Coherent Proposals for 800LR and 800ER

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Introduction

- Coherent standards at ~64Gbaud have driven development of component technology that can address a broad range of network applications (DCI, DWDM, Carrier Metro, Access Networks, etc.)
- OIF is defining 800G coherent solutions for 10km - 40km (LR/ER)
- 10km reach (LR) has historically been addressed by aligning with other applications in order to leverage economies of scale
- Which technology is best to leverage?
  - 2km technology will be technically challenging to extend the reach
  - Coherent technology with fixed wavelength lasers may more optimal

Observation on IEEE and industry history around 10 km reaches

		2km	10km	40km
25GbE	Single λ	-	Single λ	Single λ [1]
50 GbE	Single λ	Single λ	Single λ	Single λ
100GbE	Single λ	Single λ	Single λ	Single λ [2]
	4 λ	CWDM	LAN WDM CWDM	LAN WDM
200 GbE	4 λ	CWDM	LAN WDM	LAN WDM
400GbE	4 λ	CWDM	CWDM	LAN WDM
	8 λ	LAN WDM	LAN WDM	LAN WDM

Notes:
[1] tighter wavelength range
[2] tighter spectral width

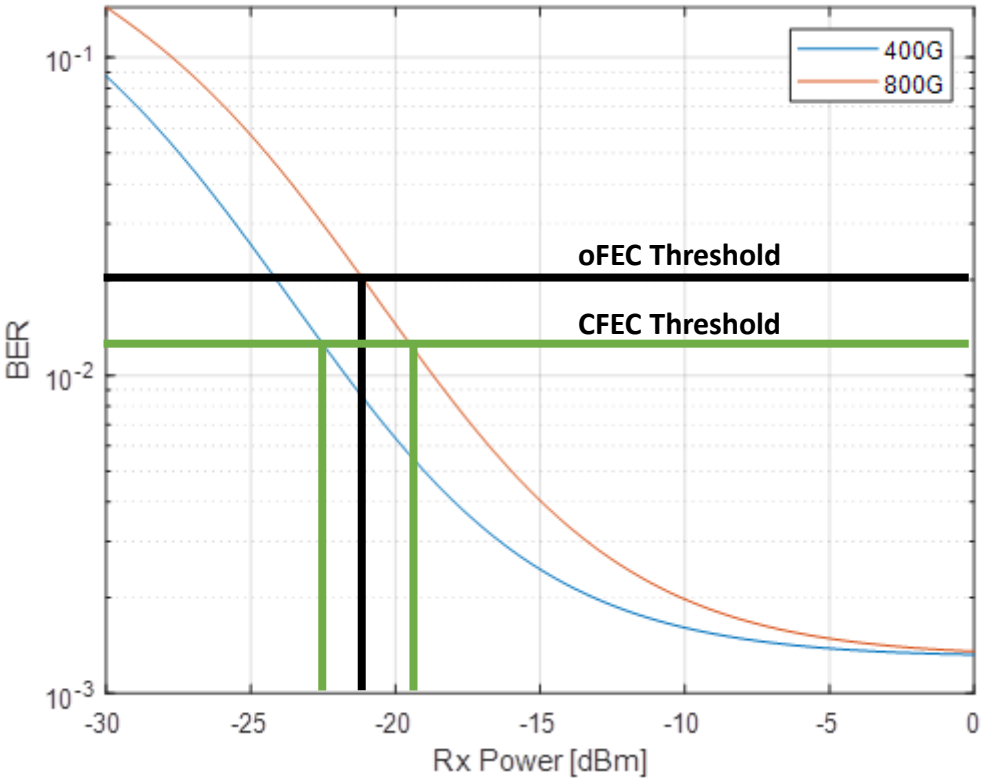
Observations:

- IEEE 802.3 has history of grouping technical solutions between reaches for leverage and economy of scale
- Lowest cost solution always used for highest volume reach (2km)
  - That solution generally extended to max reach possible
- History of grouping 10km & 40km when 2km solution not practical for those reaches (100G and 200G)
- No history of separate solutions for each reach

800ER (40km) Coherent Technical Feasibility

- OIF 400ZR specification includes an unamplified use case with an 11dB link budget
  - Unamplified use case was assumed to be niche in 400ZR and no effort was made to optimize link budget
  - Practical implementations have ~2dB margin to receive sensitivity specification
- Moving to 800G reduces sensitivity by ~3dB
- Selection of oFEC, as in OIF, can recover ~1.75dB
- Approximately -21dBm receive sensitivity is feasible
  - 11dB link budget with -10dBm transmit power
  - 21dB link budget with 0dBm transmit power
- Coherent technology offers flexibility to optimize the specification to best meet market requirements

Receiver performance with practical implementation penalty



800LR (10km) Approach

- Two approaches to supporting 10km reaches
  1. Leverage solutions from 2km applications
     - Approach used at 100G/400G
     - Custom optical implementation at 800G due to need for tighter CWDM grid for dispersion tolerance, not a binning exercise
     - Link budget is more challenging at higher data rates
  2. Leverage solutions from 40/80km (ER/ZR) applications
     - Common technology supporting multiple applications can drive economies of scale
     - Potential for more aggressive ER specification by screening highest performing parts, similar to FR/LR model in earlier generations

Industry will benefit from aligning on one solution for this market instead of fragmenting

Link Budget Considerations @ 1550nm

- 800ER
  - Fiber loss: x km @ 0.25 dB/km
  - Connector loss: 2 dB
  - Channel insertion loss: (x * 0.25) + 2 dB
    - 30km = 9.5 dB
    - 40km = 12.0 dB
- 800LR
  - Fiber loss: 10km @ 0.25 dB/km = 2.5 dB
  - Connector loss: 2dB
  - Channel insertion loss = 4.5 dB
  - Margin available for additional connector loss

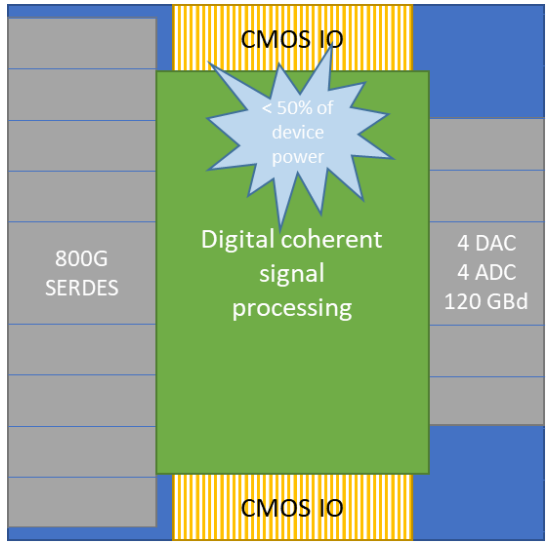
1550nm attenuation is 0.25dB/km compared to 0.43dB/km at 1310nm

Dispersion/DGD can be compensated with virtually no penalty, but need to discuss how to account for it in spec

Comparison of IC Area

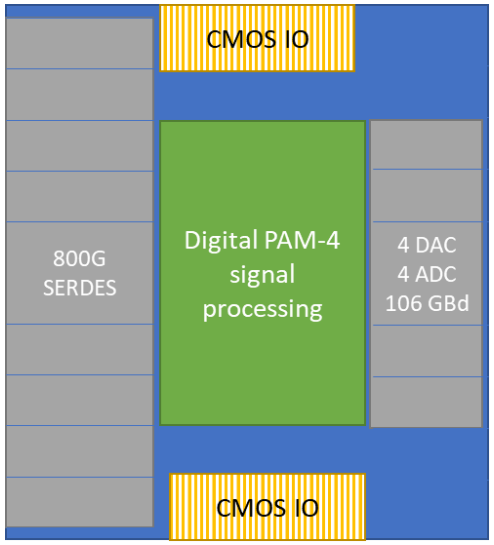
SERDES and DAC/ADC determine DSP area for these applications, not digital complexity

800G Coherent 16QAM DSP



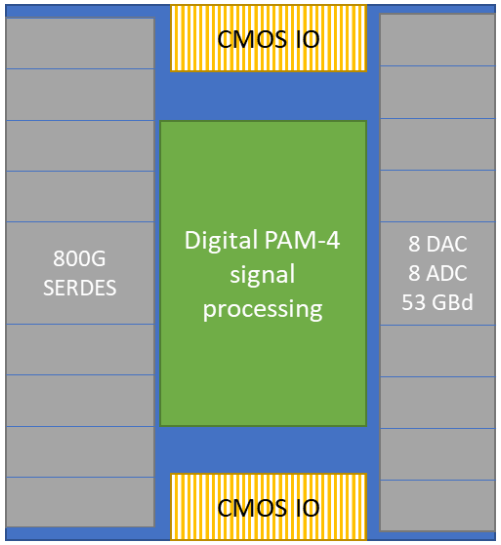
Relative size 1.15

800G 4λ PAM4 DSP



1.0

800G 8λ PAM4 DSP



1.1

Coherent 16QAM die area is similar to 4λ and 8λ PAM4

Comparison of Optics Complexity

- Modulator/Receiver
  - SiPh widely used in both coherent and direct detect implementations
  - Coherent 800G is a 4 lane technology
    - Nested MZ structure
    - Additional control required to maintain phase/amplitude relationship between lanes
    - Hybrid receiver configuration
  - Relative size of SiPh PIC

4λ PAM4	1.0
16QAM	1.25
8λ PAM4	2.0

- Laser
  - Coherent uses only one laser compared to 4 or 8 for direct detect
  - Fixed coherent laser is much simpler than full C-band tunable typically used for coherent applications
    - 1MHz linewidth or more can be utilized
  - Temperature control required for coherent and may be required for direct detect
  - 1550nm is assumed for LR to maintain commonality with ER
    - Lower fiber attenuation than 1310nm

Summary

- A stand-alone 800LR (10 km) solution may not have economic feasibility
- Achieving high yields at LR reaches is getting more challenging with direct detect at higher data rates
- Industry efforts are already defining coherent solutions that can address 10 – 40 km interfaces at 800G
  - Reuse of technology across multiple applications can drive economies of scale without excessive design burden
  - Although out of scope for current project, coherent technology also lends itself to potential future applications, such as campus interconnect, that may benefit from DWDM capability
- Propose working towards a baseline based on coherent technology to address both the 800LR (10 km) and the 800ER (40 km) SMF objectives