SDN Multi-layer Provisioning and Optimization Demonstration

This Carrier SDN demonstration is a collaboration effort between Infinera, Brocade and ESnet to integrate the router/switch layer and Intelligent Transport Network layers into a single, centralized topology view with a common provisioning control plane using the OpenFlow protocol. The demonstration shows how provisioning and optimization of bandwidth services can be automated across the multi-layer network leveraging Infinera DTN-X converged Packet-Optical Transport Network (P-OTN) systems equipped with the Open Transport Switch (OTS) software, OpenFlow capable MLXe Core Routers from Brocade, an open source controller and applications developed using RESTful northbound APIs from ESnet.

On-demand Multi-layer Provisioning: demonstrated single-step single-GUI provisioning of bandwidth services spanning both the router/switch and intelligent transport layers, which can benefit operators by reducing operational complexity, speeding service delivery and saving on operational costs.

Flow Optimization Across a Multi-layer Network: demonstrated how existing packet flows can be re-optimized based on real-time monitoring of flow characteristics and re-provisioned through the network to minimize transit traffic at the packet layer (router bypass), saving on capex and reducing energy consumption.

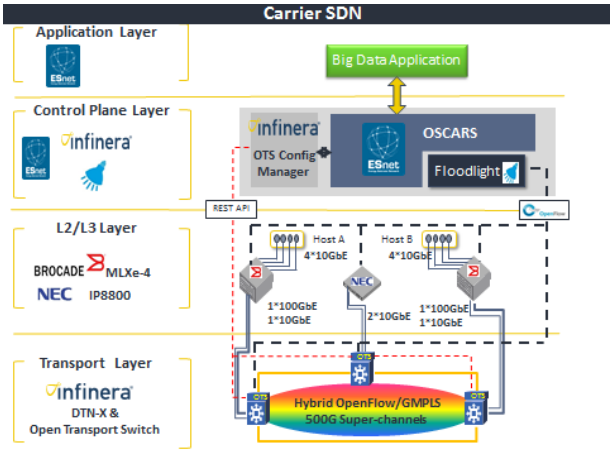

Figure 1 SDN Multi-layer Network Diagram

The demonstration was comprised of three DTN-X platforms, interconnected with long-haul fiber in a physical ring topology, with 500Gb DWDM super-channels deployed on each link. The DTN-X is part of Infinera's Intelligent Transport Network™, which provides DWDM integrated with digital OTN switching and an intelligent GMPLS control plane, enabling rapid provisioning of Ethernet over OTN bandwidth services over massive pools of DWDM capacity to inter-connect the L2/L3 packet systems. A second generation Open Transport Switch prototype was installed on each DTN-X which, in addition to supporting the OpenFlow wire protocol for transport layer data plane provisioning, was enhanced with management and configuration functions, including topology management and discovery, OTS lifecycle administration, and OTS multi-tenancy for enabling L1 Optical VPNs. OTS can be used in explicit mode where the OpenFlow protocol is used to directly program bandwidth services on every DTN-X node, or in implicit mode where

the SDN controller communicates only with a single OTS instance, which in turn leverages GMPLS for path set up. The hybrid implementation of both implicit and explicit provisioning modes within OTS enables flexibility in mixing and matching bandwidth service creation based on the specific needs of the network operator and better supports migration to an SDN framework. Additionally, native support on the DTN-X for multiple instantiations of OTS allows for resource partitioning and virtualization directly on the network element, allowing multiple third party controllers to view and manage their own transport network overlay, independently of other virtual networks.

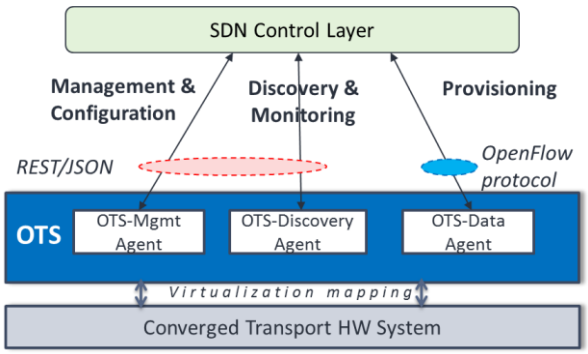

Figure 2 Open Transport Switch

At each DTN-X location, an L2/L3 packet system was connected to the transport layer via 10GbE and 100GbE short-reach optical interfaces. OpenFlow-enabled terabit-scale Brocade MLXe Core Routers, which can handle up to 128K simultaneous flows, were equipped with wire-speed 10GbE and 100GbE interfaces. The MLXe routers, each equipped with 4x10GbE and 1x100GbE, were located at two of the DTN-X locations and the NEC IP8800 was equipped with 2x10GbE at the remaining DTN-X location. The Brocade MLXe router has a fully programmable architecture to support new SDN technologies and evolving standards with over 1.1 million OpenFlow ready router ports deployed worldwide. With the industry's only OpenFlow Hybrid Port Mode, the MLXe enables service providers to seamlessly deploy OpenFlow on their existing network. They can now begin to realize the benefits of SDN for new services without any "forklift" upgrade while continuing to support traditional Layer 2/3 forwarding for legacy services on the same physical infrastructure.

The SDN Control Layer was implemented using Floodlight as the base OpenFlow controller and ESnet's On-Demand Secure Circuits and Advance Reservation System (OSCARS) application, which is a set of networking services applications that support multi-layer topology, path computation, provisioning and optimization capabilities. While this demonstration used Floodlight, it has been designed to integrate with other SDN controllers supporting the OpenFlow protocol, including OpenDaylight, Ryu, etc. OSCARS supports a multi-layer topology database that presents a unified, flattened view of the transport and packet layers.

The collaboration efforts showed how multi-vendor, multi-layer provisioning and optimization can be achieved within an SDN framework, leveraging OpenFlow protocol and RESTful APIs for control of both optical transport as well as router/switch layers. It also demonstrates how GMPLS in transport can be leveraged to achieve higher level abstraction and ease some of the transactional challenges with provisioning in a node-by-node manner across the WAN. Finally, the demonstrations show how network programmability and the concepts of centralized topology and control can help aid in not just simplifying the operations across multiple network layers using a single GUI, but also how resource optimization, especially at the IP router layer, can be achieved to lower capex and reduce energy consumption.