Update to oFEC-based single lambda baseline for 10km and 40km objectives

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*Supports proposal for 40km only

Introduction

- williams_3dj_01a_2303 summarized the benefits of an 800GBASE-LR1 and 800GBASE-ER1 implementation that can leverage 800ZR/ZR+ industry investment and support interop between them as well as with a potential future 800GBASE-ZR1
- nicholl_3dj_optx_01_230427 proposed a modification to bypass the GMP mapping used in 800ZR/ZR+ for the 800GBASE-LR1 and 800GBASE-ER1 Ethernet implementations
  - Addresses potential concern in PTP applications related to low frequency wander due to GMP
- This proposal leverages well-understood technology, broad industry investment and meets all the requirements for 800GBASE-LR1 and 800GBASE-ER1

Considerations in Coherent 800GBASE-LR1 Implementation Selection

- Market Size
  - As demonstrated in williams_3dj_01a_230206.pdf the LR market is best served by leveraging investment in adjacent applications
  - The OIF 800LR approach isn't just a different FEC compared to ZR/ZR+, it's a completely unique data path for a point solution
  - Bypassing GMP is a simple modification to the ZR/ZR+ implementation that allows significant re-use
- Overhead
  - The OIF 800LR operates at **123.6Gbaud** overhead to achieve **~1e-2 FEC** threshold
  - oFEC operates at **118.2Gbaud** with a FEC threshold of **~2e-2**
  - An oFEC-based implementation will have a broader supply base and **1.9dB (or 6km)** better sensitivity performance that can be used for either additional manufacturing or link margin
- Optical Band
  - OIF 800LR has selected O-band
  - IEEE is better served to align on C-band with 10/40km interop
- Latency
  - The majority of 10/40km applications are not latency sensitive, particularly in the use cases where coherent offers the most value
  - Deterministic latency, is the key requirement for PTP applications and oFEC latency is deterministic
  - In almost all cases, where lowest latency is required, the IMDD LR4 implementation is the better choice

Should 800GBASE-LR1 Target Inside the Data Center?

- The primary benefit of the KP4+BCH(126,110) approach is very low latency
  - Required only for applications inside the data center
  - OIF 800LR requirement for end-to-end latency of <300ns corresponds to ~60m of fiber
- There is a cost to supporting this low latency requirement
  - Unique DSP development not aligned with any other requirements
  - Higher overhead with lower gain
    - Less margin or reduced reach depending on specification approach
- The application that drove the OIF 800LR requirements also requires O-band operation
- The 800GBASE-LR4 implementation will be lower latency than either proposed coherent approach
- Latency <300ns is not necessary to meet the .3dj requirements and the only justification has been vague claims about future undefined standards

Optical Band Selection for 800GBASE-LR1/ER1

- C-band is the obvious choice for 40km
  - Dispersion is easily compensated in a coherent implementation
  - C-band amplification technology is far more mature than O-band
  - 6.75dB extra link budget required for O-band vs C-band
- C-band is far superior for a coherent implementation that addresses traditional LR use cases
  - Dispersion is easily compensated in a coherent implementation
  - Existing component and test infrastructure far outweighs any potential laser cost savings from switching to O-band lasers
  - Lower attenuation results in greater link margin
  - Interop between 800GBASE-LR1 and 800GBASE-ER1 has value to network operators
- Why is O-band being considered?
  - One very specific use case for coherent inside the data center requires O-band
  - OIF has selected O-band to address this use case
  - **This is not aligned with broad market potential in IEEE**

Transmitter Specifications

Description	800GBASE-LR1	800GBASE-ER1	Unit
Signaling rate	118.2	118.2	Gbd
Modulation format	DP-16QAM	DP-16QAM	
Channel frequency (Nominal)	**193.7**	**193.7**	THz
Channel frequency accuracy (+/-)	+/- 1.8	+/- 1.8	GHz
Average launch power (min)	-10	-2	dBm
Average launch power (max)	-6	2	dBm
Average launch power of OFF transmitter (max)	-20	-20	dBm
Laser linewidth (max)	**1.0**	**1.0**	MHz
I/Q phase error (+/-)	5	5	Deg
I/Q quadrature skew (max)	0.75	0.75	Ps
I/Q amplitude imbalance (mean)	1	1	dB
Transmitter EVM	12	12	%

Parameters in blue represent spec relaxations compared to OIF 800ZR optics

Transmitter Specifications (cont.)

Description	800GBASE-LR1	800GBASE-ER1	Unit
Transmitter OSNR	35	35	dB
Power difference between X and Y polarizations (max)	1.0	1.0	dB
Skew between X and Y polarizations (max)	5	5	ps
Transmitter reflectance (max)	-20	-20	dB
RIN average	-145	-145	dBc/Hz
RIN peak	-140	-140	dBc/Hz

Receiver Specifications

Description	800GBASE-LR1	800GBASE-ER1	Unit
Modulation format	PM-16QAM	PM-16QAM	
Frequency offset between received carrier and local oscillator	+/-3.6	+/-3.6	GHz
Receive sensitivity	-17.3	-17	dBm
Average receive input power (max)	+3	+3	dBm
CD tolerance (max)	200	800	ps/nm
Peak PDL tolerance	1.5	1.5	dB
DGD	5	10	ps
SOP tolerance	5	5	krad/s

Illustrative Link Budgets

Parameter	800GBASE-LR1	800GBASE-ER1	Unit
Power budget	7.3	15	dB
Operating distance	10	40	Km
Channel insertion loss	5.0	14	dB
Allocation for penalties	0.5	1.0	dB
Additional insertion loss allowed	1.8	0	dB

Summary

- The industry will benefit from 800GBASE-LR1/ER1 specifications alignment with higher volume interfaces
  - 800GBASE-LR4 specification aligned with DR4/FR4
  - 800GBASE-LR1/ER1 aligned with OIF 800ZR and MSA 800ZR+
- This coherent 800GBASE-LR1/ER1 implementation based on oFEC will enable cost optimization for the lower volume applications through technology reuse
  - Interoperability can be supported between LR1, ER1 and a potential ZR1 in the future
  - Design will leverage investment in 800ZR/ZR+, but interoperability with DWDM interfaces is not required
  - This approach will provide a robust specification with unallocated margin that can provide extra protection against fiber impairments or reaches exceeding 10 km
  - An oFEC-based solution offers 1.9dB better sensitivity performance than KP4+BCH that can be used for manufacturing or link margin
- This 800GBASE-LR1 proposal compliments the 800GBASE-LR4 proposal, enabling the benefits of each technology