

INTEROPERABILITY TEST REPORT

The Infinera Intelligent Transport Network Portfolio over Lumentum's White Box Optical Line System

Infinera, a provider of Intelligent Transport Networks, and Lumentum Holdings Inc. (Lumentum), a provider of innovative photonic products for cloud and networking applications, have successfully validated Infinera's portfolio of dense wavelength-division multiplexing (DWDM) platforms over Lumentum's white box optical line system. This report summarizes the results from this interoperability testing, which included Infinera's XTM Series, Cloud Xpress Family and DTN-X Family (including the XTC Series and XT Series) platforms and Lumentum's white box open line system including the 20-port TrueFlex® Transport ROADM (reconfigurable optical add-drop multiplexer).

Introduction

As bandwidth demands continue to grow exponentially, network operators have expressed their need to accelerate innovation cycles across targeted components of their transport network infrastructure. The transport functions of wavelength-division multiplexing (WDM) transponders continue to be highly specialized, requiring large-scale photonic integration to generate, steer and manage photons. Infinera is a leading provider of Intelligent Transport Networks, with award-winning photonic integrated circuit (PIC)-based super-channel platforms designed for scalability, flexibility and programmability across long-haul, metro and data center interconnect (DCI) applications. Infinera manufactures and markets a highly capable line system consisting of ROADMs, amplifiers and other key components for getting wavelengths from its PIC-based platforms onto the fiber and transmitted over a distance. However, as an alternative, a WDM line system can be constructed using standard optics and amplifiers controllable with standardized, open interfaces that give service providers the choice of which line system they deploy. Lumentum is one such company that provides a white box open line system (OLS) solution. In partnership with Lumentum, Infinera successfully validated its Intelligent Transport Network portfolio over Lumentum's white box optical line system in an industry-first interoperability test.

Network Applications

This joint solution supports an ecosystem that enables open networks for DCI and metro/edge WDM transport. The combined power of Infinera's PIC-based platforms, including the Infinite Capacity Engine (Infinera's next-generation PIC-based opto-electronic subsystem), and Lumentum's white box line system offers network operators a scalable, programmable, and automated solution for provisioning bandwidth using open standardized interfaces. Infinera's own line system (FlexILS and the XTM Series photonic layer) continue to provide scalable, feature-rich solutions enhanced for Infinera's PIC-based super-channel transport platforms across the long-haul, metro and DCI markets.

Open Network Initiatives

Infinera and Lumentum are collaborating on open packet optical transport in the [Telecom Infra Project \(TIP\)](#), which is an industry initiative co-founded by Facebook. TIP consists of multiple operators, infrastructure providers, system integrators, and others collaborating to develop new technologies and approaches to deploy telecom network infrastructure. As collaborators across various open initiatives, Infinera and Lumentum are driving the open initiative through the industry-first validation of Lumentum's white box open line system with Infinera's Intelligent Transport Network architecture.

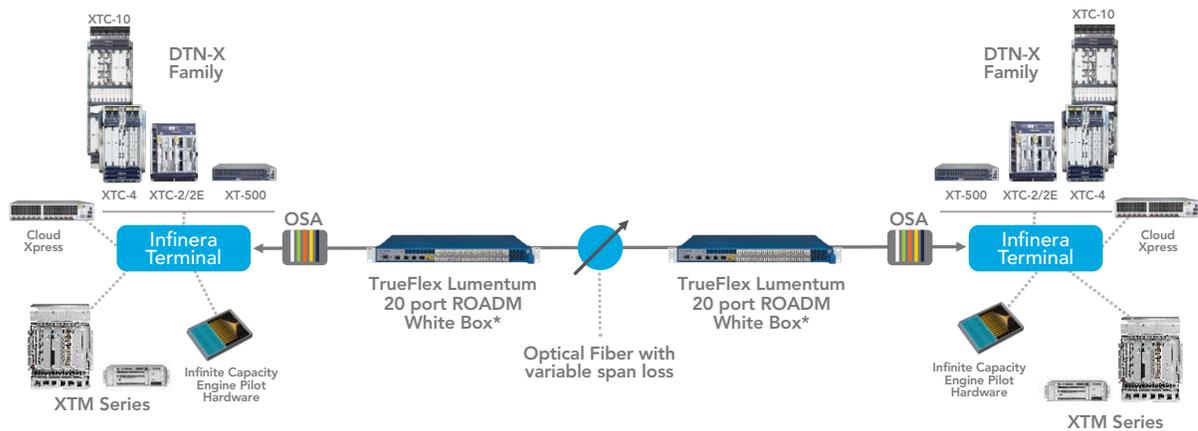


Figure 1a: Infinera and Lumentum Interoperability Setup

*Photo courtesy of Lumentum Operations LLC.

Interoperability Test Setup

Figure 1a and 1b show the setup for this interoperability test. The setup consisted of two Infinera terminal nodes connected point-to-point using a 100 kilometer (km) fiber span with added electronic variable optical attenuator (EVOA) and Lumentum white box open line system consisting of two TrueFlex Lumentum 20-port Transport ROADM white boxes. The EVOA was used to generate maximum end-to-end span loss for the link. Optical spectrum analyzers (OSAs) were placed at the ends of the setup to measure and record the optical spectrum at the start of the link and at the end of the link after it had passed through the white box ROADMs. The Infinera terminal node equipment included XTM Series, Cloud Xpress Family and DTN-X Family (including XTC Series and XT Series).

In addition to these Infinera platforms, which are generally available today, the interoperability testing also included Infinera’s next-generation Infinite Capacity Engine hardware. The Lumentum ROADM white box is 1 rack unit (RU) and features twin 1x20 TrueFlex wavelength selective



Figure 1b: Infinera and Lumentum Interoperability Setup

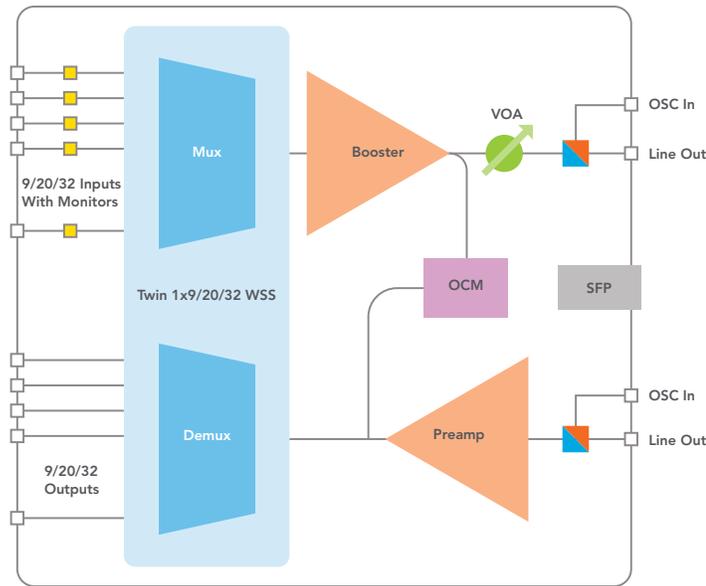


Figure 2: Lumentum White Box ROADM Schematic

switches (WSS), high power variable gain pre-amp and booster erbium-doped fiber amplifiers (EDFAs), optical channel monitoring (OCM), optical supervisory channel (OSC) termination with additional support for third-party OSC and power monitoring on ports. A schematic of Lumentum’s white box ROADM is shown in Figure 2.

Observations and Results

The interoperability test cases covered PIC-based super-channel transmission using multiple modulation formats including QPSK (quadrature phase-shift keying), 8QAM (quadrature amplitude modulation) and 16QAM over the Lumentum open line system. The test cases validated standard optical parameters including optical signal-to-noise ratio (OSNR), end-to-end connectivity, reach and successful error-free data transmission for seamless performance over metro distances.

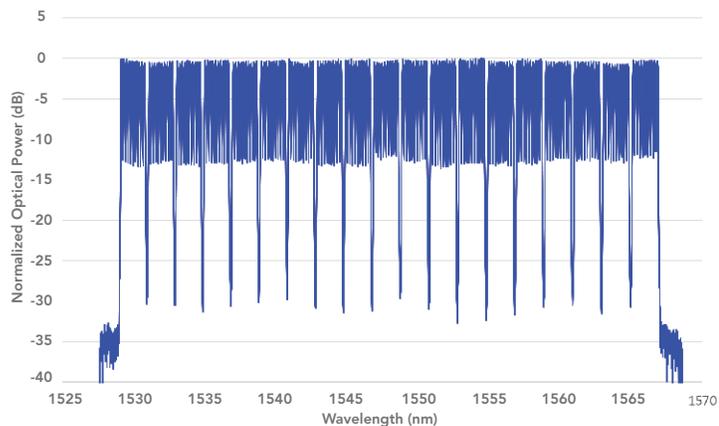


Figure 3: Optical Spectrum of 19 Super-channels Transmitted Through Open Line System

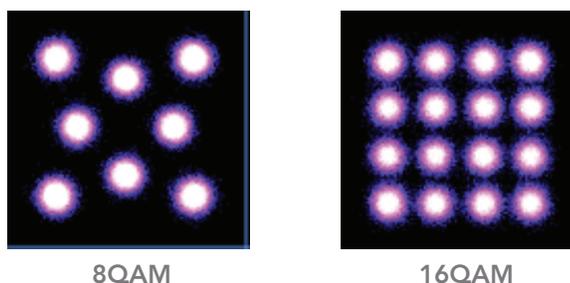


Figure 4: 8QAM and 16QAM Constellations

The test showcased the ability to load maximum fiber capacity with a single 20-port ROADM without the need for additional multiplexing layers due to the integrated muxing within the photonic integrated circuit. The integrated multiplexing allows for an economical solution and is applicable across all modulation formats including QPSK, 8QAM, and 16QAM. Figure 3 shows the optical spectrum for full capacity loading via 19 super channels. The 8QAM- and 16QAM-modulated super-channels were generated using Infinera’s Infinite Capacity Engine hardware and successfully transmitted across Lumentum’s white box open line system. Figure 4 shows the observed constellation of an 8QAM and 16QAM transmitted signal across the setup.

Figure 5 shows the optical spectrum of loading a mixed configuration including the Infinera Cloud Xpress, the XTM Series and the DTN-X Family over the Lumentum white box open line system. Waves 1, 2 and 4 through 11 are generated using the Cloud Xpress. Wave 3 is generated from the XTM Series and the remaining are generated from the DTN-X.

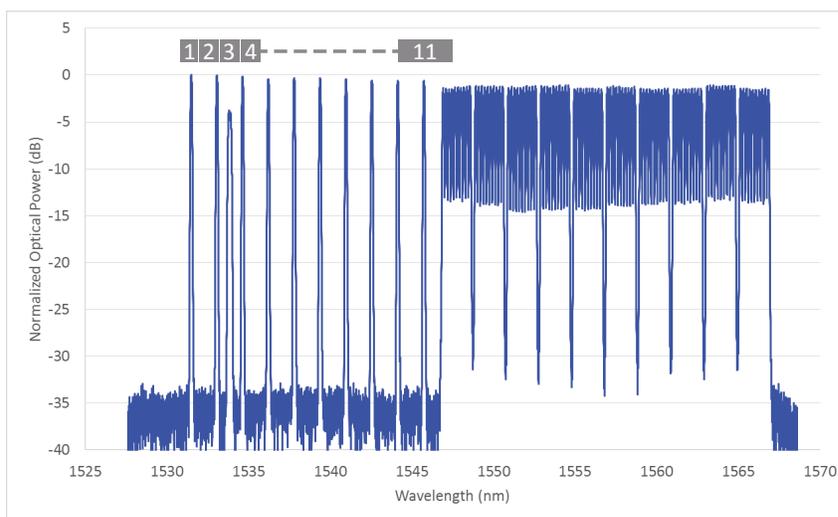


Figure 5: Combined Optical Spectrum for Cloud Xpress Family, XTM Series and DTN-X Family Across White Box Open Line System

A fully loaded joint solution achieves up to 24 terabits per second (Tb/s) of fiber capacity using the Infinite Capacity Engine at 16QAM with a metro reach of 30 decibels (dB) on a single span.

Summary

The interoperability testing successfully validated Infinera's portfolio of DWDM platforms comprising Infinera's XTM Series, Cloud Xpress Family and DTN-X Family (including XTC Series and XT Series) platforms over Lumentum's white box optical line system. The test cases successfully validated point-to-point metro fiber links carrying multiple modulations including QPSK, 8QAM and 16QAM with PIC-based super-channels over the Lumentum open line system. This successful interoperability validates Infinera's open Intelligent Transport architecture and reaffirms Infinera's commitment to its customers in delivering the innovative and open optical solutions that they need.



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