What SDN will Bring for Transport Networks?

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1. Introduction

Transport Networks (TNs) provide sufficient bandwidth and survivability to carry client signals between packet switching entities or other Internet elements, such as IP core switches and cellular gateways. The transparent nature of TNs leads to the incapability of providing service-oriented applications, and the OPEX is becoming larger due to the mixture effects of diverse physical layer features compared with data networks (DN). Traditional control plane solutions such as GMPLS were proposed to automate connection provisioning in TNs. Unfortunately, their unpopularity is caused by the complicated protocols and the increasing routing complexity. Compared with deploying such a control plane to achieve more powerful functions, so many carriers would rather manually configure transport devices and networks.

Software Defined Networking (SDN) with virtues of vertical architecture and centralized abstraction brings new probability to design a successful TN control plane framework, and further makes great impact on the transport networking architecture. Plenty of work has been done in applying SDN to TN domains (SDTN) [1,2]. Our previous work also shows potential of SDTN for Transport as a Service (TaaS) such as integrated virtualized TN resources provisioning [3-6]. In this paper, we devote our effort to describe the changes in design concept of TN with SDN framework, and further explain our particular point of view on this hot topic. We hope our work would stimulate new thinking and make sense for the prosperity of SDN technique.

2. Software Defined Transport Network

With the centralized framework of SDTN, carriers can operate TNs via abstracted C&M interfaces rather than struggling against the physical transport parameters, such as chromatic dispersion or optical power. Regulating algorithms can be run in TN controller and these parameters are automatically configured to be optimal. Besides, the open philosophy of SDN will drive the collaboration of data networks, transport networks and data centers. TN controllers can share necessary information, such as the transmission delay of candidate routes, with DN controllers to help optimize QoS. Furthermore, SDTN turns TN’s essence of connection provisioning into network service provisioning by achieving more types of functions. For instance, with specific virtualization controller, TN is capable of providing not only bandwidth connections but also sub-networks to virtual network operators (VNO), which is hard to be achieved under traditional control plane solutions.

Although these attractive features of SDTN stimulate vendors and carriers to pay much attention to the SDN technique, TN devices are originally designed to be manually configured and physical constraints keep them being modeled logically. Transport devices and networks need to be deeply improved to fit the demands of SDN.

- **SDTN devices should be sliceable and shareable.** Being sliceable and shareable are the prerequisites of being abstracted and virtualized on the analogy of virtualization in cloud computing. For instance, in elastic optical networks, a multi-flow transponder (MF-T) can be sliced into sub-transponders, and a bandwidth-variable wavelength cross-connection (BV-WXC) enables the optical spectrum being sliced into sub-wavelengths [7], as in Fig. 1. Thus, the TN controller can construct the resources pool rather than many particular devices.

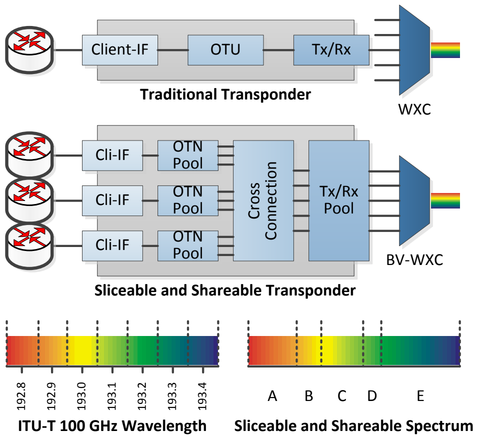

Fig. 1. Comparison of (non-)SDTN devices.

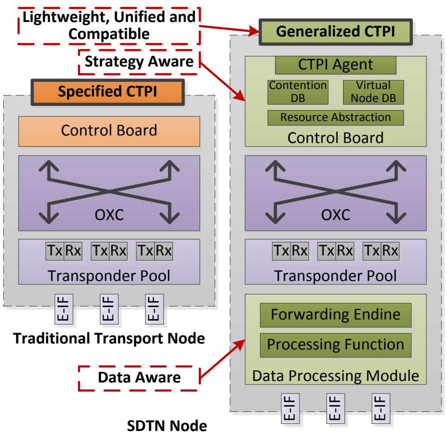

Fig. 2. Comparison of (non-)SDTN nodes.

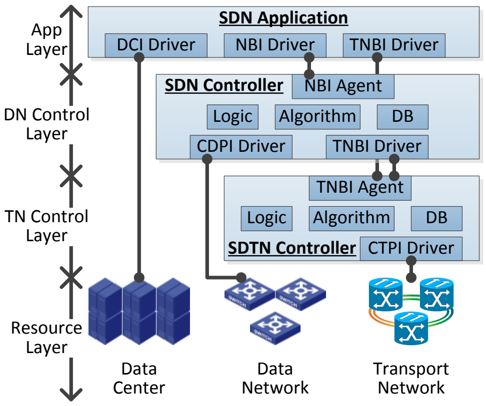

Fig. 3. Integrated SDN Architecture.

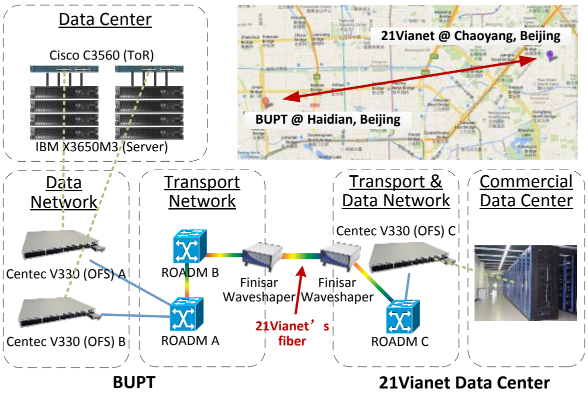

Fig. 4. Experimental Setup.

- **SDTN nodes should be capable of data-aware and strategy-aware.** Today's transport nodes are usually statically configured and cannot distinguish the carrying content, which conflicts with SDN principles. Although data are hard to be processed when they have been mapped into transport frames (e.g. Synchronous Transfer Module in SDH or Optical Data Unit in OTN), data processing modules can be installed between client interfaces and mapping modules to analogically "match and forward" the client data, as in Fig. 2. Besides, the control board (CB) of a TN node should be equipped with more powerful CPU and larger memory to do some hardware-related computing or storage tasks, e.g. contention determination and virtual node construction, in accordance with controller's strategies. These tasks cannot be done in the controller due to the absence of hardware details.
- **The control-transport-plane interface (CTPI) of SDTN should be lightweight, unified and compatible.** Bloated CTPI would repeat the same mistake of GMPLS, and the conciseness is hard to achieve if each type of transport node has its own CTPI. Thus, most of equipment-specified functions should be implemented within the nodes and the control interfaces should keep lightweight and unified. In addition, for the purpose of achieving the integration of data networks and transport networks, CTPI of SDTN should be maximally compatible with the standard SDN interfaces.

3. Integrated SDN Architecture and Experimental Demonstration

Since the collaboration of ICT infrastructure will maximize the value of SDN, an integrated architecture is proposed as in Fig. 3. SDTN is modeled as a resource pool to provide sufficient and precise bandwidth for data networks or directly for network applications. We deploy an inter-regional field demonstration from our campus to a 21Vianet's datacenter to verify the architecture, shown in Fig. 4. Datacenters are emulated with 8 IBM X3650 M3 or M2 servers and 3 Top-of-Rack (ToR) switches. Traffic from ToR is aggregated to 3 Centec V330 Switches, which are commercially compatible with OFP V1.3.0 and act as data networks. Transport networks are equipped with 3 commercial 40-wavelengths ROADMs and 2 Finisar WaveShapers. BUPT's and 21VDC's networks are connected by field-installed fiber within 21Vianet's network. Control Layer and App Layer in Fig. 3 are deployed in IBM servers which are independent from DCs. An OpenFlow-based CTPI is fully implemented, while the shareable and data-aware SDTN devices and nodes are partly emulated by hardware or software due to the immature of related techniques.

Virtual Machines Migration (VMM), as a typical service, was mainly tested and measured. When a VMM application via low-speed connection (CERNet) requires a high-speed one (21Vianet's Network), the platform would automatically configure network devices to switch to the new route, which is at most 3.9 times faster than the old route.

We believe our approach can build a smart, flexible, extensible and powerful transport networks adopting the SDN philosophy, and draw a meaningful blueprint for industries to reconsider the potential of SDTN.

Acknowledgments

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