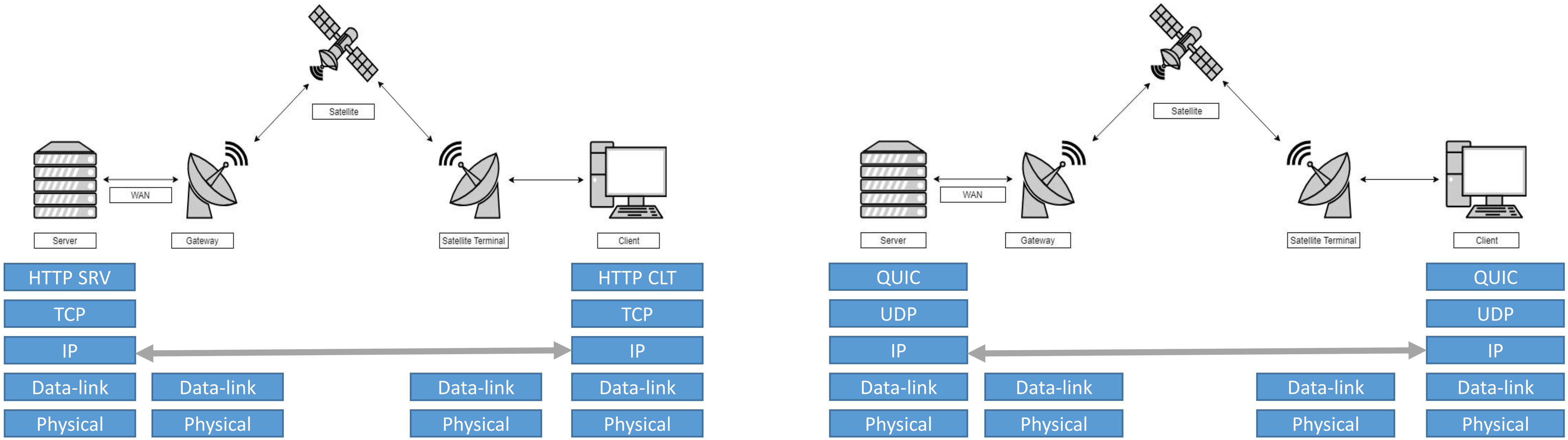
Coding and congestion control in transport draft-irtf-nwcrg-coding-and-congestion-06

Nicolas Kuhn, Emmanuel Lochin, François Michel, Michael Welzl

PRESENTED AT IETF109

Run experiments – testbed



Telecommunications for Space and Aeronautics
Innover. Simplifier. Partager.

M. Petrou, B. Tauran, D. Pradas, J. Lacan, E. Lochin

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)

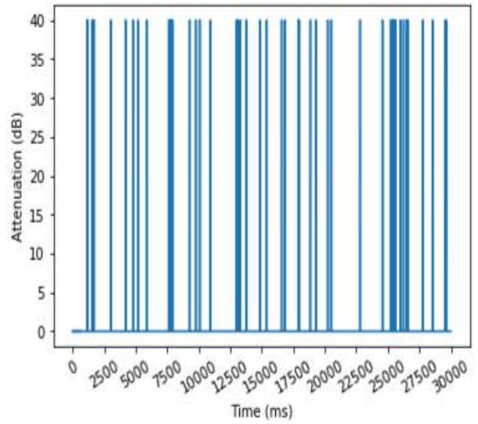


Figure 2: Attenuation over time to simulate an Optical Satellite link

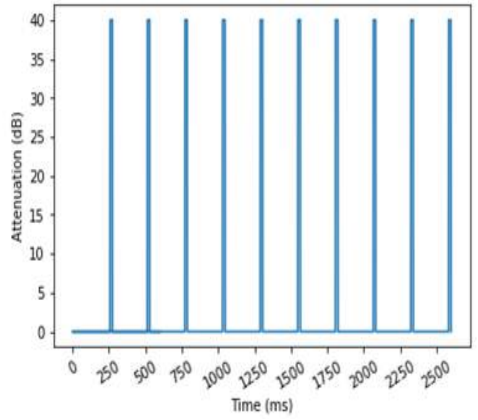


Figure 3: Attenuation over time to simulate a DVB Satellite - Mobile receptor link

TéSA Telecommunications for Space and Aeronautics
VIVERIS Innover. Simplifier. Partager.
M. Petrou, B. Tauran, D. Pradas, J. Lacan, E. Lochin

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

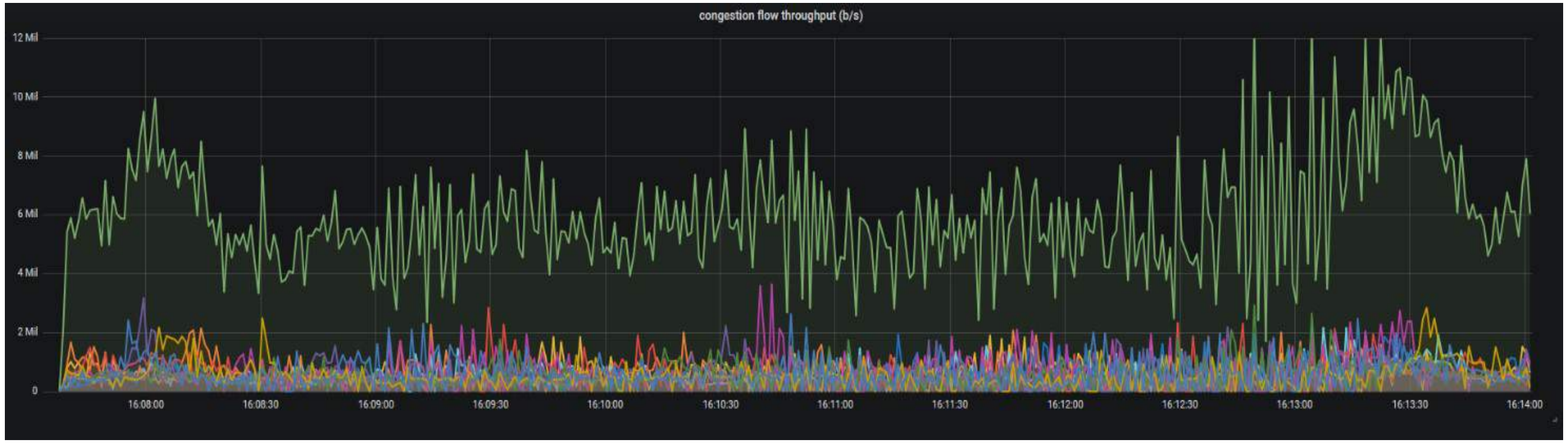
- \o/ « My FEC solutions is great »
- FEC and CC interaction depend on the CC and the FEC

TéSA Telecommunications for Space and Aeronautics
VIVERIS Innover. Simplifier. Partager.
M. Petrou, B. Tauran, D. Pradas, J. Lacan, E. Lochin

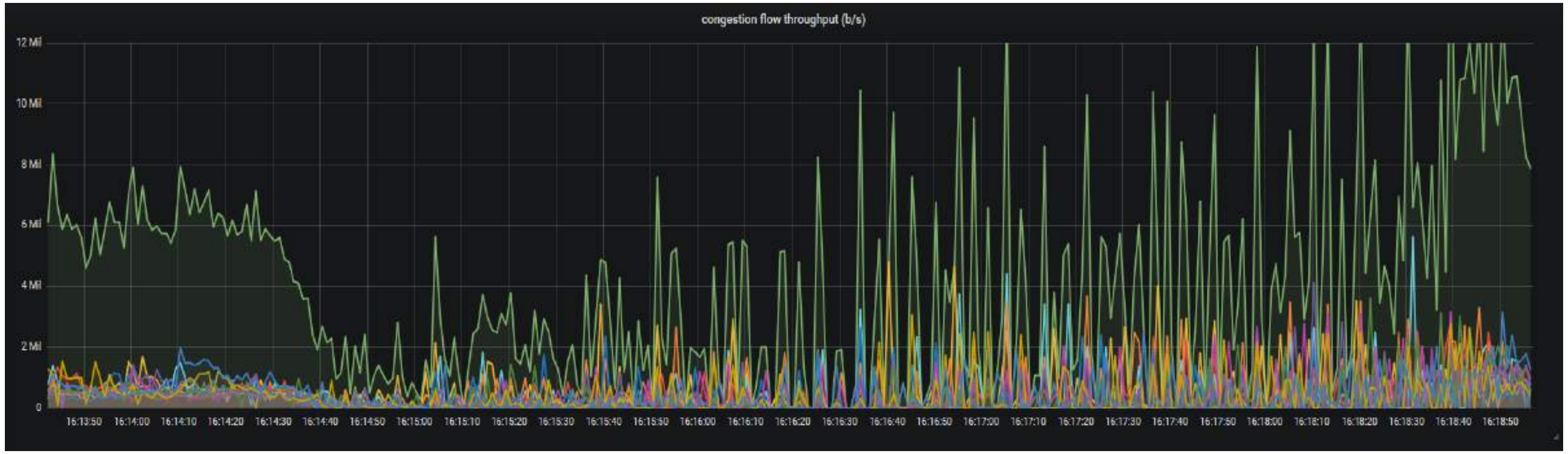
PRESENTED AT IETF109

Run experiments – results

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



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

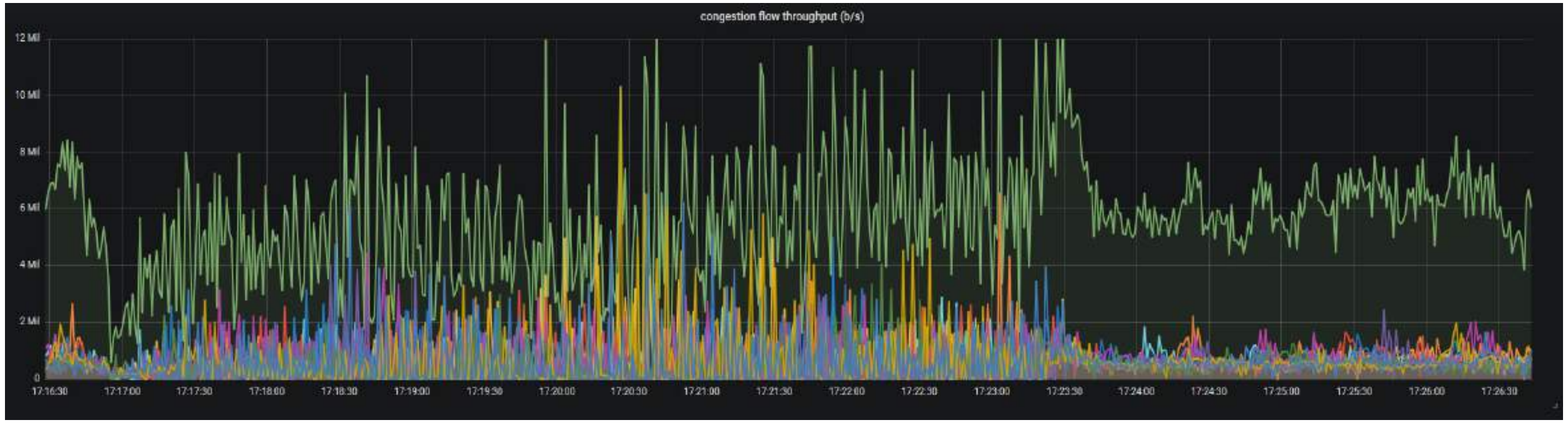


TéSA Telecommunications for Space and Aeronautics
VIVERIS Innover. Simplifier. Partager.
M. Petrou, B. Tauran, D. Pradas, J. Lacan, E. Lochin

PRESENTED AT IETF109

Run experiments – results

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



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

TéSA Telecommunications for Space and Aeronautics

VIVERIS Innover. Simplifier. Partager.

M. Petrou, B. Tauran, D. Pradas, J. Lacan, E. Lochin

Objective of the draft

- Forward Erasure Correction (FEC):
  - Help in dealing with losses at the end of transfers or with networks having non-congestion losses
  - Should not hide congestion signals
- Objective
  - Discussion on how FEC coding and congestion control can coexist
  - Encourage research community to also consider congestion control aspects when proposing and comparing FEC coding solutions in communication systems

Main changes since *-04

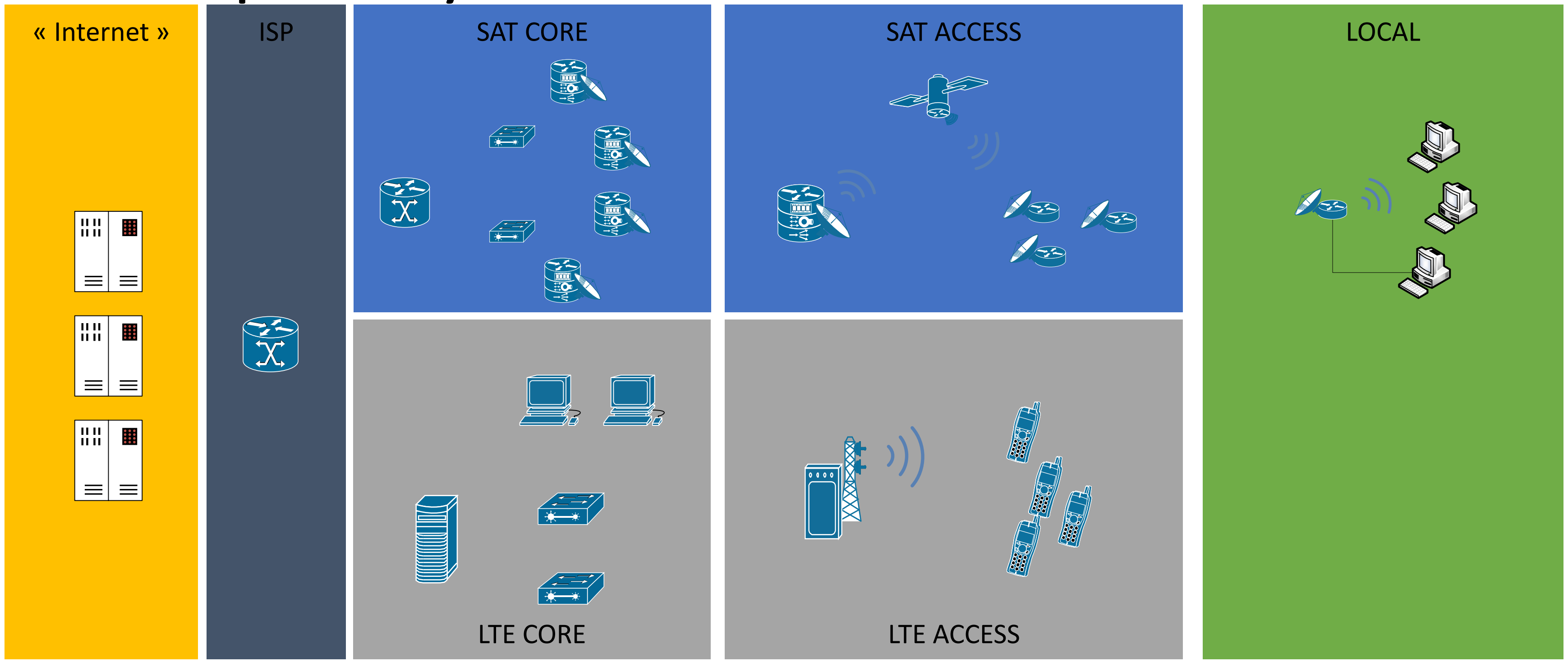
- Major reorganization of the document
- Comments from IETF 109
  - Transport multipath
  - Partial reliability
  - Partial ordering
- Comments from Vincent integrated – see discussion on the list

Table of Contents

Table of Contents

PRESENTED AT IETF109

Fairness, a policy concern



- Contractual fairness exists at CPE or UE level
- For flows sharing a same QoS and same contract, fairness discussion applies
- Following [1] fairness as the impact of the addition of coded flows on non-coded flows when they share the same bottleneck.

[1] Ware (et al.), R., "Beyond Jain's Fairness Index: Setting the Bar For The Deployment of Congestion Control Algorithms", HotNets '19 10.1145/3365609.3365855, 2019.

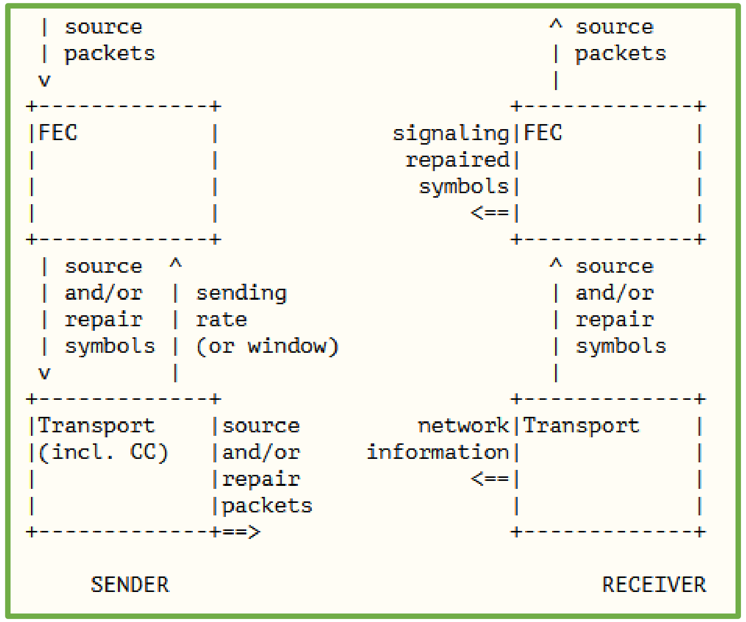
Transport Multipath

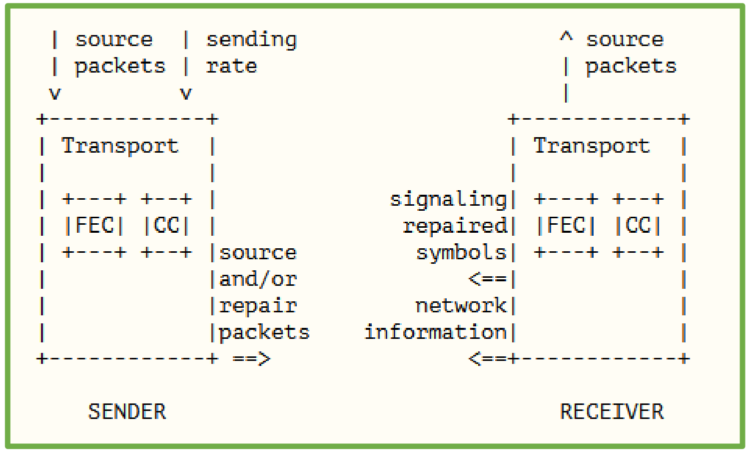
- Both stream 1 and stream 2 are in the scope
- A combination of the two is not

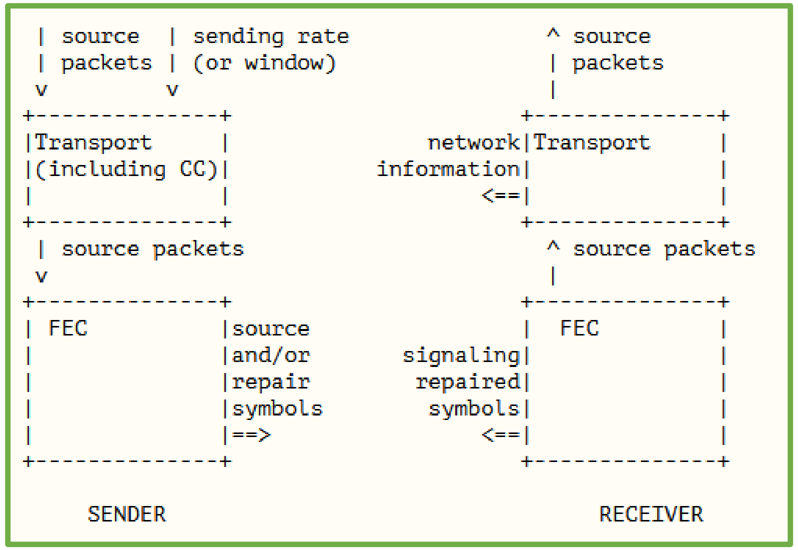
```
+-----------------------------------------------+
|                  Application                  |
|                                               |
|  +-------------------+ +-------------------+  |
|  |     Stream 1      | |     Stream 2      |  |
|  +-------------------+ +-------------------+  |
|                                               |
|  +-------------------+ +-------------------+  |
|  |        FEC        | |Multipath Transport|  |
|  +-------------------+ +-------------------+  |
|                                               |
|  +-------------------+ +-----+       +-----+  |
|  |Multipath Transport| |Flow1|  ...  |FlowM|  |
|  +-------------------+ +-----+       +-----+  |
|                                               |
|  +-----+       +-----+ +-----+       +-----+  |
|  |Flow1|  ...  |FlowM| | FEC |  ...  | FEC |  |
|  +-----+       +-----+ +-----+       +-----+  |
+-----------------------------------------------+
```

Focus on *-06

- Discussion of FEC and CC relative positions







- Over :
  - Was in *-04 : fairness, recovered symbols, coding rates, useless repair symbols
  - New in *-06: partial ordering, partial reliability, multipath transport

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

Focus on *-06

Theme	FEC above transport	FEC within transport	FEC below transport
Partial ordering	• Reordering mechanism may be required (either at transport or FEC level)	• Reordering mechanism may be required (either at transport or FEC level)	• Ordering mechanisms may be necessary at both transport and FEC levels (avoid spurious retransmissions if required by transport)
Partial reliability	• Could use inputs from the application • Depends on application requirements and the trade-off between latency and loss • Partial reliability impacts the type of FEC and type of codec that can be used	• Transport and FEC mechanisms could be conjointly designed • Depends on application requirements and the trade-off between latency and loss • Partial reliability impacts the type of FEC and type of codec that can be used	• FEC may provide an unnecessary service if it is not aware of the reliability requirements • Partial reliability impacts the type of FEC and type of codec that can be used
Multipath transport	• No impact on the FEC mechanism	• Adaptation of the coding rate of each of the single subpaths, whether the congestion control is coupled or not • Important flexibility on how the coding rate is tuned depending on the characteristics of each subpath	• FEC channel being aware of transport exploiting multiple paths • When FEC is applied to all the flows, risk for the coding rate to be inadequate for the characteristics of the individual paths

Open issues #56

- https://github.com/irtf-nwcrg/draft-irtf-nwcrg-coding-and-congestion-in-transport/issues/56

  I would say that partial reliability essentially impacts the type of FEC and type of codec you can use. If your codec does not enable a subset of the linear system to be inverted, but instead waits to have the perfect expected rank to invert and recover missing packets, you won't achieve partial reliability. Partial reliability also impacts the way you use a block FEC: in that case, I'd say use small block sizes, so that you can solve one of them but not necessarily all of them... except that it will also lower the robustness in front of long loss periods. This is typically where sliding window codes do offer a key advantage. (see https://hal.inria.fr/hal-01571609v1/en/)
- Interesting comment – the document does not comment much on coding techniques
- Currently :

```
                  Partial reliability impacts the type of FEC and
type of codec that can be used.
```

- Should we provide more details ?

Open issues #57

- https://github.com/irtf-nwcrg/draft-irtf-nwcrg-coding-and-congestion-in-transport/issues/57

  While working on RFC 8681 on sliding window codes, we tried to find appropriate parameter derivation

  techniques. It turned out to be quite difficult. You can have a look at the discussion here:

  https://www.rfc-editor.org/rfc/rfc8681.html#name-possible-parameter-derivati

- This comment is related to the open research questions
  - Impact of nature of the flow (CBR and real-time, non real-time, etc)
  - This is mentioned as follows in the document

```
For the FEC above transport case, there is a trade-off related to the
amount of redundancy to add, as a function of the transport layer
protocol and application requirements.
```

  - Should we provide more details ?

Open issues #58

- https://github.com/irtf-nwcrg/draft-irtf-nwcrg-coding-and-congestion-in-transport/issues/58
    - This is an IRTF document how is this relating to current research and where?
    - CC and NC are essentially two competing control loops - there is a lot of heritage on that topic (outside networking too) - what can NC/CC learn from that - any research questions?
    - My experience with NC is that the most gains are in low loss networks (far from network capacity) - where in fact CC protocols over react- is there research on appropriate metrics?
    - Most of the gain seems to be in last-mile/access networks - any other research?
    - All of this to say that the draft should be clearer on the type of research that is needed again when the performance is impacted 2 conflicting control loops
- Lots of work needed in the next version of the draft

Next step

- *-07 : on-going

- Address open issues and in particular research questions
- Get more feedback from the group and other groups