Baseline proposal for 10 & 40 km 800 Gb/s objectives in 802.3dj

Eric Maniloff, Ian Betty, Sebastien Gareau, James Harley -- Ciena

Bo Zhang, Kishore Kota, Lenin Patra -- Marvell

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Supporters

- **Paul Brooks – Viavi**
- **Dave Cassan [1] - Alphawave**
- **Tony Chan Carusone [1] - Aphawave**
- **Frank Chang – Source Photonics**
- **Piers Dawe – Nvidia**
- **Ali Ghiasi - Ghiasi Quantum LLC**
- **Hideki Isono - Fujistu Optical Components**
- **Cedric Lam [1] - Google**
- **Xiang Liu [1] - Huawei**
- **Jeff Maki [2] - Juniper**
- **Ernest Muhigana - Lumentum**
- **Gurinder Parhar – Source Photonics**
- **Ted Sprague – Infinera**
- **Di Zhang - Kuaishou**
- **Yanjun Zhu – Hisense**

[1] Supports BCH FEC but would prefer O band solution
[2] Supports BCH FEC for 10 km only

Overview

802.3dj includes the following 800Gb/s objectives that are suitable for a coherent optical solution

- over a single SMF in each direction with lengths up to at least 10 km
- over a single SMF in each direction with lengths up to at least 40 km

Coherent and IMDD solutions have been proposed to meet the 10 km objective

- There is a proposal to split the 10 km objective to include both single and 4 wavelength solutions

The focus here is on which coherent solution is optimal for the applications addressed by IEEE 802.3dj

Key Applications For 800GbE SMF

Campus Interconnects

- Connections between buildings 2km-10km

AI/ML

- Photonic reconfiguration has been proposed :
  - “Jupiter Evolving: Transforming Google's Datacenter Network via Optical Circuit Switches and Software-Defined Networking”, L. Poutievski et al, Proceedings of ACM SIGCOMM 2022, 2022

Optical Y cable Protection

- Loss budgets exceed FR, despite relatively short reach

5G Fronthaul

- Time sensitive accuracy can be as low as ±5 ns
  - See discussion in https://www.ieee802.org/3/df/public/23_01/0130/dekoos_3df_01_230130.pdf

Technology addressing these applications should optimize Power/Latency/Timing Uncertainty

Coherent Objectives

802.3dj

- 10/40km duplex SMF objectives

Evolution to 1.6 Tb/s

- Currently we have no duplex SMF objectives in 802.3dj
- In the future there will be a push for 1.6Tb/s SMF
- 800G/channel coherent solutions will be suitable for for 1.6Tb/s FR2 and LR2

We are adopting building blocks in 802.3dj that will be in use for years across multiple projects

- IEEE 802.3bj RS FEC was adopted in 2014 and remains a key building block

802.3ct and 802.3cw reused logical implementations defined in ITU, OpenROADM, and OIF

- These were all DWDM applications → Strong applications overlap

802.3dj 10 km & 40 km Coherent implementation

The 10 km solution is defined to support a 6.3dB loss budget consistent with existing 802.3 10km specifications

- Reduced loss in C band provide unallocated margin – useful for applications with additional loss (switches, splitters, combiners, patch panels)

The 40km solution is defined based on worst-case G.652.D fiber loss

C band operation allows multiple technology solutions to meet a higher Tx output power for 40km reach

- Mature EDFA and SOA technologies in modules can boost Tx power to meet 40km link loss

A C-Band coherent solution allows definition of a specification resulting in interoperable 10km and 40km interfaces

Coherent options for 800G

Two alternatives have been proposed for coherent 800GbE specs in IEEE 802.3dj:

- Concatenated (Type 2) RS/BCH FEC
  - Allows concatenated or segmented
  - Synchronous FEC, 63/64b coded
- Segmented FEC, GMP mapping of Ethernet payload into a DSP frame with OFEC
  - This is similar to 400GBASE-ZR in 802.3cw
  - This is a useful scheme for DWDM 80km applications, but is not a match to market requirements for single channel

BCH FEC is lower latency, lower power, and synchronous

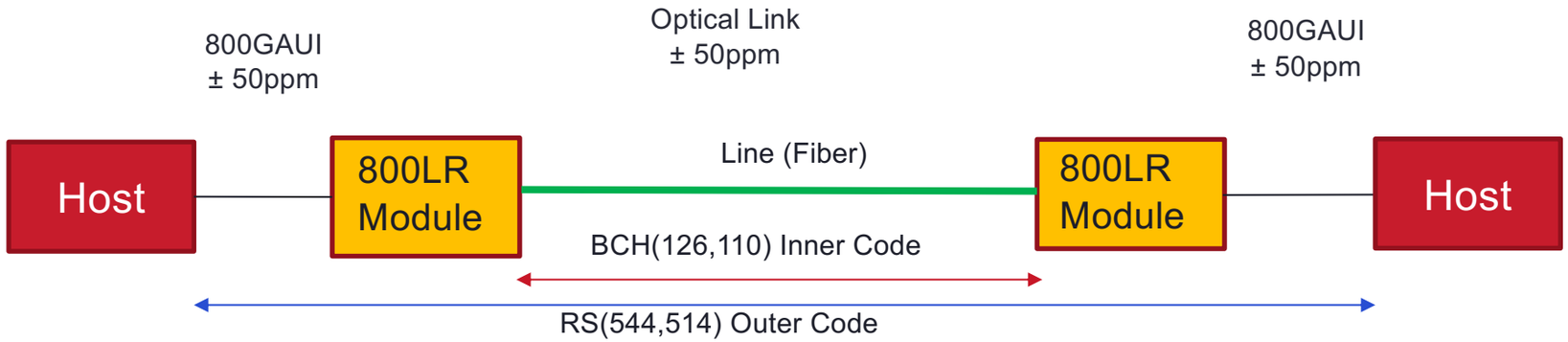
- See: https://www.ieee802.org/3/dj/public/23_01/23_0206/maniloff_3dj_01a_230206.pdf
  - Power of BCH approach is 2W lower than an 800ZR solution
  - Latency is reduced from 2 µs to 250 ns using a BCH solution (clause 119 specifies an ~800ns max delay)

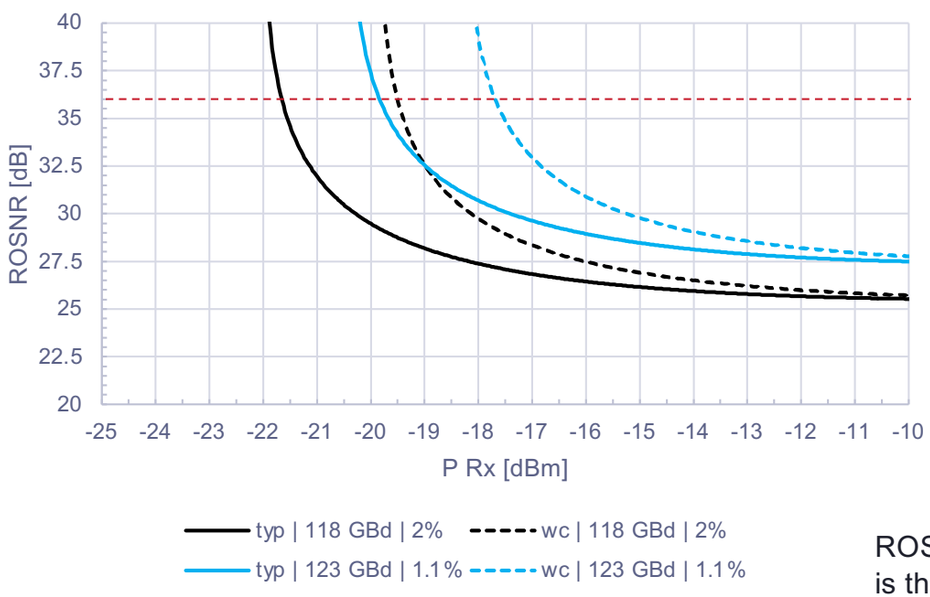
Both coherent designs will use different optical implementations from 800ZR, optimized for single channel applications.

800G LR1 will be a key building block for 1.6Tb/s

- Although we don’t currently have 1.6Tb/s objectives for duplex SMF, this will be a market requirement

800GBASE-LR1 Based on BCH(126,110) FEC





Both FEC proposals meet the optical power budgets

oFEC provides 1.9 dB of sensitivity improvement

- This is equivalent of ~6 km of fiber loss

ROSNR is the OSNR required to meet the FEC threshold. The dashed red line is the proposed Tx OSNR, and the crossing points define the Rx sensitivity.

800GBASE-LR1 and 800GBASE-ER1 Link parameters

	800GBASE-LR1	800GBASE-ER1	
Operating Distance	10	40	km
Fiber Loss	3.5	12	dB [1]
Additional Loss	2.8	2	dB [2]
Chromatic Dispersion Max	200	800	ps/nm [3]
Chromatic Dispersion Min	0	0	ps/nm
Polarization Mode Dispersion	5	10	ps
Allocation for link penalties	0.5	1	dB

Note 1: 800GBASE-ER1 Loss specification for ITU G.652.D fiber attenuation. G.652.B fiber maximum attenuation results in a 14dB maximum loss.
Note 2: 800GBASE-ER1 on G.652.B fiber is an engineered link, with no allocations for additional patch panel loss.
Note 3: Chromatic Dispersion is allocated based on G.654 maximum CD value, which is greater than the worst-case G.652.D

800GBASE-LR1 and 800GBASE-ER1 Tx Parameters

	800GBASE-LR1	800GBASE-ER1	Unit
Signalling rate	123.7±50 ppm	123.7±50 ppm	Gbaud
Modulation Format	DP-16QAM	DP-16QAM	
Optical Frequency	193.7	193.7	THz
FEC	RS(544,514,10) +BCH(126,110)	RS(544,514,10) +BCH(126,110)	
Average Launch Power (Max)	-4	2	dBm
Average Launch Power (Min)	-10	-2	dBm
Optical Frequency Accuracy	±3	±3	GHz
Laser Linewidth	1	1	MHz
In Band OSNR	36	36	dB/12.5 GHz
Power difference between X and Y polarizations (max)	1.5	1.5	dB
Skew between X and Y polarizations (max)	5	5	ps
EVMmax (max)	TBD	TBD	%
Instantaneous I-Q offset per polarization (max)	-20	-20	dB
Mean I-Q offset per polarization (max)	-26	-26	dB
I-Q amplitude imbalance (mean)	1	1	dB
I-Q phase error magnitude (max)	5	5	deg
I-Q quadrature skew (max)	0.75	0.75	ps
Average launch power of OFF transmitter (max)	-20	-20	dBm
Transmitter reflectance (max)	-20	-20	dB
Transmit output power stability	± 1	± 1	dB
RIN average (max)	-145	-145	dB/Hz
RIN peak (max)	-140	-140	dB/Hz

800GBASE-LR1 and 800GBASE-ER1 Rx Parameters

	800GBASE-LR1	800GBASE-ER1	Unit
Signalling rate	123.7±50 ppm	123.7±50 ppm	Gbaud
Modulation Format	DP-16QAM	DP-16QAM	
Optical Frequency	193.7	193.7	THz
Optical Frequency Tolerance	±3	±3	GHz
Sensitivity at TP2	-16.8	-17	dBm
Sensitivity at TP3	-16.3	-16	dBm [1]
Optical Power (Max)	-4	-4	dBm [2]
Damage Threshold	+5	+5	dBm
Receiver reflectance (max)	20	20	dB
Allocation for link Penalties	0.5	1	dB

Note [1] 800GBASE-LR1 and 800GBASE-ER1 are compliant over the 10km link

Note [2] 6dB minimum loss included for ER Tx

Summary

A coherent solution for the 802.3dj 10 & 40 km SMF objectives is presented based on a concatenated RS544/BCH(126,110) FEC code

The proposed specification can fully meet fiber parameters defined in ITU G.652, as well as G.657 (Bend insensitive) fiber

10 and 40 km specifications using the same framing and compatible optical specs provide an interoperable 10 & 40 km 800GbE implementation

This proposal results in a low power/low latency solution that can provide a key building block for 1.6Tb/s future objectives

Summary 2

1) Phy Type: 800GBASE-LR1, 800GBASE-ER1
2) FEC Type: 2
3) 2 AUI’s per link
4) Assumed BER per AUI = 1E-5
5) DSP frame with pilots will prevent burst errors by preventing Carrier phase cycle slips
6) BCH(126,110)
7) 11-Way convolutional interleaver

Thanks!