QUIC+FEC

Some results for low latency video streaming
Loss recovery in classical transport protocols (SR-ARQ)

Sending “hello, world!”

Pkt 1 [“hel”]
Pkt 2 [“lo, “]
Pkt 3 [“worl”]
Pkt 4 [“d !”]
Pkt 5 [“worl”]

ACK {1, 2, 4}

> 1*RTT

Loss detection
Retransmission

Deliver “hello, “ to the application

Store “d !” in receive buffer

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
Forward Erasure Correction for QUIC loss recovery

Abstract

This document 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


Average SSIM per video over Starlink

![Graph showing average SSIM per video over GStreamer playback buffer (ms) for RTP, QUIC, and QUIRL.]
Ratio of perfect frames (SSIM=1) over Starlink

GStreamer playback buffer (ms)
(if time) Improving `curl`’s Transfer Completion Time (TCT)

We can send repair symbols during quiescence periods, when the cwin allows it.

50kB transfers using `curl` with QUIRL

No impact when no loss occurs
Lower completion time upon losses, especially in the last flight
(if time) Improving curl’s Transfer Completion Time (TCT)

We can send repair symbols during quiescence periods, when the cwin allows it.

10MB file transfers using curl with QUIRL
Summary

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

- The QUIRL paper (soon)

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

- Discuss on slack and the mailing list
- 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! :-(