Interoperability of Programmable Data Rates Up to 400G Enabled by Open ROADM MSA

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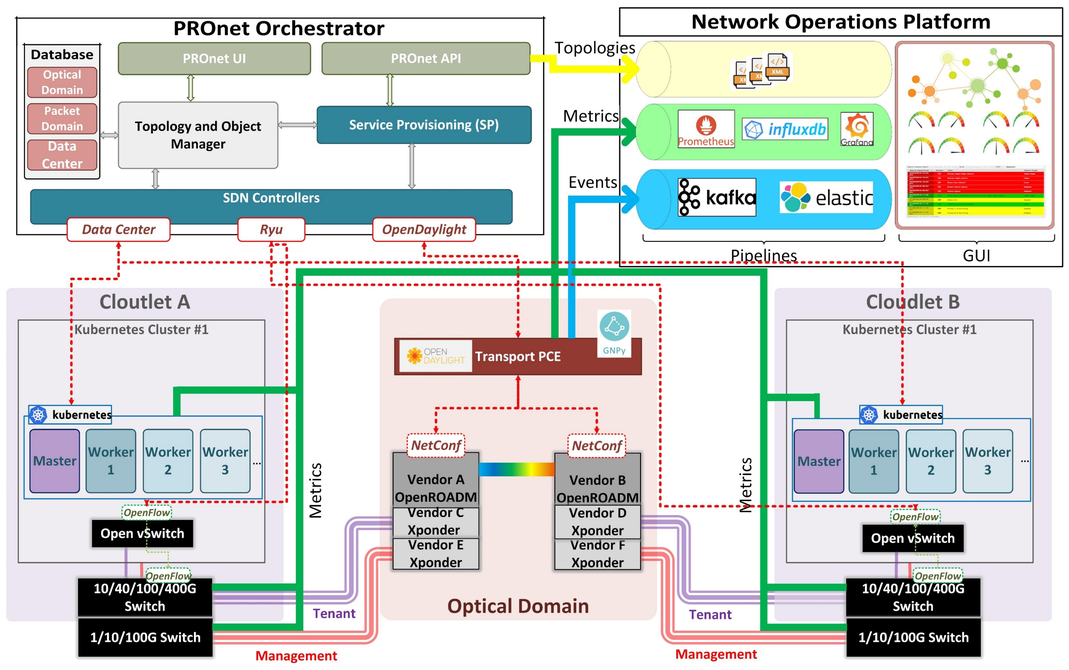
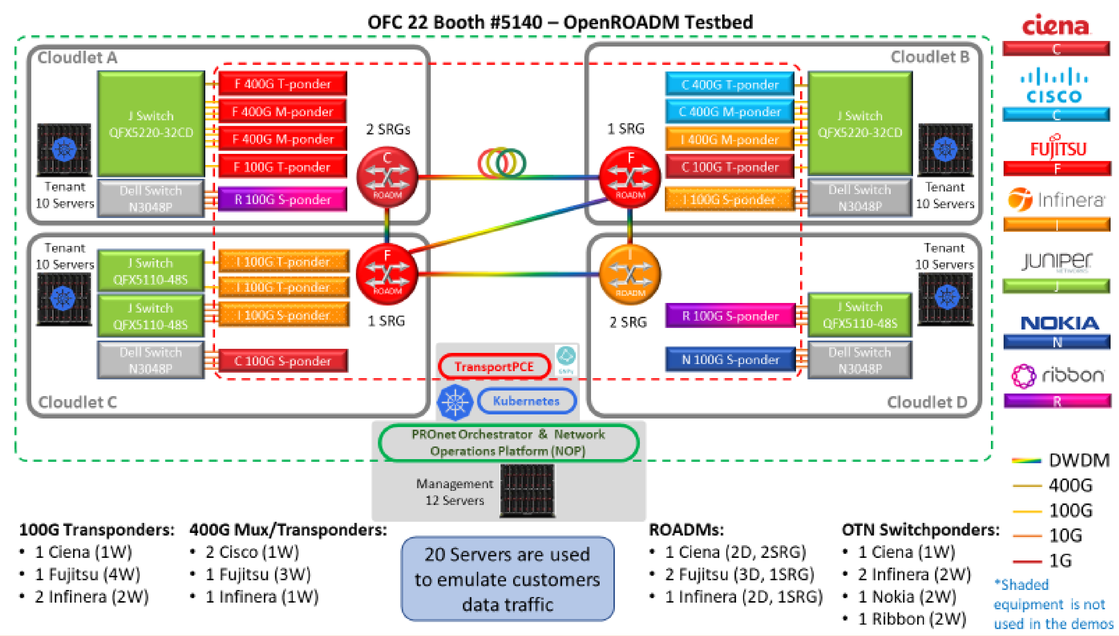
Introduction

Programmable optical fiber transport networks – among other things – are best suited for supporting bandwidth-greedy applications that do not need 24/7 connectivity. This collaborative effort showcases a reconfigurable *federated edge computing infrastructure* that takes advantage of the latest functionalities defined by the open-source Open ROADM MSA. Bare metal Kubernetes is applied for automating deployment, scaling, and management of the containerized software applications over the Open ROADM compliant optical network equipment from six suppliers featuring four ROADM nodes and a combination of 100G flexponders, Optical Transport Network (OTN) switches, 100G transponders, and 400G transponders/muxponders. This Open ROADM demo at OFC 2022 publicly showcases, for the first time, end-to-end 200G, 300G, and 400G wavelength connectivity and interoperability of lower rate services. Last year, we were first to showcase 400G Open ROADM compliant products based on the initial version of the Open ROADM 400G W Specifications and Open ROADM's support for *flexgrid DWDM capabilities*. This year we demonstrate the flexibility and programmability of these products to operate at intermediate data rates (such as 200G and 300G) and modulation schemes (16QAM, 8QAM, DP-QPSK) to provide more robust signal integrity in the presence of adverse transmission conditions.

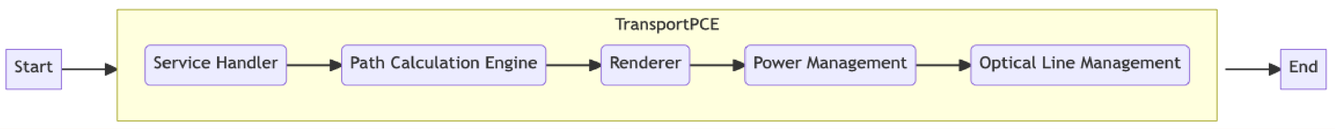




Integration of OpenROADM TransportPCE, Multi-domain PROnet NFV/SDN Orchestrator, and Network Operations Platform (NOP)

All of the optical functions implemented in this demonstration are controllable through an open standards-based API written in the data modeling language YANG. This API is accessed through an SDN controller using NETCONF interface for service provisioning and network monitoring. Four ROADM nodes, four 100G transponders, six 100G switchponders (with client rates of 1Gbps and 10Gbps), and six 400G transponders/muxponders are controlled by the ***OpenROADM TransportPCE*** plugin. TPCE is an open source plugin implemented in the OpenDaylight (ODL) controller which is now empowered by a GNPy module for both optical path validation and path computation. Five Juniper QFX Ethernet switches, a number of Dell switches and one Open vSwitch are used to interconnect a total of 52 repurposed TACC Stampede compute nodes, which are assembled to form four compute sites (or cloudlets). The ***PROnet SDN Orchestrator*** – interfaced with the TransportPCE, OpenFlow ODL controller, and Kubernetes – automatically executes the procedure to create a *SuperCloudlet*, consisting of the compute resources of two cloudlet sites that are directly interconnected by a dedicated wave service. SuperCloudlets can be created on demand to augment the availability of compute resources while offering services in the field, like health monitoring and video streaming. The **Network Operations Platform (NOP)** provides enhanced visibility into the external and internal behavior of open and disaggregated optical networks. Additional insights include real-time monitoring of metrics such as packet data rate across a multi-node OpenROADM optical network as well as status update events as the TPCE controller module provisions wave services (lightpaths) via the Apache Kafka open-source streaming analytics platform.

Main wave Service creation steps in TPCE



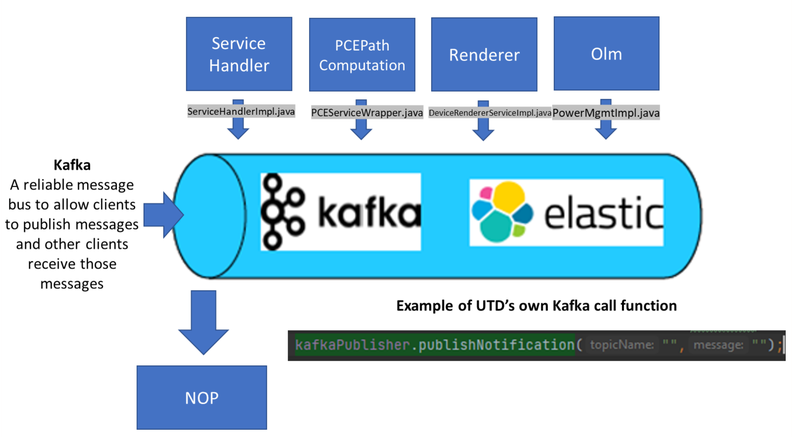
Speeding Up Testing and Validation (T&V) Platform

An automatic procedure has been designed and implemented to check and resolve potential state inconsistencies that may originate in the transport network due to procedural failures. The T&V platform will inspect all empirical checkpoints in devices and network topology to eliminate any redundant/false configurations and correct the state inconsistencies.

For example, the platform will sort through the network, categorize the devices, and delete the unwanted interfaces/configuration from each. By sorting the interfaces by their supporting relationships, T&V works through the hierarchy constraints until the device is clear. More features and checkpoints will be added into the platform as OpenROADM MSA continues to define new functionalities.

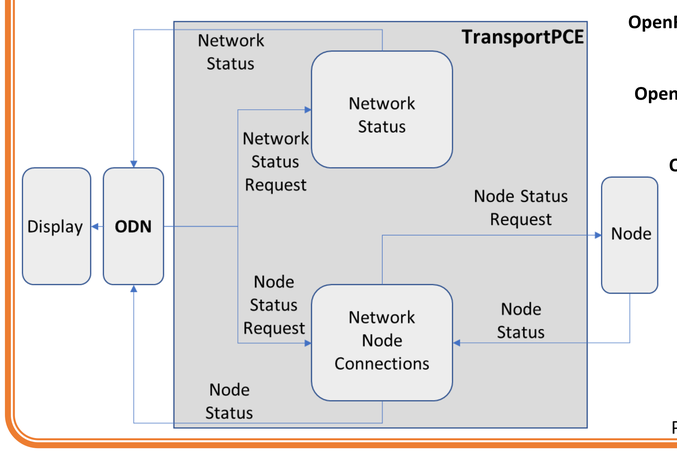
Kafka Streaming Analytics Platform

Mission: To apply instrumentation to the TPCE controller and extract the status of events like the completion of specific steps



Retrieving Optical Device and Network State (ODNS)

Due to the lack of support within TPCE for a single collection point of all alarms and statuses for devices in the network, a software module has been created with the goal of consolidating and presenting information generated by devices in the network. The software module will have the capability of collecting information automatically at set intervals or manually at a user's request. The software can be configured to output the aggregate information and present it to users or forward it to another software.



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