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Packetponder with open-source management system for future packet-optical networks

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Abstract: This paper further expands on the concept of *packetponder* by showing in vivo, in-situ wavelength tunability of common form factor pluggable transceivers using open disaggregated hardware, open source software and open APIs.

1. Introduction

Ethernet traffic is growing exponentially and future networks infrastructure will have to be optimised to accommodate such traffic with the efficient transport capabilities of the optical layer. Power consumption, as well as simplicity and flexibility will be critical requirements for future packet-optical networks [1].

Traditionally, packet-over-Dense Wavelength Division Multiplexing (DWDM) solutions are implemented using a closed-Application Programming Interfaces (APIs) Layer 2 (L2) switch ASIC, forwarding any client-side to any client-side, as well as an openly specified, disaggregated optical transponder that marries a merchant-silicon electronic packet switch and a pair of tunable coherent optical modules (Fig 1(a)) [2]. However, inspection of the open specification reveals a packet switching ASIC with statically defined entries in its forwarding database that map a pair of client-side port cages to a single line-side port cage, which considerably limits flexible provisioning.

We recently introduced the concept of *packetponder* [3], a new and simplified packet-over-DWDM architecture using tunable wavelength transceivers to optimise the use of available bandwidth and by-pass a transponder, as shown in Fig 1(b). In this paper, we give further details about this concept and experimentally demonstrate in vivo, in-situ wavelength tunability using open control and open management APIs of a commercial, programmable packet switch element.

2. Network Simplification

The proposed *packetponder* architecture enables: ① client-side to line-side - point-to-point function of a transponder; ② client-side to client-side - any-to-any function of Layer 2 switch; ③ line-side to line-side - point-to-point Ethernet cross-connect function with 3R regeneration and wavelength conversion (Fig 1(c)).

With future switches aggregating 51.4Tbit/s and transceivers 0.4-1.2Tbis/s, one can imagine that the proposed architecture utilising programmable switches and high capacity flexible pluggables would provide for full capacity when needed, reconfigure depending on energy grid load constrains and also minimises the need of extensive inventory of fixed wavelength transceivers, enabling regeneration of signals, all of which could potentially have better energy efficiency.

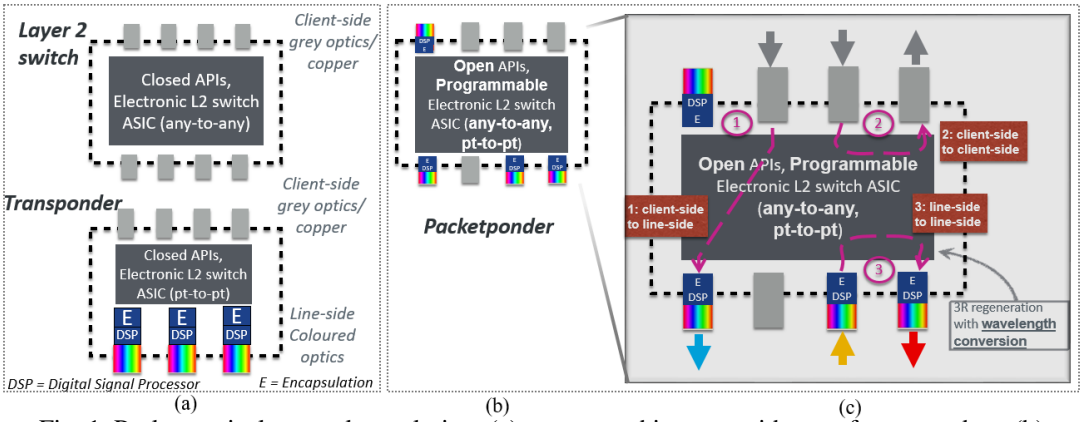

Fig. 1. Packet-optical networks evolution: (a) current architecture with use of transponders; (b) proposed *packetponder* architecture; and (c) *packetponder*'s functionalities

3. Open management system and demonstration

An efficient management and control from L0 to L2/L3 capabilities is one key to successfully impletement packet-over-DWDM [4]. We manage the *packetponder* and the pluggables using open Software and open APIs, and we demonstrate a full stack management plane to enable wavelength conversion and in-vivo, in-situ wavelength tunability of the pluggables. Fig. 2(a) outlines the programmable Software-Defined Networking (SDN) stack used for the experimental validation. ONOS was selected as the control-plane software, with gNMI as the cotrol data streaming prototol and the Yet Another Next Generation (YANG) data modelling language. Stratum was our Network Operating System (NOS) for the programmable switch, on top of Open Network Linux (ONL) and ONL Platform (ONLP). We used the controller to send a gNMI request to Stratum, which pushed the updated SFF-compliant configuration to the tunable module in order to change the frequency (or wavelength). Our choice of ONOS, Stratum and ONL/ONLP enabled full stack programmability of the switch, but alternative open, accessible SDN stack models could also be used (for example, SONiC).

Our proof-of-concept demonstrator used: an APS-Networks (BF6064X-T) switch that contained a P4 [5] Tofino ASIC; a Lumentum OpenROADM (ROADM-20); and commercial Lumentum 10G SFP+ tunable transceivers (gray and tunable) *in lieu* of OpenZR+ pluggable optical transceivers that were not available to us. Fig 2(b) shows the new extended YANG model that we created to enable wavelength reconfiguration, and Fig 2(c) describes the gNMI command used from the controller to change, in-vivo and in-situ, the frequency, here set to 194,300 THz that has been successfully implemented into the transceiver.

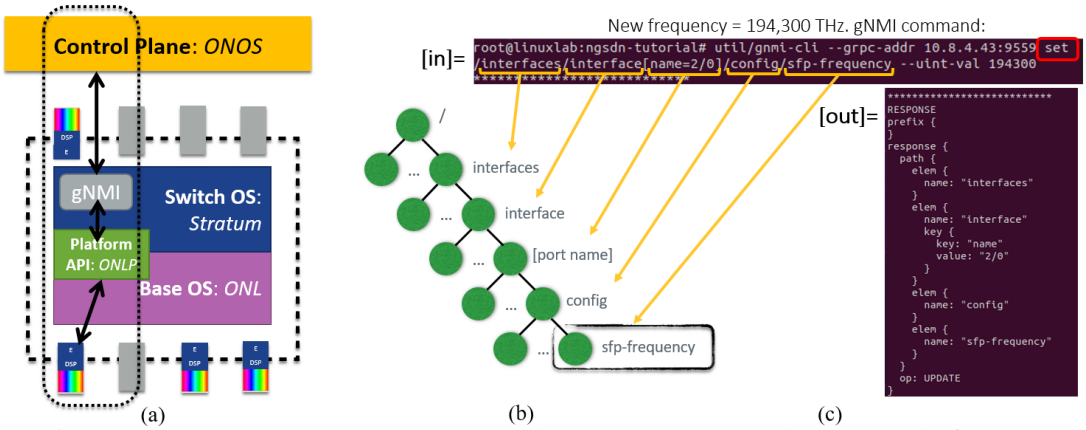

Fig. 2. (a) Open-source management system, (b) New YANG tree node to access the frequency, (c) gNMI command the set the new frequency.

4. Conclusion

We experimentally demonstrate one use-case of the *packetponder* concept that is in-vivo, in-situ wavelength provisioning, using a novel coloured line-side to line-side 3R regeneration with wavelength conversion operational mode to make the most effective use of bandwidth. This experimental proof-of-concept shows a full stack open system management of a commercial switches that combine P4 programmable switching ASICs with tunable, pluggable OpenZR+ transceivers within standard form factor front-plate cages, that obviates the requirement for an interposing transponder between an Ethernet switch and a Reconfigurable Optical Add/Drop Multiplexer (ROADM), thus simplifying optical network architectures. This has novel implications now and in the near future, when the extended reach of coherent 400G-ZR/-ZR+ pluggable optical transceivers is combined with a separate optical ROADM network.

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