Extensions for QUIC in Deep Space

Maxime Piraux, François Michel
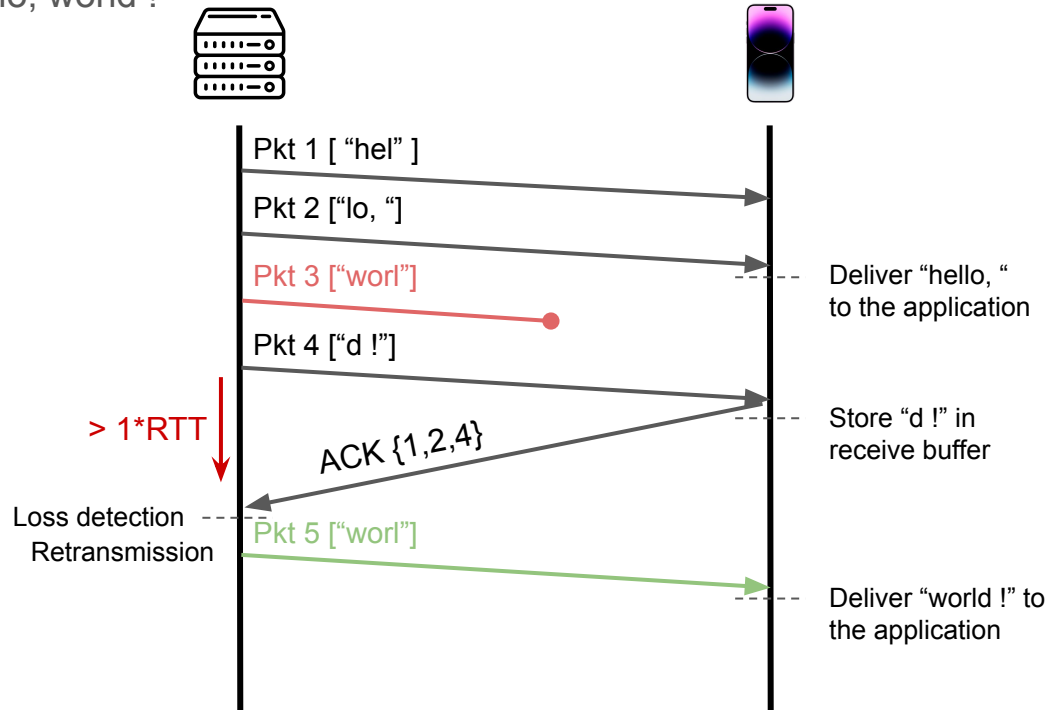
UCLouvain

WEL Research Institute

Two extensions for QUIC in Deep Space

- Our lab is active in improving and extending the QUIC protocol.

- draft-michel-quic-fec

  - Improves the loss recovery of QUIC with FEC.

- draft-piraux-quic-additional-addresses

  - Enables QUIC servers to advertise additional addresses.

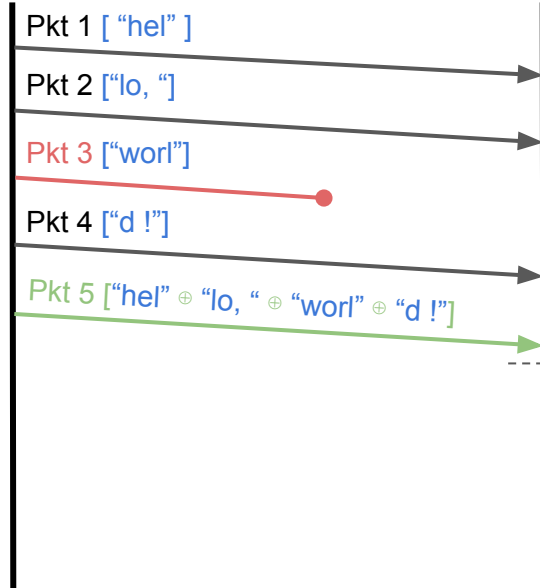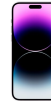- There is an interest for these extensions in a deep-space context.

Loss recovery in classical transport protocols (SR-ARQ)

Sending "hello, world !"

Pkt 1 ["hel"]

Pkt 2 ["lo, "]

Pkt 3 ["worl"]

Deliver "hello, " to the application

Pkt 4 ["d !"]

> 1*RTT

Store "d !" in receive buffer

ACK {1,2,4}

Loss detection
Retransmission

Pkt 5 ["worl"]

Deliver "world !" to the application

Forward Erasure Correction in the transport

Sending "hello, world !"

Pkt 1 ["hel"]

Pkt 2 ["lo, "]

Pkt 3 ["worl"]

Pkt 4 ["d !"]

Pkt 5 ["hel" ⊕ "lo, " ⊕ "worl" ⊕ "d !"]

Pkt 1, 2, 3, 4 contain *source symbols*
Pkt 5 contains a *repair symbol*

Reconstruct "worl"
Deliver "hello, world !"
to the application

draft-michel-quic-fec-01

Authors: F. Michel   O. Bonaventure
                  UCLouvain   *UCLouvain, WEL RI*

Forward Erasure Correction for QUIC loss recovery

Abstract

This documents lays down the QUIC protocol design considerations needed for QUIC to apply Forward Erasure Correction on the data sent through the network.

QUIRL: implementing draft-michel-quic-fec-01

Based on Cloudflare's `quiche` implementation.

- `quiche` is a production-ready implementation
- it is deployed on Cloudflare's edge servers
- used by the DNS resolver on recent Android versions
- can be integrated with `curl` for HTTP/3 queries

Using QUIRL for FFmpeg/GStreamer

- Every **RTP packet** is placed into a dedicated **QUIC stream**
  - large RTP packets cannot fit in DATAGRAM frames
- Repair symbols are sent regularly to protect one or more video frames
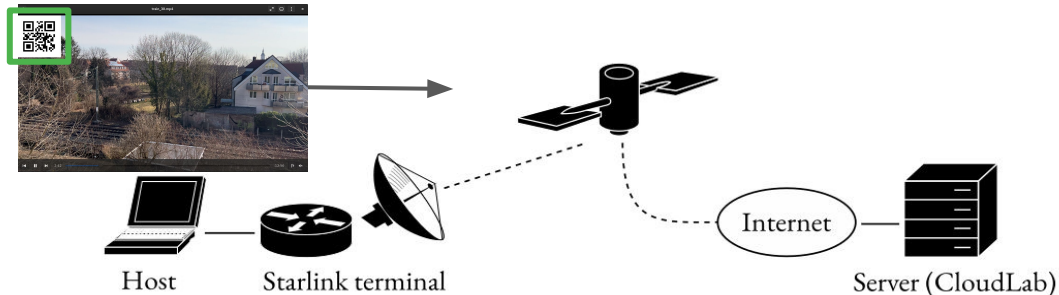- We want to minimize frames **lateness** to improve video fidelity (SSIM)
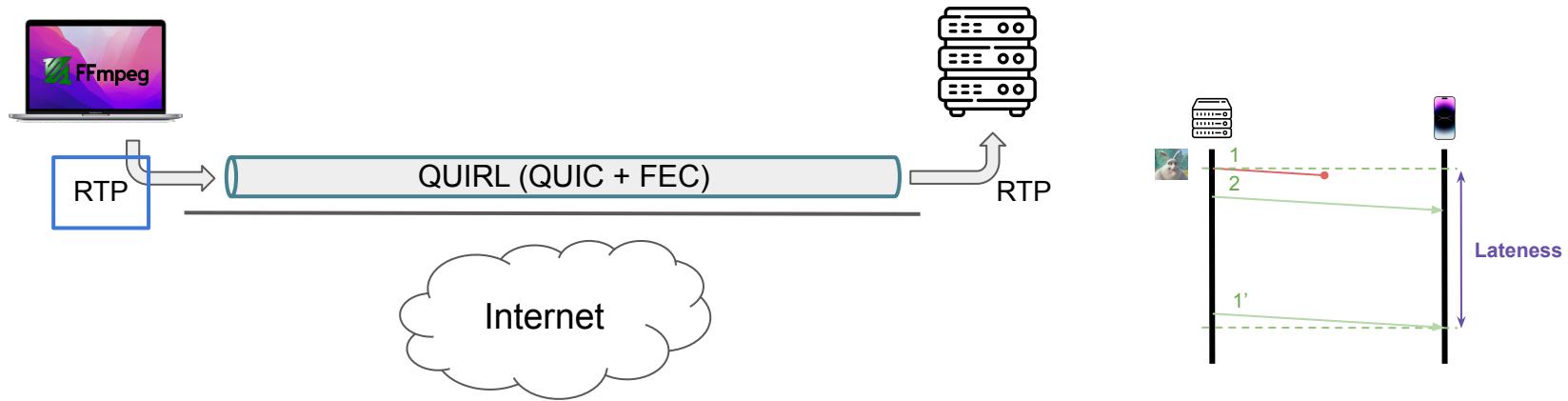
Replaying drone videos over Starlink

1000 experiments performed from a laptop in Belgium to a Cloudlab server (US)
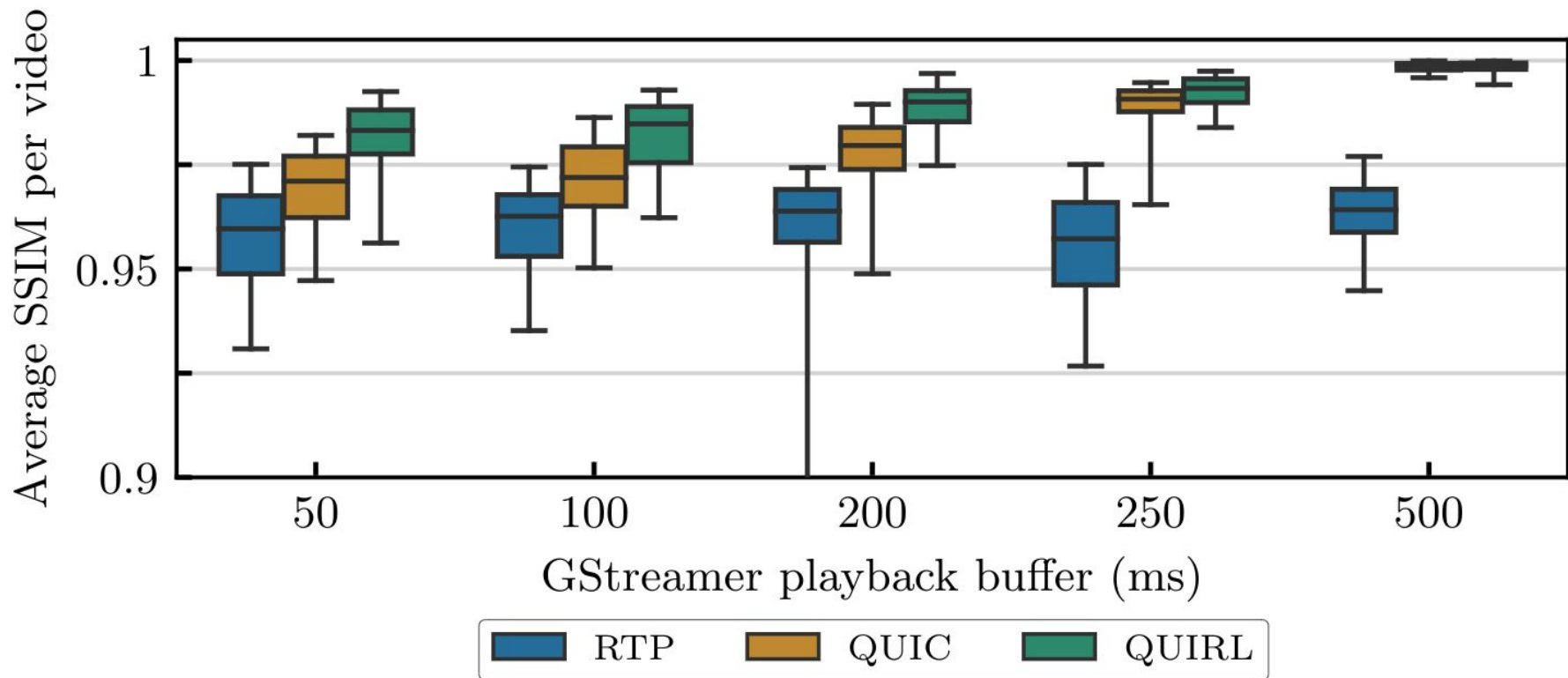
- Using 5 different playback buffer values

Real-time replay of drone videos from Baltaci *et al* (IMC '22). [1]

Used to match frames between original and playback

Host   Starlink terminal   Internet   Server (CloudLab)

[1] Baltaci, Aygün, et al. "Analyzing real-time video delivery over cellular networks for remote piloting aerial vehicles." *IMC* 2022.

Average SSIM per video over Starlink

Ratio of perfect frames (SSIM=1) over Starlink
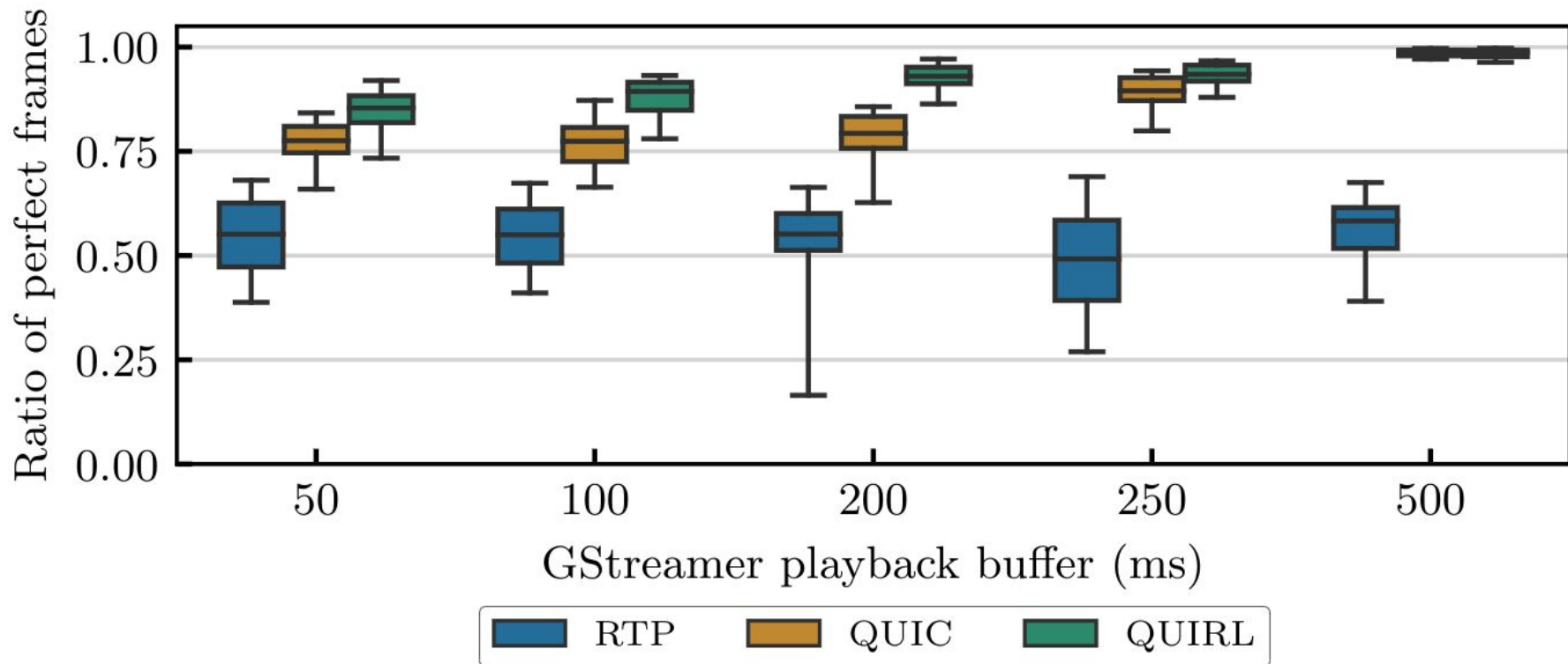
QUIC+FEC: Summary

All our work and code will soon be open source. More details can be found in:

- My thesis: https://ncs.uclouvain.be/phd/2023/10/12/michel-phd.html
- The QUIRL paper (soon)

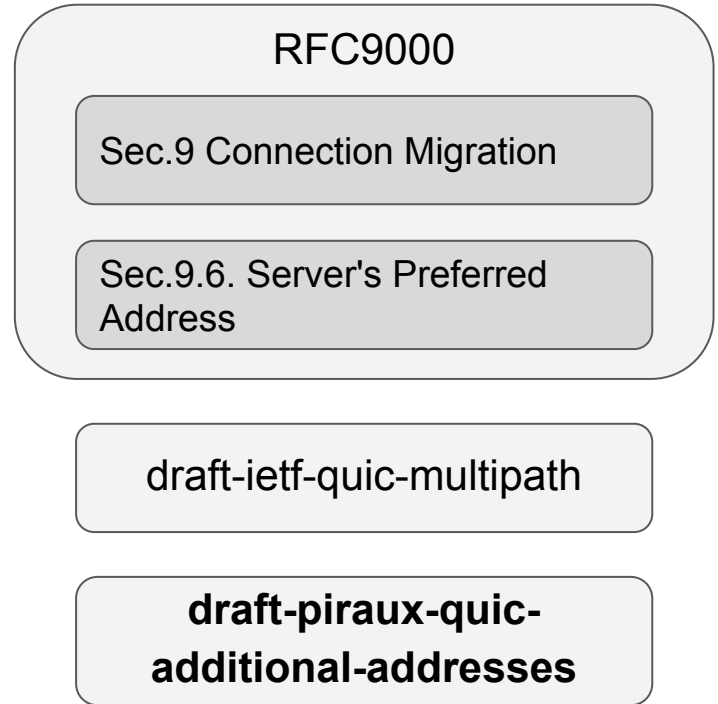If your use-cases may benefit from QUIC-FEC, here's how we could start :

- Send us an e-mail to collaborate: francois.michel@uclouvain.be
- Implementing draft-michel-quic-fec
- Please, do it with us, not on your own ! :-)

Two extensions for QUIC in Deep Space

- Our lab is active in improving and extending the QUIC protocol.

- draft-michel-quic-fec

  - Improves the loss recovery of QUIC with FEC.

- draft-piraux-quic-additional-addresses

  - Enables QUIC servers to advertise additional addresses.

- There is an interest for these extensions in a deep-space context.

draft-piraux-quic-additional-addresses

- QUIC enables clients to change local addresses at any time.

- Servers can defer clients to another address right after the handshake.

- Multipath QUIC enables the simultaneous use of several network paths.

- **We proposed a way to announce additional addresses in QUIC v1.**

RFC9000

Sec.9 Connection Migration

Sec.9.6. Server's Preferred Address

draft-ietf-quic-multipath

draft-piraux-quic-additional-addresses

13

Additional Addresses in Deep Space

- Deep space devices can have several interfaces.

    - Radio interface

    - Laser interface

- Deep space devices can attach to several networks.

    - Orbital network

    - Device-to-Earth link

- Multihomed deep space devices running QUIC servers need a way to advertise their addresses.

Additional Addresses

- QUIC servers can send a list of additional addresses that can be used on a QUIC connection.

- QUIC clients can **migrate** to **one additional address**.

- MPQUIC clients can **establish new paths** to **additional addresses**.

ADD. ADDRESSES [**IPv6**]

Client

Server