NOKIA

Recent topics in Optical Transport Networks

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Topics of recent OTN work in WP3/15

Flexible OTN (FlexO) enhancements

Optical media architecture and management

OTN support for clients faster than 400G

FlexO enhancements

Q11/15

FlexO provides a multivendor interoperable interface for beyond-100G OTN signals

- Beyond-100G OTN is arranged as a structure of *n* 100G units (ODUCn, OTUCn)
- G.709.1 "Flexible OTN short-reach interfaces" provides the base specification of the FlexO frame structure and inverse multiplexing of OTUCn over 100G, 200G, or 400G PHYs, and a FEC frame for client interfaces (also used for MFIs)
- G.709.3 "Flexible OTN long-reach interfaces" provides FEC frames for "line side" interfaces

Recent additions to FlexO:

- New FEC frame and FEC code in G.709.3 supporting "metro" applications
  - Up to 450 km reach and a few ROADM hops
- New overhead in G.709.1 to support secure FlexO transmission
  - Enables link encryption in beyond-100G OTN networks
  - Does not standardize the cipher(s) that can be used, only the locations of the overhead used to carry encryption-related information (e.g., identifying the cipher suite being used, authentication tags, etc.)

Architecture and management of optical networks

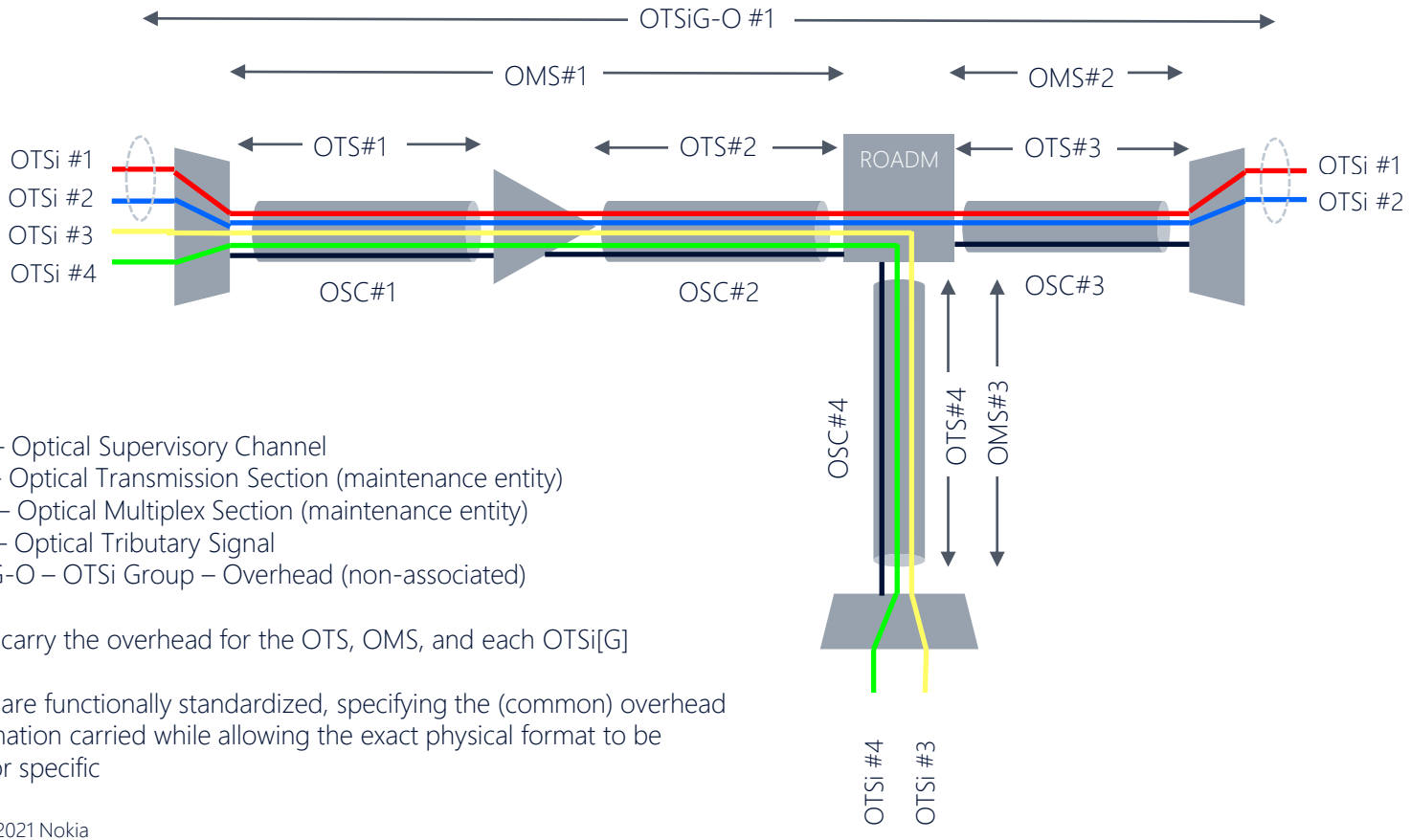
Q12/15, Q14/15

Original OTN architecture description treated the optical layer as part of OTN layer structure and described it as if it was a TDM technology

Recent work has separated the digital OTN layers from the optical media

- New Recommendation G.807 "Generic functional architecture of the optical media network" describes architecture of optical media independently of the signals it carries, as well as the use of non-associated overhead for management of the media layer
  - The optical media layer itself does not have a layered structure – it is simply fibers and optical equipment (amplifiers, optical mux/demux, etc.)
  - The non-associated overhead defined by OTN provides a management view as if there is a layered structure, but it does not create an actual structure of layers in the optical domain
  - G.807 media architecture can be used to describe the media layer for any digital layer (not specific to OTN)
- Revised Recommendation G.872 "Architecture of the optical transport network" now focuses primarily on the digital layers of OTN
- Recently consented G.876 "Management Requirement and Information/Data Model for the optical media network" describes management of the media layer

Optical Media Layer Management



OSC – Optical Supervisory Channel
OTS – Optical Transmission Section (maintenance entity)
OMS – Optical Multiplex Section (maintenance entity)
OTSi – Optical Tributary Signal
OTSiG-O – OTSi Group – Overhead (non-associated)

OSCs carry the overhead for the OTS, OMS, and each OTSi[G]

OSCs are functionally standardized, specifying the (common) overhead information carried while allowing the exact physical format to be vendor specific

OTN support for beyond 400G clients

Q11/15 now, will likely expand to Q12/15 and Q14/15 as work progresses

Rates beyond 400G are a hot topic across the standards ecosystem

Beyond 100G OTN structures (ODUCn/OTUCn/FlexO) are capable of supporting clients well beyond 400G

However, beyond-100G OTN signals operate at ~7% higher bit rate than the corresponding Ethernet signals that are the dominant client of OTN

- For the new Ethernet rates being considered, the absolute difference in bit rates is large
- Unclear if it will continue to be feasible to produce dual-rate optical modules

Why are OTN rates higher than Ethernet rates?

- OTN adds networking overhead
- OTN supports client multiplexing, so the payload area must be large enough to accommodate the networking overhead of all the clients
  - E.g., ODUC4 payload area must be large enough to carry four ODU4 in order to carry four 100GBASE-R clients, which is more than what is necessary to carry one 400GBASE-R client

OTN support for beyond 400G clients

Potential optimizations to be considered (1)

Networking overhead insertion rate has not changed in 20 years

- The ratio of overhead columns to payload columns in the OTN frame was designed to support 2.5 Gb/s transmission rates
- For higher speed clients, the ratio could be substantially reduced while still meeting the required frequency of transmission for the information elements in the overhead

Are client multiplexing requirements still the same as they were 10 years ago?

- When ODU4 was developed, it was required to carry ten 10GE clients mapped into ODU2e
- This was extended to ODUCn
  - e.g., ODUC4 needs to be able to carry four 100GE clients mapped into ODU4
- There will be some OTN container that carries 800GE – what mixes of lower speed clients is required?
  - Clearly 2x400GE will be required, but will 8x100GE be required, or would 7x100GE be good enough?
- Similarly for the container that carries 1600GE…
  - Clearly 2x800GE will be required, but will 16x100GE be required, or would 15x100GE be good enough?

OTN support for beyond 400G clients

Potential optimizations to be considered (2)

Should a dual-rate structure be considered?

- Maintain existing rates (based on OTUCn/FlexO) for general applications beyond 400G
- Introduce new optimized rates for the case where a single beyond-400G Ethernet client is being carried
  - The new optimized rates could still support lower speed clients, with limitations on the maximum number

At what rate should any such optimizations be introduced?

What types of interfaces require more optimal structures?

- Single vendor vs. multi-vendor interoperable
- "Client" vs. "line"

If multi-vendor interfaces are to be considered, the inverse multiplexing used in beyond-100G OTN locks interfaces into specific bit rates (100G, 200G, 400G); could a more generalized inverse multiplexing be defined to allow for other transmission rates, especially for "line" interfaces?

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