Open Optical Transponders, QSFP-DD 400G Pluggables, and Various Xponders Connected through a Reliable Open ROADM Transport Network with Multi-layer Performance Monitoring Capabilities

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What is Open ROADM

The **Open ROADM Multi Source Agreement (MSA)** defines interoperability specifications for Reconfigurable Optical Add/Drop Multiplexers (ROADM). Included are the ROADM switches as well as transponders and pluggable optics. Specifications consist of both optical interoperability as well as YANG data models available at OpenROADM.org. Multi-vendor Open ROADM compliant equipment is integrated into the same network solution controlled by the **open source Transport PCE (TPCE) controller**.

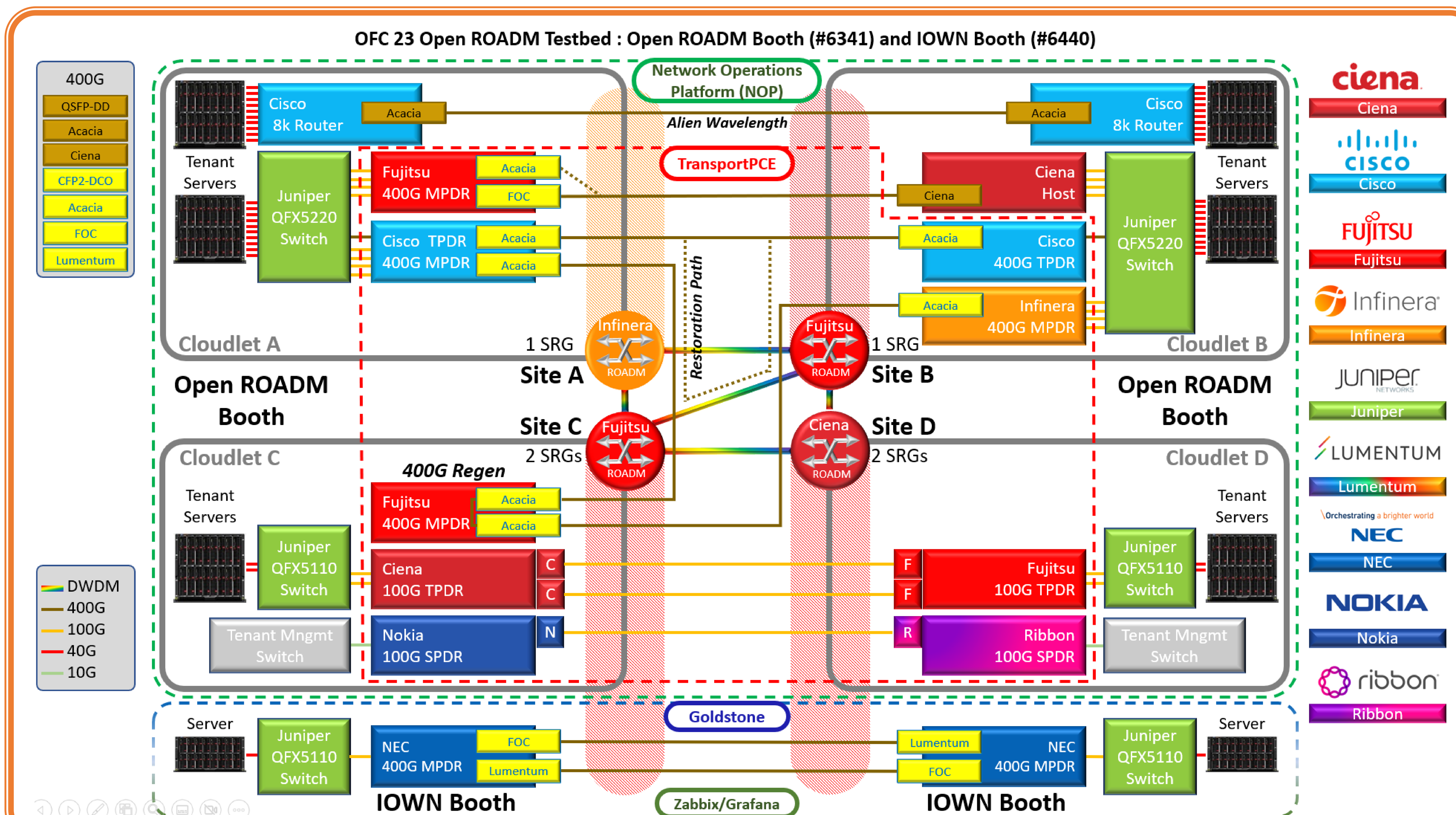
OFC 23 Demonstrations

This collaborative effort showcases functionalities and multi-vendor interoperability features in an optical network testbed that makes use of interconnected Open ROADM compliant equipment including ROADM switches, 100G switchponders (SPDR), 100G transponders (TPDR), 400G transponders, 200G/300G/400G muxponders (MPDR), a 400G single-node 3R regenerator, and CFP2-DCO and QSFP-DD 400G pluggable devices. Our Open ROADM Testbed demonstrates:

i. interoperability of CFP2-DCO 400G devices from three Original Equipment Manufacturers (OEMs)
ii. an Open ROADM compliant 400G single-node 3R regenerator,
iii. an automated path restoration mechanism at the physical layer implemented in the open source TPCE controller,
iv. interoperability between CFP2-DCO and QSFP-DD 400G pluggable devices,
v. an IPoverWDM architecture with routers hosting QSFP-DD 400G coherent plugables supporting oFEC, and
vi. various multi-layer network monitoring techniques for both optical and data packet transport layers.

QSFP-DD 400G Pluggables

We demonstrate Open ROADM compliant 400Gb/s transmission achieved via router-optimized QSFP-DD pluggables, which incorporate embedded amplification and tunable optical filtering to enable simple deployment over any type of ROADM line system. Optical signal Interoperability between CFP2-DCO 400G and QSFP-DD 400G is showcased. With the ability to support all metro ROADM client performance requisites in the small QSFP-DD form factor, these technologies expand the range of Open ROADM applications to include converged IPoverWDM architectures, which MSA Release 11.0 covers through an extension of both the device and service models to handle such use cases.



T-PCE Automated Path Restoration

Automated path restoration is a newly implemented feature in the open source Transport PCE (TPCE) controller. For any created service that is labeled as "restorable," the TPCE controller triggers a restoration mechanism at the physical layer as soon as its signal is subject to a severe power degradation (e.g., a fiber cut). Any critical degradation of the signal power level that is monitored at each ROADM node generates a notification through subscription to a NETCONF stream of the Open ROADM device. Upon receiving a change notification of the ROADM degree OTS (optical transmission section) interface operational state, TPCE computes a new candidate path that avoids the problematic degree and moves the wave service over the new path. This feature improves the reliability of Open ROADM networks.

Interoperable CFP2-DCO 400G Devices

CFP2-DCO pluggable transceivers make use of digital coherent optical signals and are designed for line-side trunk DWDM data center interconnect (DCI), metro carrier, and regional/long haul applications. We demonstrate Open ROADM compliant and interoperable CFP2-DCO 400G modules from three OEMs.

400G Open Optical Transponders in Collaboration with IOWN

The Open ROADM Testbed in booth (#6341) is connected via fiber optics, provided by OFCnet, to the equipment showcased in the Innovative Optical and Wireless Network (IOWN) networking hub (#6440). Hosted in the IOWN networking hub, open optical transponders that comply with global standards and offer validated interoperability are connected to the Open ROADM Testbed showcasing how operators can manage both computing servers and transponders using the same open source software ecosystem, while at the same time leveraging Open ROADM transport network functionalities. These features are the result of collaborative activities between the Open ROADM MSA and IOWN Global Forum for standardization (www.iowngf.org). This demo concurrently features:

- Hardware and software disaggregation through open muxponder Galileo Flex T
- Multi-vendor and multi-generation transceivers
- Open ROADM MSA compliant CFP2-DCO 400G devices
- Staircase FEC and oFEC
- Signal tunneling through wavelength between two Open ROADM nodes that are MSA compliant
- Containerized applications using Kubernetes

400G Signal Regenerator

We demonstrate an Open ROADM compliant 3R regenerator (re-amplification, re-shaping, and re-timing) with a bidirectional, single-node (all optical) design. A three-hop 400G signal is routed through Site-A, Site-C, Site-D, and Site-B, while 3R regeneration is applied at Site-C. The CD ROADM in Site-C requires two SRGs to handle the two signals (one from Site-A and one from Site-D) that must be regenerated in each direction of propagation. In this single-node design, only network interfaces are specified (e.g., OTSI, OTSI-group, OTUC4, and ODUC4 for 400G).

Retrieving Multi-Layer Performance Metrics using Open Source Packages

The demonstrated Network Operation Platform (NOP) is designed to collect cross-layer network performance metrics in an Open ROADM compliant network comprising network elements from multiple vendors in real time. Collected performance metrics include:

- Optical layer 1: ROADM link input/output power and transponder pre-FEC corrected errors
- Network layer 2&3: Per-port L2 switch data rates
- Transport layer 4: TCP parameters of active traffic flows (congestion and receive window, re-transmissions, round trip time)

Collected metrics are stored in a common data lake for both real-time and post processing to assist in achieving efficient QoS monitoring of cloud applications.

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