FEC Selection Considerations

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Introduction

- Power [loss] budget finalization and FEC selection remain co-dependent
  - FEC can improve budget at a lower cost than optical components.
  - Can we decide on stronger FEC constraints to permit lost budget to go to baseline?
- effenberger_3ca_1_1115
  - overviews “FEC gain gap” (“loss budget gap”)
  - presents several FEC codes for +1dB and +2dB electrical gain over 10G-EPON FEC
- houtsma_3ca_1_0916
  - overviews pre-coding need, NRZ impact
  - need for +1dB to +2 dB improvement, overhead limit between 13% to 20%, +’s favors RS, and more.

FEC Considerations / Decisions

- Both presentations were exploring +1dB to +2dB gain. Therefore raise bar >= 1.0dB
  - Pro's: potential margin increase for loss budget and component variation, optical budget drives costs. Coding Gain is the highest priority in the selection of a code.
- Code rates presented so far range from 87% to 70%.
  - Upstream should support a minimum of 2 * 10Gb/s links, with optical, MPCP, framing, OAM overheads.
  - Maximum FEC overhead is approximately ~18% (82% coding rate) with 25.78125 GBd
- Codeword size range of 2k to 4k bytes
  - Provides a workable balance of decoding latency, complexity, and Net Effective Coding Gain(NECG).

FEC Considerations / Decisions

- Downstream and upstream use the same single FEC code
  - Pro's: optimizes development and validation/testing relative costs, single decoding block per lane, loopback paths, equal decoding latency
  - Con: higher overhead for shorter frames in upstream
- Shortened last codeword for upstream FEC
  - Short codeword US option for Reporting efficiency
  - Requires field to convey final codeword block size that is tolerant to errors outside of the FEC
- Avoid multiple upstream FEC block codes
  - i.e. used in EPoC to increase upstream efficiency
  - Additional complexity to determine data length within grant. Also requires protected field or buffering to convey block size.
- How much optimization is necessary in the upstream?
  - Optical overhead dominates burst mode efficiency.
  - Fragmentation maintains efficiency. No longer have efficiency loss due to frame length alignment.

Still Needed

- Full overhead study
- Die size / power relative comparisons
- 25GHz serial rate capable at reasonable relative cost / size / etc.

- Question:
  - Are there any other FEC coding technologies that can be used that offer compelling performance?
  - Would the Task Force be open to exploring / selecting any if found?

Introduction: Folded BCH

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Folded BCH Overview

- Developed and used as ECC for FLASH memory
  - Provides higher NECG for a given code rate
  - Market is driving BER to be better than 10^{-15}
  - Lower power than LDPC
  - Speeds in excess of 3+GB/s (24+Gb/s)
  - No BER floor
  - Based on BCH t<=3 codes

Folded BCH Product Capabilities

FEC Code	Length (bits)	Code Rate	Electrical Coding gain(dBe) @E-12
RS(2047,1431)	10230	0.7	9.6
BCH(4095, 3081)	4095	0.75	9.6
BCH(186,161) X BCH(209,184)	38874	0.76	10.5
Folded Product Code	16384	0.8	10.1
RS(1023,847)	10230	0.83	8.5
LDPC(19200,16000)	19200	0.83	9.6
Folded Product Code	36864	0.83	9.9
Folded Product Code	16384	0.83	9.7
BCH(4095, 3501)	4095	0.85	8.5
Folded Product Code	36864	0.85	9.7
Folded Product Code	16384	0.85	9.4
LDPC(8000,6848)	8000	0.86	8.8
LDPC(16000,13952)	16000	0.87	8.9
Folded Product Code	36864	0.87	9.4
Folded Product Code	16384	0.87	9.2
Folded Product Code	36864	0.9	9
Folded Product Code	16384	0.9	8.6

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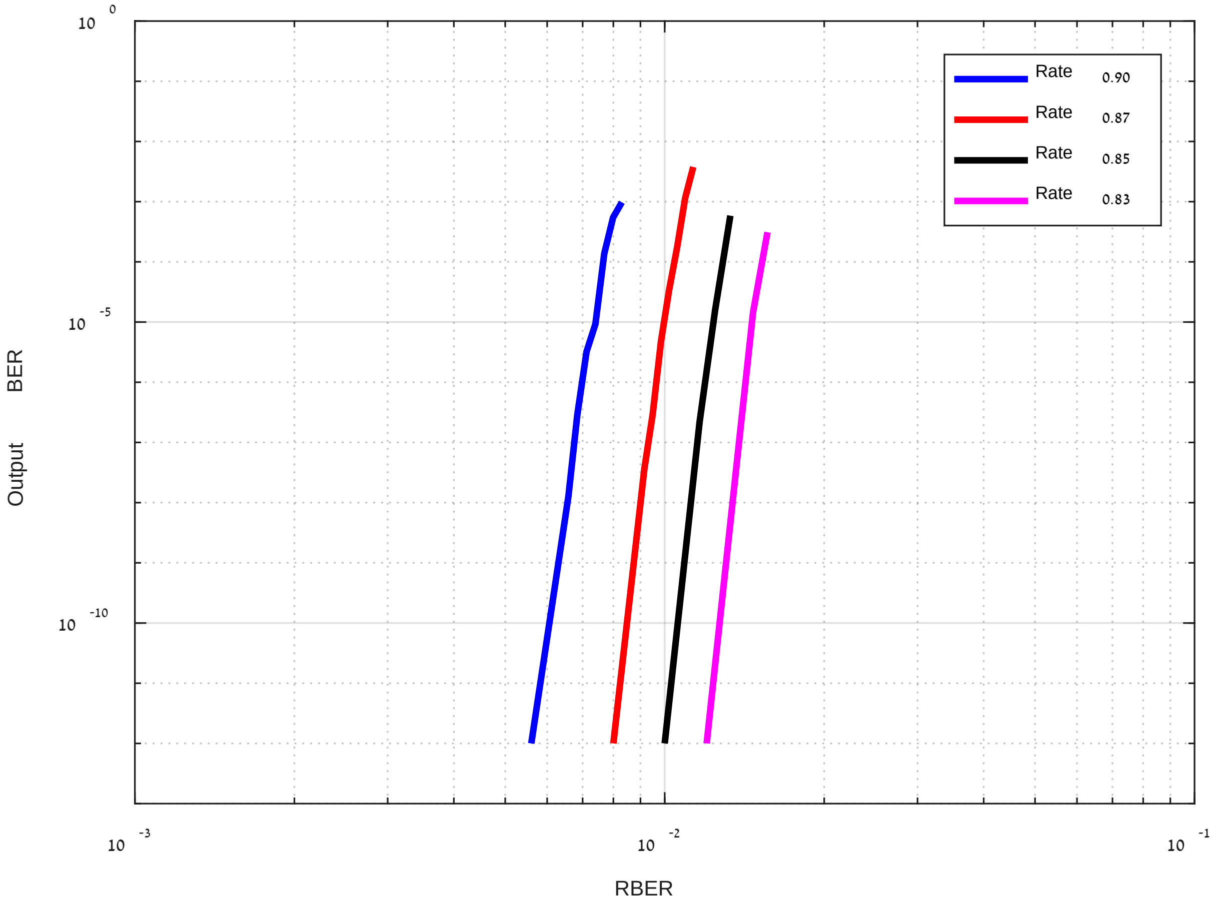
Folded BCH HARD Decoding Capabilities
4KB Codeword Size, Various Rates

- Supported input RBER for output BER $< 10^{-12}$

Code Rate	Length (Bits)	RBER	Coding Gain [dB] @1E-12
0.83	36864	1.2E-2	9.9
0.85	36864	1E-2	9.7
0.87	36864	8E-3	9.4
0.9	36864	5.6E-3	9



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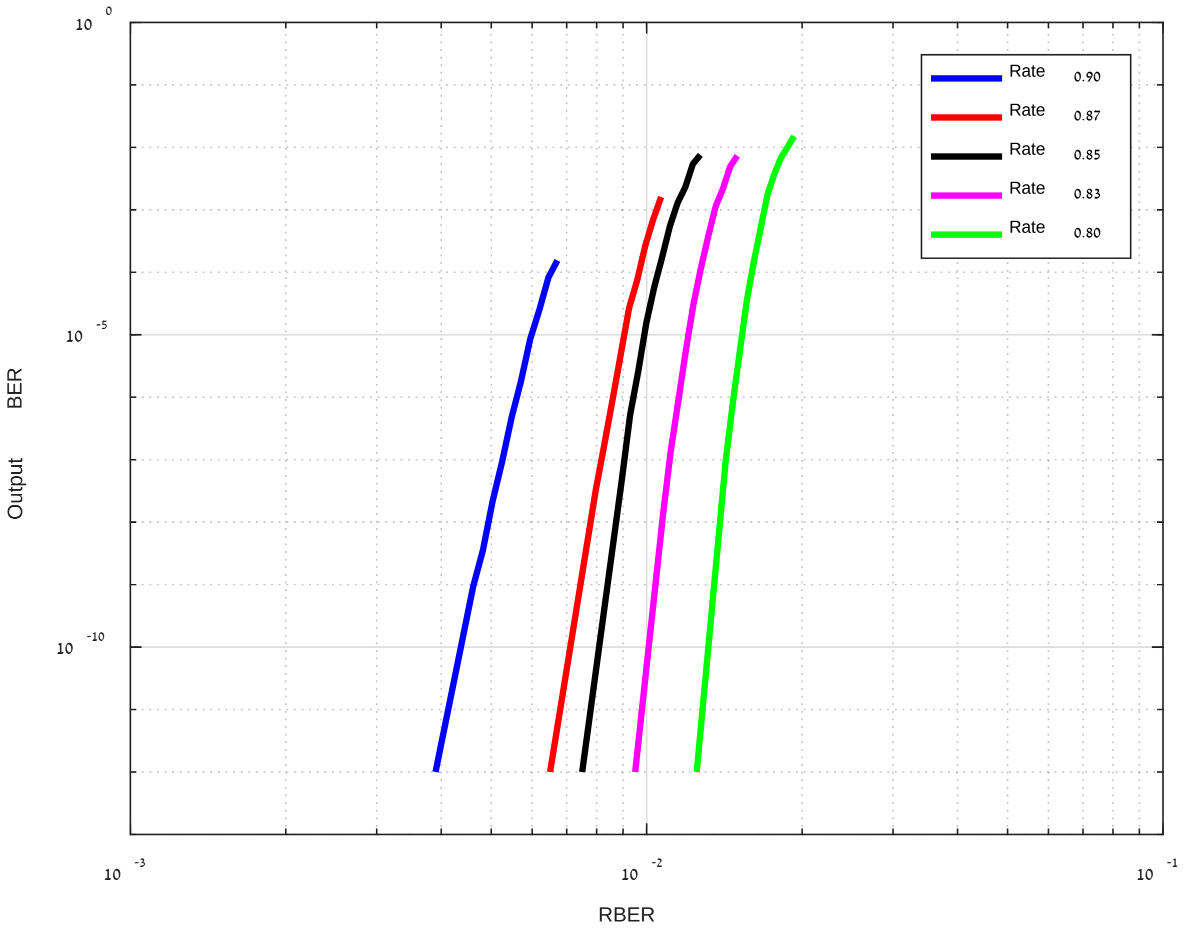
Folded BCH HARD Decoding Capabilities
2KB Codeword Size, Various Rates

- Supported input RBER for output BER $< 10^{-12}$

Code Rate	Length (Bits)	RBER	Coding Gain [dB] @1E-12
0.8	16384	1.25E-3	10.1
0.83	16384	9.5E-3	9.7
0.85	16384	7.5E-3	9.4
0.87	16384	6.5E-3	9.2
0.9	16384	3.9E-3	8.6



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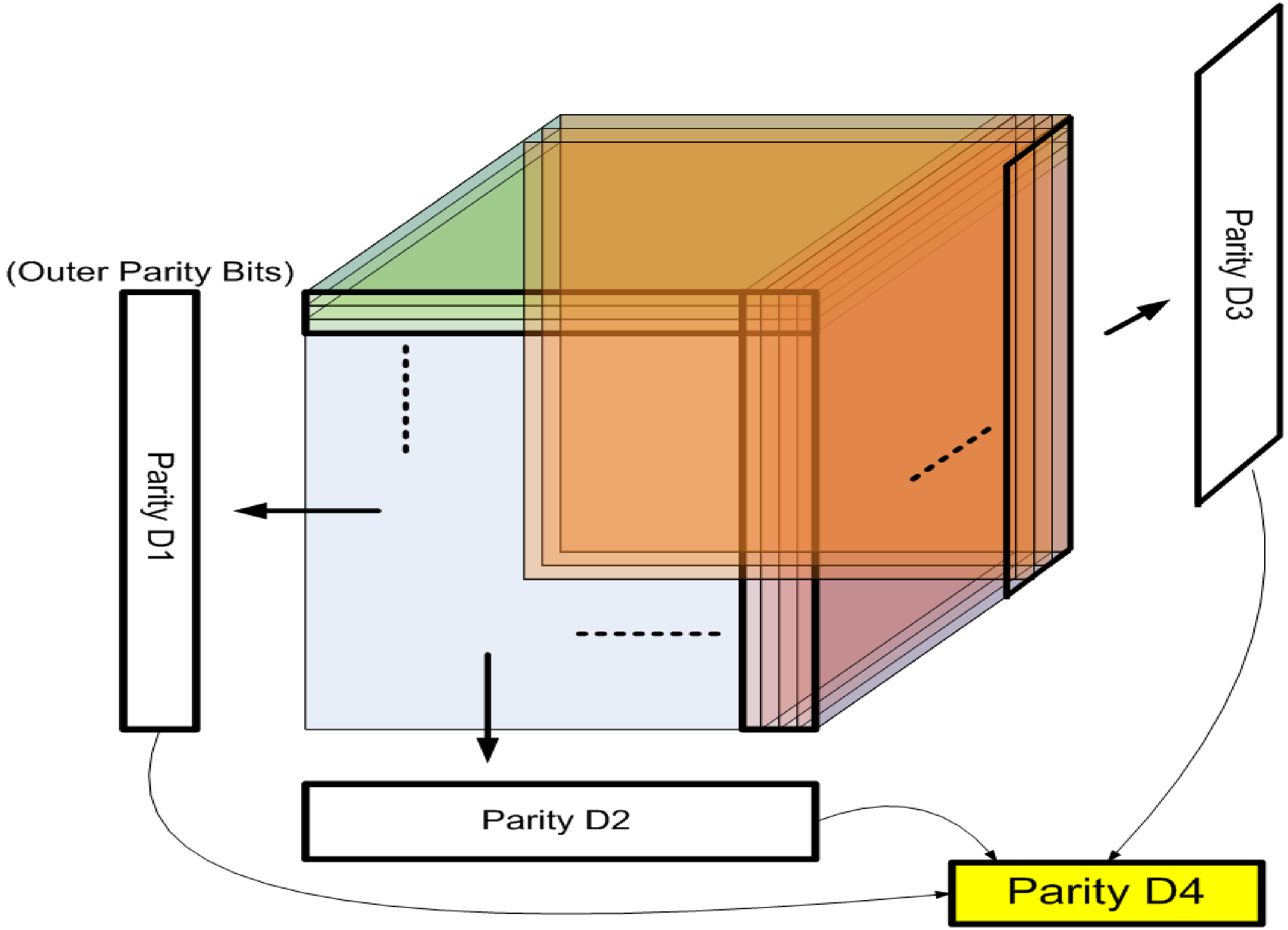
3D Encoding with Folded-BCH Components



Summary

- Presented considerations for FEC selection criteria and sizing
- Proposing:
  - Same FEC code and codeword for downstream and upstream
  - Single codeword size selected between 2K bytes and 4K bytes
    - Smallest codeword size that meets performance / gain / rate objectives minimizes US Report overhead
  - Raise performance expectation in range of +1dB to +2dB better than 10G-EPON (RS(255,223), 7.1dB)
  - Aim for 15% to 13% overhead
- Presented overview of Folded BCH for flash memory
  - Better performance than RS/BCH/LDPC for same codeword sizes and rates
  - Expect more details at future TF meetings.

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Straw Poll x

- Same FEC code and codeword size for downstream and upstream.

- Yes:
- No:
- Abstain:

Straw Poll x+1

- Single codeword size will be selected from range 2K bytes <= size <= 4K bytes. Not precluding shortened last codeword.

- Yes:
- No:
- Abstain:

Straw Poll x+2

- FEC performance to be in range of +1dB to +2dB better than 10G-EPON (RS(255,223), 7.1dB)

- Yes:
- No:
- Abstain:

Straw Poll x+3

- Desired total overhead limited to support minimum bi-directional 20Gb/s “unobstructed” (at 25.78125 GBd signaling rate).

- Yes:
- No:
- Abstain:

Thank You!

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