Simplification of Edge Network Architecture with Open Packet Switches and Pluggable Transceivers

Julie Raulin*†, Jim Zou‡, Scott Hill§, John Griffiths§, Gawen Davey¶, Alexander Jeffries¶,
Ian Cooper‖**, Paul Gunning‖, Cormac J. Sreenan† and Fatima C. Garcia Gunning*

*Tyndall National Institute, Ireland. †School of Computer Science and Information Technology, University College Cork, Ireland.
‡Adtran Networks SE, Martinsried/Munich, Germany. §Keysight Technologies, Wokingham, Berkshire, UK.
¶APS Networks B.V., Den Haag, The Netherlands. ‖BT Research and Network Strategy (RaNS), Adastral Park, Ipswich, UK.
**now with Broadband Communication Group, Lund University, Lund, Sweden.
Email: julie.raulin@tyndall.ie

***Abstract*—This paper reports and demonstrates a *packetponder* for access/metro node consolidation and aggregation using common-form-factor pluggables (CFFP), which can simplify edge network architectures.**

***Index Terms*—Packetponder, access/metro node, pluggable transceivers**

I. Introduction

Business and residential end-customers consume over-the-top (OTT) services from few in-country hyperscaler datacentres over fixed optical broadband FTTH/FTTB connectivity spanning a 3-tier hierarchy of access, metro and core nodes operated by TELCOs/ISPs. Long-reach, high-speed optical fibre is replacing short-reach local-loop copper allowing closure of access nodes e.g. central offices (CO) / telephone exchanges (TE) [1], [2]. A simpler 2-tier network comprised of edge nodes (that straddle the access/metro domains) and core nodes is now possible as depicted in Figure 1(a)(iii).

Hyperscalers deploy fleets of open, programmable 'pizzabox' network switches outfitted with merchant silicon forwarding ASICs (of bisection bandwidths now approaching 100Tb/s) and CFFPs from many competitive original design manufacturer (ODM) suppliers in their datacentres. Their growth is constrained by the power consumption of servers/switches within datacentres, e.g., in 2022 hyperscalers in Ireland consumed $\tilde{1}8\%$ of the power grid [3] [4]. Hence, repurposing the more power efficient, high bisection-bandwidth networking equipment (originally developed for hyperscalers) by ISPs and TELCOs to simplify their edge network architecture is an attractive solution.

In this invited talk, we will discuss the potential of the packetponder concept for edge network architecture simplification, showing how a novel, flexible blend of open "pizzabox" packet switches, optical switches (e.g. ROADMs) and flexible pluggables, with open source software and open APIs, are one means to this end.

Figure 1(a)(i) is a typical TELCO/ISP network architecture. It is a distributed concatenation of packet switching ASICs within each: OLT (access node); aggregating switch (metro node); transponder (metro node); and ROADM (metro/core nodes). Many *differing* form factor transceivers sit between *external* optical transmission lines and *internal* copper transmission lines within closed, vendor-specific proprietary network element chassis. These original equipment manufacturers (OEMs) vendors discourage hardware interoperability and require complex element management.

The wide availability of: low-margin compact, CFFPs; open, P4-programmable switch ASICs; and low-margin open 'pizzabox' network switches with CFFP "cages" is transformative. We reported the packetponder - shown in Figure 1(a)(ii) with CFFP "cages" with different client-side grey and lineside coherent transceivers; two separate ASICs became a single ASIC that eliminated transmission lines and transceivers [5].

Access node closure coincides with the introduction of extended-reach open CFFP OLTs [6] that fit the *packetponder* CFFP "cages" for a simplified, novel edge network architecture shown in Figure 1(a)(iii) [7]. It further reduces the number of ASICs and transceivers (between transmission lines) traversed by packets. The typical 3-tier access, metro and core network architecture becomes 2-tier of edge and core nodes. Domain-wide management and control for the access-facing edge domain (OLT to ONU) is advancing rapidly: a combination of agents [8]; the creation of an abstraction layer for the automated provisioning and management of open CFFP OLTs [9]; and control mechanisms for improved traffic management [10] was demonstrated. The core-facing edge domain is now addressed by the Metaverse-ready Architectures for Open Transport from the telecom infrastructure project (TIP) [11].

II. Experimental Demonstrator

The packetponder *edge network* proof-of-concept demonstrator can accommodate many products/services shown in Figure 1(b). Open software with defined data models was used for *in-situ* control/management of CMIS/SFF standardised CFFPs through OpenAPIs. Packets transmitted between the P4-programmable switching ASIC and the QSFP28 frontplate port cages traversed copper traces of the FR4 backplane. Each

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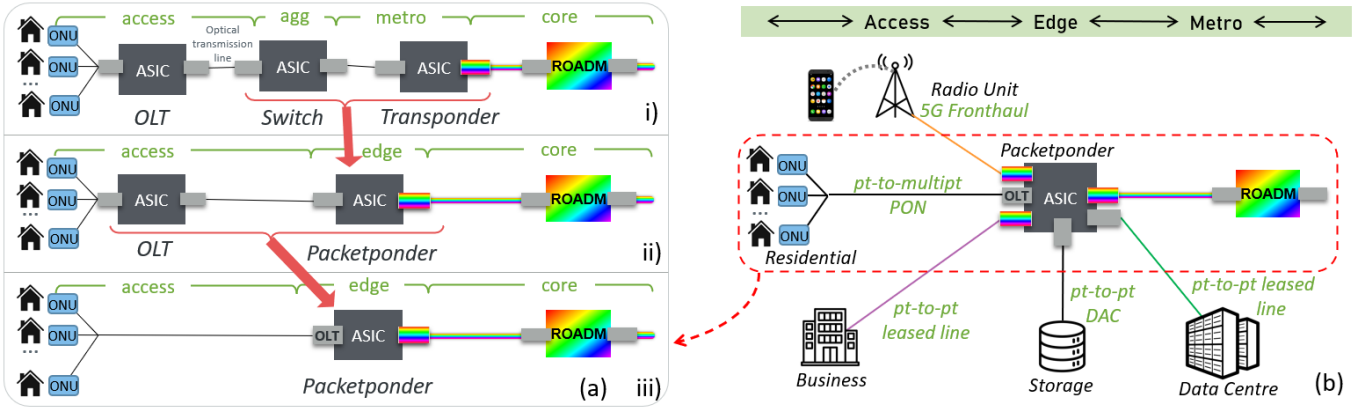

Fig. 1. (a) i) Typical network; ii) *Packetponder* [5]; iii) *Packetponder* with pluggable OLT; (b) *Packetponder* at network edge terminating: 5G fronthaul, PON and leased line *Access* services; coherent optical DWDM metro back-haul transmission via ROADM; local storage and datacentre connectivity.

cage accommodated a variety of pluggable transceivers that emulated a typical product service mix of different speeds (10 Gb/s to 100Gb/s). The coherent 100ZR CFFP provided lineside-to-lineside 3R OEO with wavelength conversion. It supported error-free packet transmission of an aggregated 99.56Gb/s signal (single channel) through 80km single-mode fibre.

The aggregation use-case emulated in this experiment, used a Keysight/Ixia XGS2-SDL test traffic generator (TTG) chassis with linecards that emitted test traffic as arranged in the first column of the table in Figure 2. The arrangement was: ports 1) and 2) and incident to a pair of independent optical network units (ONUs) which aggregated the two unidirectional flows into a single flow for transmission across a 20km PON and reception by a TiBIT XGS-PON OLT SFP+ plugabble in the *packetponder*. TTG port 3) emitted pt-to-pt traffic with a (C-Band) Lumentum 10GbE tunable optical SFP+ pluggable transceiver (for leased line emulation). TTG port 4) emitted pt-to-pt traffic (850nm-band short reach) SFP+ using a Cisco SFP-10G-SR. TTG port 5) emitted pt-to-pt traffic (C-Band) with an Adtran 25GbE tunable SFP28 pluggable (with eCPRI for 5G radio unit backhaul emulation). TTG port 6) emitted pt-to-pt traffic QSFP28 100G-direct attach copper (DAC) cable, emulating a local traffic within the rack that connect to intra-rack storage array (cached delivery network emulation).

	Port	Tx Frames	Rx Frames
1)	ONU1-ISK	5,000,000,000	
2)	ONU2-ARC	85,000,000,000	
3)	10G-tunable	100,000,000,000	
4)	10G-fixed	100,000,000,000	
5)	25G-tunable	250,000,000,000	
6)	100G-DAC	460,000,000,000	
7)	100G-O-band		1,000,000,000,000

Fig. 2. Table: Traffic Tx/Rx during a 10-hour run

Figure 2 shows error-free reception of all 10^{10} packets - that were proportionally divided depending on the line-rate of each Tx port of the TTG - at the conclusion of a ten-hour test run. It shows aggregation of the mixture of access services at 99.56Gb/s throughput traffic aggregation in a single wavelength channel, which exclude overheads. The 100Gb/s aggregation limitation is due to the equipment available to us, but this concept can certainly be expanded to 400G and beyond, with an increased availability of high-port count and high capacity open programmable switches and tunable CFFPs.

III. Conclusion

The *packetponder* - a singular programmable element - can reduce a 3-tier to a 2-tier network architecture of edge & core nodes elements. Reduced energy consumption/lower carbon footprint within a TELCOs network estate can be achieved through the consolidation of network elements - as we have shown with the *packetponder*; together with routing constraints that favour the lower-energy, lower-carbon consumption node paths across the network [12].

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