

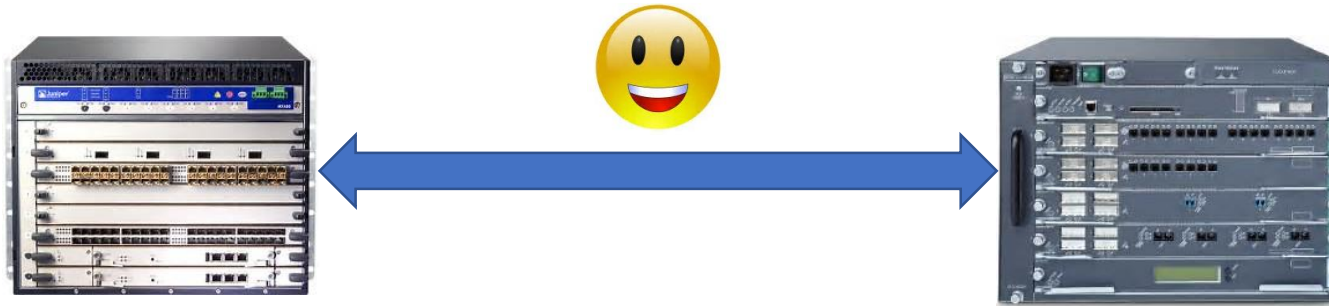
# Open Solutions for Packet Optical Networking

Robert Keys

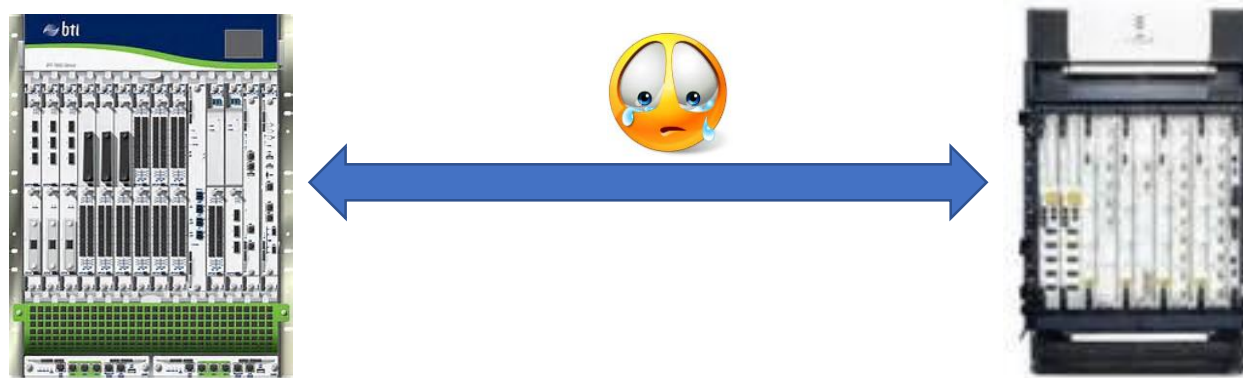
VP Engineering

Juniper Networks

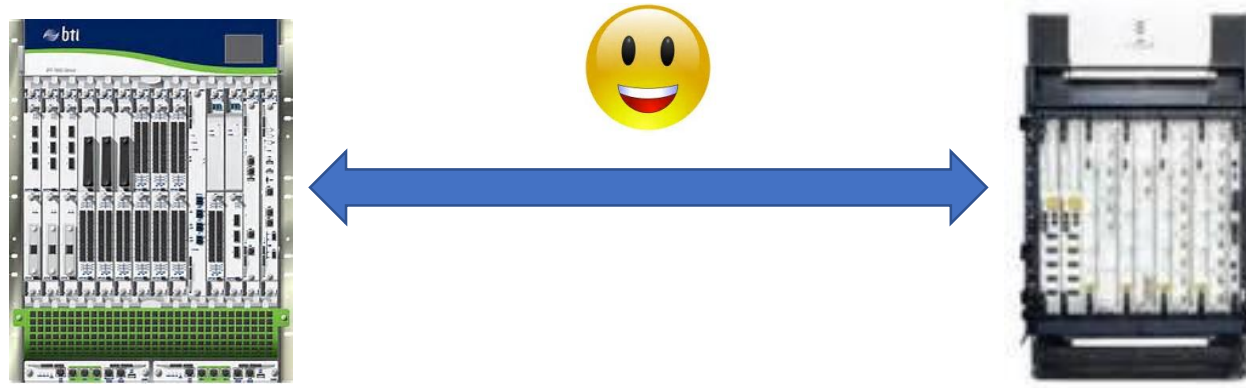
If you are a packet dude, consider yourself lucky



If you are an optical dude, consider yourself behind the times



We are working to reverse that frown .....



Open packet optical networking ..... Drive open interfaces and interoperability

Simplified networking, lower cost of operations

# Presentation objective

- The aim of this presentation is to introduce the audience to the emerging trend for open packet optical networking.
- New industry working bodies are emerging to champion this approach – openROADM, TIP, Openconfig etc.
- We will review the trend and the work on going for the audience to gain a quick tutorial on the trend.

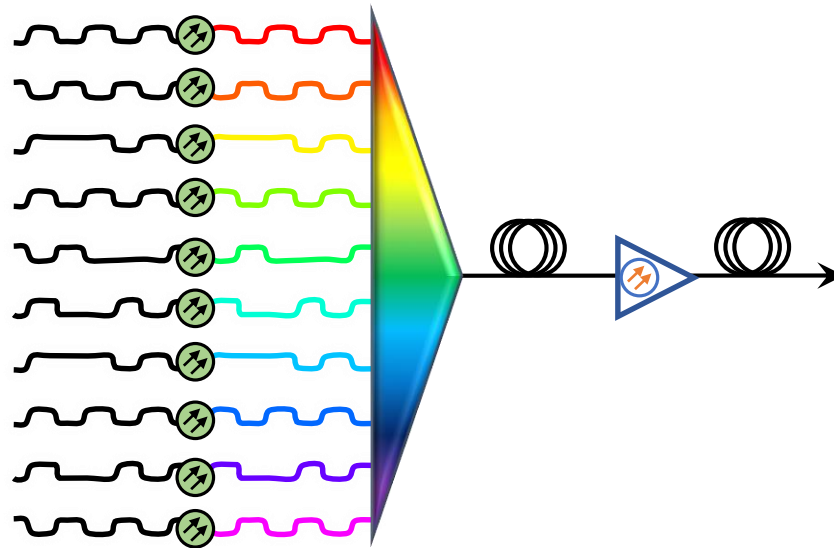
# Agenda

- Industry pivots and market adoption of open packet optical networking
- Open packet optical networking defined
- Industry collaboration – standards bodies
- The new standards bodies – openROADM, TIP
- Stepping on each others toes ....?
- Bringing it together ..... demos
- Find out more

# DWDM : increasing capacity between routers



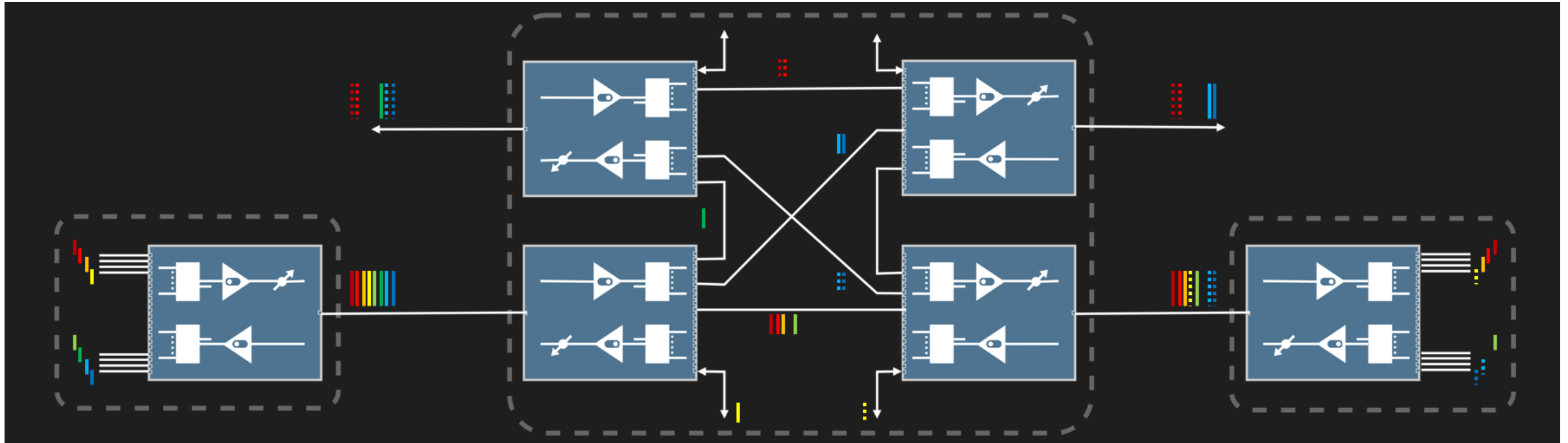
- DWDM allows for N “independent” connections between the routers, but using a single duplex fiber connection between sites



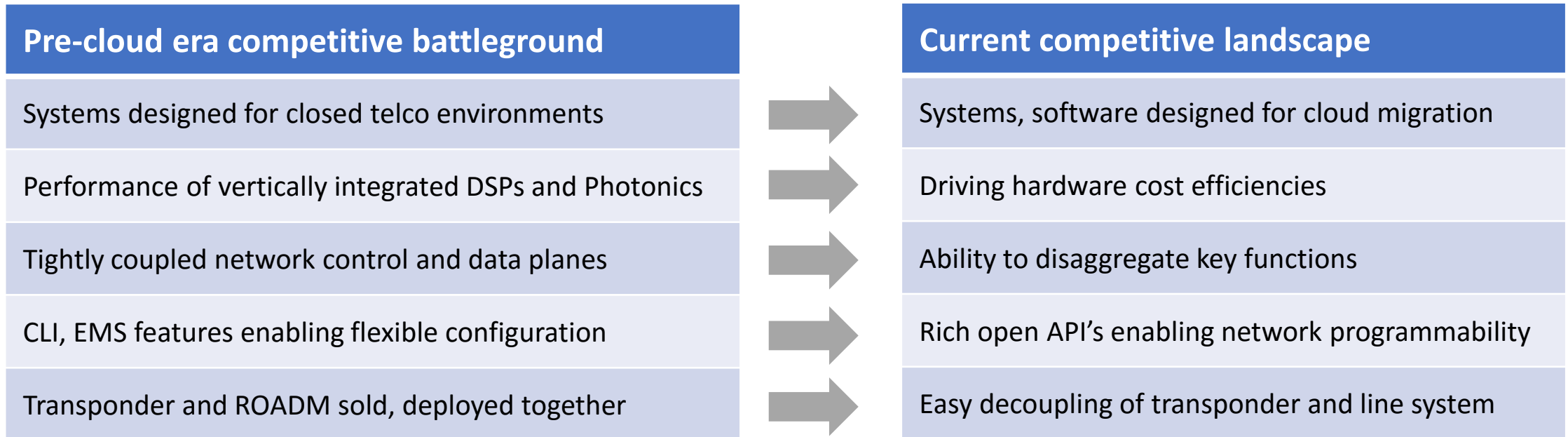
DWDM turns a single pair of fibers into 96 virtual fibers!

# DWDM Optical path switching : ROADM

- **ROADM** (*Reconfigurable Optical Add Drop Multiplexer*)
  - Optical switching in a network
  - Moving the wavelengths



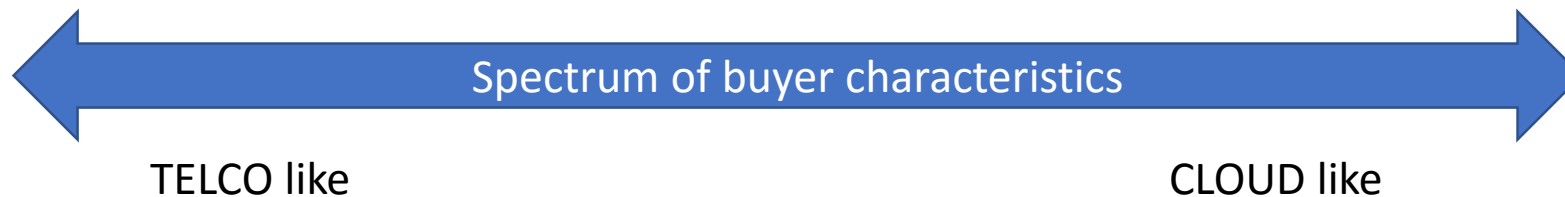
# Packet-optical competitive landscape is shifting in response to customer cloud business priorities



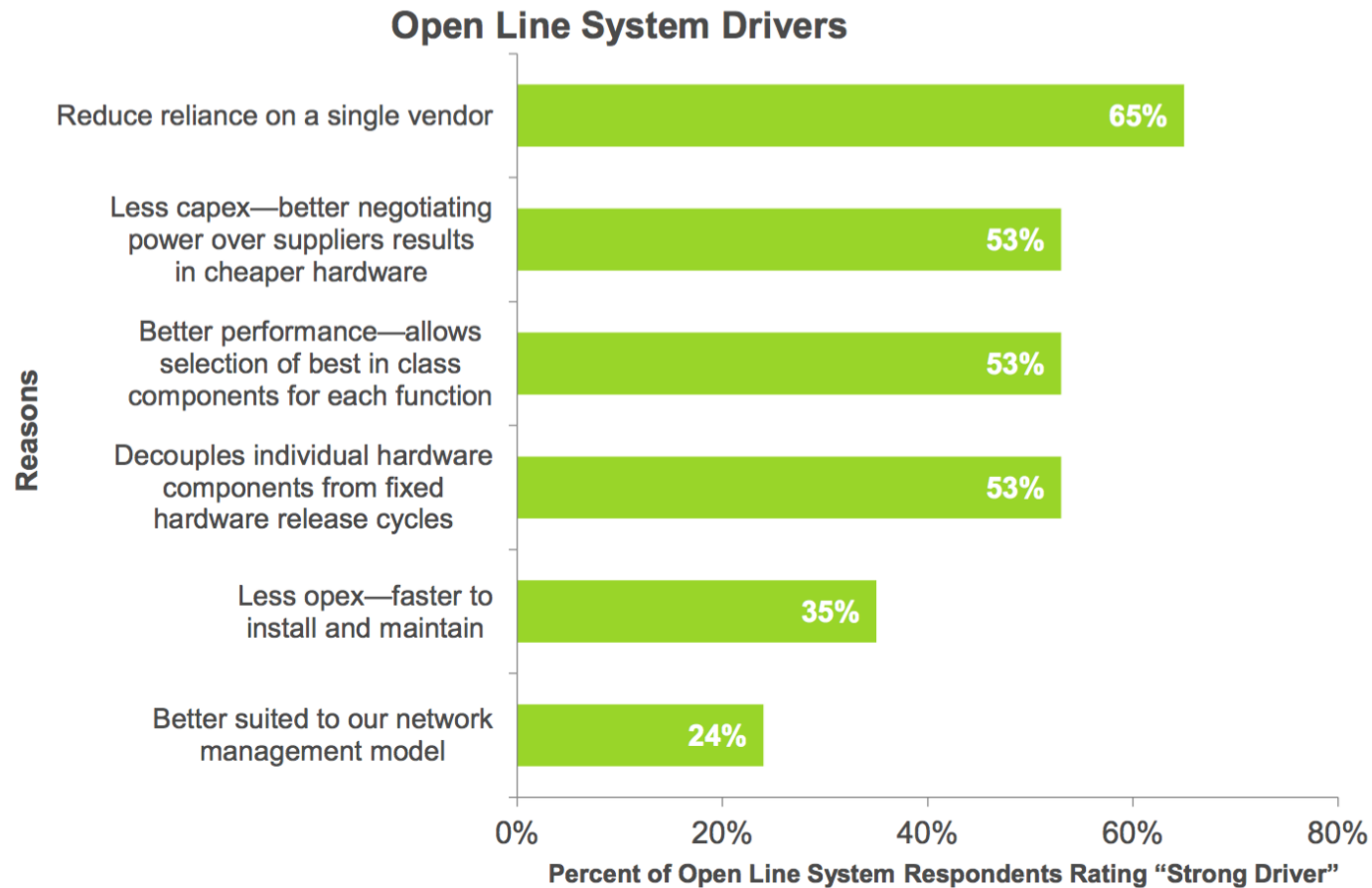


# The prototypical buyers of packet optical

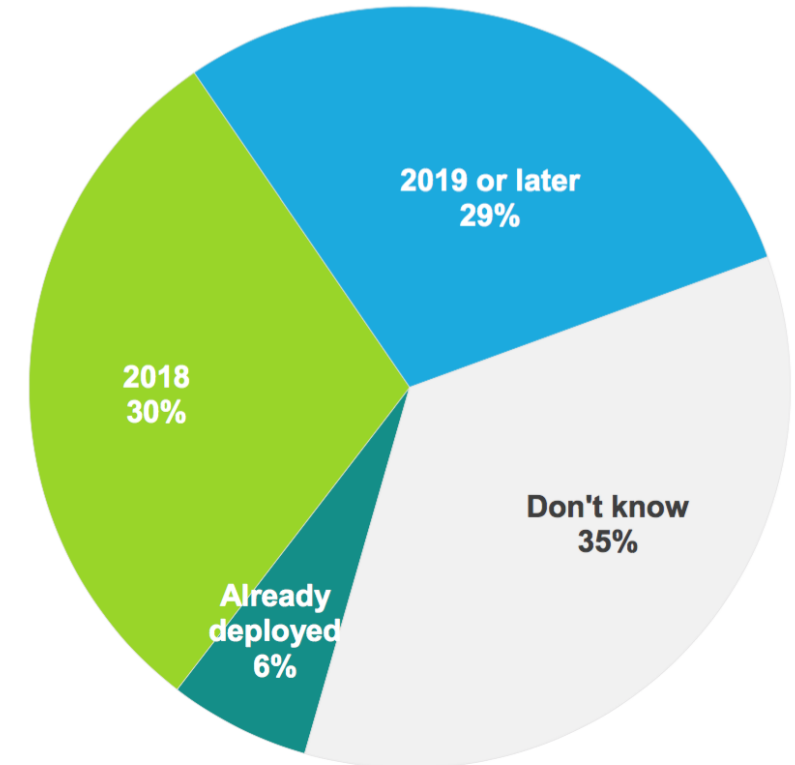
Integrated Buyer	Disaggregated Buyer
View the network as revenue – Infrastructure which is their business	View the network as COGS – infrastructure on which to run their business
Buys an integrated system built from tightly coupled solution components for a designated purpose	Buys loosely coupled solution components for fungibility
Builds infrastructure to meet relatively stable and / or predictable network demands	Builds a network to scale for relatively variable and / or uncertain capacity demands
Values strong vendor / supplier partnership to deliver a system to meet E2E performance requirements	Very little vendor / brand preference
Relies on vendors and service partners for solution & management integration	DIY for solution and management integration



# Market drivers & adoption



**Open Line System Deployment Timing**



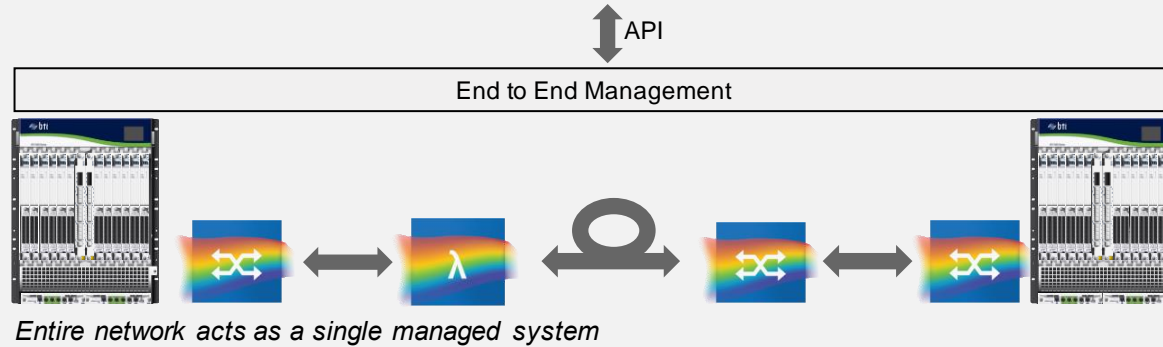
Source: IHS Markit 100G+ & ROADM Strategies Global Service Provider Survey; December 2016

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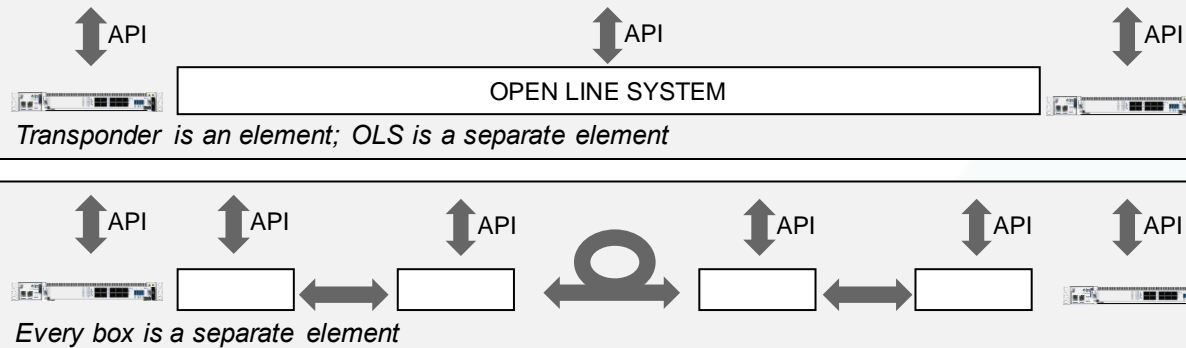
# Open packet optical networks defined

## Aggregated



Traditional: closed end to end proprietary solution;  
Vendor lock in; proprietary SW

## Dis-aggregated

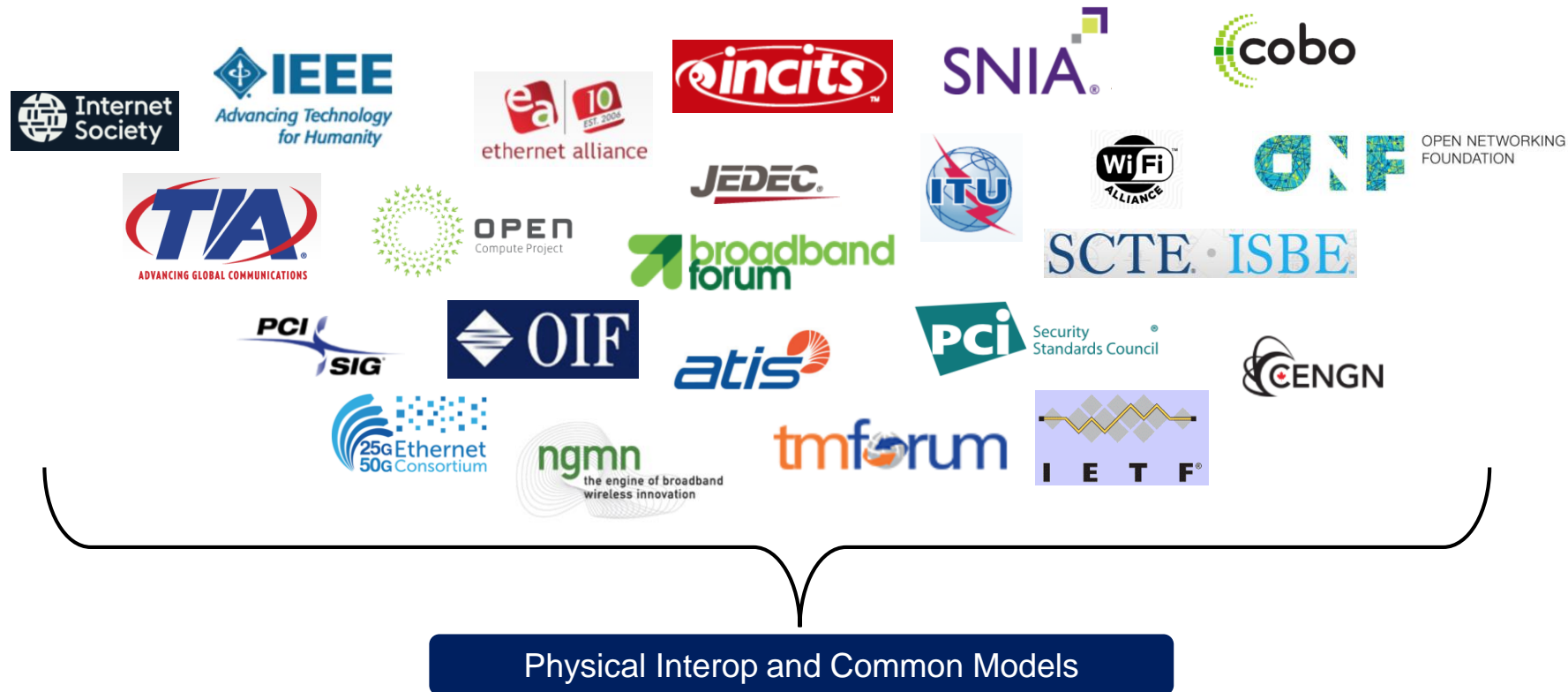


Option 1: have an optical line system from vendor A and  
the transponders from any vendor

Option 2: make the optical line elements interoperate  
and buy and deploy from any vendor

Move to open HW and open SW allows system company to break the mould of  
closed systems and vendor lock in; good for them and good for industry

# There are many standards bodies .....



There is a whole lot of effort going into making components etc standard  
Now we are turning our attention to making the solutions interoperable and open

# System perspectives to drive open networking



ONF TAPI

- Protocol between orchestrator and optical controllers and NMS
- Vendor Driven
- UML source



IETF TE Topo

- Models L1 transport topology and connectivity parameters



AT&T OpenROADM

- ROADM focused
- Limited Operator Support
- No Flex Grid support



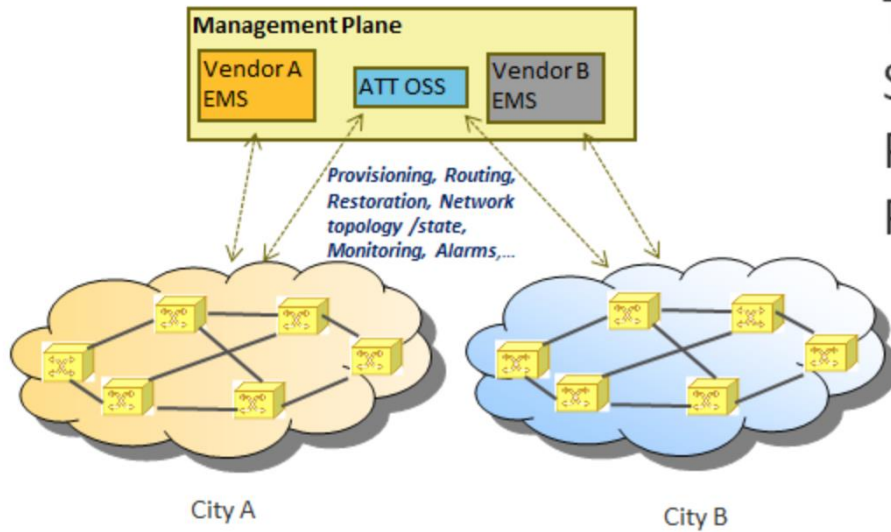
Google OpenConfig

- Focus on Routers, but optical devices also included.
- Configuration and Telemetry only
- Significant Operator Support

# The new groups driving industry collaboration

- Open ROADM
- Telecom Infra project
- ONF
- Open config
- ON2020

# OpenROADM



TODAY'S ROADM SYSTEMS REQUIRE A SINGLE VENDOR WITH TIGHT COUPLING OF PROPRIETARY SOFTWARE (EMS AND PLANNING TOOLS)

Need to be able to overbuild metros on a office-by-office basis

Need for open, standardized interfaces and much less proprietary SW



# Introduction

- OpenROADM is a multi-source agreement (MSA) between multiple manufacturers to make products which are compatible across vendors, acting as de facto standards, establishing a competitive market for interoperable Optical products.
- Established in Spring of 2015, a successful plugfest in February 2016 resulted in the publishing of the specifications.

# Objectives

- The Open ROADM project has at its core
  - the drive towards faster pace innovation and competition
  - as well as increased volumes through mass adoption
  - coupled with optical layer flexibility and software control to overcome all the disadvantages of today's ROADM system
- This will be achieved through a common
  - NETCONF/YANG APIs between all components and a Controller
  - Multi-wave Interface between ROADMs
  - Single-Wave Interface between transponders or pluggable optics

# Group Members



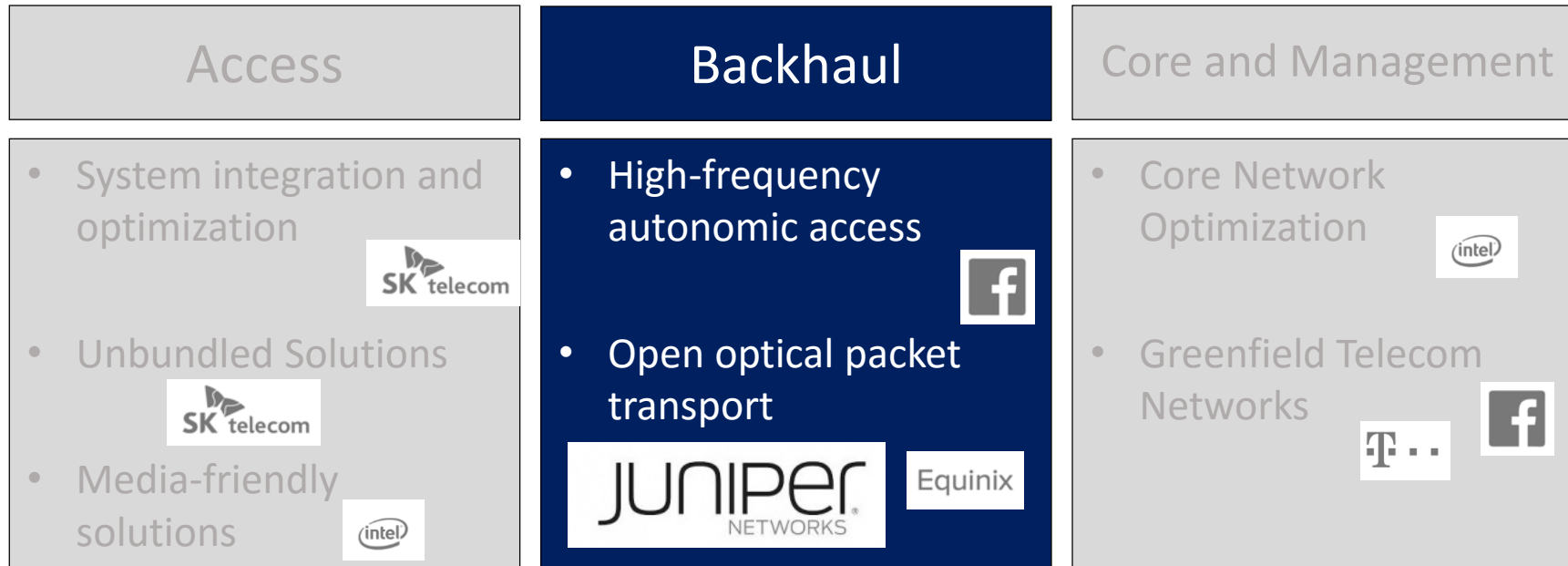
In openROADM networking companies and providers of networking equipment are working co-operatively to create useable operational models for open networking



# Deliverables (Q22017)

- Optical Specification - Single Wavelength and Multi Wavelength (v1.07)
- OpenROADM YANG Model (v2.0)
  - New features include support for OTN protection, FlexGrid, in-line amplifier for reach extension and a new I2RS-compliant Network abstraction model
- Documentation suite
  - OpenROADM Overview (v1.0)
  - OpenROADM Model Whitepaper (v1.0)
  - OpenROADM Network Model Overview (v1.1)

# Telecom Infra Project



# Telecom Infra Project

## What we try to accomplish!

Many exciting challenges ahead of us:

- Connecting the un-connected billions requires a global effort
- Connectivity in times of cloud and social networking changes dramatically towards SDN & programmability and sheer data consumption

The industry does not deliver at the innovation speed that we need to!

## How we try to accomplish!

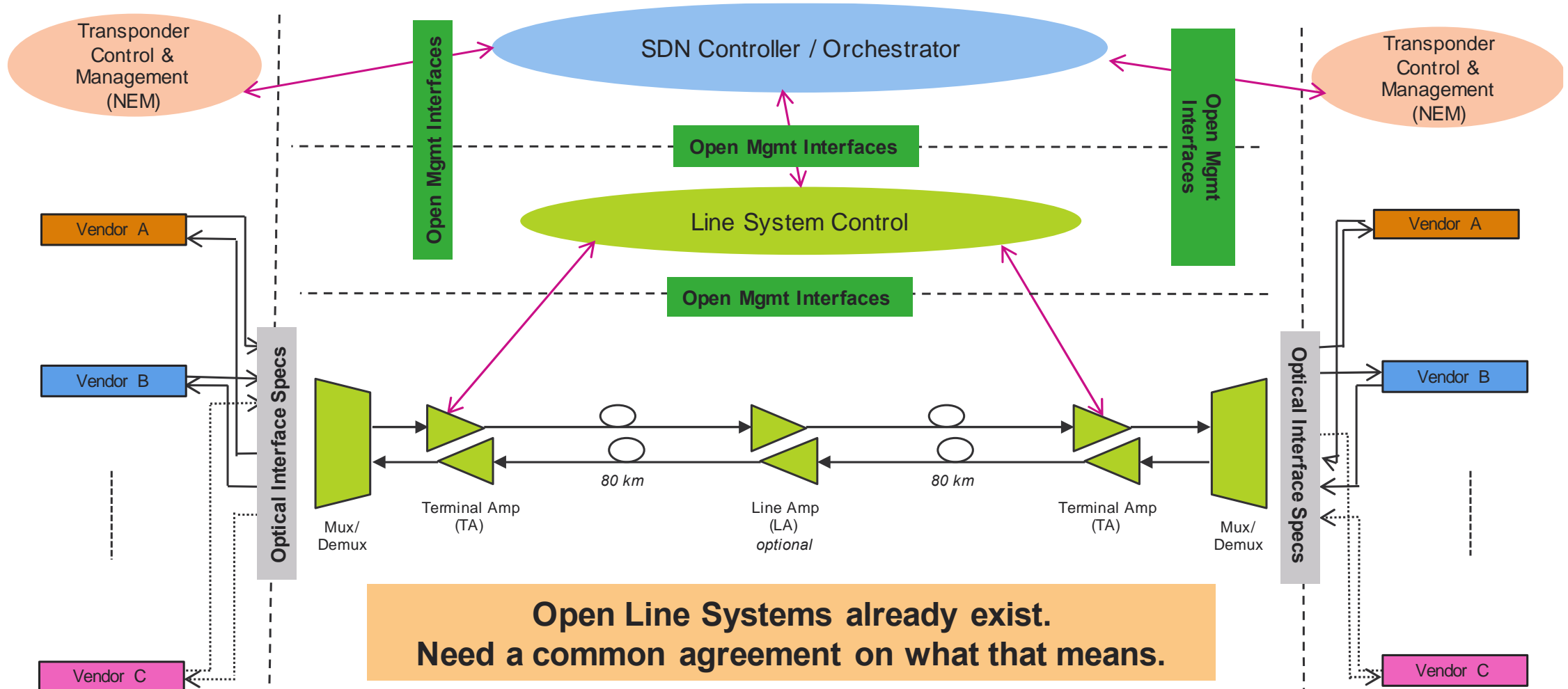
- Break-up a stove-piped industry from vertical to horizontal
- Enable new innovation paradigms with lower barrier of entrance and faster adoption
- Enable the SW model for S/R/T – SDN!
- Re-use DC technologies for the WAN
- Enable an eco-system of creativity and adoption by focusing the valuable R&D resources on innovation

## Open Optical Packet Transport Group

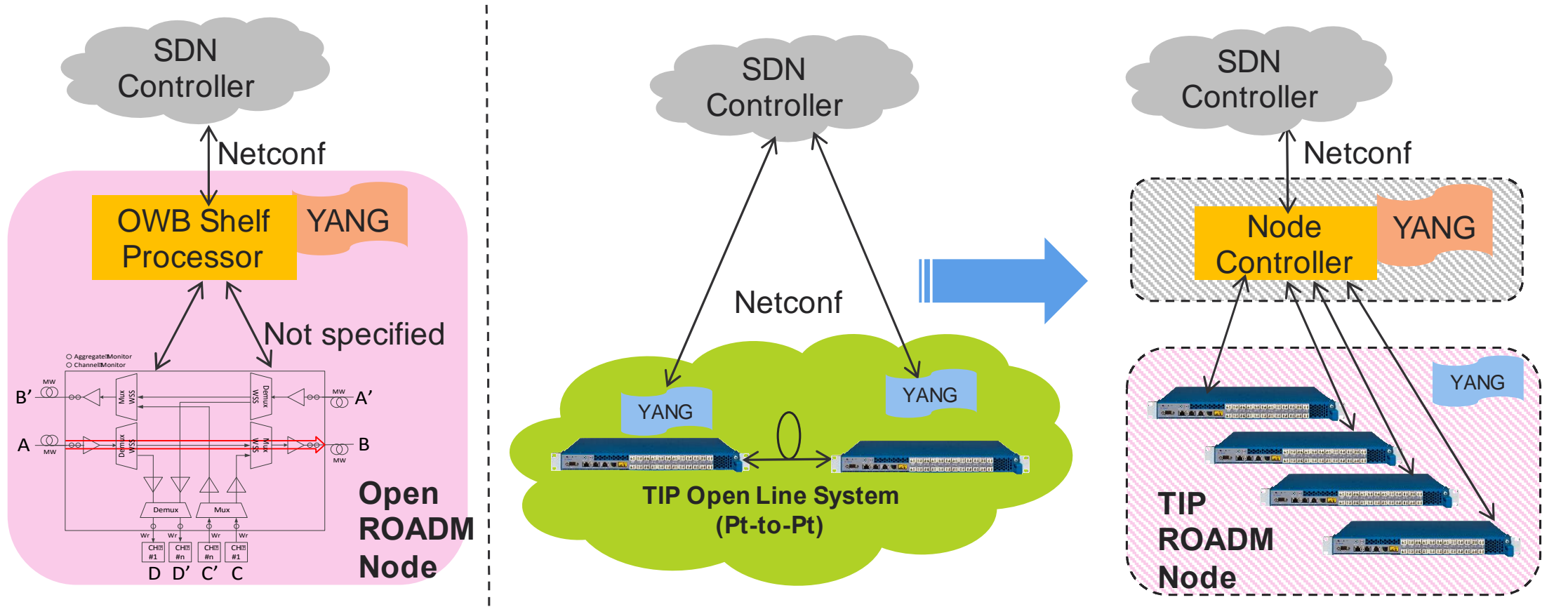
Define Dense Wavelength Division Multiplexing (DWDM) open packet transport architecture, that triggers new pace of technology innovation and flexibility, and avoids implementation lock-ins.

Essentially we are dealing with opening up:  
Switching, Routing and Transport (S/R/T)

# TIP open line system



# Stepping on each others toes .....



We are all working together .... Great progress. Need to ensure that we sweat the details and create a single model. Ot at least models that are aligned, especially in SW / API's.



# OpenROADM Trials

- Spring 2015 – Plugfest
  - Initial Members only
  - v1.0 of the specification
- AT&T December 2016
  - The operator used a 100-gigabit optical wavelength in its Dallas area network to connect two IP-MPLS routers using transponders and ROADMs from multiple optical equipment vendors
- Orange Q2 2017
  - Orange is targeting its own lab trials in the first half of this year using a simplified OpenDaylight SDN controller working with ROADMs from three systems vendors. “We want to showcase the technology and prove the added value of an open ROADM,” says Xavier Pougnaud.

# TIP – operator trials



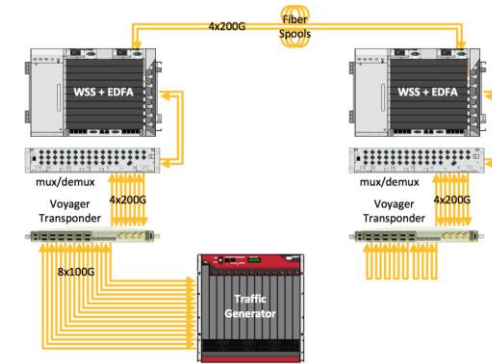
## Why Voyager Transponder at Equinix?

Equinix Wants to Enable and Foster Innovation

- Equinix supports a disaggregated hardware and software model that will speed up innovation for network components and technology.
- Equinix wants to be the place where hardware and software vendors come together with major service providers to create a TIP ecosystem.
- Equinix is creating a new data center design support model for this type of hardware to enable network and cloud service providers to interconnect and grow the TIP ecosystem.

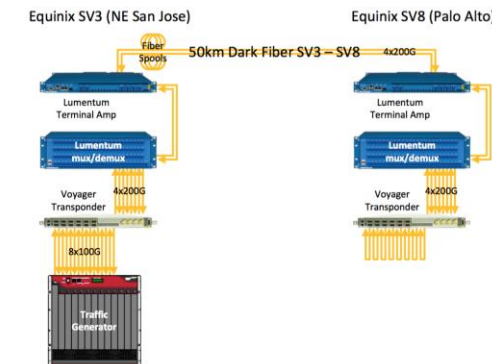
## Lab Trial at Equinix SV3

Active Line System Configuration

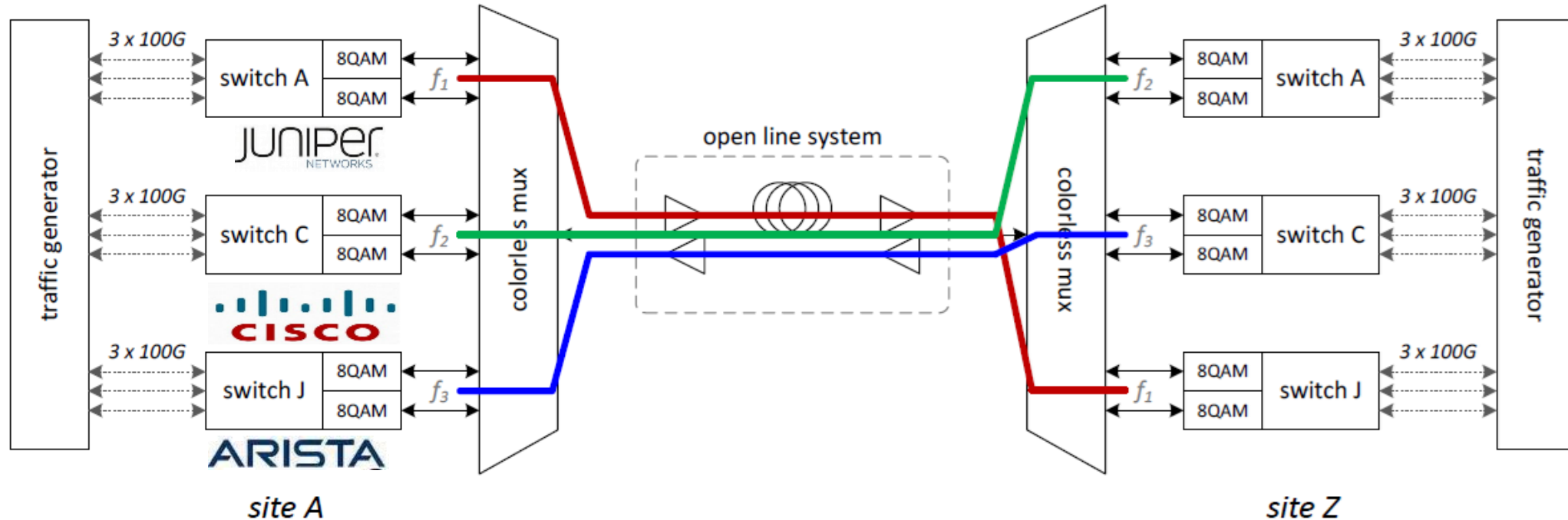


## Field Trial Between Equinix SV3 and SV8

Open Line System on 50km Dark Fiber Span Between San Jose and Palo Alto



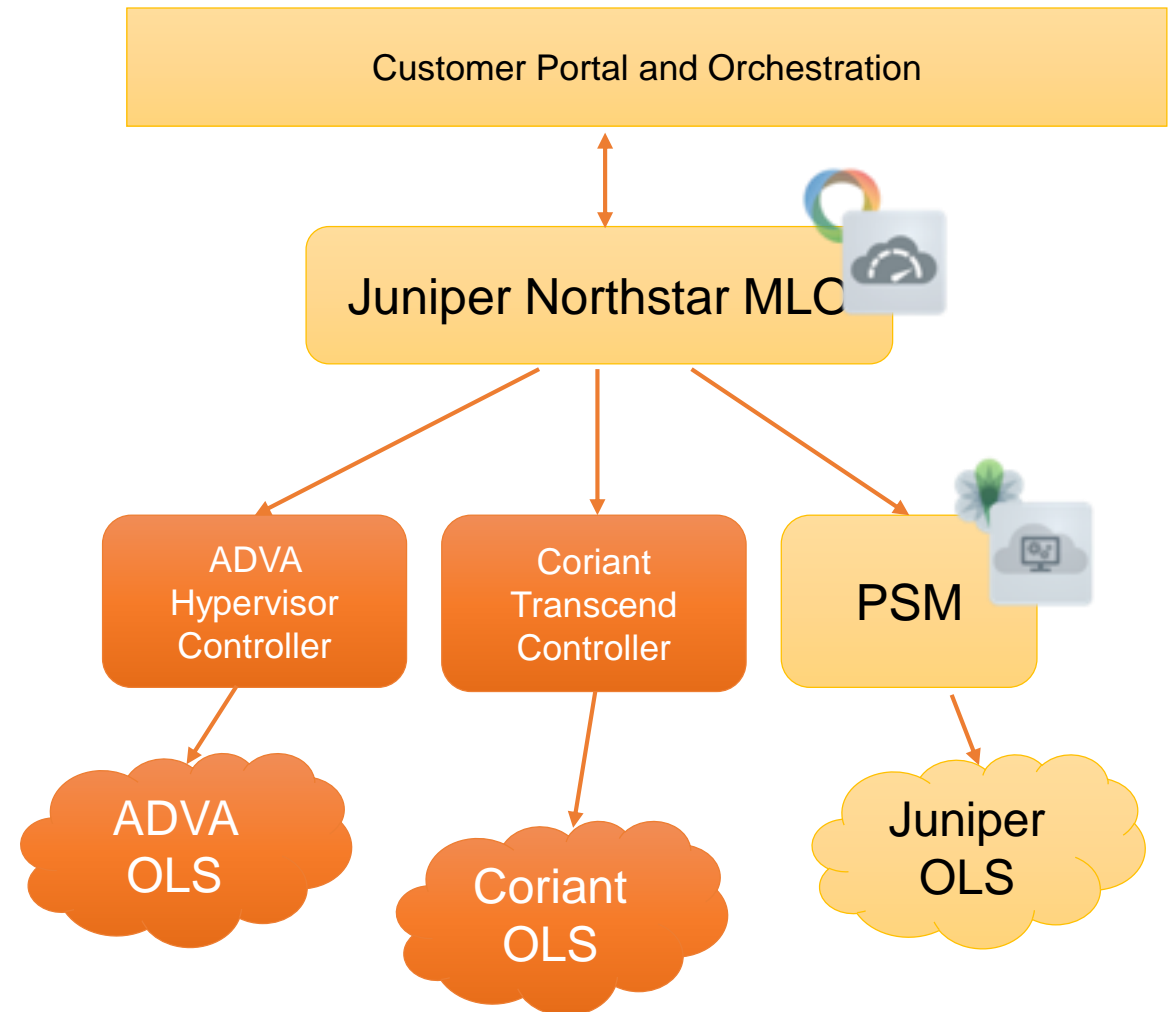
# Microsoft – Transponder Interoperability



- ✓ Open line system consists of hybrid Raman/EDFA for long spans, EDFA only for shorter spans, and flex-grid ROADMs
- ✓ 8QAM transmission over 2000km LEAF fiber, 104 channels total, 37.5GHz spacing
- ✓ 16QAM transmission over 1000km LEAF fiber, 104 channels total, 37.5GHz spacing

# 2017 OIF T-SDN Demo

- Targeting Service Provisioning utilizing common API between transport controller and higher layer controller or orchestrator.
- Includes NFV element for inclusion in ETSI NFV POC.



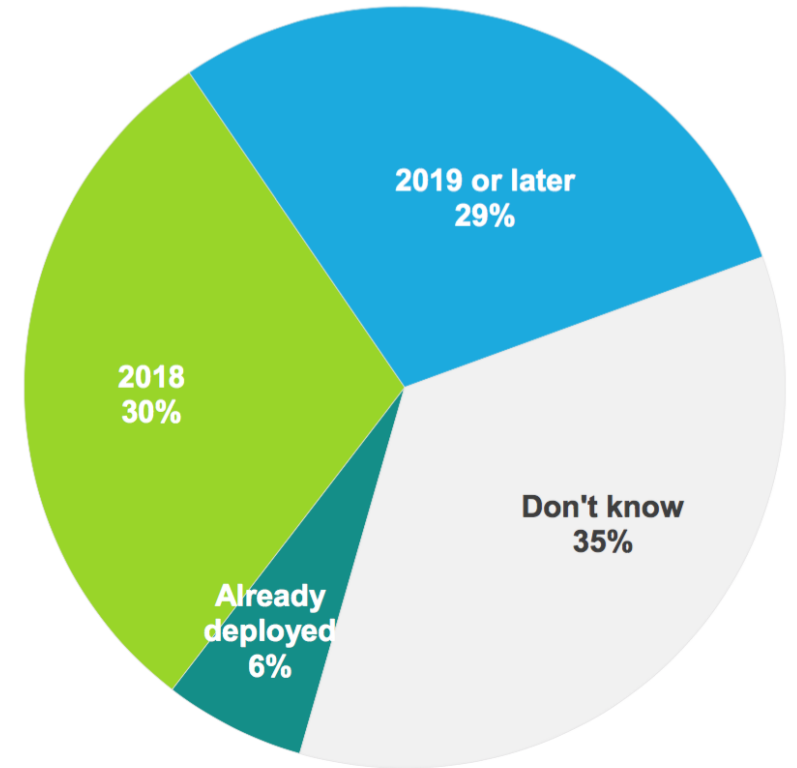
# Conclusion

- Great progress in driving interoperability and open standards into the optical domain
- We are still in early days
- But, please consider open packet optical networking as you plan your next packet optical transport solution
- Forget about legacy design rules
- Embrace the “cult of the open”

Momentum is building

I look forward to seeing more open packet optical networking in your RFP's

Open Line System Deployment Timing



# Find out more .....

- openROADM
  - <http://www.openroadm.org/home.html>
- Telecom Infra Project
  - <https://telecominfraproject.com>



Dr. Robert Keys is currently Vice President Engineering at Juniper Networks. His focus is on driving packet optical network transformation. He joined Juniper Networks through their acquisition of BTI Systems in 2016 where he served as Chief Technology Officer and Senior Vice President of Product Management. He has over 20 years of communications engineering and leadership experience and prior to joining BTI Systems Robert served as Chief Engineer at Bookham (now Oclaro), and held various influential roles in the development organization at Nortel, where he was responsible for the successful development and delivery of multiple optical products to market. He has more than 12 patents granted in the area of optical communications. Robert has a Ph.D & M.Sc in Electronics and Electrical Engineering and a B.Sc in Physics from the University of Glasgow.

## Contact

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