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)

informatiques mathématiques

National Institute of
Information and Communications Technology

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-nwcrg-2.pdf

informatiques mathématiques

National Institute of
Information and Communications Technology

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)**

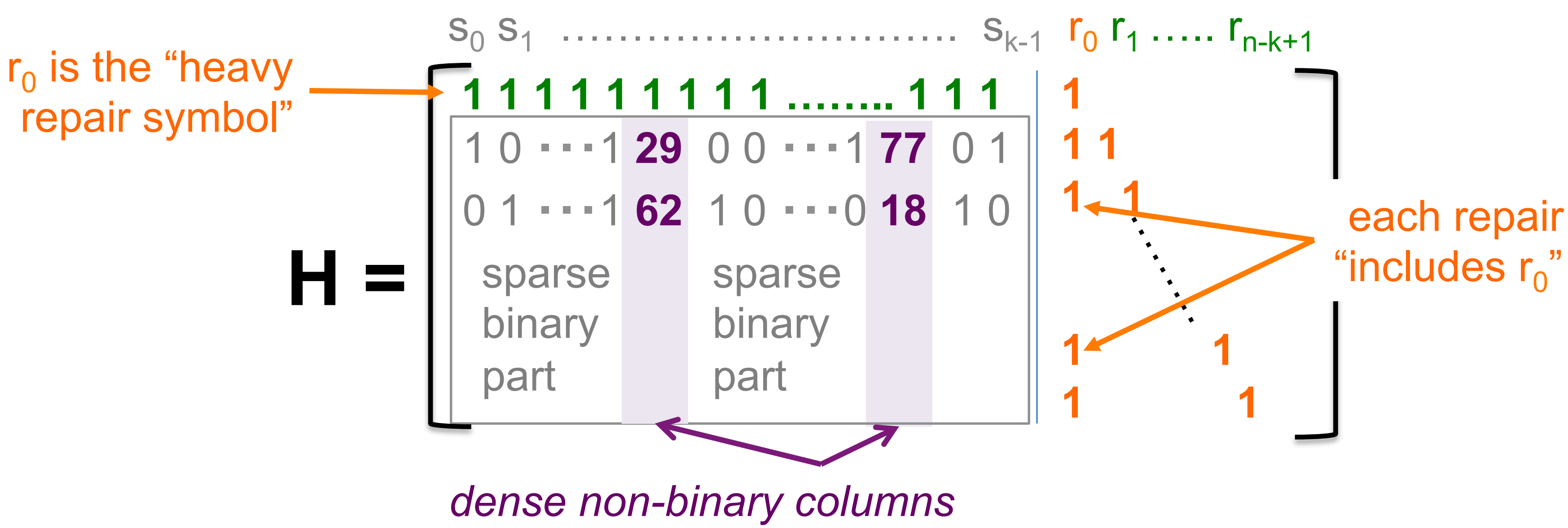
Two key ideas

- 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

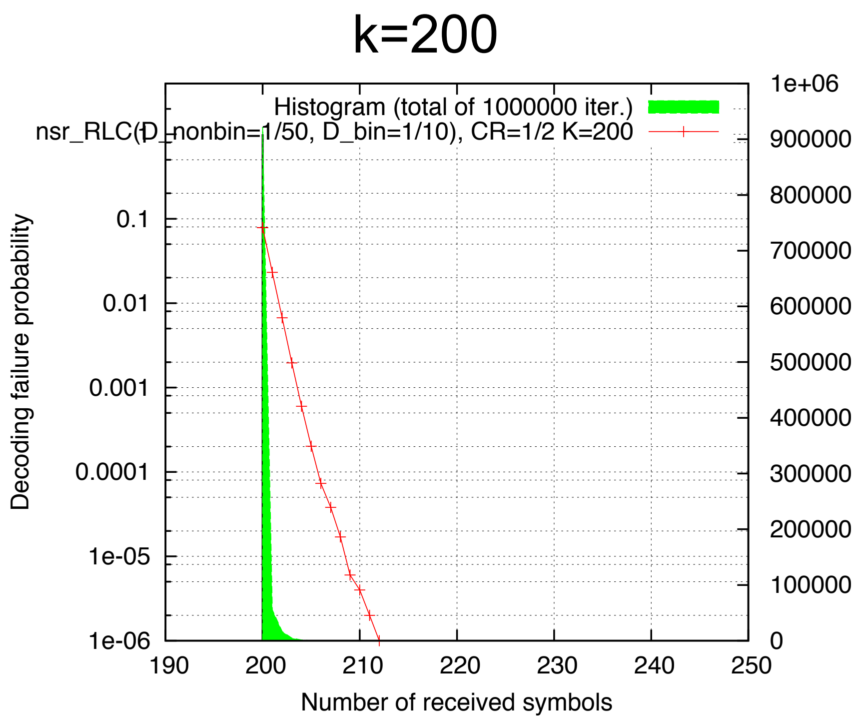
- 3 key parameters
  - **k** — **block or encoding window size**
  - **D_bin** — **controls the density of the sparse sub-matrices**
  - **D_nonbin** — **controls number of dense non-binary columns**
    - {D_nonbin, D_bin} depend on k and a target maximum average overhead

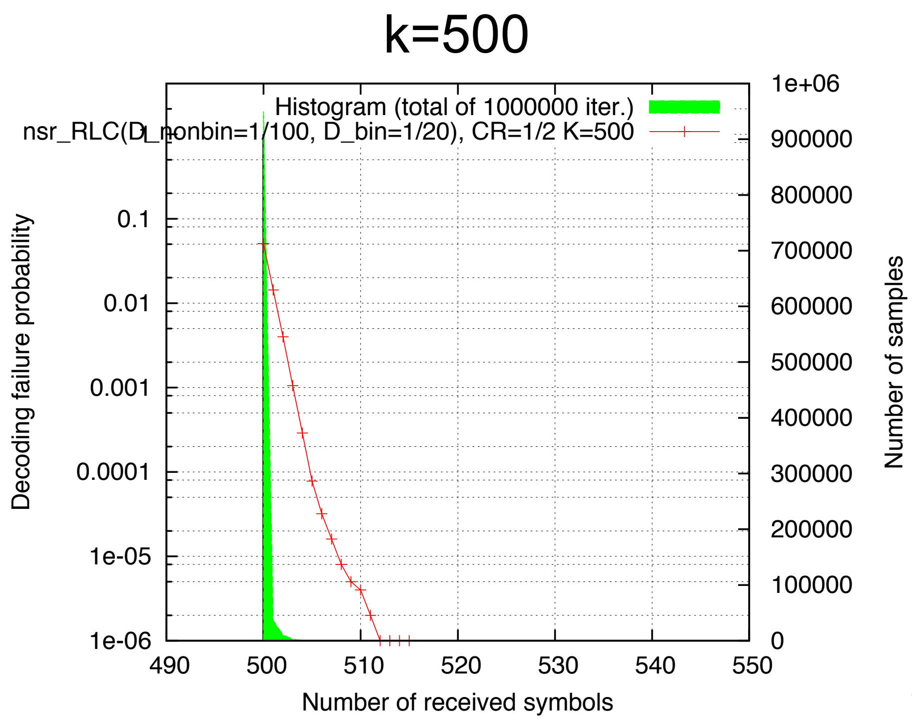
- example: in **block** mode



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 $k*10^{-3}$ add. symbols needed)
- and when looking at decoding failure proba. curves
  - no visible error floor at 10^{-5} failure probability ☺



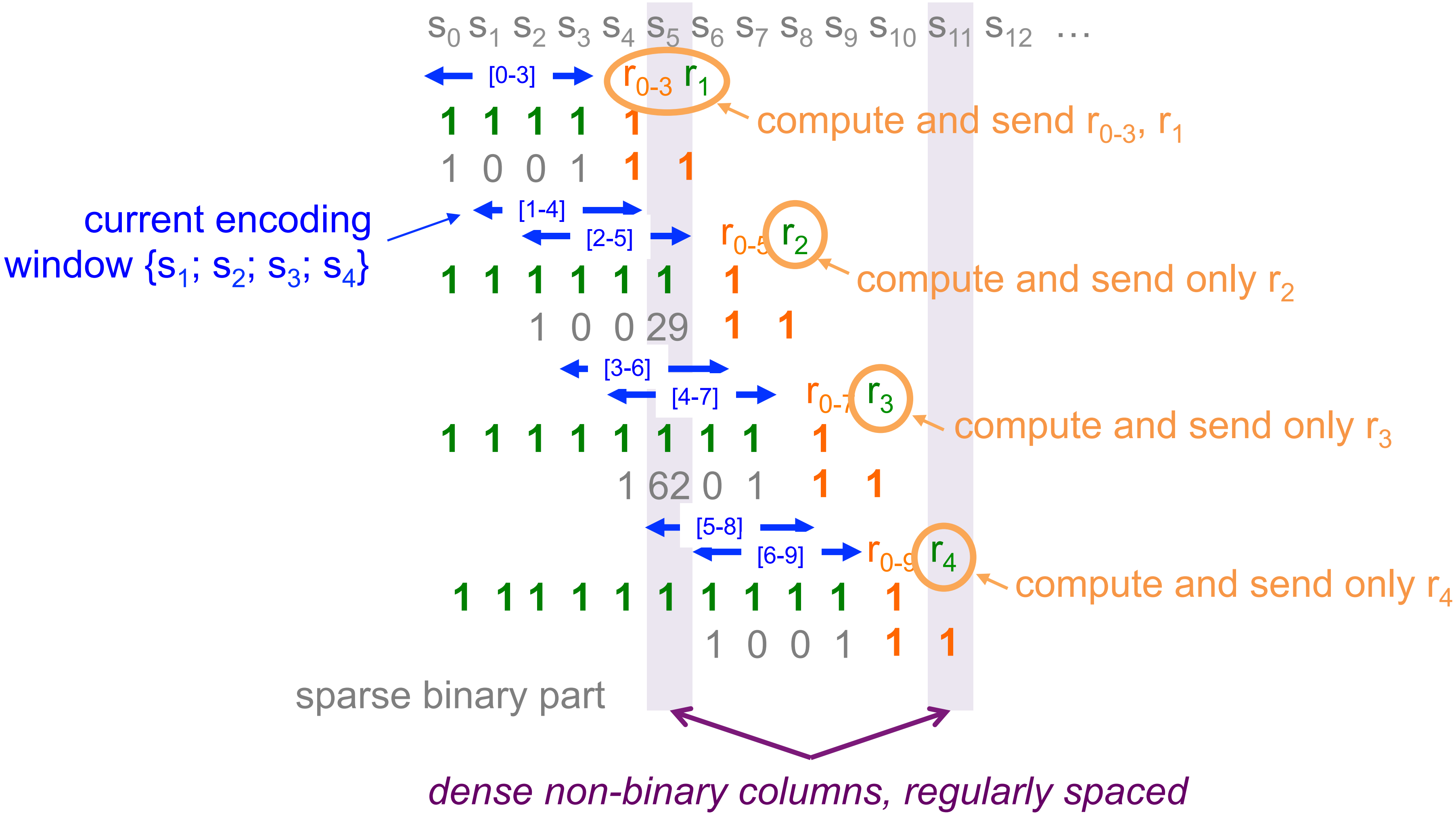


What about **sliding window** mode?

National Institute of
Information and Communications Technology

Structured RLC in sliding window mode

- with a fixed length (k) sliding window
  - example: k=4, CR=2/3 ⇒ send one repair after 2 src symbols

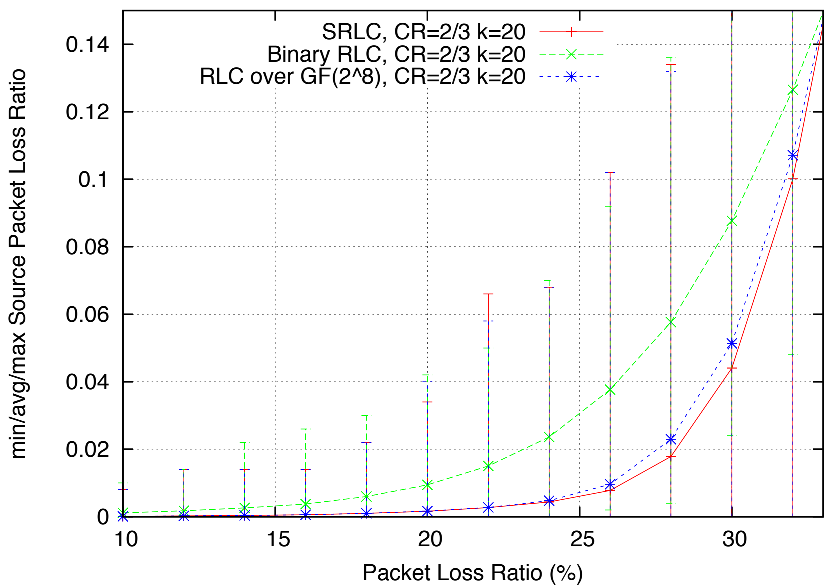


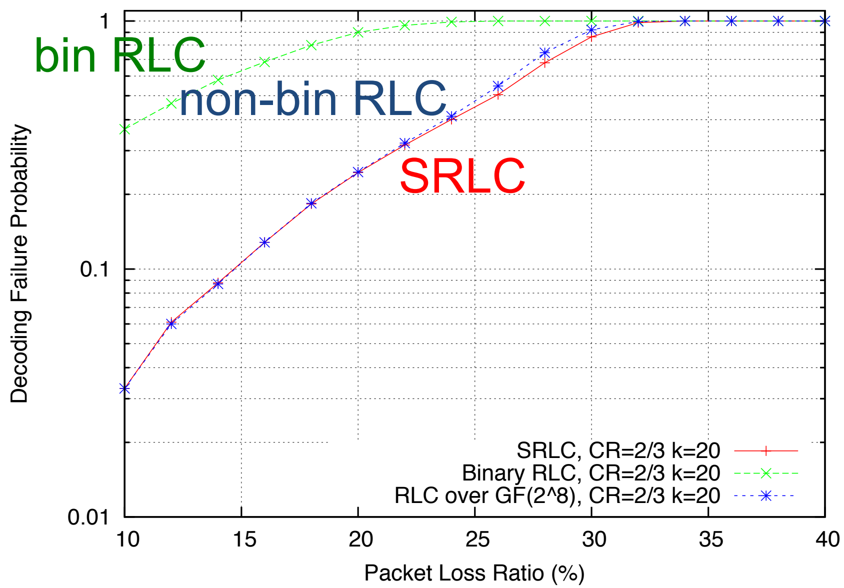
Struct. RLC in sliding window mode (cont')

- 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_{nonbin}/D_{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*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

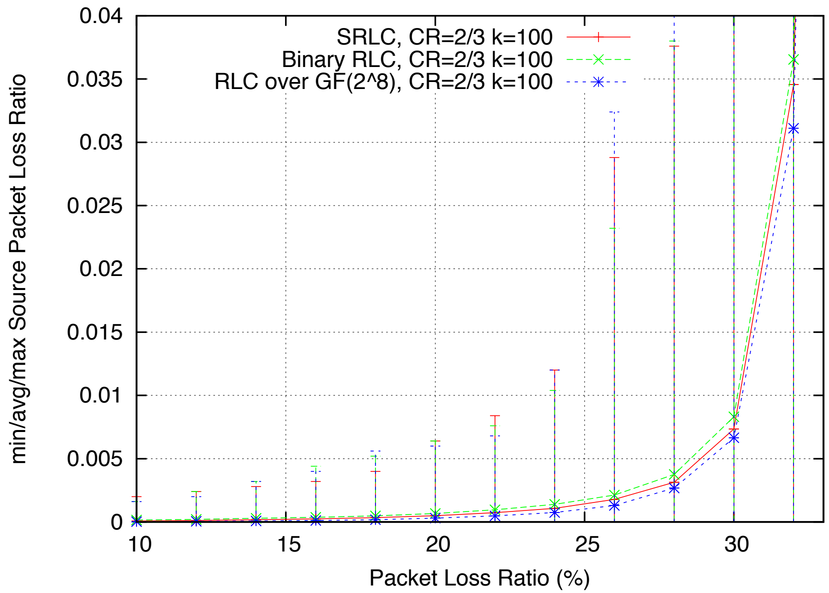


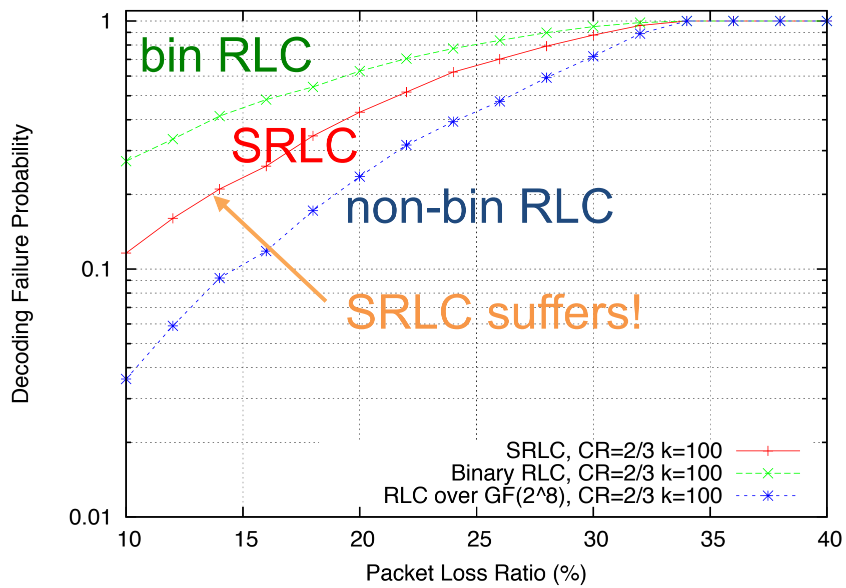


- non-bin coefficients are essential
- the heavy repair symbol improves performance WRT. RLC over $GF(2^8)$

A few experiments… (cont')

- test conditions (medium k=100)
  - the encoding window (size k = 100) slides over a flow of 25*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

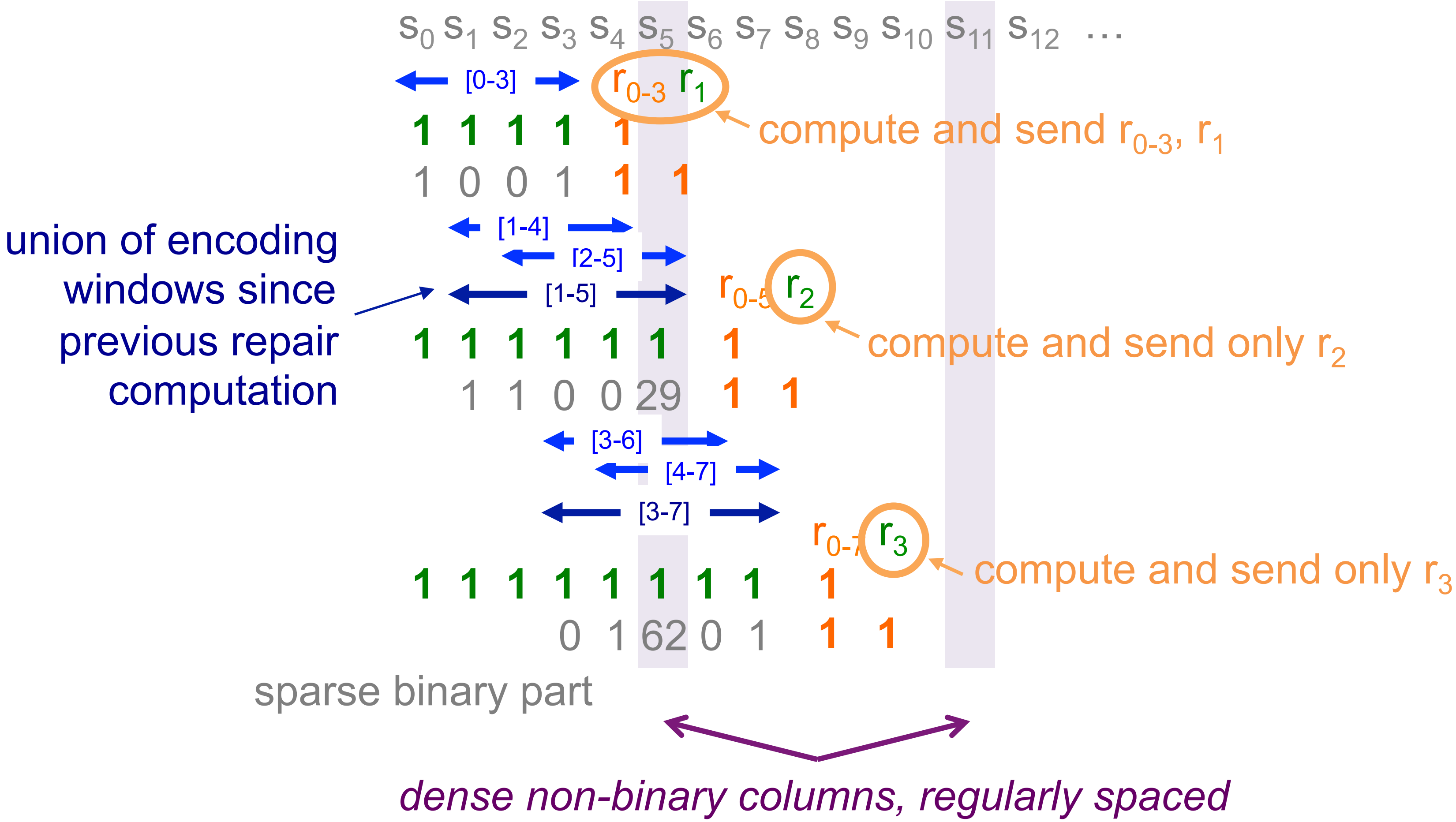




- we reused D_bin/D_nonbin values computed for the block mode, which is perhaps not appropriate here…

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!

informatiques mathématiques

National Institute of
Information and Communications Technology