



## Structured RLC codes: an update

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# ***Structured RLC codes: an update***

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**IETF89, NWCRG meeting**

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(☒ part of the work done while visiting Inria as post-doctorate)

## **Note well**

- **we, authors, didn't try to patent** any of the material included in this presentation
- **we, authors, are not reasonably aware** of patents on the subject that may be applied for by our employer
- if you believe some aspects may infringe IPR you are aware of, then fill in an IPR disclosure and please, let us know

<http://irtf.org/ipr>

# Our proposal and some results in **block** mode... A reminder

For details, see:

<http://www.ietf.org/proceedings/88/slides/slides-88-nwcrq-2.pdf>

# Goals (from IETF88)

- design codes that
  - can be used indifferently as **sliding/elastic/block** codes
  - can be used with encoding window/block sizes in **1-10,000s symbols** range
    - keep high enc./decoding speeds and erasure recovery performance in all cases
  - can be used as **small-rate** codes
    - it's not necessarily required, but it simplifies many things
  - focus only on use-cases that need **end-to-end coding**
    - e.g. for FLUTE/ALC, FECFRAME, or Tetrys
  - enable **compact and robust signaling** (essential!)
    - vectors can help for tiny k values but it's unfeasible above
    - use a known function + key (e.g. PRNG + seed)

## *Two key ideas*

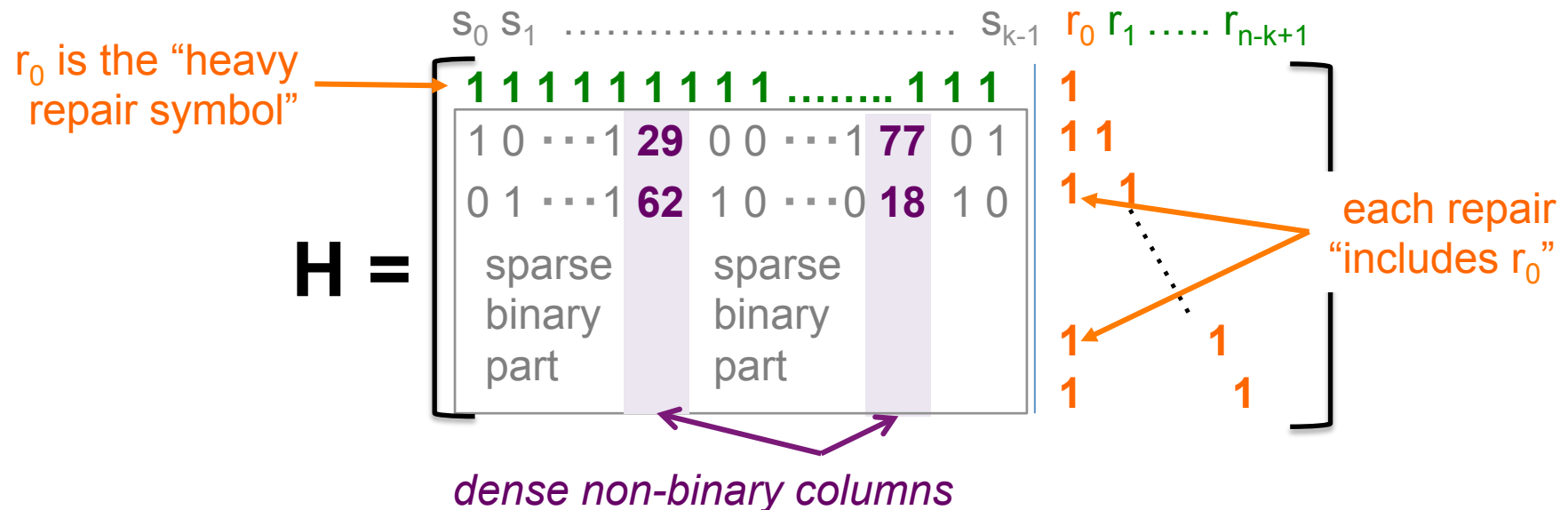
- idea 1: mix binary and non binary coefficients
  - most equations are **sparse** and coefficients **binary**
  - a limited number of columns are **dense** and use **non-binary** coefficients on  $GF(2^8)$
- idea 2: add a structure
  - add a **single dense row** (e.g. XOR sum of all source symbols) and make **all repair symbols depend on it**

# Let's put ideas 1 and 2 together

- 3 key parameters

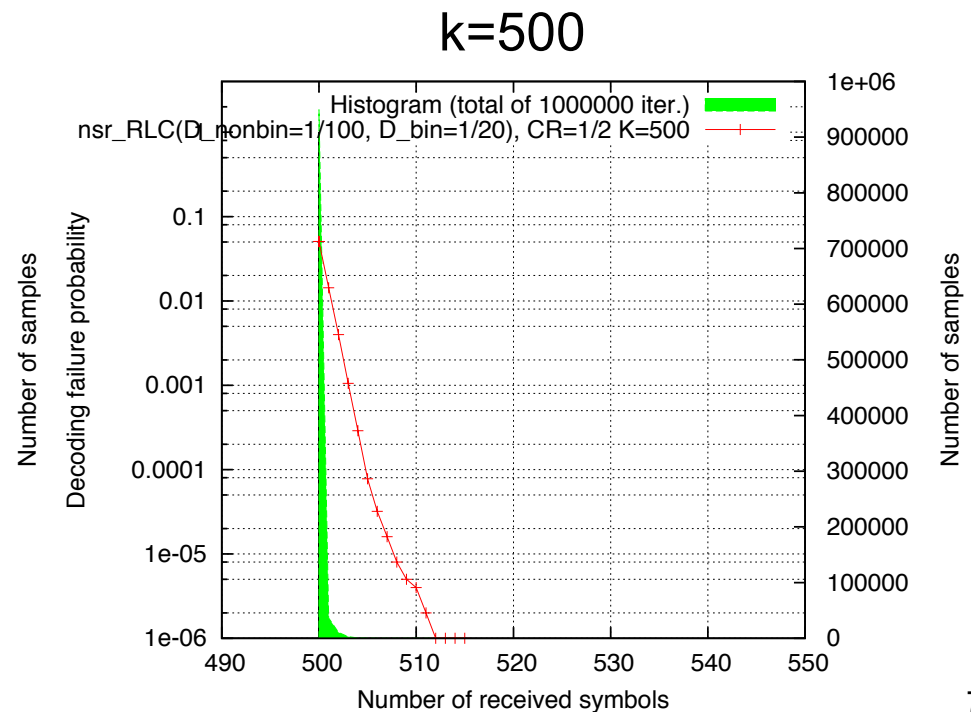
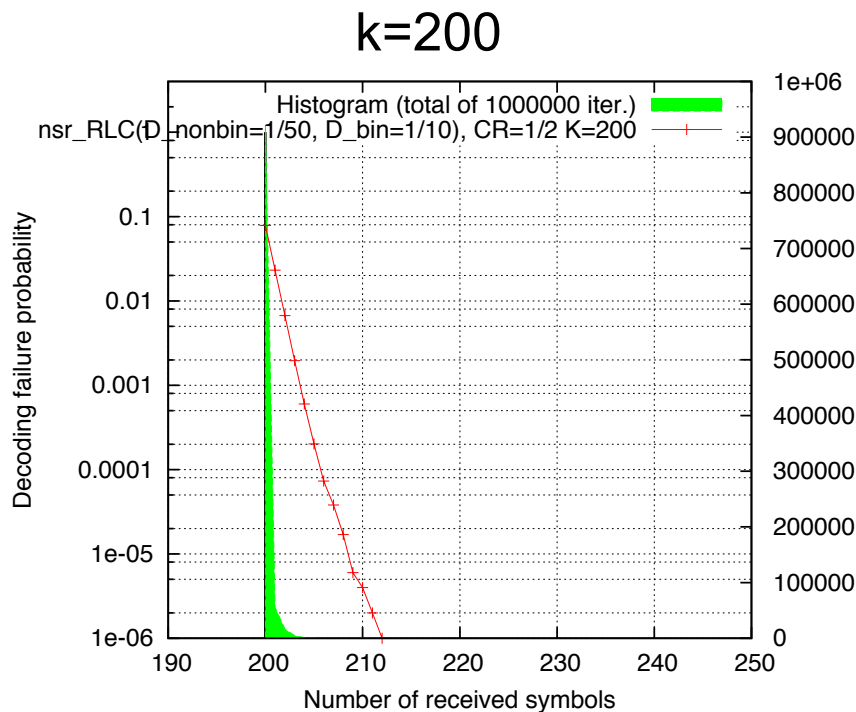
- $k$  block or encoding window size
- $D_{bin}$  controls the density of the sparse sub-matrices
- $D_{nonbin}$  controls number of dense non-binary columns
  - $\{D_{nonbin}, D_{bin}\}$  depend on  $k$  and a target maximum average overhead

- example: in **block** mode



# It works well as a **block AL-FEC code**

- it works well on average...
  - parameters are chosen so that the average overhead is always below, say  $10^{-3}$  (meaning  $k \cdot 10^{-3}$  add. symbols needed)
- and when looking at decoding failure proba. curves
  - no visible error floor at  $10^{-5}$  failure probability ☺



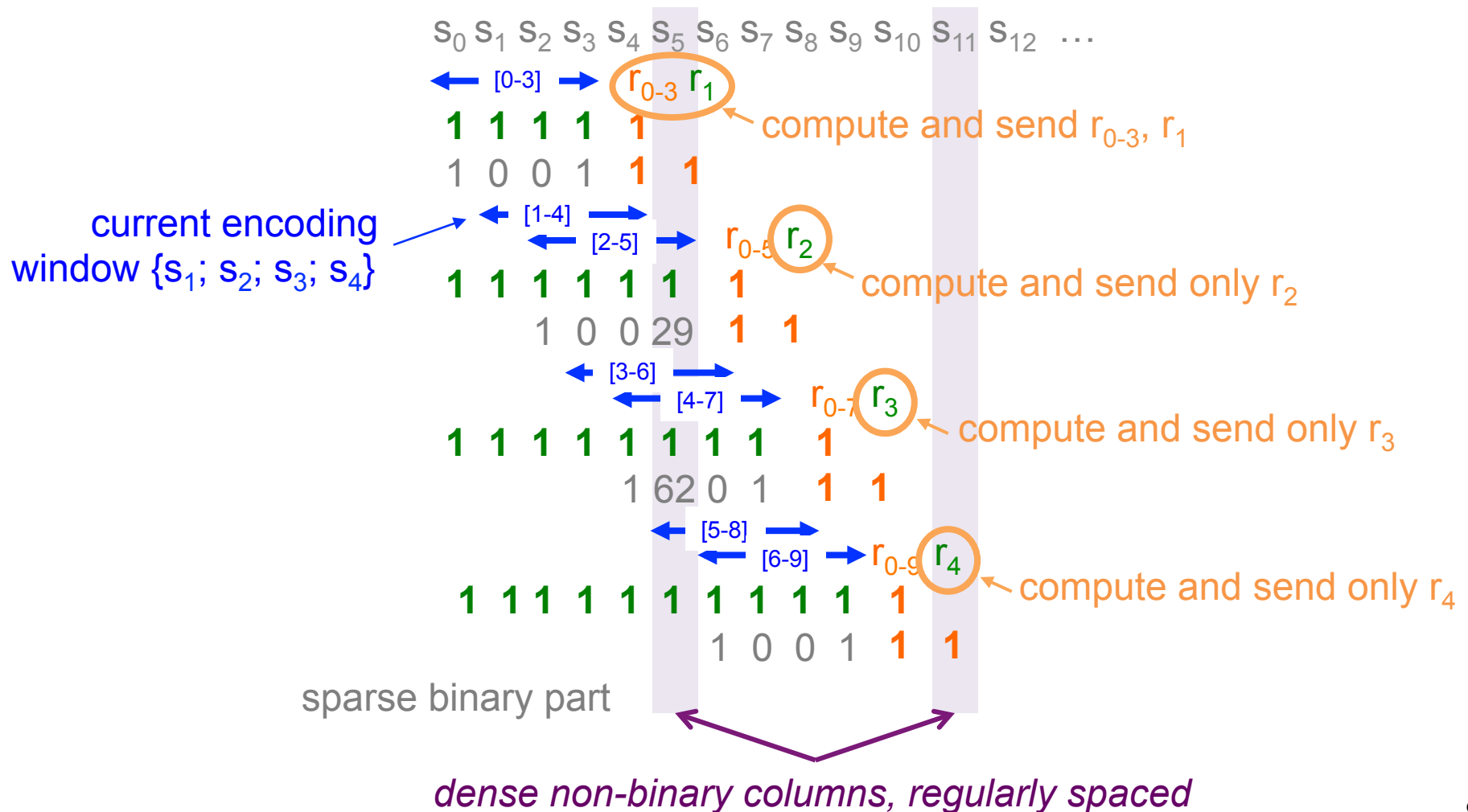


# What about **sliding window** mode?

# Structured RLC in sliding window mode

- with a fixed length ( $k$ ) sliding window

○ example:  $k=4$ ,  $CR=2/3 \Rightarrow$  send one repair after 2 src symbols



# Struct. RLC in sliding window mode (cont')

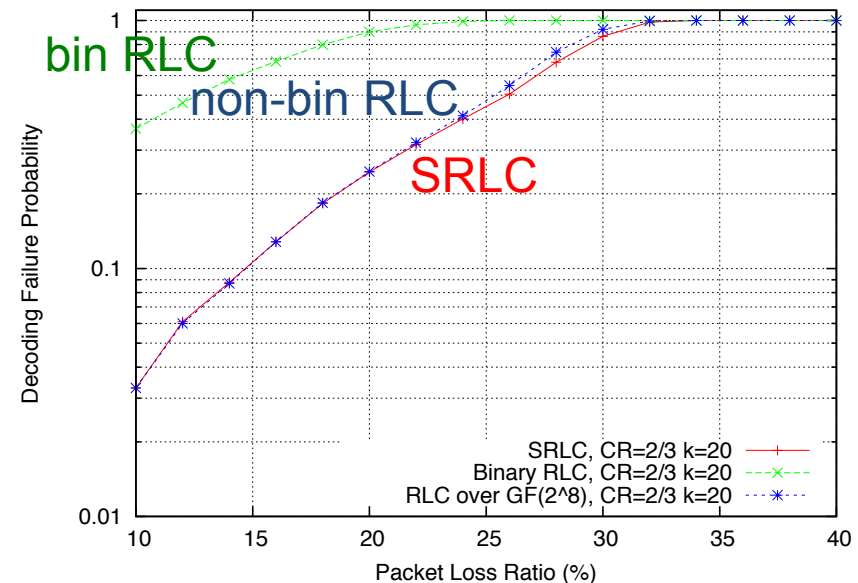
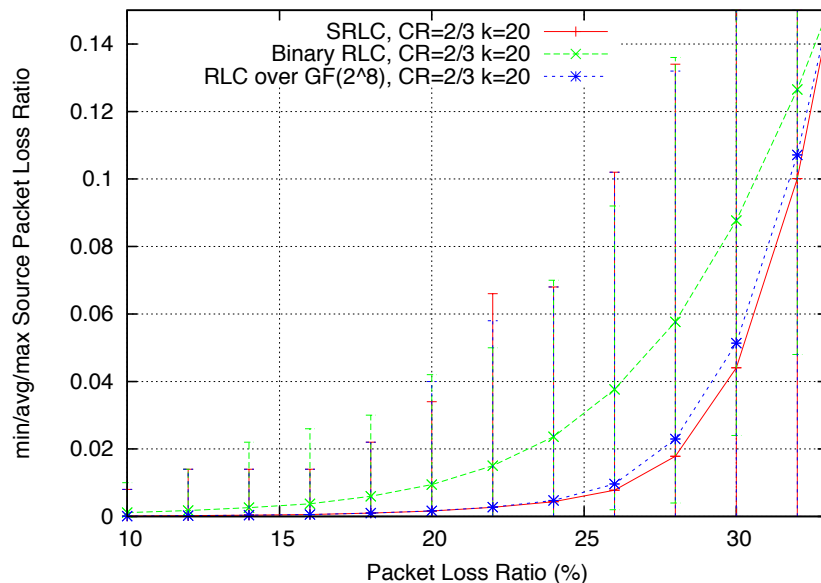
- about the previous example

- at session start, we wait  $k$  symbols to be available, and then compute and send a few repair symbols to match the target code rate
- afterwards we mix source and repair symbols in a periodic way
- each repair that is not a heavy symbol “accumulates” the current heavy repair symbol
  - i.e. the **XOR sum from  $s_0$  to the highest known symbol**
  - **the current sum repair symbol is sent from time to time**
- the  $D_{\text{nonbin}}/D_{\text{bin}}$  are set according to the fixed  $k$  value and desired average overhead, using pre-calculated tables

# A few experiments

- test conditions (small  $k=20$ )

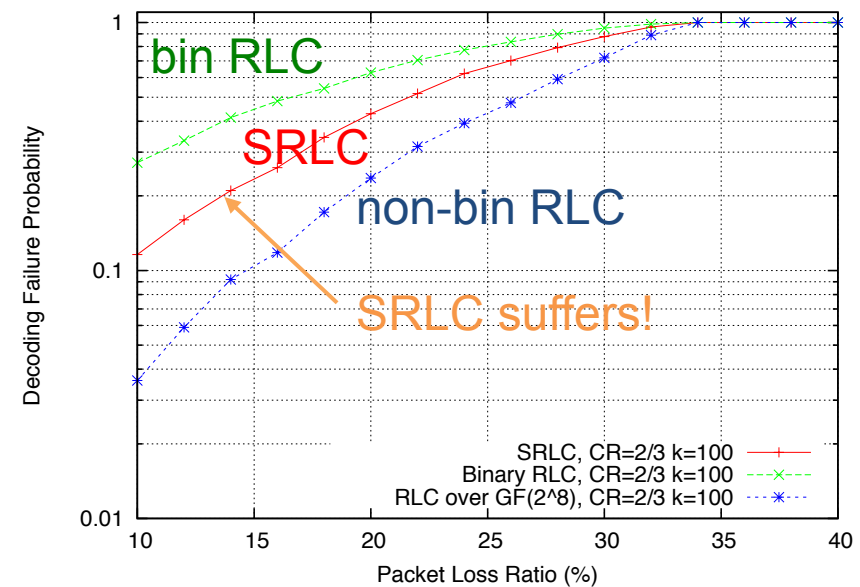
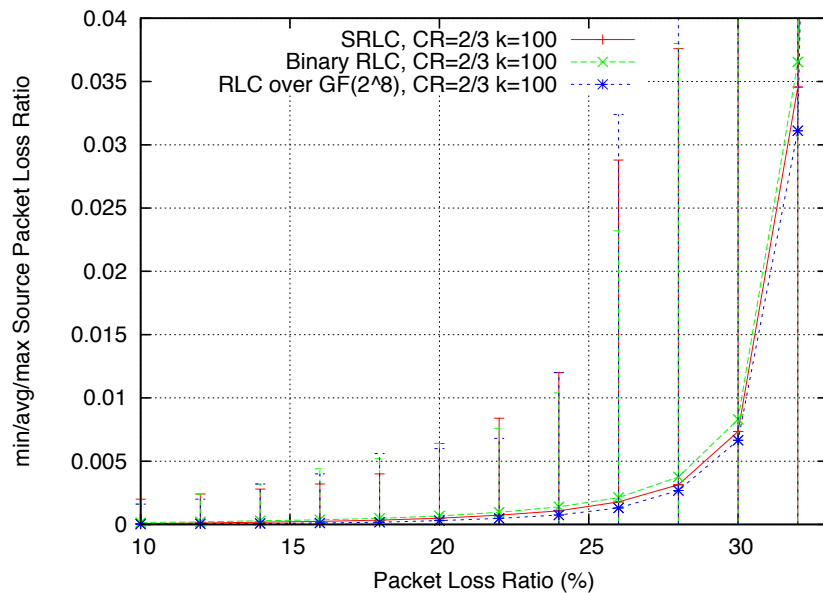
- the encoding window (size  $k = 20$ ) slides over a flow of  $25 \cdot k = 500$  source symbols
- $CR = 2/3$ , send 1 repair after 2 source symbols
- plot  $Pr_{fail}(plr)$  post-repair curves for the whole transmission
  - does not catch the number of non recovered source symbols



- non-bin coefficients are essential
- the heavy repair symbol improves performance WRT. RLC over  $GF(2^8)$

# A few experiments... (cont')

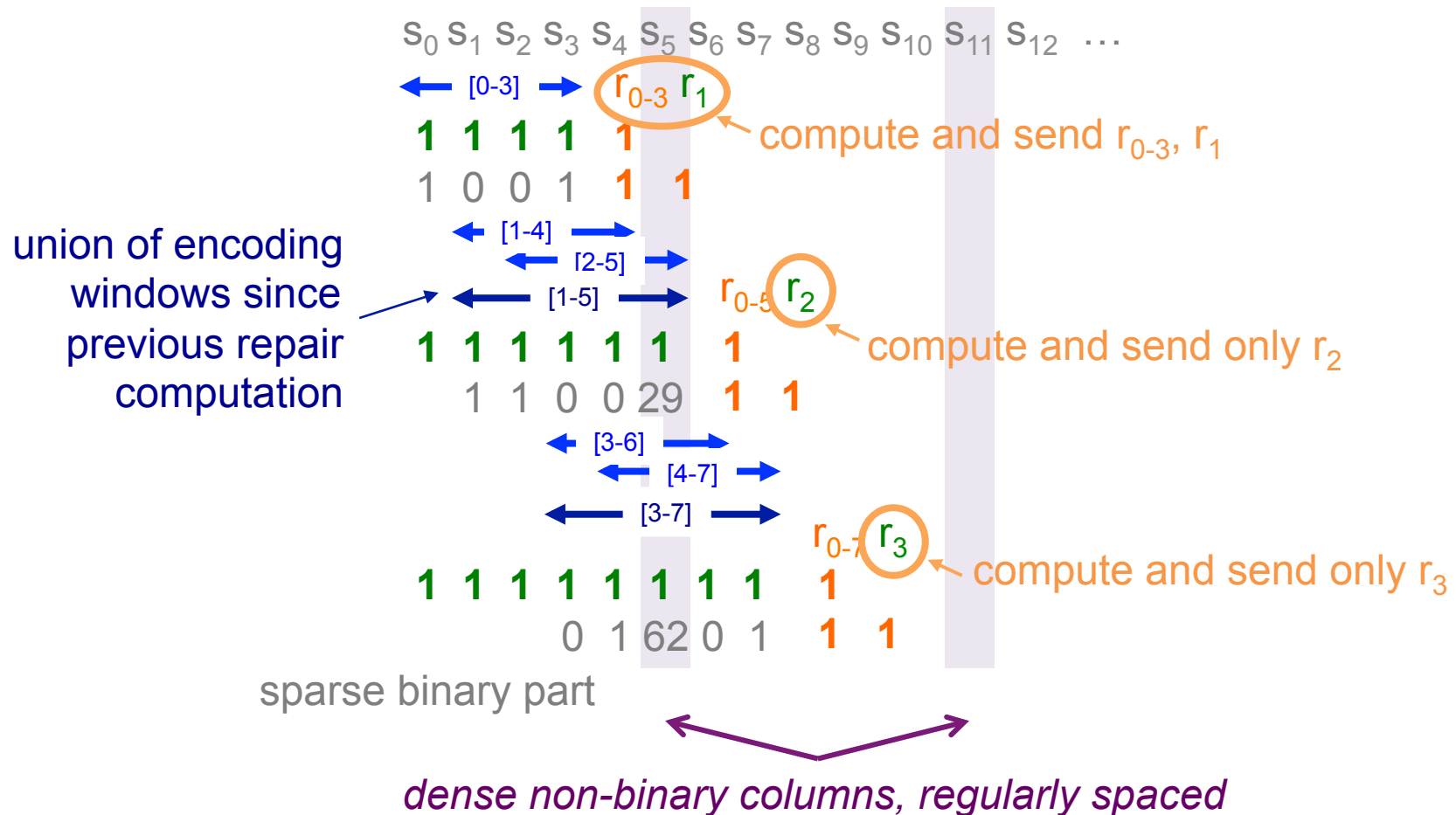
- test conditions (medium  $k=100$ )
  - the encoding window (size  $k = 100$ ) slides over a flow of  $25 \cdot k = 2500$  source symbols
  - $CR = 2/3$ , send 1 repair after 2 source symbols
  - plot  $Pr_{fail}(plr)$  post-repair curves for the whole transmission
    - does not catch the number of non recovered source symbols



- we reused  $D_{bin}/D_{nonbin}$  values computed for the block mode, which is perhaps not appropriate here...

# An improvement (under progress)

- consider the union of encoding windows when computing new repair symbols...
  - will make a difference with small  $k$  and high CR values



# Conclusions

# Conclusions

- our proposal tries to take the best of RLC
  - fill in the gap between sliding/elastic window codes and block codes
  - use the right technique (bin vs. non-bin coefficients) at the right time, in the right way
    - find balance between erasure recovery perf. and complexity
- a lot remains to be done yet...
  - how **fast** is it?
    - e.g., compared to our optimized LDPC-Staircase/RS codecs
  - how does it **scale** with  $k$ ?
    - e.g., compared to our optimized LDPC-Staircase codec
  - define **signaling** aspects
    - it's a critical practical topic



# Thank you!



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Information and Communications Technology**