Architecting Cloud-native Optical Network with Whitebox Equipment

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Abstract: A flexible and open mean of implementing an optical network by using whitebox equipment with the Transponder Abstraction Interface is proposed. Examples of automation and monitoring device/performance information using an open transport platform are described.

1. Introduction

To handle the rapidly increasing data traffic generated by SNS and video-streaming services, open and new technologies for disaggregating hardware and software have been implemented in hyperscale data centers (DCs). Storage-virtualization technology (the process of grouping the physical storage from multiple network storage devices to improve the capacity and fault tolerance) and server-virtualization technology (the process of using software to create multiple partitions or virtual instances on single servers) has become widespread. In 2015, efforts to make packet transport networks "open" were accelerated, and the "Switch Abstraction Interface," a common interface for switch ASICs, was officially adopted by the Open Compute Project (OCP), which enabled disaggregation of hardware and software in the packet transport. Technologies that disaggregate hardware and software not only improves flexibility through redundancy but also prevents "vendor lock-in" and lowers the barrier to entry of new entrants, enabling hardware and software to evolve and be improved individually. Moreover, the evolution of open-source software (OSS), Linux-based architecture accelerates automation of operations within datacenters (such as zero-touch provisioning and streaming telemetry).

As various cloud services appear, "interconnect services"—which connect data centers and other connection points of cloud services on demand—have also appeared, and the flexibility of optical transport networks is expected to improve. When the virtualization technology developed for data centers spreads to optical transport network field, it will be possible to combine storage, computing, and networking resources in remote locations flexibly on demand. Two examples of applications of such virtualization technology are (i) high-speed hard-disk backup via a wide area network to avoid damage from natural disasters such as large-scale power outages and floods, and (ii) transmission of multi-channel uncompressed ultra-high-definition images captured at a sporting event via a network to a broadcast station, where they are then edited and compressed. Such applications make it possible to optimally allocate ICT resources and reduce capital expenditure.

In this paper, we review recent developments on the whitebox approach for optical transport network where virtualization technology including the contributions from NTT on coherent transponders and related open source software interface.

2. Challenges to overcome

Optical transport technology has reached a major turning point owing to the advent of "digital coherent technology" around 2010. Transport devices have rapidly improved in terms of throughput, dimension and power saving with coherent digital signal processing (DSP). The technology that compensates waveform degradation caused by physical phenomena such as chromatic dispersion and polarization fluctuation with digital circuits has been a prime factor in improving performance. From an operational perspective, coherent DSP has the potential to dramatically improve flexibility of network designing; complicated analog parts like dispersion compensation fibers are replaced with the dispersion compensation function of DSP, and the latest generation of DSPs enables per-lambda 200Gbps Long Haul transport by QPSK, 400Gbps Metro by 16QAM, or 600Gbps ZR by 64QAM with single LSI.

Remaining issues regarding utilizing virtualization technology in the optical transport domain are creating a new architecture for disaggregating hardware and software, and the process of digitizing analog characteristics of optical components.

(1) Standardization of interfaces that remove complexity of hardware among vendors

(2) Implementation of Linux-based platform that can accelerate the use of OSS

(3) Adaptation of APIs and tools for designing and optimizing optical-transmission paths

(4) Enabling monitor of parameters and performance of equipment without external measure

(5) Establishment of "network resource discovery" and an automatic-optimization method for a multi-vendor environment

3. Status of achievements

3.1 Whitebox packet transponder

Conventionally, the management-control interfaces of transponder included many elements that were different and often proprietary among vendors which have been a barrier to the disaggregation of hardware and software. In December 2017, a "transponder abstraction interface (TAI)", the first interface specification and architecture that disaggregate the hardware and software of transponders was proposed by NTT, to the Open Optical & Packet Transport project group of the Telecom Infra Project (TIP-OOPT). The TAI and the software libraries of different vendors allow multi-vendor optical network elements to be managed and controlled using common software codes [1]. Disaggregating hardware from software can offer incorporation of the latest technologies evolving rapidly in an independent cycle. Since February 2018, network operating system (NOS) vendors, original design manufacturing (ODM) vendors, optical vendors and other partners participate in the creation of TAI libraries. NOS vendors have incorporated these libraries into their commercial software products.

The pictures in figure 1 show the whitebox packet transponders "Cassini" and "Galileo" (their designs were contributed to TIP-OOPT) that integrate x86 processor, switch ASIC and coherent optics on modular-type open hardware. Their software architecture is same as an OCP-compliant whitebox switch which is easy to adapt to operational tools such as Open BMC and ONIE that allows operators to automate operations without being tied to specific vendors. In addition, the TAI and vendor libraries enable multi-vendor compatibility of coherent modules CFP2-ACO/DCO. An "open" transponder applicable to virtualization technology has been created by whitebox approach.

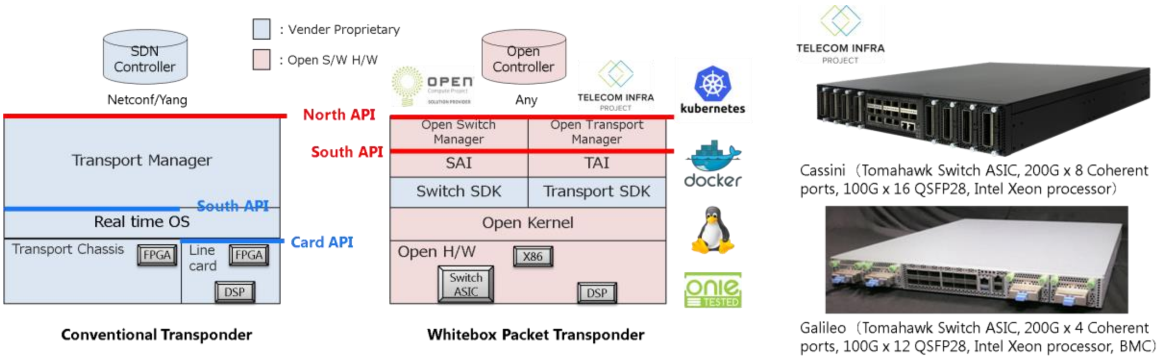

Fig. 1. Conventional transponder (left) and Whitebox packet transponder (right)

3.2 New initiatives for design and optimization of optical transmission path

Aiming to create practical and multi-vendor compatible line systems, some organizations such as TIP-OOPT and Open ROADM MSA are working on defining open API [2]. TIP-OOPT also promotes the development of "GNPy" which is an open-source, community-developed library for building route planning and optimization tools [3]. Its goal is to build an end-to-end simulation environment which defines the network models of the optical device transfer functions and their parameters.

An "open transport" concept with TAI is shown in the left diagram of Figure 2. If an open API such as TAI can be defined for the coherent DSP and optical module in the transmission equipment, operators can use information about transmission-path performance parameters such as SNR, chromatic dispersion, polarization-mode dispersion, and received optical power for automatically designing and optimizing optical transmission paths. An example of a whitebox packet transponder and GNPy on an SDN controller for automate provisioning is shown in the right diagram of Figure 2. When the whitebox packet transponder starts operating the CFP module and coherent DSP send information about the capability of components (DWDM frequency range, maximum optical output power, modulation format, FEC type, and maximum chromatic-dispersion tolerance) to the transport manager and SDN controller, and the SDN controller keeps track of resources on the network. At the same time, the transport manager connects to the opposite equipment via default 100G QPSK mode with staircase FEC, and then measures the performance (received optical power, received SNR, etc.), and sends the measurement result to the SDN controller. The SDN controller compares the performance values measured by the transport manager with the margin of the optical transmission path designed by using GNPy, selects the optimal communication mode, and sends the operational configuration to the transport manager. In the example in the figure, there is a surplus OSNR margin in the optical-transmission path, so 200G 16QAM (with larger bandwidth than 100G QPSK) is selected as the configuration during operation.

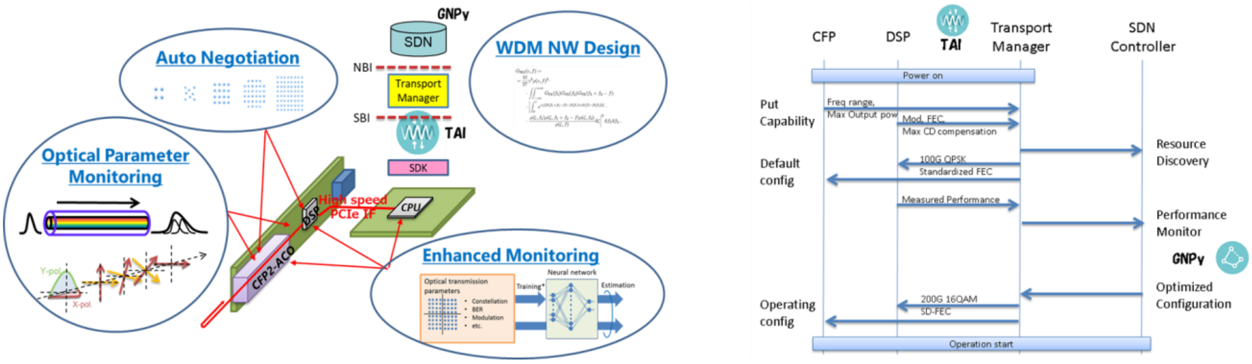

Fig. 2. “Open Transport” Concept (left) and Auto Provisioning (right)

4. Future challenges

To make auto provisioning available in multi-vendor environment, it is necessary to define some new APIs on the TAI and to standardize the automation procedure. The latest optical fiber monitoring technology with coherent DSP such as visualizing longitudinal signal power profile [4] will be a key enabler of automated network designing over multiple spans. Enhanced monitoring and analysis are made possible by implementing the latest machine-learning applications by using x86 processor and Linux-based architecture of whitebox. It has already been reported that constellation analysis using sparse coding is effective for root cause diagnosis [5].

5. Conclusion

To utilize virtualization technology in the optical transport domain, creating a new architecture for disaggregating hardware and software, and the process of digitizing analog characteristics of optical components is essential. The TAI and vendor libraries enabled incorporation of the latest technologies rapidly in an independent cycle, multi-vendor compatibility of coherent modules and adaptability of automatic operation tools without being tied to specific vendors.

6. References

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