# Construindo redes corporativas de alta performance e mais eficientes com Routed Optical Networking
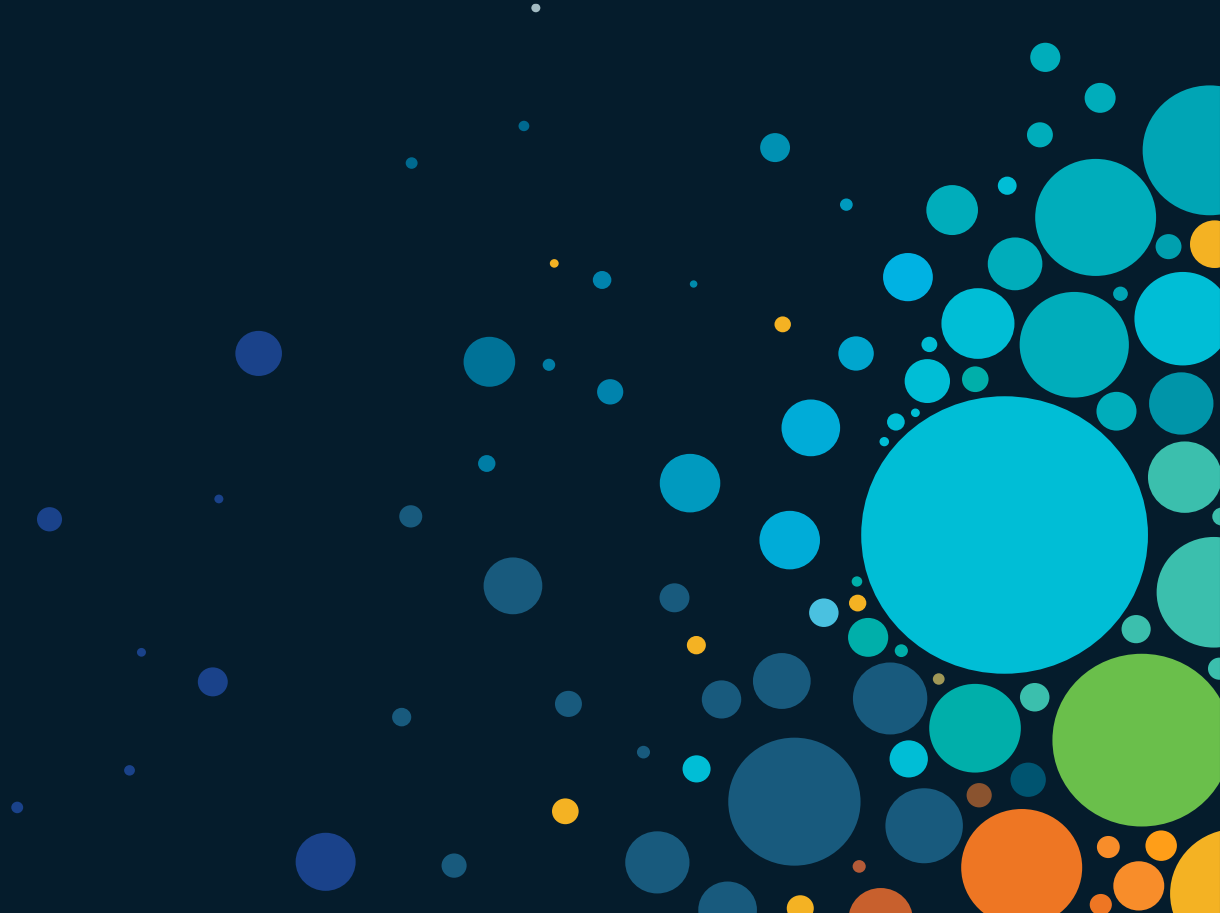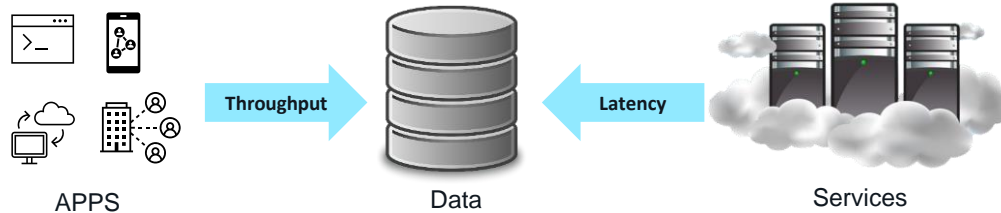
Emerson Moura
Adalberto Lins
Cisco

# Agenda

- Introdução

- Principais tecnologias

- Casos de uso para redes corporativas

- Conclusão

Introduction

# Business Drivers for Scaling Enterprise Networks

**The Problem Definition:** **Data Gravity**



APPS　　　　Data　　　　Services

- Data Gravity is one of the key issues causing poor apps performances and user experiences with hybrid-cloud

- When applications and data are scattered in different locations, a private service backbone network with the following characteristics is required:

  - High bandwidth plus low and consistent latency

  - Time to market (Immediate Services Availability)

  - Reduced OpEx

# Impact in Enterprise Architecture

- Distributed applications

- Data and application placement optimization

- Hybrid – Multi-cloud Adoption

- Dynamic, on-demand connectivity at high speeds

- Disaster Recovery

- Sustainability

## Connectivity: From 100Gbps to 400Gbps and beyond

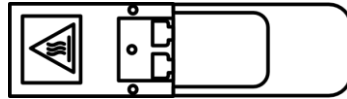# Why moving to 400Gbps is so important?

# Routing innovations bring scale, simplicity and sustainability

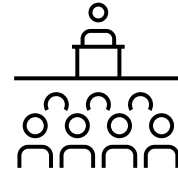## Breakthrough technologies that enabled 400GE and beyond:
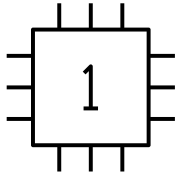
### Silicon

- Enabling >10 Tbps / RU
- SoC and multi-purpose
- Lowest power and footprint per bit

### Optics

- QSFP-DD56 - best port density, excellent power/thermal profile
- Digital Coherent Optics (DCO) - SiPh, 5 nm-7 nm DSPs, QSFP-DD56 400G DCOs
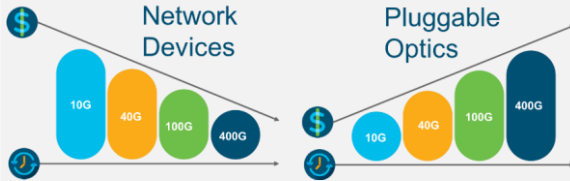
### Open, Standards

- 400G Optics: 400ZR, OpenZR+, OpenROADM
- DWDM: OpenROADM, Open Line Systems
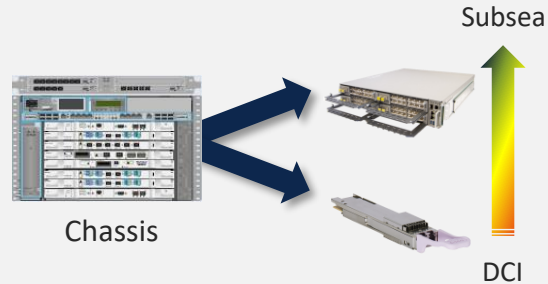- Data Models: OpenConfig

# Practical impact of industry innovations

**Devices vs Pluggables Cost**

Network Devices

10G  40G  100G  400G

Pluggable Optics

10G  40G  100G  400G

**Ratio: Router port cost < Optic cost**

**Optical Systems Evolution**

Chassis

Subsea

DCI

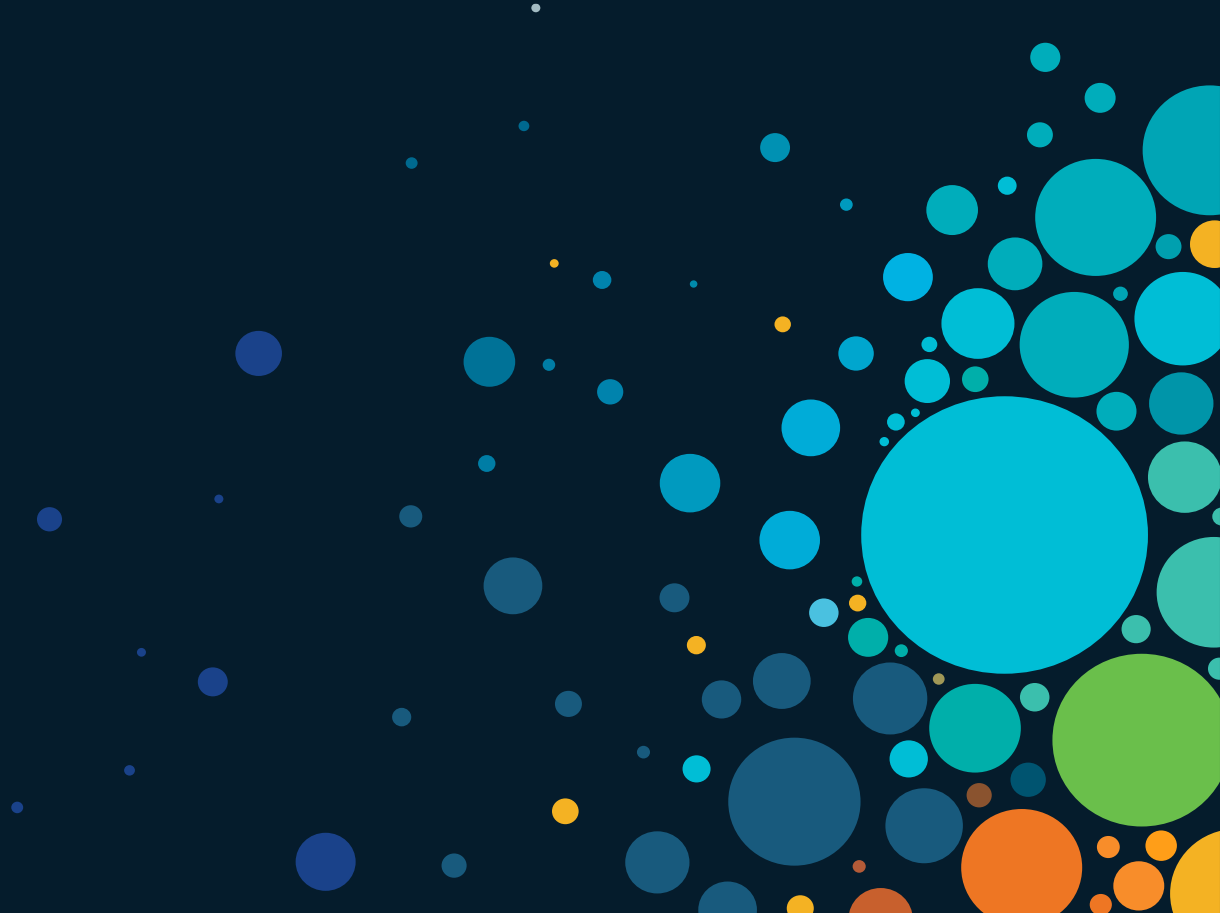**Chassis Based Solutions → Pluggables**

**Routing Bandwidth Scale**

Traffic demand    NPU Capacity

Time
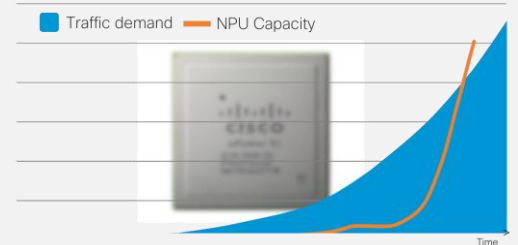
**NPU capacity> Projected Traffic Demand**

How can we use all the recent industry innovations to re-think the way we build high capacity and performance networks?

# Routed Optical Networking

# What is Routed Optical Networking (RON)?

A strategy to simplify networks through:

| What? | How? | Technology | |
|---|---|---|---|
| IP+Optical Integration | 400G DWDM pluggable in routers (400ZR/OpenZR+) | • Digital coherent optics (Acacia) | |
| L1/L2/L3 services convergence | SR+EVPN, circuit style and private line emulation (PLE) in routers | • Massively scalable silicon<br>• Segment routing | leaba<br>semiconductor<br>EVPN  SR |
| Network automation | SDN controllers, open APIs, data models | • Hierarchical controller<br>• IP & optical controllers<br>  (Cisco +3rd party) | sedona systems<br>Crosswork Automation |

# Today's Layered Network



Packet Layer

TDM Layer

Wave Layer

DWDM Management Plane
OTN Management Plane
Packet Management Plane

Packet Control Plane (IP/MPLS, SR)

OTN Control Plane (ASON/GMPLS)

DWDM Control Plane (WSON/SSON)
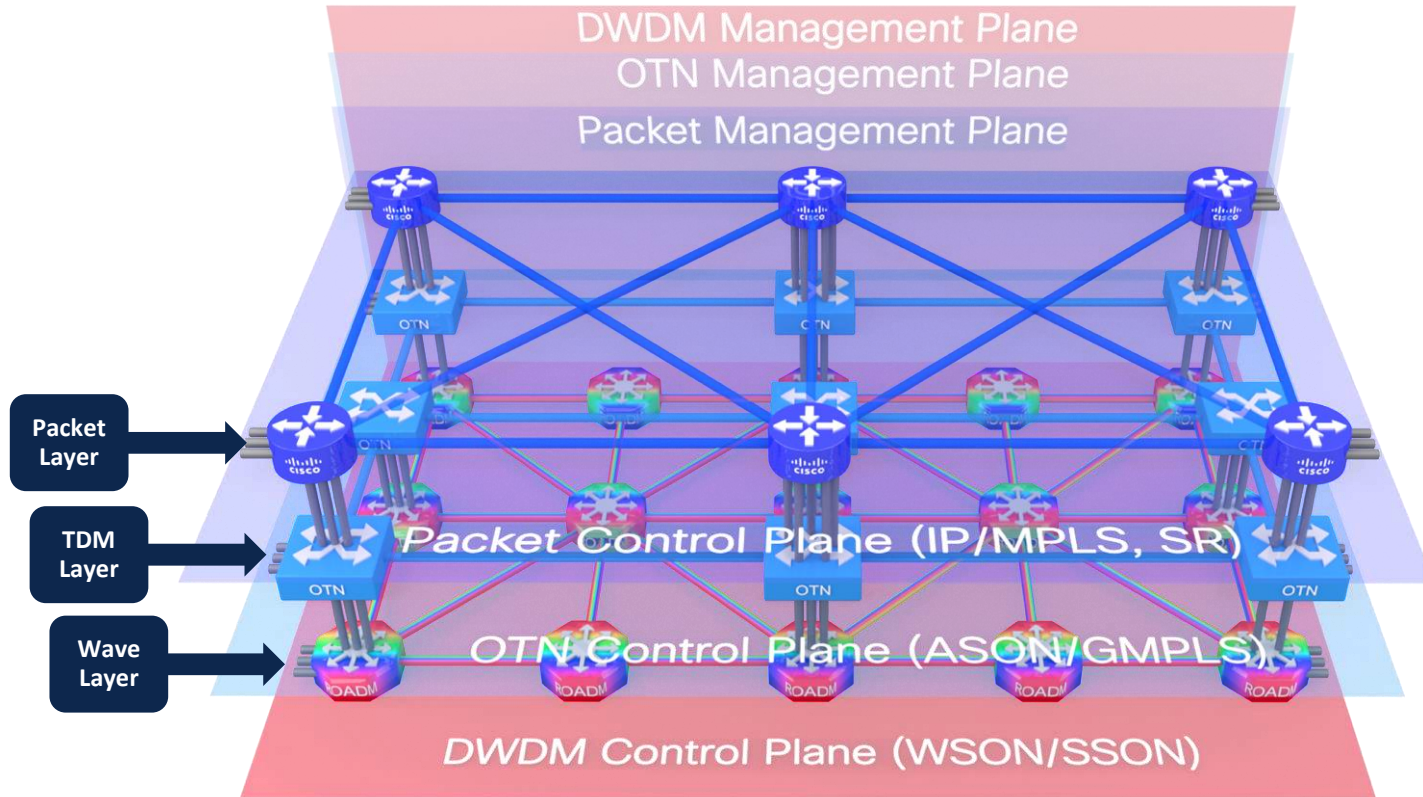
# Routed Optical Networking
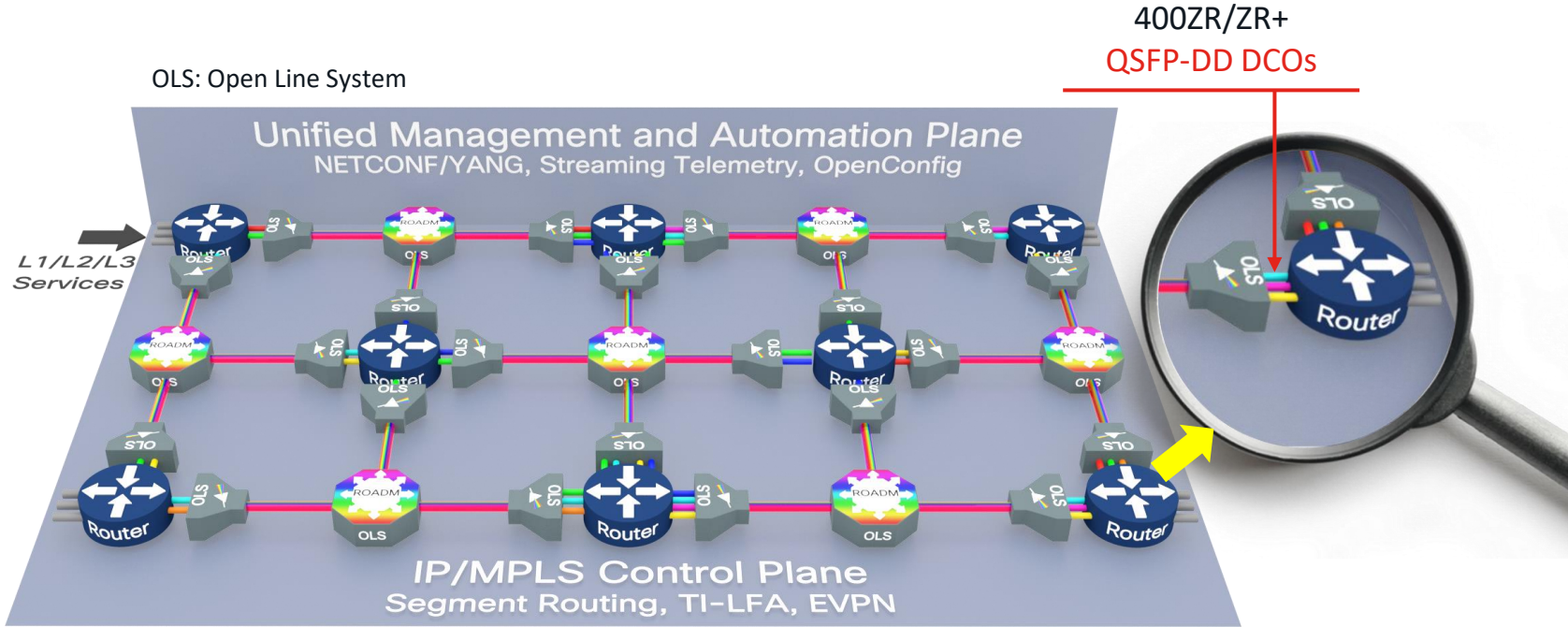


**Simplifies the network, opens it for innovation and lowers costs.**

# Why Routers with DCO optics?

| Innovation | Extended Reach | End-to-End IP | Fewer Devices | Operational Efficiency |
|---|---|---|---|---|
| Lower costs, sustainability, open standards based | Up to 1000's of kms | Better ROI and TCO | Reduced installation and integration/operational costs | Simplified network design, optimized network utilization |

# Removing Hardware Complexity and Cost
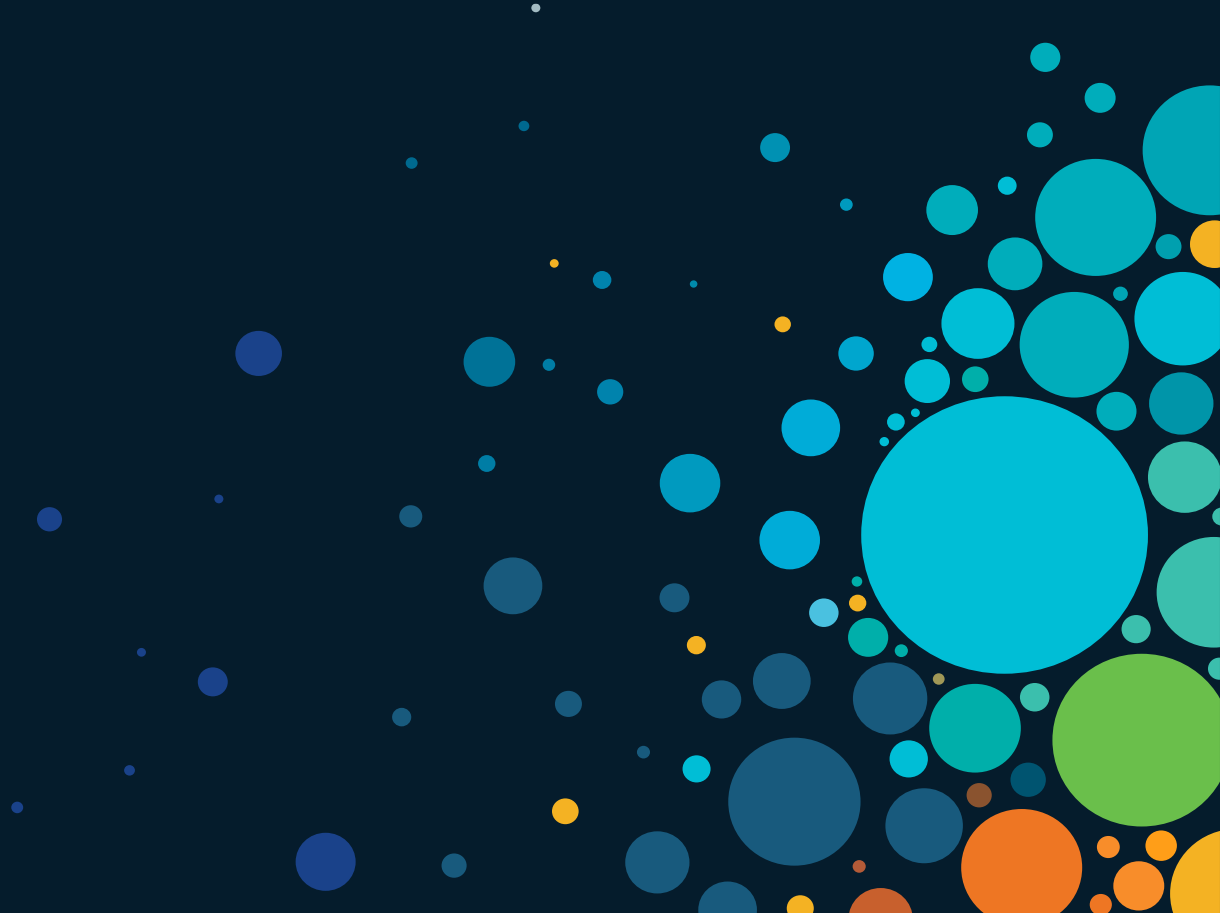
## Traditional Approach to connect routers via DWDM

SR Optic

SR Optic

Router

Fiber Jumper

Transponder/
Muxponder

Fiber Jumper

Optical
Line System

## Routed Optical Networking

400Gb DCO

Router

Fiber Jumper
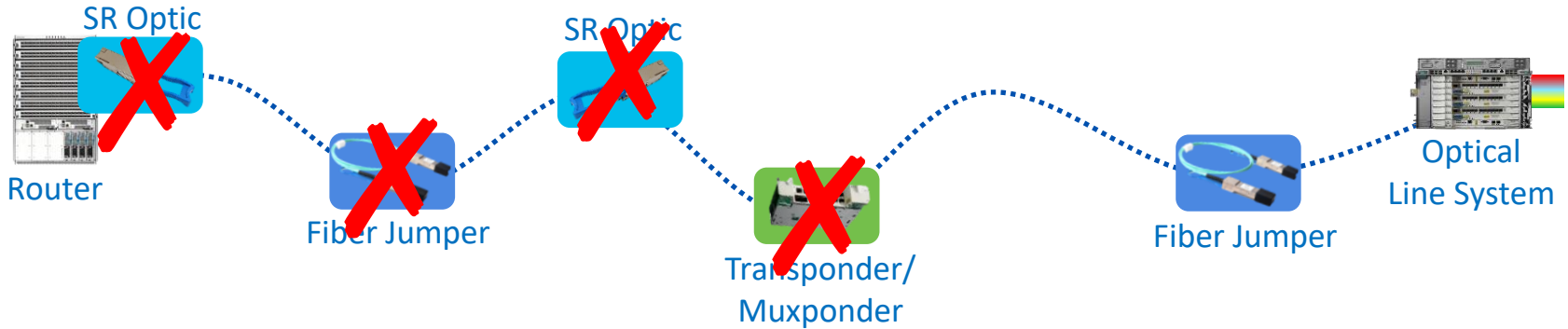
Optical
Line System
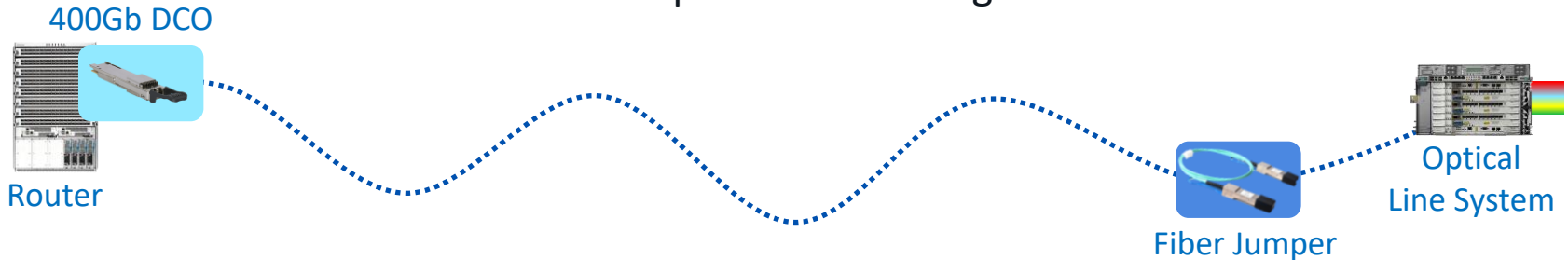
# Technology Building Blocks

# Technology Innovations Driving Routed Optical Networking

## Silicon

Multi Tbps NPUs
Power-efficient, compact DSPs

## Optics

400Gbps Digital Coherent Optics – DCO
Silicon Photonics
Quad SFP - Double Density - QSFP-DD

## Software

Programmable
Model driven
Secure and resilient
Feature rich
Segment Routing and EVPN

## Systems

Multi Tbps Routers
Simplified ROADMs
Modern management and automation frameworks
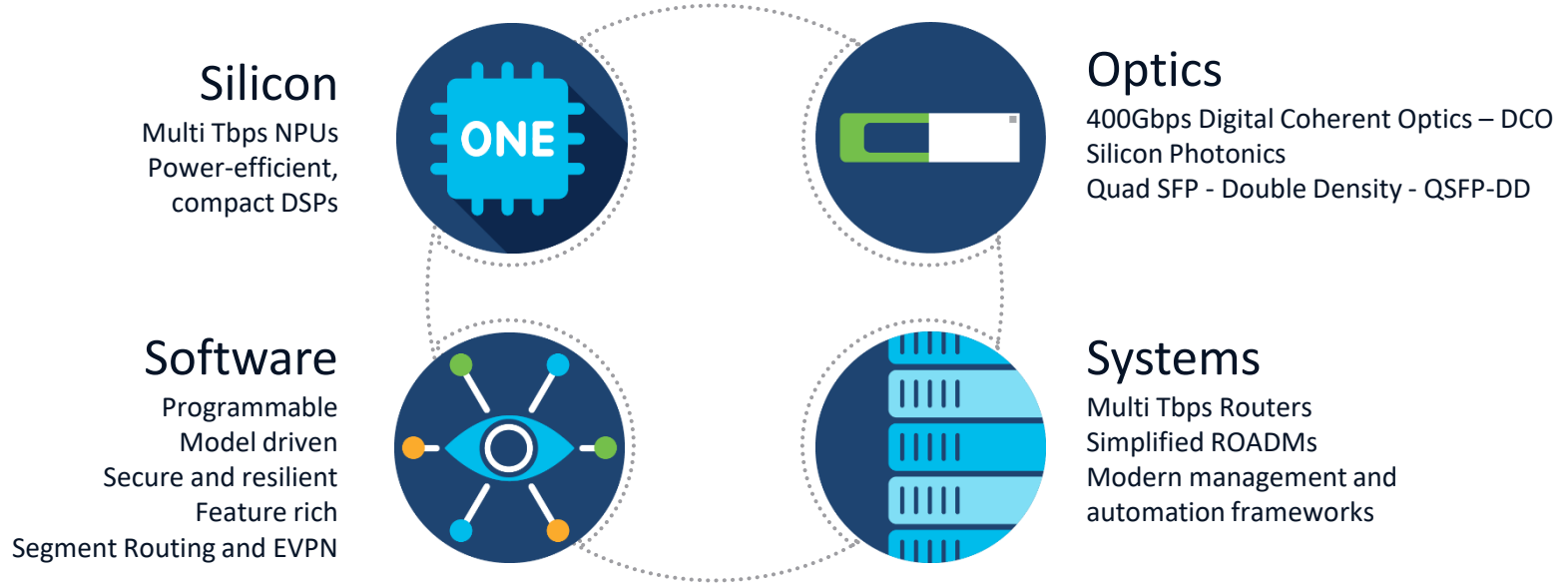
# What is a DCO transceiver?

DCO = Digital Coherent Optic

Typical 100G Coherent
transponder line card
for 300x300mm layouts

$$$
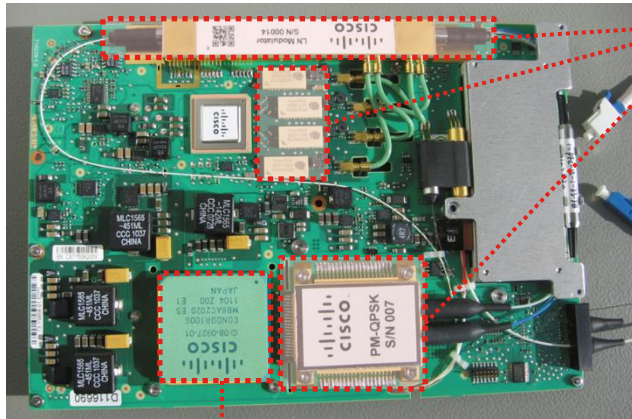
Discrete
Photonic
Elements

Silicon
Photonics
Integration
Advanced
Packaging
Integration

PIC with
Multi Chip
Packaging

QSFP-DD
400G DCO

Digital Signal
Processor

28nm

Moore's
Law

7nm

$
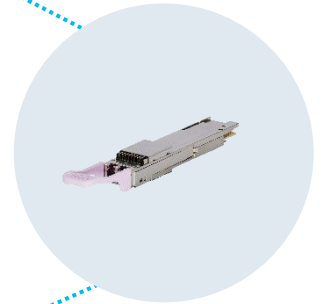
Uses standard
400G host port
> 10x decrease
in power/bit

# 400G DCO Standards and Industry Specifications

**OIF 400ZR**

Simplified functionality
Edge optimized FEC (C-FEC)

400GE → Client → Line → 400ZR

Up to 120km reach

**Open ROADM**

Flexible Client Mapping +
High Performance FEC (oFEC)

100G
200G
300G
400G
Ethernet
OTN
FlexO

Client → Line →

100G
200G
300G
400G
OpenROADM

Extended reaches

**OpenZR+ MULTI-SOURCE AGREEMENT**

100GE
200GE
400GE
Nx 100GE
(Muxponder Mode)

Client → Line →

100G
200G
300G
400G

Extended reach

Simplified functionality +
High performance FEC (oFEC)

High performance pluggable modules
Multi-vendor interoperability

# Segment Routing Benefits

## Standardized

10+ years of IETF work
key Cisco contributions

## Transport and Services

Transport : IS-IS, OSPF, BGP-LU
Services: L3VPN, 6PE, 6vPE, EVPN-
ELAN, EVPN-VPWS, Multicast … over
SR or SR-TE …

**SR**
Segment Routing

‫‪CISCO‬‬

## Proven by many Live Deployments

100+ Production Deployments 200+
Customer Engagements

## IPv4 to IPv6 migration

IPv4 to IPv6 migration: SRv6 shipping
since Jan 2019 w/ strong lead
operators and eco-system support

TiLFA • Microloop avoidance • Seamless deployment Day-1 • SRTE Native algorithms • Horizontal
Network Automation • Value-added OAM • Performance Monitoring toolkit

# Segment Routing = Network Simplification
Do more with less

## Unified MPLS

**Services**

| BGP |
| T-LDP |

**Transport**

| BGP-LU |
| RSVP-TE |
| MPLS LDP |
| IGP |
| IP |

SR — Segment Routing

EVPN

| BGP-EVPN |
| **IGP/SR** |
| **IP** |

Simplified
Protocol Stack
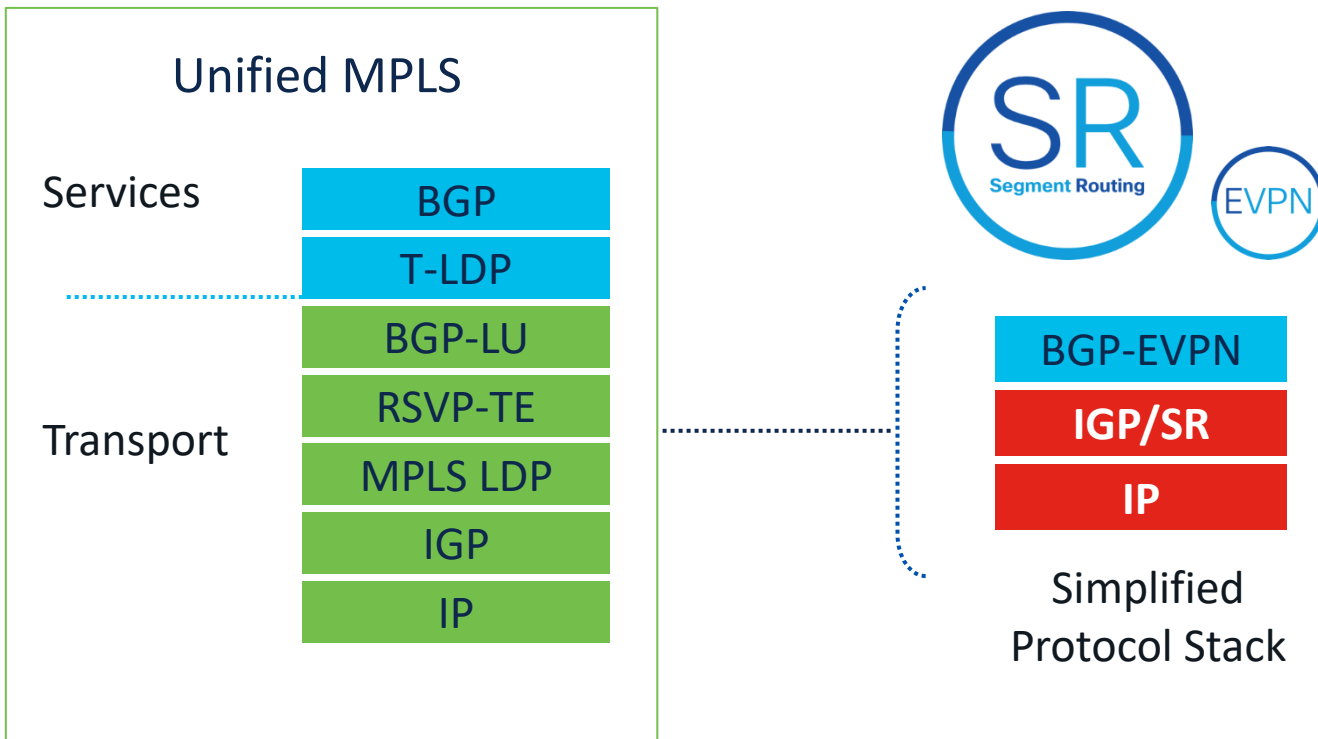
# Circuit-Style Segment Routing (CS-SR)



REST

Controller / SR-PCE

Oper Data (Telemetry)

Topology (BGP-LS)

PCEP

Protect Path

Working Path

g

a

h

b

c

d

e

f
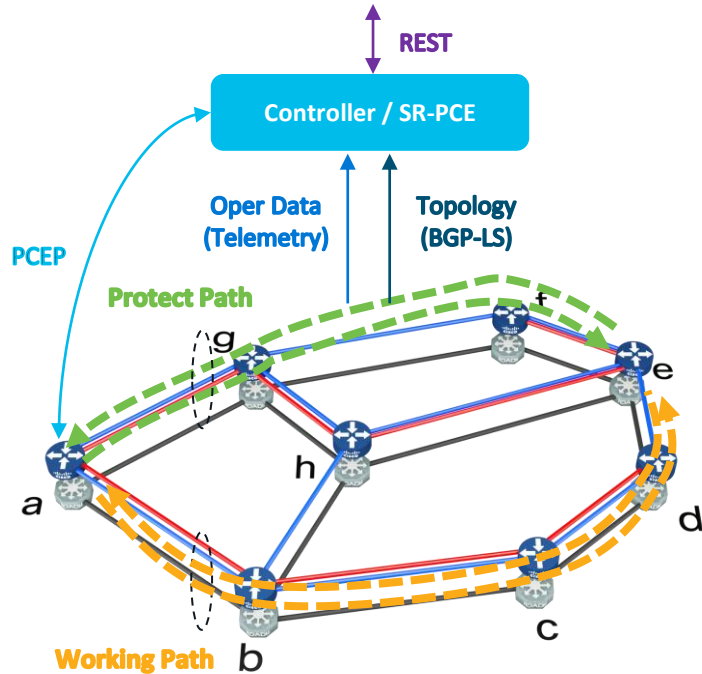
* Assumes all link IGP metrics equal

- In order to deliver Private Line and Wavelength services, the IP network must support circuit-style capabilities like a traditional architecture:

✓ Co-routed bi-directional path

✓ Control plane independent persistence

✓ Path integrity monitoring with end-to-end path protection switching

✓ Non-ECMP path with guaranteed latency

✓ Guaranteed bandwidth

✓ Controller/SR-PCE network abstraction layer

# Private Line Emulation (PLE)

- **CS-SR** provides the strict circuit-style TE required for supporting Private Line services over IP

- **PLE** provides the packetization, clock synchronization and OAM

- **EVPN-VPWS** is the signaling protocol and demultiplexing mechanism for PLE services

- Low latency thanks to modern silicon, router designs and SR latency aware routing

## PLE
- Multi-protocol (OTN, SONET/SDH, Ethernet, FibreChannel)
- SyncE, no control protocol visibility, no MTU limits

## EVPN-VPWS
- EVPN mechanism for Point-to-Point services
- Extensions added (PLE attribute) to support delivery of bit-stream services

## Circuit-Style SR (CS-SR)
- Guaranteed bandwidth
- Persistent, co-routed, bi-directional paths
- 1:1 End-to-end path protection and restoration

# Private Line Emulation innovation

End-to-end packet-based L1 services

Site 1          Site 2          Site 3

DS1/OCn

OCn /10G / 100GE

A    M    Z

DS1/OCn

OCn /10GE / 100GE

Segment Routing Network
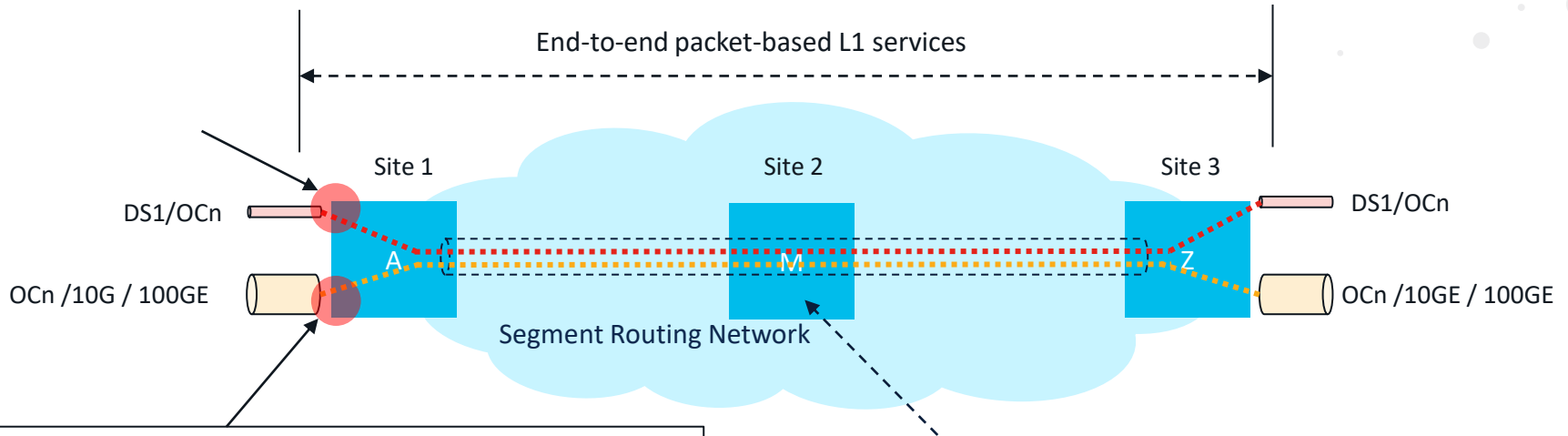
Traffic is bitstream transparent, *i.e.* encapsulates entire bitstream including overhead and control protocols

Midpoints are not aware of services
All they know is how to forward traffic

⋯⋯⋯ SAToP/CEP service

⋯⋯⋯ Private Line Emulation service

# PLE payload types

| SONET/SDH | OTN | Ethernet | Fibre Channel |
|-----------|-----|----------|---------------|
| | ODU0 | 1GE | FC100 |
| OC48/STM16 | ODU1 | | FC200 |
| | | | FC400 |
| | | | FC800 |
| OC192/STM64 | ODU2/ODU2e | 10GE | |
| | | | FC1600 |
| | | | FC3200 |
| | ODU4 | 100GE | |

1Gbps

100Gbps

Future
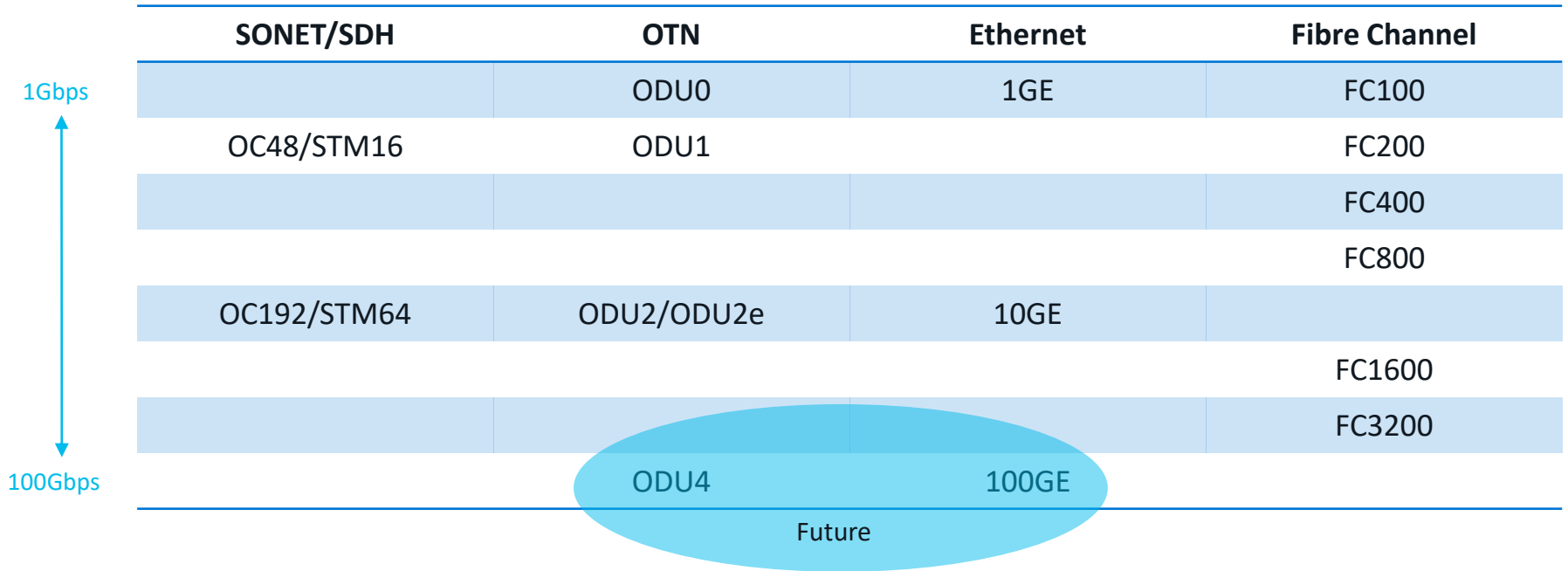
# Network Automation for Routed Optical Networking



**Unified API**

Services Layer — EVPN-VPWS

L3 IP Network+SR

IP + Optical using ZR/OpenZR+

Cisco Optical

**Crosswork Network Controller**
- Visualization
- Telemetry
- Traffic Eng
- ZTP
- TE and xVPN Provisioning

**Crosswork Hierarchical Controller**
- ML/MD Visualization
- ML/MD Provisioning

IETF Service/Topology

**CISCO** Optical Network Controller
- Optical line system mgmt
- Optical service mgmt

ONF TAPI

3rd Party Optical

# Cisco Crosswork Hierarchical Controller

# Routed Optical Networking - Key Takeaways

- Routed Optical Networking is a
new architecture vision that greatly improves
the economics and sustainability of
networking including:

  - Improved network performance and efficiency
  with IP+Optical integration leveraging Digital
  Coherent Optics (DCO) technology, resulting in
  less hardware and higher utilization of network
  assets

  - Simplified network architecture & operations

  - Service convergence using a single IP/MPLS network, adding Private Line Emulation

  - Improved failure protection & restoration and reduced risk

  - Optimal traffic forwarding for applications and content



**Routed Optical Networking Architecture**

Unified Management and Automation Plane

Packet Control Plane (IP/MPLS, SR, RSVP-TE)
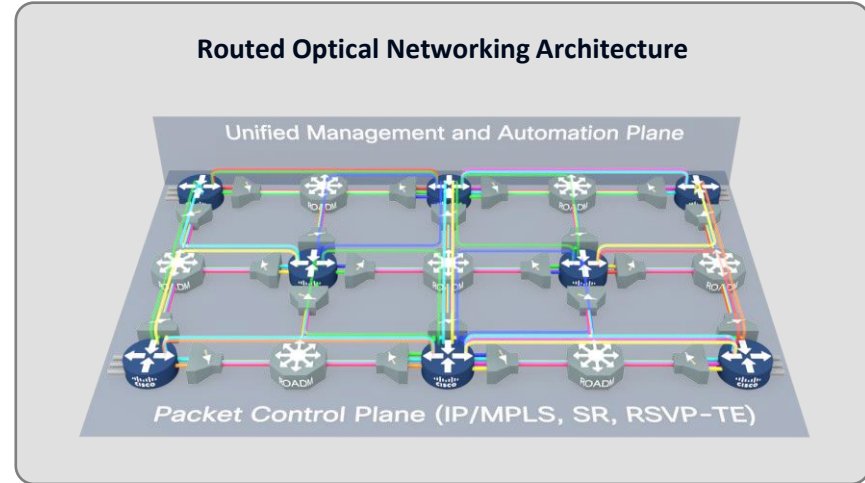
# Casos de uso para redes corporativas
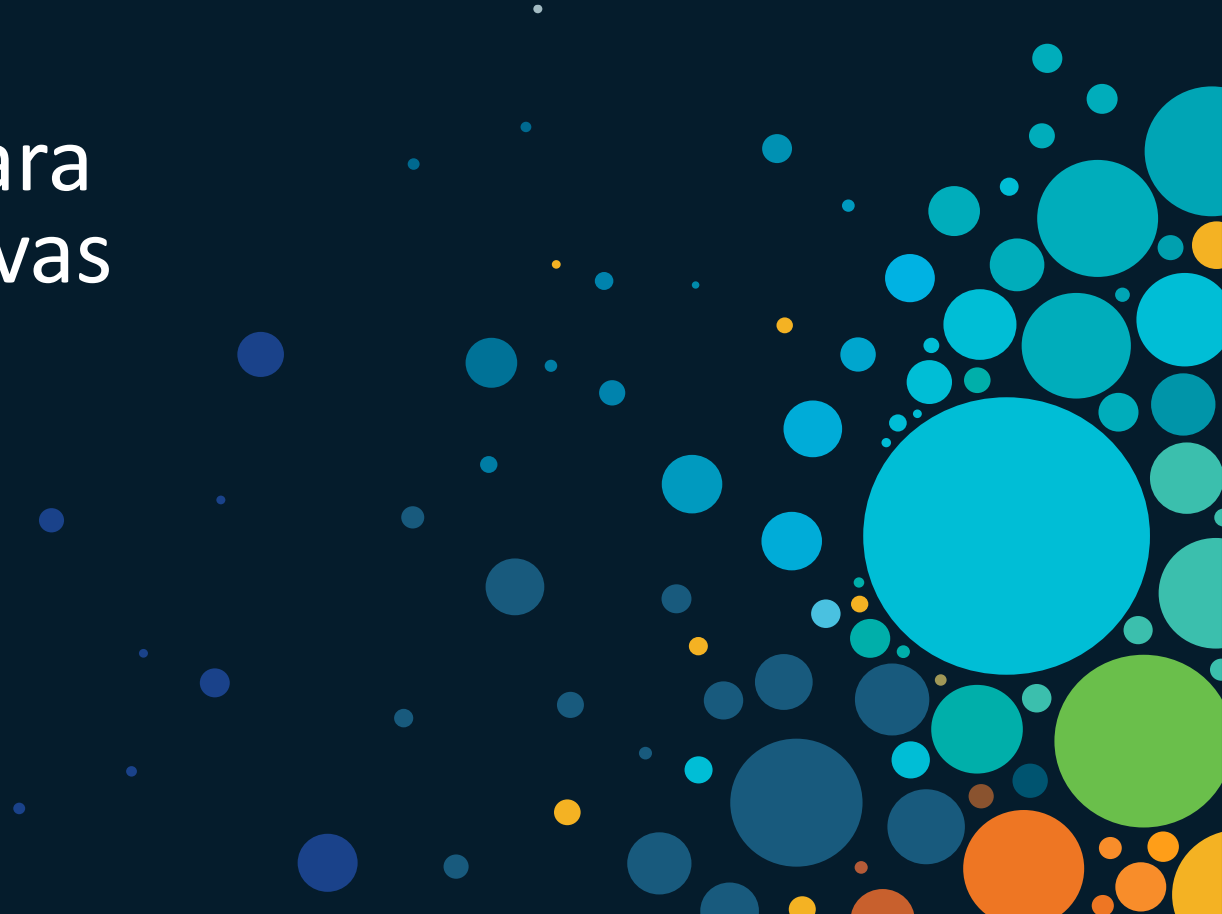
# Routed Optical Networking Press Releases

https://www.cisco.com/c/en/us/solutions/
service-provider/routed-optical-
networking/index.html#~customer-stories



"The Cisco Routed Optical Networking solution paired with Cisco 8000 series routers with 400 GbE optics will enable us to build a network that will have a transformational impact on Ethiopia and serve as a model for connecting the estimated 3.8 billion citizens around the world that are still without access to high-speed internet."
Dawit Birhanu, CEO and Co-founder, WebSprix



"Thanks to game-changing innovations that span across silicon, optics, and routing systems, complex layers can finally converge into a simpler and more scalable architecture"
CEO Blog: Five Predictions in 2021



"Windstream expects to begin deploying ZR+ coherent pluggable modules in the second half of 2021, a technology that has applicability in as many as 80% of our existing links."
Buddy Bayer, Chief Network Officer, Windstream



"Over the last couple of years, Colt and Cisco have built a strategic relationship centered on innovation, and we're excited to continue to push boundaries for our customers and the industry. We know the requirement for ultra-high bandwidth services is increasing. With Cisco's technology in specific layers of our network, we'll have a scalable and efficient packet core network that fulfils the connectivity demands of our customers across the globe." Vivek Gaur, Vice President Network Engineering for Colt
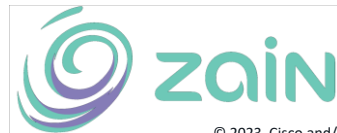


"Reimagining mobile networking is at the very heart of Rakuten Mobile's strategy, and our decision to go full-speed ahead on SRv6 and Cisco Routed Optical Networking demonstrates our effort to take advantage of technology innovation at every layer of the stack," said Tareq Amin, Chief Technology Officer, Rakuten Mobile. "We knew that Cisco would walk in lock-step with us as we worked through each phase needed to implement this new technology and align it to our business goals."



""Solutions in the market today typically require two or three different platforms to deliver what the company needs, including Link Net. The Cisco Routed Optical Networking solution converges IP and Optical, thus simplifying our network with a more efficient and overall effective solution, and ultimately optimizing the utilization of our capex and opex." said
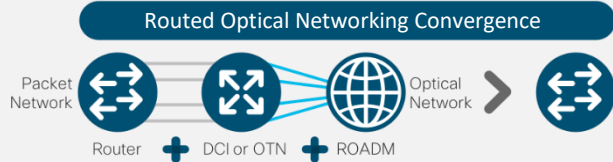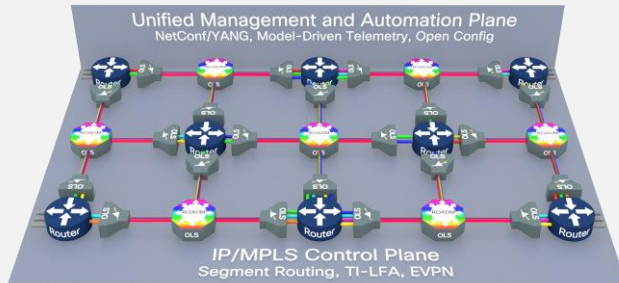Marlo Budiman, President Director and CEO of PT Link Net Tbk.

# Routed Optical Networking use Cases



Unified Management and Automation Plane
NetConf/YANG, Model-Driven Telemetry, Open Config

IP/MPLS Control Plane
Segment Routing, TI-LFA, EVPN

Routed Optical Networking Convergence

Packet Network

Router + DCI or OTN + ROADM

Optical Network

✓ Transponder replacement by DCO transceivers

✓ Full services convergence over IP/MPLS – L1/L2/L3

✓ Network automation across IP and Optical

✓ Services orchestration across IP and Optical

✓ Applicable network scenarios:

  - Nx100G to Nx400G **Access** and **Aggregation** networks for residential broadband, mobile and business services

  - Nx400G connectivity for **Edge**, **Core** and **Peering**

  - **Data Center Interconnects**

  - **Metro**, **Regional** and **Long-Haul** networks

  - **Linear**, **Ring** or **Mesh** network topologies

# Deployment Options
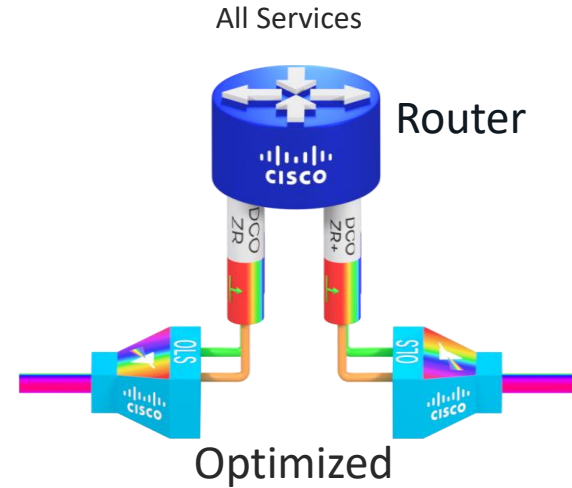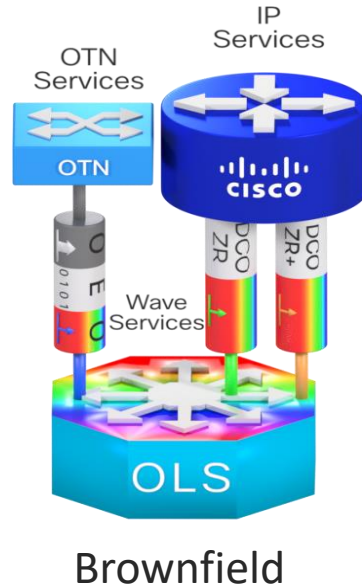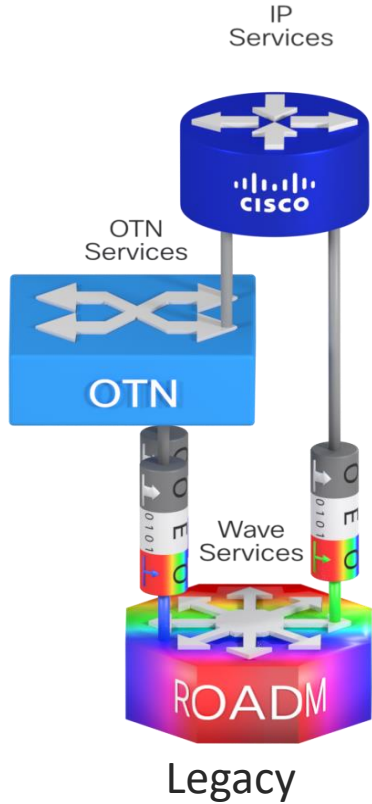
# 400G DCO and Muxponder interoperability use case

## Asymmetric solution if remote end routers are not being upgraded to 400G

- Router 400G port is configured as 4x100G fan-out mode as ZR+ pluggable will transport those 100GE streams onto a single wavelength at 400G
- On the remote location, an interoperable muxponder will break out 4 individual 100G interfaces to the 100G router, supported on 1004 and NCS2K 1.2Tbps Muxponder
- Another option is to use an additional router which gives the benefit of packet stat muxing, can use 1x400G or 4x100G mode



400G DCO @ 4x100G mode

400G DCO, 1x400 or 4x100G

1x400G or 4x100G
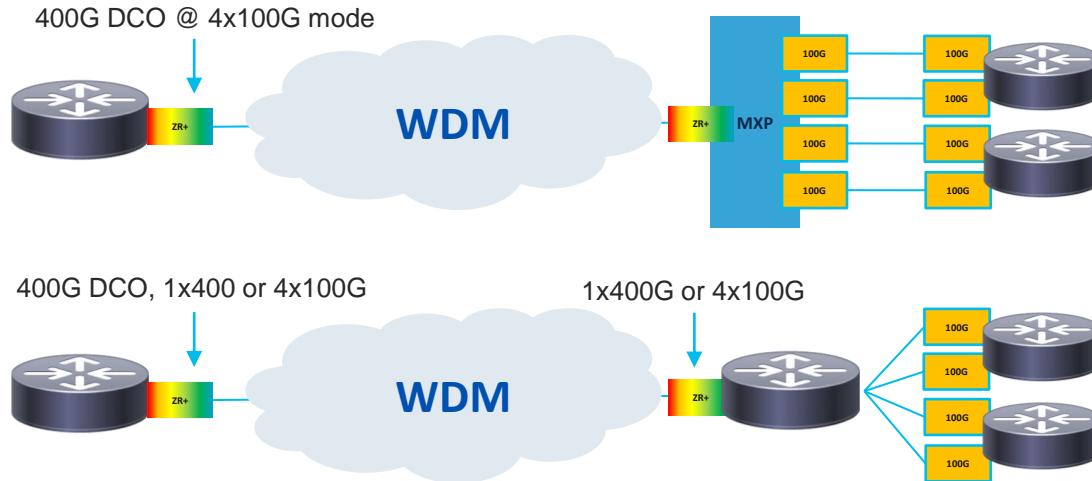
# QSFP-DD Open Line System (OLS)

- Bi-directional EDFA amplification integrated into pluggable QSFP-DD

  - Up to 17dBm Output Power

  - 7dB to 25dB Gain Range for Booster EDFA

  - 2dB to 25dB Gain Range for Pre-amplifier

  - 2.4THz C-band range

- Can be used in conjunction with 64Chs Mux/Demux to support up to 32 wavelengths (75GHz grid)

- Passive 8 channel coupler/splitter integrated into a single cable available for low-end applications
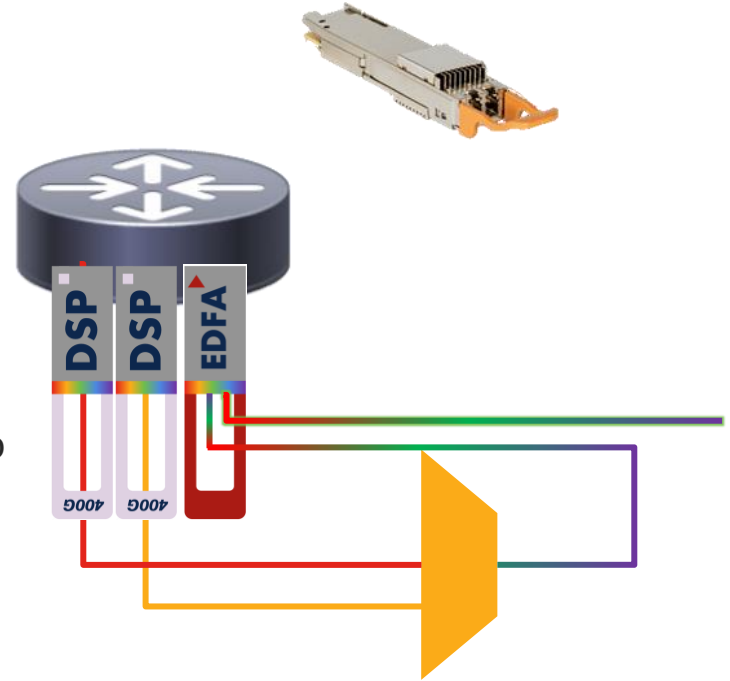
# 400G Router Portfolio

## NCS 540

## NCS 5700

## CISCO 8000

## ASR 9000



**NCS1K-MD64**

**NCS1001**

8000

9900

540

5700

**400G-ZR/+ QSFPDD's**

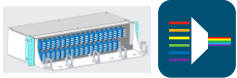**Amplified Solution**

**Supporting 120km without intermediate sites**

8000

9900

540

5700
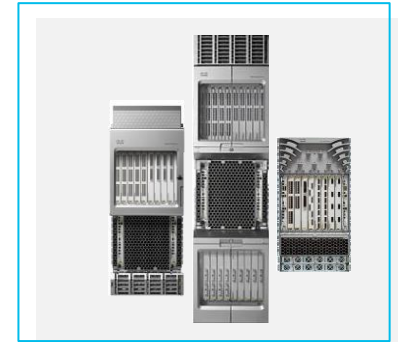
IOS-XR End-to-End

# Cisco Nexus & Catalyst 400G Switch Portfolio

**Nexus 3400-S**

**Nexus 9300 GX**
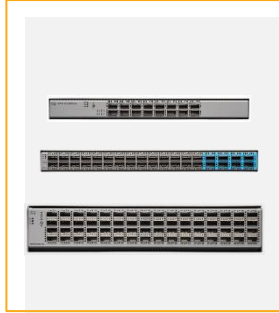
**Nexus 9500 GX**
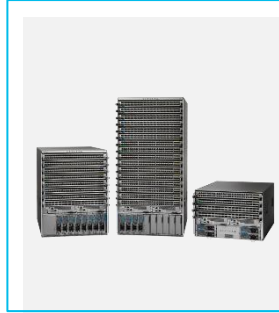
**Nexus 9500 R Series**

**Nexus 9000 GX2, GX3**
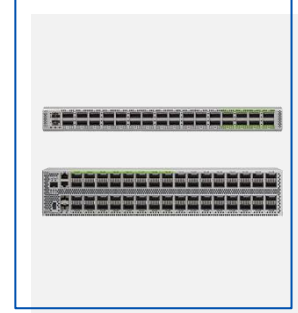


**Catalyst 9500X & 9600X**
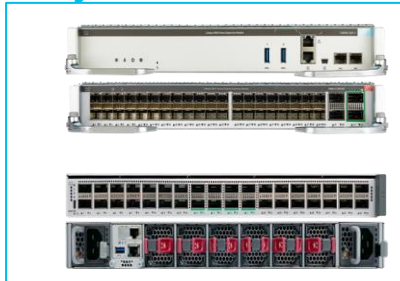
# Use Case Now – Replace Transponders with DCO Pluggables

**Prior Architectures
2-3 discrete layers**
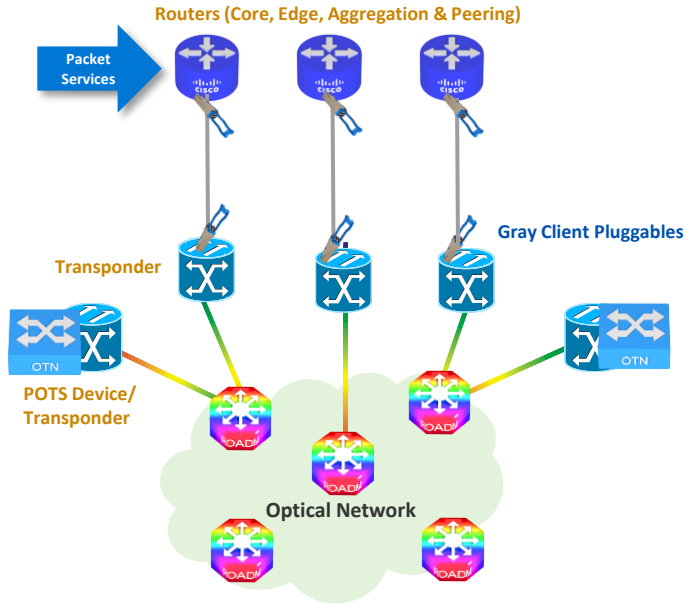
**Leverage DCO Pluggables and
available Automation Tools**



**CNC**
IP orchestration, path optimization & Visualization

**EPNM**
IP & Optical Management

Routers (Core, Edge, Aggregation & Peering)

Packet Services

Transponder

Gray Client Pluggables

POTS Device/ Transponder

Optical Network

DCO Netconf/ Yang Telemetry & Config

Eliminate Dedicated Transponders & Grey Optics via ZR/ ZR+ on routers

Alien wavelength over Cisco NCS2k or 3rd Party Open Line System (OLS)

**200G-CFP2-DCO's are available now
400G-QDD-DCO's and 400G-CFP2-DCO's are available too**

# Simple P2P DCI Optical Transport with QDD-OLS



DC A

Router / QDD-ZR/ZR+
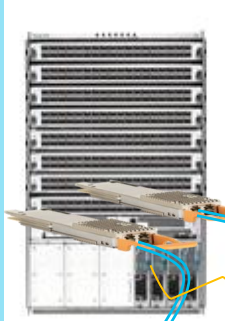
NCS1K 64ch 2RU Mux-DMx

DC B

ZR or ZR+ for DCI
QSFP-DD form for
Transport
Optimization
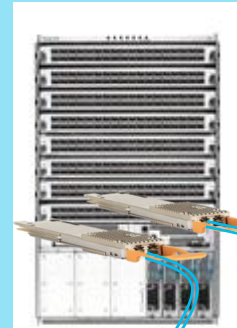
30dB 120km spans

OLS in a **QSFP-DD** transport optimization provides optical amplification in a pluggable QSFP-DD form-factor for Low and high channel count application

ODD-EDFA

Open Line System
OLS

Coupler / mux-demux

Coupler Mux-demux
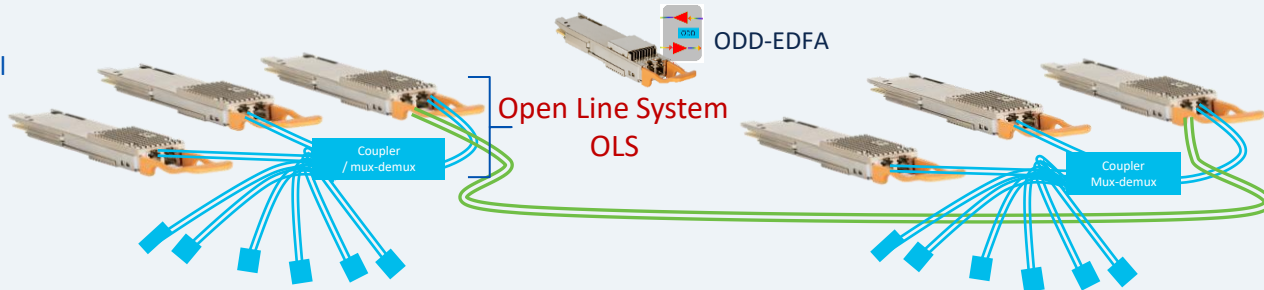
# Data Center -  Underlay connectivity for distributed DC



DC n

DC 1

DC 2

NR/ZR+ DWDM

Spine

Spine

Leaf

Leaf

Leaf

Leaf

VM VM VM

VM VM VM
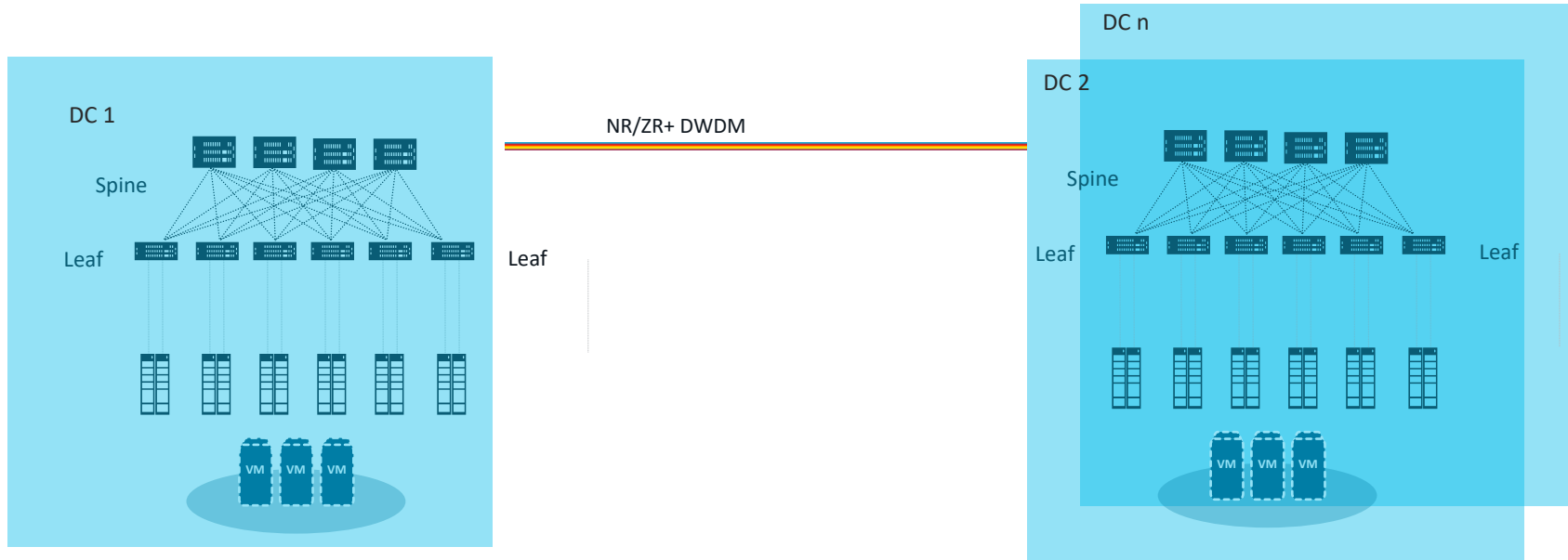
Nexus 9800 DC Spine / DCI Edge switch powered by Si1 with integrated 400G BZR+ optics
eliminating need for a separate DWDM transponder for bandwidth and reach

# PLE is Real!

- Supported client types
  - 1GE, 10GE
  - OC48/STM16, OC192/STM64
  - Fibre channel (1, 2, 4, 8 ,10 ,16 and 32G)
  - OTU2, OTU2e

- Any mix of client types supported

- Supported in NCS-55A2 (peyto) and NCS-57C3 (Eryie)



NC55-OIP-02



NCS-55A2



NCS-57C3

# Both PLE and CS-SR are "open"

- PLE data plane
  - https://datatracker.ietf.org/doc/html/draft-schmutzer-pals-ple
  - 4th revision introduced how to carry 200GE and 400GE
- Circuit-style SR policies
  - Two drafts
    - https://datatracker.ietf.org/doc/html/draft-schmutzer-pce-cs-sr-policy
    - https://datatracker.ietf.org/doc/html/draft-sidor-pce-circuit-style-pcep-extensions
  - Presentation of both drafts at IETF113 triggered great interest and lead to support from multiple vendors and customers

# Leveraging SR-MPLS & SR-TE to Build A Resilient DCI
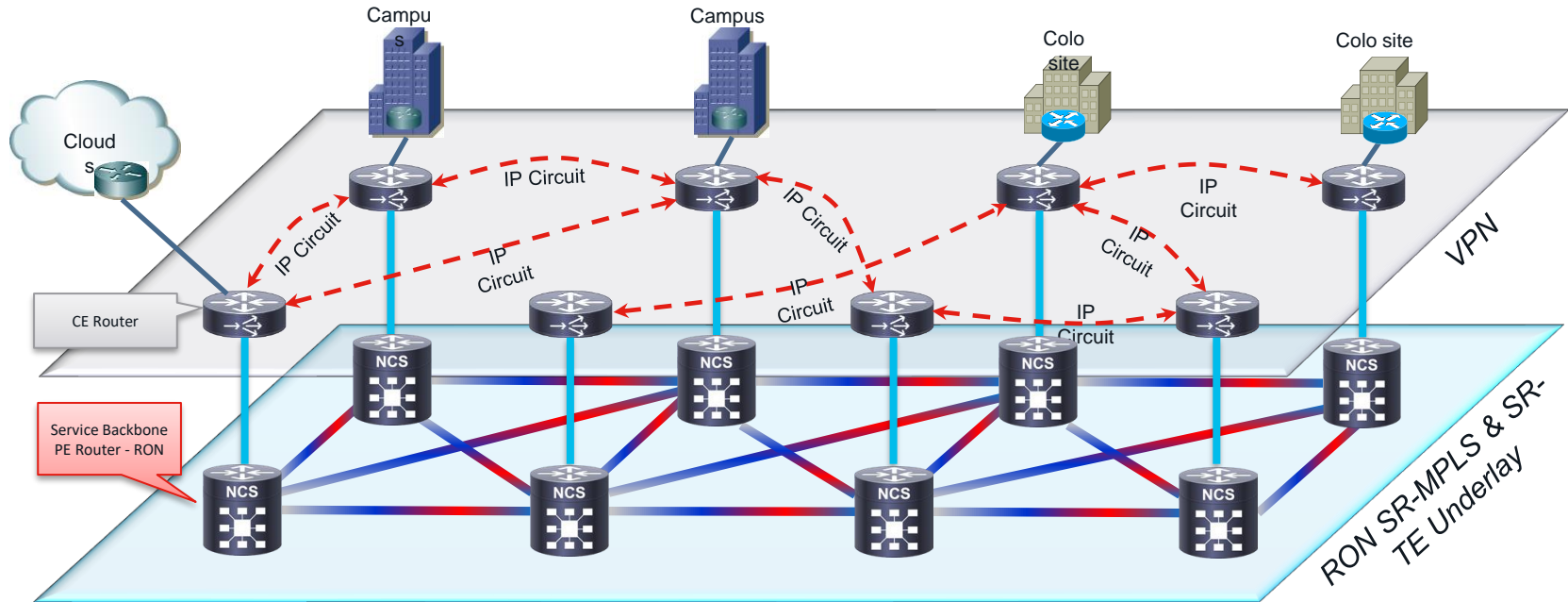
# Hybrid Cloud : Resilient Service backbone
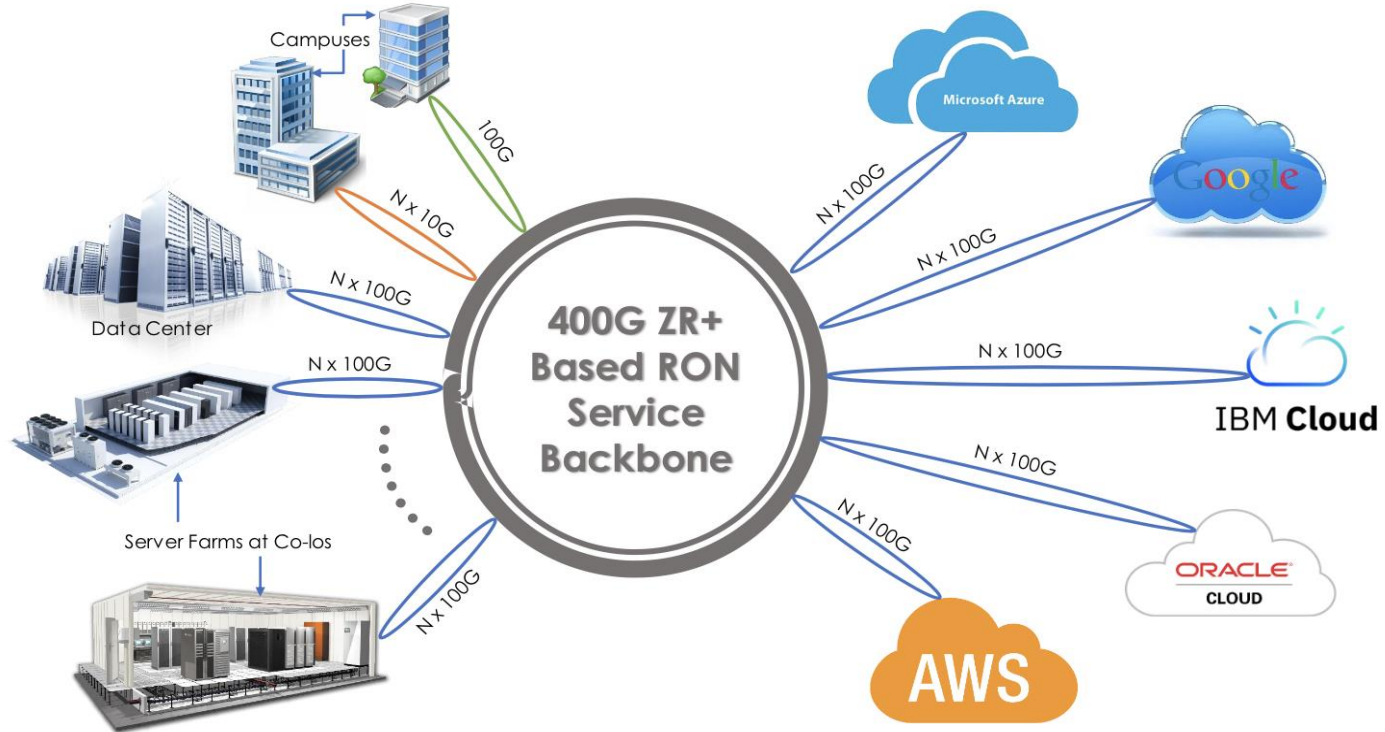


Cisco 8000 (powered by Si1) / ASR 9900 / NCS 5700 XR router in the WAN backbone with integrated
400G BZR+ optics for high-speed connectivity for Cloud Onramp eliminating need for DWDM transponder
for bandwidth and reach

# Enterprise underlay connectivity for distributed campus
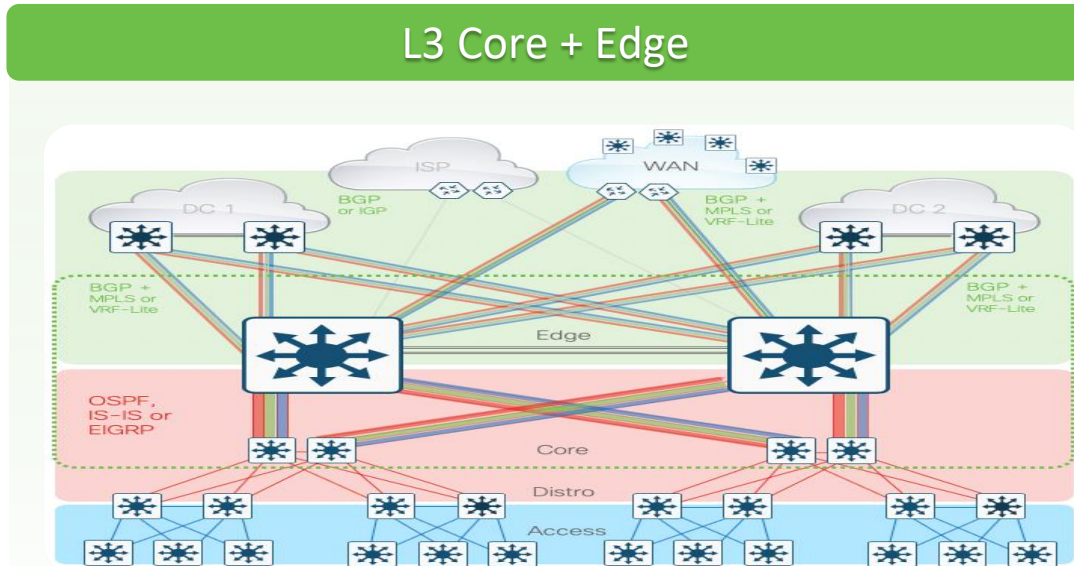


**L3 Core + Edge**

- **L3 Core** + **Edge Services**
- DCI, WAN, Internet
- Edge Security, VPN & OGACL
- Complex H-QoS

Catalyst 9600X Campus Core switch powered by Si1 with integrated 400G ZR?ZR+ optics
  eliminating need for a separate DWDM transponder for bandwidth and reach

# SD-WAN use case : City / State / Federal Net Agency connectivity

BZR+ DWDM

Agency

vEdge

Agency

vEdge

Agency

Transport Network
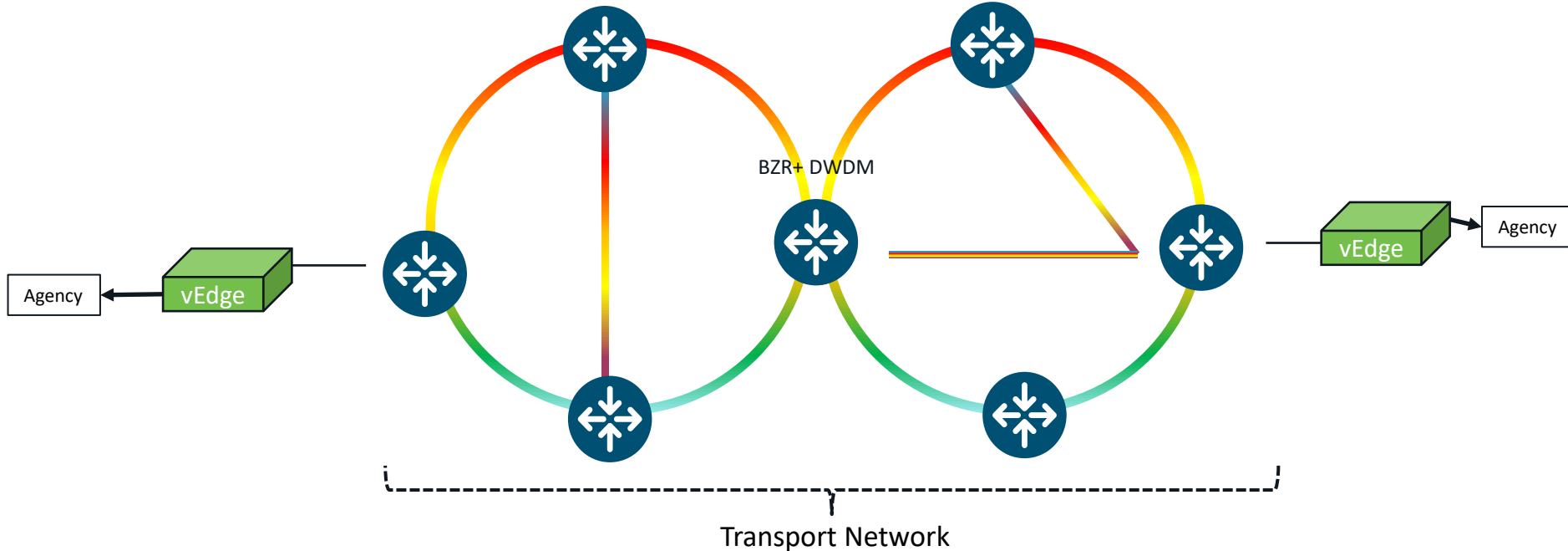
ASR 9900 / NCS 5700 core transport XR router with feature-rich capabilities and integrated 400G BZR+ optics eliminates need for a separate DWDM transponder for bandwidth and reach. vEdge device providing SD-WAN overlay over SR transport underlay powered by RON

# IOT use case : Non carpeted OT space / rural broadband

BZR+ DWDM

IE
IE
IE
IE

NCS 540 access transport XR router with integrated 400G BZR+ optics
eliminates need for a separate DWDM transponder for bandwidth and reach

# Govt. Pvt. WAN : x-arch blueprint with RON as foundation



Critical Infrastructure

Public Safety

Vehicle Area Network

5G

Municipal Utilities

Cyber Vision

Identity Services

SCADA

Flow Analytics

I/O    Controller    Instrumentation    HMI

CBRS/5G Edge

Private

RAN    Fronthaul    Midhaul    NCS

Slicing

RAN    Fronthaul    Midhaul    NCS

Carrier

Transportation

Roadways    Rail and Mass Transit    Digital Ports    Airports and Aviation

CUR WB

WiFi    LoRa    W IFi    LoRa

Cisco edge intelligence

Secure Common Core Services

Cybersecurity

CyberVision    Flow Analytics    Cisco DUO    Zero Trust Architecture

Cisco Firepower    Cisco AMP    Cisco Umbrella    ISE

Policy Enforcement

Collaboration and Contact Center

WebEx Contact Center    Cisco Unified Contact Center

webex by cisco

Data Center and Cloud

SaaS

Secure Data Center

AppDynamics

ThousandEyes

Secure Workload

Cisco Intersight

AppDynamics

aws

ORACLE

Routed Optical Core

NCS

SD-WAN

SD-WAN

Government and Resident Services

Municipal Facilities

IoT Sensors & Controls

Smart Buildings

Siemens IOT Sensors    POE Lighting    OT devices    Rules engine

Cameras    Access Point    Blinds    Edge Controllers

Education

5G    CURWB

Underserved Communities

5G    Municipal WiFi

CURWB    PON Edge

Optical

Multi-Domain Orchestration

# Conclusion

# The Benefits of a Routed Optical Network
## Analysts believe massive savings – we believe the savings are even greater



**5 Year Cumulative OPEX Breakdown**

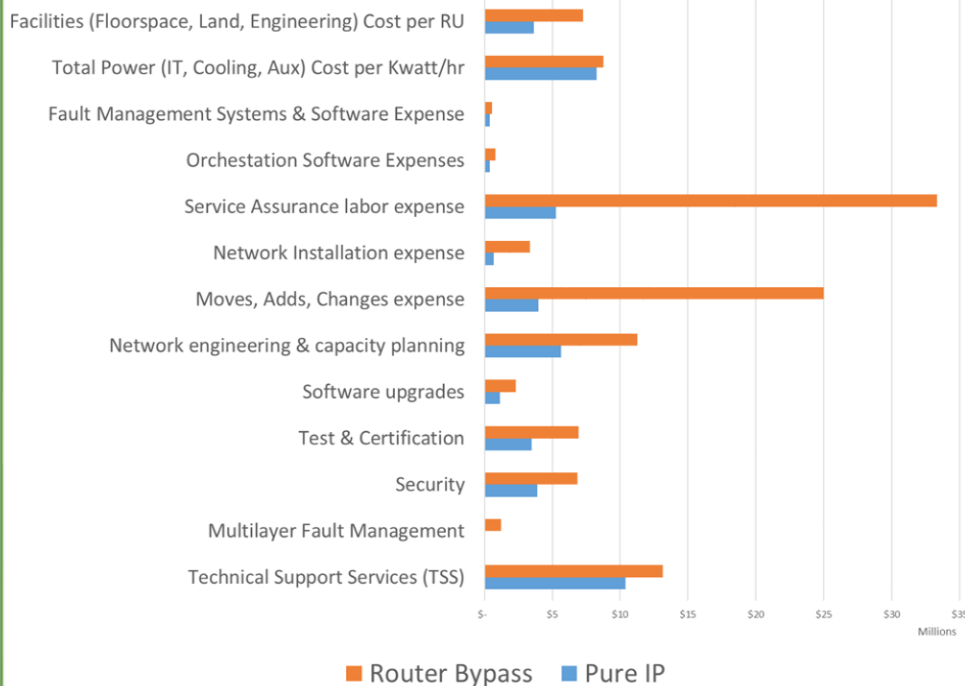(Bar chart comparing Router Bypass and Pure IP across categories: Facilities (Floorspace, Land, Engineering) Cost per RU; Total Power (IT, Cooling, Aux) Cost per Kwatt/hr; Fault Management Systems & Software Expense; Orchestation Software Expenses; Service Assurance labor expense; Network Installation expense; Moves, Adds, Changes expense; Network engineering & capacity planning; Software upgrades; Test & Certification; Security; Multilayer Fault Management; Technical Support Services (TSS). X-axis in Millions: $-, $5, $10, $15, $20, $25, $30, $35. Legend: Router Bypass, Pure IP)

✔ Converges all services onto a single network layer

✔ Eliminates siloed IP & Optical operational layers

✔ Integrates transponders and "grey" optics

✔ Integrates OTN Services and ROADMs

✔ Space, power and operational savings

✔ Shorter Time-to-Market for services