Update on key technical decisions for the 802.3dj coherent optical objectives

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IEEE P802.3dj

September 2023 Interim

Overview

Several key technical decisions remain in order to adopt coherent baselines for 802.3dj 10 & 40km single wavelength objectives

The following have been adopted:

- BCH FEC for the 10km objective
- DP-16QAM signaling for the 40 km objective

Key items to be resolved to adopt baselines include:

- Wavelength(s) for the 10km & 40km objectives
- FEC for the 40 km objective
- Number of lasers/frequency accuracy for each implementation

This contribution provides information on the open items, and some of the pros/cons of the options

Wavelength selection: O band vs C band

Based on information presented[1], the following loss coefficients are assumed:

- O band 0.43 dB/km
- C band 0.28 dB/km

Based on these loss coefficients, the following fiber losses are determined[2]:

- 10km: O band 4.3 dB, C band 2.8 dB
- 40km: O band 17.2 dB, C band 11.2 dB

For the 40km objective, the reduced loss allocation in C band provides a substantial advantage in technologies:

- Both FEC schemes proposed for 40km require optical amplification in the module's Tx
- C band losses enable either micro EDFA's or SOA's to meet the power budget

1: https://www.ieee802.org/3/dj/public/adhoc/optics/0423_OPTX/stassar_3dj_optx_01a_230427.pdf
2: https://www.ieee802.org/3/dj/public/23_07/maniloff_3dj_01a_2307.pdf

10km Wavelength selection

At 10 km, the expectation is that we will have the same optical power budget for either wavelength selection

- As discussed in the 802.3cu Task Force, many applications of LR parts require the loss rather than the reach

C band for 10km reduces the fiber loss by 1.5 dB compared to O band

- This provides additional loss budgets for other optical components, such as optical switches

O band for 10km provides potential pathways for reduction of module power

- Reduced Chromatic Dispersion at 10km allows the potential for time domain DSP

Power reduction opportunities may be limited:

- Symbol rate ADC has prohibitive penalty for skew > 3 ps [Ref 3]
- Estimates of practical power savings for low CD shows little difference [Ref 4]
  - Rx equalization is estimated at ~25% of total DSP power, complexity of solutions results in a small difference

3: https://www.ieee802.org/3/dj/public/23_05/gui_3dj_01a_2305.pdf
4: https://www.oiforum.com/get/53782

C vs O band DSP analysis

Analysis of the impacts of skew were modeled (see ref 4) with the following assumptions

- Tx and Rx Polarization skew = 2.5 or 5 ps.
- Fiber DGD mean = 1.6 ps

Resulting Maximum Polarization skew at Rx ~8 to 13 ps. Based on analysis this is ~3-5x too large for sample rate ADC designs

Band selection requires information on realistic O band power savings, to compare to loss savings in C band

C band has potential advantages in re-use of technologies from other coherent designs and 40km interop

More data is needed to make determination for 10 km wavelength

40km FEC selection

BCH FEC has been adopted for 10 km

- BCH FEC has latency and power savings, and is an Ethernet optimized design

OFEC and BCH have been proposed as options for 40km

- Both schemes meet the loss budget, with similar optical implementations based on Tx amplification
- OFEC has a reach advantage equivalent to ~6km fiber

OFEC is being implemented in OIF for 800ZR DWDM applications

- These designs could be reused for 800GBASE-ER1 with a fixed laser

The power savings of BCH for 10km are still relevant for 40km

Using the same logical design for 10 & 40km in 802.3dj potentially allows 10/40km interop

- Consistent with IEEE 802.3 approach for previous rates see: https://www.ieee802.org/3/dj/public/23_05/nowell_3dj_02_2305.pdf

Number of lasers / frequency accuracy

Currently coherent designs use a single shared laser for Tx & Local Oscillator

Laser frequency accuracy of ≤ ~1.8 GHz is needed in DWDM systems to avoid adjacent channel crosstalk

Rx frequency acquisition & operating range allows worst case offsets between the two lasers

A DFB laser +TEC results in potential cost savings see:

- https://www.ieee802.org/3/df/public/22_11/maniloff_3df_01_2211.pdf

Relaxing laser frequency spec to ≥ ± 10 GHz should be considered for optimal designs

Potential Laser Solutions

Two approaches exist to using lasers without lockers:

- Two laser solution with Rx lasers tracking to match Tx frequency
- Single laser solution with tracking parameters defined to allow both ends to tune

Determining the laser strategy is important to adopting baselines:

- Impacts potential Rx frequency tracking requirements
- Acquisition with large frequency offsets needs consideration
- Potential optimization of optical power budgets

Two laser solutions bring potential advantages:

- Bidirectional support (2 wavelength)
- Improved optical power budget

Both 10 & 40km solutions should consider these options, and select optimal solutions for single wavelength applications

Summary

Several key items remain to be resolved to adopt baseline specifications for the 802.3dj coherent objectives

10 km Wavelength:

- Needs comparison for O band power savings to weigh against C Band advantages

40 km FEC:

- Both OFEC and BCH FEC can meet the 40km reach objectives
- Reuse of 800ZR design needs comparison to a potentially power optimized Ethernet solution

Laser implementation:

- Moving to a simplified laser approach will help coherent proved optimal single channel solutions
- Separate Tx/Rx lasers have an advantage in simplified tracking of larger frequency offsets

Thanks!