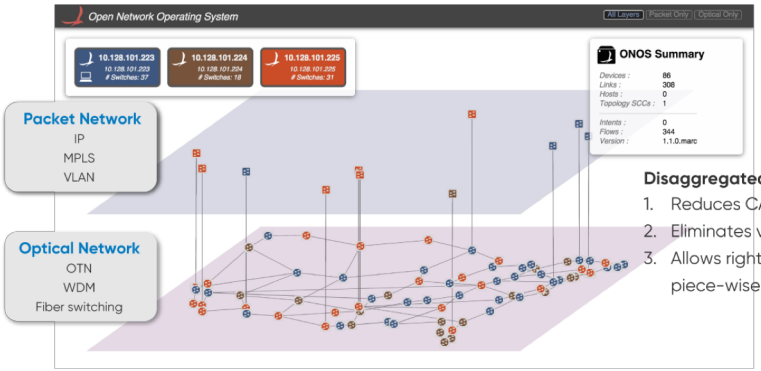
ONF Open Disaggregated Transport Network (ODTN) (01/2018 – 12/2018)

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



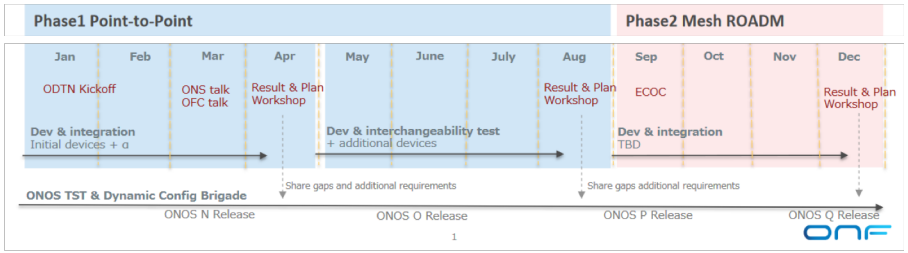
Logically Centralized Control

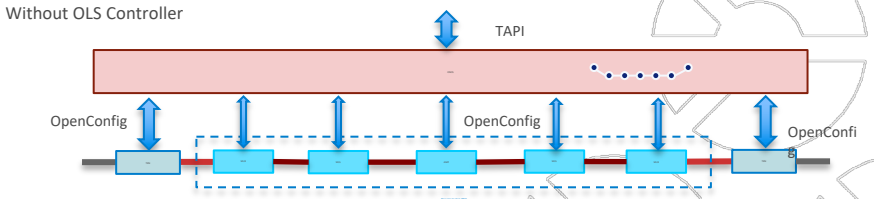
1. Optimize resource usage
2. Dynamic traffic provisioning
3. Multi-layer resiliency

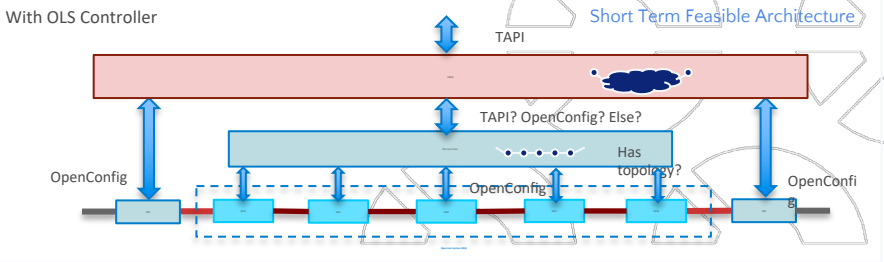


Disaggregated Transport Network

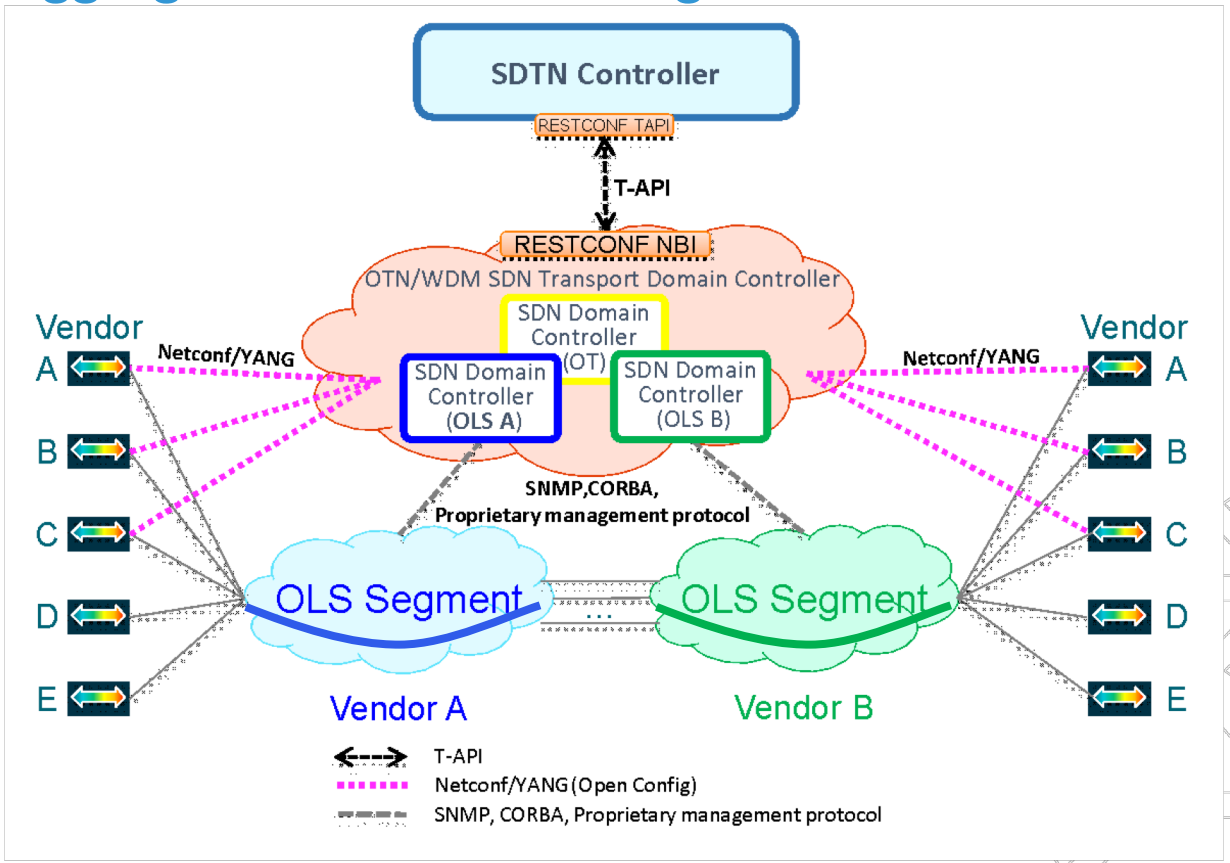
1. Reduces CAPEX & OPEX
2. Eliminates vendor lock-in
3. Allows rightsizing and piece-wise upgrades







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

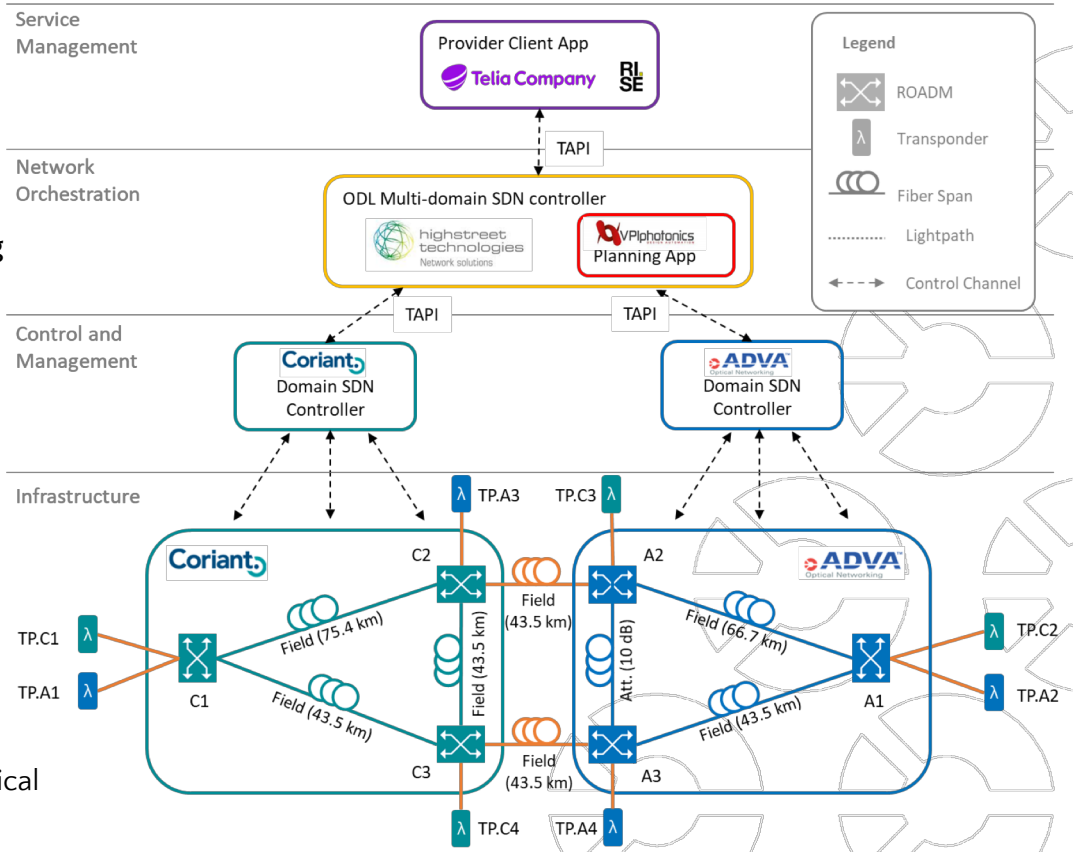
- Transport Orchestrator (highstreet technologies)
- Planning Application (VPIphotonics) (Bundled in Transport Orchestrator)

Control and Management layer

- SDN Domain Controllers (ADVA and Coriant)

Infrastructure layer

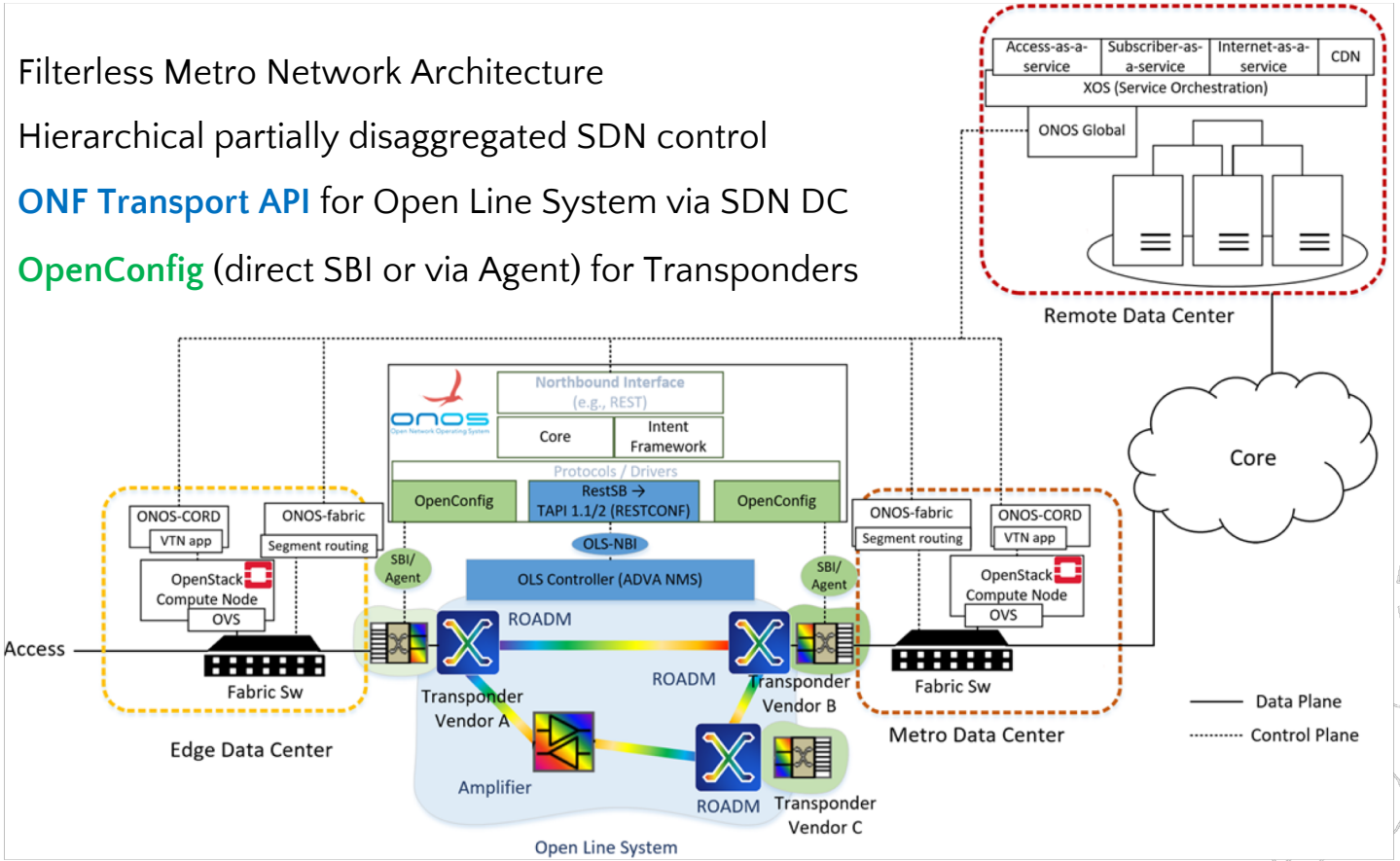
- ROADMs and transponders (ADVA and Coriant)
- Transparent ROADM line port interconnect
- Alien wavelength interconnection passing both vendors optical domains



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

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