NETFLIX

Buffer sizing and AQM observations at Netflix

RIPE 78 - MAT
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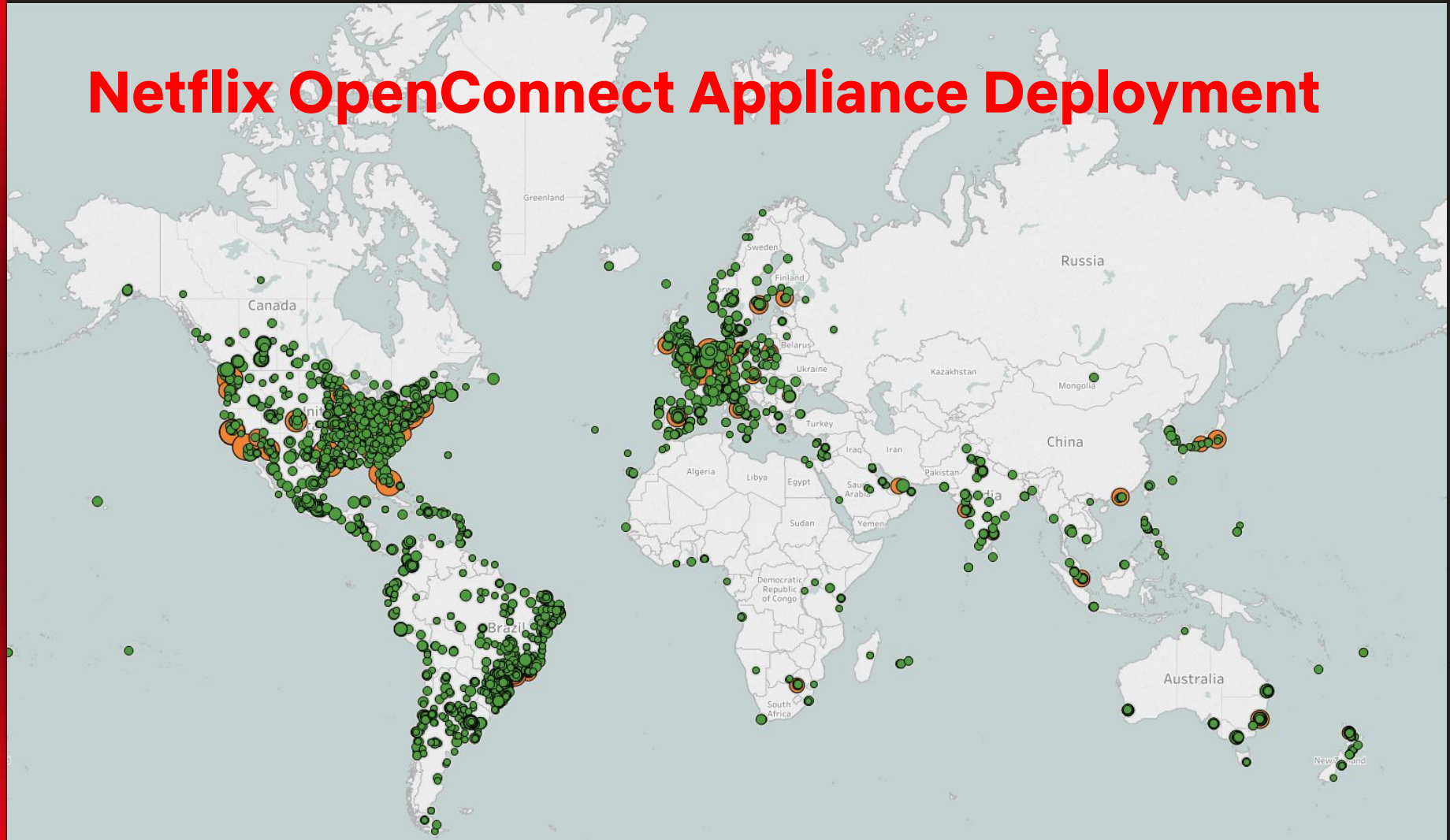
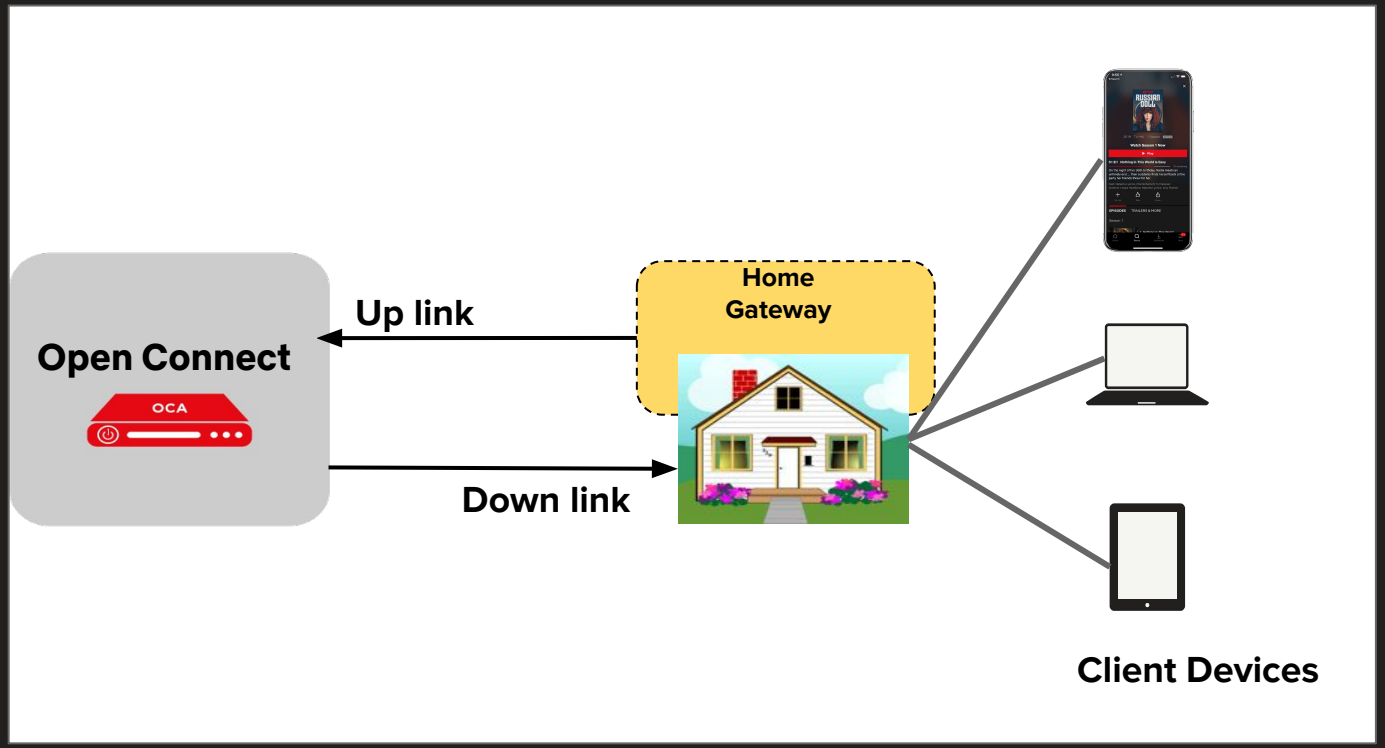
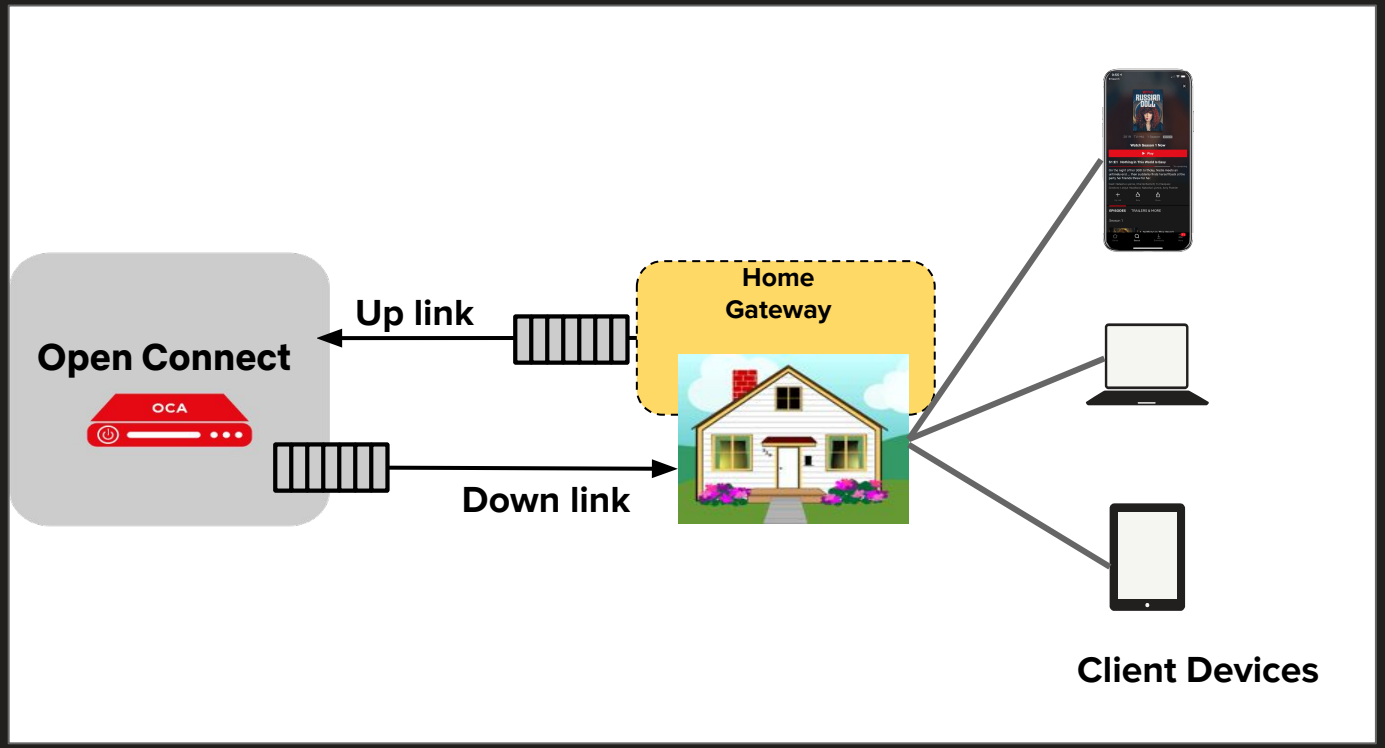
Netflix OpenConnect Appliance Deployment



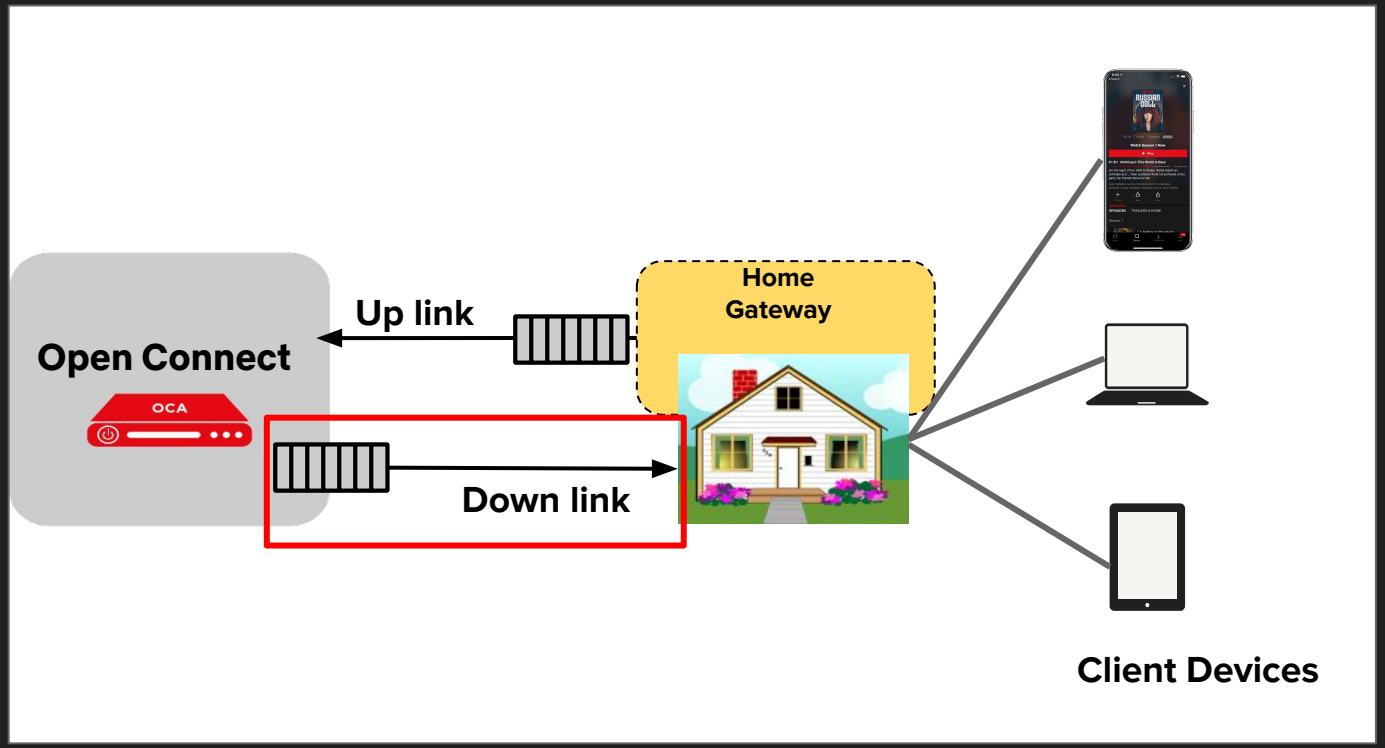
Congestion: Downstream vs. Upstream



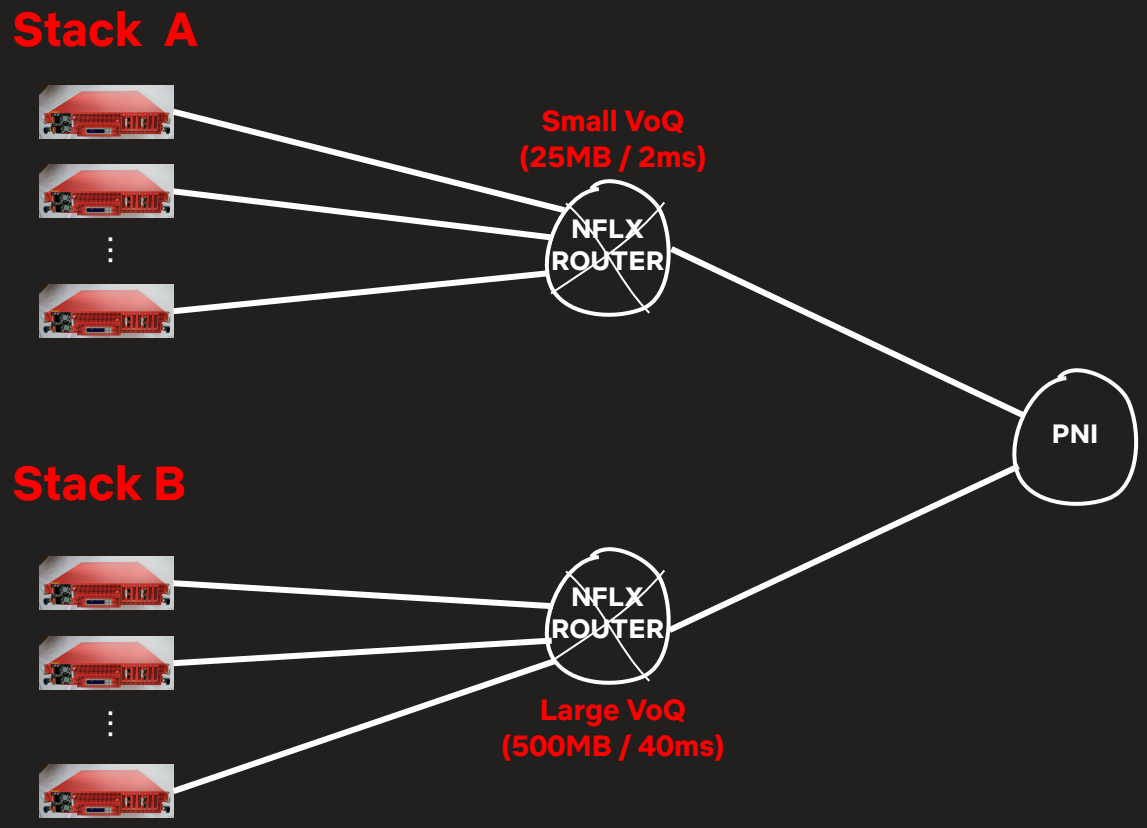
Congestion: Downstream vs. Upstream



Congestion: Downstream vs. Upstream



Experimental Setup - Downstream Congestion



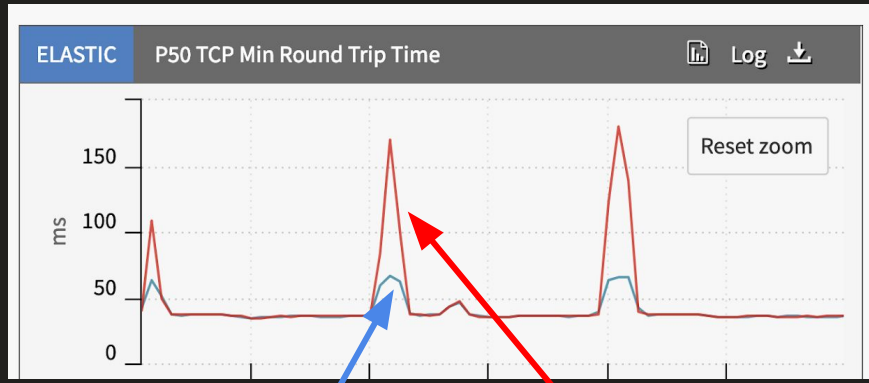
Experimental Setup (Cont.)

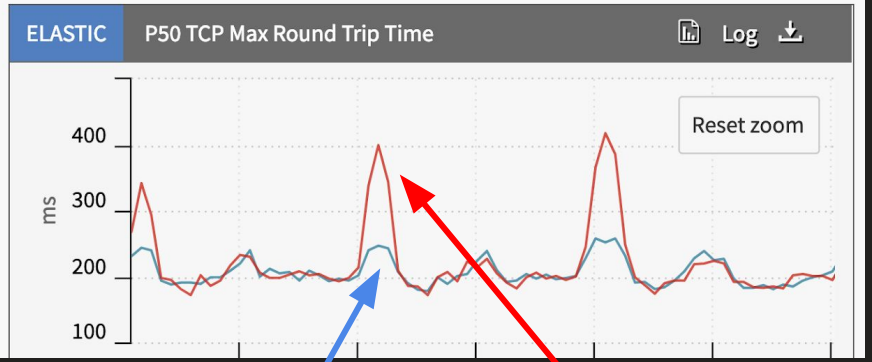
- TCP New Reno + RACK
- Traffic is distributed equally across the stacks
- Router buffer size is the only variable

Caveat:

- Not a randomized A/B experiment
- Preliminary observations, lots of questions

Network Metrics under Congestion





Small buffer stack

Big buffer stack

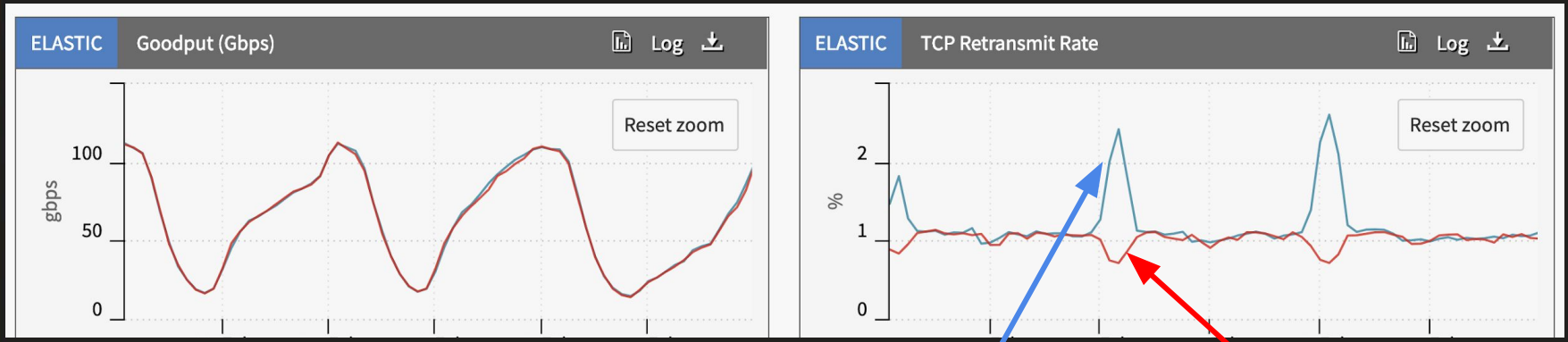
~100ms difference on median of min RTT

Small buffer stack

Big buffer stack

~150ms difference on median of max RTT

Network Metrics under Congestion

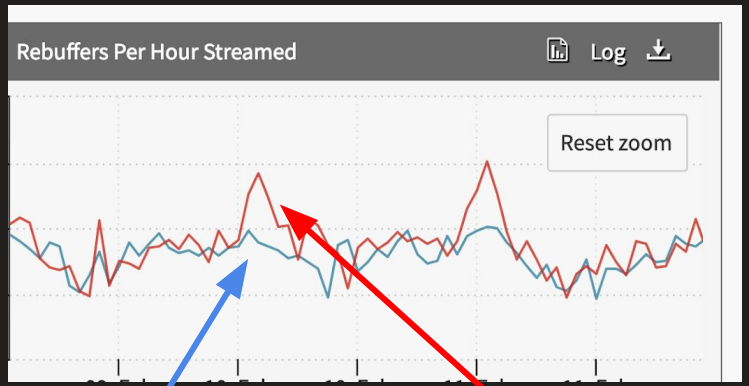


Small buffer stack

Big buffer stack

~1.5% extra of packet retransmission rate

QoE Metrics under Congestion

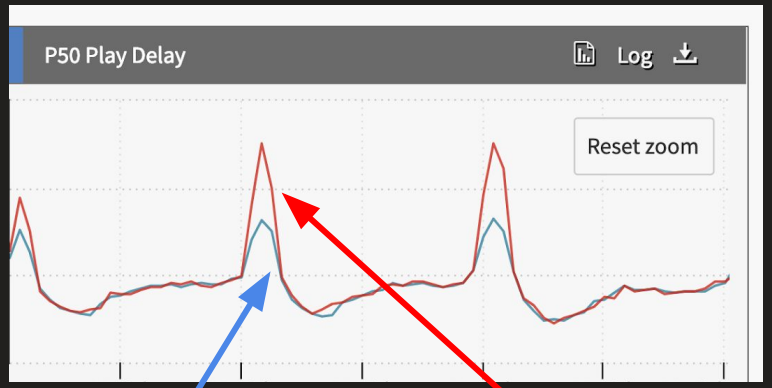


Small buffer stack

Big buffer stack

Big buffer stack increases rebuffer rate by ~30%

QoE Metrics under Congestion

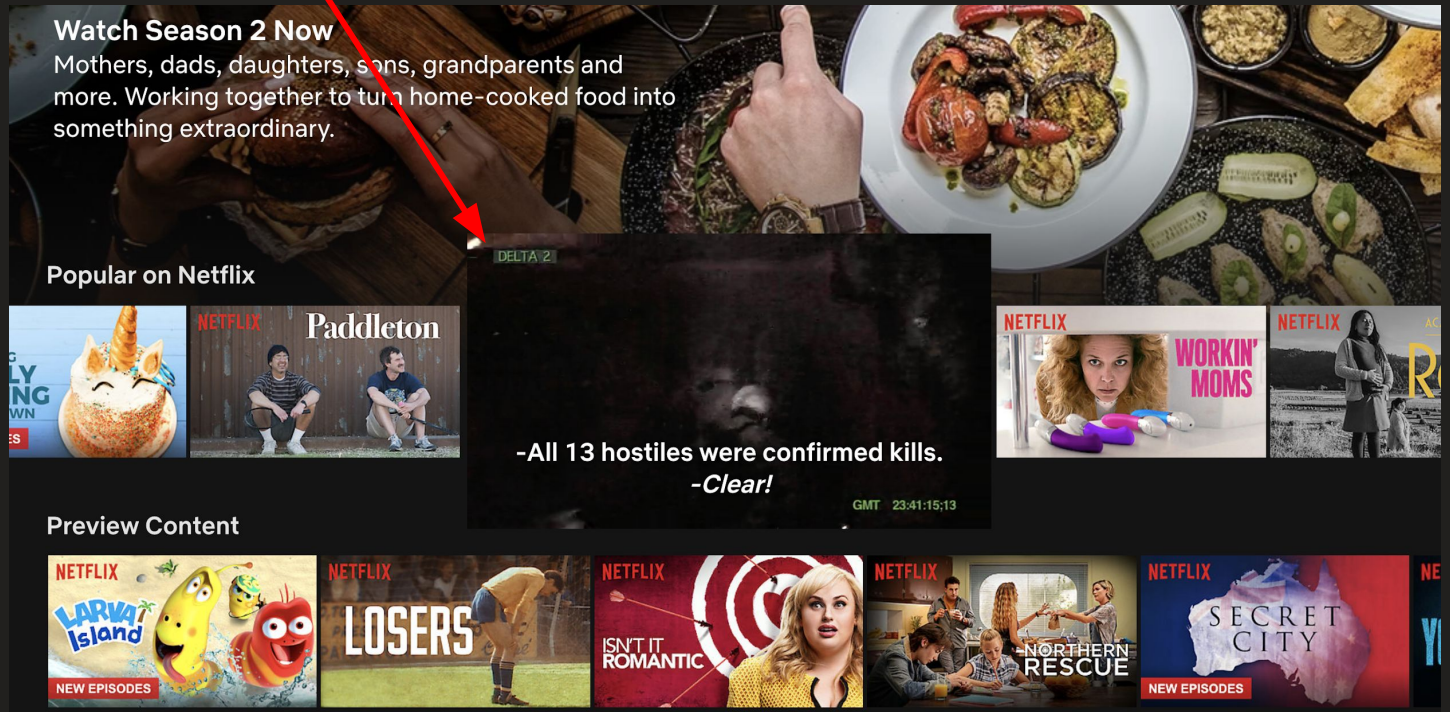


Big buffer stack

Small buffer stack

~1s difference on
median play delay

Supplemental Playback



Impact of Play Delay on Supplemental Playback

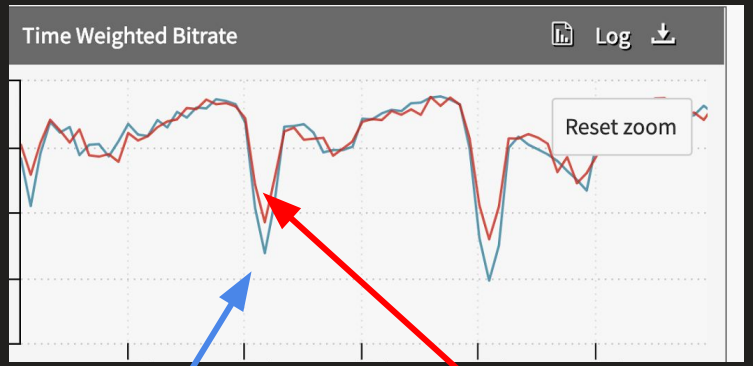
Browser Players

	# of Standard Playback (normalized)	# of Supplemental Playback (normalized)
Stack A (small buffer)	1.02	1.32
Stack B (big buffer)	1	1

Sampled TV Devices

	# of Standard Playback	# of Supplemental Playback
Stack A (small buffer)	1.03	1.19
Stack B (big buffer)	1	1

Video Quality under Congestion

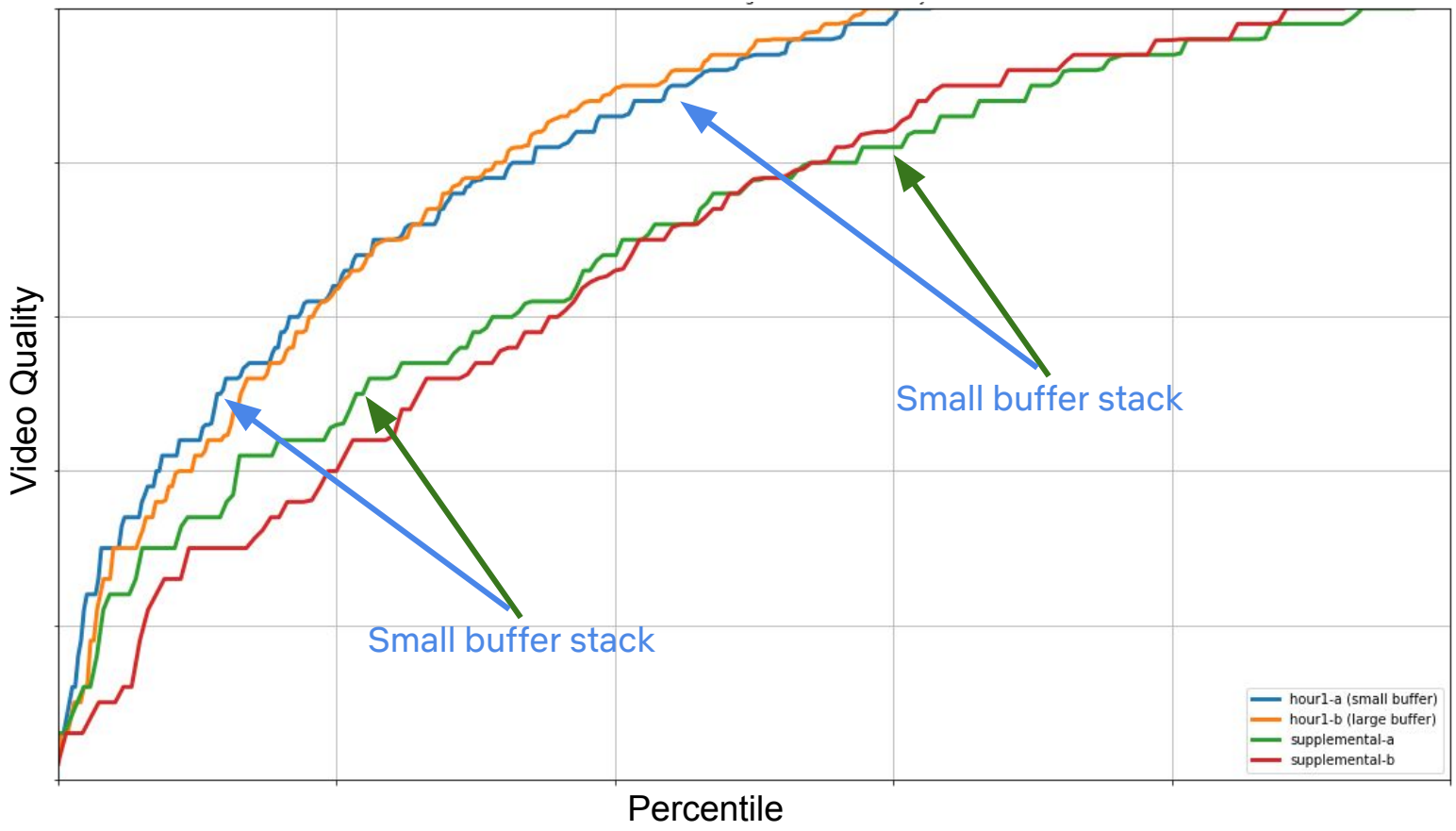


Small buffer stack average video quality (measured by bitrate) drops by 3%

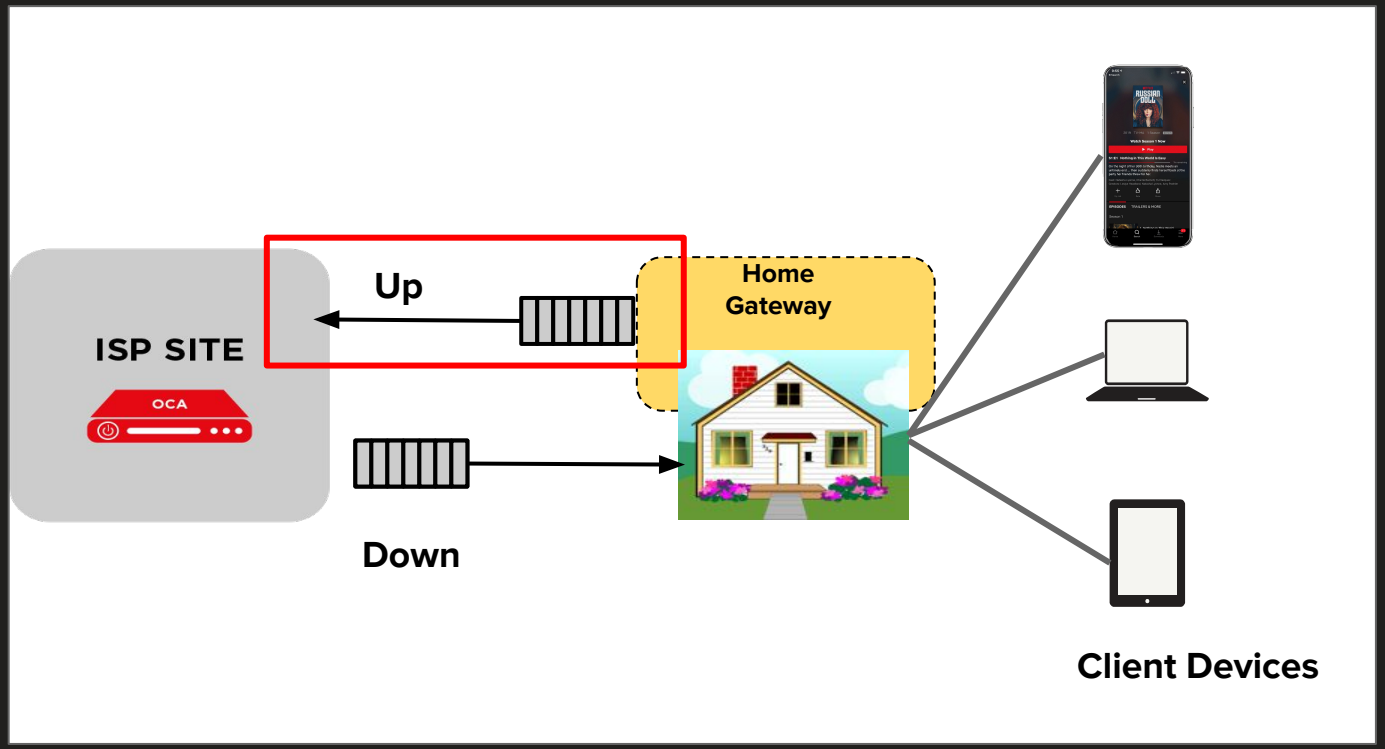
Big buffer stack

Small buffer stack

Video Quality under Congestion



Lab Experiment Setup – Upstream Congestion

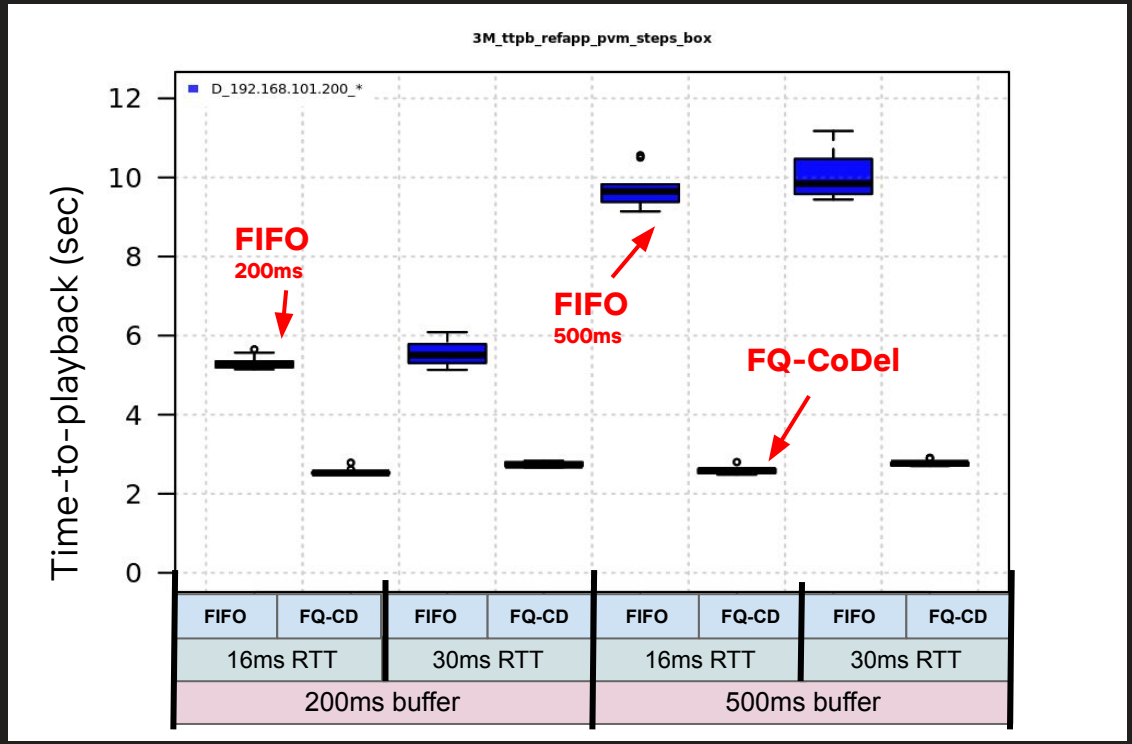


Test conditions

- **PHY speeds:** 15Mbps down / 3Mbps up
- **Buffering:** 500ms down / {200,500}ms up
  - FIFO down / FIFO up (common scenario)
  - FIFO down / FQ-CoDel up (proposed scenario)
- **Competing flow:**
  - Bulk data upload (constant TCP data stream)

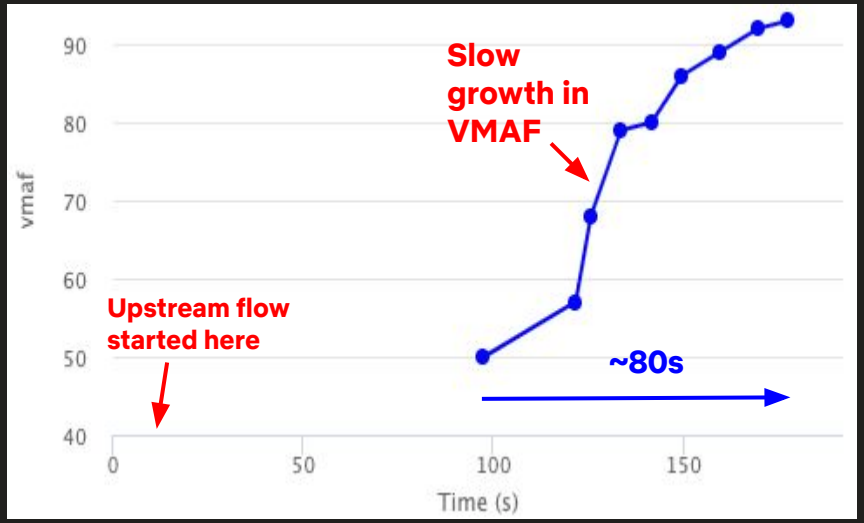
Congested: Play delay & Time to playback

(One bulk connection for upstream congestion, 16ms base RTT, 10 repeats)

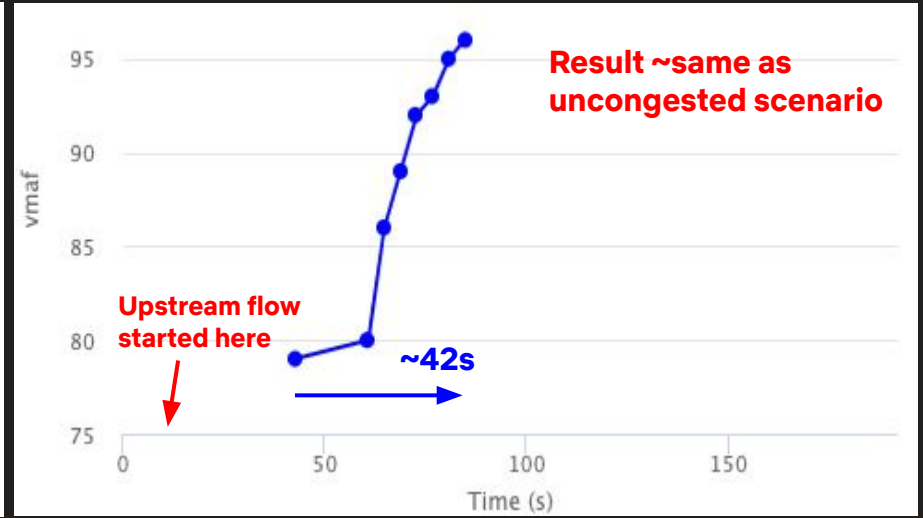


Congested: VMAF vs time

(One bulk connection for upstream congestion, 16ms base RTT, refapp launched at t=20) via PVM



FIFO upstream



FQ-Codel upstream

Summary

- Downstream congestion:
  - Sizable QoE improvement on small buffer stack
    - Play delay, Rebuffer rate, Video quality
      - Even though retransmission rate is higher
    - Network metrics are important, but the community should pay more attention to the customer-facing QoE metrics.
- Upstream congestion:
  - Lab tests show that AQM improves QoE
    - Play delay, Video quality

Thank You

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Backup Slides

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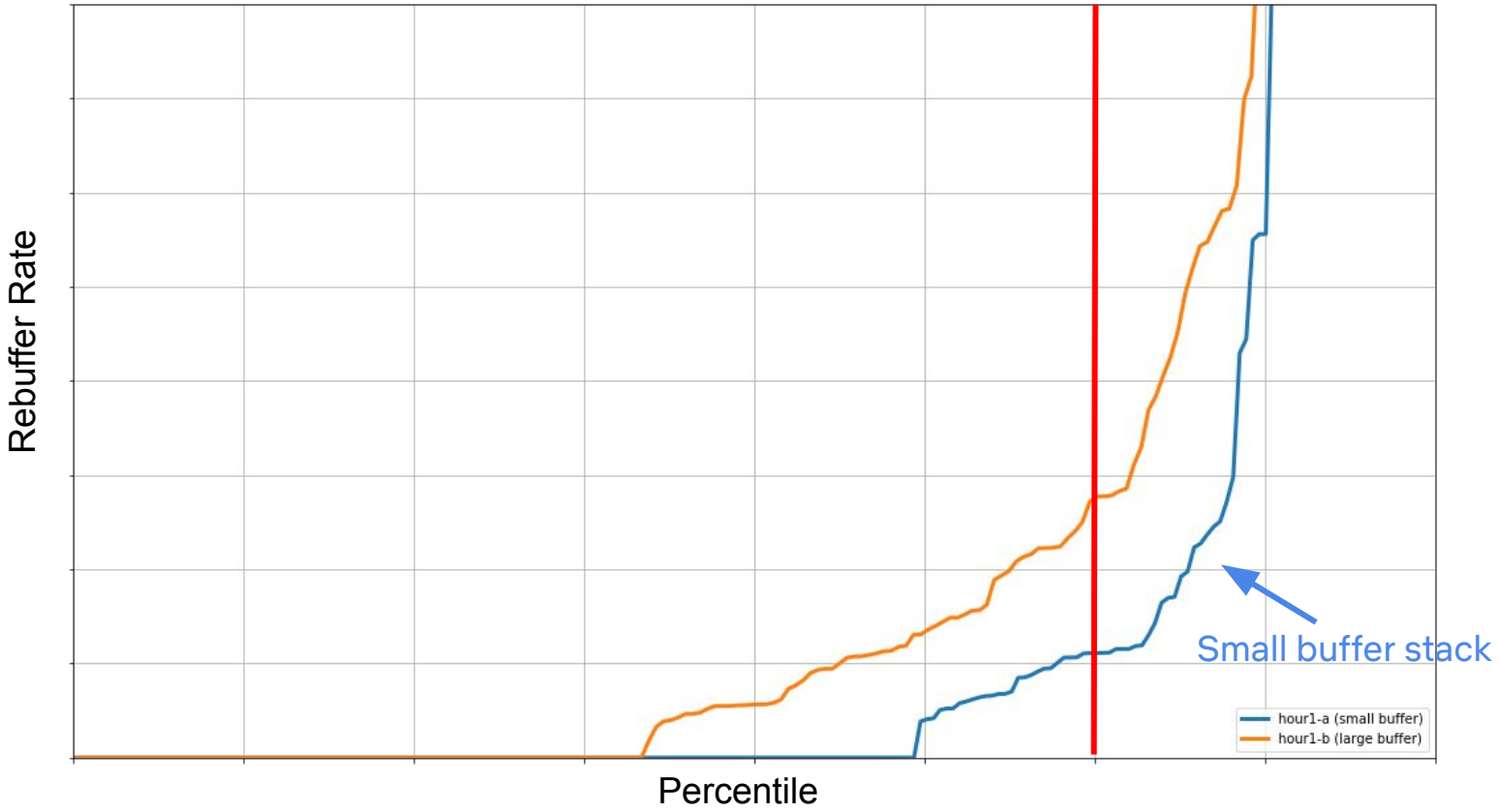
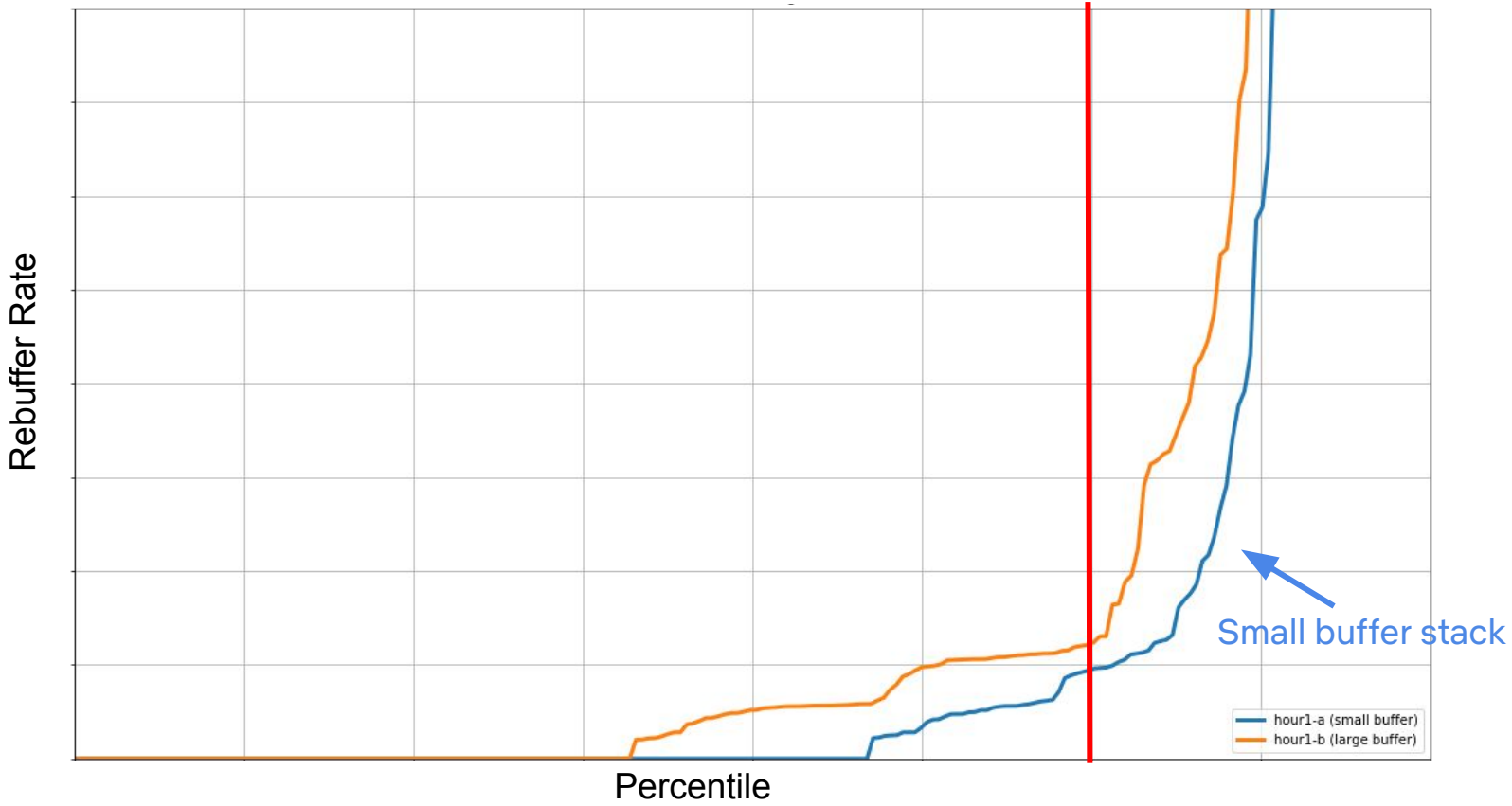
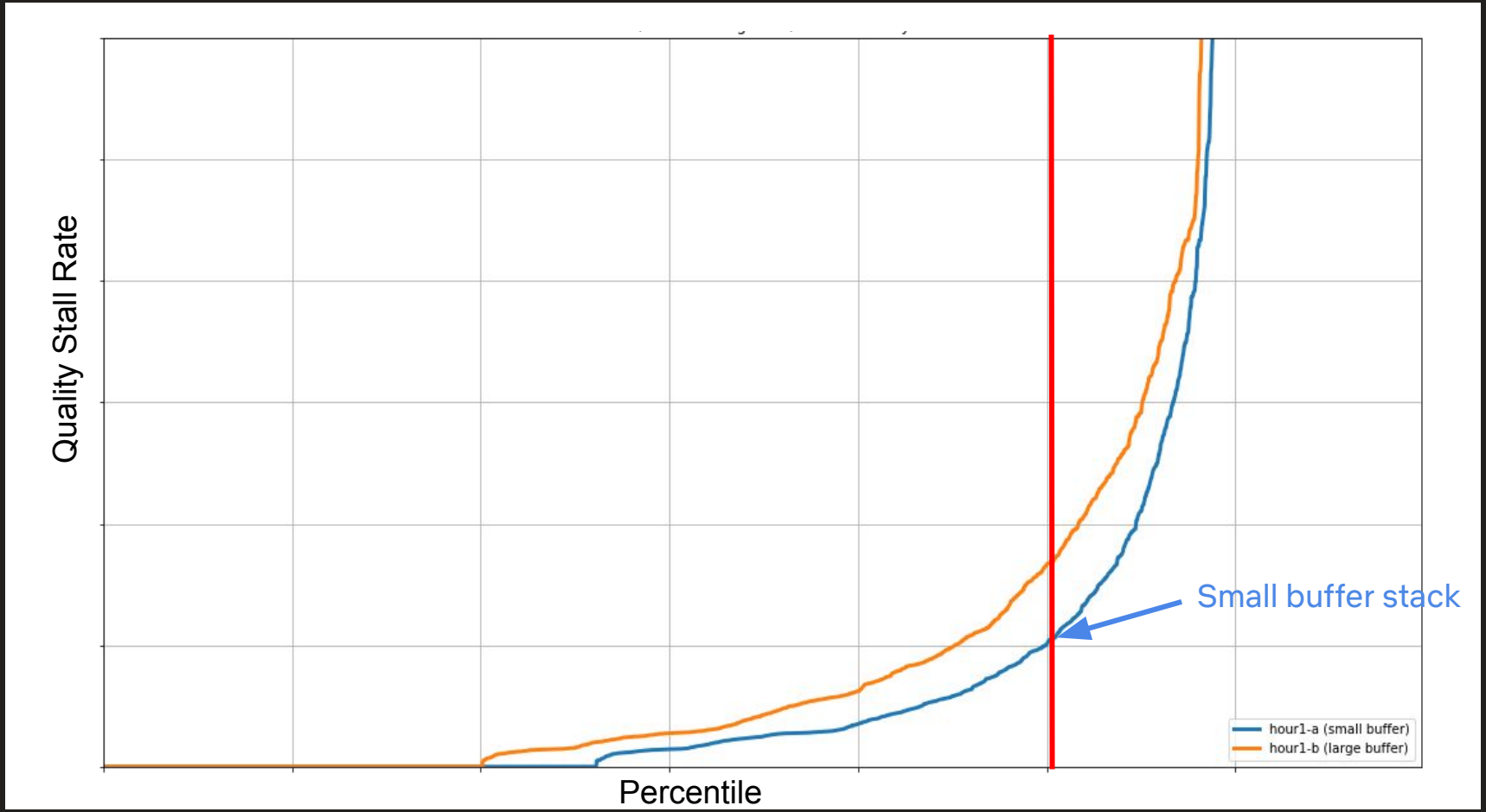
Rebuffer Rate - Browser Player - Congested Hour



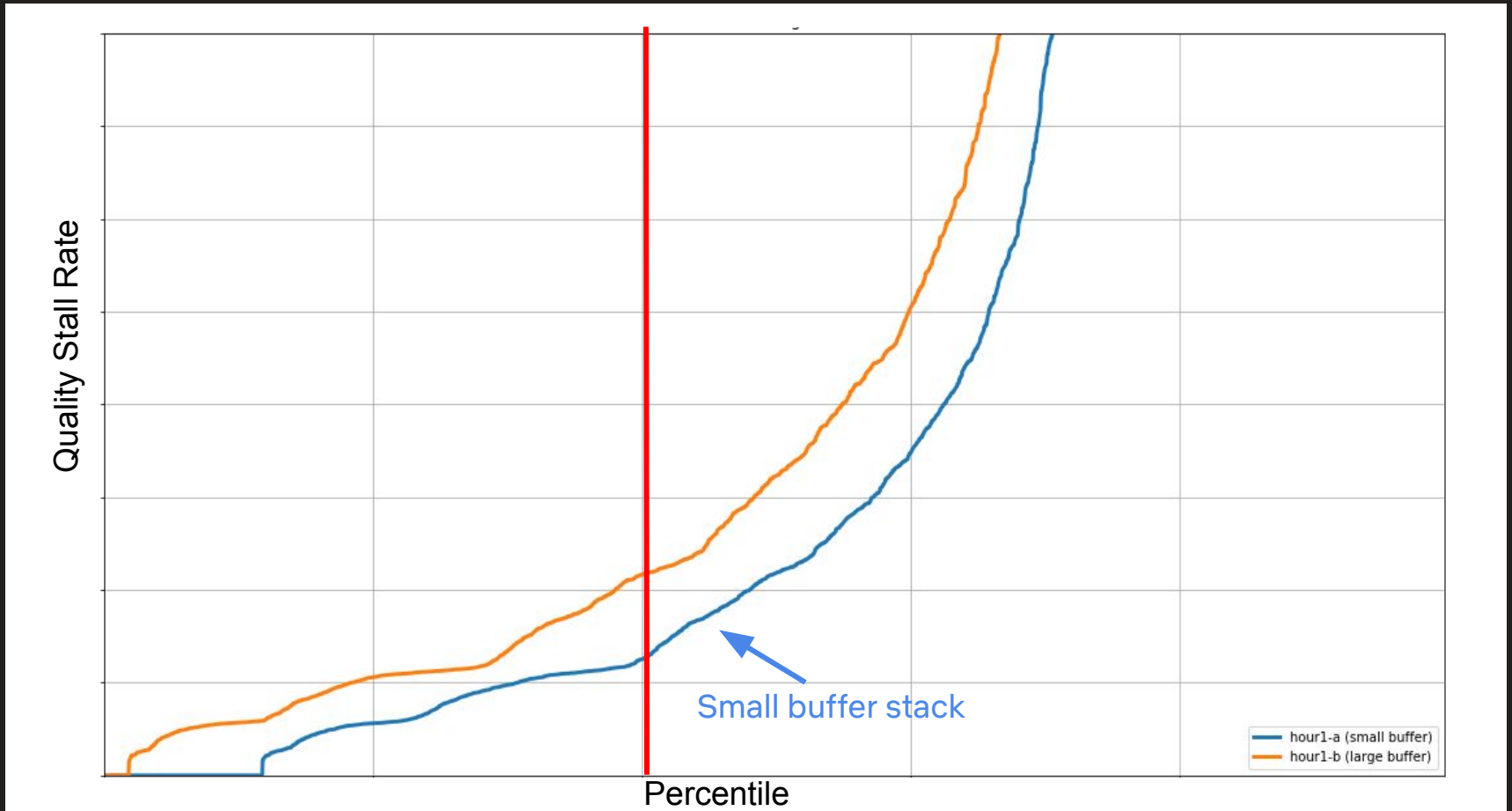
Rebuffer Rate - TV Player - Congested Hour



Perceivable Quality Degradation Rate - Browser player - congested hour

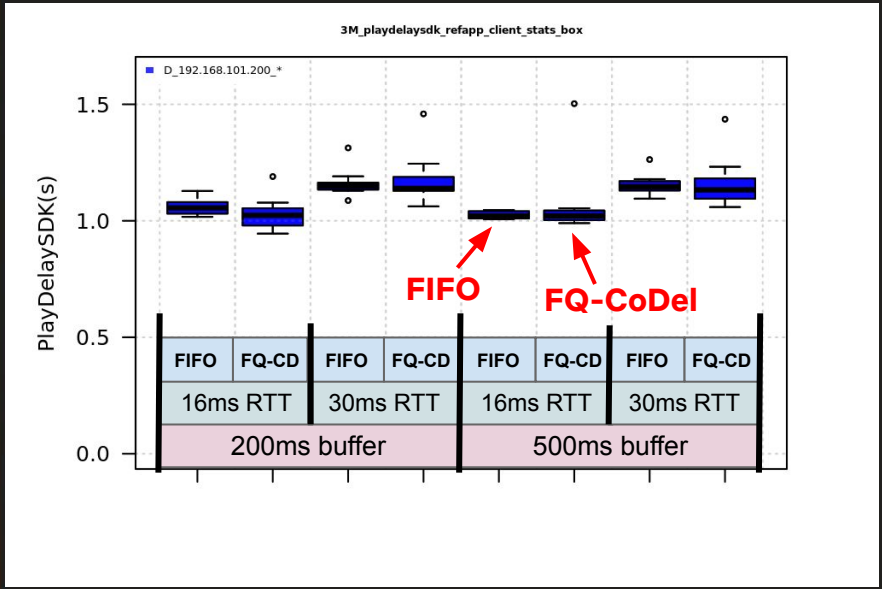


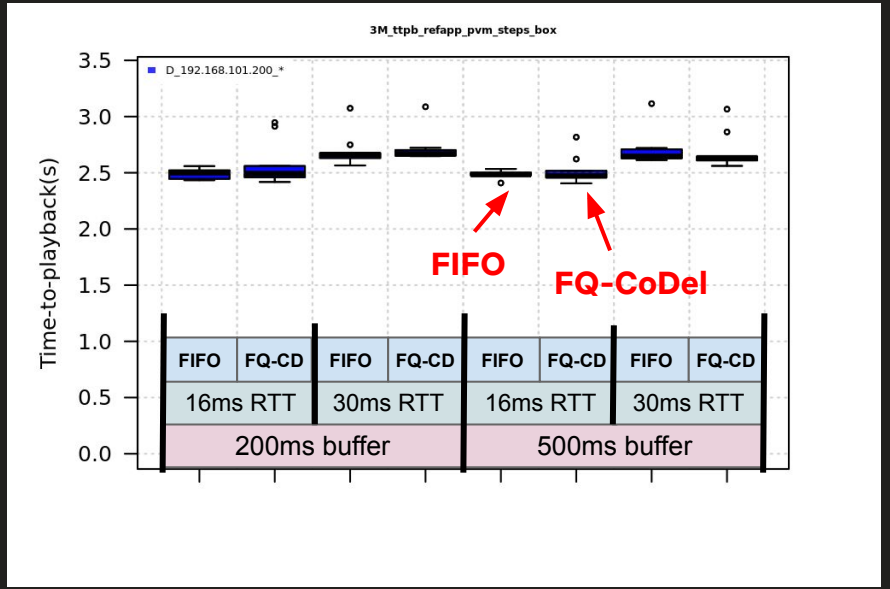
Perceivable Quality Degradation Rate - TV player - congested hour

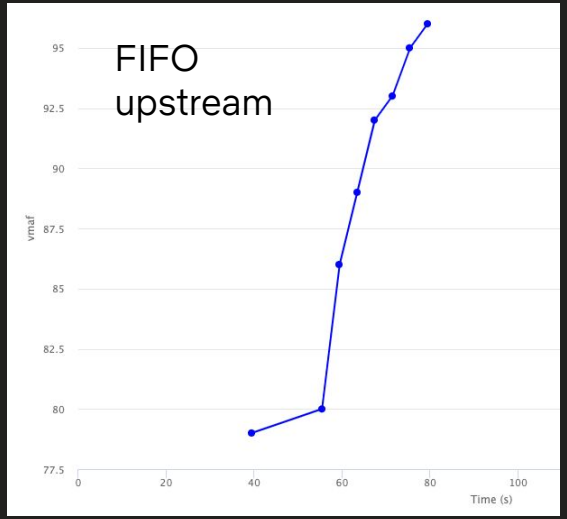
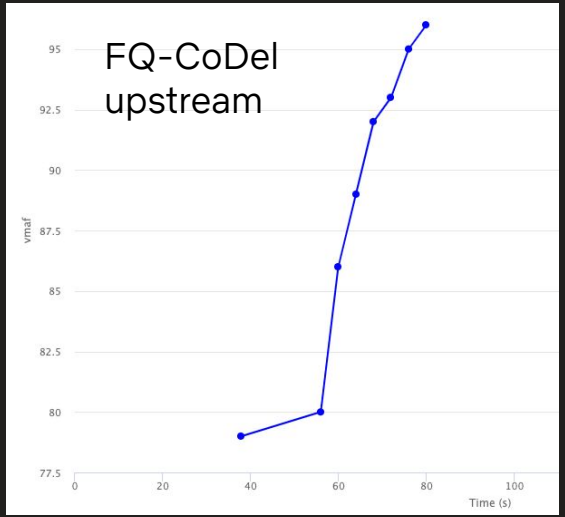


Baseline: Play delay & Time to playback

(No upstream congestion, 16ms base RTT)





Baseline: VMAF vs time

(No upstream congestion, 16ms base RTT, refapp launched at t=20 via PVM)