

Construction of good Non-Binary Low Density Parity Check codes

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http://www-labsticc.univ-ubs.fr/nb_ldpc/

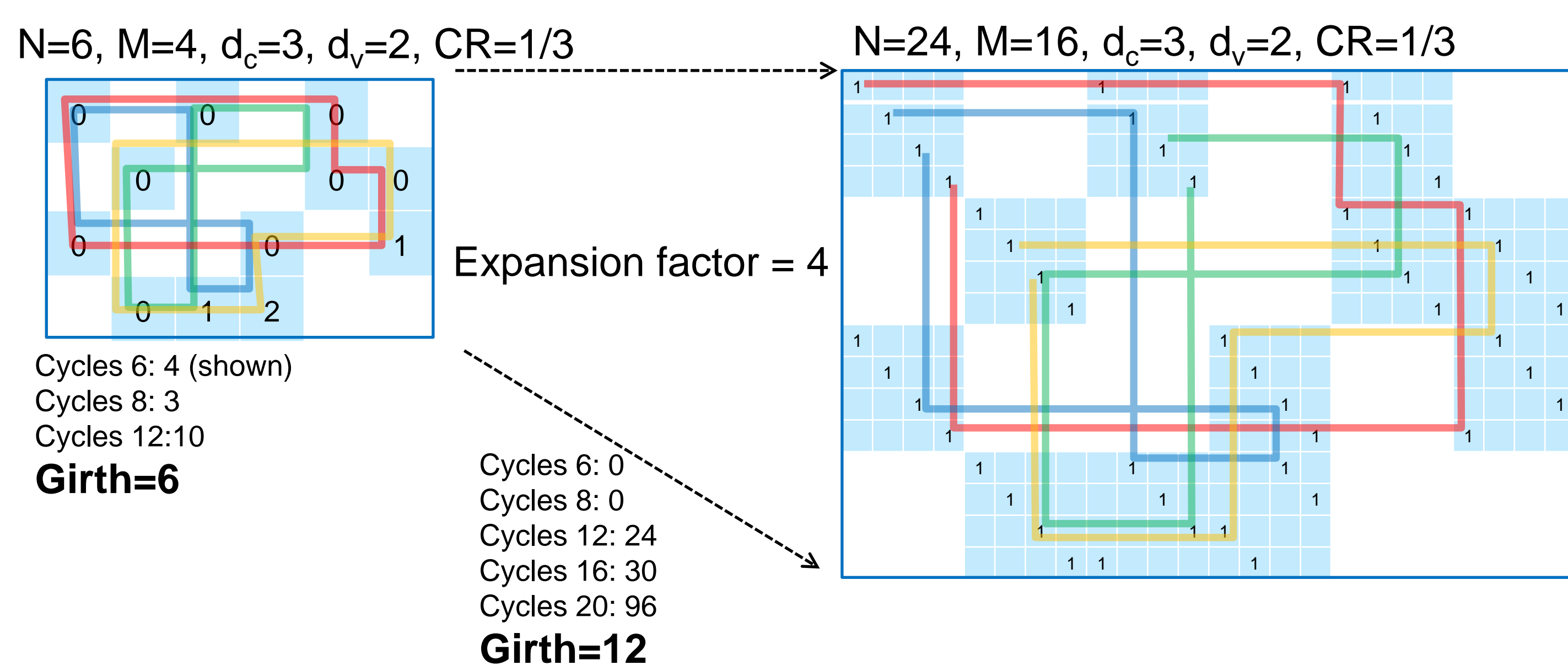


Introduction

Non-Binary Low-Density Parity-Check codes have better communication performance than their binary counterparts. Design of regular $(2,dc)$ LDPC codes over $GF(q)$ with both good waterfall and error floor properties is a complex task.

Girth optimization in Quasi-Cyclic LDPC codes [1]

QC-LDPC codes replace 1's of a matrix by shifted identity matrices. A cycle in the base matrix can be annealed in the QC-LDPC code by choosing shifting value such that the sum of shifting values in a cycle of the matrix is different from 0 modulo q .



Optimization of NB Parity Check Coefficients [2] [3]

An optimized sets of coefficients can effectively replace the random selection of coefficients often used in NB-LDPC construction over high order Galois Field, and thus helps the construction of new generations of NB-LDPC codes with better decoding performance. The sets of optimized coefficients are computed from the binary image of a parity checks of degree d_c .

Cycle "cancellation" in NB-LDPC codes [3]

With $d_v = 2$, each cycle of length g implies $g/2$ variables. This cycle can generates non-null codewords that imply only the $g/2$ variables of the cycle if the following property is not fulfilled:

$$\prod_{k \in E_{cv}} h_k \neq \prod_{l \in E_{vc}} h_l$$

where E_{cv} (respectively E_{vc}) is the set of edges of the cycle from check node to variable node (respectively from variable node to check node).

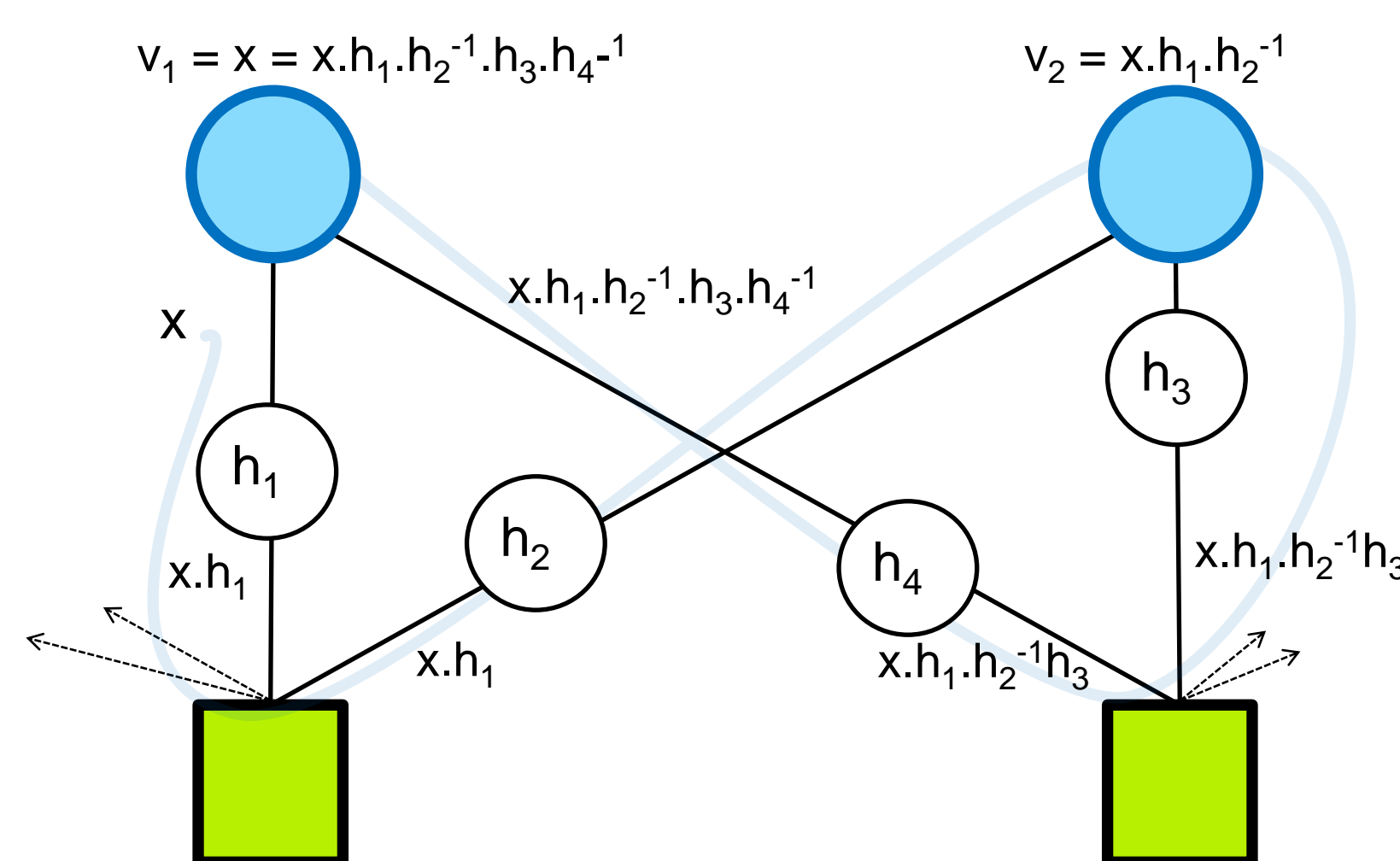
Example: if $h_1 \cdot h_3 = h_2 \cdot h_4$

Then $h_1 \cdot h_2^{-1} \cdot h_3 \cdot h_4^{-1} = 1$
 $\Rightarrow (v_1, v_2, 0, \dots, 0)$
 $= (x, xh_1h_2^{-1}, 0, \dots, 0)$
is a codeword.

If $h_i = \alpha^{a_i}$

Condition becomes :

$$\sum_{i=1}^{g/2} a_{2i-1} - \sum_{i=1}^{g/2} a_{2i} \neq 0 \quad \text{mod } q-1$$



Demo:

Please, select (or propose) a prototype matrix as well as the expansion factor and the Galois Field order.

... and let us construct a good NB-LDPC matrix that fulfill your requirements !

Toolbox



We have developed a wide range of tools to construct good NB-LDPC code. We also developed testing environment for the codes and a web site to promote new matrices with simulation results

We are using powerful dedicated software's with flexibility of bash.



gecode.cpp

Constraint solving toolkit



AFF3CT

A Fast Forward Error Correction Tool



bash.sh

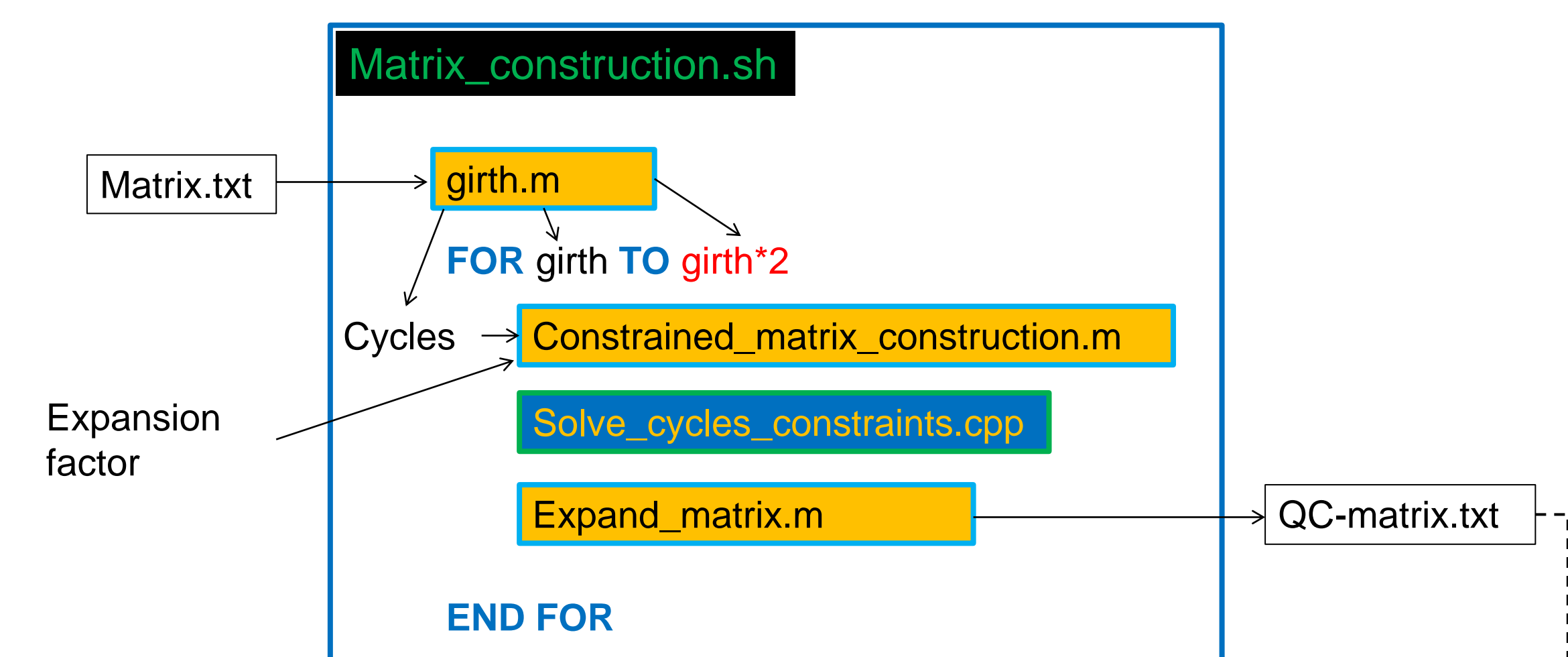
Command line interpreter



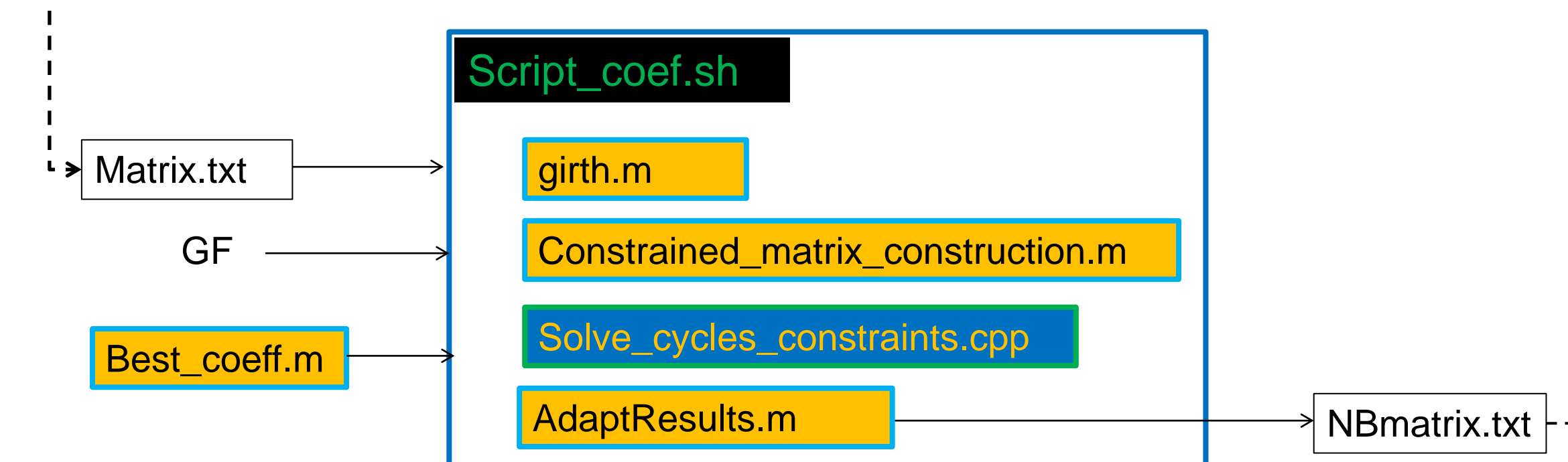
GNU Octave

Matrix manipulation

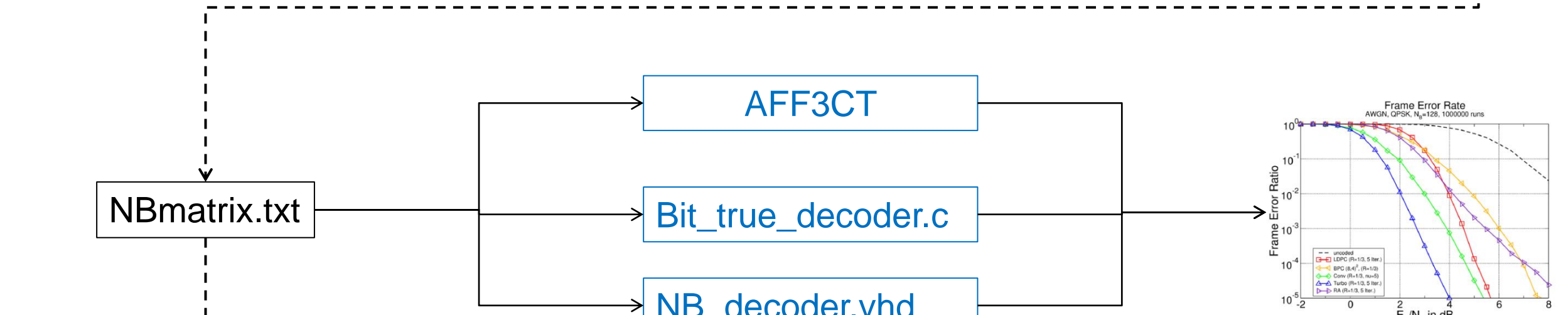
Matrix Expansion (binary) [1]



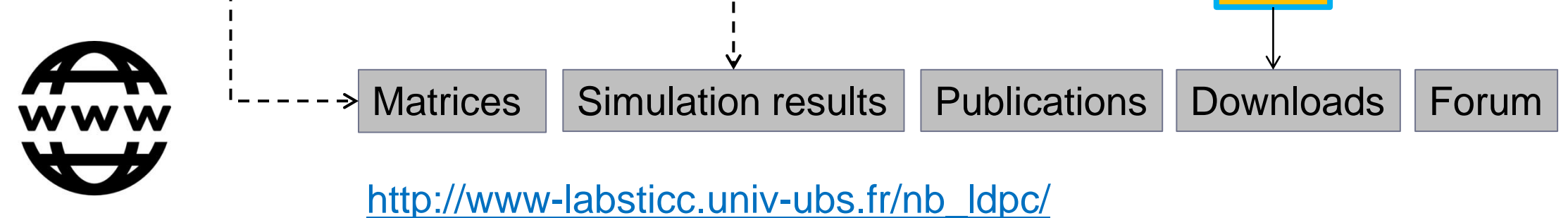
GF coefficient optimization [2] and cycle "cancellation" [3]



Simulations



website



Example of NB-LDPC code generated using `Matrix_construction.sh` and `Script_coef.sh`

Show_matrix.m

Conclusion

We developed a complete framework to construct good NB-LDPC code. We also developed testing environments for the codes and a web site to promote new matrices with simulation results

- [1] M. P. C. Fossorier, "Quasicyclic low-density parity-check codes from circulant permutation matrices," in *IEEE Transactions on Information Theory*, 2004.
[2] E. Boutillon "Optimization of Non Binary Parity Check Coefficients", 2017 <https://arxiv.org/pdf/1708.01761.pdf>
[3] Charly Poulliat, Marc Fossorier, David Declercq. « Design of regular $(2,dc)$ -LDPC codes over $GF(q)$ using their binary images ». *IEEE Trans. Commun.*, 2008.