Improving QoE of ABR Streaming Sessions through QUIC Retransmissions

MM18

HTTP/2 Over TCP VS Over QUIC

- HTTP/2 makes several improvements over its predecessor HTTP/1.1
  1. multiplexing
  2. header compression
  3. an option where the web server can push content to the client proactively

- combination of HTTP/2 and TCP has several performance issues
  - Delay (3-way handshake for each connection setup)
  - issue of head of line (HOL) blocking

- Quick UDP Internet Connections protocol (QUIC)
  - designed to combine the speed of UDP with the reliability of TCP and, thus overcome these issues

DASH-based ABR approach (SQUAD)

- One specific feature of SQUAD is the ability to retransmit segment in a higher quality than they were originally transmitted to reduce frequent quality changes during a streaming session
- HTTP/1.1 : inability to efficiently schedule retransmissions
- HTTP/2 : makes such retransmissions more efficient (multiplex)
  - the impact of losses and the resulting HOL blocking has not been studied
- QUIC can further improve SQUAD with retransmissions, since it eliminates the HOL blocking issue

Contributions

1. switches in quality representations that result in a gap occur in almost 36% of all streaming sessions. In the case of mobile clients this number increases to 50%

2. perform a systematic comparison of the multiplexing feature of HTTP/2 and QUIC

3. QUIC retransmissions can significantly improve the average quality bitrate while simultaneously minimizing bit rate variations

QoE metrics

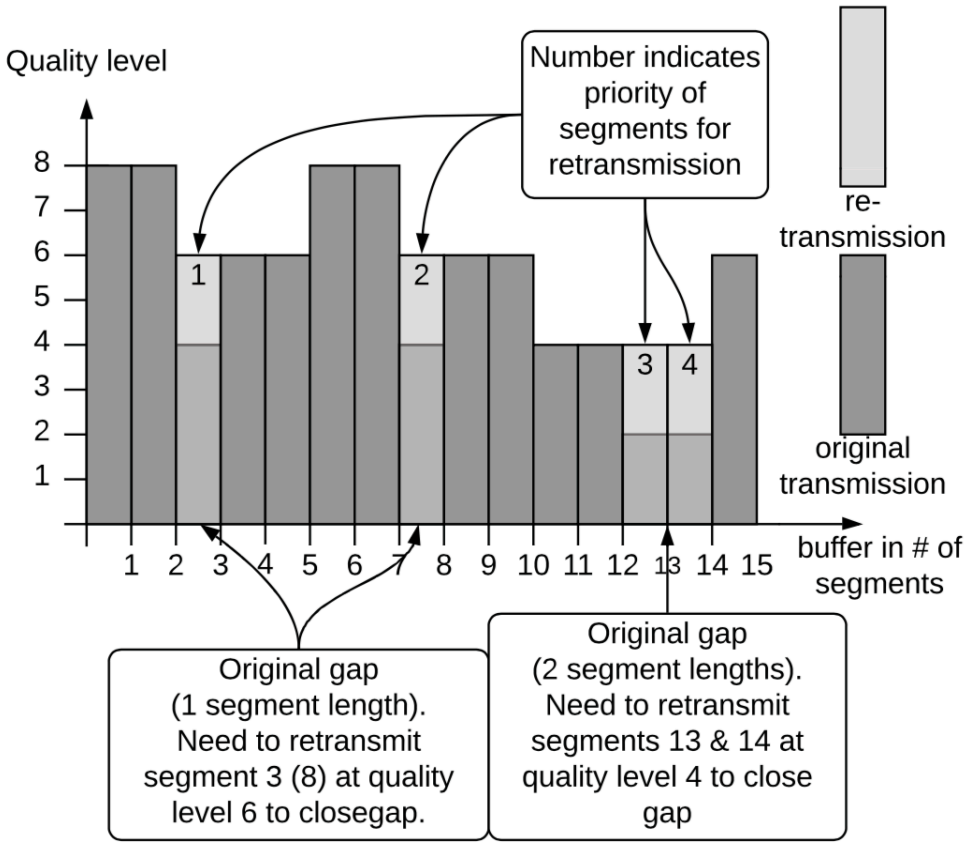
1. Average Quality Bitrate (AQB)

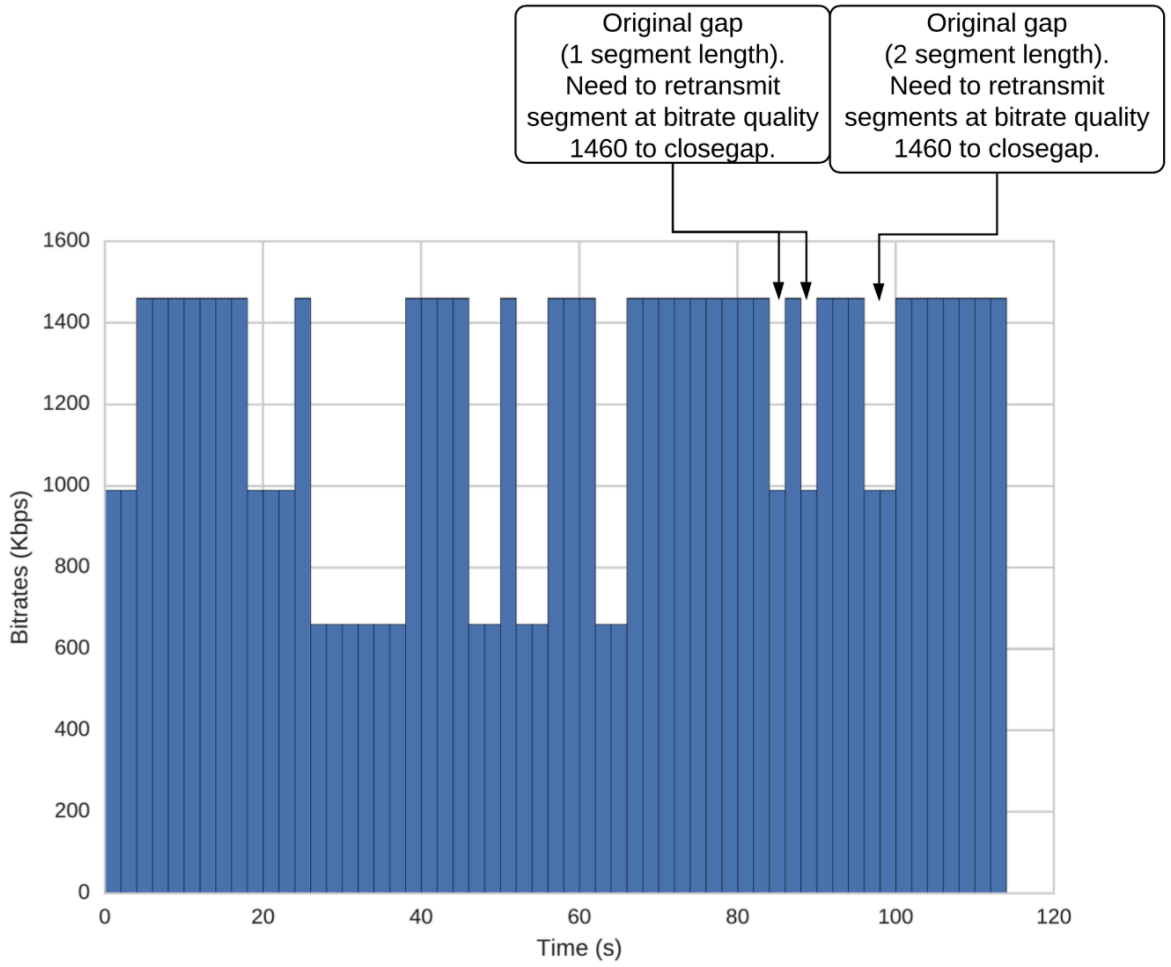
2. Number of Quality Switches (#QS)

3. Spectrum (H)
   - The spectrum of a streamed video is a centralized measure for the variation of the video quality bitrate around the AQB. A lower H indicates a better QoE

4. Rebuffering Ratio (RB) : $RB = E[\frac{t_a - t_e}{t_e}]$

Quality Gaps

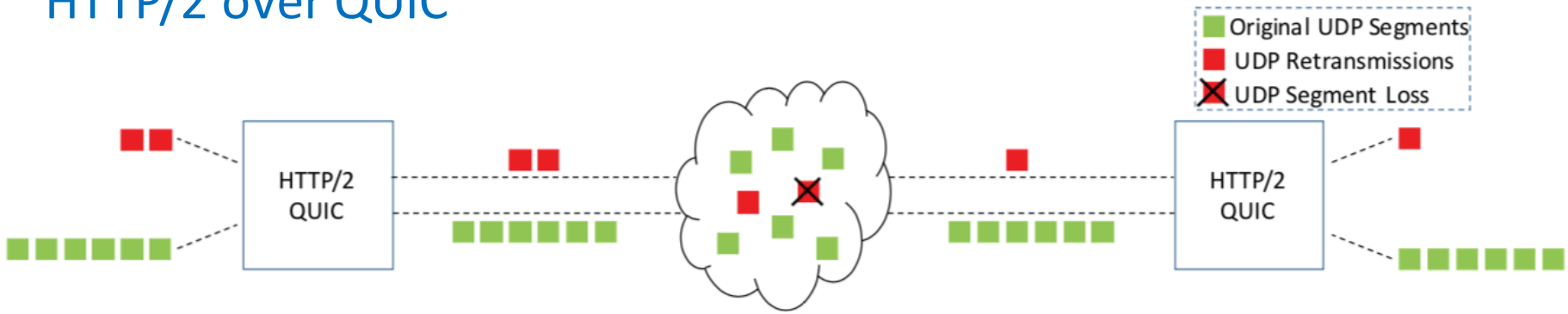




HTTP/2 over TCP vs over QUIC

HTTP/2 over TCP

HTTP/2 over QUIC



HTTP/2 over TCP vs over QUIC

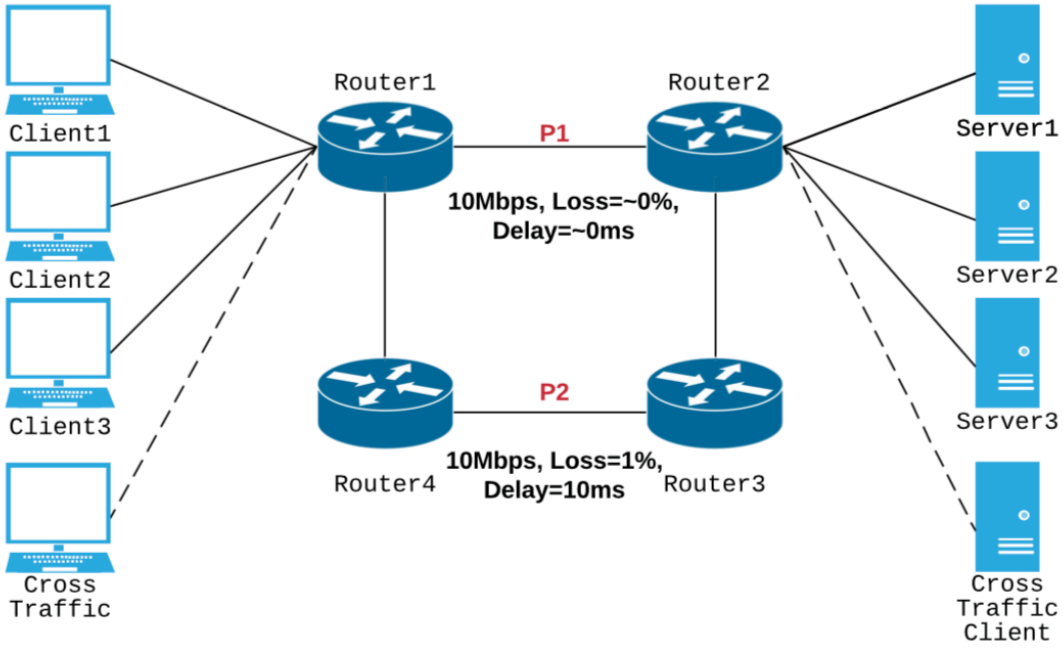
- The application can decide if the lost retransmitted UDP datagram should be retrieved again or not
  1. buffer fill level
  2. position of the retransmitted segment in the buffer
  3. observed download rate

Evaluation Design

1. BigBuckBunny dataset that comprises a 300s-long video with a 2s segment duration and the corresponding MPD file.

2. extended the MPD file by providing the size of each segment in each of the available quality levels

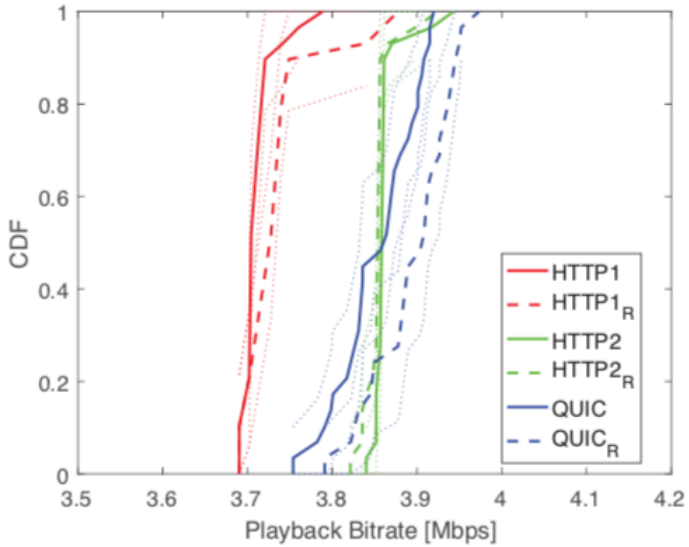
3. The quality bitrates available in this MPD file are the following: {0.09, 0.13, 0.18, 0.22, 0.26, 0.33, 0.59, 0.79, 1.03, 1.24, 1.54, 2.48, 3.52, 4.21}Mbps.

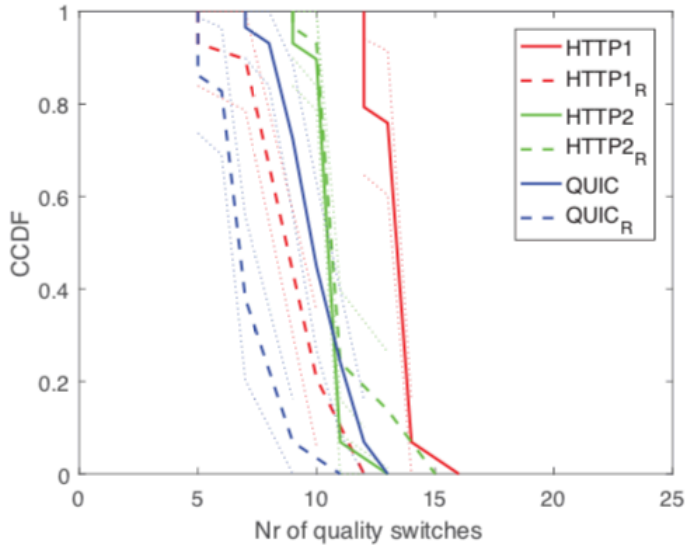


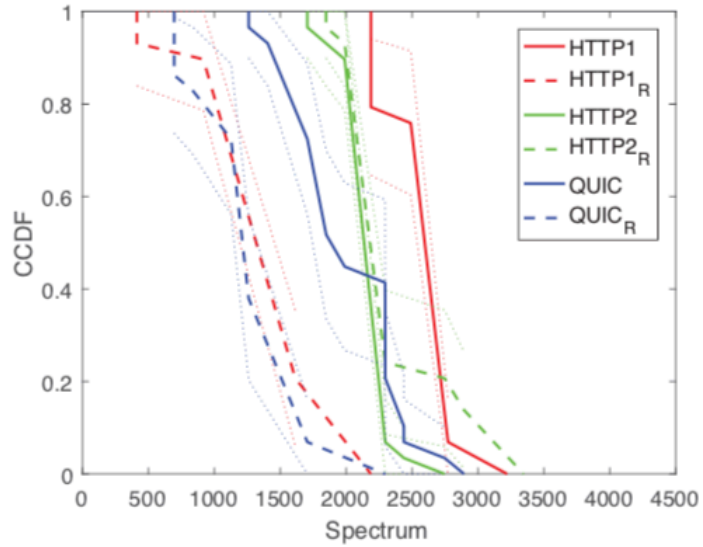
Single Client: Rate Limiting with UDP

- compare the performance of HTTP/1.1, HTTP/2 and QUIC in a controlled environment

1. repeating a stepwise variation of cross traffic where the duration of each step is 11s
   - {0-11s: 0Mbps, 12-23s: 3Mbps, 24-35s: 6Mbps, 36-55s: 9Mbps, 56-67s: 6Mbps, 68-79s:

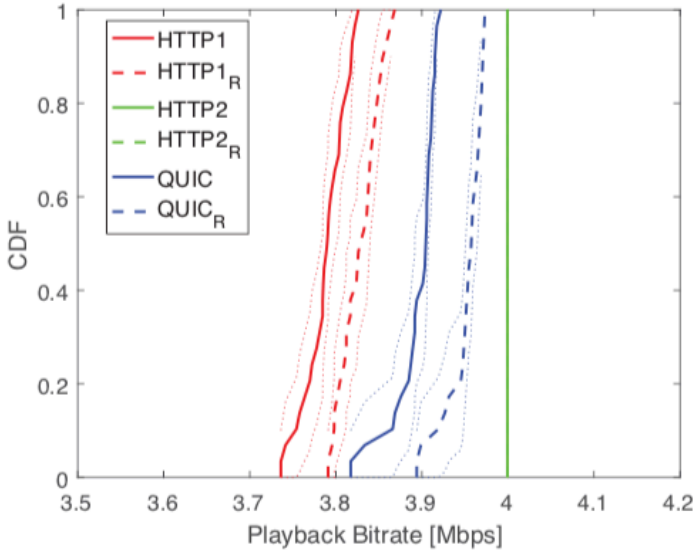


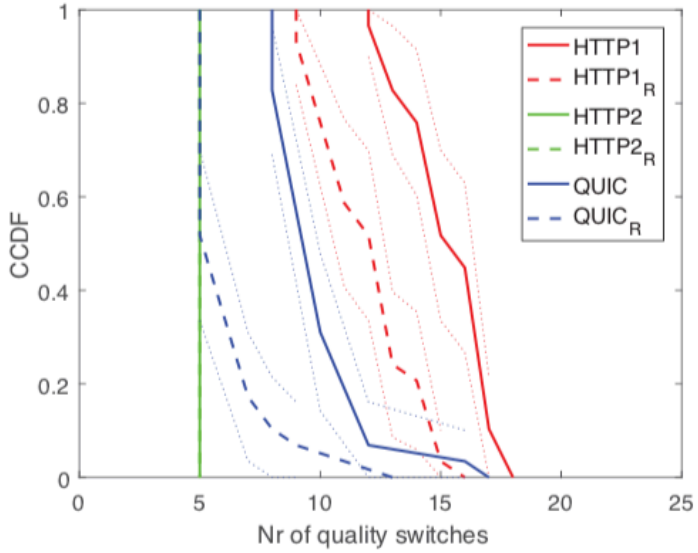


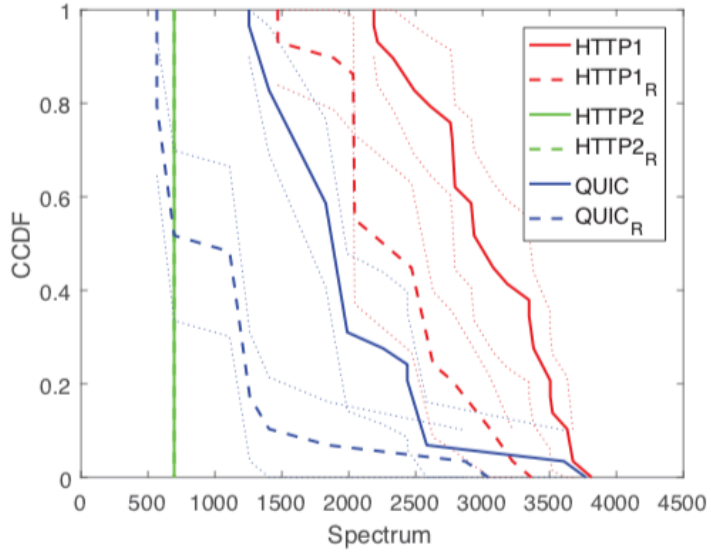


Single Client:Rate Limiting with UDP

2. "W" shaped bottleneck
   - {0-20s: 9Mbps, 21-40s: 5Mbps, 41- 60s: 9Mbps, 61-80s: 0Mbps}



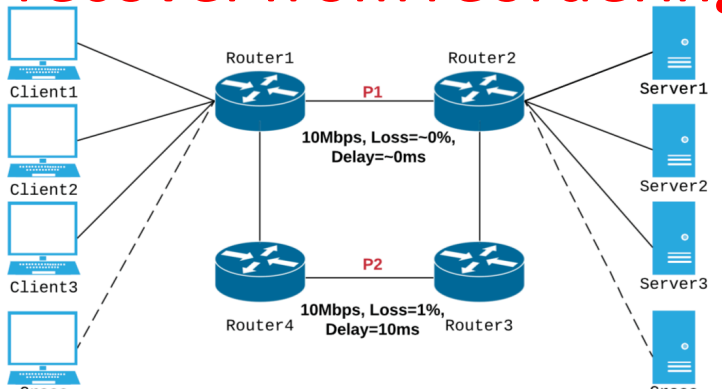


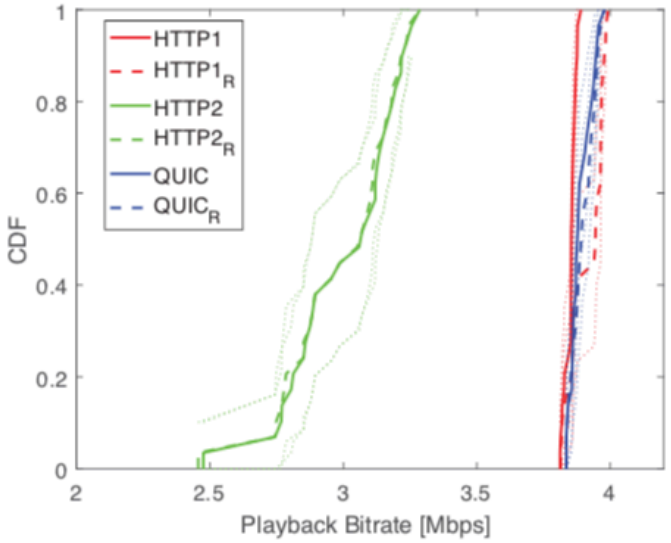


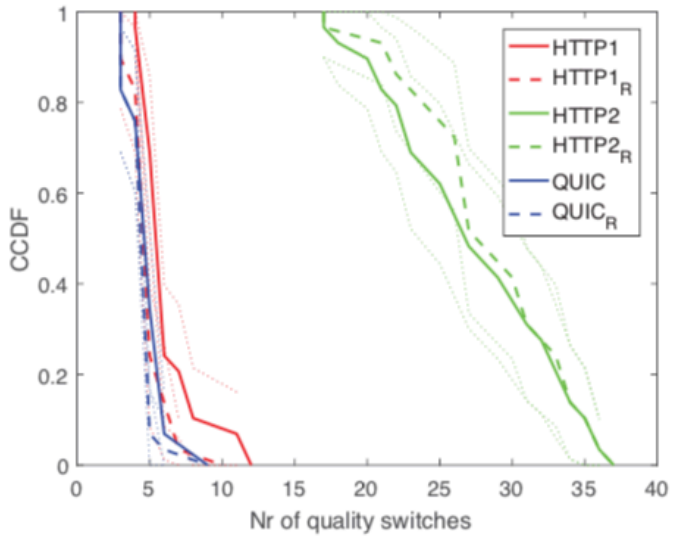
HTTP/2 clients appear to experience the best QoE,
but have high rebuffering ratio, RB, of 4%

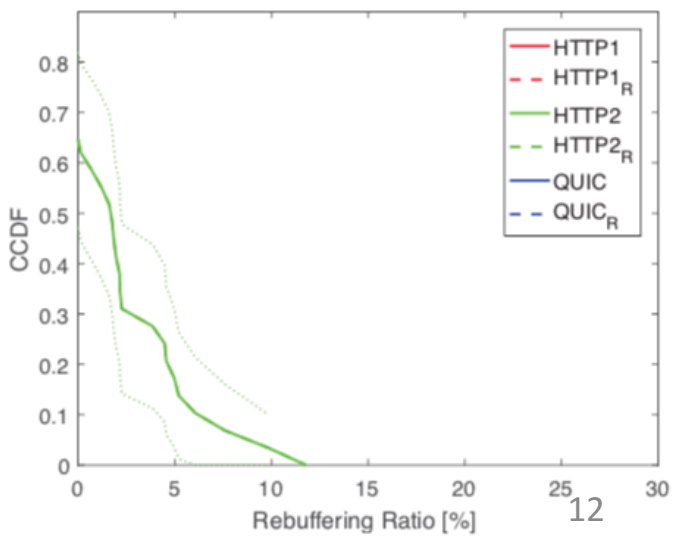
Single Client: Re-ordering and HOL

- the ability of HTTP1.1, HTTP/2, and QUIC to recover from reordering of packets
  - Switch between P1 and P2



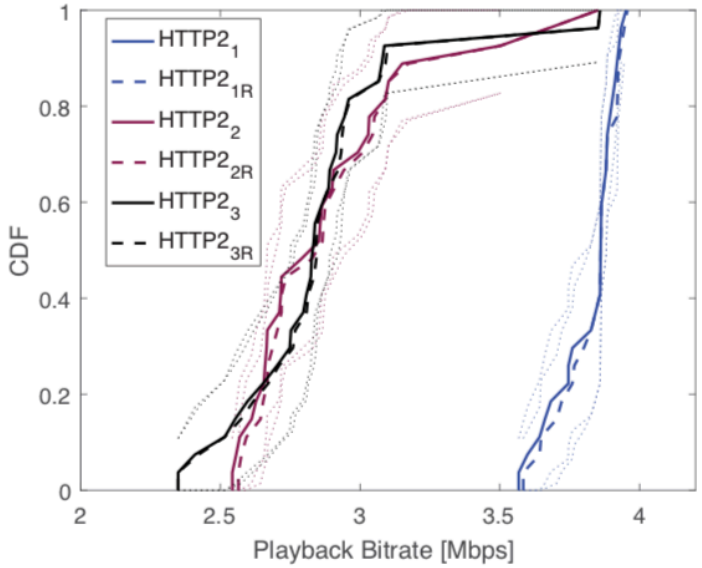


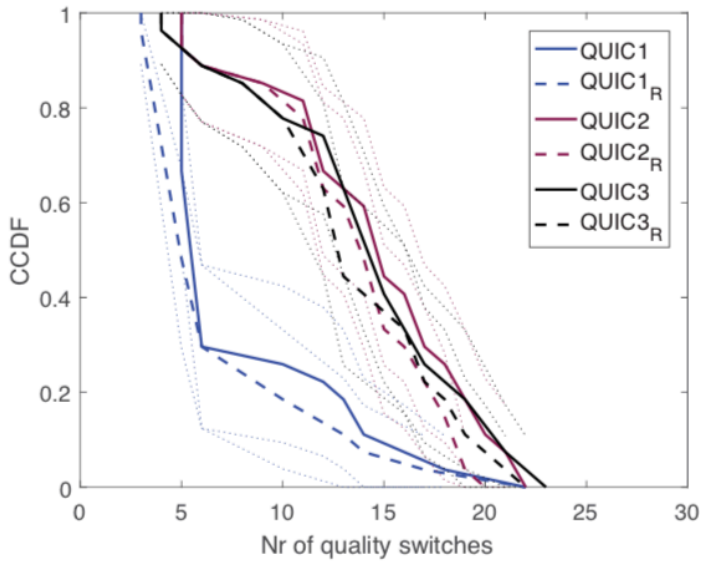


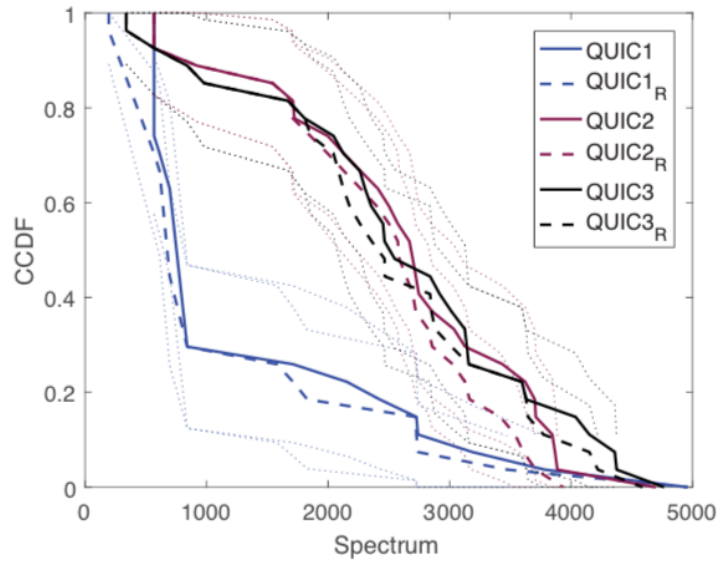


Parallel Clients: Competing Traffic

- Three QUIC Clients

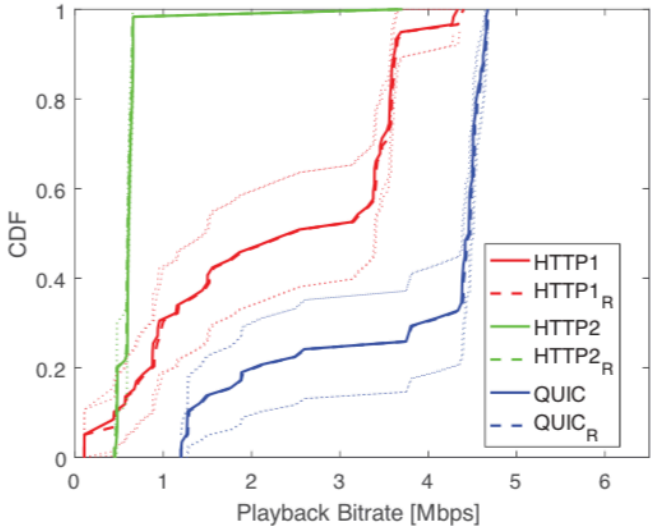


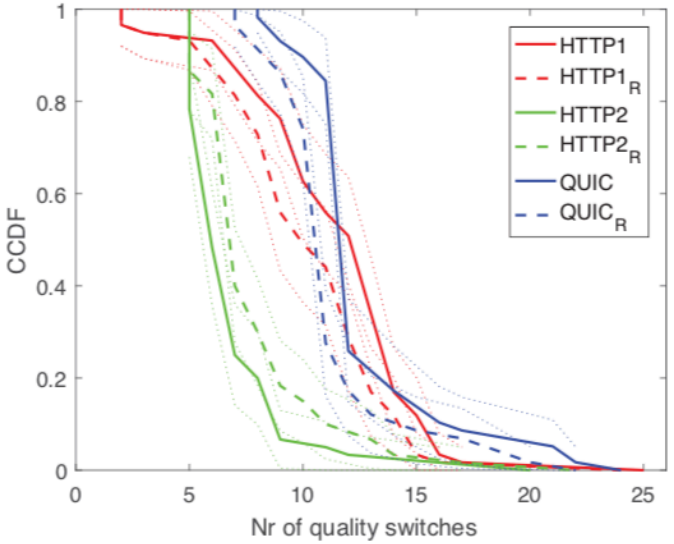


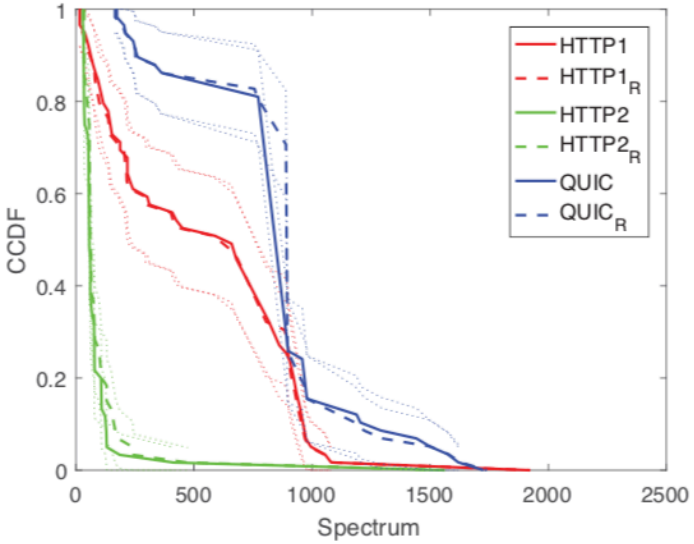


	Client1	*Client2*	*Client3*
Average %Retransmissions	0.8±1.3	1.7±1.3	1.0±0.9

Real Internet Measurement







	AQB (Mbps)	AQB_R (Mbps)	$\#QS$	$\#QS_R$	H	H_R	$RB_R(\%)$
Internet: HTTP/1.1	5.31±0.1	5.66±0.1	8.48±1.4	3.82±2.1	490±213	242±312	0
Internet: HTTP/2	2.12±0.6	2.13±0.6	9.09±2.6	6.98±2.5	552±280	447±255	0±10.8
Internet: QUIC	5.31±1.9	5.44±0.2	7.91±1.8	5.81±1.7	445±299	351±273	0

Conclusion

- leverage the multiplexing feature of QUIC and HTTP/2
  - implement parallel retransmissions in a higher quality
  - maximizing average quality bitrate
  - minimizing bitrate variations throughout the duration of a streaming session

- QUIC retransmissions provide a significantly better QoE than TCP in high latency, high loss networks while exhibiting comparable QoE in low latency, low loss networks