Rate-Compatibility and Incremental Redundancy HARQ for 802.16j LDPC codes

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Purpose:

Propose a Rate-Compatible and IR HARQ for 802.16j to improve reliability and throughput performance on relay links.

Rate-Compatibility and Incremental Redundancy HARQ for 802.16j LDPC codes

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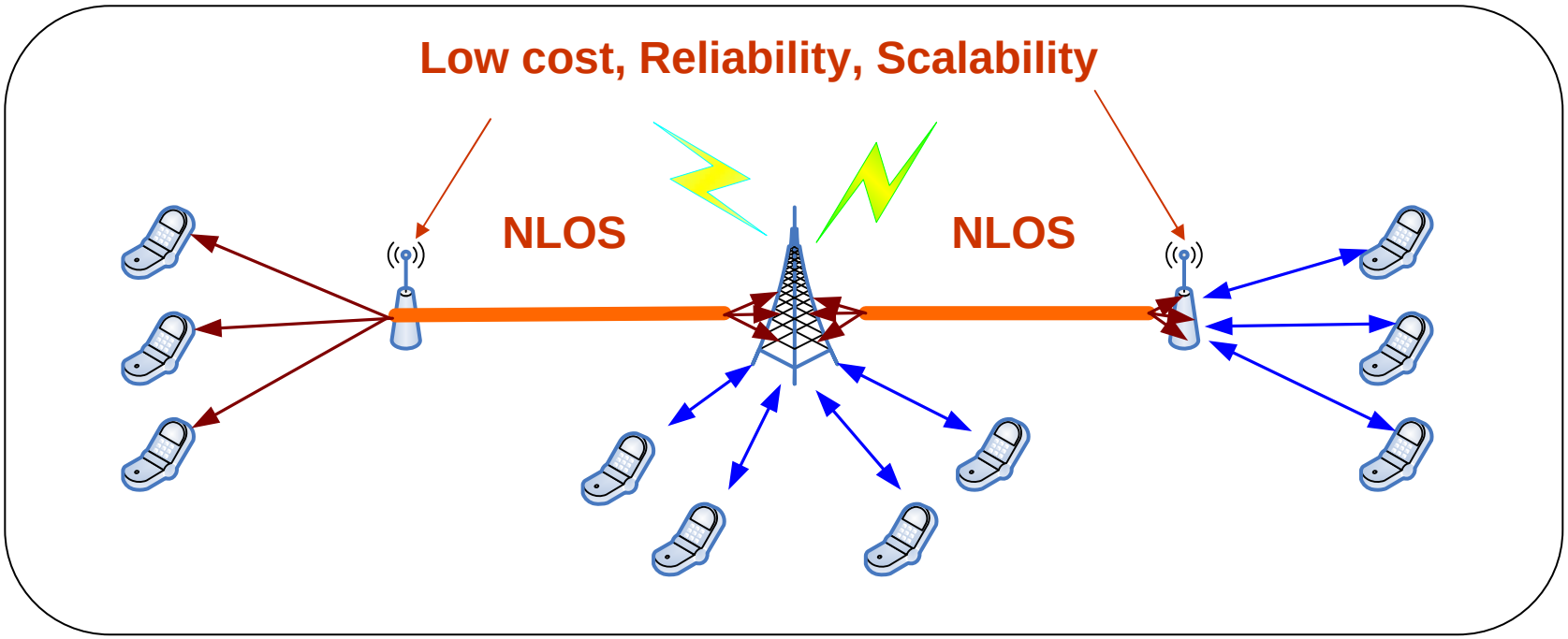
Concept of Enhanced Hybrid ARQ (Rate Compatible LDPC)

- The concept of “Enhanced Hybrid ARQ” is to provide Low cost, Reliability and Scalability.



Motivation –Requested issues

- LDPC codes can provide lower cost hardware than CTC.
- High reliability on low data-rate region. → Expansion of coverage area
- Coexistence of the proposed RC-LDPC codes and the current 802.16e LDPC codes.
  → Minimize of additional circuits for RC-LDPC codes

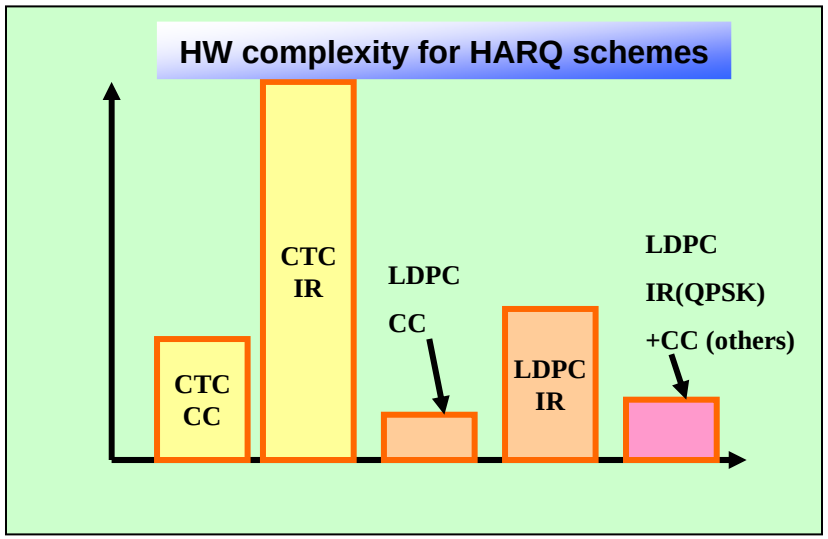


Fig1. Low Cost

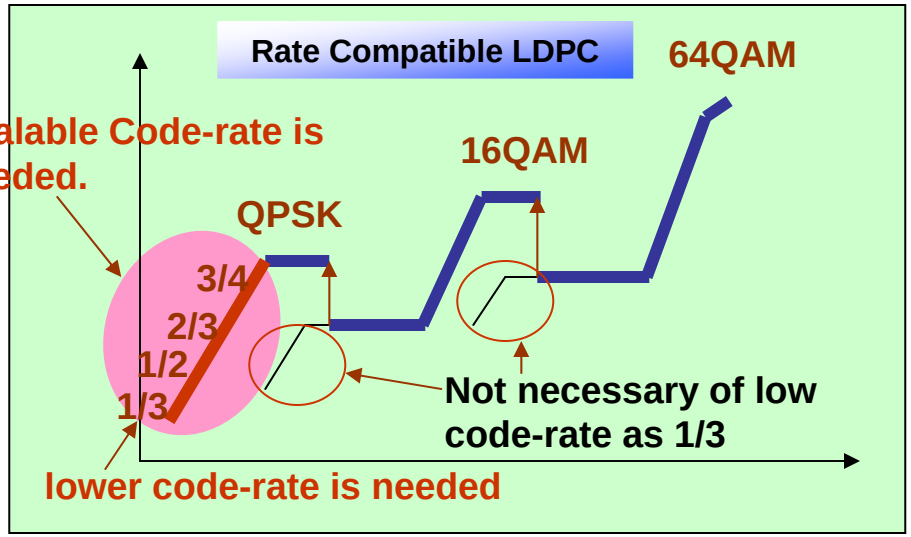


Fig2. Reliability and Scalability

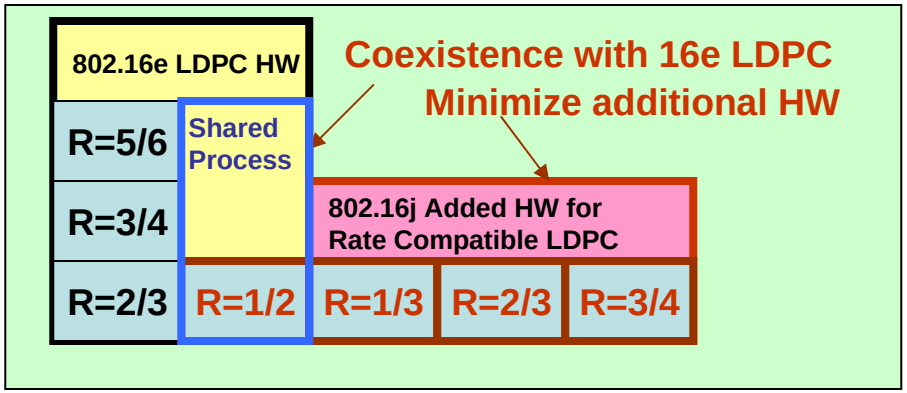


Fig3. coexistence of current LDPC

Apply to 802.16e LDPC codes

Rate=1/2 code

H_{CH}

-1	94	73	-1	-1	-1	-1	-1	55	83	-1	-1	7	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	27	-1	-1	-1	22	79	9	-1	-1	-1	12	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	24	22	81	-1	33	-1	-1	-1	0	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1
61	-1	47	-1	-1	-1	-1	-1	65	25	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1
-1	-1	39	-1	-1	-1	84	-1	-1	41	72	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	46	40	-1	82	-1	-1	-1	[illegible]	0	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1
-1	-1	95	53	-1	-1	-1	-1	-1	14	[illegible]	[illegible]	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1
-1	11	73	-1	-1	-1	2	-1	-1	47	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1
12	-1	-1	-1	83	24	-1	43	-1	-1	-1	51	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1
-1	-1	-1	-1	-1	94	-1	59	-1	-1	70	72	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1
-1	-1	7	65	-1	-1	-1	-1	39	49	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0
43	-1	-1	-1	-1	66	-1	41	-1	-1	-1	26	7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0

Extend for Rate=1/3 code

Z D 0

A I I

-1	94	73	-1	-1	-1	-1	-1	55	83	-1	-1	7	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	27	-1	-1	-1	22	79	9	-1	-1	-1	12	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	24	22	81	-1	33	-1	-1	-1	0	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
61	-1	47	-1	-1	-1	-1	-1	65	25	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	39	-1	-1	-1	84	-1	-1	41	72	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	[illegible]	[illegible]	-1	82	-1	-1	-1	79	0	-1	-1	-1	-1	[illegible]	[illegible]	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	[illegible]	-1	-1	-1	-1	-1
-1	-1	95	53	[illegible]	[illegible]	-1	-1	-1	14	18	-1	-1	-1	-1	-1	-1	[illegible]	[illegible]	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	[illegible]	-1	-1	-1	-1	-1
-1	11	73	-1	-1	-1	2	-1	-1	47	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
12	-1	-1	-1	83	24	-1	43	-1	-1	-1	51	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	94	-1	59	-1	-1	70	72	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	7	65	-1	-1	-1	-1	39	49	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
43	-1	-1	-1	-1	66	-1	41	-1	-1	-1	26	7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	17	-1	9	-1	-1	-1	20	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	36	-1	-1	-1	-1	-1	-1	7	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	5	-1	-1	-1	-1	-1	-1	5	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	23	-1	11	-1	-1	-1	23	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	5	-1	32	-1	-1	-1	38	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-1	-1	7	-1	-1	-1	-1	-1	-1	19	-1	-1	-1	-1	-1	-1	-1	[illegible]	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	[illegible]	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	31	-1	23	-1	-1	-1	48	-1	-1	-1	-1	-1	[illegible]	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	[illegible]	-1	-1	-1	-1	-1
-1	-1	-1	-1	-1	29	-1	37	-1	-1	-1	7	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1
-1	-1	6	-1	-1	-1	-1	-1	-1	3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1
-1	-1	1	-1	-1	-1	-1	-1	-1	2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1
-1	-1	-1	-1	-1	37	-1	26	-1	-1	-1	8	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1
-1	-1	3	-1	-1	-1	-1	-1	-1	6	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0

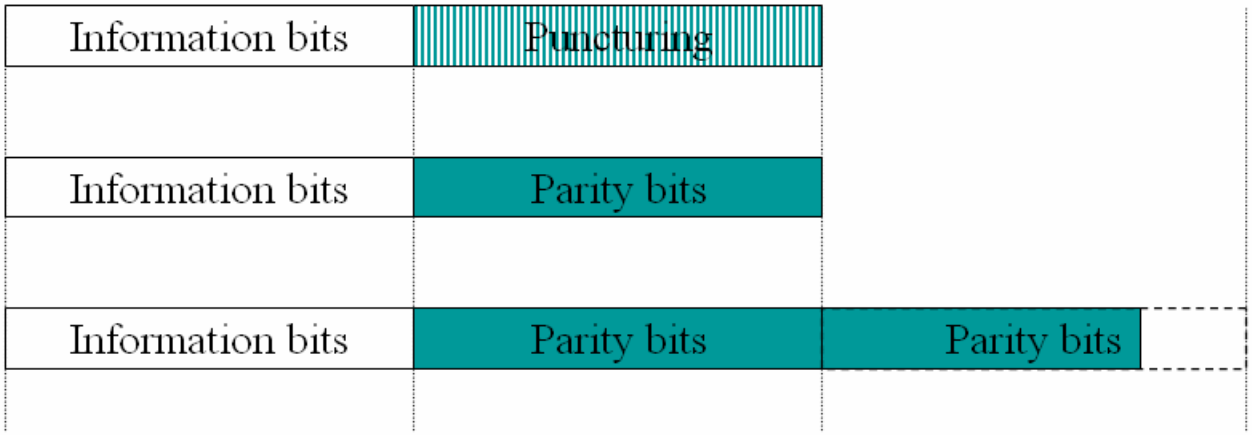
Rate-Compatible LDPC codes

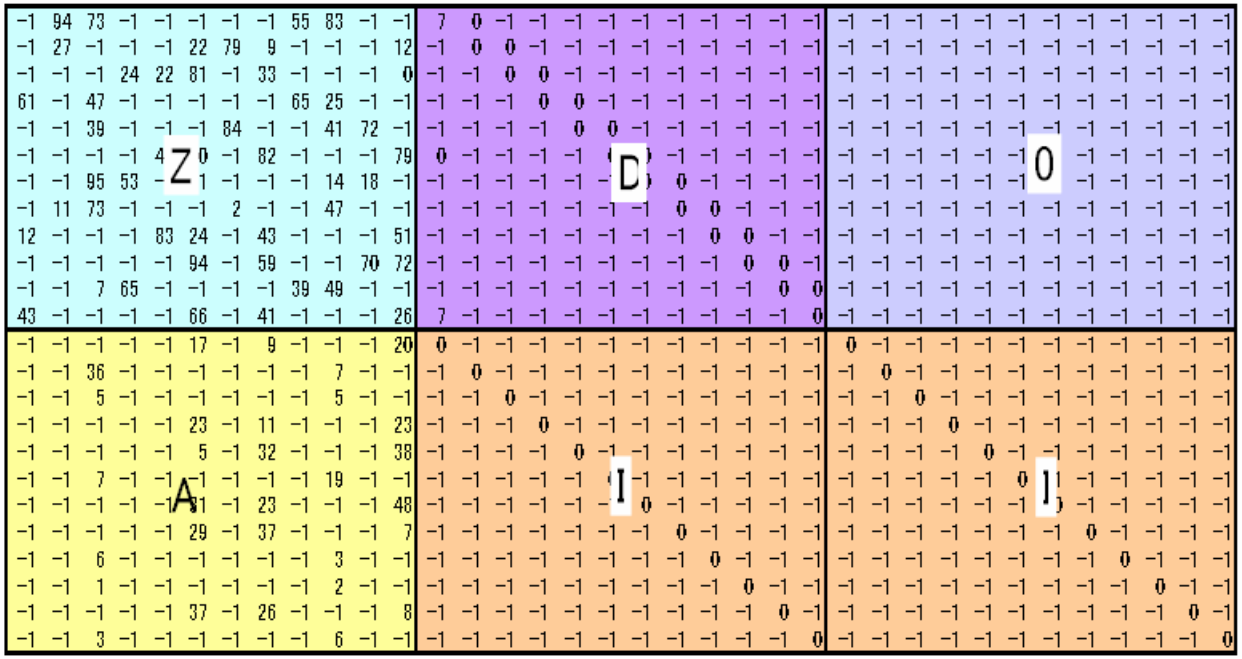
IR with Mother Rate=1/3 parity check matrix

Rate>1/2

Rate=1/2

Rate<1/2





- In addition to puncturing, extended parity matrixes are used to achieve flexible coding rate and rate compatibility

- 802.16e LDPC will be used as the baseline for enhancement of the RC-LDPC

Comparison with Turbo

Table. Operations count comparison of sub-optimal decoders LDPC and TC decoders.

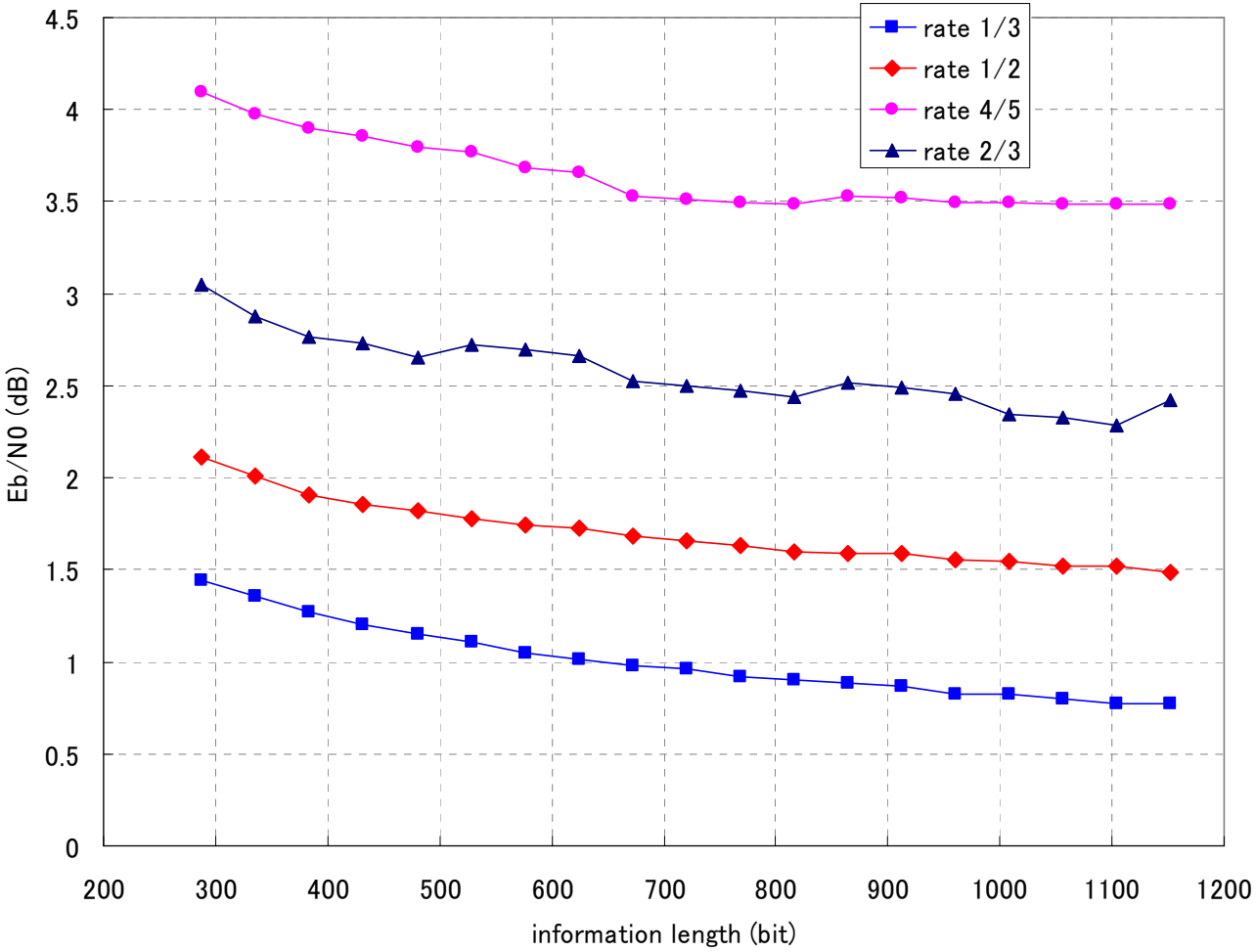
	LDPC	TC	Complexity of LDPC / Complexity of TC
Algorithm	LBP Min-Sum+Offset	Max Log Map +extrinsic scaling	
Number of Iterations	20	8	
Total cost (R=1/3)	38.5K x 20 = 770K	171K x 8 = 1368K	56%
Total cost (R=1/2)	28.8K x 20 = 576K	171K x 8 = 1368K	42%
Total cost (R=3/4)	20.6K x 20 = 412K	171K x 8 = 1368K	30%

Reference: R1-060874, ” **Complexity Comparison of LDPC Codes and Turbo Codes** ”

3GPP TSG RAN WG1#44bis, Athens, Greece 27-31 Mar. 2006.

Performance of RC LDPC

Performance for RC LDPC codes based on the 16e LDPC codes



Performance of RC LDPC

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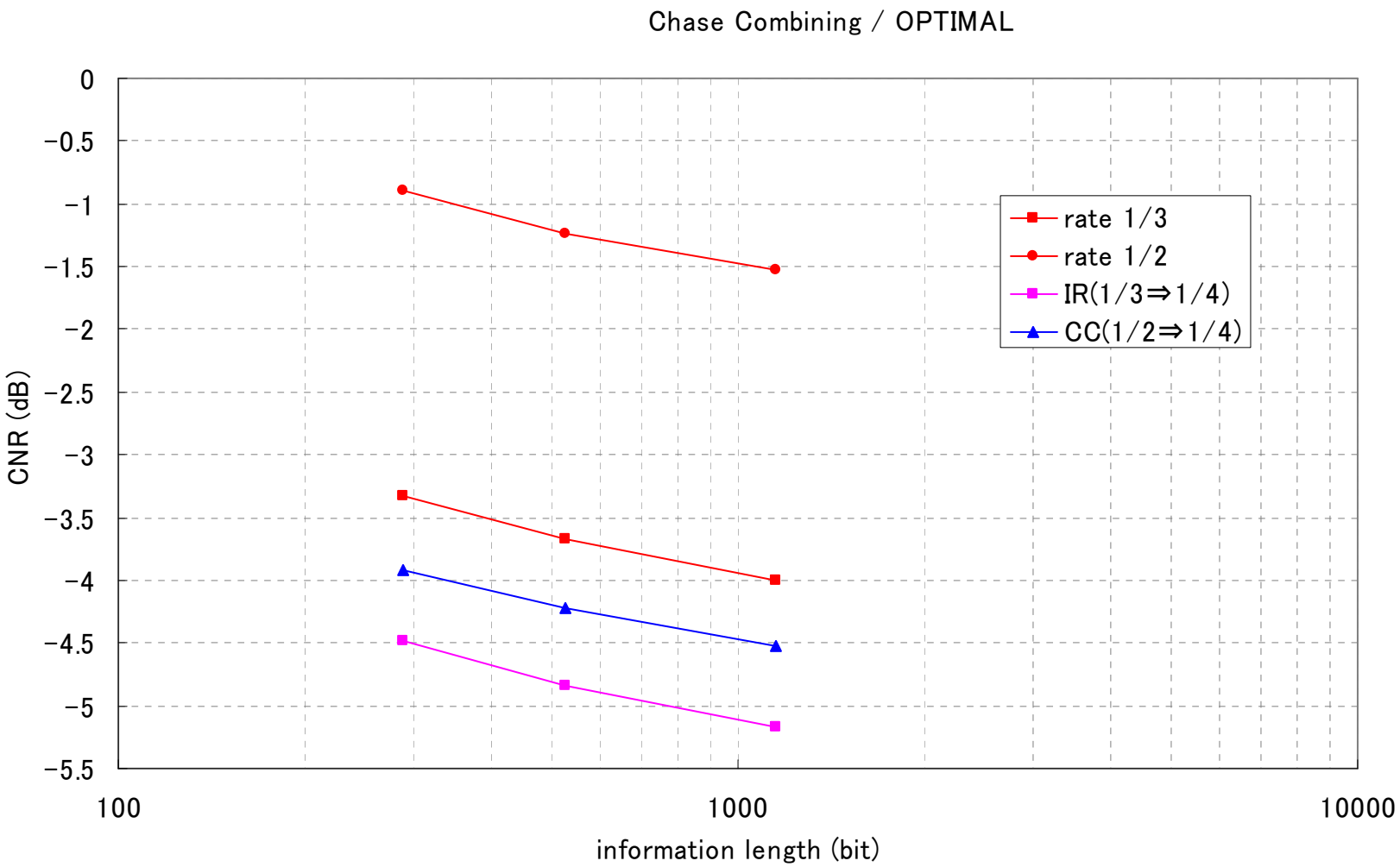
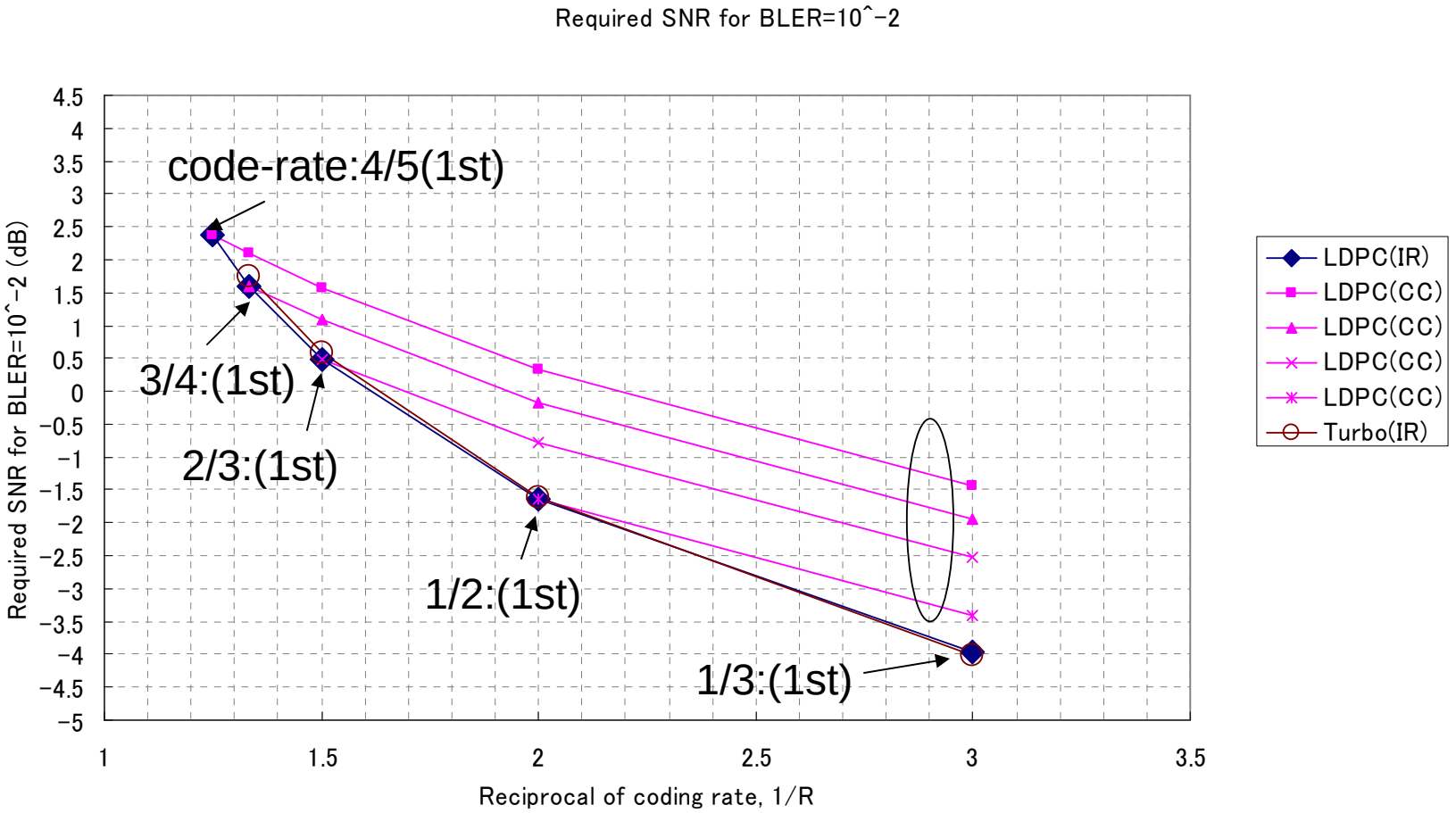
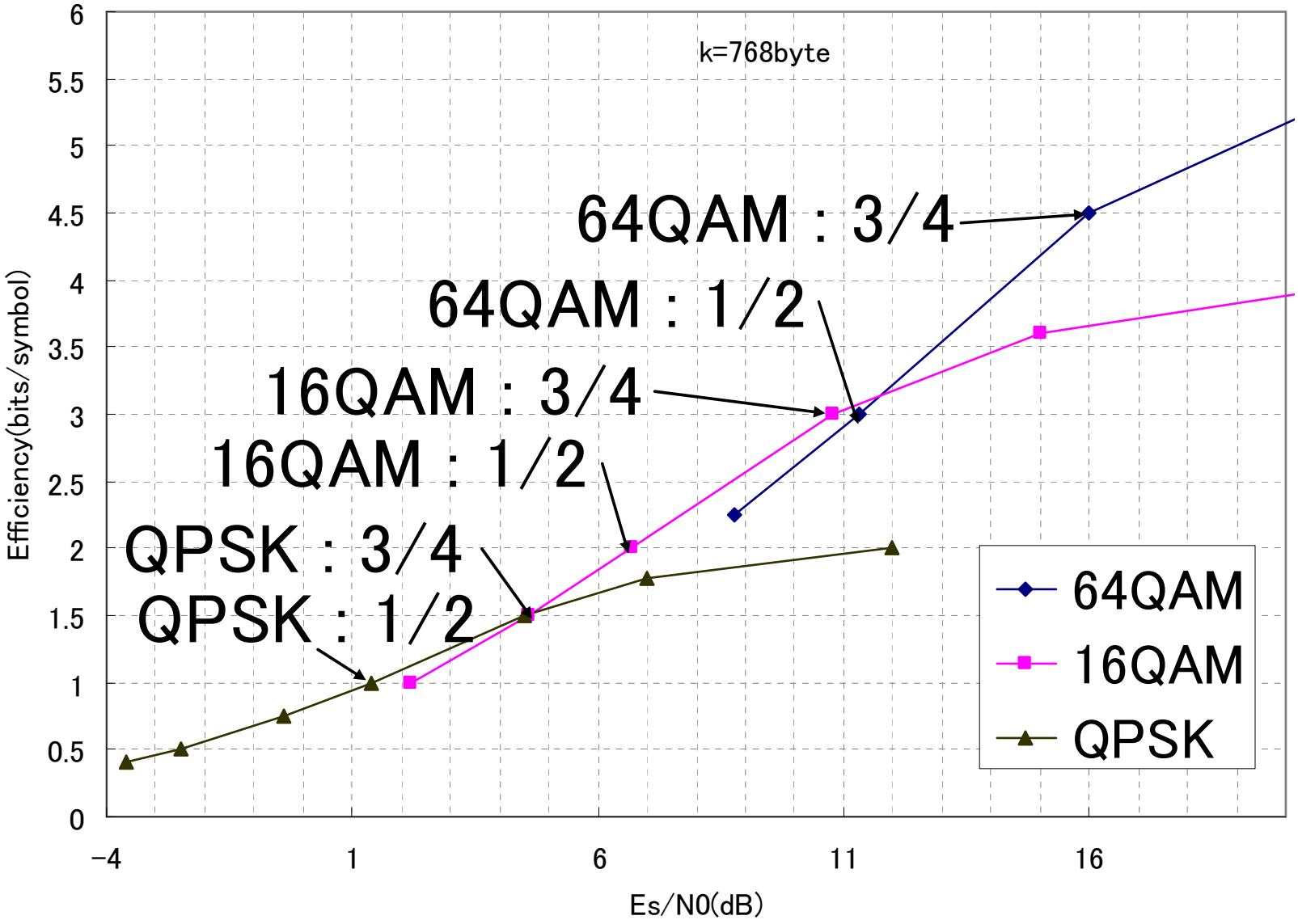


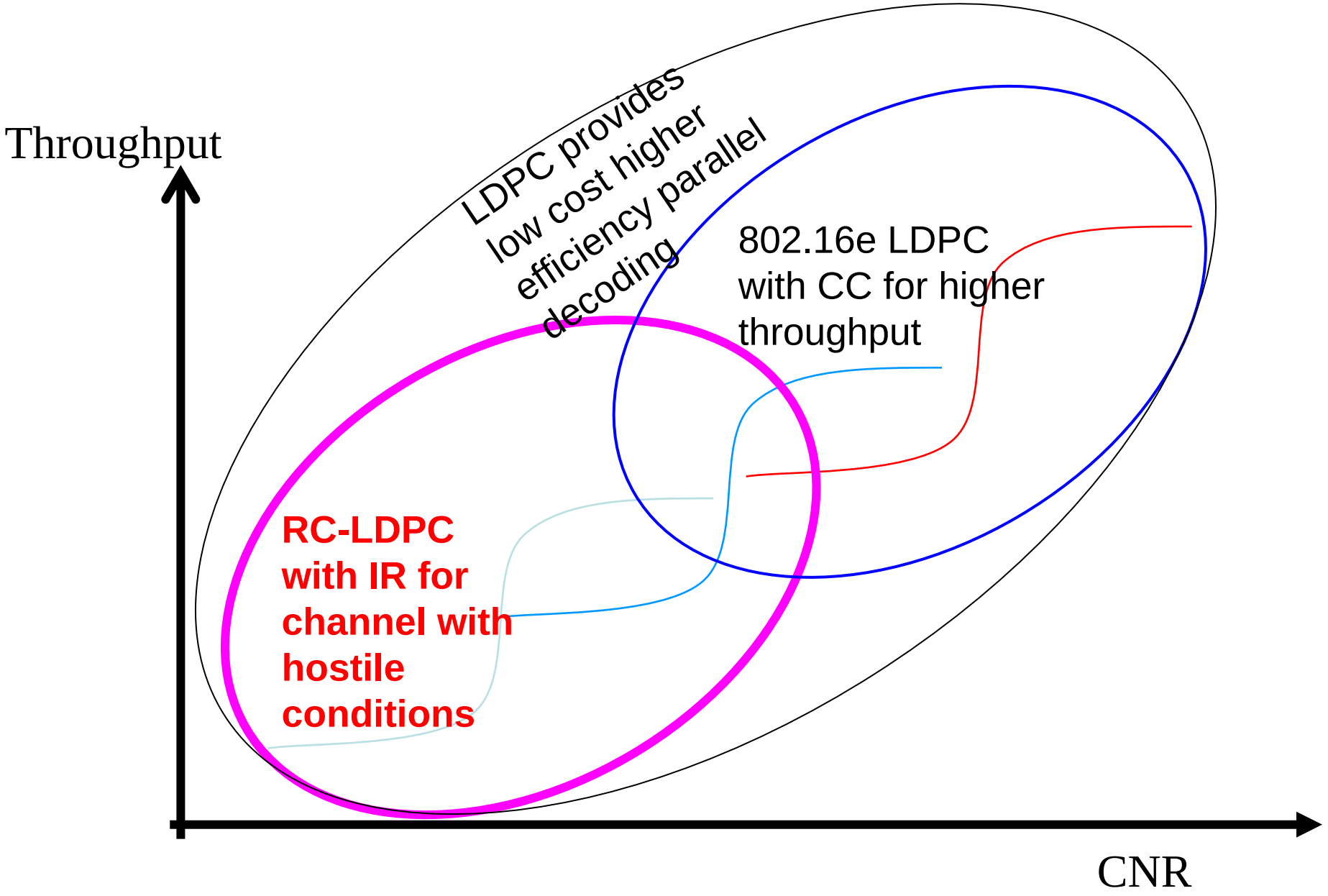
Throughput Performance of LDPC Chase Combining and IR HARQ



Throughput Performance of LDPC Chase Combining and IR HARQ



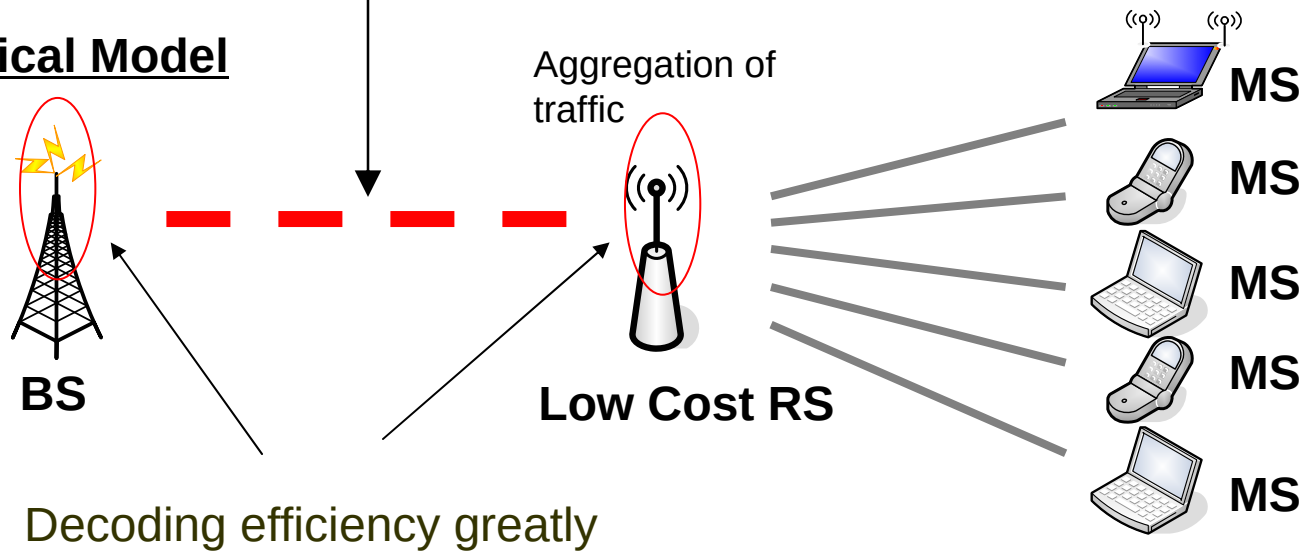
RC-LDPC and 802.16e LDPC



Merits of RC-LDPC and 802.16e LDPC

Improved robustness provided by RC-LDPC low code rate and HARQ IR especially for channels with hostile conditions

Our Typical Model



Decoding efficiency greatly improved by LDPC and making high throughput and low cost RS/BS possible for UL and DL

Conclusions

- LDPC support high throughput with less hardware complexity and lower cost compared to Turbo codes

- RC-LDPC is an enhanced version of the 802.16e LDPC
  - 802.16e LDPC will be used as a baseline
  - RC-LDPC is rate compatible
  - Backward compatible to 802.16e LDPC
  - 802.16e LDPC with CC HARQ provides support for higher throughput link

- RC-LDPC provide improved robustness for channel in hostile conditions with
  - Low code rate such as 1/3 code rate
  - Incremental Redundancy for HARQ