FEC for Upstream: 8K LDPC Code

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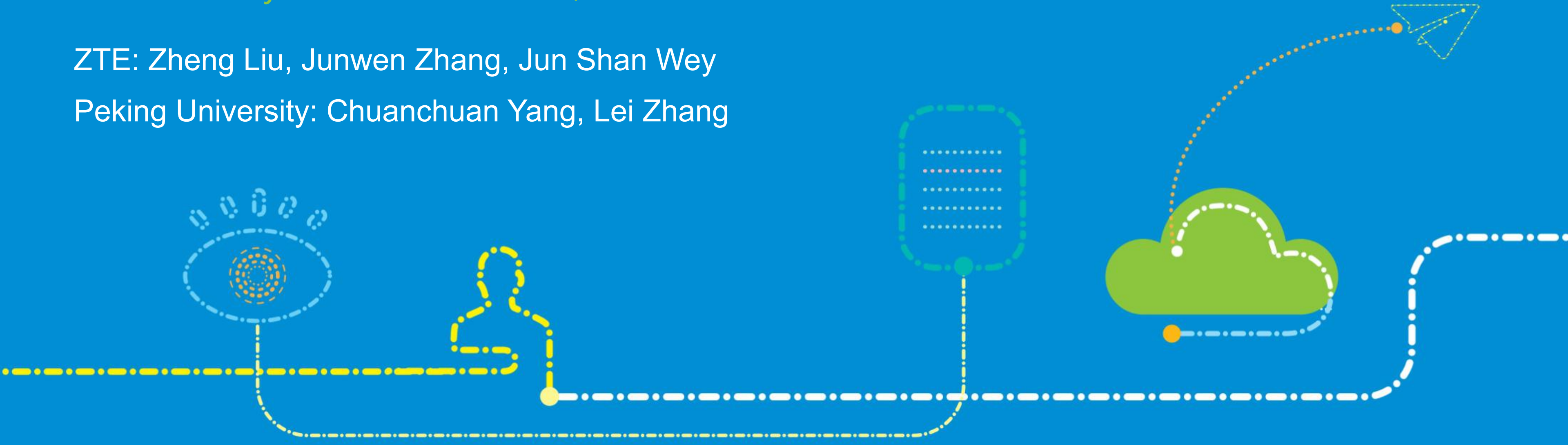


Introduction

This contribution presents an FEC proposal for NG-EPON upstream

- Background and Requirements
- 8K LDPC codebook
- Complexity and Latency Analysis
- Summary

Background and Requirements

- In the Nov 2017 meeting, the 802.3ca Task Force decided to adopt LDPC FEC for downstream (laubach_3ca_1a_1117, laubach_3ca_1_0517). However, no FEC coding scheme has decided for upstream
- For upstream, shorter code length (<18K) is preferred to reduce the latency. Further analysis is needed to determine the code performance and code rate (bonk_3ca_1_1117)
- In this contribution, we present a 8K LDPC coding scheme with improved performance in latency and computation complexity.

ZTE

8K (8*40*200) LDPC codebook

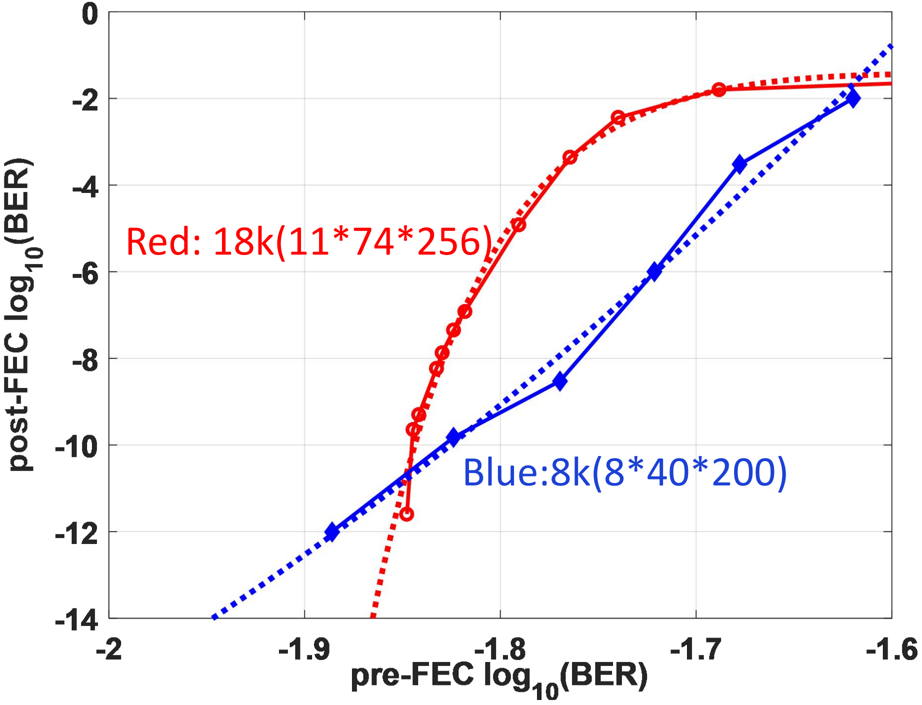
Codebook information

column num	row num	sub-matrix size	codeword length	parity length	information length	max of row weight	max of col weight	code rate
40	8	200	8000	1600	6400	25	7	0.8

Advantages:

- Shorter codeword allows for lower complexity and latency when decoding
- Sparsity of H matrix is maintained compared with 18K LDPC code, thus reduce memory usage during encoding
- Dual-diagonal parity structure enables both forward and backward iteration to generate parity bits, thus the encoding time is shortened

Simulation of BER performance



- Channel model: AWGN
- Simulation result for LDPC code is based on soft decision input
- 8K code is capable of correcting error rate to 1e-12

Complexity is reduced by 67% comparing to 18K LDPC code

Complexity of Single iterative step:

Number of Add Operation	Number of Sign Operation	Number of Find Minimum Operation
row_num*row_weight*2	row_num*row_weight	row_num*row_weight*2

Complexity depends on row_num and row_weight:

	18k(11*74*256)	8k(8*40*200)
row_num	2816	1600
row_weight	34.7	19.75
Complexity (row_num*row_weight)	99,715	31,600

Ref: Single-Scan Min-Sum Algorithms for Fast Decoding of LDPC Codes, IEEE Information Theory Workshop, Chengdu, China, 2006

End-to-end latency depends on many factors

Encoding and Decoding Latency:

- Pre-FEC BER=1e-2
- Post-FEC BER<1e-12
- All values are an average over 1000 simulation results

I/O Latency of Decoder:

- Directly proportional to the codeword length
- Each bit of codeword is read by the decoder in one clock cycle

	LDPC(8*40*200)	LDPC(18944,16128)
Encoding	0.67	1
Decoding	0.30	1
I/O latency of decoder	0.42	1

Summary

- An 8K LDPC(8*40*200) code length is a good choice for upstream direction
- Comparing to 18K LDPC code
  - Code rate is 0.8
  - 8K code is capable of correcting error rate to 1e-12
  - Complexity is reduced by 67% (33% of 18K code)
  - End-to-end latency is also much reduced
- We propose to compare potential short codewords before making the final selection for upstream

Thank You!

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Codebook of 8K QC-LDPC 8*40*200

97	-1	-1	49	-1	44	60	-1	24	-1	-1	44	-1	106	102	-1	-1	-1	123	-1	10	-1	41	16	-1	24	32	-1	43	21	-1	104	1	0	-1	-1	-1	-1	-1	-1
99	10	-1	50	-1	6	-1	-1	-1	101	29	49	97	-1	61	112	79	-1	-1	45	25	-1	44	-1	30	-1	-1	67	-1	-1	-1	97	-1	0	0	-1	-1	-1	-1	-1
-1	79	101	-1	-1	-1	121	26	-1	-1	59	-1	115	77	119	-1	113	-1	-1	-1	16	113	-1	101	8	-1	-1	77	-1	28	1	-1	0	-1	0	0	-1	-1	-1	-1
105	60	-1	123	13	85	-1	55	75	-1	-1	-1	-1	104	-1	113	-1	107	119	120	-1	107	-1	-1	-1	93	-1	107	38	-1	44	-1	-1	-1	-1	0	0	-1	-1	-1
70	34	107	-1	24	-1	117	-1	89	58	26	63	-1	-1	-1	111	105	85	-1	-1	-1	-1	61	86	-1	-1	43	-1	59	-1	77	-1	-1	-1	-1	-1	0	0	-1	-1
68	88	124	-1	83	-1	-1	42	-1	87	-1	-1	112	-1	-1	-1	-1	88	127	114	-1	89	-1	-1	82	85	42	-1	-1	30	-1	100	1	-1	-1	-1	-1	0	-1	-1
69	102	70	36	-1	-1	100	-1	82	-1	24	-1	-1	99	107	-1	-1	8	-1	36	-1	19	47	-1	71	22	8	-1	-1	20	-1	99	8	-1	-1	-1	-1	-1	0	-1
81	37	26	28	13	42	-1	-1	111	-1	22	-1	102	101	90	-1	-1	81	-1	108	13	45	44	-1	26	40	9	118	13	54	-1	98	22	-1	-1	-1	-1	-1	-1	0