A new class of parity-check concatenated polar codes using belief propagation decoding

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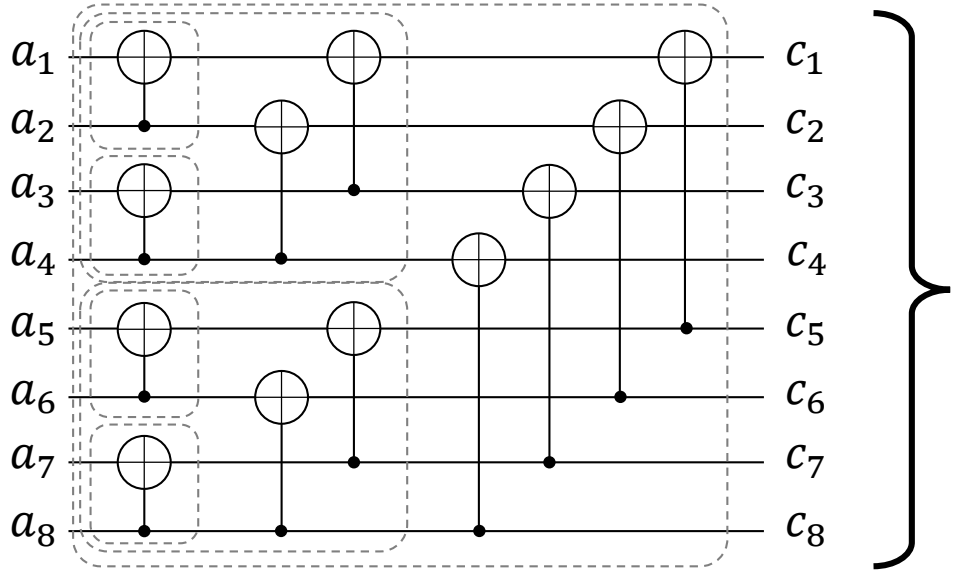
- # Preliminary

Polar codes
Various concatenated polar codes

Polar Codes

- Definition of Polar Codes

k message bits
$n-k$ zeros



n coded bits

$\boldsymbol{c} = \boldsymbol{aG}$, where $\boldsymbol{G} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}^{\otimes t}$

Code rate $R_p = k/n$

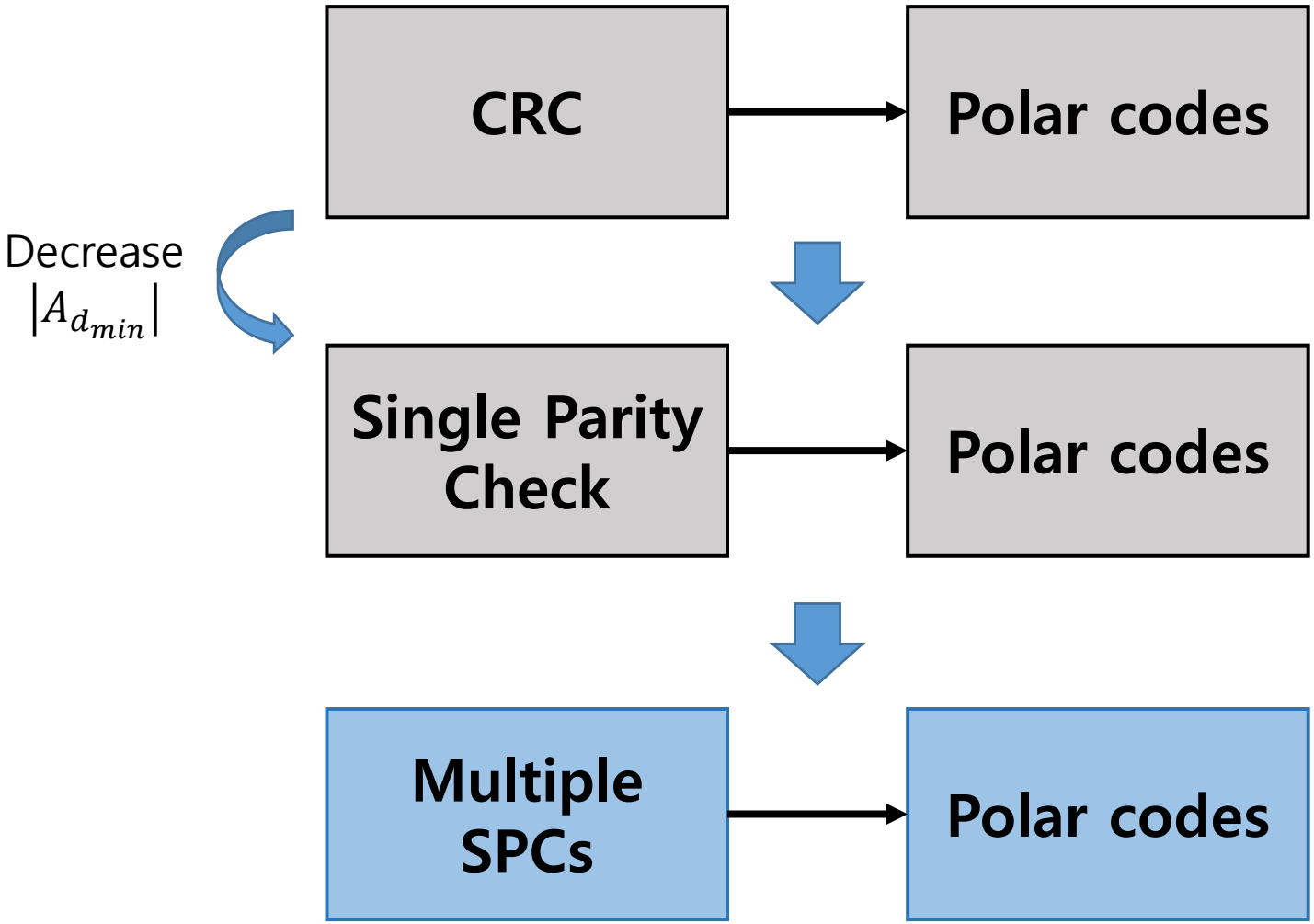
Successive Cancellation Decoding

- Decode messages sequentially

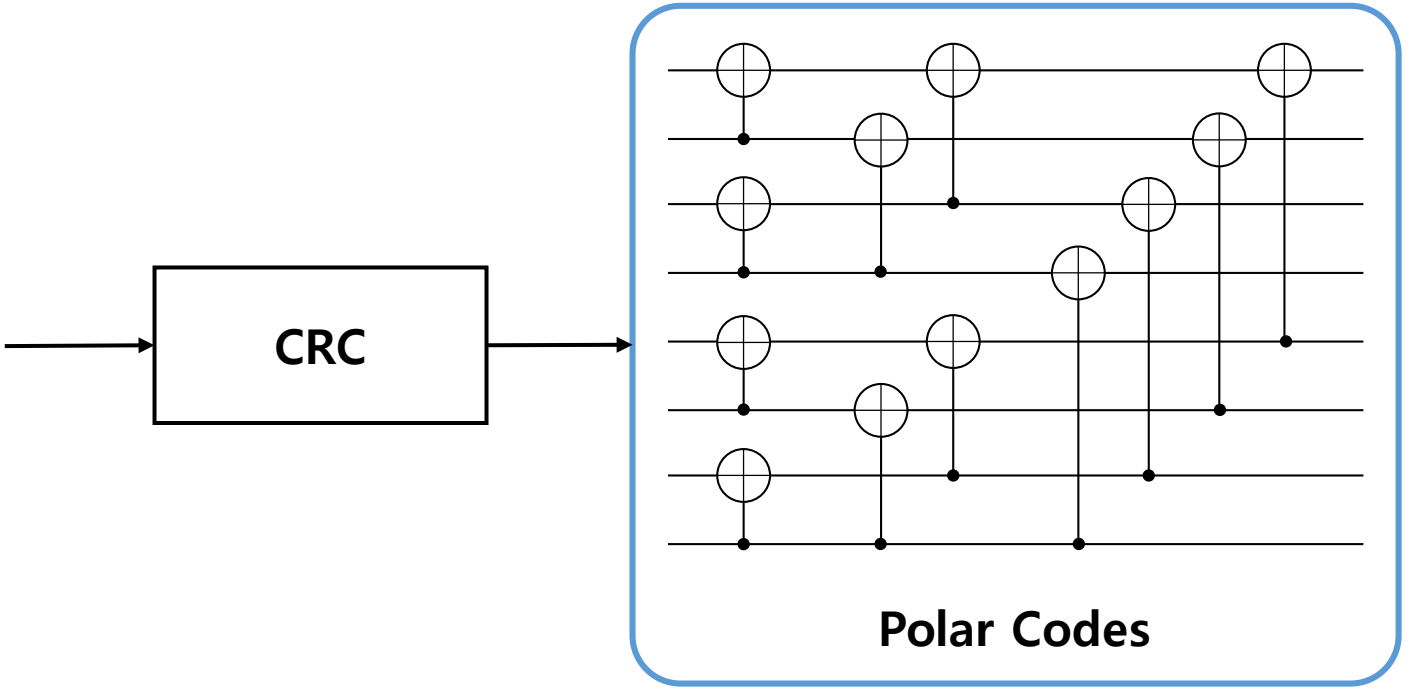
A polar code is defined by..

- Number of zeros (frozen bits)
- Position (index) of frozen bits
- Number of coded bits($n = 2^t$)

Various concatenated polar codes

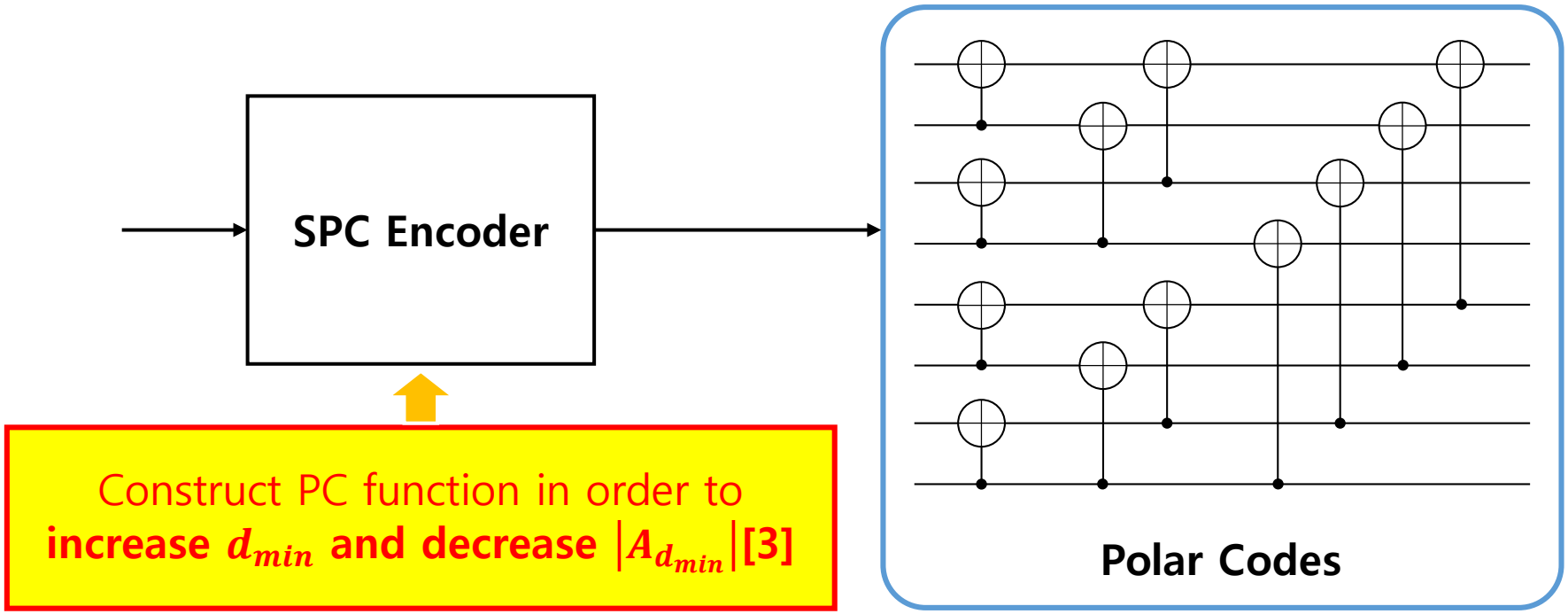


CRC-aided Successive Cancellation List Decoding of Polar Codes



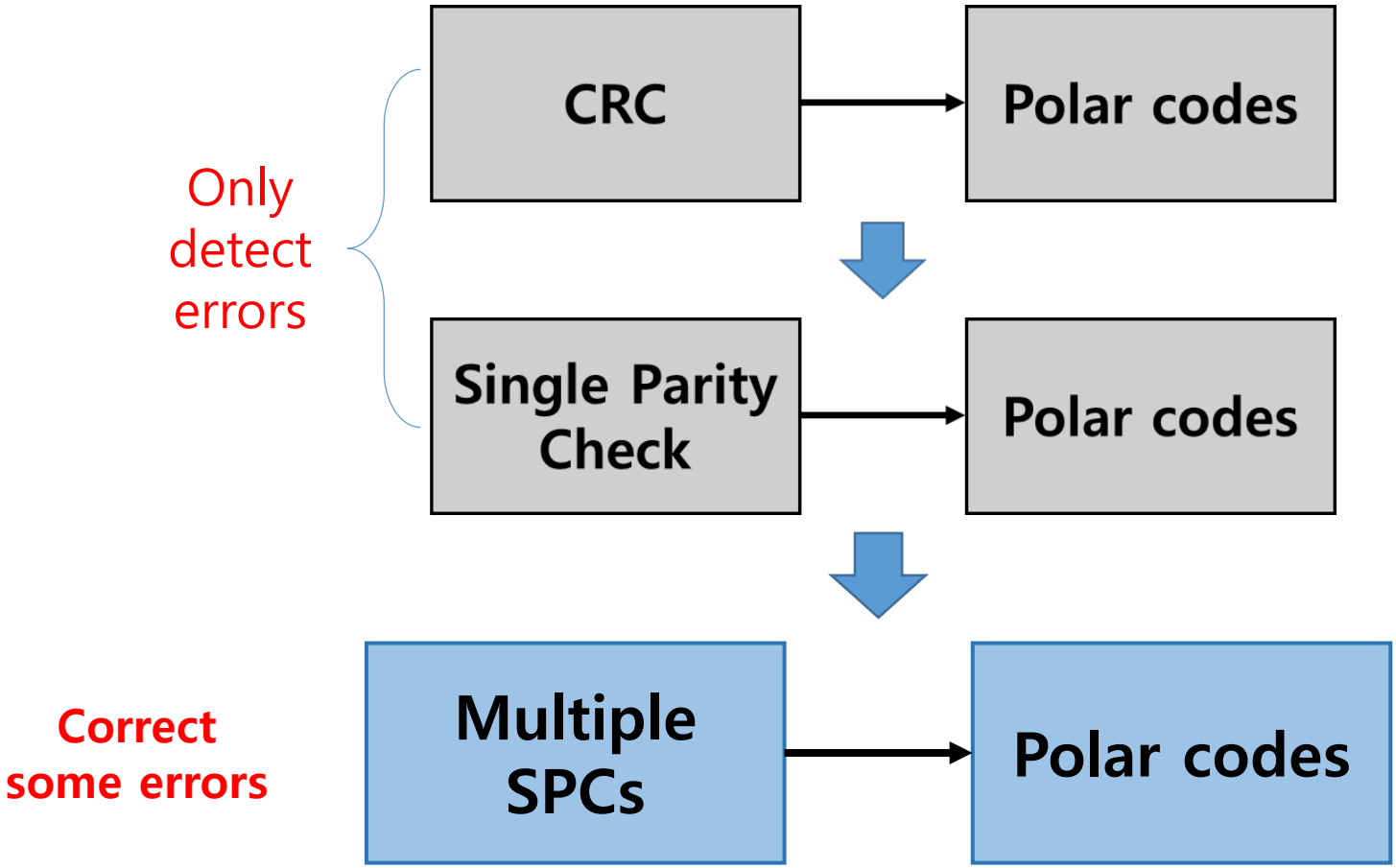
- Successive Cancellation List (SCL) Decoding with CRC codes [1]
  - L candidates of decoded message vectors for each stages
  - Select the most reliable message vector; if satisfying the CRC, decoding ends

Parity-Check Concatenated (PCC) Polar Codes



- Successive Cancellation List(SCL) Decoding with SPC codes [2]
  - SPC works in middle of decoding process
  - Replace SPC instead of CRC
  - More performance improvement than CRC-aided SCL decoding of Polar Codes and PCC polar codes

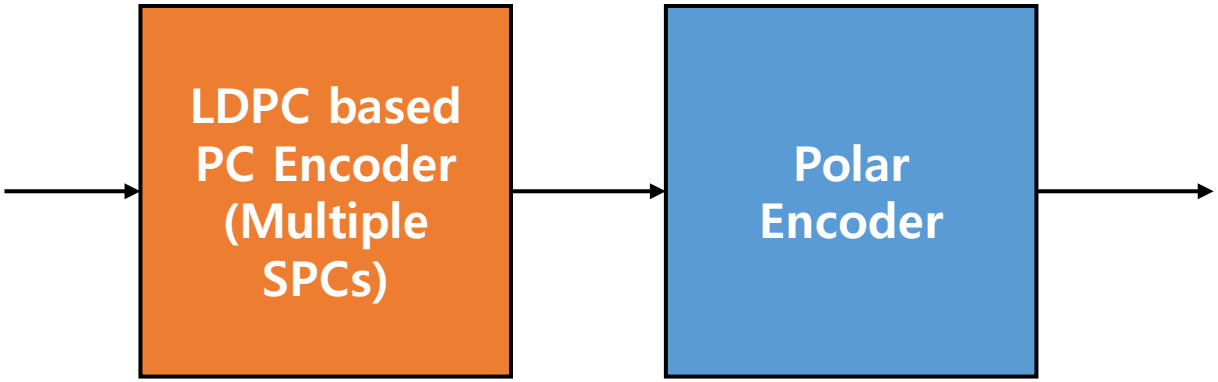
Motivation


Only detect errors
CRC
Polar codes
Single Parity Check
Polar codes
Correct some errors
Multiple SPCs
Polar codes

- # LDPC based PCC polar Codes

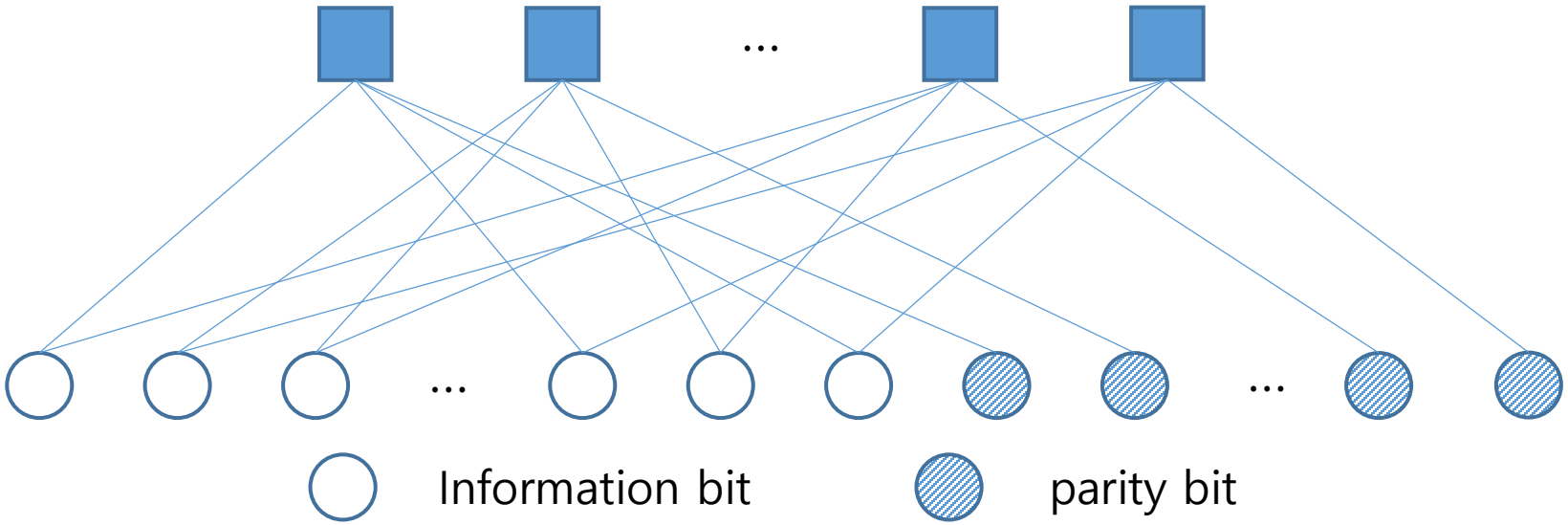
Construction
Decoding
Parameters and simulation results

LDPC based PCC Polar Codes



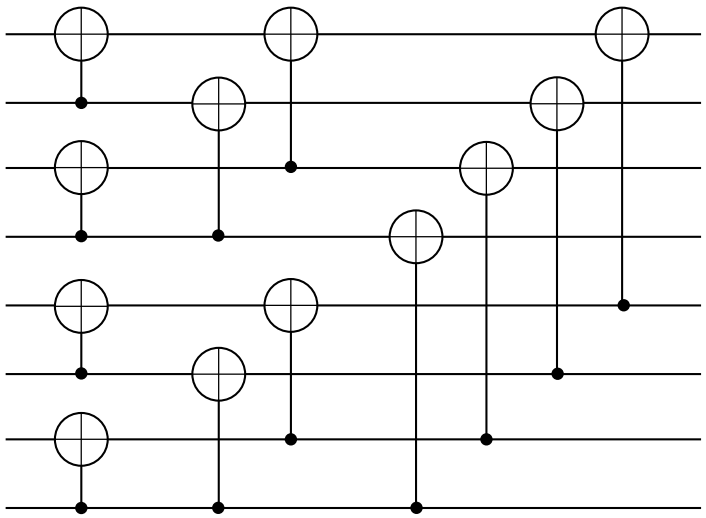
- Low Denstiy Parity-Check(LDPC) based Parity-Check concatenated polar codes
  - Construct PC functions similar to Raptor-Like LDPC Codes
  - Use Belief Propagation(BP) decoding for LDPC based parity-check codes, SCL decoding for polar Codes
  - Slight performance improvement than PCC polar codes based on MHW codewords[3]

Construction of LDPC based PCC polar codes

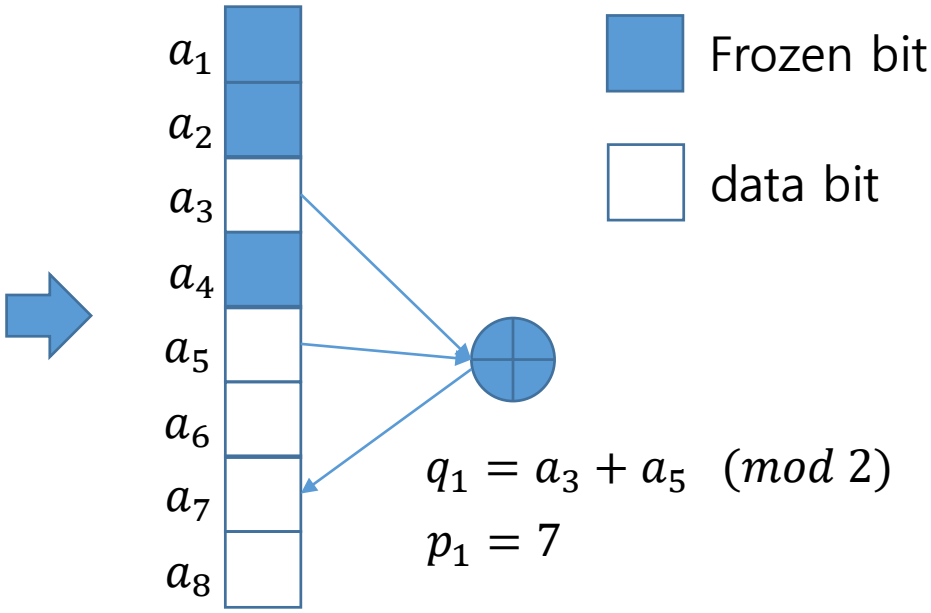


- Construction rules
  - Every check nodes has one parity-check bits
  - Degree of check nodes must be even number
  - Information bits in less reliable subchannels connected to the check nodes

Decoding of LDPC based PCC polar codes



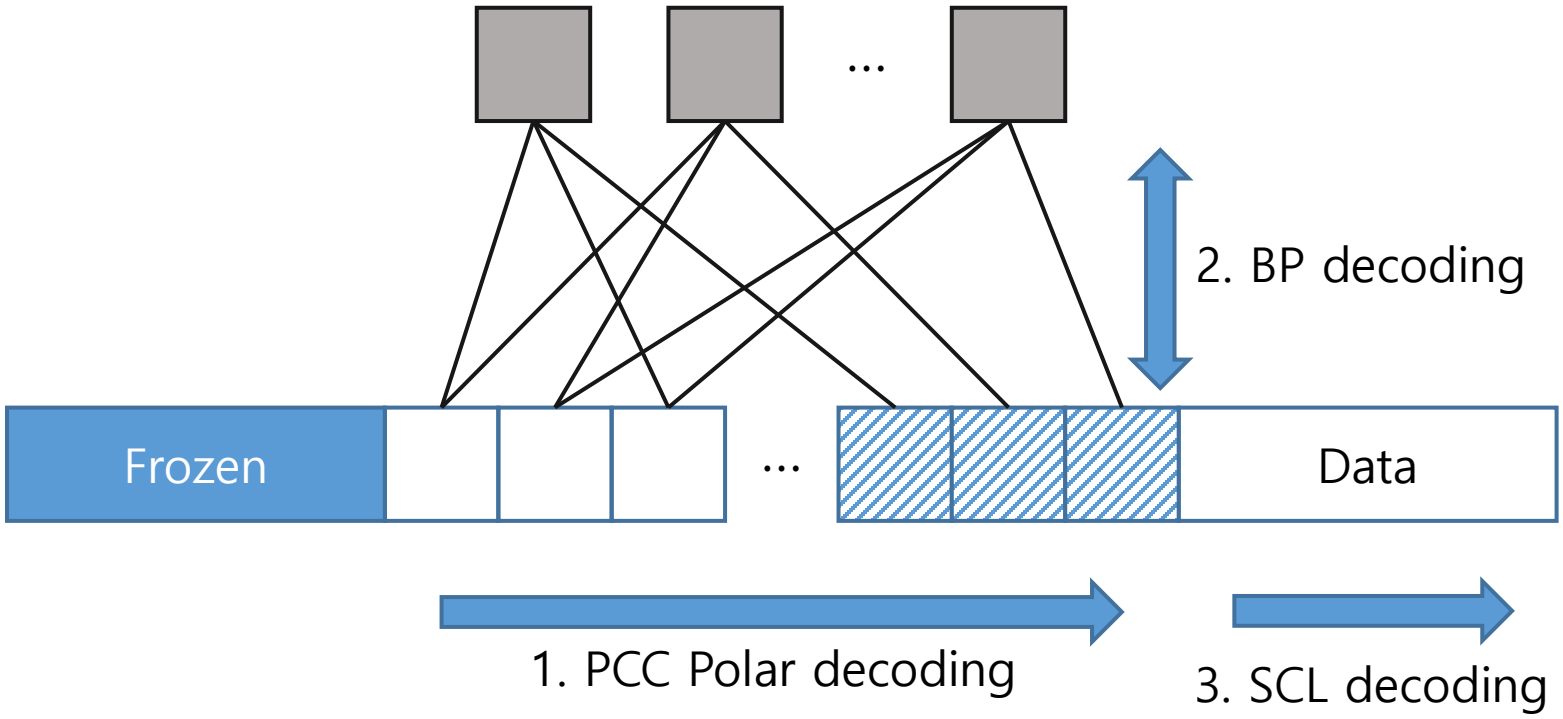
SCL decoding of Polar Codes



- Parity-Check equation
  - q_j j-th parity bit
  - p_j bit index of j-th parity bit

Decoding of LDPC based PCC polar codes

- LDPC based PCC polar codes decoding procedure

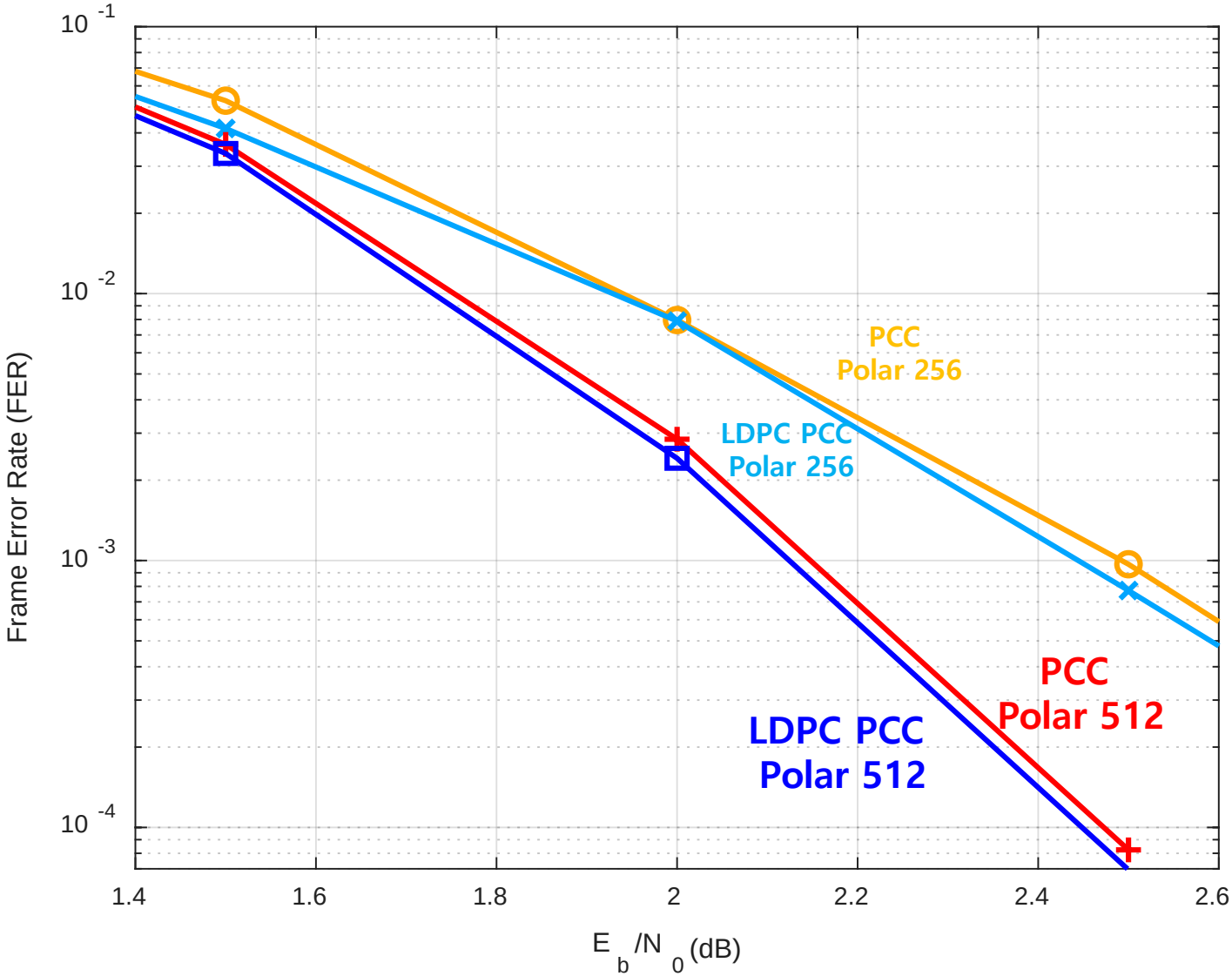


Simulation

- Parameters of LDPC based PCC polar Codes
  - BPSK modulation, AWGN channels

	C_{256}	C_{512}
Code rate	0.5	0.5
Code length	256	512
# of PC bits	18	24
# of PC equations	18	24
# of max iterations	10	10
# of connected info. bits	42	72

Simulation Results



Conclusion

- Construct LDPC based Parity-Check concatenated polar codes and its decoding methods
  - Slight performance gain in sense of FER

- In future work,
  - We will consider multiple LDPC based PC equations for polar codes
  - We will concatenate linear block codes for outer and polar codes for inner with SC decoding

References

[1] I. Tal, and A. Vardy, "List Decoding of Polar Codes", IEEE Trans. on Inform. Theory, vol. 61, no. 5, pp. 2213-2226, May 2015.

[2] T. Wang, D. Qu, and T. Jiang, "Parity-Check-Concatenated Polar Codes", IEEE Comm. Lett., vol. 20, no. 12, pp. 2342-2345, Dec. 2016.

[3] J. Park, I. Kim, H.-Y. Song, "Construction of Parity-Check-Concatenated Polar Codes Based on Minimum Hamming Weight Codewords", Electronics Letters, vol.53, no.14, pp.924-926, July 2017.

Thank you for listening

Q & A