OTN support for Beyond 400 Gb/s Ethernet

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Introduction

- Liaison Letter from ITU-T SG15 (oLS) OTN support of Ethernet clients beyond 400 Gb/s
- Prior presentation OTN support for Beyond 400 Gb/s Ethernet

Long history of projects with OTN support objectives (more in the backup on specific elements relevant to each of these projects)

- IEEE Std 802.3ba-2010 40 Gb/s and 100 Gb/s Ethernet
- IEEE Std 802.3bg-2011 40Gb/s Ethernet Single-mode Fibre PMD*
- IEEE Std 802.3bm-2015 40 Gb/s and 100 Gb/s Fibre Optic
- IEEE Std 802.3by-2016 25 Gb/s Ethernet
- IEEE Std 802.3bs-2017 200 Gb/s and 400 Gb/s Ethernet
- IEEE Std 802.3cc-2017 25 Gb/s Ethernet over Single-Mode Fiber
- IEEE Std 802.3cd-2018 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet
- IEEE Std 802.3cm-2020 400 Gb/s over Multimode Fiber
- IEEE Std 802.3cn-2019 50 Gb/s, 200 Gb/s, and 400 Gb/s over greater than 10 km of SMF
- P802.3ct 100 Gb/s over DWDM systems Task Force
- IEEE Std 802.3cu-2021 100 Gb/s per lane Optical PHYs
- P802.3cw 400 Gb/s over DWDM systems Task Force
- P802.3db 100 Gb/s, 200 Gb/s, and 400 Gb/s Short Reach Fiber Task Force

* Variant on the theme: Provide optical compatibility with existing carrier 40Gb/s client interfaces (OTU3/STM-256/OC-768/40G POS)

Customary “Motherhood and Apple Pie” Objectives (last 14 years)

- Support full-duplex operation only
- Preserve the Ethernet frame format utilizing the Ethernet MAC
- Preserve minimum and maximum FrameSize of current Ethernet standard
- Provide appropriate support for OTN

Benefits of “appropriate support for OTN”

- What’s in it for ITU-T?
  - (see earlier liaison statement)
  - Single OTN mapping for a given Ethernet bit rate, independent of PMD type
  - Significant reuse of technology and commonality of component supply chains (see following slides)
- What’s in it for IEEE 802.3?
  - While the largest volume of ports may be sold inside the data center, OTN transport of Ethernet is an important part of the overall ecosystem: in building networks, you don’t want to have to step down to a lower service rate every time you need to interconnect things hundreds or thousands of km distant
  - Significant reuse of technology and commonality of component supply chains (see following slides)

Examples of Technology Reuse between IEEE 802.3 and ITU-T SG15

- For 100G OTU4, ITU adopted the 20-lane striping of 100GBASE-R to be able to use a “blind bit muxing” PMA for parallel lane modules (OTL4.4, in G.709 Annex C)
- ITU reuse of RS(544,514) FEC and Ethernet-style lane striping for 100G, 200G, 400G “FlexO” interfaces carrying OTUCn over bonded (dual-rate, Ethernet capable) client modules (G.709.1)
- IEEE 802.3 reuse of G.709.2 frame format and Staircase FEC for P802.3ct 100GBASE-ZR
- (3-way) reuse across OIF 400ZR, ITU-T G.709.3 FlexO long-reach interfaces, P802.3cw 400GBASE-ZR of basic frame format with concatenated HD Staircase/SD Hamming FEC encoder/decoder (CFEC)
- ITU reuse of RS(544,514) for 25G and 50G OTN interfaces (G.709.4)

Technology Reuse Examples – continued
Examples of dual-use pluggable modules for Ethernet and Transport applications

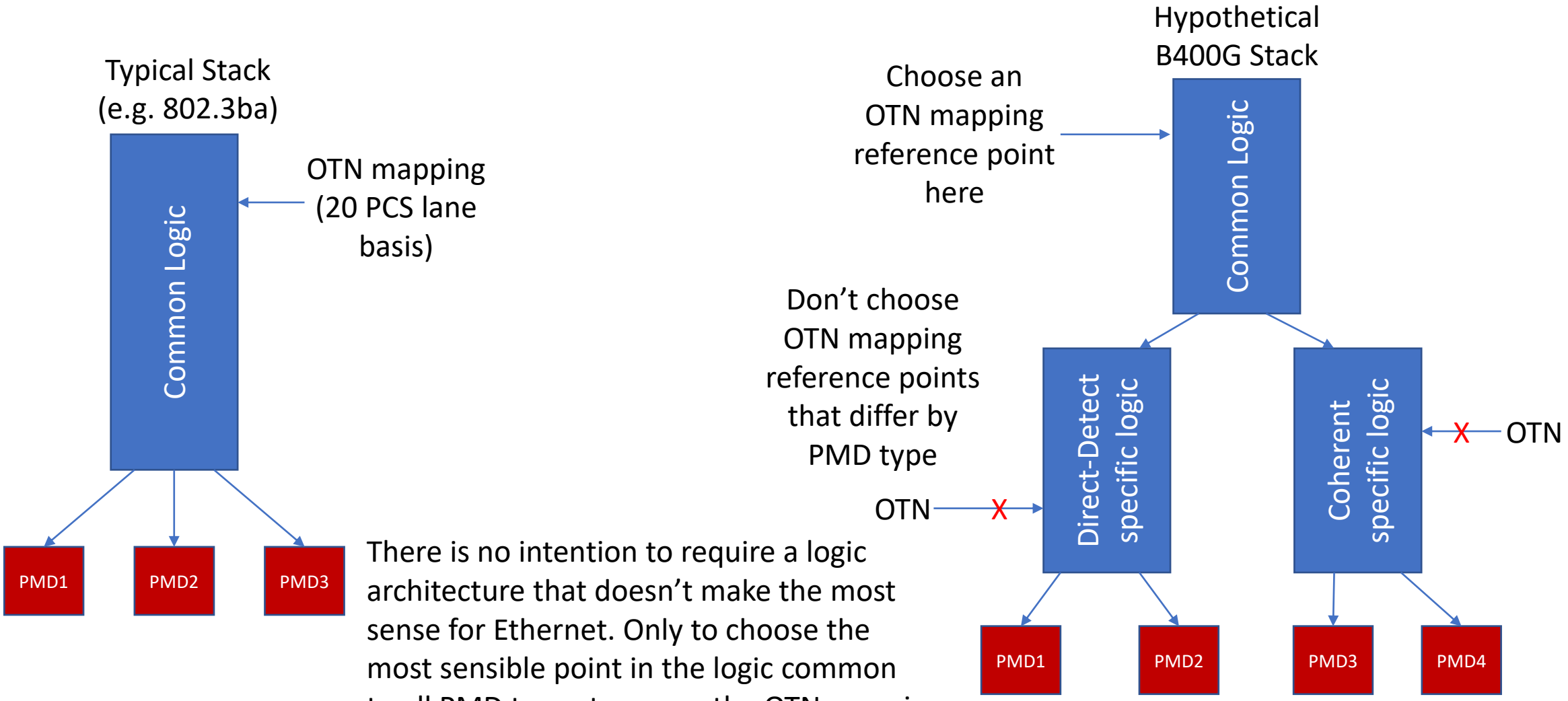
Ethernet Spec (optical and logic)	ITU-T Optical	ITU-T Frame Format
40GBASE-LR4 (clause 87)	G.695 C4S1-2D1	G.707 STL256.4 or G.709 OTL3.4
40GBASE-ER4 (clause 87)	G.695 C4L1-2D1	
100GBASE-LR4 (clause 88)	G.959.1 4I1-9D1F	G.709 OTL4.4 or G.709.1 FOIC1.4
100GBASE-ER4 (clause 88)	G.959.1 4L1-9C1F	
CWDM4 MSA	G.695 C4S1-9D1F	
4WDM 40km “ER4-lite”	G.959.1 4L1-9D1F	
200GBASE-FR4 (clause 122)	G.695 C4S1-4D1F	G.709.1 FOIC2.4
200GBASE-LR4 (clause 122)	G.959.1 4I1-4D1F	
400GBASE-FR8 (clause 122)	G.959.1 8R1-4D1F	G.709.1 FOIC4.8
400GBASE-LR8 (clause 122)	G.959.1 8I1-4D1F	

IEEE Std 802.3cu-2021 equivalent specifications still to come following recent approval

What is the cost of appropriate support for OTN?

- ZERO. Anything that would add cost, complexity, or power to an Ethernet interface not transported over an OTN network would not be appropriate.
  - No previous projects that included an “OTN support” objective have incurred any additional cost, complexity, or power due to that objective
- The most important aspect of “appropriate support” in previous projects was choosing a suitable OTN mapping reference point, which falls out naturally from the way 802.3 normally defines the logic layers to have maximum commonality across different PMD types. A typical architecture would allow a single kind of MAC/PCS/FEC chip to be on a host board, supporting many different PMD types differentiated only by the type of pluggable module inserted – example on the next slide

Example
Identification of OTN mapping Reference point



There is no intention to require a logic architecture that doesn't make the most sense for Ethernet. Only to choose the most sensible point in the logic common to all PMD types to use as the OTN mapping basis

Proposal

Considering:

- There are benefits to IEEE 802.3 and to ITU-T to ensure the ability to efficiently transport new higher speed Ethernet over OTN;
- There are benefits to the industry arising from technology sharing and component supply chain;
- Any negative implication of omitting a customary “motherhood and apple pie” objective should be avoided unless there is a specific negative message intended;
- A positive message is sent to the industry in general;
- The long-time positive and productive working relationship between IEEE 802.3 and ITU-T is preserved;
- The cost of having such an objective is zero.

The Beyond 400 Gb/s Ethernet Study Group should adopt the following objective:

- Provide appropriate support for OTN

BACKUP

Previous and current projects with OTN support objectives How was OTN support provided?

- The prior presentation OTN support for Beyond 400 Gb/s Ethernet (slide 5 in particular) explains the types of problems the OTN support objective is intended to avoid
- IEEE Std 802.3ba-2010 40 Gb/s and 100 Gb/s Ethernet
  - Single clause 82 PCS per new Ethernet bit-rate allows for single OTN mapping to be used for all 40GBASE-R and 100GBASE-R PMD types
  - Clarification that any signal not using valid PCS control block types is not Ethernet (allowing 40GBASE-R to be transcoded to fit OPU3)
- IEEE Std 802.3bg-2011 40Gb/s Ethernet Single-mode Fibre PMD*
  - Retains single clause 82 PCS for new 40GBASE-FR PMD, allowing same OTN mapper to be used as for P802.3ba PMD types
- IEEE Std 802.3bm-2015 40 Gb/s and 100 Gb/s Fibre Optic
  - Retains single clause 82 PCS for new 40GBASE-ER4 PMD type and existing 100GBASE-R PMDs using new CAU4 C2M, allowing same OTN mappers to be used as developed for 802.3ba
- IEEE Std 802.3by-2016 25 Gb/s Ethernet
  - All 25GBASE-R PMD types use the same Clause 107 PCS (based on Clause 49 66B coding, essentially a 2.5× sped up 10GBASE-R PCS), allowing a specific 66B stream to be used as the basis for the OTN mapping
  - The PCS clock is preserved by the Clause 108 RS FEC sublayer (deleted idles exactly equal inserted CWM, the 257B transcoding crunching exactly equals inserted RS-FEC parity, preserving ability to use for some SyncE over OTN applications
- IEEE Std 802.3bs-2017 200 Gb/s and 400 Gb/s Ethernet
  - All 200GBASE-R and 400GBASE-R PMD types use the same clause 119 PCS. There is an explicitly identified OTN mapping reference point in clause 119.2.4.1.
- IEEE Std 802.3cc-2017 25 Gb/s Ethernet over Single-Mode Fiber
  - New 25GBASE-LR and 25GBASE-ER PMD types use the same clause 107 PCS and clause 108 RS FEC sublayer as PMD types from IEEE Std 802.3by-2016 and use exactly the same OTN mapping

* Variant on the theme: Provide optical compatibility with existing carrier 40Gb/s client interfaces (OTU3/STM-256/OC-768/40G POS)

Previous and current projects with OTN support objectives How was OTN support provided?

- IEEE Std 802.3cd-2018 50 Gb/s, 100 Gb/s, and 200 Gb/s Ethernet
  - New 100GBASE-R and 200GBASE-R PMD types use existing clause 82 and clause 119 PCSs (the latter with an explicitly identified OTN mapping reference point). New 50GBASE-R PMDs all use the same clause 133 PCS, which is a “sped up” 40GBASE-R PCS (per clause 82) with different AM spacing due to the RS(544) FEC codeword structure. Existing OTN mappings for 100GBASE-R and 200GBASE-R clients are preserved. At the time of this project, there was no 50G OTN interface, and the single mapping was into OPUflex.
- IEEE Std 802.3cm-2020 400 Gb/s over Multimode Fiber
  - New 400GBASE-R PMD types use exactly the same clause 119 PCS with its explicitly identified OTN mapping reference point, and the same OTN mapping can be used for the new PMD types introduced.
- IEEE Std 802.3cn-2019 50 Gb/s, 200 Gb/s, and 400 Gb/s over greater than 10 km of SMF
  - 50GBASE-ER uses the same clause 133 PCS as 50GBASE-LR introduced by P802.3cd, and the same OTN mapping is used. 200GBASE-ER4 and 400GBASE-ER8 use the same clause 119 PCS as 200GBASE-LR4 and 400GBASE-LR8 with the identified OTN mapping reference point. All OTN mappings for prior 50GBASE-R, 200GBASE-R, and 400GBASE-R PMD types work without change.
- P802.3ct 100 Gb/s over DWDM systems Task Force
  - Uses the same clause 82 PCS as all prior 100GBASE-R PMD types. Reuses the ITU-T G.709.2 frame format and Staircase FEC from 100G OTN metro interfaces, omitting most OTN-specific overhead but otherwise identical to how 100GBASE-R is mapped into OPU4/OTU4. Optical parameters largely consistent with (and based on) ITU-T G.698.2 DW100U-8A2(C)F application code. Permits interconnection with some pre-existing OTN implementations.
- IEEE Std 802.3cu-2021 100 Gb/s per lane Optical PHYs
  - New 100GBASE-LR1/FR1 PMD types use existing clause 82 PCS. New 400GBASE-FR4 and 400GBASE-LR4-6 use existing clause 119 PCs with identified OTN mapping reference point. Existing OTN mappings for 100GBASE-R and 400GBASE-R clients can be used without change.
- P802.3cw 400 Gb/s over DWDM systems Task Force
  - Existing draft uses current clause 118XS consistent with clause 119 PCS with identified OTN mapping reference point, and existing 400GBASE-R mapping into OTN can be used without change. Frame format and FEC consistent with FlexO-4-DSH from G.709.3.
- P802.3db 100 Gb/s, 200 Gb/s, and 400 Gb/s Short Reach Fiber Task Force
  - Still early with no adopted baselines, but expectations are that the 100GBASE-R clause 82 PCs and 200GBASE-R/400GBASE-R clause 119 PCS with its identified OTN mapping reference point will be used without change and existing 100GBASE-R, 200GBASE-R, and 400GBASE-R client mappings over OTN will be usable without change.

THANKS!