FEC and NC performance evaluation

<update from Sept. 2018 Interim meeting presentation>

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Previous presentations

- **Already mentioned in NWCRG as an interesting topic + a few hints**
  - ✓ **"Performance and Feature Comparison of Erasure Correcting Coding Software Libraries", Steinwurf**
    - https://www.ietf.org/proceedings/89/slides/slides-89-nwcrg-4.pdf

- **Also, for a concrete use-case:**
  - ✓ **"FECFRAME–extension: Adding convolutional FEC codes support to the FEC Framework", Vincent Roca et al. (slides 13-23)**
    - https://datatracker.ietf.org/meeting/98/materials/slides-98-tsvwg-sessb-63-fecframe-drafts-00

Several aspects

1. **Codec parameters**
   - how to initialize/control the codec?
2. **Performance metrics**
   - what?
3. **Evaluation methodology**
   - how?
4. **Communication channels considered**
   - which use-cases?

5. **Tools**
   - a hackathon's project?

yes, but codec is #1 prio

Topic 1: defining the codec parameters

- **what are the parameters?**
- **how to derive the parameters?**
  - depending on the flow features (real-time or not)

Topic 1: defining the codec parameters (2)

- **we often express windows in number of symbols**
  - e.g., if we assume **CBR** flows (e.g., before or after FEC encoding), with symbols of fixed size, time constraints of a real-time flow are easily translated into # symbols
  - e.g., an encoding window of maximum size 20 symbols

- **otherwise we can express windows in seconds**
  - e.g., an encoding window size of 0.2s means “as many symbols that can fit in a 0.2s encoding window”

- **symbol size (E) (in bytes)**
  - assumed constant

Topic 1: defining the codec parameters (3)

- **at an encoder**
  - code rate (cr)
  - current and max **encoding window size** (ew_size/ew_max_size),
    - ✓ **in symbols or seconds**

  - with a **real-time flow**: **max. FEC-related latency budget** (max_lat)
    - ✓ **in seconds**
    - ✓ **max amount of time to devote to FEC encoding and decoding**
    - ✓ **used to derive ew_max_size along with other parameters**

Topic 1: defining the codec parameters (4)

- **at a decoder**
  - **linear system maximum size** (ls_max_size)
    - **in symbols**
    - **max. number of received or lost source symbols in the linear system**
  - with a **real-time flow**: **decoding window max. size** (dw_max_size)
    - **in symbols or seconds**
    - **maximum number of received or lost source symbols that are still within their latency budget**

```
                                ls_max_size
/---------------------------------^-------------------------------\

       late source symbols
 (pot. decoded but not delivered)            dw_max_size
/--------------^-----------------\ /--------------^---------------\
src0 src1 src2 src3 src4 src5 src6 src7 src8 src9 src10 src11 src12
```

Topic 1: defining the codec parameters (4)

- **a possible, non exhaustive, answer: “RLC FEC Scheme”**
  - see: https://tools.ietf.org/html/draft-ietf-tsvwg-rlc-fec-scheme

- **is there another (better?) way to derive these parameters?**

Topic 2: Performance metrics

- **usual metrics:**
  - erasure correction performance
    - ✓ **average overhead, decoding failure probability WRT number packets received, …**
  - codec oriented
    - ✓ **encoding and decoding speed, number of finite field operations, maximum amount of memory, …**

- **but also:**
  - required code rate (i.e., amount of redundancy) to achieve a certain quality (residual packet erasures below a threshold, e.g., 10^{-3}), for a FEC-related latency

Topic 2: Performance metrics (2)

- **time is difficult to catch…**
  - e.g., to evaluate FEC-related latency on the whole path
    - ✓ **requires to be reproducible**
    - ✓ **easier with a CBR source flow**

Topic 3: Evaluation methodology

- **3 main approaches**
  - theoretical analyzes *important but not addressed thereafter*
  - simulated end-to-end transmission **yes, our focus**

    + fully controlled and reproducible

    - accuracy needs to be checked
  - real-world experiments *important, but not addressed thereafter*

    + maximum accuracy (if done correctly)

    - complex, partial control, less reproducible

Topic 3: Evaluation methodology (2)

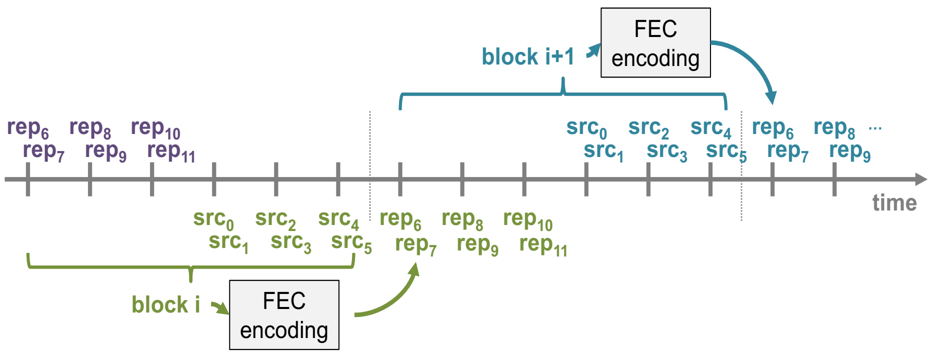
- **example of simulated transmission system: “eperftool”**
  - (cf. http://openfec.org)

- *a single process for everything*
- *no true transmission, it’s simulated*
- *true FEC encoding, true FEC decoding, with a fully operational codec*
- *packet losses are simulated (various loss models, possibility to use true loss traces)*

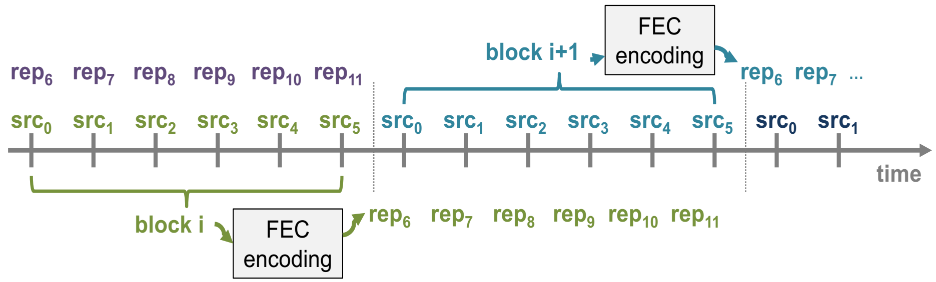
Topic 3: Evaluation methodology (3)

- **beware of codec design choices**
  - how source and repair packets are transmitted (tx order) will impact results significantly…
  - example: block FEC code, CBR output

single output leaky bucket: sending repair packets takes time and delays source packets



two output leaky buckets: repair and source packets transmitted in parallel



Topic 3: Evaluation methodology (4)

- less an issue with sliding window FEC codes
  - ✓ **there's an incentive to encode and transmit regularly**
  - ✓ **unlike block codes, there's usually no big bunch of repair packets to transmit**

Topic 4: Communication channels considered

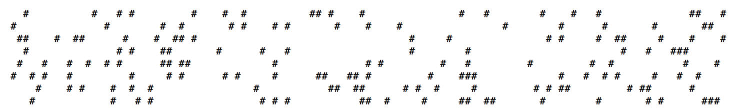
- **we need channel models representative of a target use-case**

- **we've been using 3GPP SA4 official mobility traces**
  - which packets are lost?
  - not universal (obtained under precise circumstances) but useful
  - freely available

    (see https://hal.inria.fr/hal-01571609v1/en/)

❍ **vehicle passenger** ⇒ **losses are "evenly" spread**

4 different average loss rates (1%, 5%, 10%, 20%)

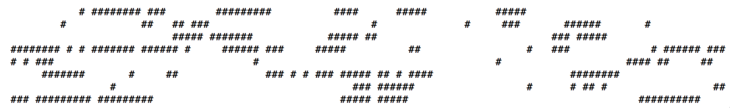


each "#" indicates a loss

120 km/h vehicle passenger, 20% average loss rate

❍ **pedestrian** ⇒ **loss bursts**

4 different average loss rates (1%, 5%, 10%, 20%)



3 km/h vehicle passenger, 20% average loss rate

- **do we have something else?**

Wrap up

- **perf. evaluation is essential but non trivial**
- **requires to also define codec parameters and their derivation**

- **outcomes:**
  - a new I-D?
  - a new hackathon project?

sure!

stay focused: codec is #1 prio

- **we need to share experience/tools/channels/good practices/…**
  - who’s interested in addition to myself and Morten?