Coding and congestion control in transport draft-irtf-nwcrg-coding-and-congestion-04

Nicolas KUHN

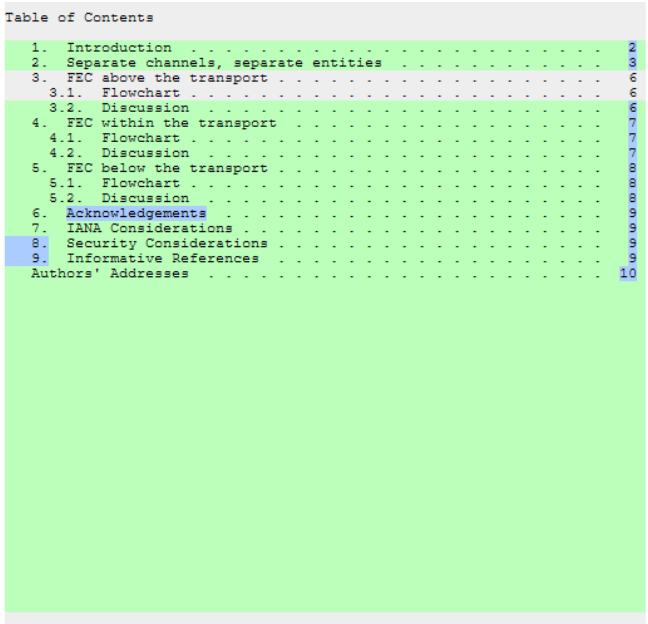
Emmanuel LOCHIN

François MICHEL

Michael WELZL

What has been done since IETF108

- Run experiments
- Add a large discussion section



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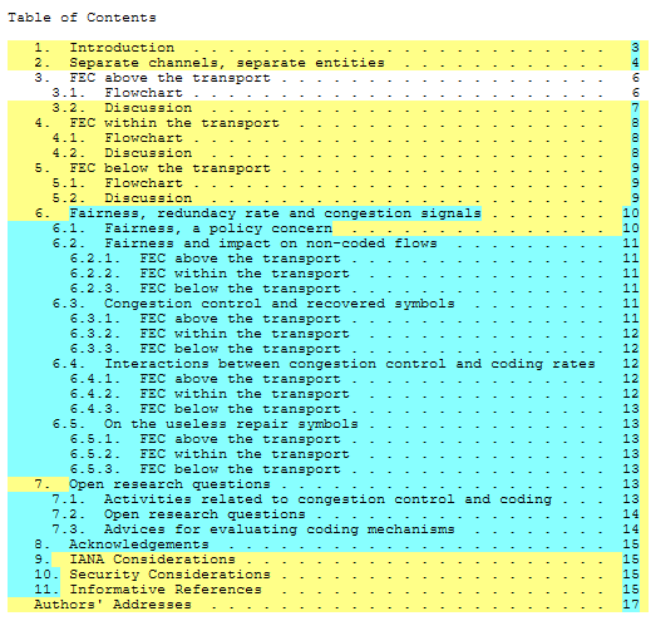

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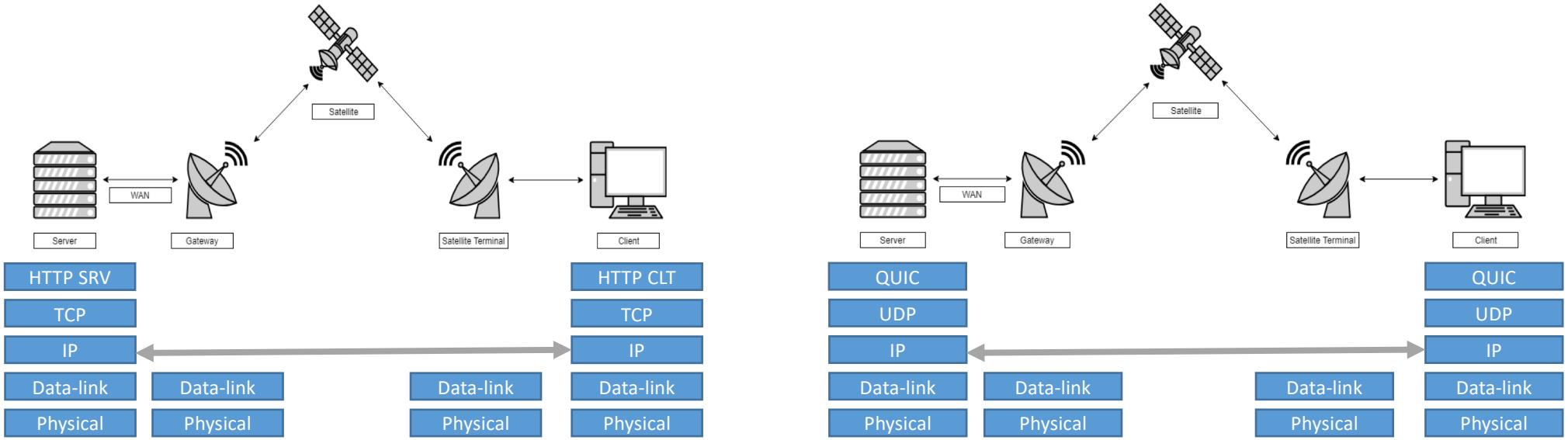
Run experiments – testbed



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Run experiments – configuration

- Configurations
  - Satellite link
    - With losses (mobile end users, optical links)
    - No losses
  - LAN
    - No losses
    - Wi-Fi
  - Congestion
    - Single flows
    - Load generated with variable amount of flows
- Partial results shown here (under submission)

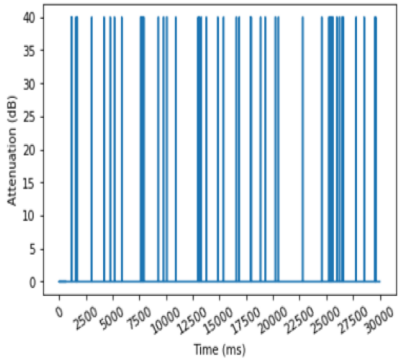

Figure 2: Attenuation over time to simulate an Optical Satellite link

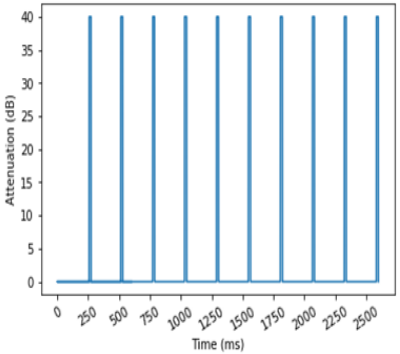

Figure 3: Attenuation over time to simulate a DVB Satellite - Mobile receptor link

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Run experiments – results

- 20 MB download – median over 20+ tests
- Mobile use case scenario

FEC Tunnel	Wi-Fi	Congestion	TCP	QUIC
Y	Y	Y	204	251
Y	Y	N	41	35
Y	N	Y	195	204
Y	N	N	43	30
N	Y	Y	792	740
N	Y	N	651	325
N	N	Y	646	1061
N	N	N	527	604

- \o/ « My FEC solutions is great »
- FEC and CC interaction depend on the CC and the FEC

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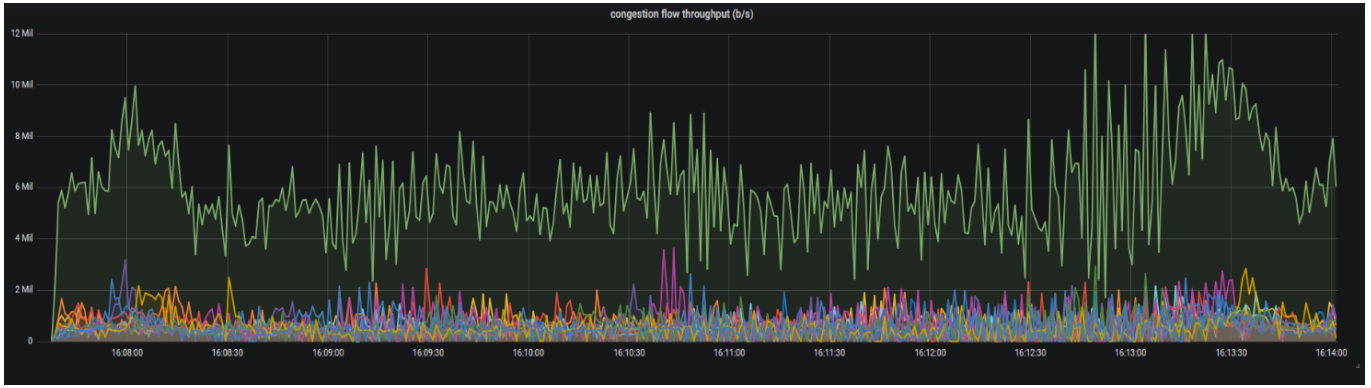
Run experiments – results

- 10 non coded TCP flows vs 10 non coded TCP flows – cumulated throughput of the 10 non coded TCP flows



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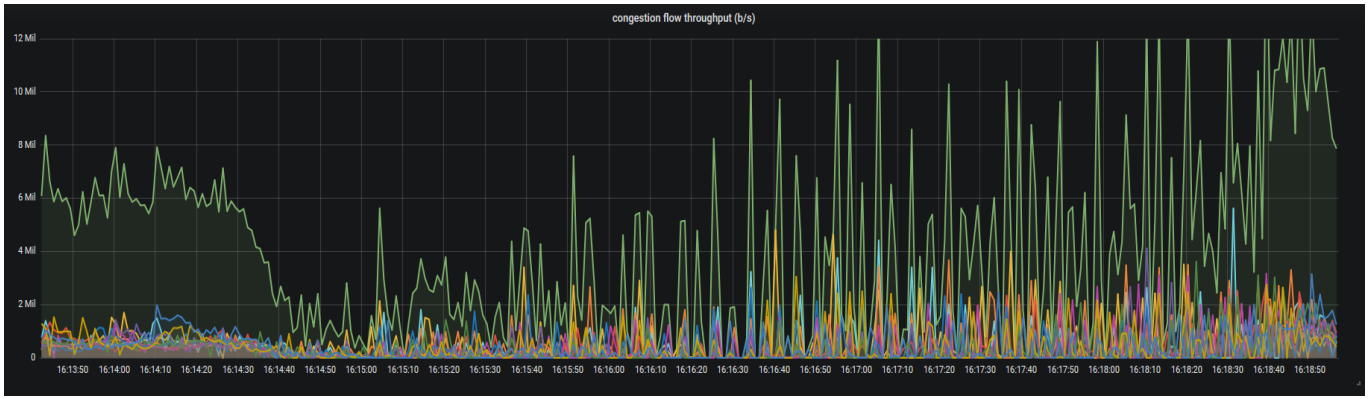

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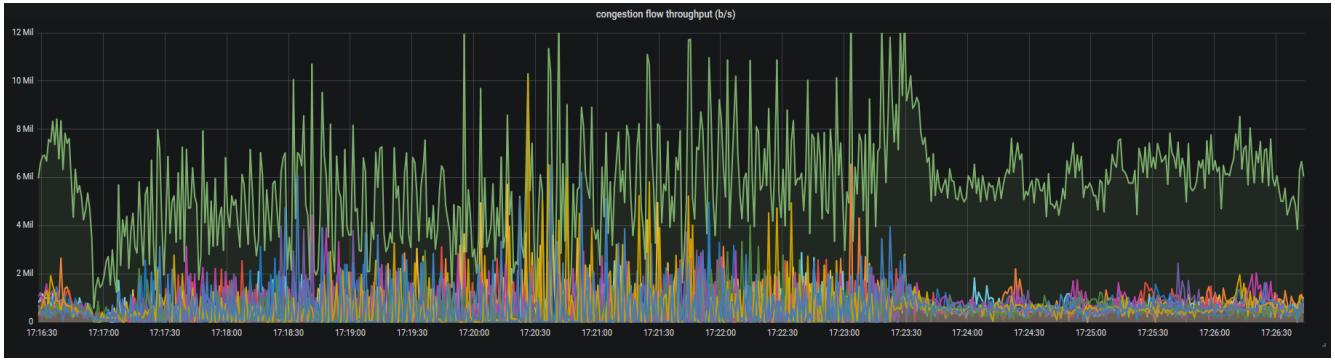

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Introduction

- Forward Erasure Correction (FEC)
  - a reliability mechanism that is distinct and separate from the retransmission logic in reliable transfer protocols such as TCP
  - Using FEC coding can help deal with transfer tail losses or with networks having non-congestion losses
  - However, FEC coding mechanisms should not hide congestion signals.

➢ Discussion of how FEC coding and congestion control can coexist

➢ Encourage the research community to also consider congestion control aspects when proposing and comparing FEC coding solutions in communication systems

Separate entities

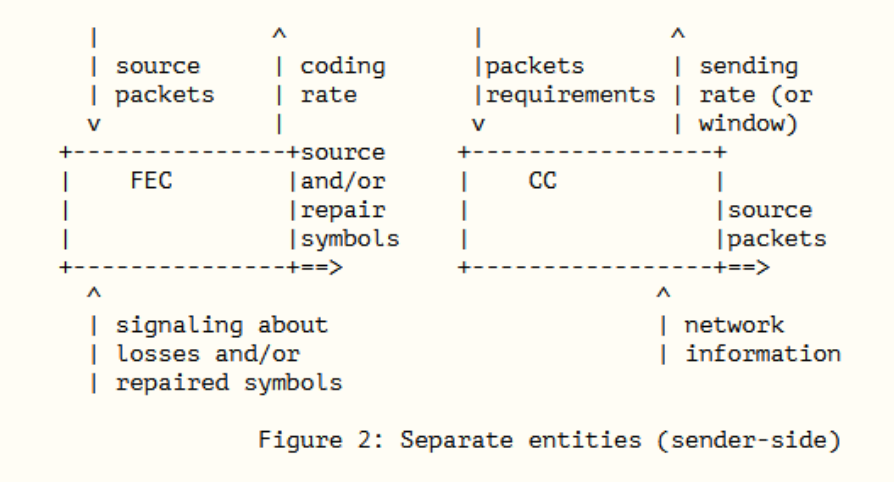


Figure 2: Separate entities (sender-side)

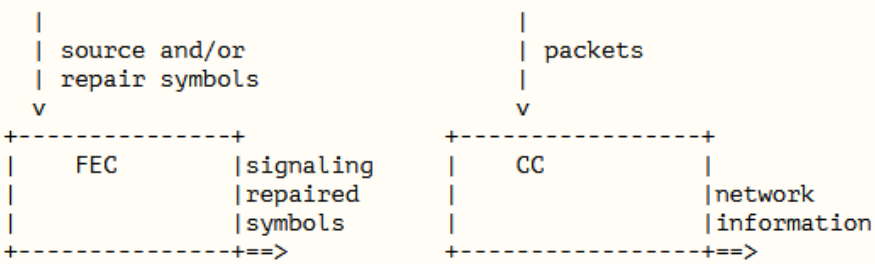


Figure 3: Separate entities (receiver-side)

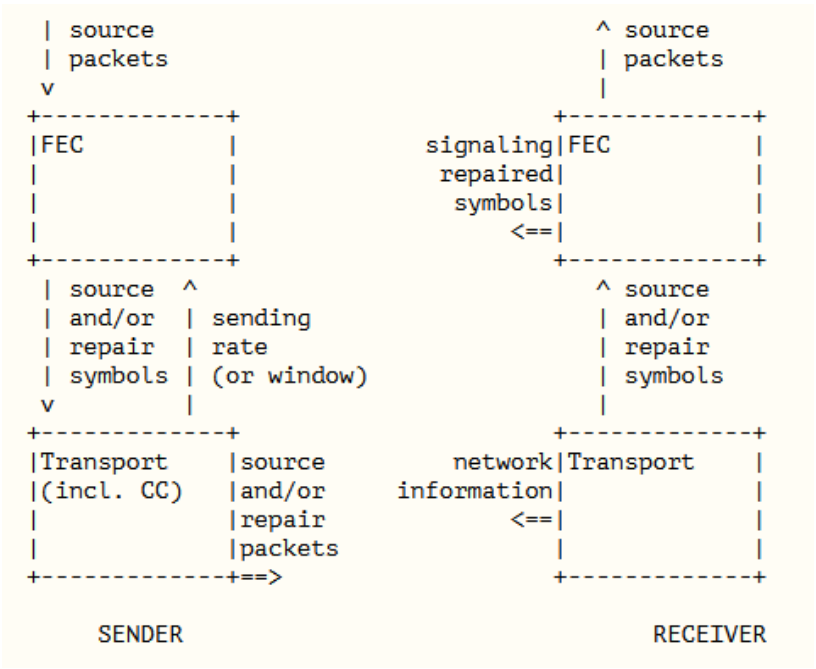
- CC channel carries
  - Source packets from a sender to a receiver
  - Packets signaling information about the network (number of packets received vs. lost, ECN marks, etc.) from the receiver to the sender
- FEC channel carries
  - repair symbols (from the sender to the receiver)
  - potential information signaling which symbols have been repaired (from the receiver to the sender).

Choice of transport layer protocol

- Choice of the adequate transport layer may be related to application requirements
- Unreliable data transfer
  - non-reliable transport service (e.g. UDP or DCCP [RFC4340])
  - or partially reliable transport protocol such as SCTP with partial reliability [RFC3758])
- Reliable data transfer
  - a retransmission mechanism at transport to guarantee the reliability of the file transfer (e.g. TCP)

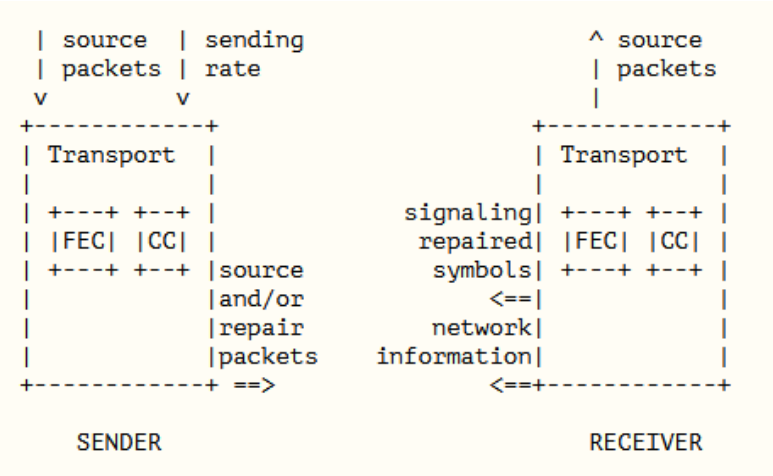
➢ Depending on how the FEC and CC functions are scheduled (FEC above CC, FEC in CC, FEC below CC), the impact of reliable transport on the FEC reliability mechanisms is different

FEC above transport



- Require that the transport protocol does not implement a fully reliable data transfer service
- For reliable transfers, coding
  - does not guarantee better performance
  - would mainly reduce goodput for large file transfers.
- Improved quality of experience for latency sensitive applications such as VoIP
- FEC overhead does not contribute to congestion in the network
- With congestion control at the transport layer: repair symbols are sent following the congestion window.

FEC within transport

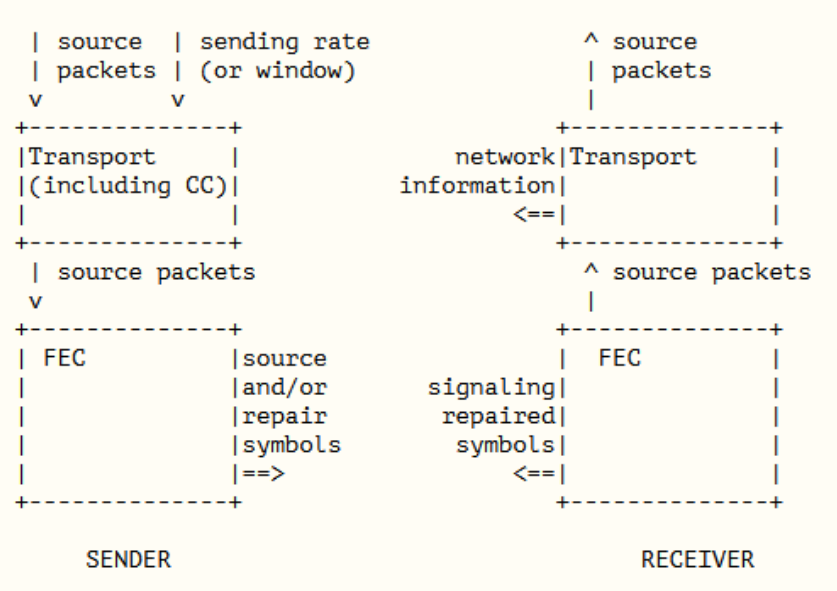


- Allows a joint optimization between the CC and the FEC
- The transmission of repair symbols does not add congestion in potentially congested networks but helps repair lost packets (such as tail losses).
- For reliable transfers, including redundancy reduces goodput for large file transfers but the amount of repair symbols can be adapted, e.g. depending on the congestion window size.

➢ Trade-off between the cost in capacity used to transmit source packets and the benefits brought out by transmitting repair symbols (e.g. unlocking the receive buffer if this is limiting).

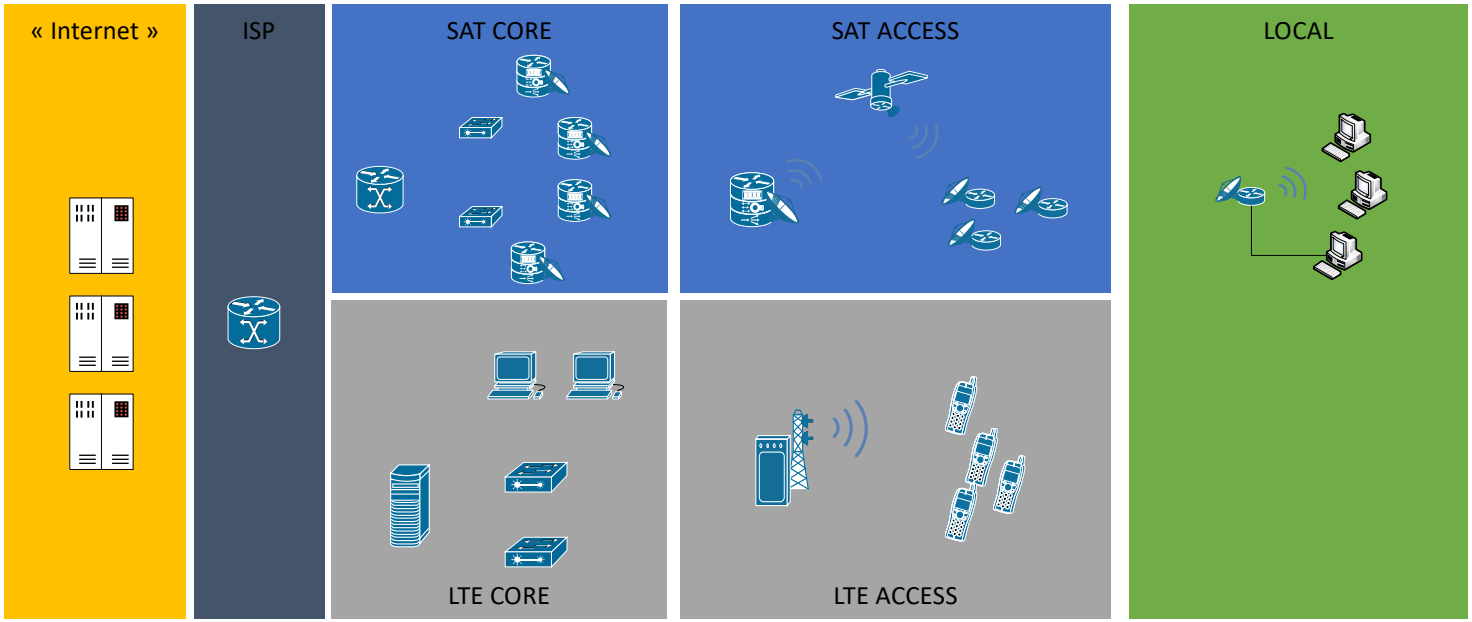
- The coding ratio needs to be carefully designed.

FEC below transport



- Including redundancy adds congestion without reducing goodput
- Leads to potential fairness issues : bitrate is higher than the CC's computed fair share due to the sending of repair symbols and the losses are hidden from the transport.
- Can result in performance gains when there are persistent transmission losses along the path

Fairness, a policy concern



- Contractual fairness exists at CPE or UE level
- For flows sharing a same QoS and same contract, fairness discussion applies

Discussion

Theme	FEC above transport	FEC within transport	FEC below transport
Fairness and impact on non-coded flows	No impact of FEC	Specific interaction between congestion controls and coding schemes can be proposed	Can drastically reduce the goodput of non-coded flows Specific signaling (e.g. ECN) can be proposed
Congestion control and recovered symbols	Relevance coding at the application layer related to the needs of the application Real-time applications: reduction of the number of retransmission	Endpoint may exploit different protocols for each channel Receiver may indicate both the number of source packets received and repair symbols that were actually useful in the recovery process of packets	Congestion control may behave as if no coding scheme is introduced Specific signaling (e.g. ECN) can be proposed
Interactions between congestion control and coding rates	Coding rate applied at the application layer mainly depends on the available capacity given by the congestion control underneath Adapting the coding rate to the minimum required data rate of the application may reduce packet losses and improve the quality of experience	Flexibility in the trade-off between (1) reducing goodput when useless repair symbols are transmitted, and (2) helping to recover sooner from transmission and congestion losses	The coding scheme is not aware of the congestion control implementation, making it hard for the coding scheme to apply the relevant coding rate.
On the useless repair symbols	Depends on application needs. The only case where adding useless repair symbols does not result in reduced goodput is when the application needs a limited amount of goodput (e.g., VoIP traffic). The useless repair symbols would only impact the amount of data generated in the network.	The sender may exploit the information given by the receiver to reduce the number of useless repair symbols and the resulting goodput reduction	Useless repair symbols only impact the load of the network without actual gain for the coded flow

Open research questions

There is a general trade-off, inherent to the use of coding, between
(1) reducing goodput when useless repair symbols are transmitted and
(2) helping to recover from transmission and congestion losses.

FEC above transport	FEC within transport	FEC below transport
Trade-off related to the amount of redundancy to add, as a function of the transport layer protocol and application requirements	Recovering lost symbols may hide congestion losses to the congestion control (1) Disambiguate acked packets from rebuilt packets (2) New signaling methods and FEC-recovery-aware congestion controls (3) Dynamic coding rates	How to improve the quality of experience while guaranteeing fairness with other flows ? What is the relevance of FEC when there are multiple streams that exploit the FEC channel

Advices for evaluating coding mechanisms

- Map the contribution with the proposed organization in this document
- Consider congestion control when proposing FEC mechanisms
- When hiding the packet loss signal from the congestion control
  - 1) advantages vs ignoring a portion of encountered losses at the congestion control
  - 2) discuss the impact of hiding losses from the congestion control mechanism

So what ?

- Some reorganization of the document is needed
- Questions ? Comments ?