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Multimedia Congestion Control: Circuit Breakers for Unicast RTP Sessions

draft-ietf-avtcore-rtp-circuit-breakers-03

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With thanks to Stephen McQuistin and Martin Ellis for additional simulation and analysis work

Changes since -02

- Technical changes:
  - Section 4.3: reorder the text to be clearer that the sender is allowed to reduce it's sending rate by a factor of ten when the congestion circuit breaker fires, to see if this resolves the problem, before it has to cease transmission.
  - Section 4.2 and Section 4.3: add text about sessions with a large enough number of media streams that the receivers have to generate round-robin RTCP reception reports.
  - Section 4.3: clarify what RTCP reporting interval is used to trigger the circuit breaker
  - Add Section 7 on the Impact of RTCP Reporting Groups
- Various editorial fixes also made

RTP Circuit Breaker Performance

- Does the RTP circuit breaker work?

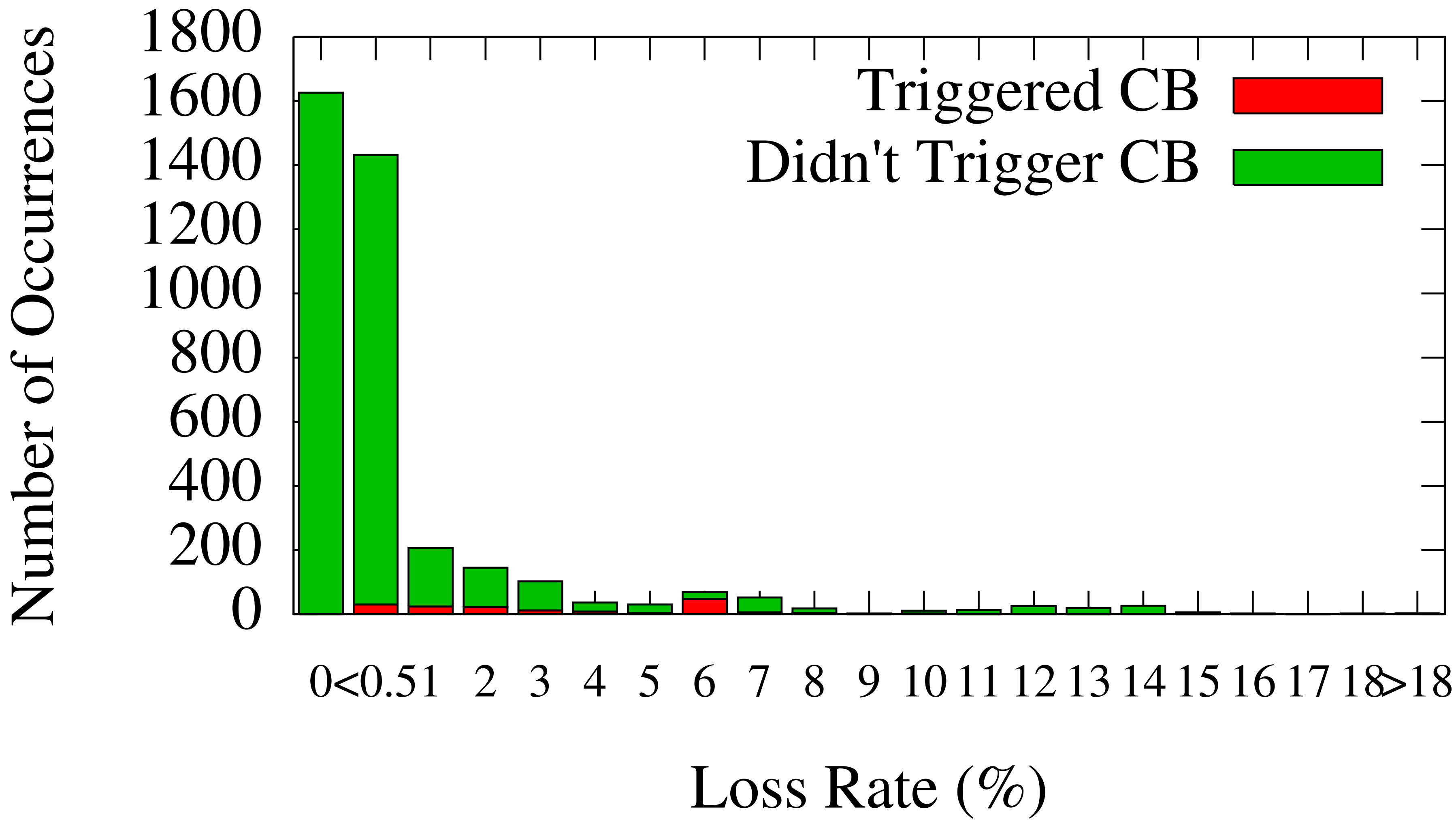
- Some very early results to present
  - Measurements of streaming to residential hosts
  - Testbed experiments

Performance on Residential Links

- Captured RTP packet traces to residential users
  - CBR traffic flows; range of bit rates (1–8.5Mbps); 1–10 minute duration
  - Well-connected server; clients on standard home ADSL and cable modem links in the UK and Finland
  - 3833 traces; ~230,000,000 packets
- Simulated RTCP matching the RTP packet traces
- Observed when circuit breaker triggers

M. Ellis, C. S. Perkins, and D. P. Pezaros, "End-to-end and network- internal measurements of real-time traffic to residential users," in Proc. ACM MMSys, San Jose, CA, USA, Feb. 2011.

Distribution of Traces by Loss Rate



- Circuit breaker triggers in 167 traces out of 3833
- Overall packet loss rate a poor predictor of whether circuit breaker will trigger

Circuit Breaker Triggers by Loss Pattern

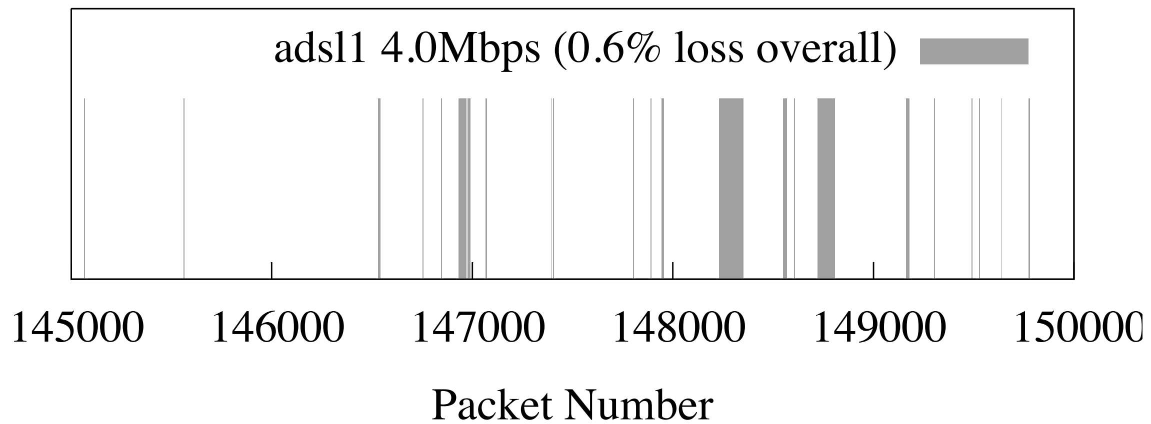
- Categorised packet traces according to RFC 3611 burst loss metric
  - 42% traces are loss free
  - 23% traces have non-bursty loss
  - 35% traces have bursty loss

"A burst is a period during which a high proportion of packets are either lost or discarded due to late arrival. A burst is defined, in terms of a value Gmin, as the longest sequence that (a) starts with a lost or discarded packet, (b) does not contain any occurrences of Gmin or more consecutively received (and not discarded) packets, and (c) ends with a lost or discarded packet." – where the recommended value of Gmin = 16

- All packet traces triggering the RTP circuit breaker have bursty loss

Loss Pattern	Triggered	Did not trigger
Loss free	0.0%	100.0%
Non-bursty loss	0.0%	100.0%
Bursty loss	12.4%	87.6%

- Example circuit breaker trigger:
  - 10 second period with 4% packet loss
  - 2 standard RTCP intervals; many reports if using reduced minimum interval



Circuit Breaker Triggers by Sending Rate

- Likelihood of triggering circuit breaker increases with sending rate
- Most likely to trigger circuit breaker when sending rate is close to edge link capacity
- Analysis and further tests ongoing, but results are consistent with circuit breaker triggering due to congestion

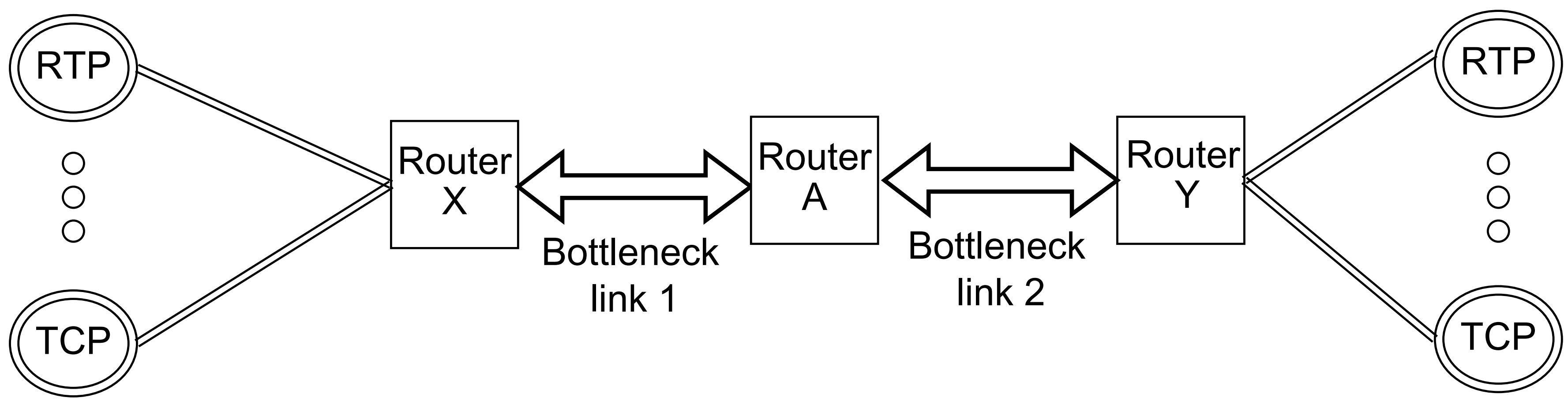
	Sending Data Rate (Mbps)					
Link	1.0	2.0	4.0	5.0	6.0	8.5
adsl1	0%	0%	12%	-	37%	-
adsl2	0%	0%	-	-	-	-
adsl3	0%	0%	-	-	-	-
adsl4	0%	0%	0%	6%	0%	-
adsl5	0%	0%	0%	7%	38%	-
adsl6	0%	0%	22%	0%	48%	-
adsl7	2%	9%	-	29%	-	-
cable1	0%	17%	-	-	-	-
cable2	0%	0%	0%	6%	4%	17%
cable3	0%	0%	-	14%	-	-
cable4	0%	0%	-	2%	-	-
cable5	0%	0%	-	2%	-	-
finadsl0	0%	0%	-	4%	-	-
fincable0	0%	6%	-	100%	-	-

Fraction of traces triggering circuit breaker
(bars show negotiated rate of edge link)

Effects of Circuit Breaker Parameters

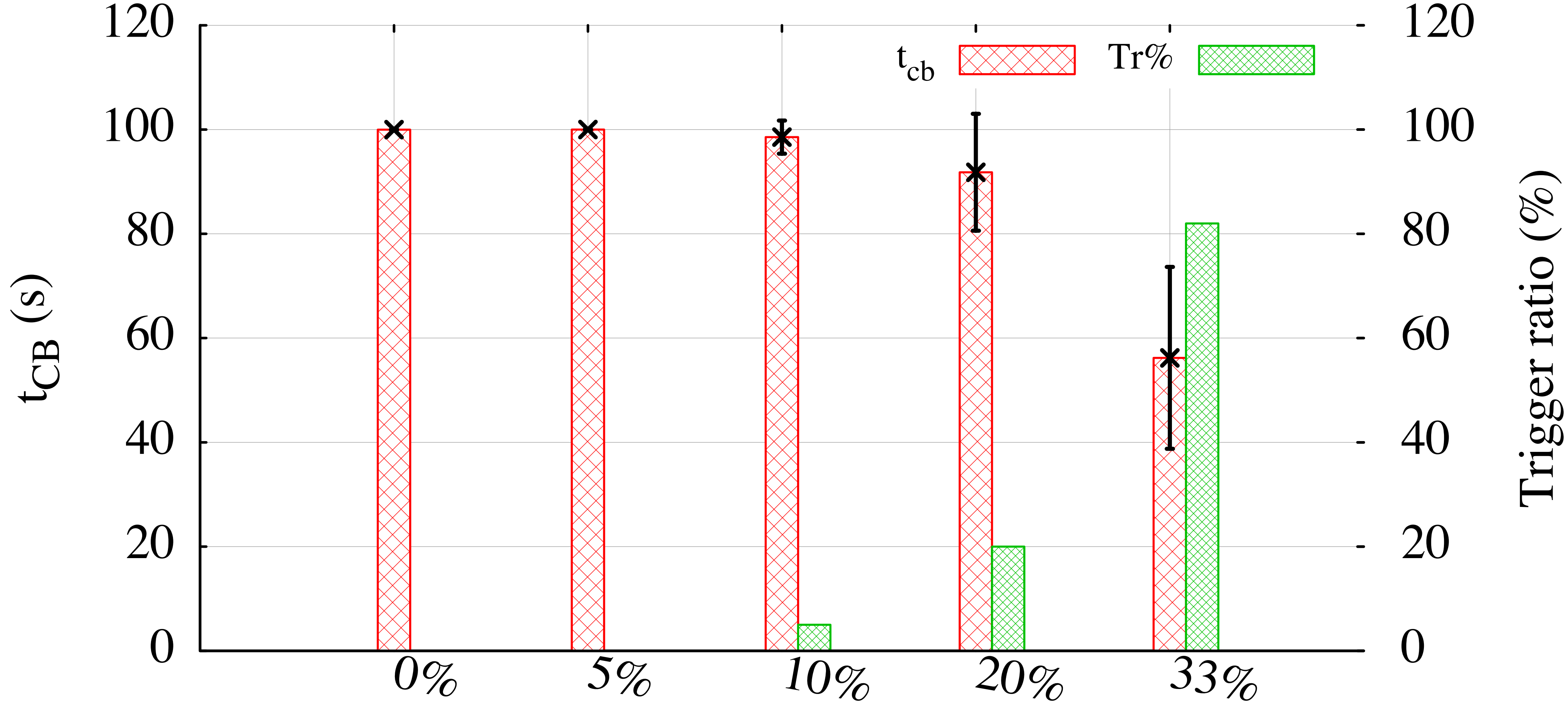
- Use Padhye TCP model instead of Mathis model: number of low-loss rate bursty traces triggering circuit breaker doubles
- Trigger after 3 reporting intervals: slight reduction in number of traces triggering circuit breaker

Testbed Experiments



- Gstreamer for video calls
  - 1 Mbps
  - “akiyo” and “foreman” sequences
- TCP simulated by iperf
- Dummynet for varying link characteristics
- Gilbert-Elliot model for packet loss

Impact of Losses



t_{CB}: time it takes to trigger the circuit breaker after the impairment is introduced

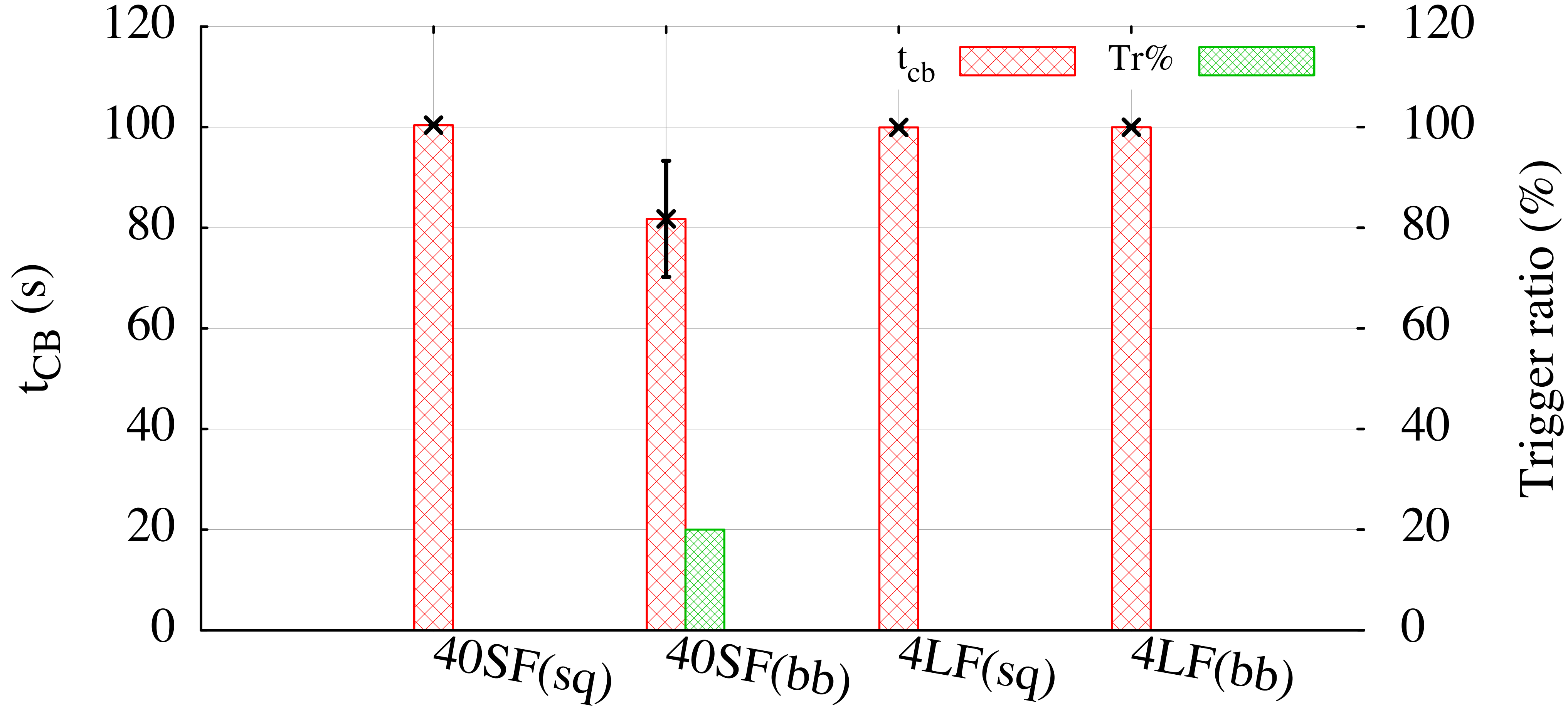
Experimenting with Buffer Bloat

- QueueSizepackets = (QueueSizesec * Throughputbps)/(MTU * 8)
- Droptail queues
- Buffer bloat (bb): 5sec
- Short queue (sq): 100ms

- Short TCP flows: are modelled as a sequence of web page downloads interleaved with idle periods (on-off traffic).
- The sizes of the web pages are obtained from a
- uniform distribution between 100kB and 1.5MB.
- Lengths of the idle periods are drawn from an exponential distribution with the mean value of 10 seconds.
- Long TCP flows: have infinite data to send and run for the duration of the experiment

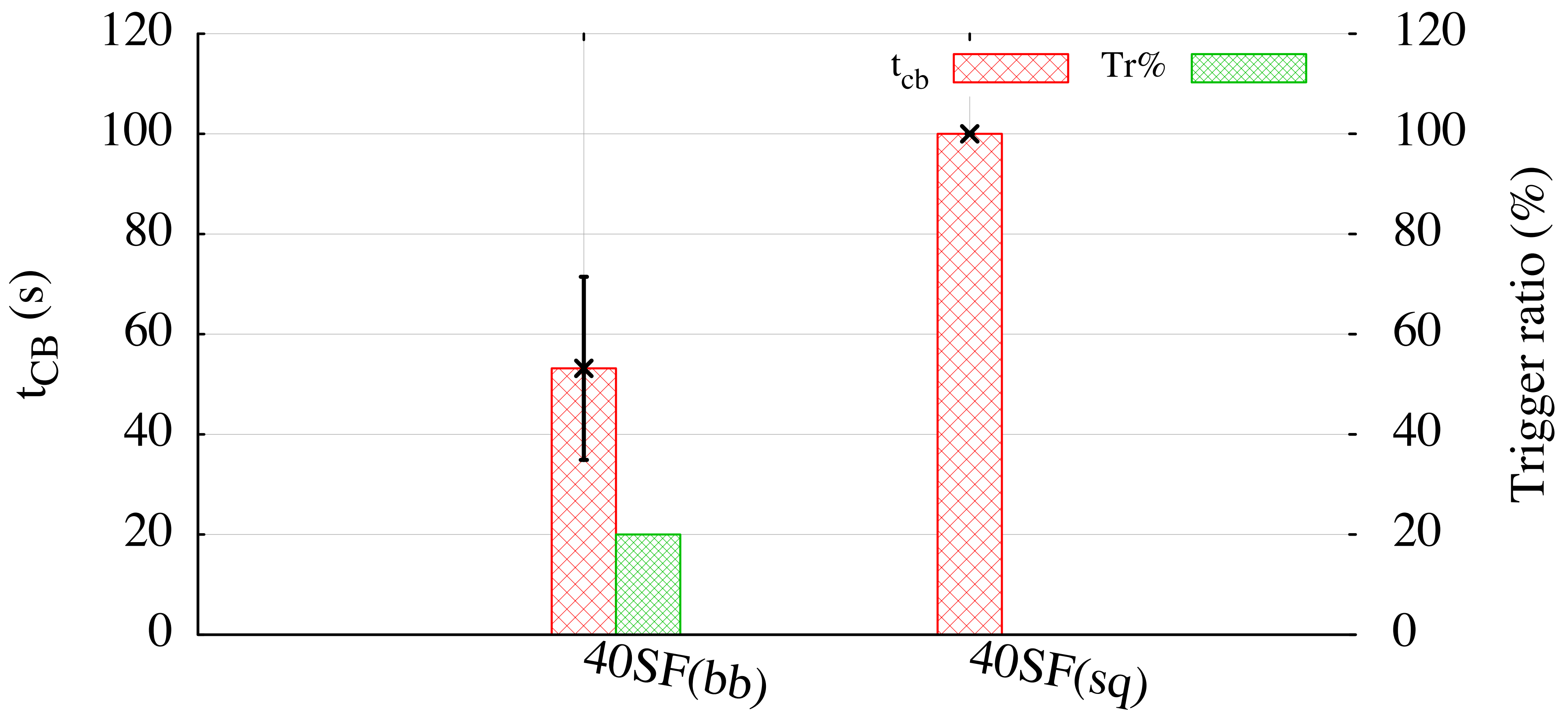
11

Results: Buffer Bloat



Buffer bloated queue fills up the queue. Bursty losses are detected at the endpoints which triggers the circuit breaker.

Results: Streaming AWS–Helsinki



5 RTP flows and 40 TCP flows sent between AWS (Ireland) and Helsinki

Conclusion

- Initial analysis shows circuit breaker behaving roughly as desired – more experiments needed
- Might consider if number of RTCP intervals needed to trigger circuit breaker should scale inversely with reporting interval, to give a constant time to trigger
    - High loss rates for relatively short time periods can trigger circuit breaker now – maybe not desirable?