For Immediate Release

February 6, 2023

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Reliable *Open ROADM Transport Network* & *Open Optical Transponder* in support of Plug & Play Data Center Demonstrated at Recent SC 2022

At the recent Super Computing (SC) conference and exposition in November, a group of Open ROADM Multi-Source Agreement (MSA) members demonstrated optical network equipment elements from multiple suppliers that seamlessly interoperate at data rates up to 400G. The public Open ROADM MSA standards are defined for both the optical data plane and control plane. Participants included AT&T, Ciena, Cisco, Fujitsu, Infinera, Juniper, NEC, Nokia, NTT, Orange, and Ribbon in collaboration with the researchers at the OpNeAR laboratory at the University of Texas at Dallas (UT Dallas), Keio University, Japan, and Politecnico di Milano, Italy.

Open ROADM MSA has been defining interoperability specifications for disaggregated optical transport networks since 2015. 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. This open software and disaggregated hardware approach enables new architectures, such as the open All-Photonic Network (APN).

The open APN architecture interconnects medium-scale decentralized data centers by creating high-speed and low-latency direct Dense Wavelength Division Multiplexing (DWDM) wave services between communication endpoints (compute servers) and achieving end-to-end communication with deterministic performance. Data center operators can make use of open source operational applications to perform zero-touch provisioning and fault detection using streaming telemetry.

This collaborative effort at SC'22 showcased functionalities and multi-vendor interoperability features in an optical network testbed that makes use of four ROADM nodes and a combination of 100G flexponders, Optical Transport Network (OTN) switches, 100G transponders, 400G transponders, and 200G/300G/400G muxponders including one open muxponder.

For the first time MSA members also showcased new hardware and software functionalities that take the APN concept closer to reality. These functionalities included interoperability of

CFP2-DCO 400G devices from three Original Equipment Manufacturers (OEMs) (Acacia, FOC, and Lumentum), an open 400G muxponder architecture defined by a service provider, 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, and various multi-layer network monitoring techniques for both optical and data packet transport layers. These demonstrations were carried out over a single testbed composed of multiple network elements provided by several OEMs.

The SC'22 demo showcased an *open optical transponder* that complies with global standards and offers validated interoperability. Operators can manage both computing servers and transponders using the same open source software ecosystem, while at the same time leverage Open ROADM transport network functionalities. Demonstrated features included hardware and software disaggregation in compliance with Telecom Infra Project (TIP) Phoenix and MUST (Mandatory Use Case Requirements for SDN Transport) multi-vendor and multi-generation transceivers, Open ROADM MSA compliant CFP2-DCO 400G modules with staircase FEC and oFEC, signal tunneling through wavelengths between two Open ROADM nodes that are MSA compliant, and containerized applications using Kubernetes.

Two new functions to improve signal reliability in Open ROADM transport networks were also demonstrated in the SC'22 testbed. First, an Open ROADM-compliant 3R regenerator with a bidirectional single-node (all optical) design was applied to a 400G signal routed through three 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 was 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). Any critical degradation of the signal power level that is detected 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 to circumvent the problematic degree and reroutes the wave service over that path.

This demo proved that the same (TPCE) code can be used to implement complex functions over a heterogeneous network consisting of equipment from different vendors if 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 Application Programming Interfaces (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.

“Since 2022 AT&T has been ramping our active deployment of Open ROADM MSA compliant optical network equipment in metro areas with nodes capable of supporting 100G and 400G,” says Lynn Nelson, AT&T’s Director of Optical Platform Development. “For AT&T a key value proposition of the interoperability enabled by Open ROADM is flexibility, which encourages competitive costs, accelerate technology introduction, helps reduce life-cycle costs, and allows networks to remain viable longer. The functionalities demonstrated at SC’22 confirm the ability of Open ROADM-compliant equipment to support operators’ networking needs.”

“As a founding member of and key contributor to Open ROADM MSA, Ciena is committed to supporting our customers on their digital journey, enabling open, scalable, and automated networks that can easily evolve to 400G, 800G, and beyond,” says Nick Benvenuti, Ciena’s Senior Director of Product Line Management. “We are proud to continue our leadership in evolving the specifications and breaking new ground with the inclusion of performance optics into the MSA, improving optical performance with the MW (multi-wavelength interface) specifications, and creation of an interoperable coherent 800Gb/s specification.”

“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 SC’22,” 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, 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 SC’22 validated 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.”

“Open and disaggregated networking is becoming a critical feature of transport networks to make communication infrastructure sustainable with an ecosystem of healthy technologies. We are very excited to see the progression of interoperable networking functionalities in the SC22 demonstration,” said Koichi Takasugi, Director of Frontier Communication Laboratory. “NTT is committed to accelerating the open networking development by providing operator requirements and reference implementation models,” he added.

“Service providers should be able to tailor their optical networks to meet their unique needs, using best-of-breed disaggregated building blocks, with an ability to separate network functions,” 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 the design, planning and management of their optical networks.”

“Super Computing 2022 gave us the opportunity to demonstrate the ability of Transport PCE controller to restore a high rate 400G service running over a multi-vendor optical infrastructure based on Open ROADM equipment. This shows how initial development performed over an emulated platform can be tested and deployed over real infrastructure in a limited time,” says Gilles Bourdon, Vice president of Wireline Networks and Infrastructure at Orange.

The UT Dallas Network Operations Platform (NOP), entirely built with open source modules and originally introduced at OFC 2021, was 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, were also visualized using NOP. Additionally, as a new feature introduced at SC’22, NOP was used to capture and display real-time PM (performance metrics) from the optical testbed equipment.

“The openness of optical networks is the game-changing innovation of our times,” says Sebastian Troia, Assistant Professor at Politecnico di Milano in Italy, and Fulbright scholar at the University of Texas at Dallas. “This year's Open ROADM demonstration at SC'22 brought for the first time an Open ROADM-compliant all-optical regenerator and an automatic path restoration application. By using regenerators, long-distance and high-speed signal quality are guaranteed, while restoration procedures will be automatically triggered by means of the Transport PCE when any of the links the signal goes through experiences a severe power degradation. Meanwhile, this year's Super Computing showcased the first centralized and remote multi-layer monitoring of open optical networks. Traffic monitoring and analysis is essential to achieving quick troubleshooting and resolving issues when they occur, to not bring network services to a standstill for extended periods of time. Based on entirely open-source software, we showcased how the centralized Network Operations Platform (NOP) monitors the optical network's physical and network layer performance monitoring parameters in real time. Moreover, thanks to the programmability of open optical networks and switches, lightpaths dedicated for monitoring are created so that mirrored layer 2 traffic can be analyzed remotely."

The Reconfigurable In-Network Security sensor (REINS) concept was demonstrated over an underseas connection between SC'22 in the USA and NICT and Keio University in Japan. In REINS, "traffic data in the network is mirrored (in the USA) and forwarded to the network operation and management center (NOC) (in Japan) via 'Reconfigurable Probe', where it is analyzed in real-time to detect changes and anomalies in the network," said Naoaki Yamanaka, Professor of Keio University. In the SC'22 demo the reconfigurable probes were dynamically activated in the testbed while their mirrored data was transmitted over a dedicated wave service routed through the Open ROADM testbed. At the other end of the wave service the Keio privacy control BOX was deployed to remove sensitive data from the mirrored data before forwarding it to the NOC in Japan.