Design of a generic FEC API

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What does it mean?

- API compatible with **MDS and non-MDS** codes
- API compatible with **fixed-rate and rateless** codes
- API compatible with **block and sliding window** codes
- API compatible with codes for **end-to-end and in-network re-encoding** use-cases

The KEY question: why should we do it?

- ease FEC-enabled software development
  - an API provides guidelines
  - a common API reduces dependencies, making it easier to remove a codec and plug another one
- ease benchmarking
  - of codes, of codecs, of full solutions
- ease development of a future reference FEC codec
  - (see discussion, later)

The KEY question: why should we do it? (2)

- ease its adoption by SDO (standards developing org.)
  - a key asset for FEC scheme adoption by an SDO!
  - in the mid-term, an open API & open-source free codec is benefic to everybody…
  - … even to those who already have a commercial offer

- because it's feasible
  - within NWCRG, several of us developed FEC codecs / APIs

Yes, it's feasible

- we (Inria) did it
  - **public OpenFEC (http://www.openfec.org/) provides API for Reed-Solomon and LDPC-Staircase**
  - **commercial, non-public OpenFEC adds support for Raptor and RLC**
    - adding sliding window code support (e.g., RLC) required major evolutions of the API
- but
  - we're not sure it's the best API
  - we'd like to have an open, standardized solution

Close-up on requirements

- What does it mean that the API should be compatible with:
  1. MDS and non-MDS codes?
  2. fixed-rate and rateless codes?
  3. block and sliding window codes?
  4. codes for end-to-end and codes for in-network re-encoding use-cases?

Close-up 1: MDS vs. non-MDS codes

- "Maximum Distance Separable" or "ideal" code
  - **with a (k, n) block code, any subset of k encoding symbols out of the n possible enables to recover lost source symbols**
  - **said differently, with a linear code, any sub-system is non-singular**

- impact:
  - **ideal code:**
    - decoding with >= k encoding symbols **always** succeeds
    - one knows in advance what will happen
  - **non-ideal code:**
    - decoding with >= k encoding symbols **may or not** succeed
    - API should enable a new decoding attempt, with additional symbols, if more are still expected

not too complex to address

Close-up 2: fixed rate vs. rateless codes

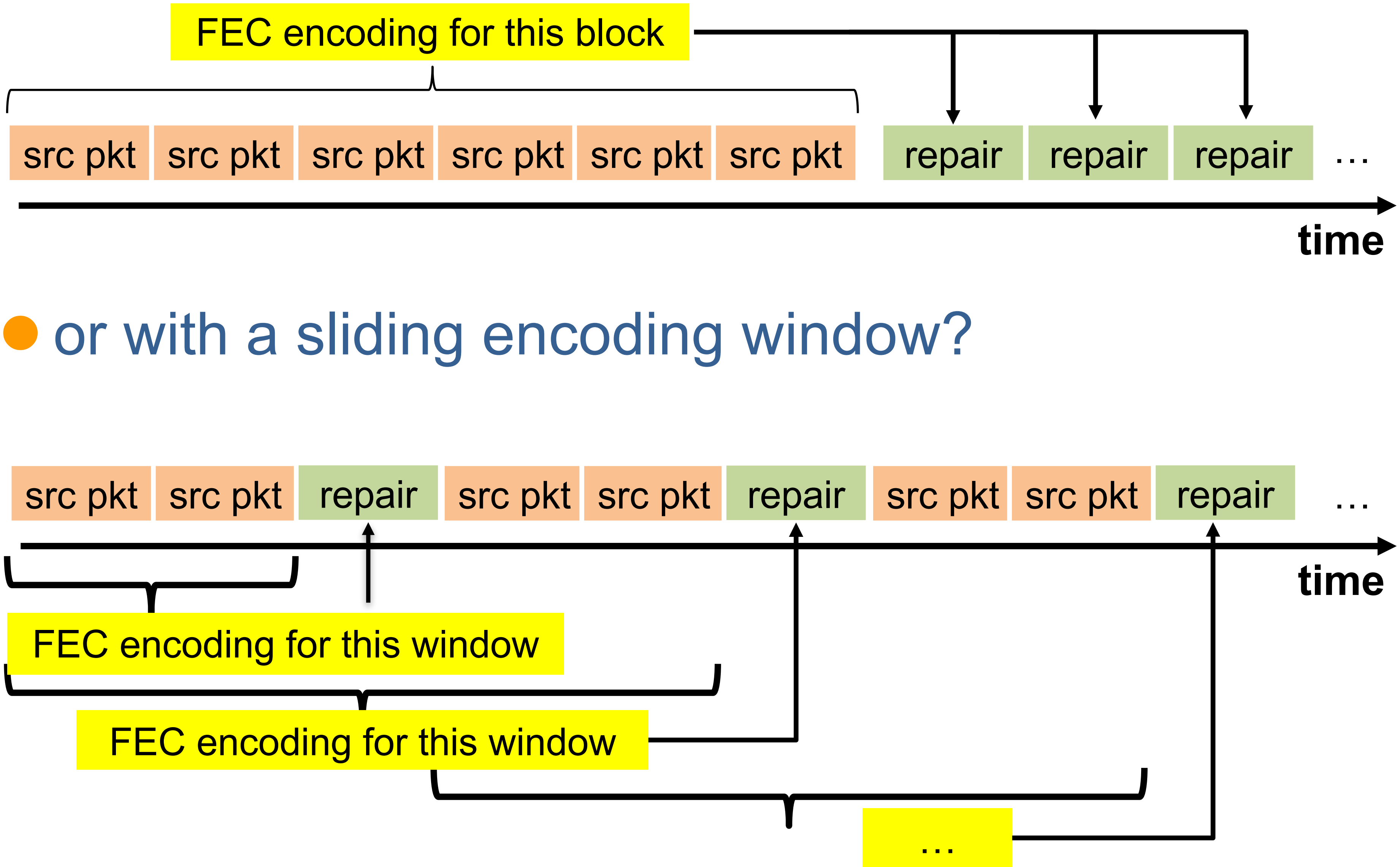
- is the number of repair symbols pre-defined (fixed rate) or potentially infinite (rateless)?
  - **Reed-Solomon, LDPC, etc. → fixed-rate**
  - **Raptor, RLC, RLNC, etc. → rateless**

- consequences on API:
  - **use a function like:** `build_repair_symbol()` **to produce a new repair symbol each time it's called**
  - **avoid using tables of predefined size for encoding symbols**
    - main consequences are internal to the codec!

not too complex to address

Close-up 3: block vs. sliding window codes

- does the codec encode on a per-block basis?
- or with a sliding encoding window?



Close-up 3: block vs. sliding window (2)

major consequences!

- impact 1
  - **block: manage a known set of source symbols**
    - a different codec instance for each block: `create/release_codec_instance()`
  - **sliding window: continuously changing set of source symbols**
    - requires a single codec instance for the whole session
    - `add_symbol_to/remove_symbol_from_coding_window()`, `reset_coding_window()`
    - a callback `symbol_removed_from_coding_window()` is needed if the coding window is totally managed by the codec

Close-up 3: block vs. sliding window (3)

- impact 2
  - **block decoding**
    - can defer decoding until a sufficient number of encoding symbols have been received (e.g., exactly k with MDS codes), then call `finish_decoding()`
    - test if a block is decoded: `is_decoding_complete()`
  - **continuous decoding**
    - on-the-fly decoding required with `decode_with_new_source/repair_symbol()`
  - **in both cases, need a callback to be informed of newly decoded symbols:** `decoded_source_symbol_callback()`

Close-up 4: end-to-end vs. in-network re-encoding

- end-to-end means:
  - single encoding and decoding operation
  - a **single** input flow of **source** symbols

- network coding means:
  - potentially **multiple** in-transit **re-encoding** operations, usually a single decoding operation
  - various forms of intra-flow / inter-flow coding
  - several open questions in terms of symbol identification!

major consequences!

Close-up 4: end-to-end vs. re-encoding (2)

- impact: coefficient management differs
  - RLNC (in-network re-encoding), **sender**:
    - if coefficients are computed in the codec, `get_coding_coefficients()` helps the application to retrieve them and copy them into the repair packet
    - otherwise `set_coding_coefficients()` informs the codec of the coefficients to use before doing encoding
  - RLNC (in-network re-encoding), **receiver**:
    - `set_coding_coefficients()` informs the codec of the coefficients carried in the packet
  - RLC (end2end) draft-ietf-tsvwg-rlc-fec-scheme-00:
    - coefficient generation internal to the FEC codec from a "key" carried in each repair packet
    - no need for `get/set_coding_coefficients()`, communicating the key to the codec is sufficient

Various additional aspects

- address different decoding algorithms, even for the same code
  - **the decoding algorithm can impact the approach**
    - on-the-fly decoding (e.g., with iterative decoding for Raptor and LDPC, or with sliding window codes) uses a `decode_with_new_repair_symbol()` function
    - otherwise a `finish_decoding()` function launches one-time decoding
- rely on callback functions for important events
  - `decoded_source_symbol()` **callback (potentially another callback when a source symbol is about to be decoded but calculations not yet performeds)**
  - `removed_from_coding_window()` **callback**
- FEC scheme specific control parameters
  - `set/get control parameter()`

Next steps

- launch an API design team?
  - who wants to join?
  - focusses on FEC codes only (not protocols)

- work on an I-D
  - will leverage on existing codec development works (various implementations)
    - having different point of views required to improve API quality
  - is it feasible for next IETF?