Multi-path QUIC Extension and Experiments

draft-liu-multipath-quic

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Basic design for multi-path quic

- A minimally-scoped extension based on QUICv1.
- Bidirectional path
- Keep the packet header formats unchanged and use Connection IDs
- Congestion Control, RTT measurements and PMTU discovery are per-path
- Only three extension frames.

More details: https://datatracker.ietf.org/doc/draft-liu-multipath-quic/
Experimental Motivation & Methods

Motivation

• To verify if we can obtain real performance gain with the use of multi-path QUIC in short-form video streaming
• To better understand the challenges of using multi-paths for video applications.

Methods

• A/B Test with 100K participants who upgraded to test versions.
  • Two contrast groups running in parallel.
  • Multi-path users are zero-rated.

• Client-side: Taobao Mobile Android app with single/multi-path QUIC

• Server-side: Edge server for video service

• Both client & server use XQUIC as protocol implementation

Protocol used in experiments
https://datatracker.ietf.org/doc/draft-liu-multipath-quic/
A/B test results of vanilla multi-path scheduling

Min-RTT Scheduler

Downloading 1MB video chunk

A sample from the experiment

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<th></th>
<th>avg</th>
<th>p50</th>
<th>p90</th>
<th>p95</th>
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</table>

Multi-path head-of-line blocking

If one of the paths is not working, packets sent to that path will be lost. It will take time to correct these losses. [https://huiitema.wordpress.com/2021/01/26/implementing-multipath-in-quic/](https://huiitema.wordpress.com/2021/01/26/implementing-multipath-in-quic/)
Use re-injection to overcome MP-HoL

Multi-path SHOULD achieve no worse performance than single path

Figure 3: Use re-injection to overcome multi-path HoL blocking
(a) Without re-injection, packets lost on the slow path would block the fast path. (b) With re-injection, lost packets on the slow path can be quickly recovered from the fast path.

Get better quality of service now, but more than 15% additional traffic costs?
- Still too expensive for users and video services

Figure 4: Different modes of re-injection: (a) Traditional (appending) mode, (b) stream priority-based mode to address stream blocking and (c) video-frame priority-based mode to address video frame blocking.

- Use QoE feedback to control the aggressiveness of re-injection
- For VoD: QoE feedback contains info related to client’s video buffer level
Scheduler with QoE feedbacks

Throughput (Mbps) vs Time (s)

Path1
Path2

Buffer level (MB) vs Time (s)

Trace

No-reinjection

Re-injection wo. QoE

Re-injection w. QoE

Buffer level (MB) vs Time (s)

Re-inject
Buffer level
Re-inject bytes

Re-injection after first frame

Re-inject
Buffer level
Re-inject bytes

Re-injection after first frame
QoE-driven scheduling A/B test

Improvement median: 2.3%-8.9%
Improvement 95th: 9.4%-34%
Improvement 99th: 19%-50%

Re-injection traffic overhead reduce from 15% to 2%
Summary

• Obtaining good performance with multi-path QUIC is not straightforward

• Need to overcome MP-HoL blocking

• Leverage QUIC to collaborate with application

• Use QoE feedback (balance cost and performance)
  - It’s optional, don’t be worry about binding application layer and scheduler on transport layer
  - QoE feedback and Scheduler algorithm may depend on application scenarios
  - QoE_Control_Signal frame is used for experiments
  - Maybe need an additional transport parameter for algorithm and QoE feedback format negotiation

For more details ...
Multi-path Transport Questions for Discussion

Does multipath QUIC need additional signaling to mitigate path HOL-blocking?
• As it’s hard to predict future network conditions, use timely QoE would help multi-path scheduling and re-injection get better results

What is very much in scope is what mechanisms does a multi-path quic design need to be deployable at scale?
• Simple and clear extension, easy to get deployed
• obtaining real gain on QoE