

# NB-LDPC check node with pre-sorted input

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[http://www-labsticc.univ-ubs.fr/nb\\_ldpc/](http://www-labsticc.univ-ubs.fr/nb_ldpc/)

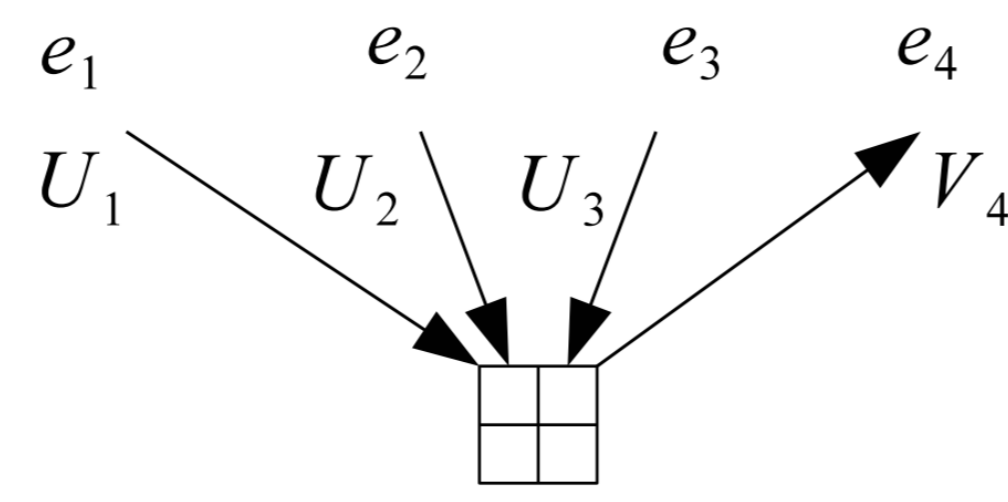
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## Introduction

Non-binary low-density parity-check codes have better communication performance than their binary counterparts but they suffer from higher complexity, especially for the check node processing.

$$e^+(x) = -\log \left( \frac{P(e=x)}{P(e=\bar{x})} \right)$$

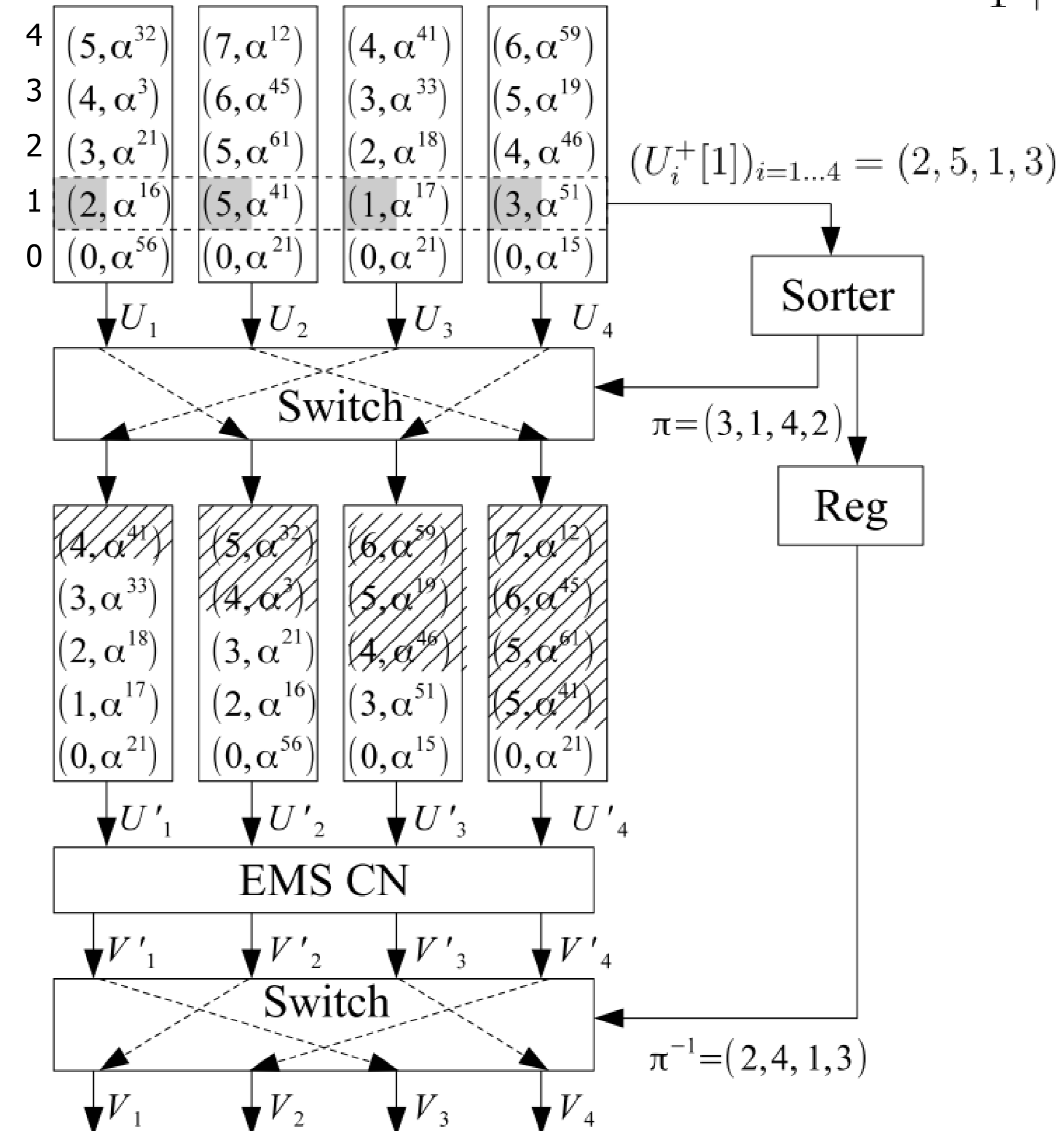


$$v_i^+(x) = \min \left\{ \sum_{i'=1, i' \neq i}^{d_c} U_{i'}^+[j_{i'}] \mid \bigoplus_{i'=1, i' \neq i}^{d_c} U_{i'}^\oplus[j_{i'}] = x \right\}$$

A sorting of the input vectors based on a reliability criteria is performed prior to the check node processing. This presorting process allows the Extended Min-Sum (EMS) [1] check node process to focus its effort mainly on the weakest inputs.

## Presorting Principle

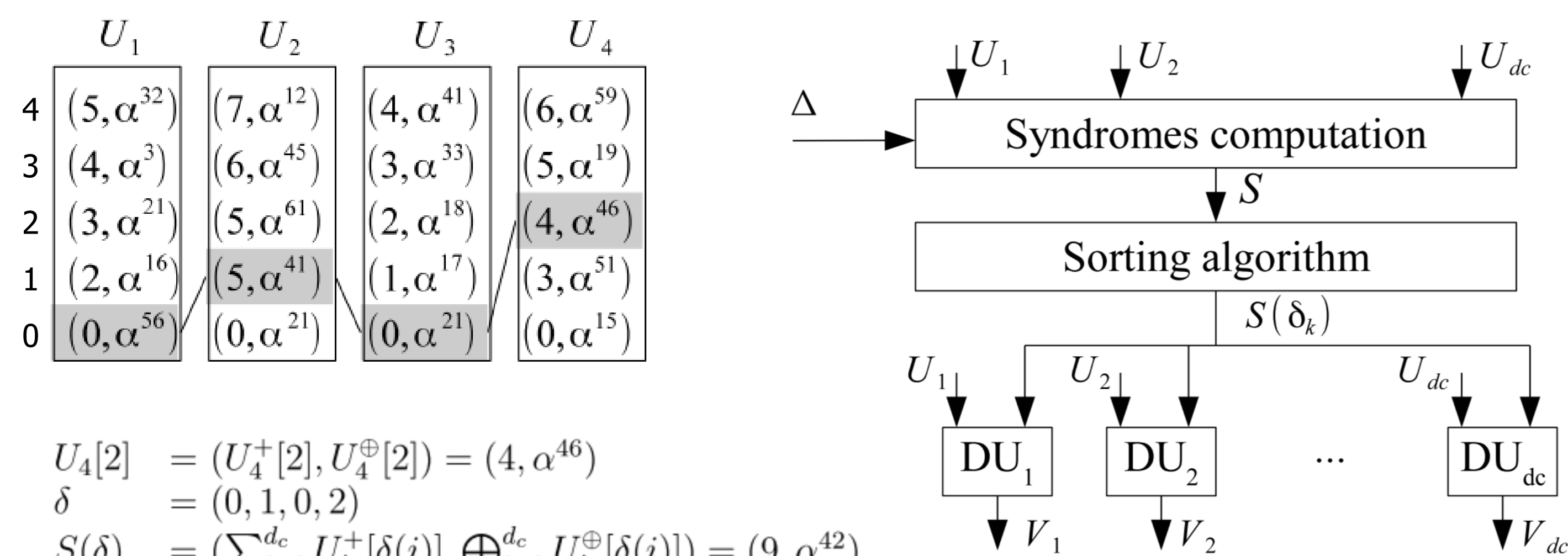
$$P(e_i = U_i^\oplus[0]) \approx \frac{1}{1 + e^{-U_i^+[1]}}$$



The inputs are presorted based on the reliability of the second most reliable GF of each input.

The presorting process reduces statistically the number of deviation paths required to generate the most reliable CN outputs.

## Syndrome-based CN processing [2]



$$U_4[2] = (U_4^+[2], U_4^\oplus[2]) = (4, \alpha^{46})$$

$$\delta = (0, 1, 0, 2)$$

$$S(\delta) = (\sum_{i=1}^{d_c} U_i^+[\delta(i)], \bigoplus_{i=1}^{d_c} U_i^\oplus[\delta(i)]) = (9, \alpha^{42})$$

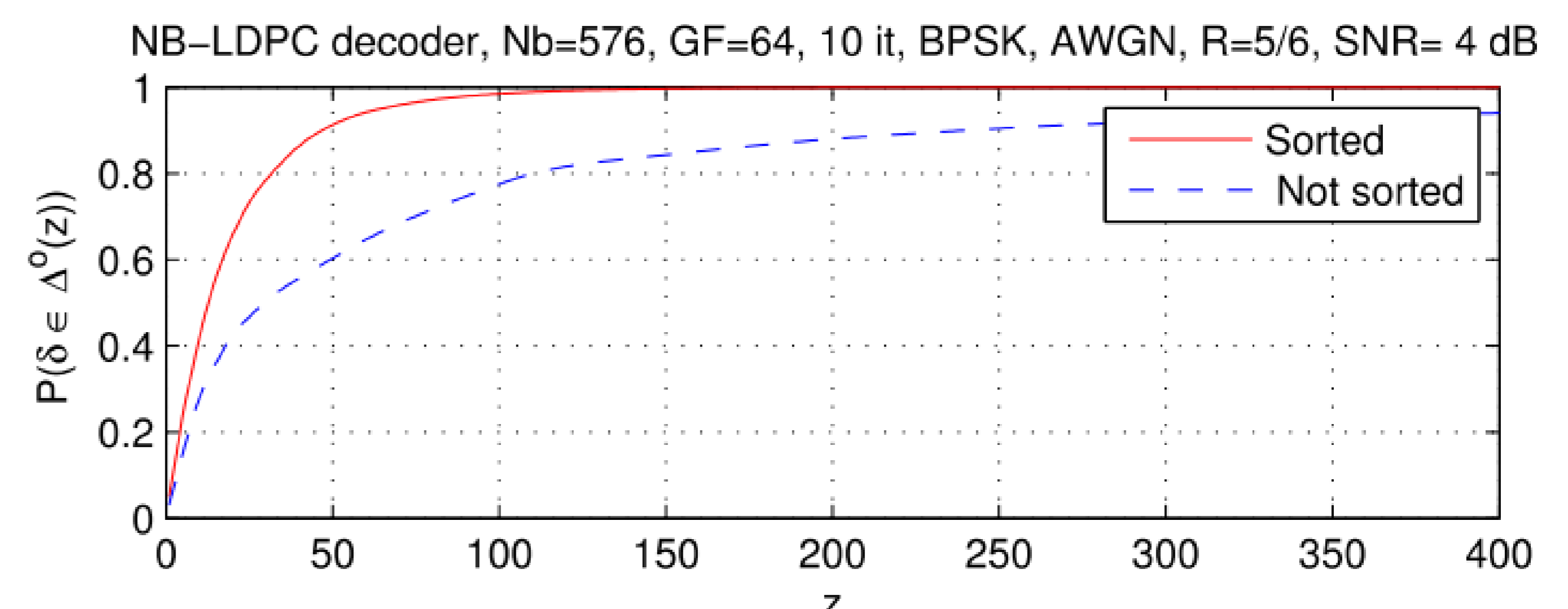
\$\delta\$ : Deviation path  
 \$S(\delta)\$ : Syndrome associated with \$\delta\$  
 \$\Delta\$ : Deviation-path set  
 \$z\$ : Cardinality of \$\Delta\$ (\$z = |\Delta|\$)  
 DU : Decorrelation Unit

Syndrome-based CN allows high parallelism compared with a Forward-Backward CN [3]. However, for high check node degree, \$z\$ increases drastically, thus leading to high complexity hardware design.

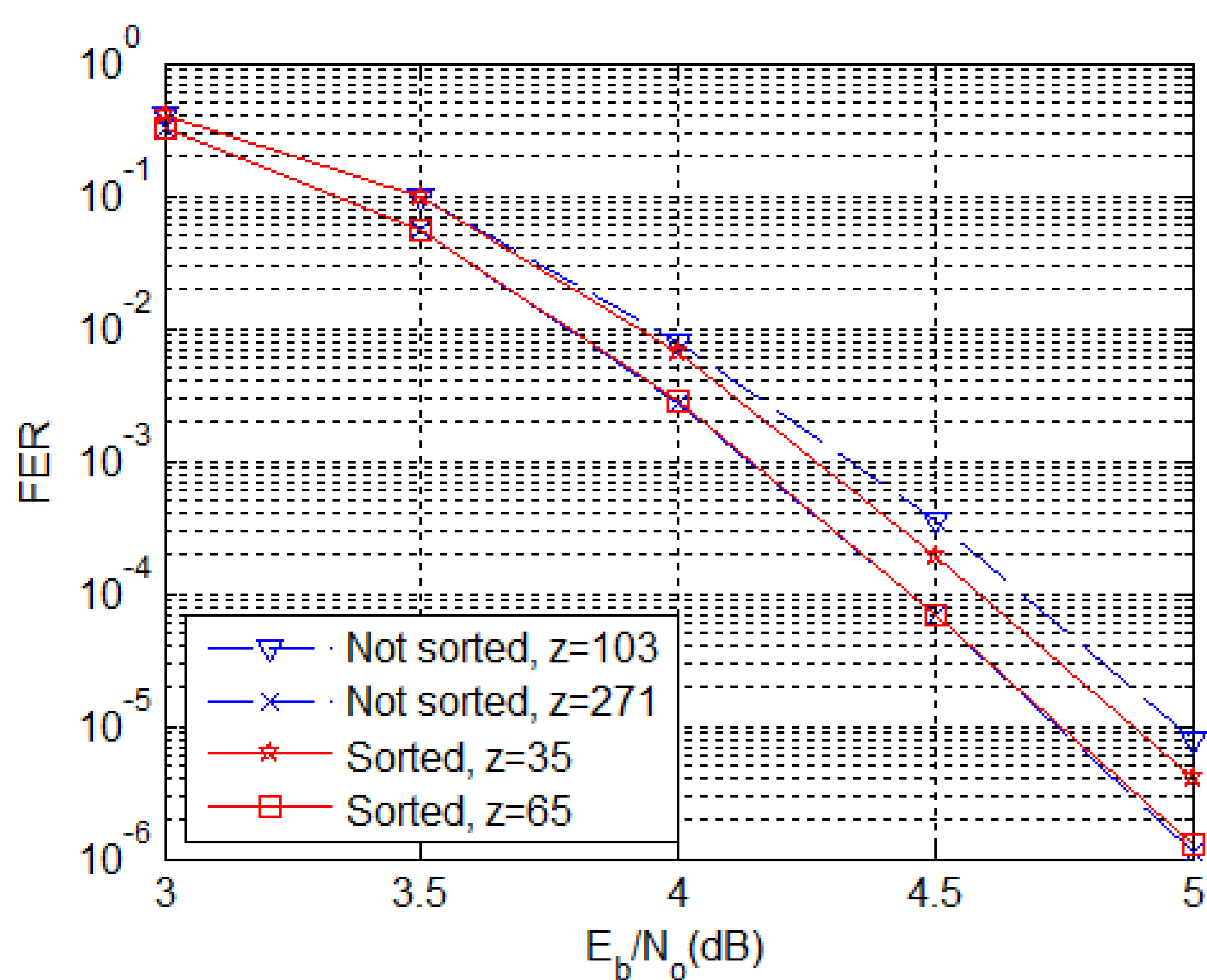
## Deviation-path set construction

- Run a Monte-Carlo simulation memorizing how many times each deviation path contributes to generate an output.
- Sort the deviation path in decreasing order of their contribution rate.
- Generates \$\Delta^0(z)\$ as the set of the first \$z\$ deviation paths of the sorted list.

The figure shows the probability that a deviation path \$\delta\$ used to generated an output in the Monte-Carlo simulation belongs to \$\Delta^0(z)\$ as a function of \$z\$, with and without presorting.



## Simulation results



Simulation results of NB-LDPC decoding algorithms for (576, 480) code over GF(64) under AWGN channel and BPSK modulation. The cardinality of the deviation-path set can be reduced by a factor of 4, without performance degradation.

## Conclusion

We show that input message presorting creates a polarization of the space of deviation paths that generate valid CN outputs. Proof is given for a check node of degree 12 in GF(64) for the syndrome based algorithm with a number of computed syndromes reduced by a factor of four which directly impacts the check node complexity without performance degradation.

- [1] A. Voicila, D. Declercq, F. Verdier, M. Fossorier, and P. Urard, "Low-complexity decoding for non-binary ldpc codes in high order fields," *ICT 2010*
- [2] P. Schläfer, N. Wehn, M. Alles, T. Lehnigk-Emden, and E. Boutillon, "Syndrome based check node processing of high order NB-LDPC decoders," *ICT 2015*
- [3] M. C. Davey and D. J. C. MacKay, "Low density parity check codes over GF(q)," in *Information Theory Workshop, 1998*