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Reliable Open ROADM Transport Network with Multi-layer Performance Monitoring Capabilities Demonstrated at OFC'23 March 07-09

A group of Open ROADM Multi-Source Agreement (MSA) members will demonstrate optical network equipment elements from multiple suppliers that seamlessly interoperate at data rates up to 400G. Participants include AT&T, Ciena, Cisco-Acacia, Fujitsu, Infinera, Juniper, Lumentum, NEC, Nokia, NTT, Orange, and Ribbon in collaboration with the researchers at the OpNeAR laboratory of the University of Texas at Dallas and Politecnico di Milano.

The Open ROADM MSA defines interoperability specifications for disaggregated optical transport networks. These specifications, which also include YANG data models, address Reconfigurable Optical Add/Drop Multiplexers (ROADM), transponders, and pluggable optics. Multi-vendor Open ROADM compliant equipment can be integrated into the same network solution and controlled by the open source Transport PCE (TPCE) controller.

The collaborative effort at OFC'23 will showcase functionalities and multi-vendor interoperability features in an optical network testbed that makes use of interconnected Open ROADM compliant equipment including ROADM nodes, 100G flexponders, Optical Transport Network (OTN) switches, 100G transponders, 400G transponders, 200G/300G/400G muxponders, a 400G single-node 3R regenerator, and CFP2-DCO and QSFP-DD 400G pluggable devices.

Demonstrated functionalities will include interoperability of CFP2-DCO 400G devices from three Original Equipment Manufacturers (OEMs), an Open ROADM compliant 400G single-node 3R regenerator, an automated path restoration mechanism at the physical layer implemented in the open source TPCE controller, interoperability between CFP2-DCO and QSFP-DD 400G pluggable devices, an IPoverWDM architecture with routers hosting QSFP-DD 400G coherent pluggables supporting oFEC, and various multi-layer network monitoring techniques for both optical and data packet transport layers. These demonstrations will be carried out over a single testbed composed of multiple network elements provided by the participating OEMs.

For the first time the equipment in the Open ROADM booth (#6341) will be connected via fiber optics, provided by OFCnet, to the equipment showcased in the Innovative Optical and Wireless Network (IOWN) Global Forum networking hub (#6440). Hosted in the IOWN networking hub, *open optical transponders* that comply with global standards and offer validated

interoperability will be 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. Demonstrated features will include hardware and software disaggregation with open Application Programming Interfaces (API) interfaces, Open ROADM MSA compliant CFP2-DCO 400G modules, signal tunneling through reserved wavelengths between two Open ROADM nodes that are MSA compliant, and containerized applications using Kubernetes. These features are the result of collaborative activities between the Open ROADM MSA and IOWN Global Forum for standardization (www.iowngf.org).

For the first time at OFC, we will also 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 will be 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 Release 11.0 covers through an extension of both the device and service models to handle such use cases.

Two recently added functions to improve signal reliability in Open ROADM transport networks will also be demonstrated in the OFC'23 testbed. First, an Open ROADM-compliant 3R regenerator with a bidirectional single-node (all optical) design will be applied to a 400G signal routed through four ROADM sites in the testbed. In this single-node design, only network interfaces must be specified (e.g., OTSI, OTSI-group, OTUC4, and ODUC4 for 400G) to achieve reliable high-data rate connections over multi-hop and/or long-distance physical routes.

Second, the automated path restoration mechanism newly implemented in the open source Transport PCE (TPCE) controller will be applied to overcome unexpected quality degradations of a 400G service in the Open ROADM testbed. For any created wave service that is labeled as "restorable," the open source TPCE controller triggers a restoration mechanism at the physical layer as soon as its signal is subjected to a severe power degradation (e.g., a fiber cut). Upon receiving a change notification of the ROADM degree optical transmission section (OTS) interface operational state, TPCE computes a new candidate path to circumvent the problematic degree and reroutes the wave service over that path.

This demonstration will prove that the same (TPCE) code can be used to implement complex functions over a heterogeneous network consisting of equipment from different vendors as long as these optical devices offer Open ROADM compliant interfaces. This feature greatly simplifies network operation and accelerates application developments.

The implemented optical data plane specifications are available on the Open ROADM download page, www.openroadm.org, along with the YANG data models that define the control plane

interoperability APIs. Combined, these features enable easy plug-and-play of different supplier's hardware.

To make this work possible, the Open ROADM MSA forum and TIP brought together experts from different operators and suppliers to collaborate on a common goal. The multi-vendor environment creates an opportunity to work with the best minds in the optical transport network industry to define specifications and build innovative solutions and products that can interoperate and provide choices to network operators.

“AT&T is actively deploying Open ROADM MSA compliant optical network equipment and plans to have more than 10 metro markets supporting 100G and 400G traffic by year end,” says John Gibbons, AVP, Packet Core and Optical Transport, AT&T. “For operators, the interoperability enabled by Open ROADM can encourage lower costs, accelerate technology introduction, help reduce life-cycle costs, and allow networks to remain viable longer. The Open ROADM MSA continues to lead the industry in introducing new interoperable capabilities, as demonstrated by the Open ROADM demo at OFC 2023.”

“As a founding member of the Open ROADM MSA, we are proud to continue our leadership in evolving the specifications and breaking new ground with the inclusion of performance optics, and creation of an interoperable coherent 800Gb/s specification including the industry’s first interoperable PCS modulation”, says Nick Benvenuti, Ciena’s Vice President of Product Line Management. “Continuing to push the envelope, we are also innovating on form factor with the development of Open ROADM-compliant router-optimized QSFP-DD pluggables to expand deployment options over ROADM line systems.”

“As a member of Open ROADM, Cisco believes simplification and open networking are essential to deploying massively scalable and programmable networks,” says Lorenzo Ghioni, Cisco’s Senior Director for Product Line Management. “Cisco has been leading in the scalability of high-performance solutions and new architectural solutions to deliver new services in this rapidly changing market.”

“Multivendor interoperability is critical for service providers to realize the high degree of innovation and flexibility enabled by open networks,” said Francois Moore, Optical Strategist for the Photonics Business at Fujitsu. “As a founding member of the Open ROADM MSA, Fujitsu is proud to support the industry coordination and collaboration that will make these benefits possible.”

“Open ROADM collaboration continues to push open optical networking forward as demonstrated at OFC’23,” said Julia Larikova, VP, Product Line Management at Infinera. “The progress being made in interoperability and operational consistency with groups like Open ROADM MSA and TIP is accelerating the adoption of open optical networking by service providers. Infinera is proud to be a leader and collaborator in the open networking environment enabling operators to better leverage best in class technologies and increase supply chain diversity.”

“As a member of Open ROADM, Lumentum is committed to providing fully interoperable and flexible network infrastructure as we move towards 400G, 800G, and beyond,” said Marc Stiller, Vice President of Product Line Management, Coherent Modules at Lumentum. “We are proud to contribute to the Open ROADM MSA and lead the ongoing evolution of high-performance optical components and modules needed to support network growth and evolution.”

“As a member of Open ROADM, the creation and expansion of open optical networks are essential to enabling next-generation optical transport network,” says Sou Satou, Senior Director, Network Solutions Business Division, NEC Corporation. “NEC is pleased to deliver optical transport products to the Open ROADM community. The demonstration at OFC’23 will validate NEC products capabilities and the value of the open and disaggregated network.”

“Nokia is pleased to be delivering to the Open ROADM community upgrades to our P-OTN solutions, including increased switching capacity, fifth-generation coherent WDM uplinks, and 400GE service interfaces, providing Open ROADM operators the ability to offer a wide range of services from 1G to 400G while scaling their networks,” says James Watt, Vice President, Nokia Network Infrastructure - Optical Networking Division. “This demo with 100G uplinks validates Nokia’s OTN switching capabilities for providing the services and solutions needed by operators to maximize the value of the open and disaggregated network.”

“NTT believes that an open and disaggregated approach is essential for achieving a more flexible, cost-effective, and seamlessly upgradable communication infrastructure. This demonstration of an open and disaggregated optical network proves its usability and potential, and we are committed to continuing our efforts to advance the development of open optical networks as members of the Open ROADM MSA,” says Takashi Saida, Director of Transport Innovation Laboratory at NTT. “We are proud to continue our activities to accelerate the open optical network development, which aligns with the vision of the IOWN Global Forum,” he added.

“Service providers should be able to tailor their optical networks to meet their unique needs, using best-of-breed disaggregated building blocks,” says Rafi Leiman, Vice President of Product Management for Ribbon. “Being part of the Open ROADM MSA movement aligns with our leadership in offering customers multiple levels of flexibility in implementing exceptional optical transport and line system networks, including using Ribbon’s own 1.2T wavelength transport and shared spectrum line system solutions.”

“In an increasingly dynamic and uncertain context, it is important for operators to master their supply chain and regain control of their network”, says Gilles Bourdon, Vice president of Wireline Networks and Infrastructure at Orange. “Interoperability between optical transport infrastructure equipment and the ability to control devices via open interfaces are key. OpenROADM and Transport PCE are two essential bricks in the implementation of this strategy.”

The UT Dallas Network Operations Platform (NOP), entirely built with open source modules and originally introduced at OFC 2021, will be used to handle Kafka message-based status information from Transport PCE to enhance programmable use of the Open ROADM transport network. Key metrics, such as bandwidth utilization and equipment alarm status, will be visualized using NOP. Additionally, NOP will be used to capture and display real-time PM (performance metrics) from the optical testbed equipment.

“The concept of observability is very popular right now in the information technology world – what cannot be measured cannot be improved – even though the control systems underpinnings of the concept go back at least 60 years” says Nathan Ellsworth, Ph.D. candidate and Research Associate at UT Dallas. “OFC’23 is the third year we have demonstrated continuous improvements in our student-developed open-source Network Operations Platform (NOP). In retrospect, this could have been named the Network Observability Platform. We started with layer 2 metrics via SNMP and then added status update messages from the OpenROADM-compliant Transport PCE optical transport controller. We added collection and display of optical performance metrics, such as input & output power levels and pre-FEC Corrected Errors. Most recently we have also added layer 3 TCP metrics collected via ePBF from inside the operating system kernel of our application servers running on top of our programmable optical transport network layer. Having all four of these layers together in one “data lake” gives us not only great insights into the current behavior of the system, but the potential to predict future performance based on analysis of historical data collected over time. The convergence of cutting-edge technologies, such as 400G clients and optics, SDN network controllers, software containerization, streaming telemetry, time-series databases, machine learning, the vast landscape of open-source software (especially in Python), and eager participation in these demonstrations by our many hardware vendor and network operator collaborators provide a very fertile environment for fruitful research and discoveries by our students and partners.”