



THE EVOLUTION OF COHERENT PLUGGABLE OPTICS

Jon Baldry

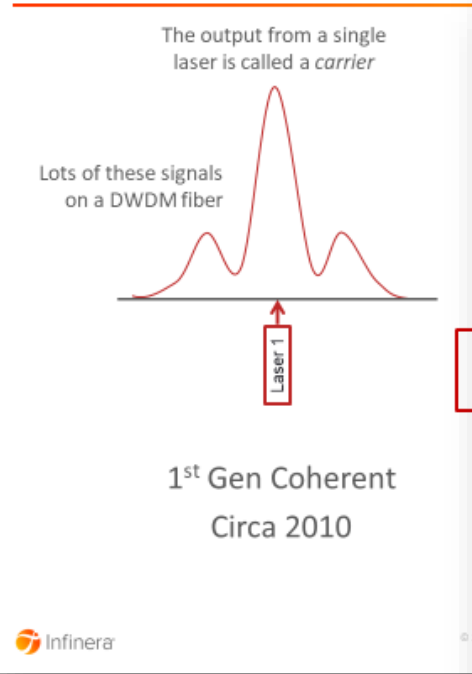
UKNOF52 – London – September 2023



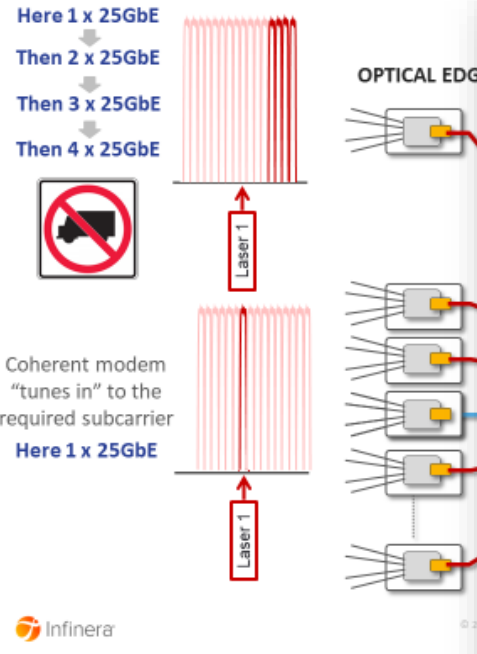
Looking Back at UKNOF49

My colleague Geoff Bennett introduced a new concept in optical networking...

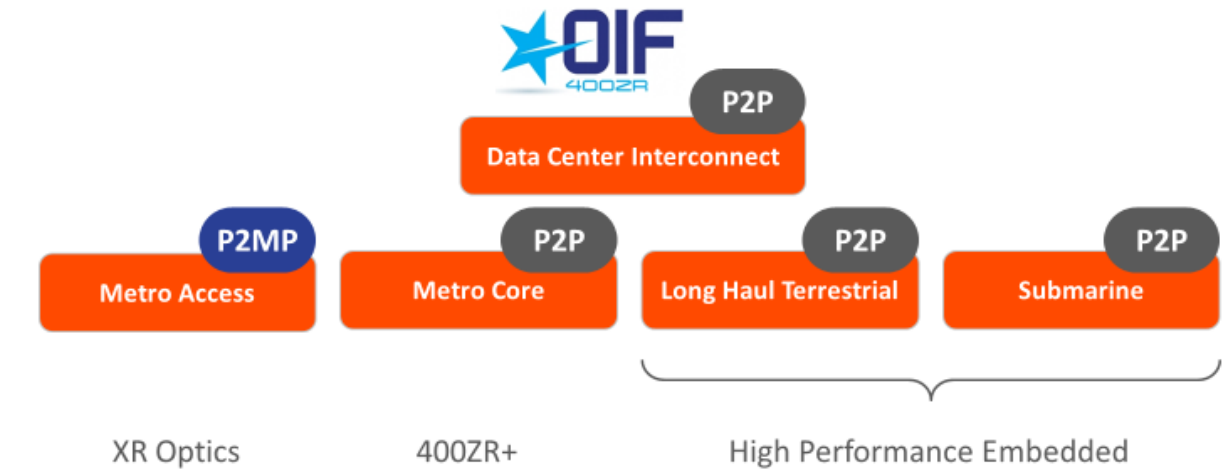
I need to tell you about subcarriers...



How We Might Use Subcarriers



The Coherent Landscape



Point-to-multipoint optics!

How Have Optics Evolved Since UKNOF49?

1

ADVANCES IN
PLUGGABLE OPTICS

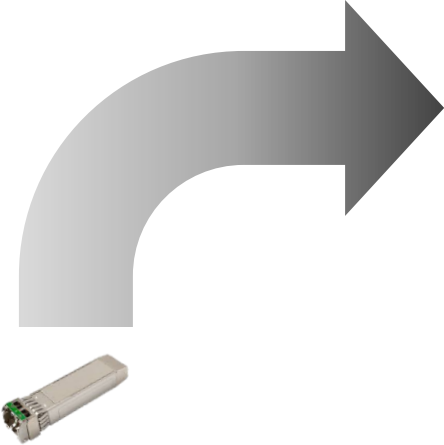
2

ADVANCES IN
EMBEDDED OPTICS

3

THE MOVE TO
OPEN NETWORKS

Trend: Coherent Optics are Becoming Increasingly Intelligent



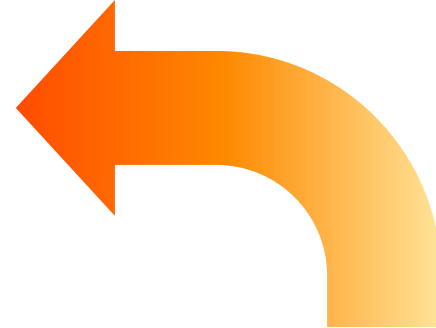
Intelligent Optics

- ✓ NRZ optics – 25G and below
- ✓ Local management access and remote in band management
- ✓ Demarcation (remote management)
- ✓ Layer 2 service aware



Intelligent Coherent Optics

- ✓ Coherent Optics
- ✓ P2P and P2MP architectures
- ✓ Single fibre/PON overlay capable
- ✓ Local management access and remote in band management
- ✓ Out of band communication channel for discovery
- ✓ Dual management - host based and host independent
- ✓ Packet parsing capability
- ✓ Modulation format options
- ✓ Topology Aware

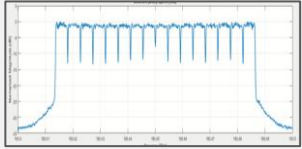


ZR+ Optics

- ✓ Coherent optics – 100G and above
- ✓ Modulation formats for performance vs capacity balancing
- ✓ ROADM capable with 0dBm launch power



Looking Inside Intelligent Coherent Pluggables



Subcarrier-based architecture

DSP

✓ System on a Chip



Software configurable Point-to-Point and Point-to-Multipoint control plane



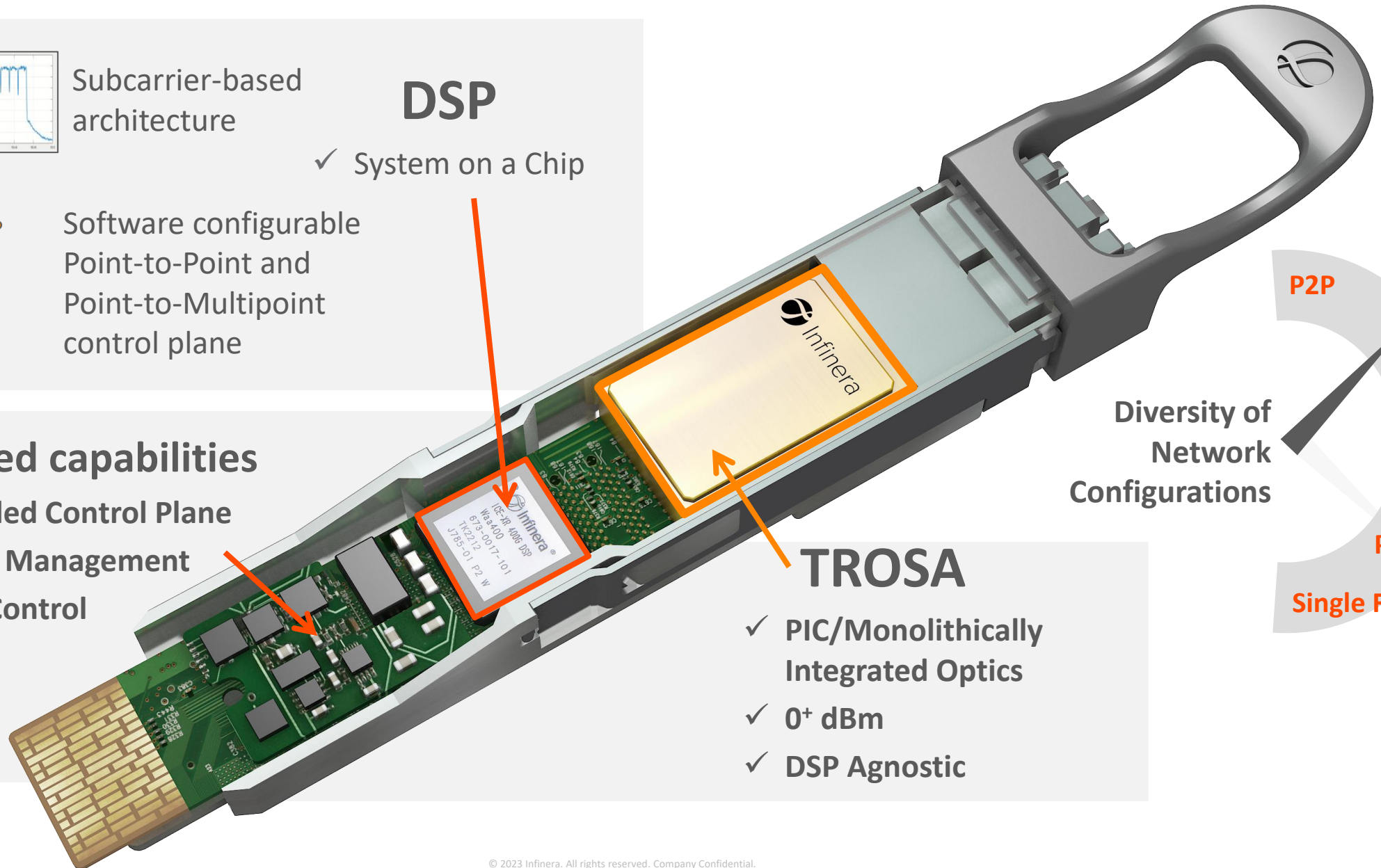
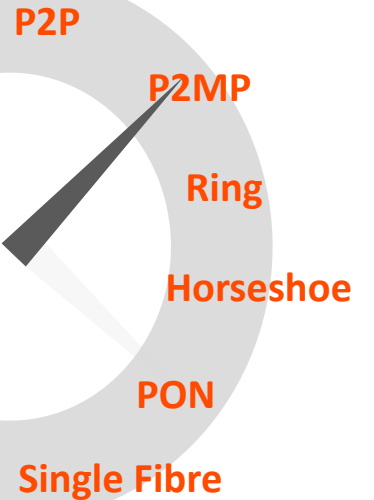
Integrated capabilities

- ✓ Embedded Control Plane
- ✓ Remote Management
- ✓ Power Control
- ✓ OSA

TROSA

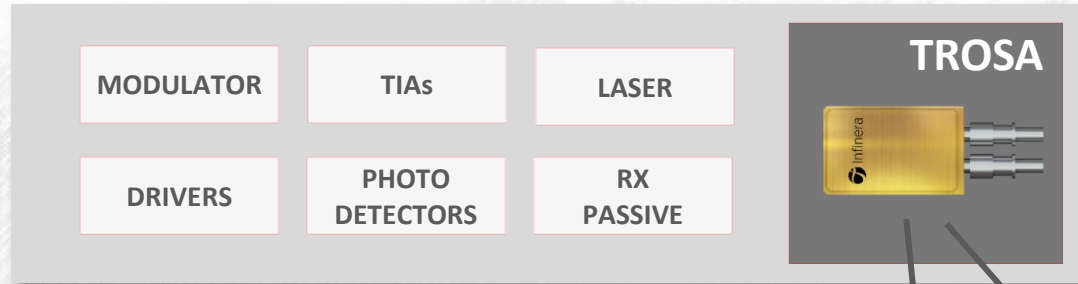
- ✓ PIC/Monolithically Integrated Optics
- ✓ 0+ dBm
- ✓ DSP Agnostic

Diversity of Network Configurations

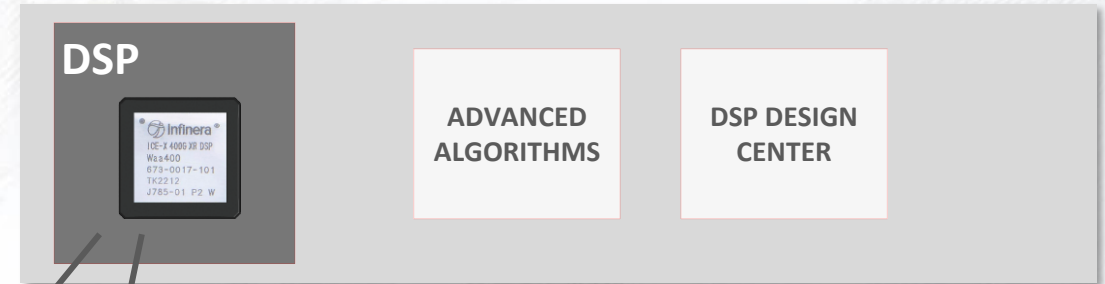


Modular, Building Block Design Strategy

ANALOG OPTICS



DIGITAL SIGNAL PROCESSING

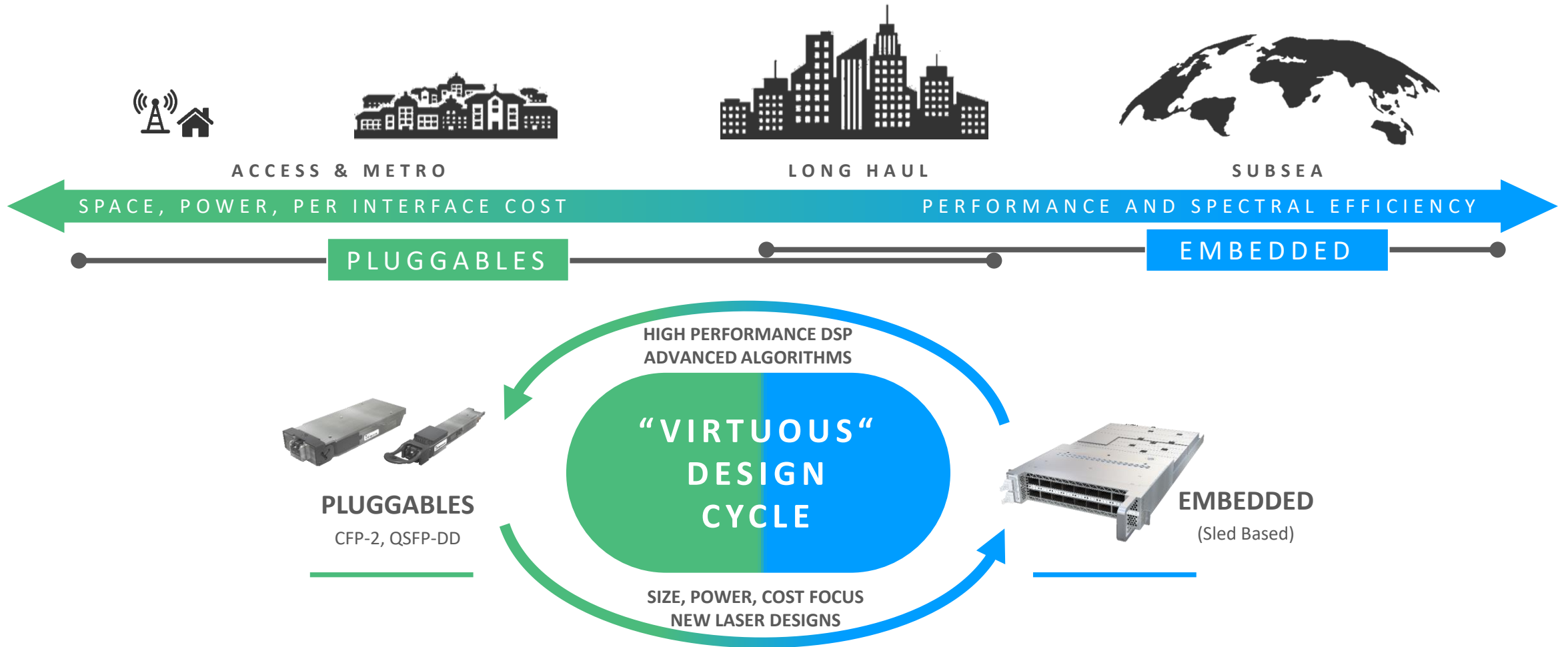


PLUGGABLES
CFP-2, QSFP-DD

EMBEDDED
(Sled Based)

COST EFFECTIVELY BUILD MORE ENGINES FOR MORE APPLICATIONS

Coherent Optics Evolution



INNOVATION IN EMBEDDED DRIVES PLUGGABLES, AND VICE VERSA

Pushing Performance with Embedded Optical Engines



4th Gen
2018

1.2Tbs
200G Wave
32Gbaud

100G
Everywhere



6th Gen
2021

1.6Tbs
800G Waves
100Gbaud

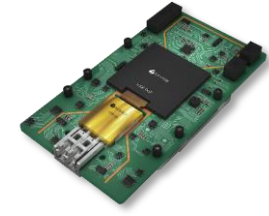
400G
Everywhere



7th Gen
2024

2.4Tbs
1.2T Waves
148Gbaud

800G
Everywhere



8th Gen
To Be Announced

4.8Tbs+
2.4T Waves
>300Gbaud

1.6T
Everywhere

**DRIVING DOWN COST PER BIT
AND POWER PER BIT**

Building a Better Pluggable

PERFORMANCE



Maximize resource utilization

PROGRAMMABILITY



Maximize addressable applications

MANAGEABILITY



“A tool is ever only as good as your ability to use it”

Performance



1,800KM – LIVE NETWORK

400G QSFP-DD

Spectrum shared with multiple vendors

400G 16QAM and SMF-28 fiber

*Arelion

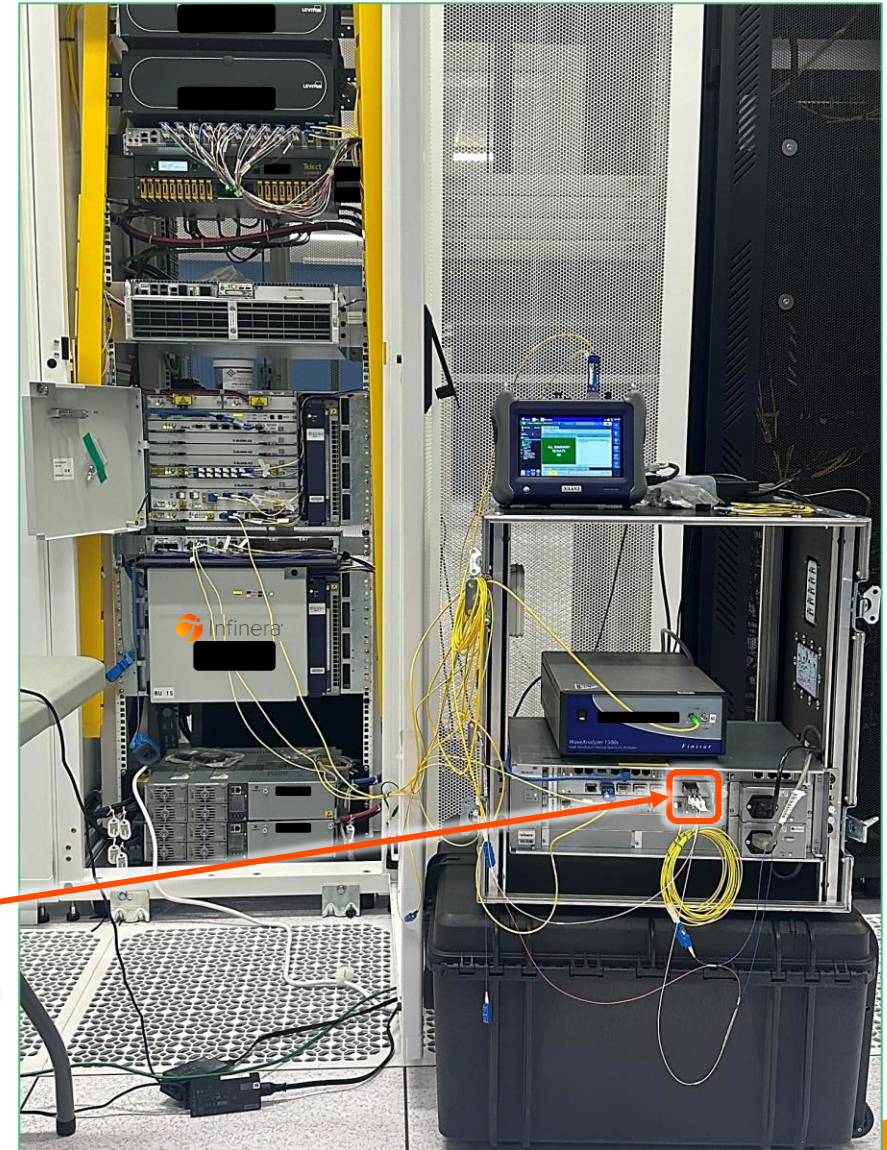
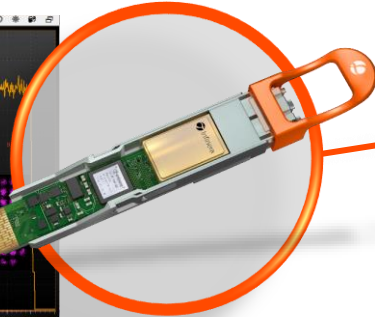
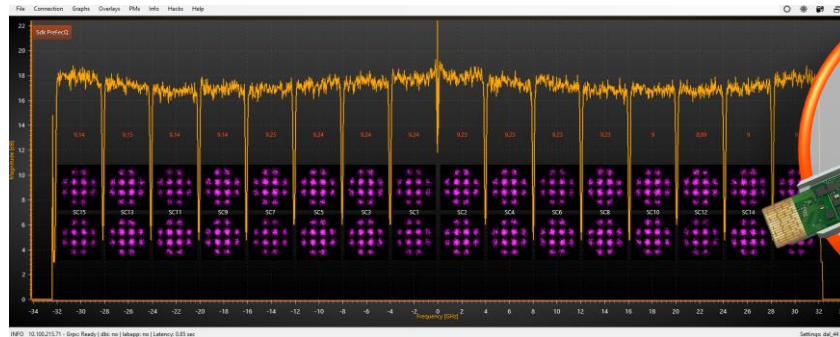


DALLAS



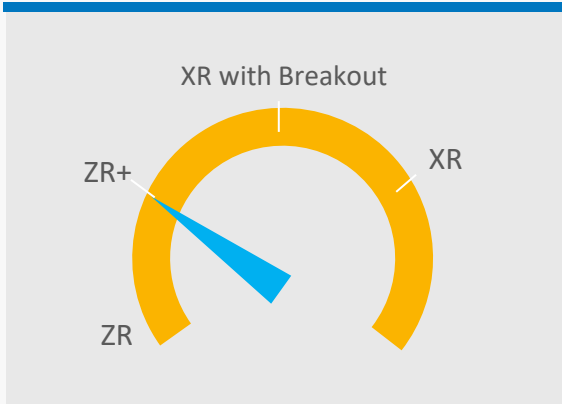
MEMPHIS

ICE-X 400G ZR+

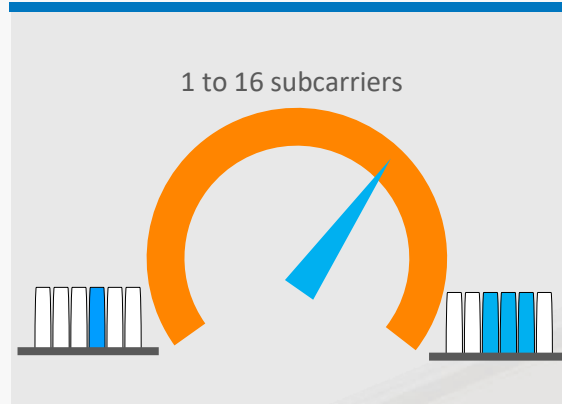


Programmability

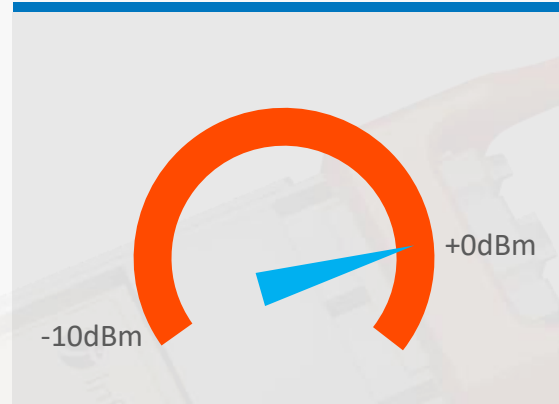
MODE



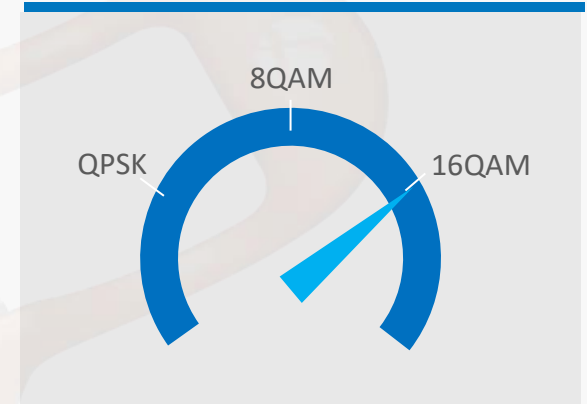
SPECTRUM



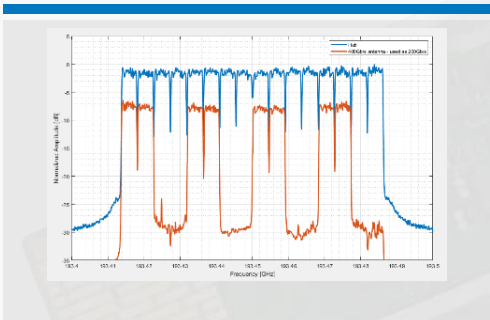
LAUNCH POWER



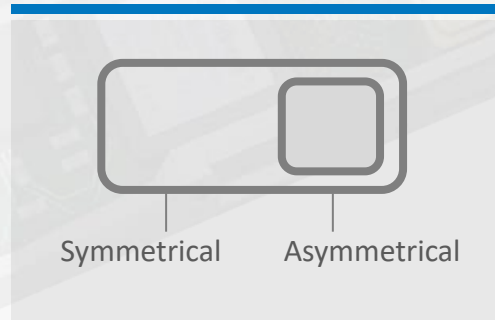
MODULATION



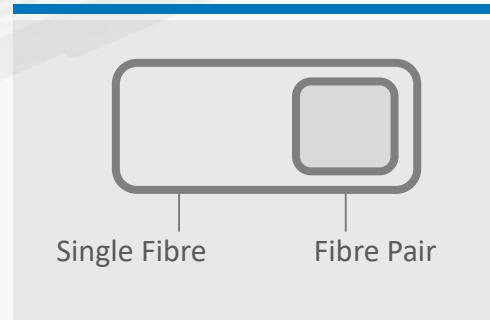
DIGITAL SUBCARRIERS



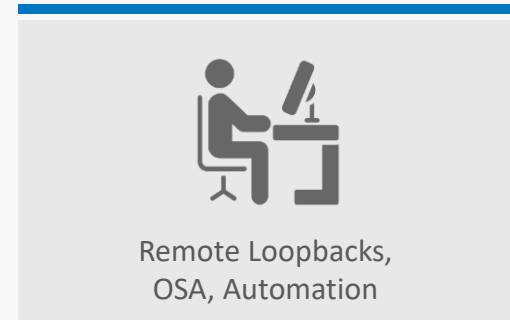
TRAFFIC FLOW



FIBRE



REMOTE MANAGEMENT

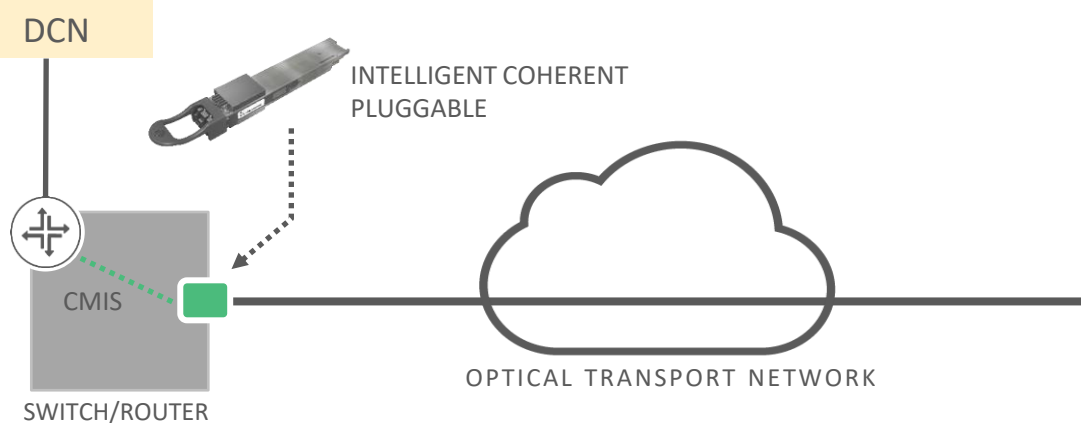


MAXIMIZE ADDRESSABLE APPLICATIONS

Manageability – We Need Multiple Approaches...

HOST BASED MANAGEMENT

DIRECT MANAGEMENT VIA ROUTER and CMIS



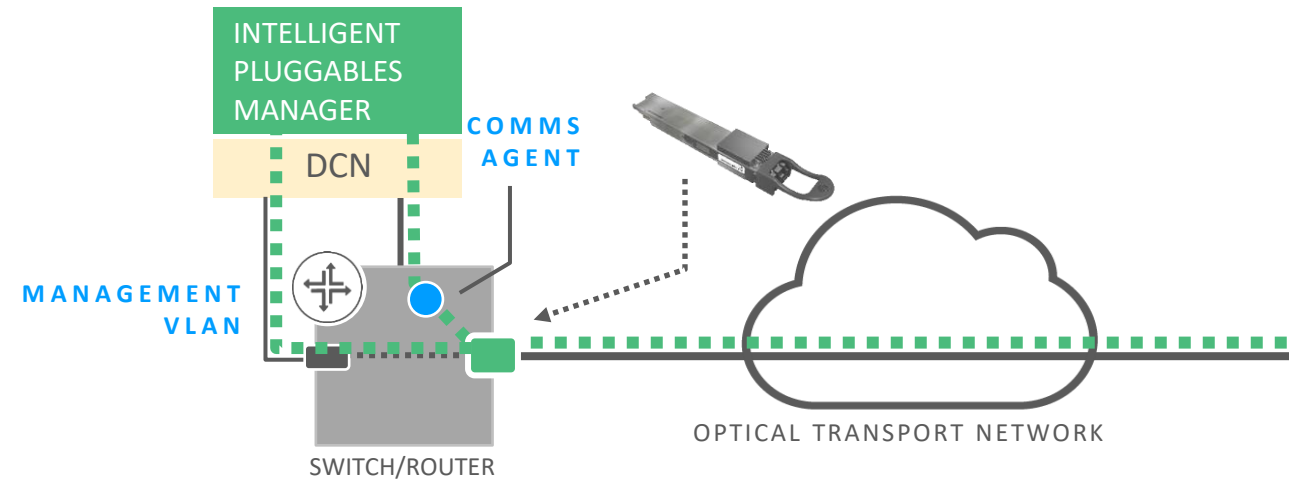
MANAGE LIKE ANY COHERENT OPTIC

- Wavelength settings
- Basic Performance monitoring

CMIS: Common Management Interface Specification

HOST INDEPENDENT MANAGEMENT

DIRECT MANAGEMENT VIA COMMS AGENT OR MANAGEMENT VLAN THROUGH DATA PLANE



ADVANCED MANAGEMENT OPTIONS

- Uniformity across all host platforms
- Wavelength settings and subcarrier assignment (for P2MP)
- In-band management (remote site)
- Advanced diagnostics
- Faster innovation

Open XR Forum Driving Manageability Specs



OPEN XR FORUM LAUNCHES WITH TIER 1 NORTH AMERICAN AND EUROPEAN SERVICE PROVIDERS



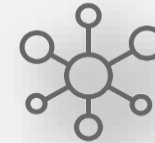
5 MEMBERS



37 MEMBERS



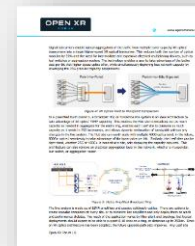
19 Network Operators
13 Network Equipment Providers
5 Component OEMs



Numerous PoCs



Management Specifications and Roadmap

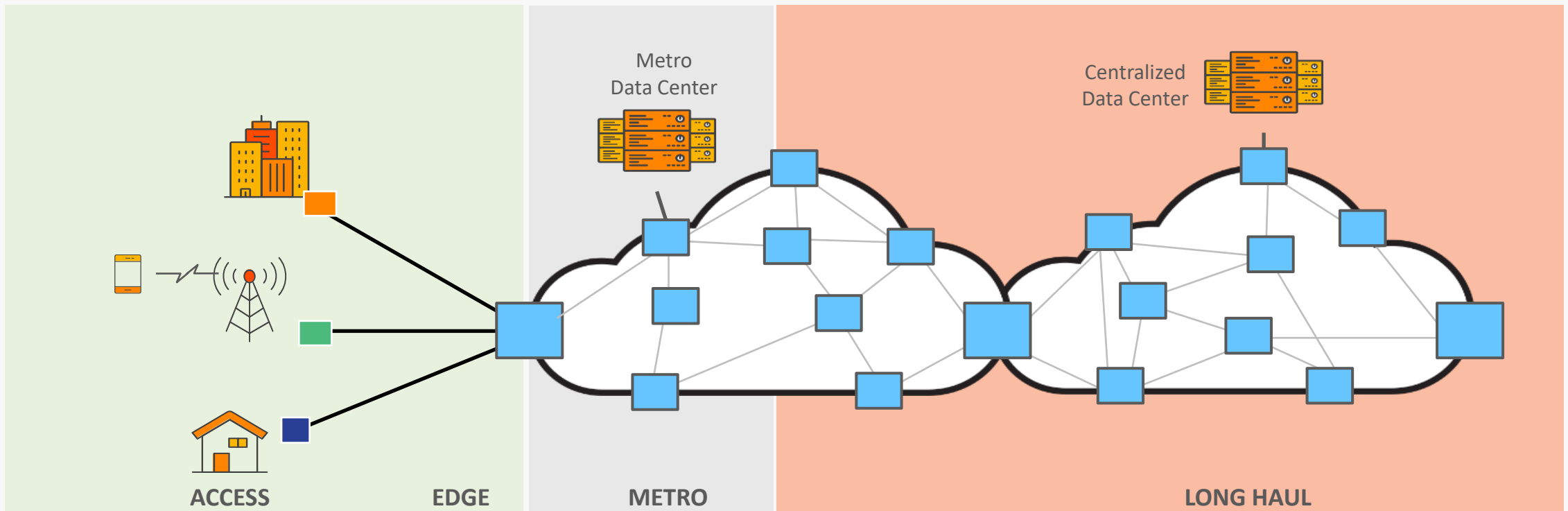


Published technical Papers



Working Groups

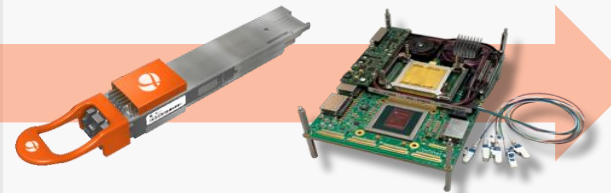
Further Evolution of Coherent Pluggables



- Automation
- 100G
- Single Fibre
- PON Overlay
- Demarcation
- Lower power consumption
- Wider set of host devices
- iTemp
- High-volume manufacturing



400G Coherent Pluggables



- +800G
- PCS
- Power consumption as a function of Gb/s and reach
- Complement Embedded optical engines

What About Optical Network Architectures in General?



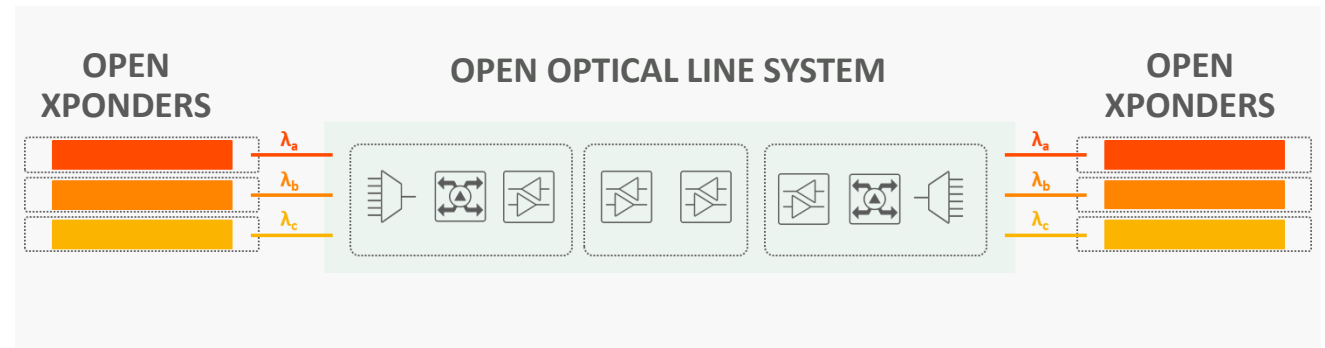
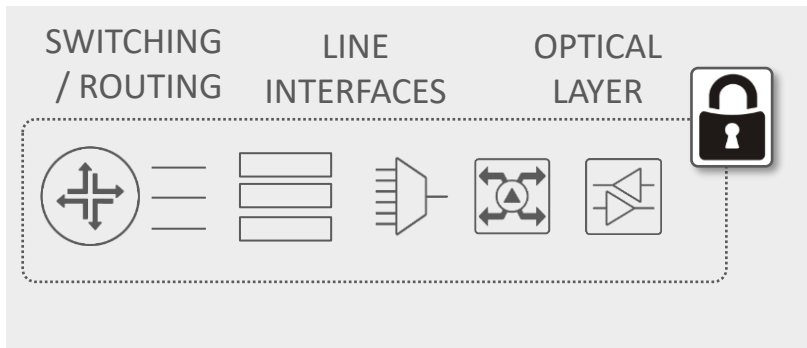
The Move to Open

TRADITIONAL CLOSED SOLUTIONS

OPEN OPTICAL NETWORKING

SINGLE-VENDOR SOLUTIONS

MULTI-VENDOR SOLUTIONS



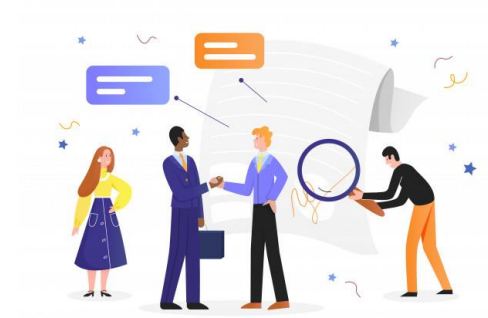
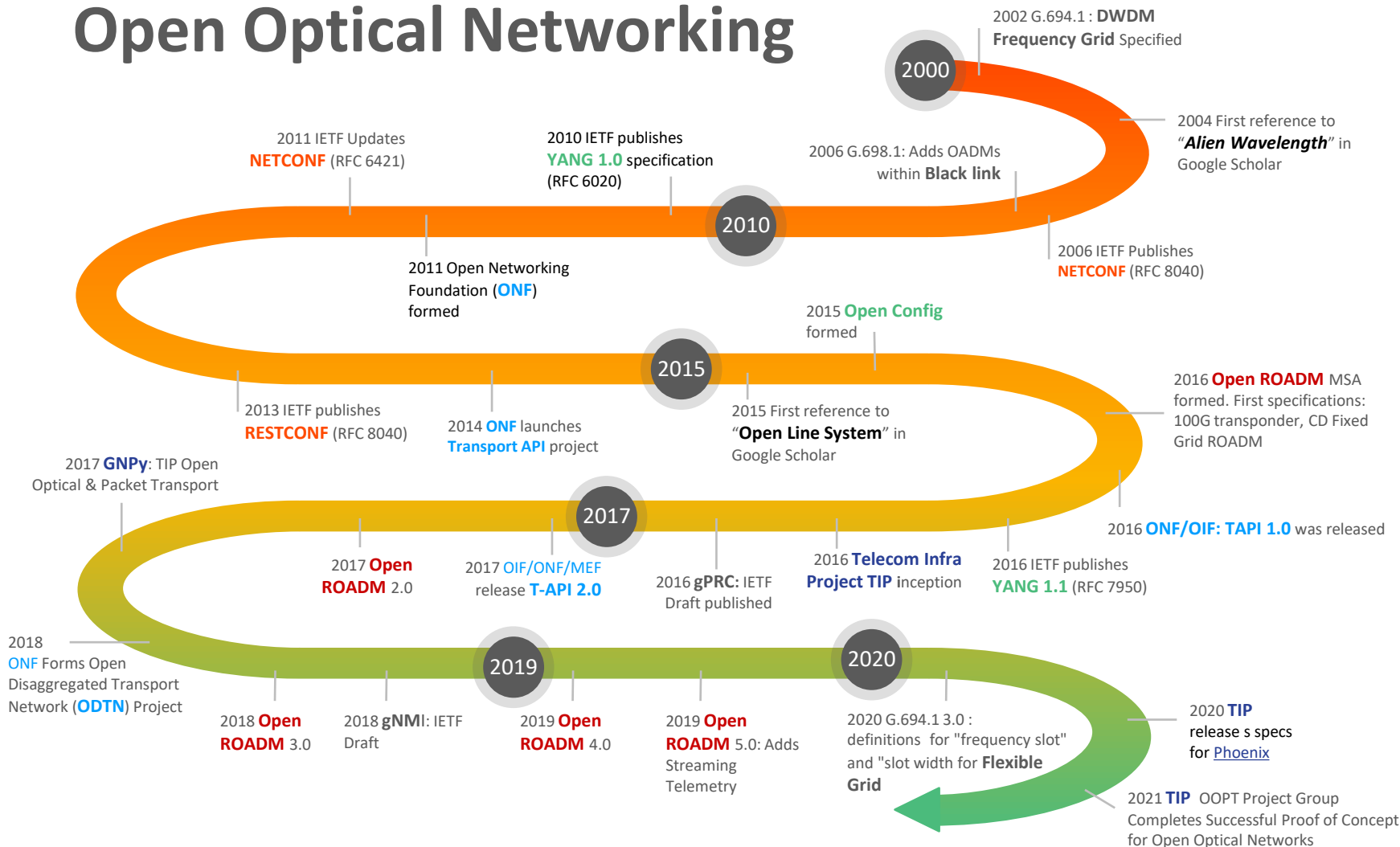
LIMITED CHOICE, DEPENDENCY

MORE CHOICE | FASTER INNOVATION | IMPROVED ECONOMICS

ACCELERATED OPTICAL ENGINE DELIVERIES AND REDUCED RISK

20 Years of Evolution

Open Optical Networking


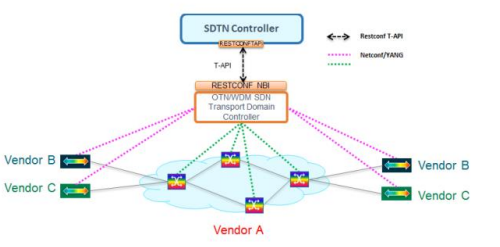


Initiatives, Agreements and Standards




Industry Collaboration and Convergence on Automation


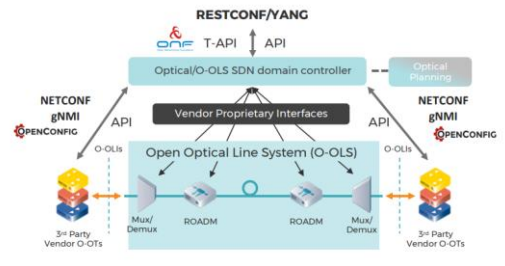
ONF


Leveraging IETF ACTN SDN framework



TIP

NEW: ETSI open-source group for TeraFlowSDN aligning with TIP MUST architecture




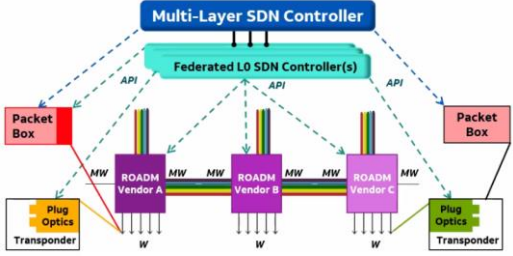
OIF

OIF 2020: TRANSPORT SDN API INTEROPERABILITY DEMO
Accelerating worldwide adoption of Transport SDN



2023 OIF interop demo under planning

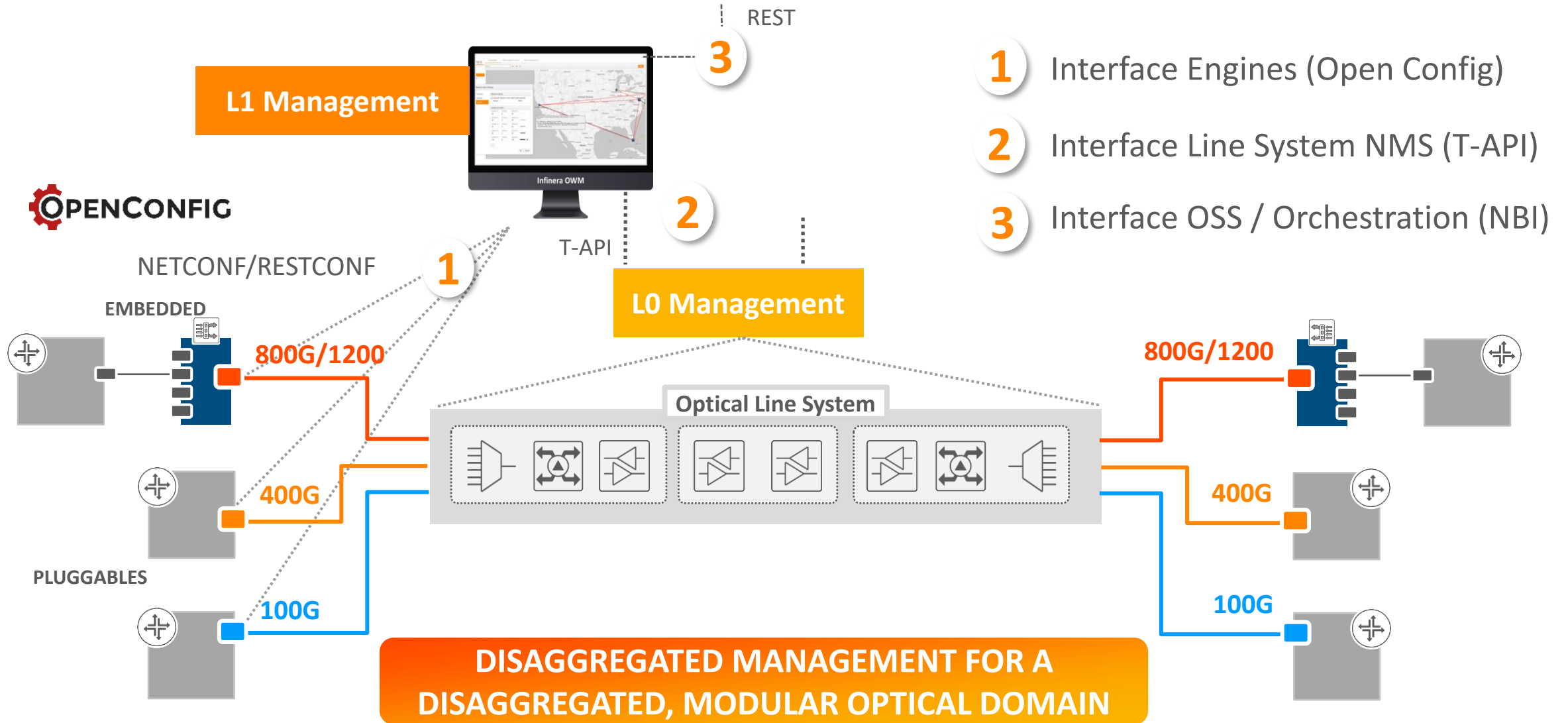
OpenROADM

AT&T implementation

Convergence Accelerating the Adoption of Open Optical Networking

Again, We Need to Make it Manageable!

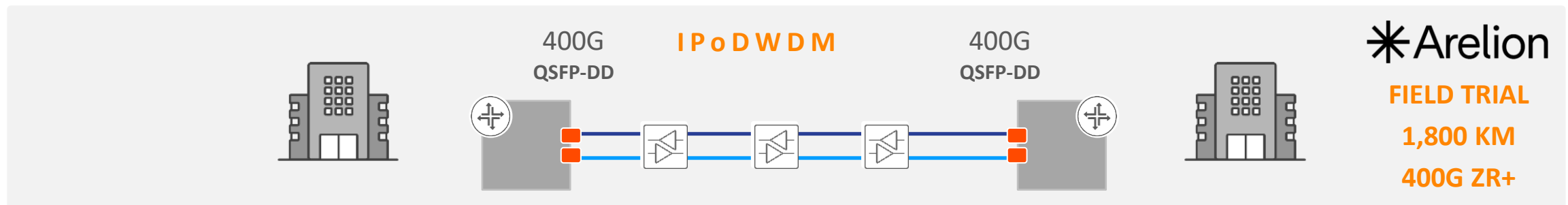
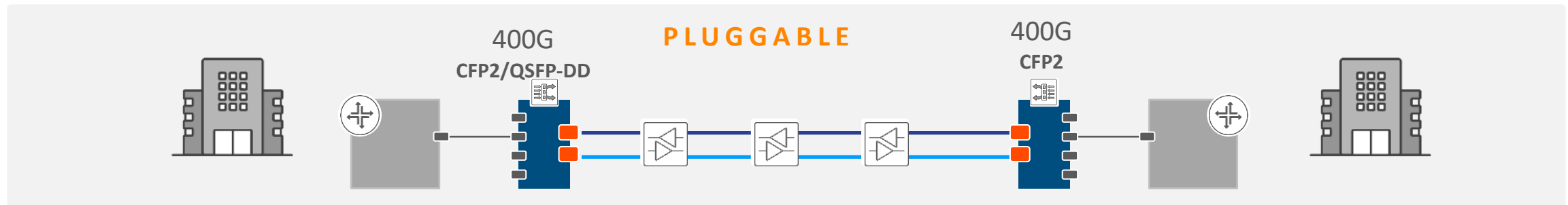
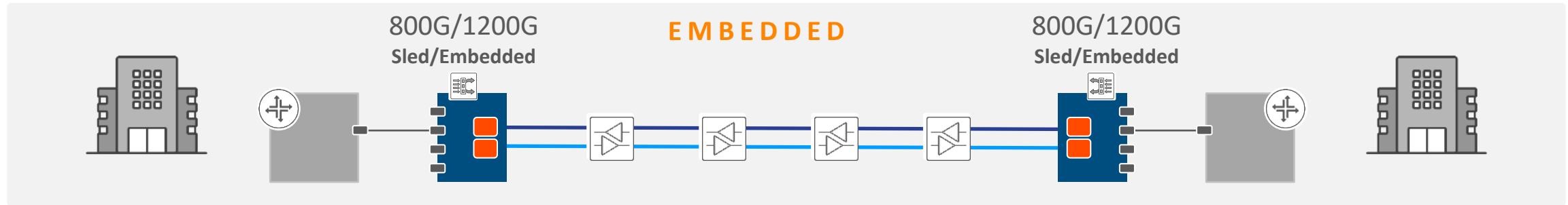


- 1 Interface Engines (Open Config)
- 2 Interface Line System NMS (T-API)
- 3 Interface OSS / Orchestration (NBI)

So What? Where Can I Use All This?



Data Centre Interconnect – Multiple Options Required

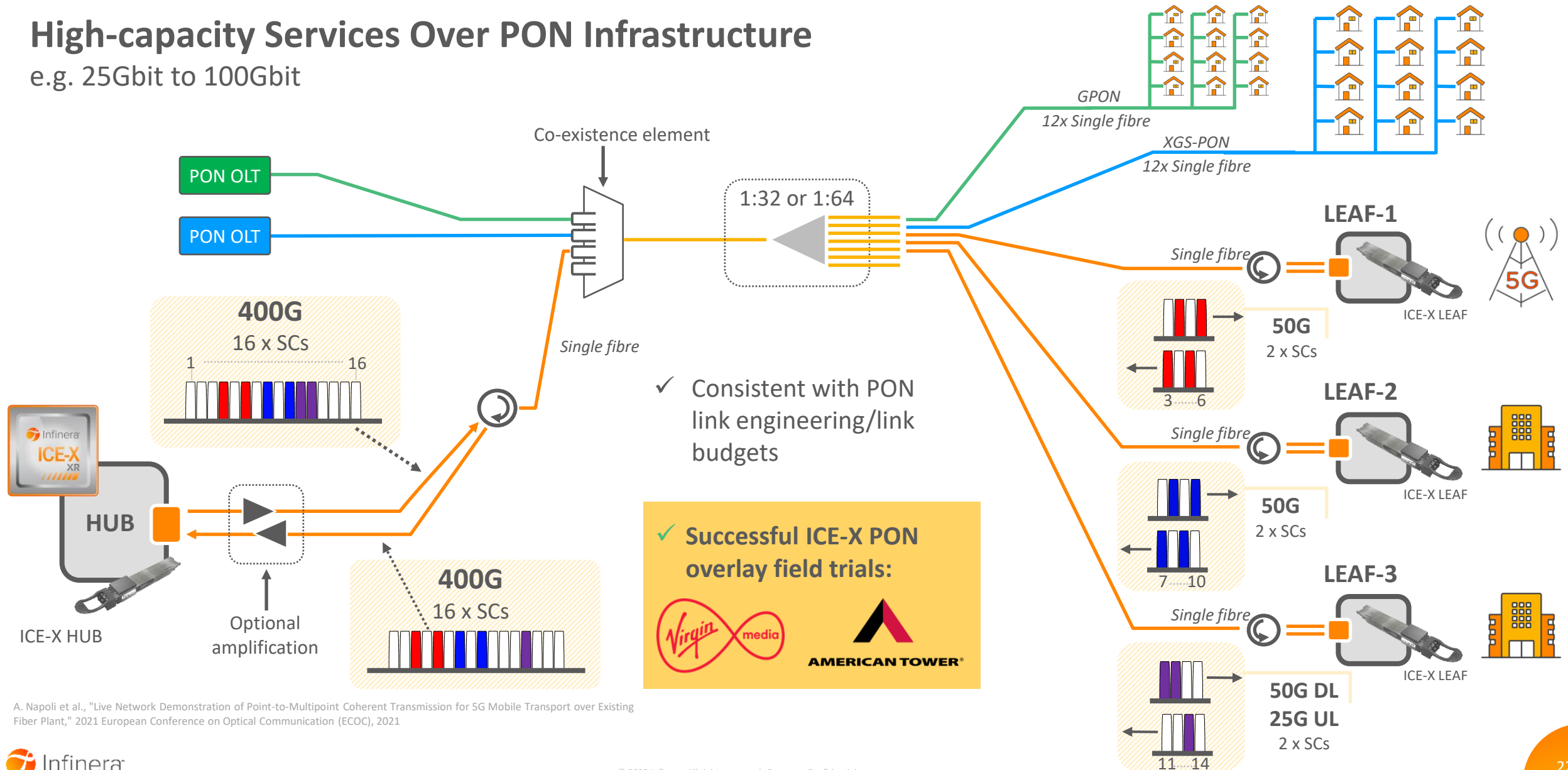


A MIX OF EMBEDDED AND PLUGGABLE TECHNOLOGIES IN OPTICAL AND NON-OPTICAL GEAR

PON Overlay Application

High-capacity Services Over PON Infrastructure

e.g. 25Gbit to 100Gbit



A. Napoli et al., "Live Network Demonstration of Point-to-Multipoint Coherent Transmission for 5G Mobile Transport over Existing Fiber Plant," 2021 European Conference on Optical Communication (ECOC), 2021

Summary: Key Takeaways

1

ADVANCES IN PLUGGABLE OPTICS

- PERFORMANCE
- PROGRAMMABILITY
- MANAGEABILITY

2

ADVANCES IN EMBEDDED OPTICS

- PERFORMANCE
- NETWORK
EFFICIENCY

3

THE MOVE TO OPEN NETWORKS

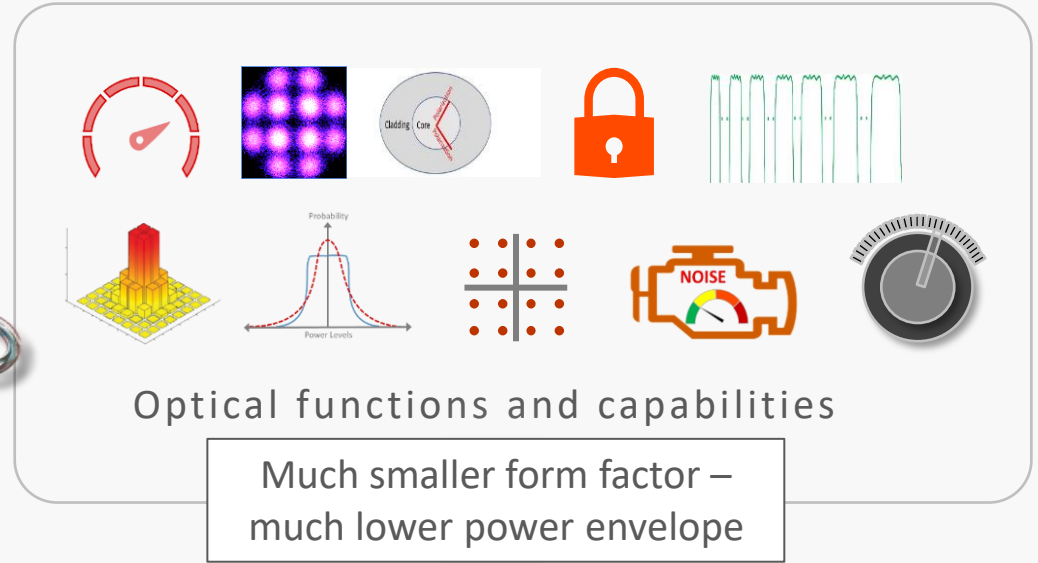
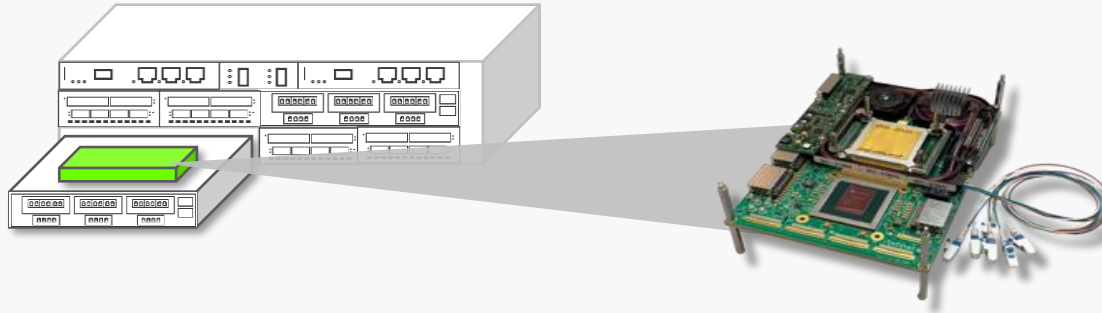
- STANDARDIZATION
- MANAGEABILITY



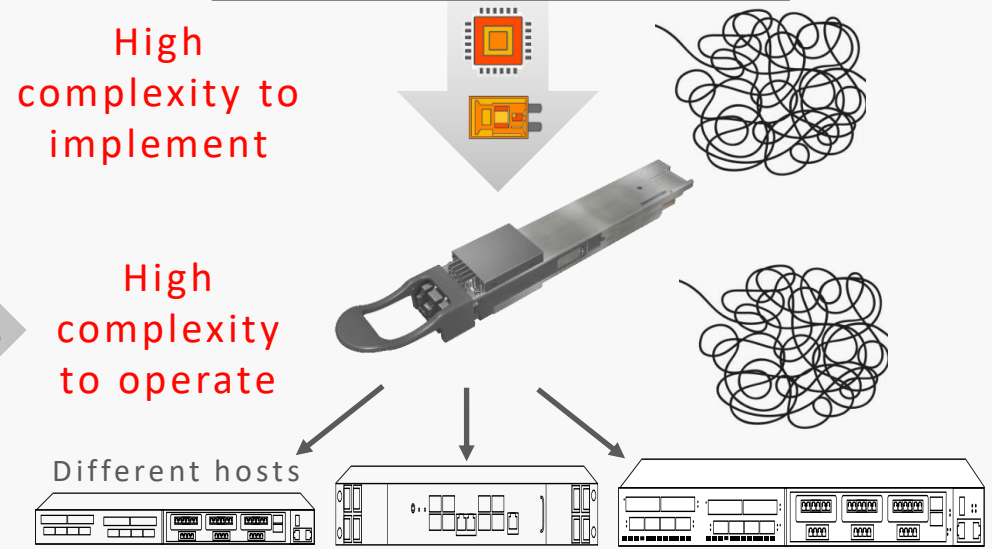
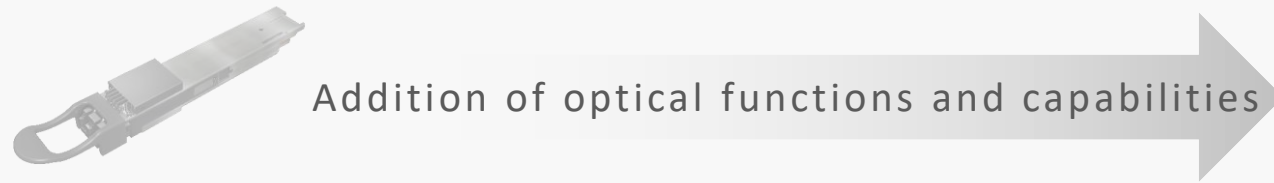
Thank You

Manageability

Embedded Optical Engines



Evolving Coherent Pluggables

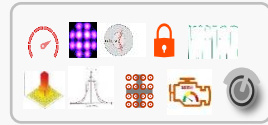


Manageability

EVOLVING COHERENT PLUGGABLES



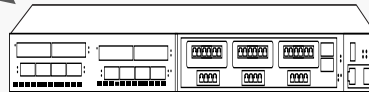
OIF PROJECT



Dual-Management



Different hosts

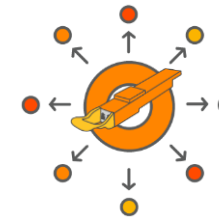


- ✓ Support of APIs into the coherent pluggables
- ✓ Abstraction of the optical layer from the IP layer
- ✓ Centralized management within the optical domain

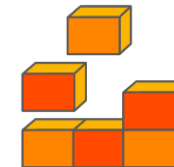
BENEFITS



Automated Engineering and Deployment



Host agnostic



Disaggregated Network Architecture