

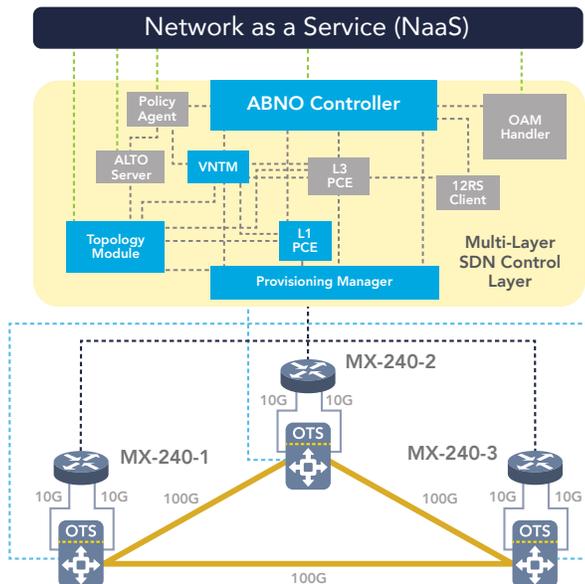
TELEFONICA/INFINERA NETWORK-as-a-SERVICE (NaaS) DEMONSTRATION USING SDN

This exhibit demonstrates how Telefonica rapidly integrated Infinera's programmable Intelligent Transport Network and their IP/MPLS layer together into a multi-layer IETF-based Application Based Network Operations (ABNO) controller, leveraging Infinera's SDN Open Transport Switch (OTS) along with standardized protocols and controller components. The motivation behind this exhibit is to show a proof-of-concept of an ABNO architecture for facilitating Network-as-a-Service (NaaS) in a multi-vendor, multi-layer environment. Conceptually, this capability could be offered to automate the delivery of bandwidth services in real-time based on end-customer requests, eliminating the typical OpEx a carrier would generally incur when employing manual processes and workflows. This dynamic capability can also enable carriers to rapidly develop new innovative service capabilities, free from the constraints of proprietary network operating systems and traditional management systems. Key elements of the demonstration include:

Open SDN framework: this collaboration demonstrates a multi-layer PCE-based controller architecture based on IETF's ABNO proposal and demonstrates its ability to orchestrate and provision bandwidth services in real-time across a multi-vendor IP/MPLS and optical transport network, using a variety of APIs.

Rapid innovation framework: Telefónica leveraged the dynamic on-demand provisioning capabilities of the SDN controller to rapidly develop a prototype user-initiated "one-touch" NaaS service capability, capable of provisioning resources spanning multiple networking layers and dynamically allocating bandwidth resources as needed, without requiring manual configuration or provisioning.

Infinera's Open Transport Switch: OTS provides a lightweight, software abstraction of the optical transport system and virtualizes the underlying optical network resources so bandwidth can be easily programmed via the ABNO controller. The purpose-built design of OTS enables rapid integration and innovation, in contrast to other solutions that repurpose large and heavyweight Element Management Systems (EMS) in their SDN implementations.



Application:

Dynamic MPLS tunnel service creation in multi-layer, multi-vendor environment.

Multi-layer PCE-based controller:

Point and click IP/MPLS services w/automatic router & transport layer provisioned automatically.

Provisioning Manager supports:

- REST/JSON
- OpenFlow
- Netconf/YANG
- PCEP

Topology Module supports:

- REST/JSON
- BGP-LS
- OSPF-TE

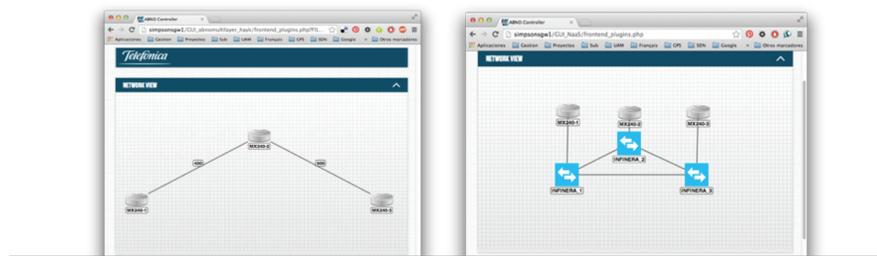
Within the ABNO controller, both an L3 PCE and L1 PCE are employed, along with the usage of standard PCEP protocol for communication between controller building blocks. The control layer solution demonstrates how the ABNO architecture can be used to automate and simplify the operations associated with two use-cases: 1) provisioning of an IP link along with the underlying optical transport capacity, and 2) end-user initiated provisioning of MPLS services. Orchestration and execution of the provisioning requests to the IP/MPLS and optical network layers is demonstrated.

From the ABNO Controller southbound to the physical network, a mixture of provisioning protocols is architecturally employed to demonstrate the ability of the ABNO architecture to manage across various provisioning related APIs, including OpenFlow, REST, NETCONF, and PCEP. Additionally, protocols involved in multi-layer topology discovery and maintenance include REST, BGP-LS, and OSPF-TE are supported, demonstrating the capability for an SDN framework to leverage and integrate information from existing topology discovery protocols that are in use today.

The demonstration consists of three brand-name IP/MPLS routers and three Infinera DTN Packet-Optical Transport Network (P-OTN) platforms, interconnected in a 100G bandwidth-virtualized ring topology. 10G short-reach optical interfaces are used to interconnect the IP/MPLS layer to the optical transport layer. Within this multi-layer network, Infinera’s Open Transport Switch (OTS) is demonstrated, offering a native OpenFlow protocol and a RESTful API for supporting provisioning, configuration management, and topology discovery functions. In one use-case scenario, the optical transport layer’s own GMPLS control plane is configured to allow dynamic path establishment through the optical transport layer, either from the OpenFlow controller or using the RESTful API.

Two views of the network are provided during the demonstration:

- **Administrative view:** network administrators can access a single-pane GUI for provisioning new IP links. This single-touch operation triggers multiple provisioning requests within ABNO to the multi-layer network, based on the Virtual Network Topology Manager’s (VNTM) view of the multi-layer, multi-vendor network.
- **User view:** a separate GUI is presented to end users, where they can view their network topology and dynamically request MPLS bandwidth services from the network.
- Screenshots from the administrator and end-user views are shown below:



Summary

This demonstration shows how an SDN control framework based on IETF’s ABNO proposal could be implemented to support the orchestration and provisioning of services across a multi-vendor, multi-layer IP/MPLS and optical transport network. A working prototype developed by Telefonica using multi-layer PCE for Layers 1 and 3 is shown, demonstrating how SDN technologies and centralized control plane approach can help realize dynamic Network-as-a-Service capabilities on carrier backbones.