FEC Choices for 802.3ca

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Optical power budget gap in 802.3ca

- There is a power budget gap for signal channel 25G EPON
  - The gap could be filled with combination of FEC gain, higher TX power and higher RX sensitivity
- Power budget gap for multi-channel 50G and/or 100G is bigger and more difficult to fill
  - FEC alone cannot composite WDM mux/dmux loss
  - SOA is needed; channelized SOA may be needed because of the 20nm width. The cost is a serious concern.
- The signal channel 50G EPON with PAM4 modulation needs a SOA to compensate the 4-5 dB PAM4 power penalty.
  - The gap may be easier to fill with SOA

This contribution discusses the FEC choice for 25G EPON, 50G EPON, 100G system point of view

FEC proposals for 25G

- BCH, RS and LDPC have been proposed
- Recent debates were focused on the choices between RS and LDPC
- One opinion was to use higher FEC code gains possible to loosen the spec on TX power
- Other opinion was to choose small code size FEC to lower the latency
- No convergence on the subject yet
- The 50G PAM4 will add another consideration to FEC choices

Code gains, latency, complicity and 50G PAM4 may need considering together along with the applications

FEC code gains, latency and complexity

FEC code gains and latency*

	Length	Rate	NECG [1] (dB)		M Gates (approximately)	Latency (μsec)
			AWGN	Gilbert Burst		
LDPC	(18493,15677)	0.848	2.46	1.85 [2]	Encoder(E): 0.15 to 0.3 Decoder(D): 1.5	E: 2.0 + 0.77 (buffer) = 2.77 D: 2.15 + 0.77 (buffer) = 2.92 [4] Total = 5.69 [5]
RS	(1023, 847)	0.83	1.34	1.35	1.06	E+D: 0.77
RS	(2048,1536)	0.75	1.8 [3]	-na-	3.3	E+D: 1.54

* laubach_3ca_1a_0917.pdf

- **The code gains for AWGN of LDPC (184931,15677) is 0.66dB (36%) higher than RS (2048,1536)**
- **The latency of LDPC (184931,15677) is 4.15us (269%) longer than RS (2048,1536)**
- **Implementation of LDPC is more complicated**

Applications of LDPC and RS

- The Low Density Parity Check code was first introduced in 1960's. It's practical implementations didn't happen only until recent years
- The LDPC is mostly used in copper and wireless system due to its good performance in these channels
  - DVB, G.hn, EPOC, DOCSIS 3.1, etc.
- LDPC was used in delay insensitive network/system such as broadcast, home network, residential access network, etc.
- RS has been used in fiber optical communication system, long-haul, metro and access

LDPC or RS for 25G EPON?

- The power budget gap of 25G can only be filled with FEC code gains and higher TX power (fix APD RX sensitivity. No optical amplification)
- The emerging killer applications of high-speed PON, such as 25G EPON, may be in the network transport section, for example 5G mobile fronthaul and backhaul.
- Low latency is essential for these applications
  - 5G mobile fronthaul latency budget allocated for PON section ~ 250us
  - Although FEC delay is a small portion, but it can't be reduced once it is there
- Transmitter technology has been improving, leave the 0.66dB power budget difference to TX is feasible

Choose small code size FEC for lower latency for network transport applications

LDPC or RS for 50G PAM4?

- In order to compensate the 4 to 5 dB power penalties of PAM4, optical amplification, such as SOA, is needed for 50G serial PON
- The power budget gap can be easily filled with proper choose the optical amplification gains
- LDPC has no advantage for 50G PAM4 in comparison with RS
  - LDPC has higher latency, higher complexity
  - The extra code gain of LDPC is covered by SOA
- RS is a better choice for 50G PAM4

Conclusions

- **Low latency is essential for emerging network transport applications for 25G and 50G EPON**
- **For 25G EPON with NRZ, choosing a small FEC code size to lower latency and leverage TX power is an optimized solution**
- **For 4x25G since SOA are needed, RS is a better choice**
- **For 50G EPON with PAM4, RS is a better choice**

Thanks

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