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Vincent Roca, Kazuhisa Matsuzono

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Structured RLC codes: an update

Vincent Roca (Inria, France)

Kazuhisa Matsuzono (NICT, Japan) ✕

IETF89, NWCRG meeting

March 6th, 2014, London

(✕ 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

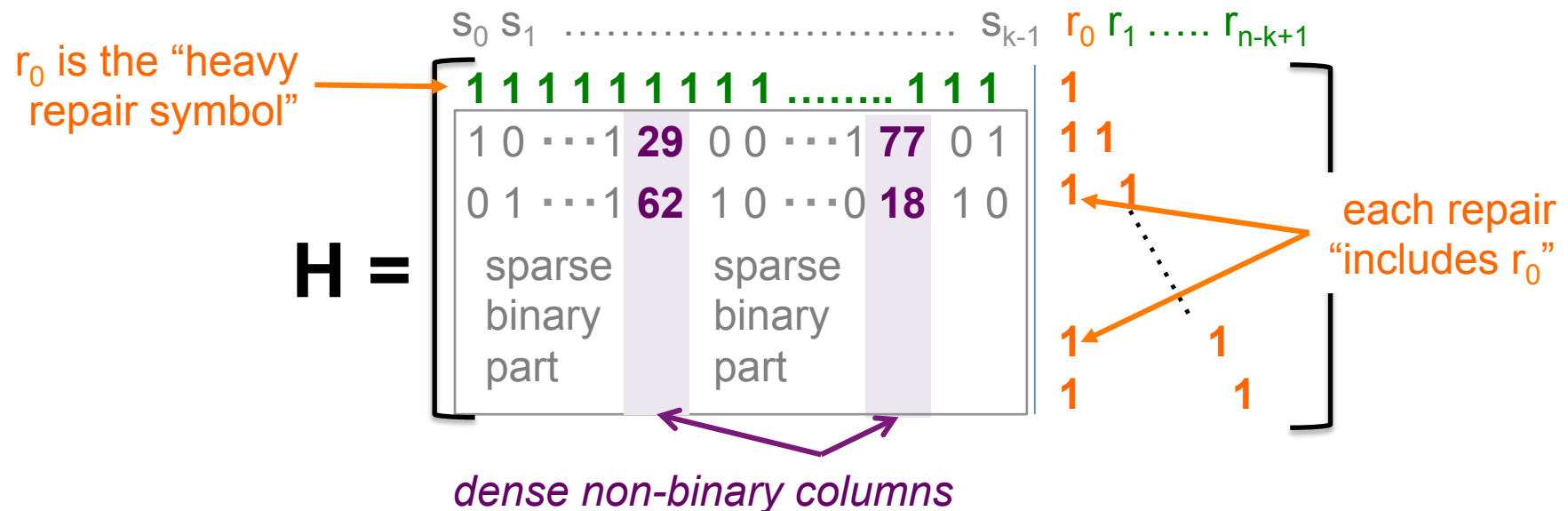
- idea 1: mix binary and non binary coefficients
 - most equations are **sparse** and coefficients **binary**
 - a limited number of columns are **dense** and use **non-binary** coefficients on $GF(2^8)$
- idea 2: add a structure
 - add a **single dense row** (e.g. XOR sum of all source symbols) and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

Let's put ideas 1 and 2 together

- 3 key parameters

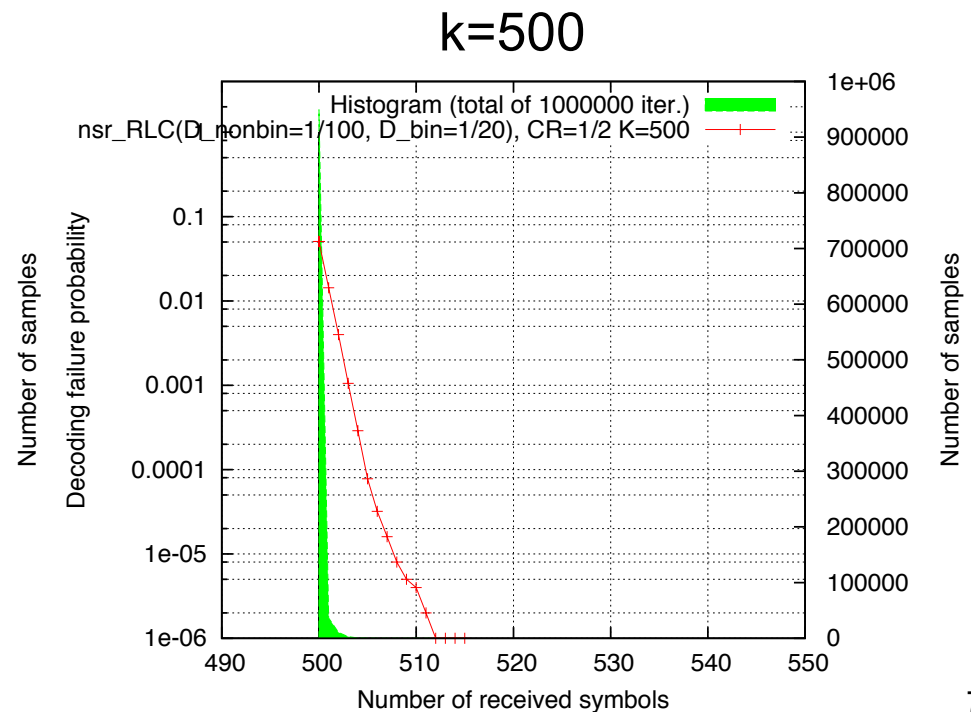
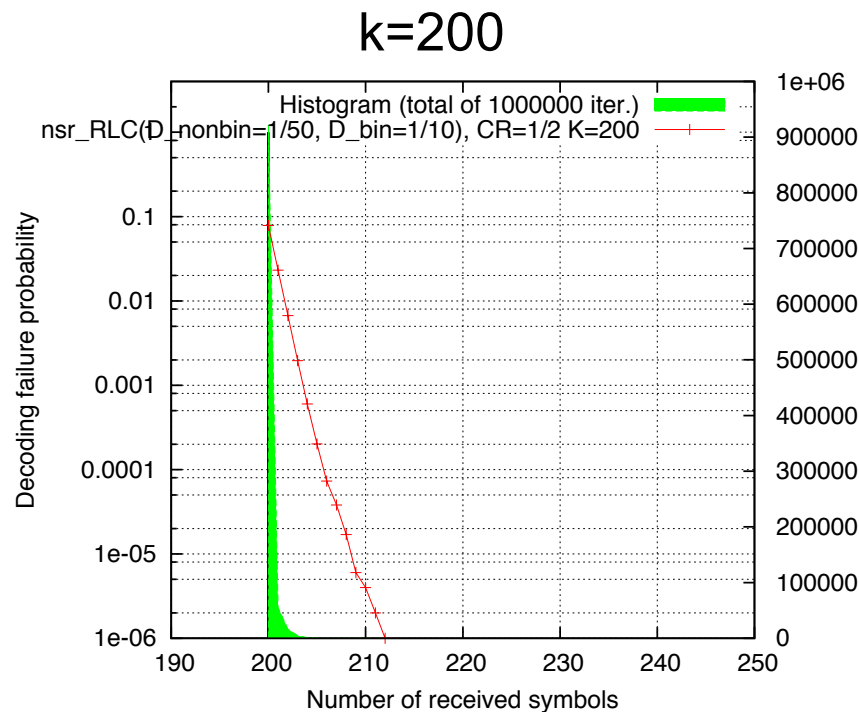
- k block or encoding window size
- D_{bin} controls the density of the sparse sub-matrices
- D_{nonbin} controls number of dense non-binary columns
 - $\{D_{nonbin}, D_{bin}\}$ depend on k and a target maximum average overhead

- 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 ☺

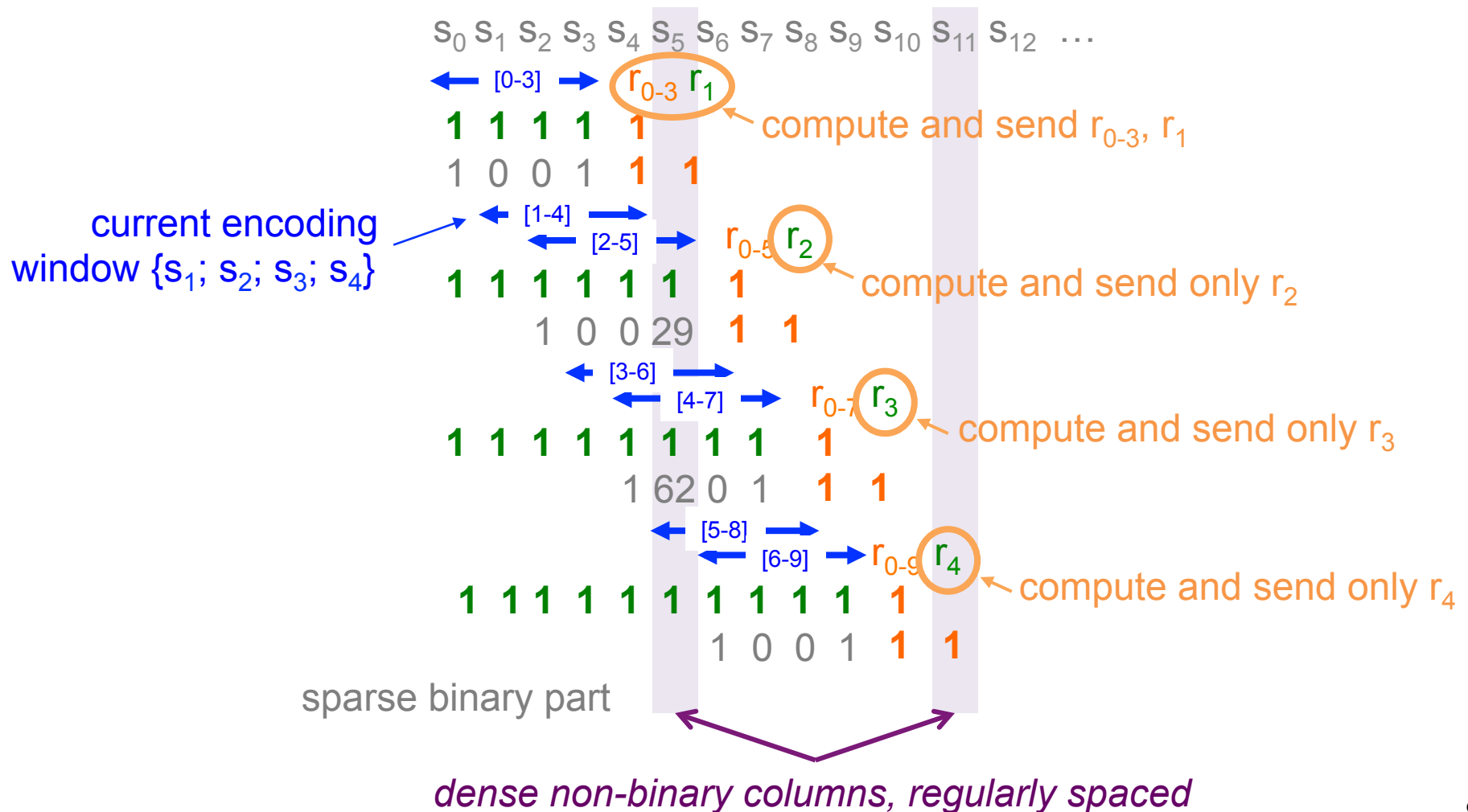


What about **sliding window** mode?

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')

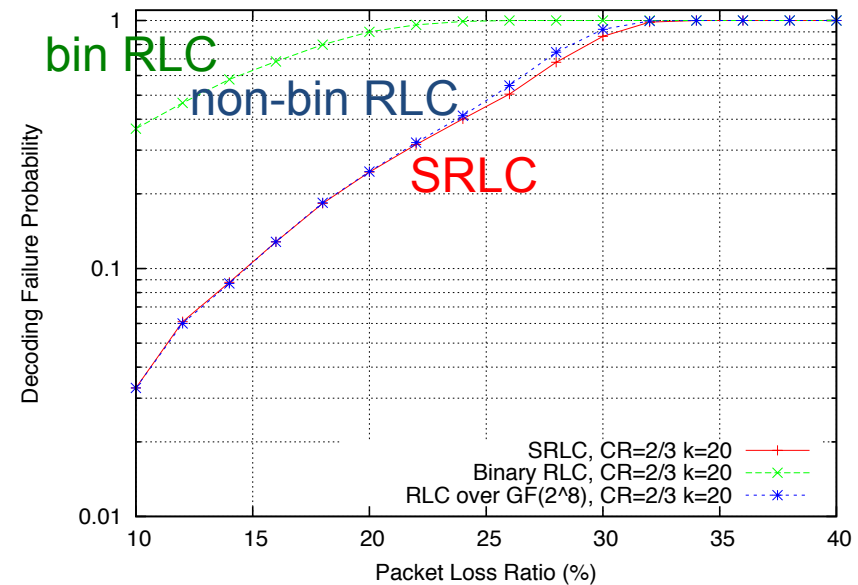
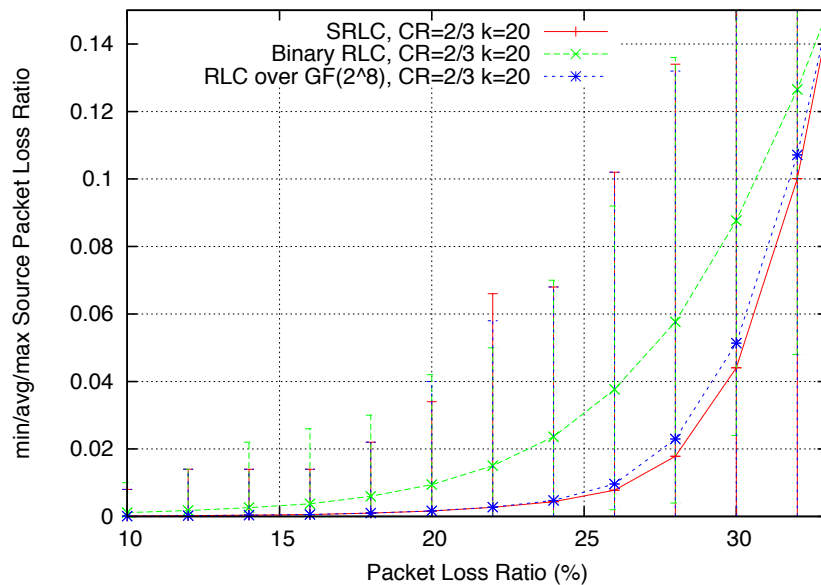
- about the previous example

- 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 $k=20$)

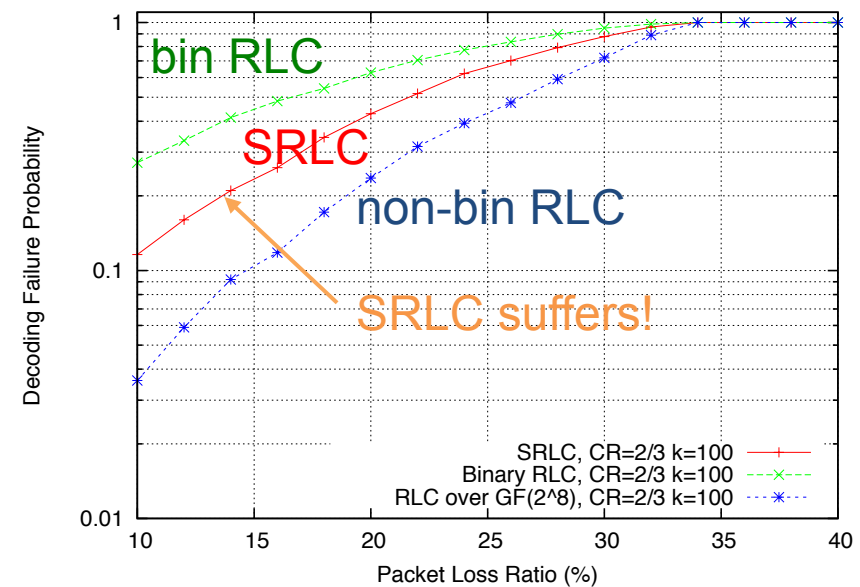
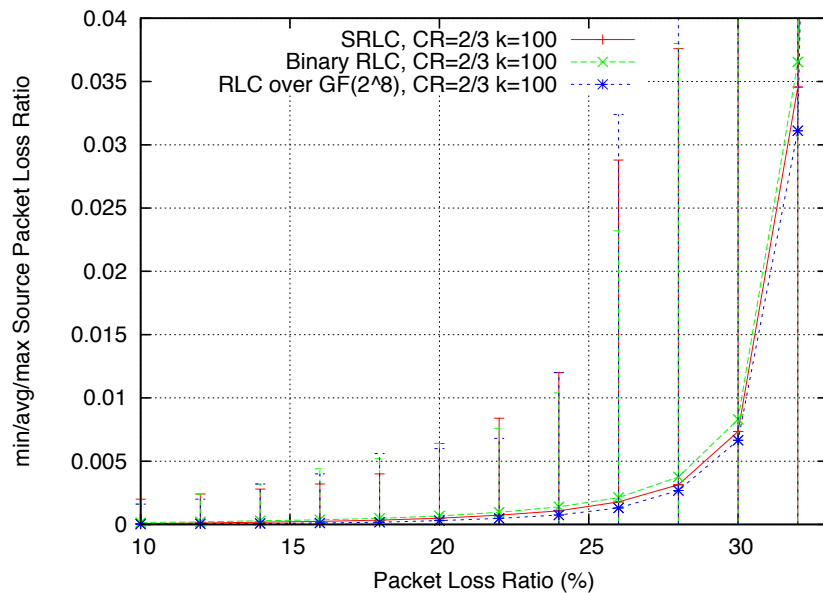
- the encoding window (size $k = 20$) slides over a flow of $25 \cdot k = 500$ source symbols
- $CR = 2/3$, send 1 repair after 2 source symbols
- plot $Pr_{fail}(plr)$ post-repair curves for the whole transmission
 - does not catch the number of non recovered source symbols



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

A few experiments... (cont')

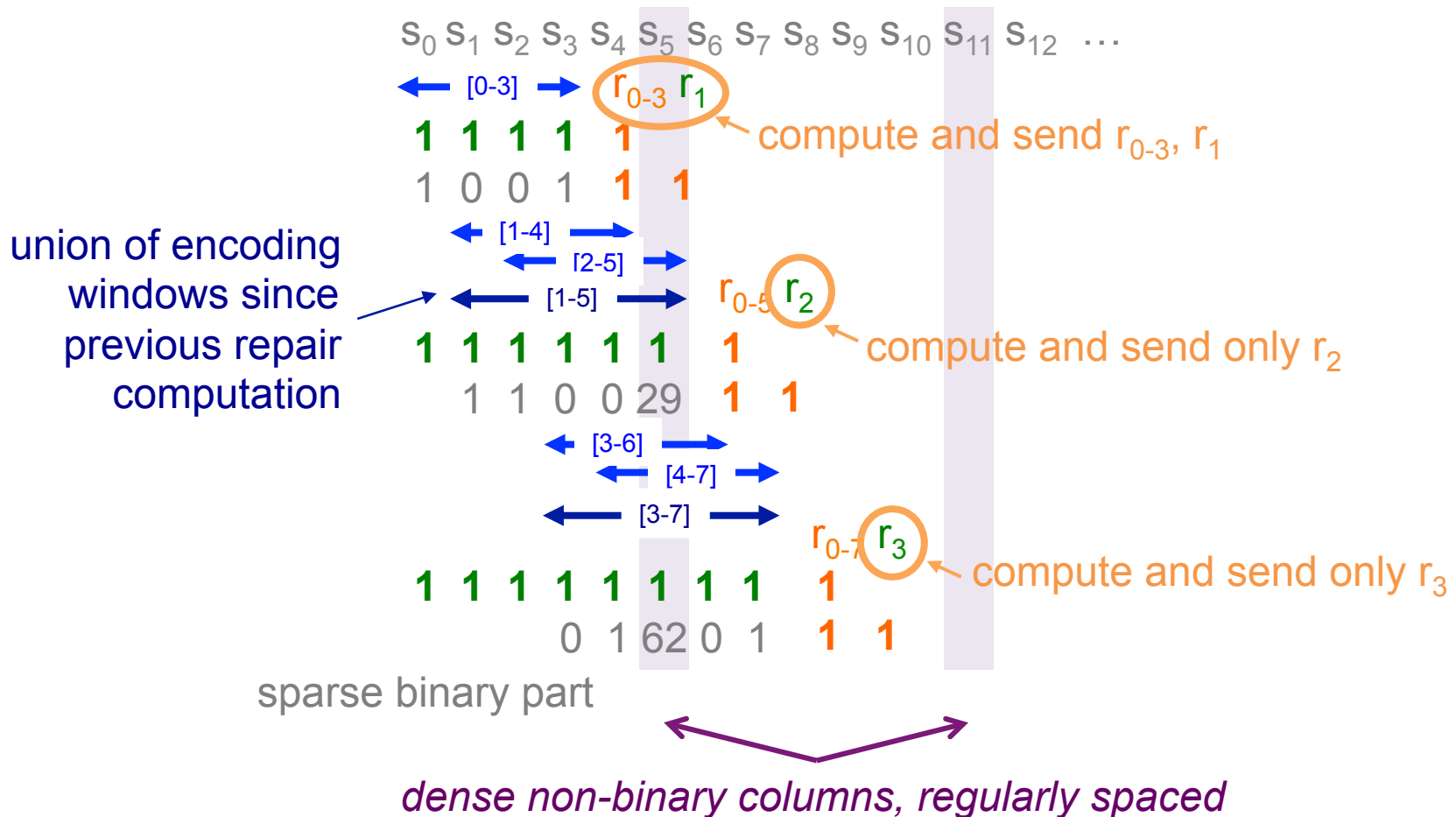
- test conditions (medium $k=100$)
 - the encoding window (size $k = 100$) slides over a flow of $25 \cdot k = 2500$ source symbols
 - $CR = 2/3$, send 1 repair after 2 source symbols
 - plot $Pr_{fail}(plr)$ post-repair curves for the whole transmission
 - does not catch the number of non recovered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



**National Institute of
Information and Communications Technology**