

OTN Support

What is it and why is it important?

400 Gb/s Ethernet Study Group

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Steve Trowbridge

Alcatel-Lucent

Supporters

- John McDonough (NEC)
- Ghani Abbas (Ericsson)
- Martin Carroll (Verizon)
- Sam Sambasivan (AT&T)
- Pete Anslow (Ciena)
- Peter Stassar (Huawei)
- Bill Szeto (Xtera)

History of Ethernet in Wide Area Networks

- Transport networks of 1970s, 1980s
 - Optimized for transport of 64 kbps services (voice, modem, FAX)
 - The minority of traffic was data such as Ethernet
 - Since transport over distance was expensive, transport was nearly always sub-rate (e.g., bridge together 10 Mb/s LANs using DS-1 at 1.544 Mb/s)

What changed?

- Capabilities and capacity of transport networks grew to make “full rate” Ethernet transport more feasible
- An accident of arithmetic with the historical growth of Ethernet (factors of 10 every 8-10 years) and the historical growth of transport networks (factors of 4 every 3-5 years) brought the rates agonizingly close at around 10 Gb/s:
 - 10GBASE-R at 10.3125 Gb/s
 - STM-64/OC-192 at 9.95328 Gb/s
 - OTU2 at 10.709225316 Gb/s with a payload rate of 9.995276962 Gb/s

How was this addressed at 10G?

Badly!

- IEEE 802.3 recognized the problem and tried to address it by defining two different “flavors” of 10G Ethernet – one for WAN (10GBASE-W) with a frame format and bit-rate consistent with STM-64/OC-192, and one for LAN (10GBASE-R) with a more “natural” Ethernet format
- In the market, not all vendors implemented 10GBASE-W, and other factors influenced willingness to deploy it
- Lots of market confusion about what is payload, what is overhead, what is line code in the Ethernet signal format
- Lots of rumors about proprietary features making use of preambles, IPG, etc., that could “break” if every bit wasn’t carried created market pressure to “carry every bit” – but even this was selective

How was this addressed at 10G? continued

- Lots of standard and proprietary options emerged in the market to transport 10GBASE-R:
 - GFP-F into OPU2 carries everything but preambles and IPG
 - 10GBASE-W into OPU2 using the same mapping as STM-64/OC-192
 - Initially non standard mapping via GFP-F including preambles and sequence ordered sets (but not IPG) into an expanded OPU2 “borrowing” part of the ODU2 overhead area for payload transport
 - Two flavors of over-clocked ODU2 mappings (with and without the fixed-stuff columns used in the STM-64/OC-192 mapping)
 - Initially captured in ITU-T G.supp43, some options later migrated into the standard

40 Gb/s and 100 Gb/s Ethernet

What did we do differently in 802.3ba?

- With fresh memories of the “pain” from 10Gb/s Ethernet, we adopted an OTN support objective!
- We realized that there was a similar risk as at 10G. While 100G transport was still in early stages of standardization, 40G transport had been deployed for some years with bit-rates of 39.813120 Gb/s (STM-256/OC-768) and 40.150519322 Gb/s (OPU3 payload capacity)

How was the OTN support objective met in 802.3ba?

- Create clarity that the line code is not payload, and exclude the line code as a playground for proprietary extensions, creating confidence in transcoding implementations
 - Identify non-standardized 66B control block types as bit sequences that “shall not be transmitted and shall be considered an error if received”
 - Note that proprietary features are still possible – just do them properly by purchasing an OUI and do them PDU or slow protocol-based
- The 40G bit-rate problem is solved with a 1024B/1027B transcoding of the 64B/66B line code into standard OPU3

Additional Features that have become considered important elements of OTN support

- Single PCS!
 - For a given MAC rate, there is a single canonical format that can be used in the OTN mapping. You don't need to develop a new mapping for every new Ethernet PMD, just convert to the canonical format
 - Canonical format for 100 Gb/s Ethernet: twenty PCS lanes, deskewed and 66B-block serialized
 - Canonical format for 40 Gb/S Ethernet: four PCS lanes, deskewed and 66B-block serialized, then 1024B/1027B transcoded
 - Allows different Ethernet PMDs of a given rate to be used at the OTN ingress and egress – e.g., 100GBASE-LR4 at the ingress and 100GBASE-SR10 at the egress
 - Example: 100GBASE-KP4 has an aggregate bit-rate of 108.75 Gb/s which doesn't fit the OPU4 payload area of 104.35597533 Gb/s. No worries: just terminate the FEC, correcting errors. Trans-decode 256B/257B to 64B/66B with standard alignment markers, deskew and 66B block serialize to map the resulting 103.125 Gb/s signal into OPU4 and interconnect to ANY 100 Gb/s Ethernet PMD at the OTN egress!

Additional Features that have become considered important elements of OTN support

- Ethernet Optical Module Reuse for Transport client and handoff (IrDI) optics:
 - 10G became a dominate transport rate because 10G serial Ethernet optics made 10G STM-64, OC-192, OTU2 client optics less costly than 2.5G STM-16, OC-48, OTU1 client optics
- While most 40G/100G Ethernet interfaces were parallel, transport interfaces took advantage of the modules by defining parallel (STL, OTL) versions of transport frame formats to take advantage of the modules
- Higher bit-rates of OTN interfaces were compensated by the fact that OTU3 and OTU4 ran with FEC and initially standardized 40GBASE-R, 100GBASE-R ran without. The coding gain of the FEC compensated for the increased bit-rate
- Corresponding specifications:
 - G.959.1 Application code 4I1-9D1F corresponds to 100GBASE-LR4
 - G.959.1 Application code 4L1-9C1F corresponds to 100GBASE-ER4
 - G.695 Application code C4S1-2D1 corresponds to 40GBASE-LR4

Goal for 400G module reuse

- A 400G optical module developed for 400 Gb/s Ethernet should be reusable for a 400 Gb/s OTN client or IrDI application
- If 400 Gb/s includes a “native” FEC, this might be addressed by:
 - Terminate the Ethernet FEC at the OTN ingress/egress so that the FEC chosen for a single link doesn't have to correct double link errors
 - The 400G OTN frame has its own FEC
 - When reusing the 400G Ethernet optical modules for OTN client and IrDI applications, any difference in coding gain between OTN FEC and Ethernet FEC and the difference in bit rate will have to be taken in to account in the link budget

Recommendation

- Follow the lead of P802.3ba, P802.3bg, and P802.3bm by adopting the following objective:

Provide appropriate support for OTN