Considerations on the "10km @ 800Gb/s" objective

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Motivation

As summarized in the Chair's report in April, dambrosia_b400g_02_210426, the group has adopted the below objectives of physical layer specification.

- Adopted by B400G SG, Apr 2021
- Approval by 802.3 WG Pending

- Support a MAC data rate of 800 Gb/s
- Support full-duplex operation only
- Preserve the Ethernet frame format utilizing the Ethernet MAC
- Preserve minimum and maximum FrameSize of current IEEE 802.3 standard
- Define a physical layer specification that supports 800 Gb/s operation over 8 pairs of MMF with lengths up to at least 50 m
- Define a physical layer specification that supports 800 Gb/s operation over 8 pairs of MMF with lengths up to at least 100 m
- Define a physical layer specification that supports 800 Gb/s operation over 8 pairs of SMF with lengths up to at least 500 m
- Define a physical layer specification that supports 800 Gb/s operation over 4 pairs of SMF with lengths up to at least 500 m
- Define a physical layer specification that supports 800 Gb/s operation over 4 pairs of SMF with lengths up to at least 2 km
- Define a physical layer specification that supports 800 Gb/s operation over 4 wavelengths over a single SMF in each direction with lengths up to at least 2 km
- Define a physical layer specification that supports 800 Gb/s operation over a single SMF in each direction with lengths up to at least 10 km
- Define a physical layer specification that supports 800 Gb/s operation over a single SMF in each direction with lengths up to at least 40 km

Observations

- **Need to draft responses to criteria – and ensure all claims can be supported**
- **10 km / 40 km @ 800 Gb/s Objectives**
  - **Technical feasible?**
  - **Economical feasible?**
  - **Supporting presentations?**

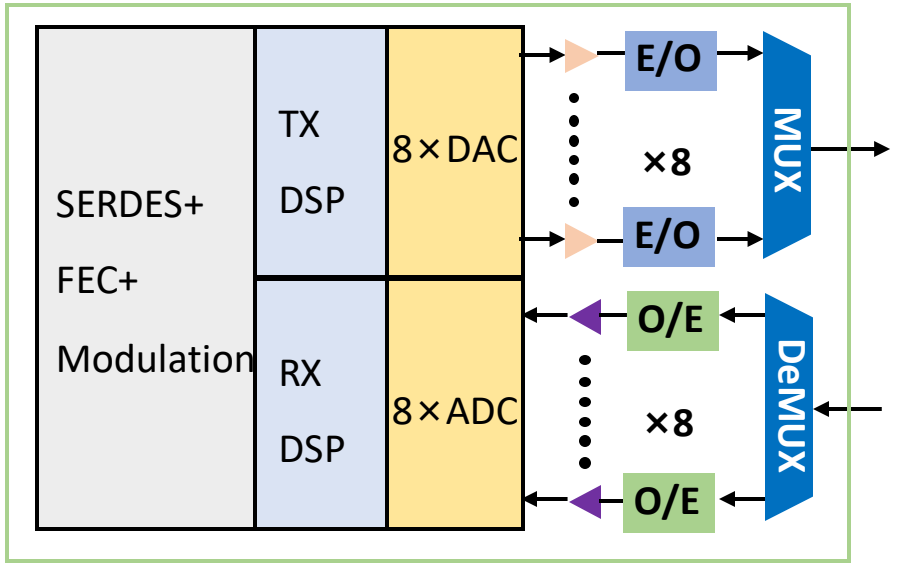
This contribution discusses several feasible schemes, targeting at technical feasibility for the objective:

- 800Gb/s over a single SMF in each direction with length up to at least 10 km.

Option 1 for 10km @ 800Gb/s

800G LR8 using 8 wavelengths over a single SMF in each direction with lengths up to at least 10 km:

- Low-cost and energy-efficient direct detection solution, reusing the 50GBaud optics;
- Preferring LWDM over CWDM due to smaller chromatic dispersion for the edging wavelengths at O Band;
- Leveraging the FEC and DSP of 400GE;
- Requiring 8×cooled lasers.



Option1: 800G-LR8

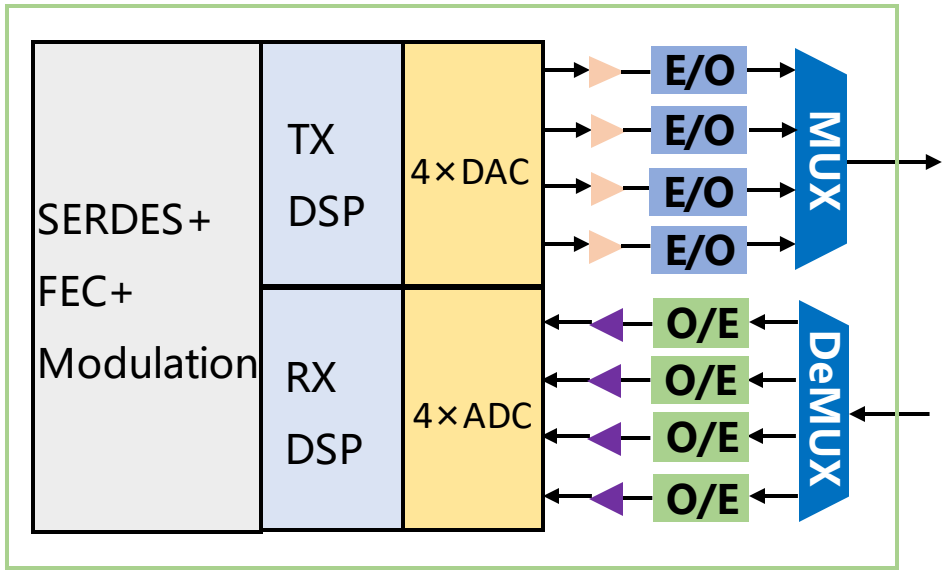
Item	Parameter
Modulation format	PAM4
Symbol rate	53GBaud
The number of DAC/ADC pairs	8/8
The number of lasers/transceivers	8
Wavelength	1273.54nm, 1277.89nm, 1282.26nm, 1286.66nm, 1295.56nm, 1300.05nm, 1304.58nm, 1309.14nm

1. http://100glambda.com/.
2. Shigeru Kanazawa *et al.*, "High Output Power and Compact LAN-WDM EADFB Laser TOSA for 4× 100-Gbit/s/λ 40-km Fiber-Amplifier-Less Transmission," 2020 OFC.

Option 2 for 10km @ 800Gb/s

800G LR4 with 4 wavelengths over a single SMF in each direction with lengths up to at least 10 km:

- Halved optoelectronic components compared with Option 1;
- Preferring the use of LWDM due to increased chromatic dispersion penalties at higher symbol rate;
- Requiring larger bandwidth components and stronger FEC than KP4.



Option2: 800G-LR4

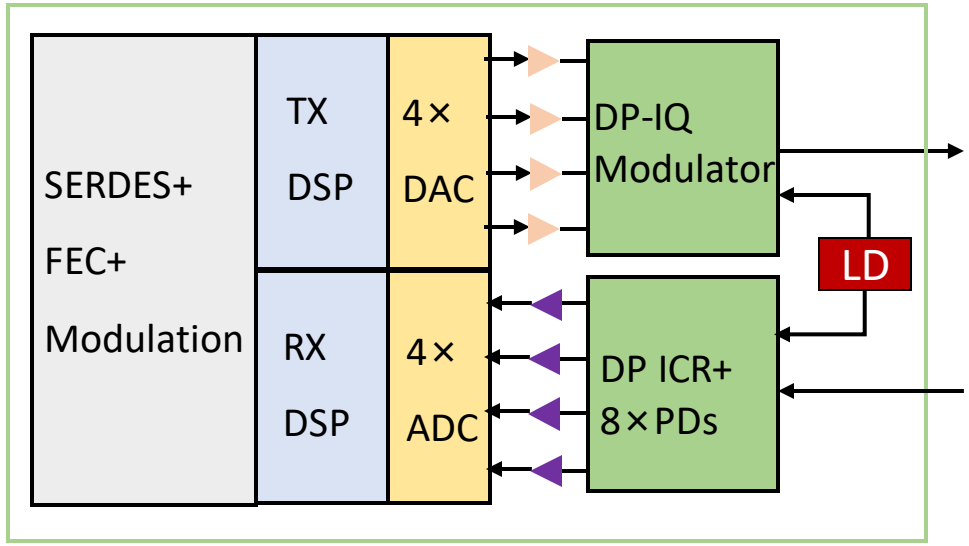
Item	Parameter
Modulation format	PAM4
Symbol rate	112.5GBaud
The number of DAC/ADC pairs	4/4
The number of lasers/transceivers	4
Wavelength	1295.56nm, 1300.05nm, 1304.58nm, 1309.14nm.

1. 800G Pluggable MSA: https://www.800gmsa.com/
2. J. Zhang *et al.*, "280 Gb/s IM/DD PS-PAM-8 transmission over 10 km SSMF at O-band for optical interconnects." 2020 OFC.
3. Shigeru Kanazawa *et al.*, "Transmission of 214-Gbit/s 4-PAM signal using an ultra-broadband lumped-electrode EADFB laser module." 2016 OFC.

Option 3 for 10km @ 800Gb/s

800G LR1 utilizing single wavelength over a single SMF in each direction with lengths up to at least 10 km:

- Digital coherent detection with 800Gb/s per lane;
- Preferring C band wavelength, due to the relatively low fiber loss and the effective chromatic dispersion compensation by coherent DSP;
- Requiring 100GBaud+ optoelectronic components.



Option3: 800G-LR1

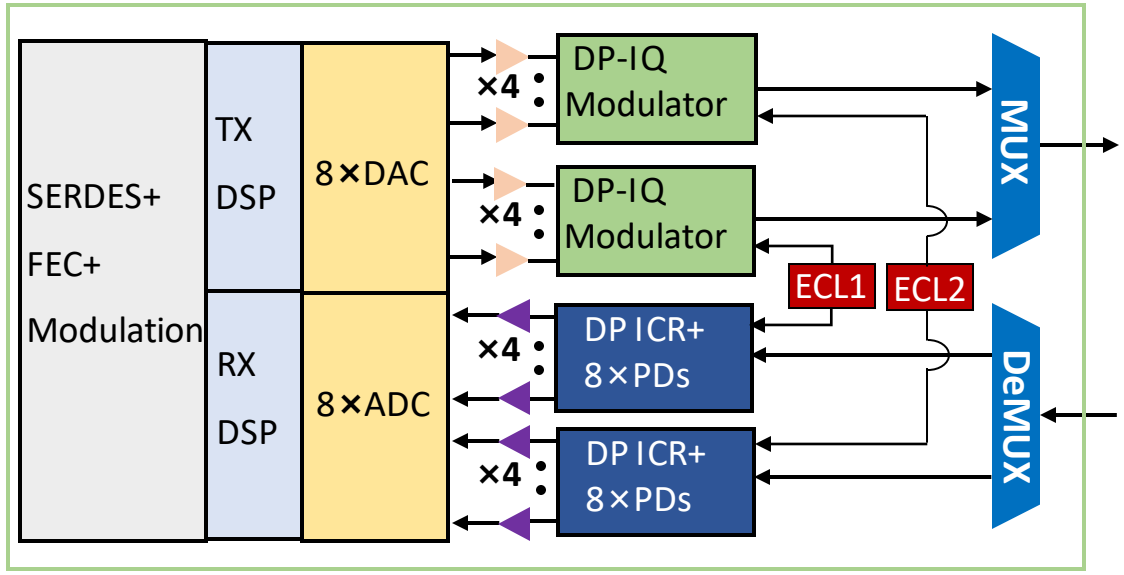
Item	Parameter
Modulation format	DP-16QAM
Symbol rate	116GBaud
The number of DAC/ADC pairs	4/4
The number of lasers/transceivers	1
Wavelength	C band, e.g. 1547.72nm

800LR: https://www.oiforum.com/technical-work/hot-topics/800g-coherent/

Option 4 for 10km @ 800Gb/s

800G LR2 with 2 wavelengths over a single SMF in each direction with lengths up to at least 10 km:

- Digital coherent detection with 400Gb/s per lane, leveraging current 400ZR ecosystem;
- The challenges of size and power consumption for QSFP-DD/OSFP;
- Requiring two narrow-linewidth ECLs.



Option 4: 800G-LR2

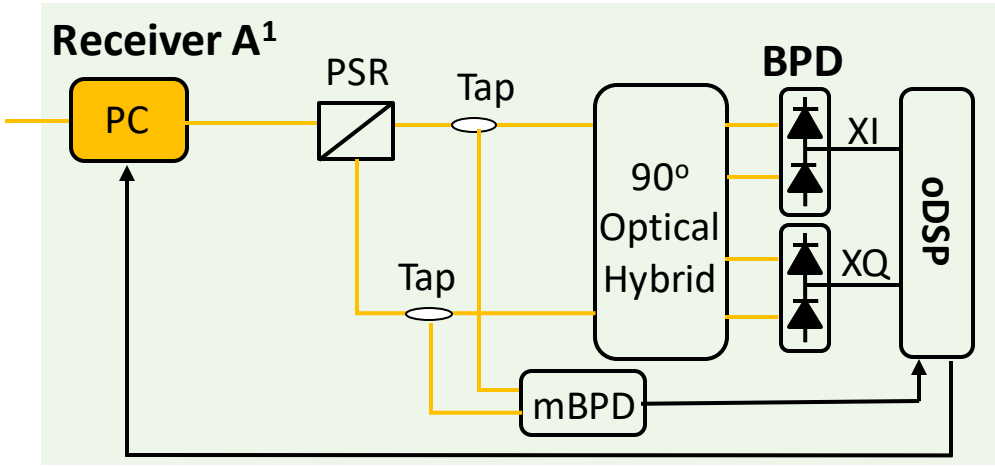
Item	Parameter
Modulation format	DP-16QAM
Symbol rate	60GBaud
The number of DAC/ADC pairs	8/8
The number of lasers/transceivers	2
Wavelength	Two adjacent channels at C Band, e.g. 1547.72nm, 1548.51nm

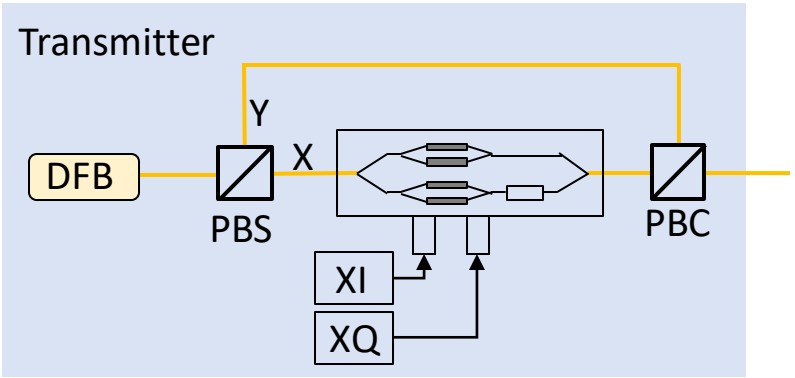
IEEE P802.3cw: https://www.ieee802.org/3/cw/index.html

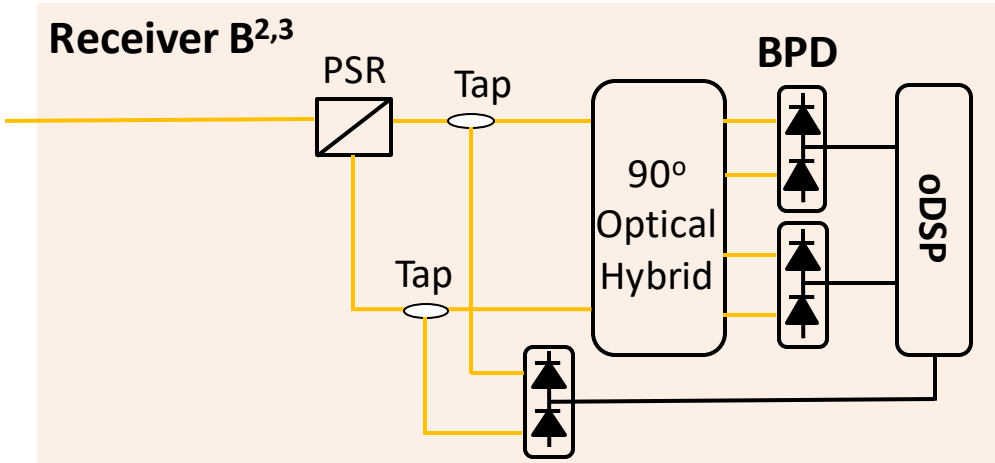
Option 5 for 10km @ 800Gb/s (1/2)

800G LR4 with 4 wavelengths over a single SMF in each direction with lengths up to at least 10 km:

- Self-homodyne detection (SHD) with 200Gb/s per lane;
- PC (polarization controller) in receiver A can be integrated with single-polarization ICR;
- Besides receiver B, other types of SVDD receiver structure can also be used.





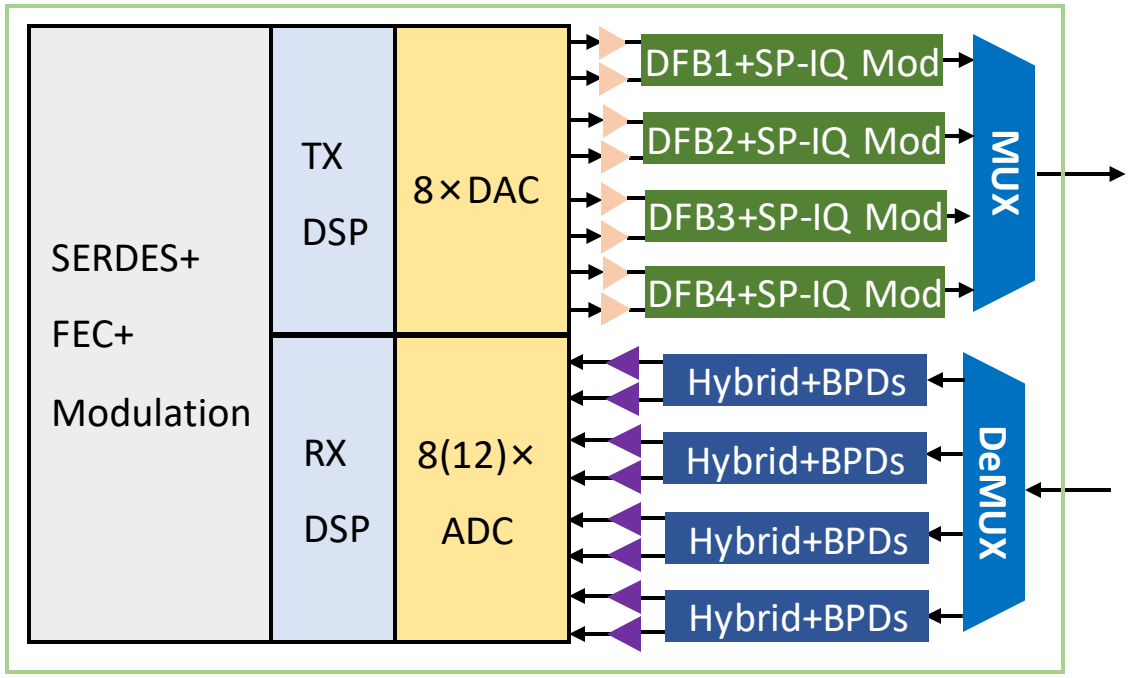


1. Y. Wen *et al.*, Optics Express, 28(15), 21940-21955.
2. W. Shieh *et al.*, APL Photonics 1(4), 040801 .
3. S. Zhang *et al.*, "224-Gb/s 16QAM SV-DD Transmission Using Pilot-Assisted Polarization Recovery with Integrated Receiver," in 2021 OFC, paper W7F.4.

Option 5 for 10km @ 800Gb/s (2/2)

800G LR4 with 4 wavelengths over a single SMF in each direction with lengths up to at least 10 km :

- Self-homodyne detection (SHD) with 200Gb/s per lane;
- Reusing four uncooled DFB lasers (O Band CWDM4) and simple DSP;
- Newly designed transceiver architecture.



Option 5: 800G-LR4

Item	Parameter
Modulation format	SP-16QAM
Symbol rate	60GBaud
The number of DAC/ADC pairs	8/8(12)
The number of lasers/transceivers	4
Wavelength	1271nm, 1291nm, 1311nm, 1331nm

Feasible Schemes for 10km @ 800Gb/s

Scheme	8×100Gb/s Direct Detection	4×200Gb/s Direct Detection	1×800Gb/s Coherent	2×400Gb/s Coherent	4×200G SHD
Wavelength	LWDM	LWDM	Fixed λ (C Band)	Fixed λ_1, λ_2 (C Band)	CWDM
Laser	8×Cooled DFBs	4×Cooled DFBs	1×Cooled ECL	2×Cooled ECLs	4×Uncooled DFBs
DAC/ADC pairs	8/8	4/4	4/4	8/8	8/8(12)
Symbol Rate	53GBaud	112.5GBaud	116GBaud	60GBaud	60GBaud

Summary

This contribution discusses several schemes, which are technically feasible for the objective that 800Gb/s over a single SMF in each direction with length up to at least 10 km:

- IMDD-based schemes with single lane rate of 100Gb/s or 200Gb/s coupled with LWDM is feasible for 10 km @ 800Gb/s, leveraging the low dispersion.
- 800G-LR with single lane rate of 800 Gb/s is another option and has been discussing by the industry.
- 800G-LR2 multiplexing two 400Gb/s coherent modules is also technically feasible.
- Self-coherent detection scheme, using four low-cost uncooled DFB lasers and simple DSP, can also support this objective.

Thank you.