Optical Transport Technologies for Data Center Interconnections (DCI)

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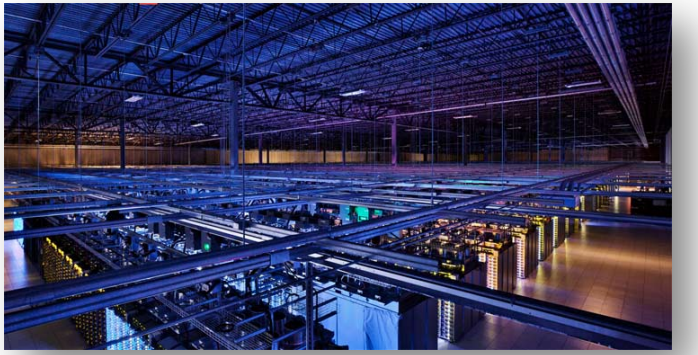
AusNOG 10, Sydney, Sept 2, 2016

Topics

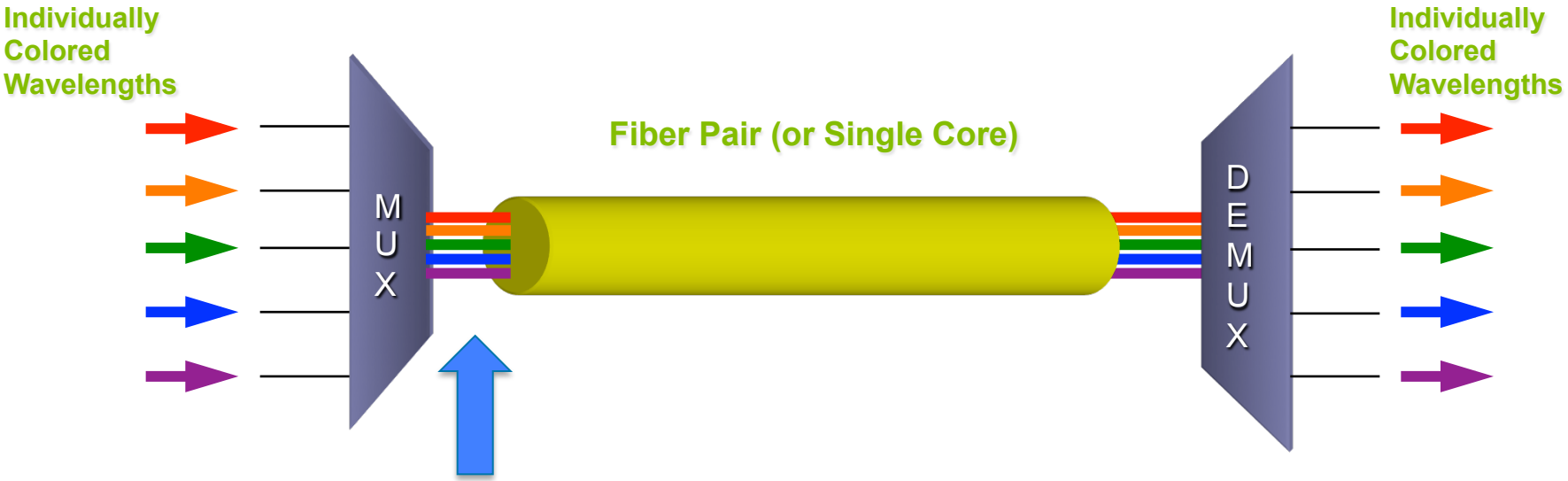
- **Fundamental Building Blocks of DWDM Links**
- **Key Elements for Flexible and Scalable DWDM Networks**
- **New Optical Trends for Data Center Interconnected Networks**

Interconnections “Within” a DC

- **Between racks on the same floor and/or different floors**
  - X-connection has been one of the main revenue streams for colocation providers
  - For telco and content providers, x-connections monthly cost can be a big part of the OPEX, especially in carrier-dense, expensive DCs
  - Low cost DWDM point to point solutions have been deployed to reduce monthly recurring cost
  - There is also application to use WDM to connect large-scale switches in spine-and-leaf architecture within ‘hyperscale’ DCs



Basic DWDM Point-to-Point

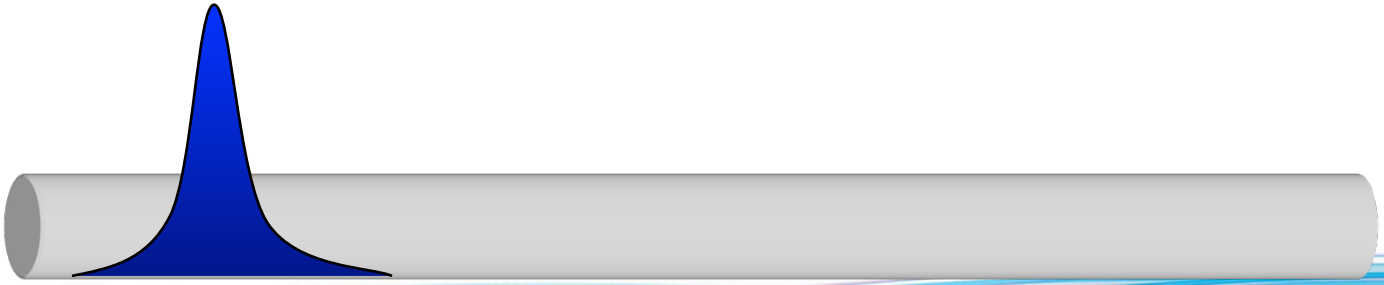


Equally spaced channels (aka standard ITU grid)

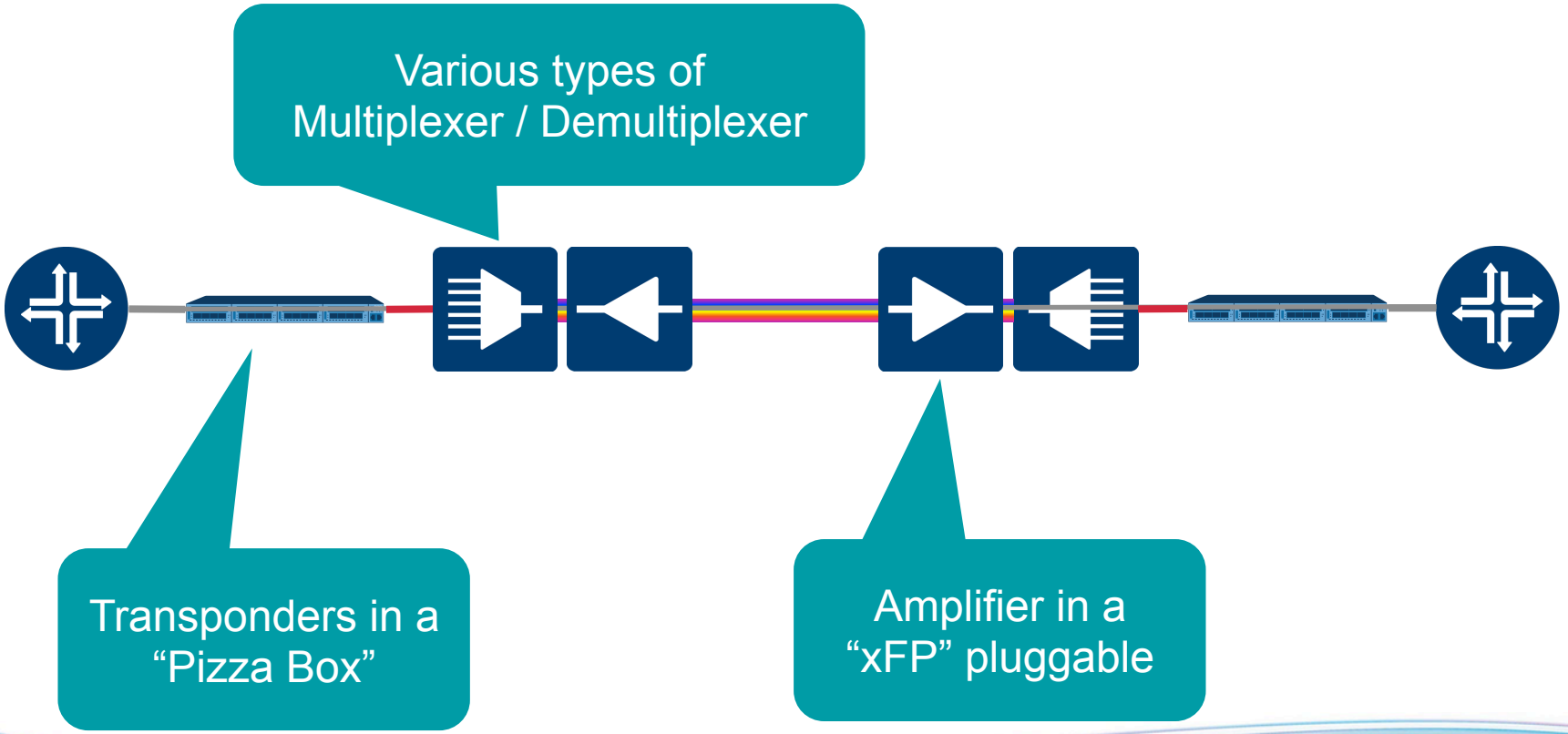
Basic Power Link Budget Calculation

- Optical light transmitted through fiber will lose power
- Attenuation caused by Scattering, Absorption and Stress
- Other related parameter: fiber length, fiber type, transmission bands, and external loss components such as connectors, splices and other passive components
- Typical fiber loss: 0.20 dB/km – 0.35 dB/km, although in some regions fiber loss can be as high as ~0.5 dB/km
- <u>Basic Power Link Budget Calculation:</u>

  Fiber loss + connector loss + multiplexer loss + safety margin ≤ Power Budget
  (i.e. Transmit – Receive Power on the transceiver)



Elements for DWDM Point-to-Point Connection



Miniaturization: EDFA Technology Example
MSA / Module Based → XFP / Pluggable Based

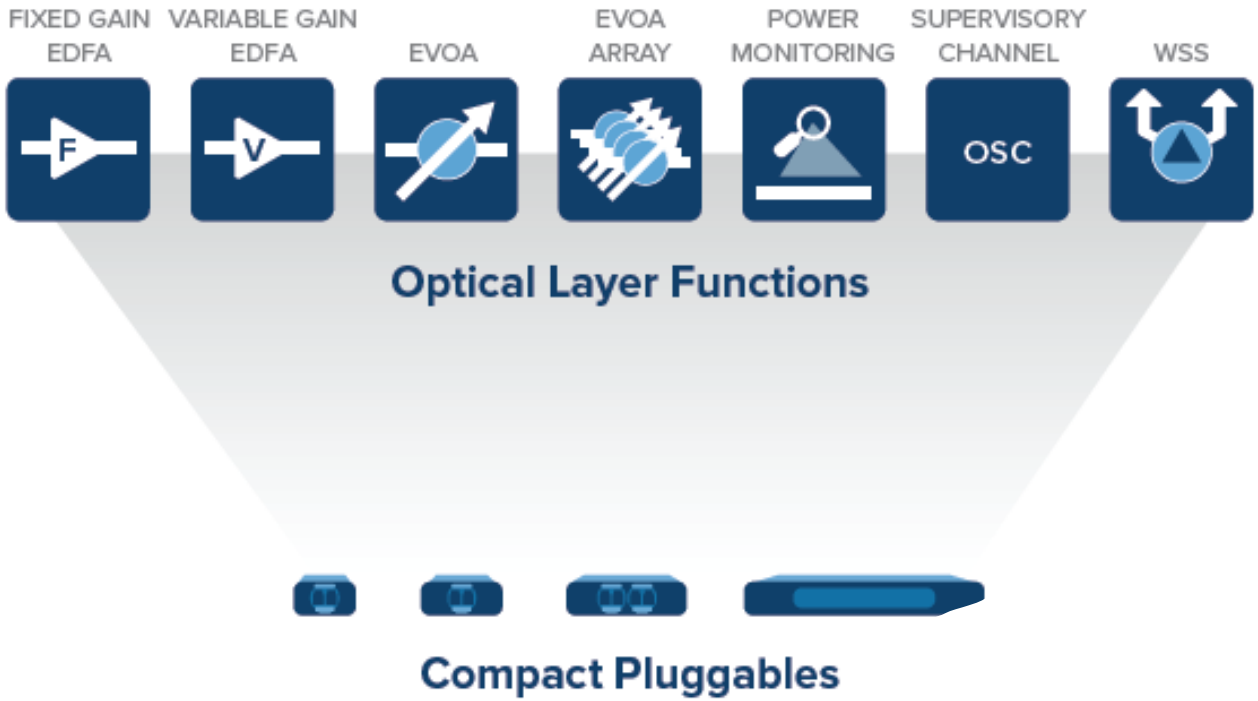
XFP-EDFA

EDFA: MSA (90x70mm²)

EDFA: Ultra-Mini (60x40mm²)

EDFA: XFP & OFP2

Additional Optical Layer Functions to be “Pluggable”



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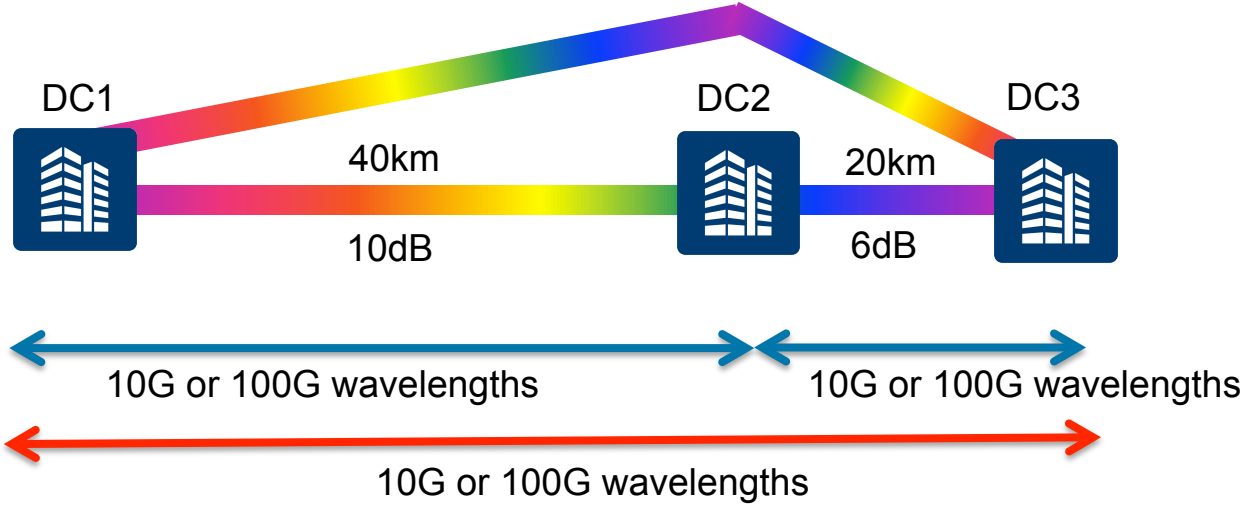
- **Key Elements for Flexible and Scalable DWDM Networks**
- **New Optical Trends for Data Center Interconnected Networks**

Metro and Regional Interconnection “Between” DCs

- **Between two or more DCs**
  - **Colocation providers** need high-speed connectivity to make their tenants feel like all cross-connections are “virtually” made in the same DC
  - **Dark fiber providers** want to expand their business from sell “dark” fiber to “grey” fiber, and from “grey” fiber to wavelength services
  - **Content providers** decide to spend money from leasing capacity to building their own DWDM network to reduce the transmission cost and TCO over a defined period

Graphic credits – please see footnote

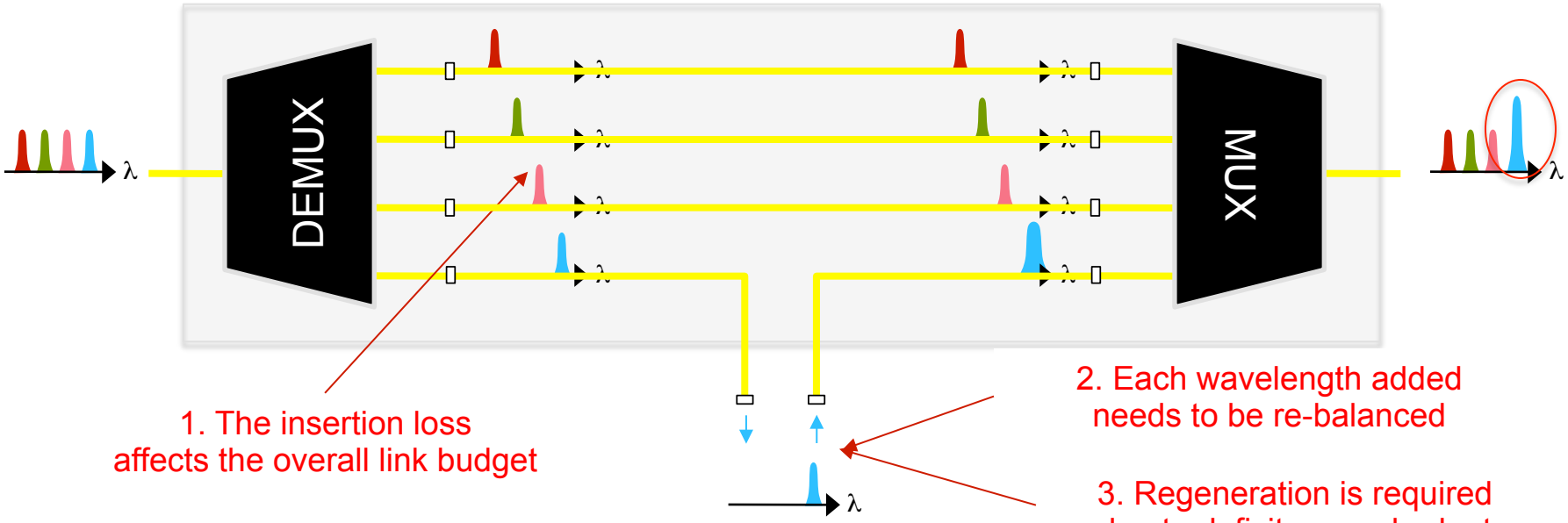
For Multi-point, Ring and Mesh Fiber Networks…



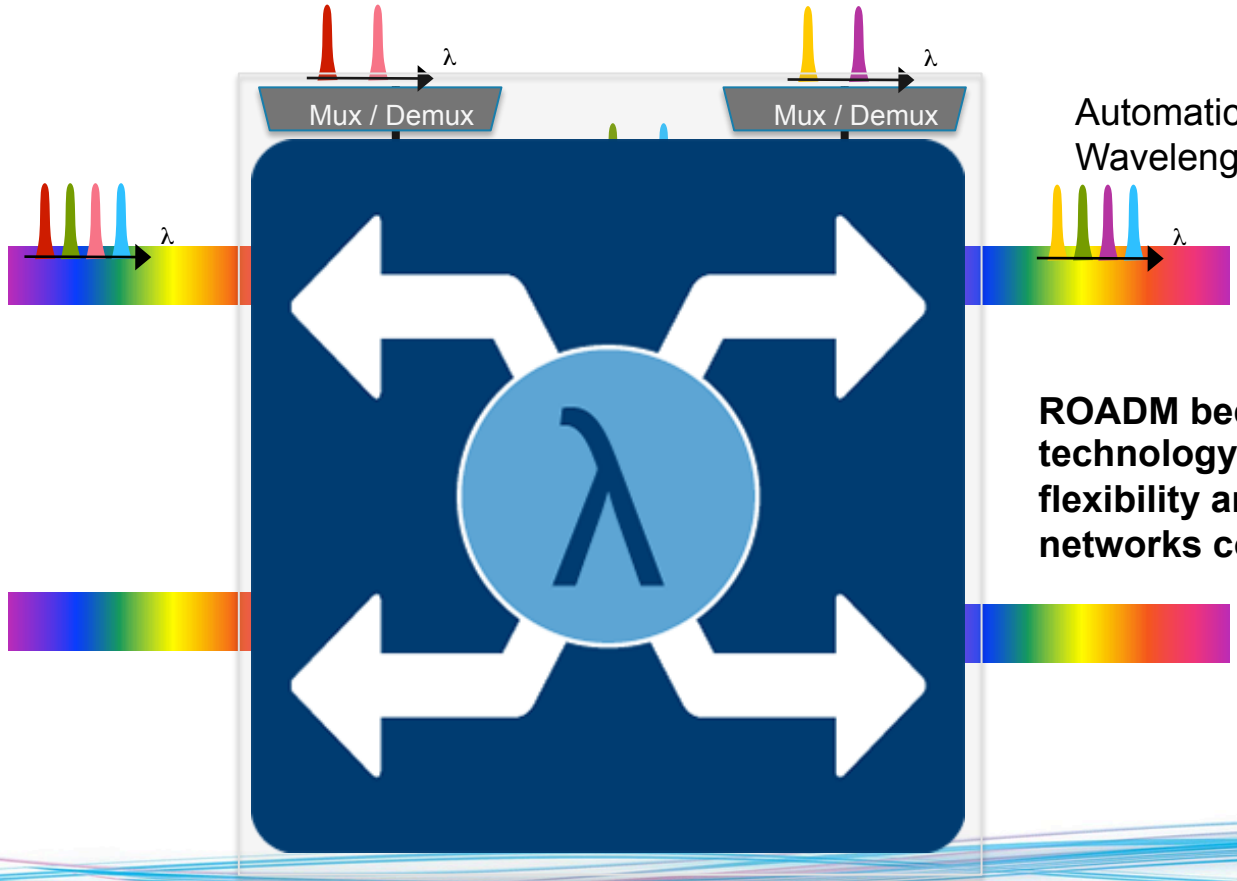
- Initially point to point links are deployed between DCs
- The challenge arises when some of the wavelengths are needed to be dropped at DC2 while the rest of the wavelengths will need to be “expressed through” DC2
- Cost of terminating the wavelengths at DC2 = regeneration with transponders = $$$ per λ

Challenge of Partial Add/Drop Traffic…

From DC1 **Traffic Add/Drop @ DC2** **To DC3**



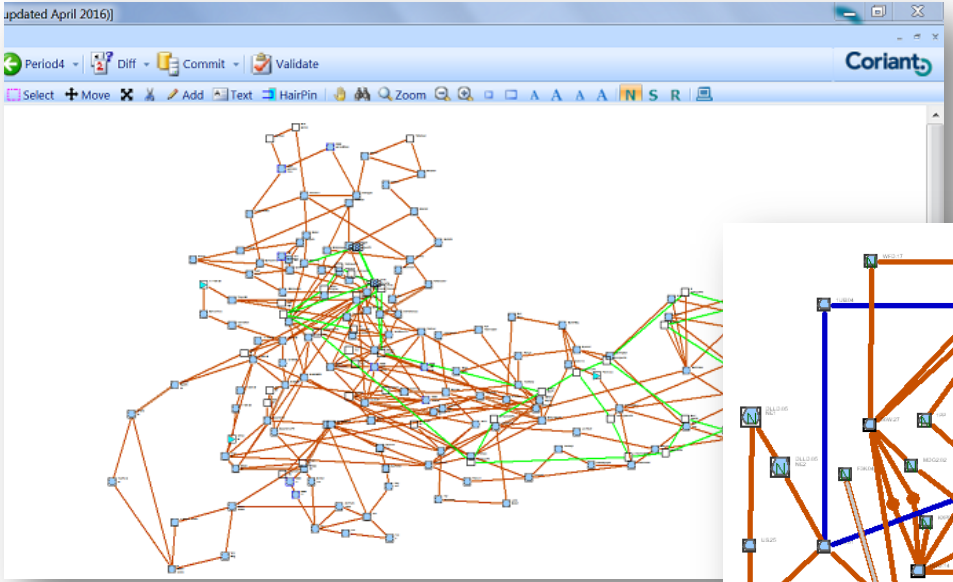
ROADM – Key Element for Building Flexible DC Networks



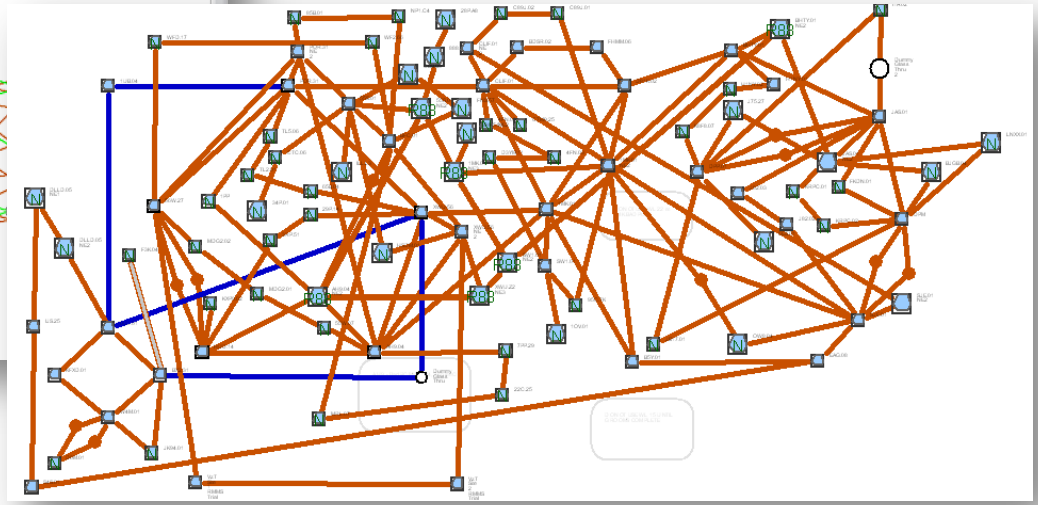
Automatic Power-Balanced Wavelengths

ROADM becomes an essential technology to enhance the flexibility and scalability of optical networks cost effectively.

Real World Examples of ROADM Networks…



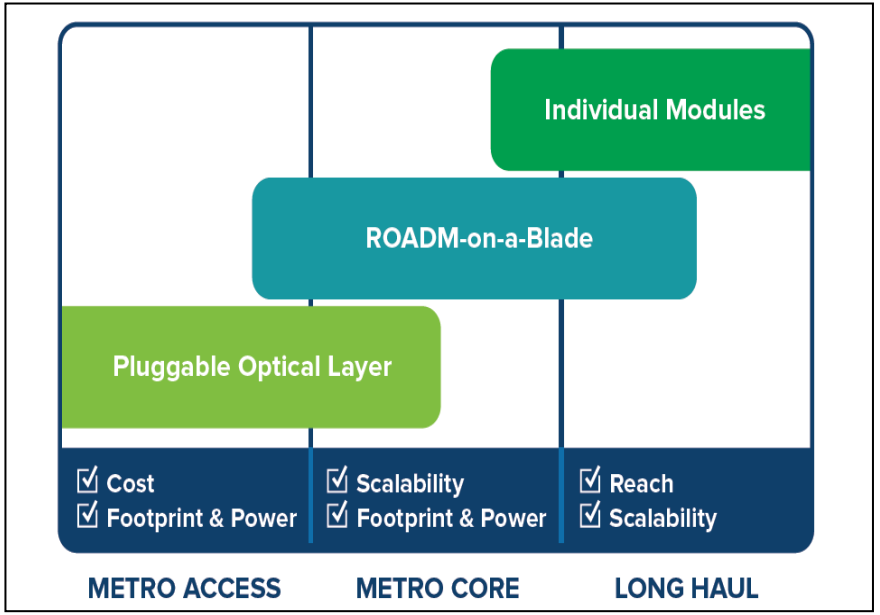
Large-scale DCI networks can be designed cost effectively…



… with latest ROADM technologies, including colorless, directionless, contentionless, gridless functionalities

ROADM Architectures Available for DC-to-DC Interconnection

Metric
Footprint & Power
Flexibility (to mix & match components)
ROADM Scalability (Degrees, Channels)
Advanced ROADM Add/ Drop (CDC, Gridless)
Performance/Reach
Ease of Installation
Cost of Replacing Failed Hardware/Sparing



Which type of ROADM architecture is right for you?
It depends on your application and design objectives.

Content

- Fundamental Building Blocks of DWDM Links
- Key Elements for Flexible and Scalable DWDM Networks
- **New Trends for Data Center Interconnected Networks**

What are Drivers for Open Line Systems (OLS)?

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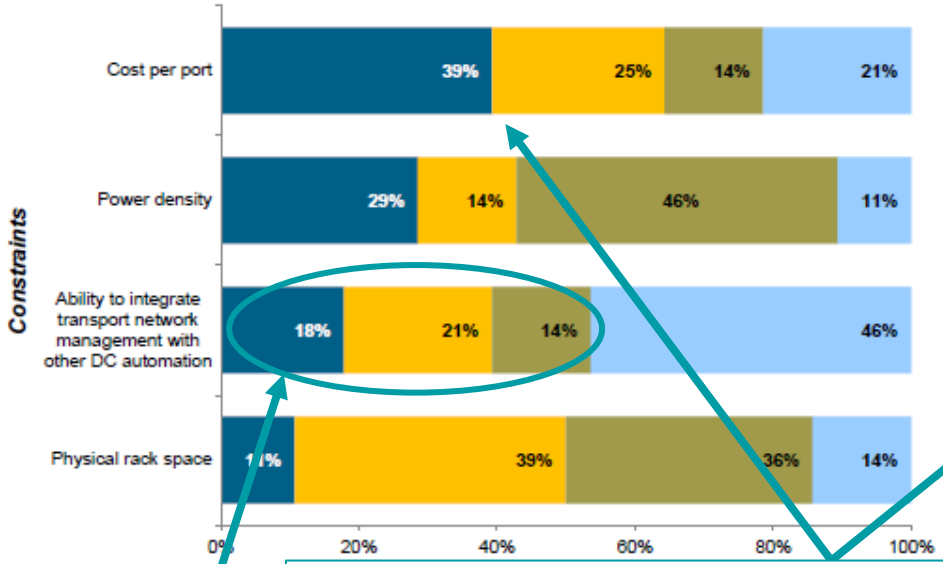
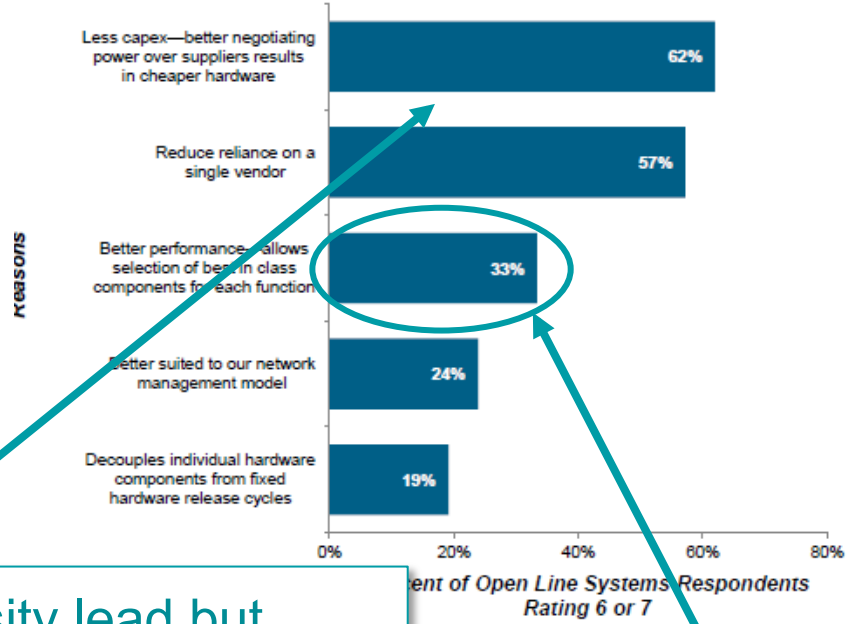
DCI Applications Constraints



Open Line System Drivers



Cost/port and power density lead but …

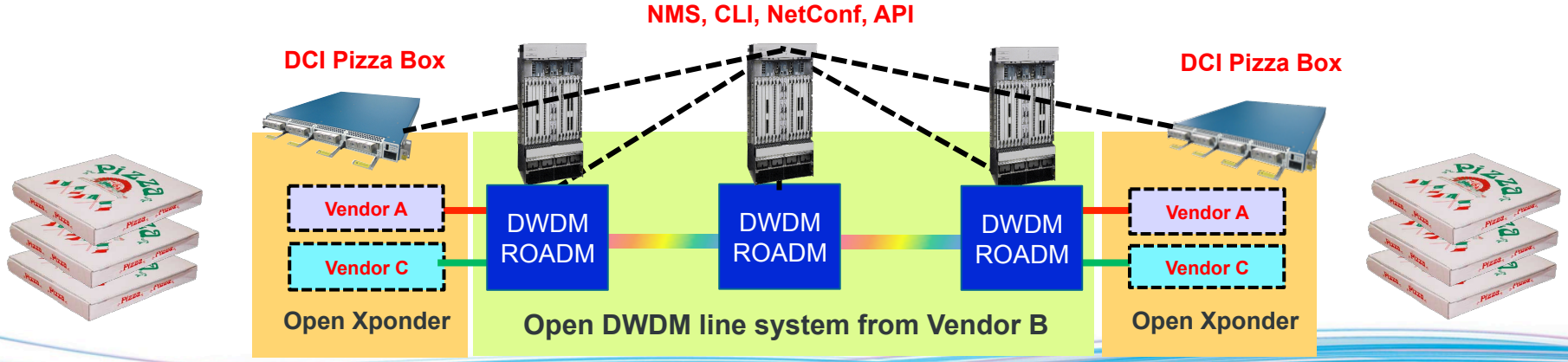
… ease of integration and DC automation is key, and…

… requirement for Best-in-Class functions emerging

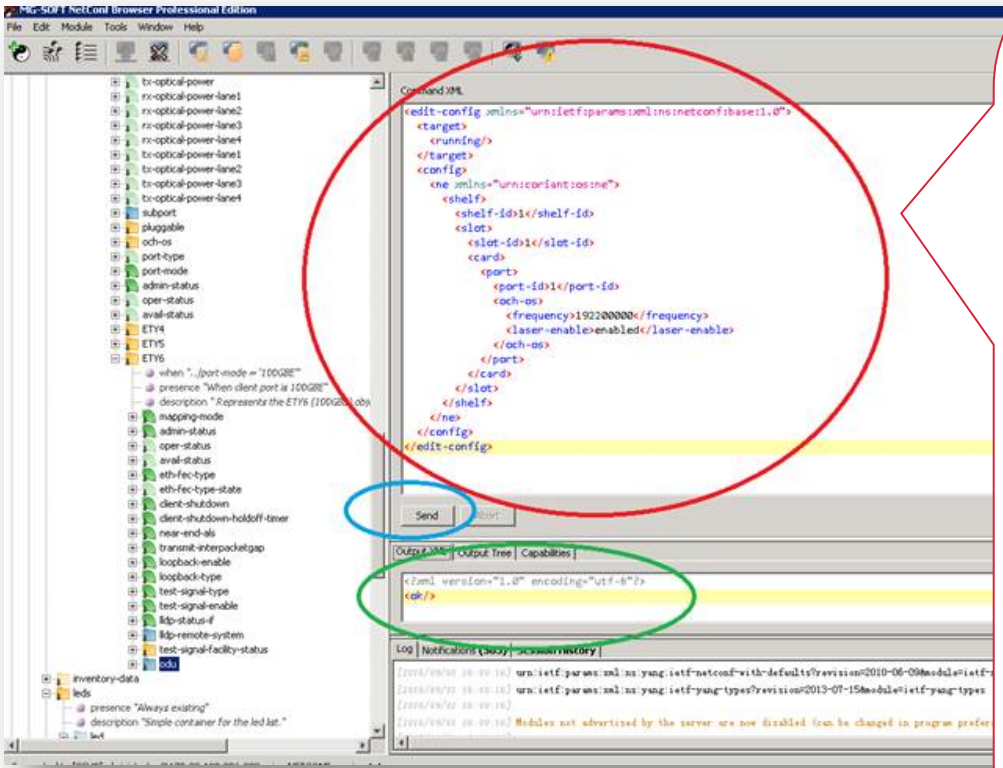
Source: IHS/Infonetics: 100G+ and ROADM Strategies, Global Service Provider Survey (Nov. 2015)

Open Line System Concept is Gaining Traction

- **Open Line System (OLS) Model**
  - Open network decouples “optical layer” from “wavelength service layer”
  - Open software interfaces make network management simpler
  - SDN applications or customized web portals make automation at the transport layer possible
  - A transponder (wavelength generator) is simply managed as a switch



Simple Netconf Example on a DCI Pizza Box




```
<rpc message-id="101"
        xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">

<edit-config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
 <target>
  <running/>
 </target>
 <config>
  <ne xmlns="urn:coriant:os:ne">
   <shelf>
    <shelf-id>1</shelf-id>
    <slot>
     <slot-id>1</slot-id>
     <card>
      <port>
       <port-id>1</port-id>
       <och-os>
        <frequency>192200000</frequency>
        <laser-enable>enabled</laser-enable>
       </och-os>
      </port>
     </card>
    </slot>
   </shelf>
  </ne>
 </config>
</edit-config>
</rpc>
```

Marching into a New World of Transport Networking…

- **Consideration for Operations**
  - How does the network operator ensure end-to-end optical performance?
  - Who is responsible for support and troubleshooting across domain boundaries?

- **How "Open" the Physical Transport Layer Will Be?**
  - How does the industry achieve interop for OLS with different transponder technologies and suppliers?
  - There are new models of disaggregation for the industry to consider

Innovations Beyond Transmission Level…

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- **Improvement of Core Optical Technologies is Essential**
  - Driving for smaller, faster & lower power modules
  - Higher order modulation, tightly integrated packaging and assembly, volume manufacturing, etc..
- **Operational Innovation**
  - Embrace a new way of thinking to break incumbency and vendor lock-in, e.g. Open Line System
  - In search for value to be gained from OpEx improvements, not just CapEx reduction

Thank You.

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