QUIC & Satellite Return Link

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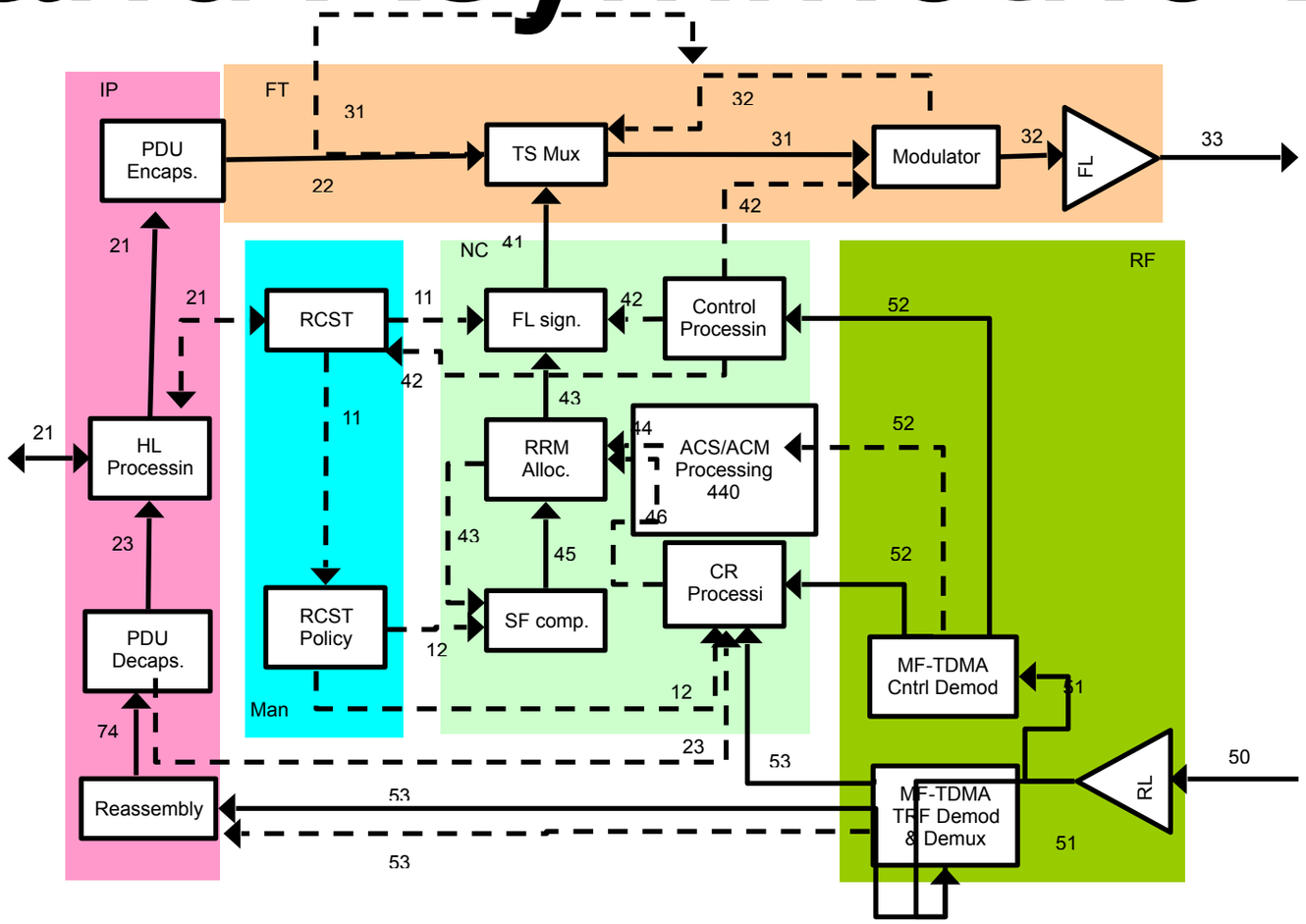
TCP and Asymmetric Paths



ACK traffic can constrain forward link throughput

Asymmetry in broadband satellite, cellular mobile, DOCSIS

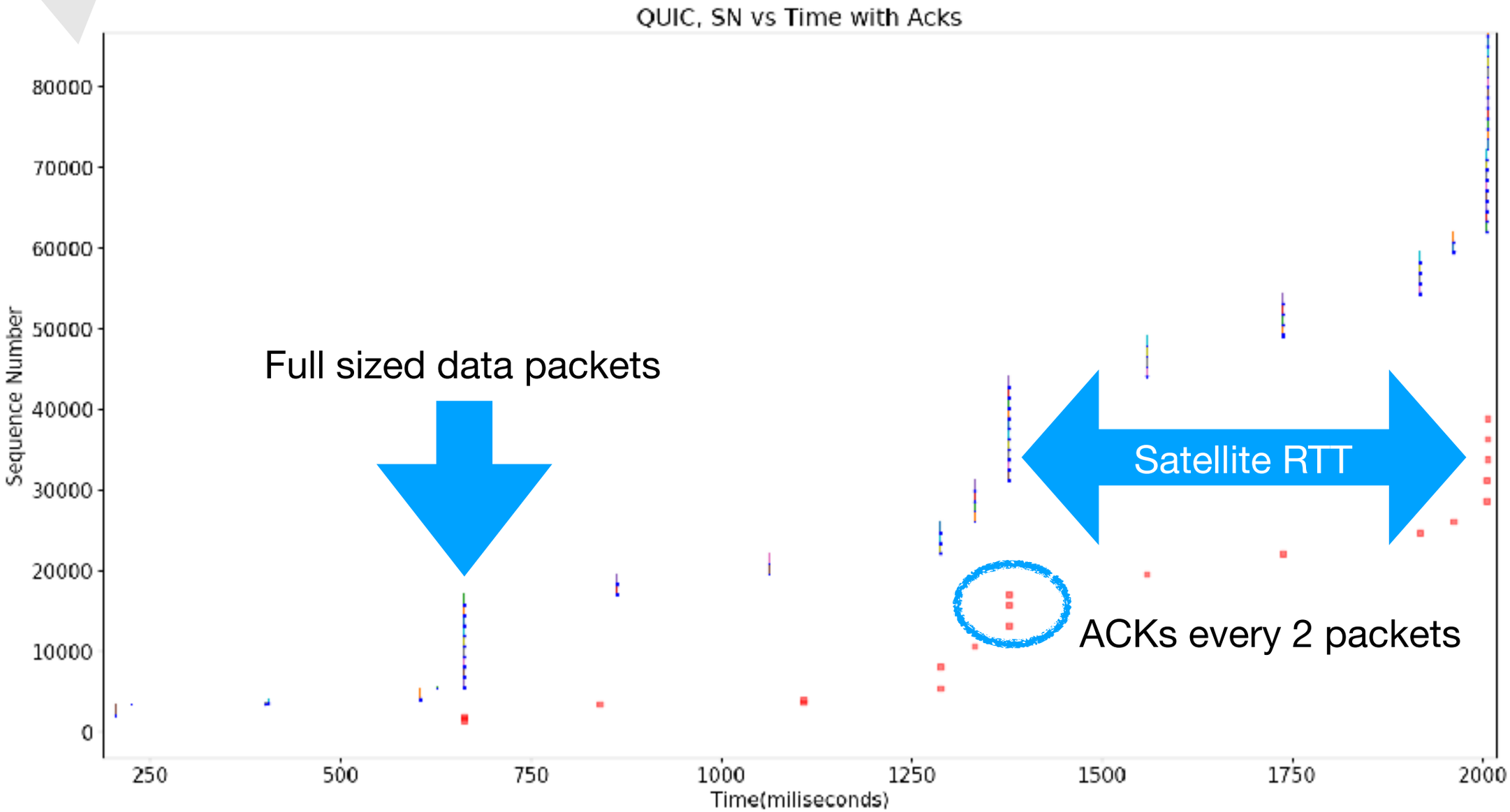
- ACKs are expensive (RRM allocation, LTE scheduling)
- Historically, ACK thinning (by PEPs and similar boxes)

Plot considerations

- Satellite experiments: Quicly on Hylas 1, 630 ms average delay, 8.5Mb up/1.5Mb down
- Byte Sequence Number = TCP-style Sequence Number derived from QUIC packet length in bytes
- View at the sender
- This type of plotting gives a direct comparison to TCP SN/time plots

Byte Sequence Number (Vertical) v. Time with standard ACK Policy, using quickly over a satellite path

QUIC - Sender View

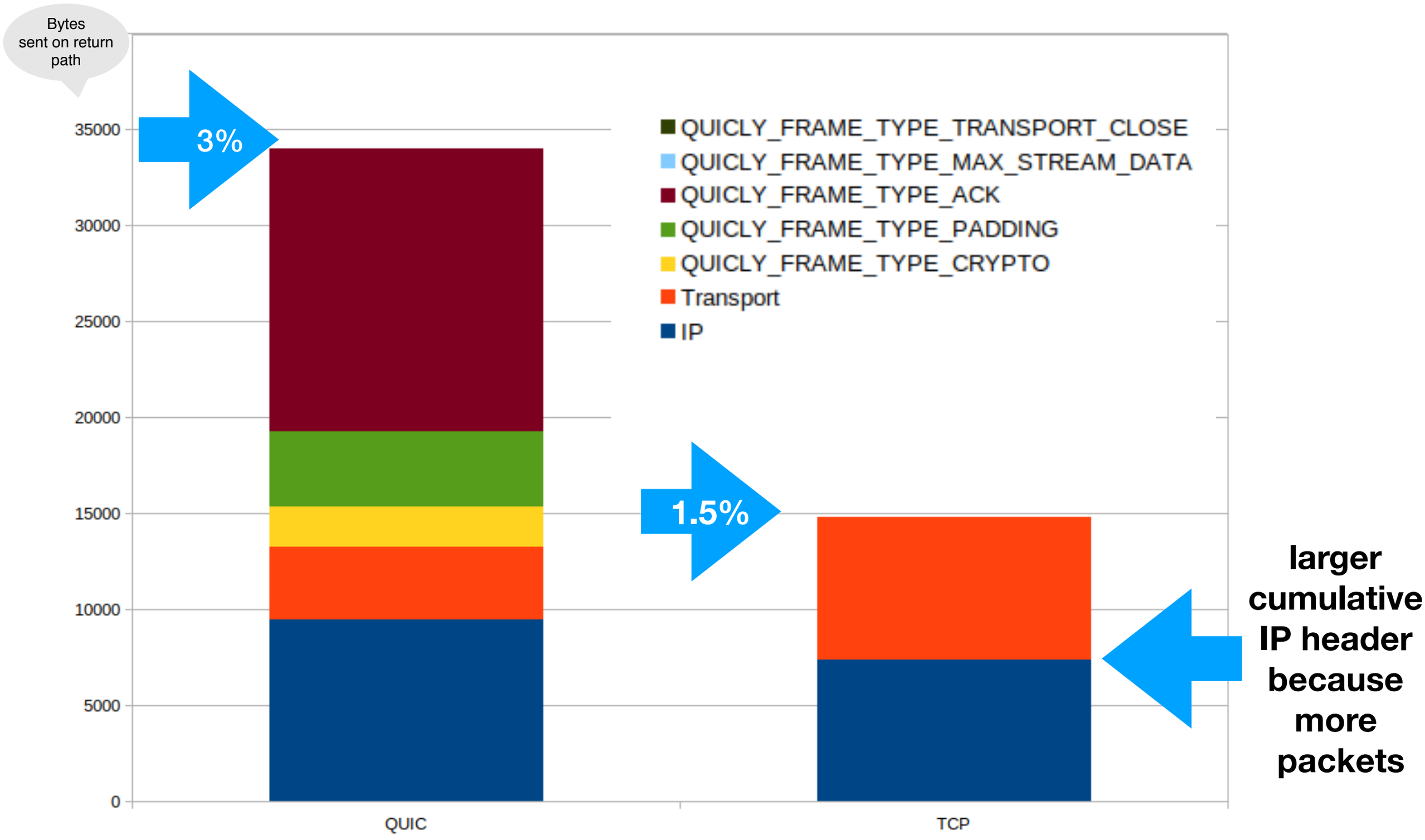


There is an ACK delay interval (set to 25ms in Quicly)

ACKs every 2 packets (mimics TCP)

There is no DAASS (not needed)

Linux TCP vs Quicly draft 22 on a satellite path with an average delay of 630 ms; HTTP/TLS1.3 TCP transfers

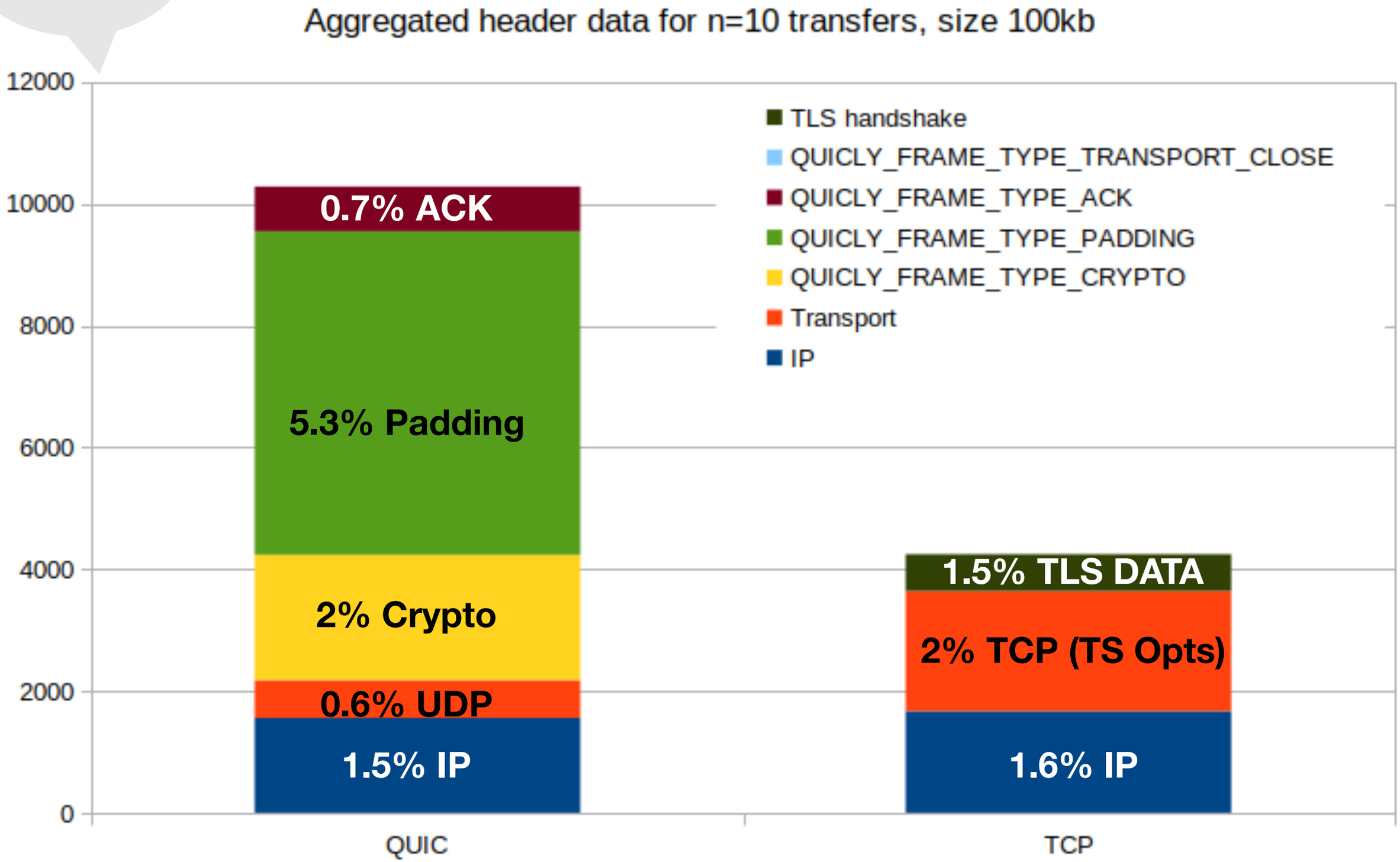


Experiment: changing the QUIC ACKing policy

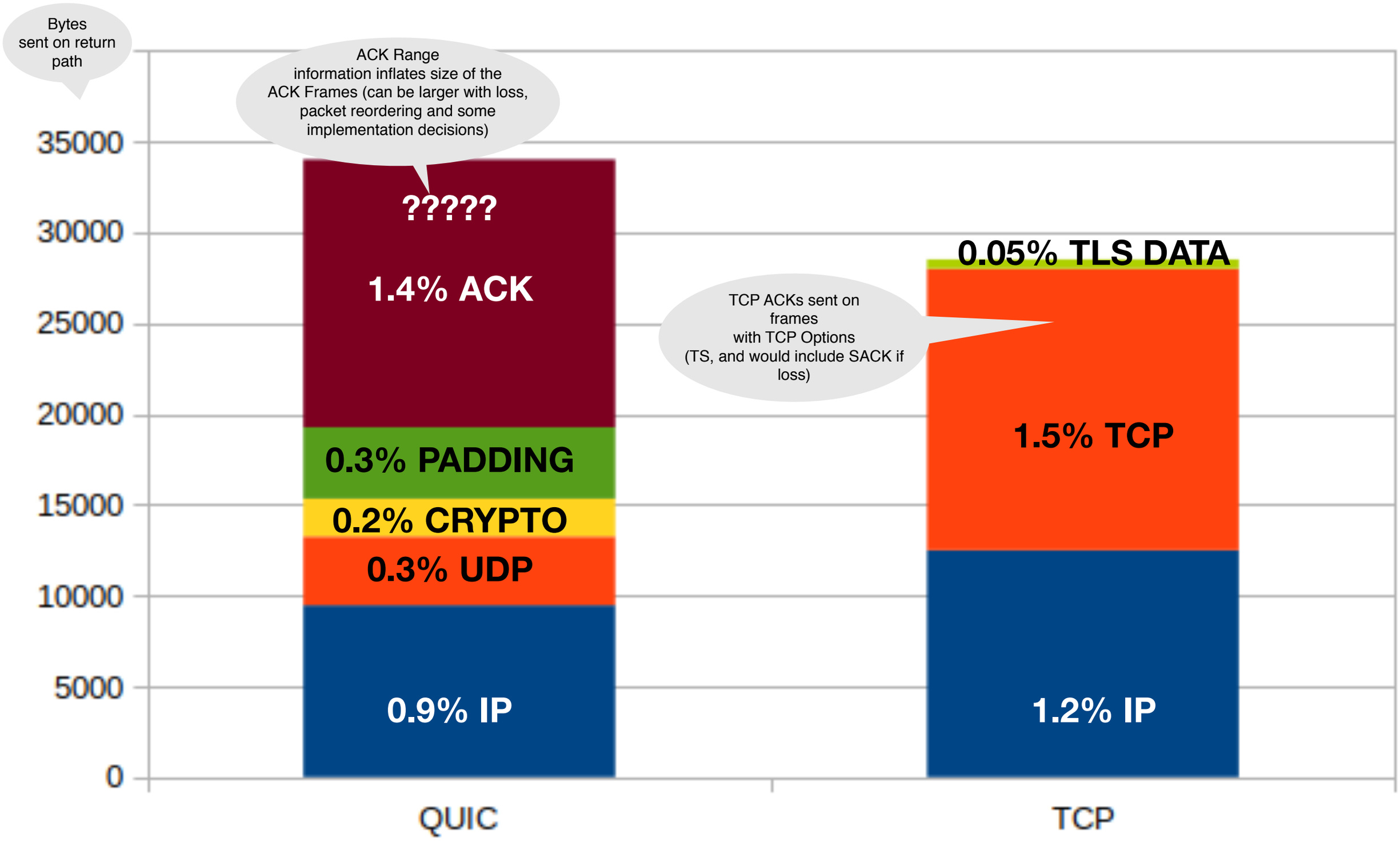
- Real satellite link + VDSL broadband (long RTT vs short RTT)
- We modified Quicly to ACK every 10 segments (not in spec)
- We performed 10MB downloads ACKing every 2 segments
- We repeated the download ACKing every 10 segments
- Effects on congestion control were evaluated in PN over Time plots

Linux TCP vs Quicly draft 22 on a satellite path with an average delay of 630 ms; HTTP/TLS1.3 TCP transfers

Bytes sent on return path for a forward transfer of 100kB



Linux TCP vs Quicly draft 22 on a satellite path with an average delay of 630 ms; HTTP/TLS1.3 TCP transfers



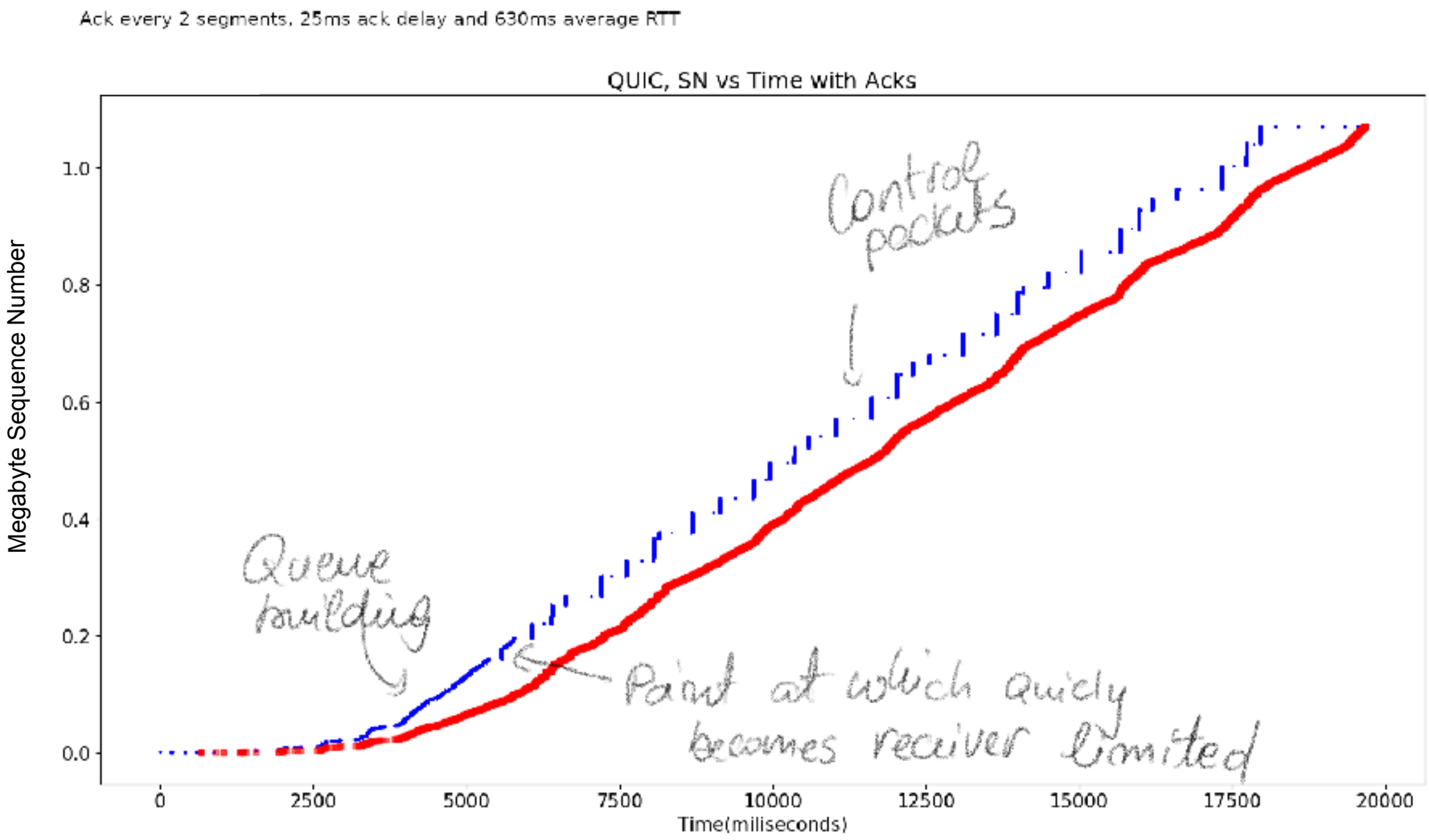
How large are QUIC ACKs

- QUIC ACK frames can be as little as 4 bytes with no upper limit
- While there is no loss or reordering, they should stay small
- Assuming an ACK every 2 segments, and sizes of {1280, 1500} for {QUIC, TCP}, this table estimates overhead

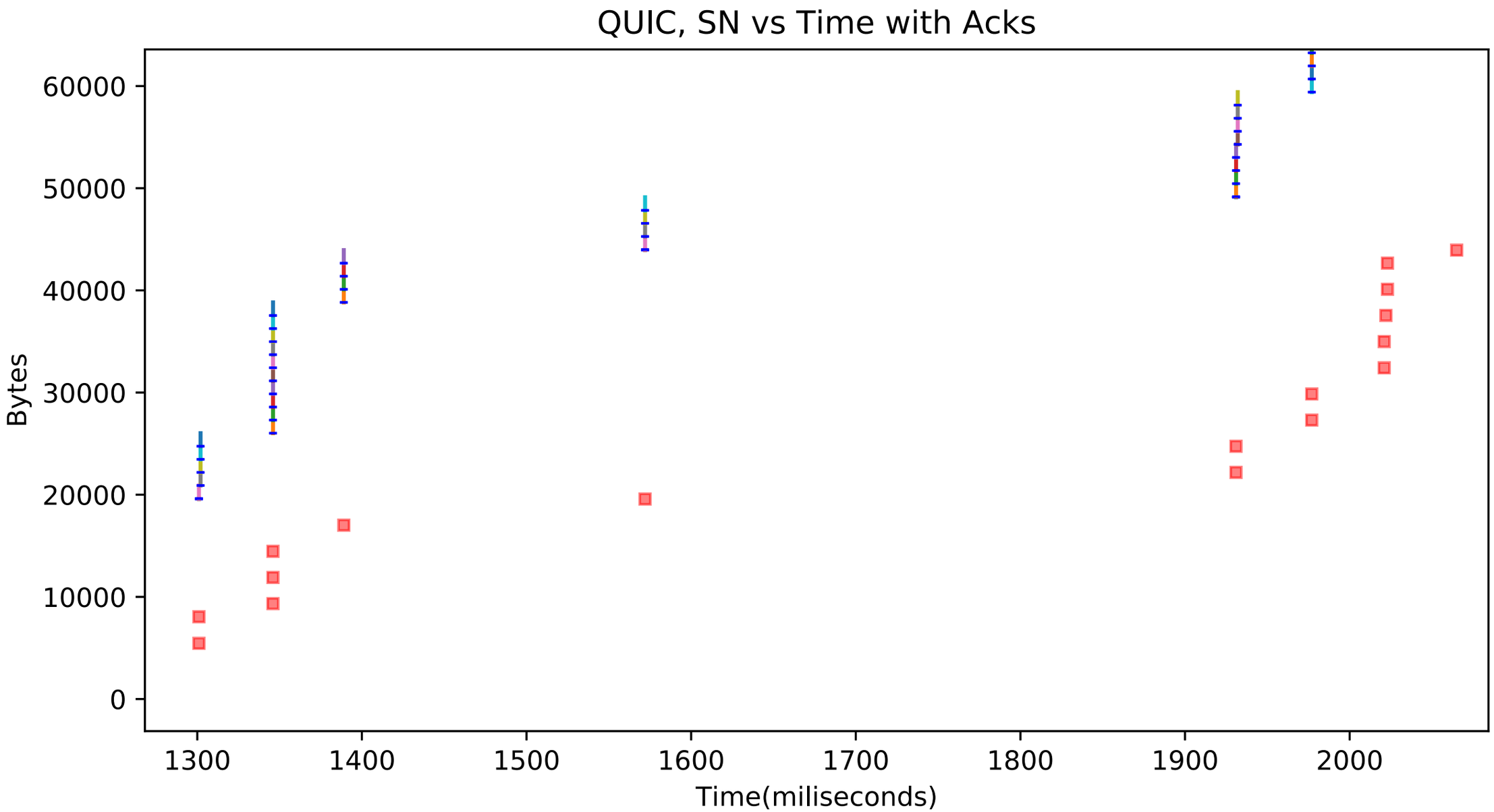
	TCP	QUIC
IP	0.66%	0.78%
TCP-TCP+TSOpts	0.6%-1.06%	0
UDP	0	0.31%
ACK frame	0	0.2% - ?*
TOTAL	1.12% -1.72%*	1.29%* -?

- *Does not include DAASS behaviour

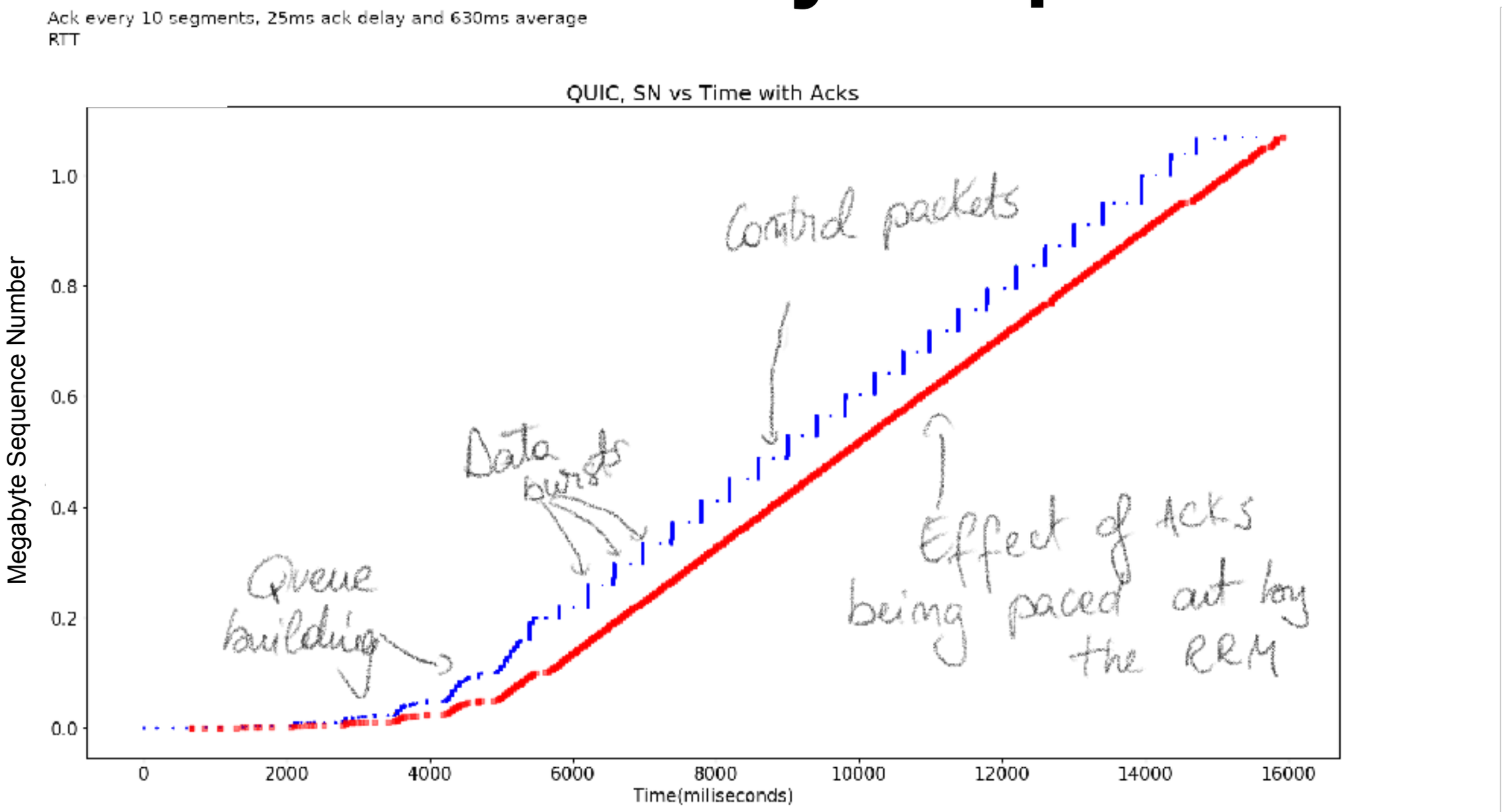
Satellite:
QUIC ACKs every 2 packets



ACK every 2 packets

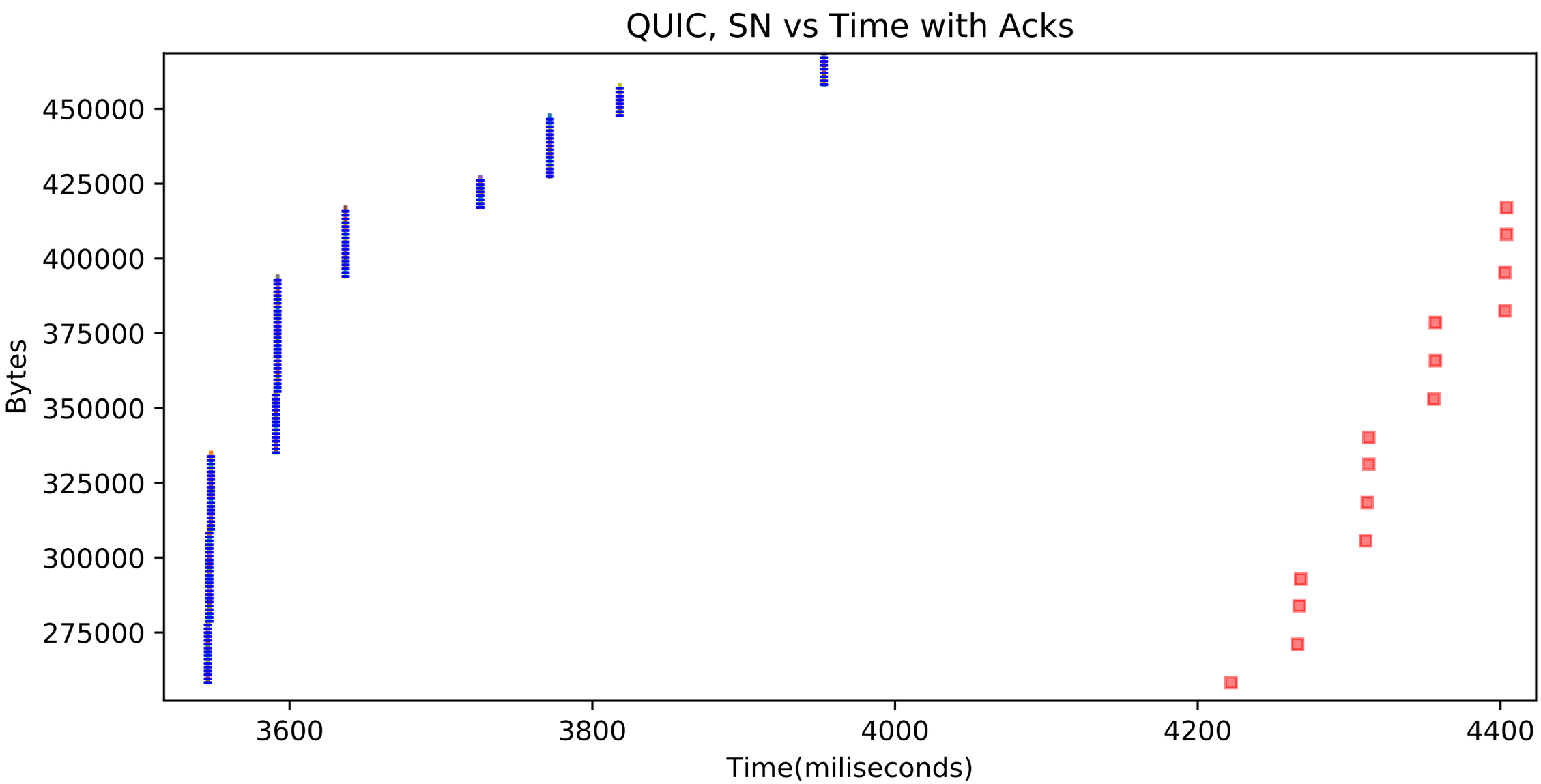


Satellite:
QUIC ACKs every 10 packets

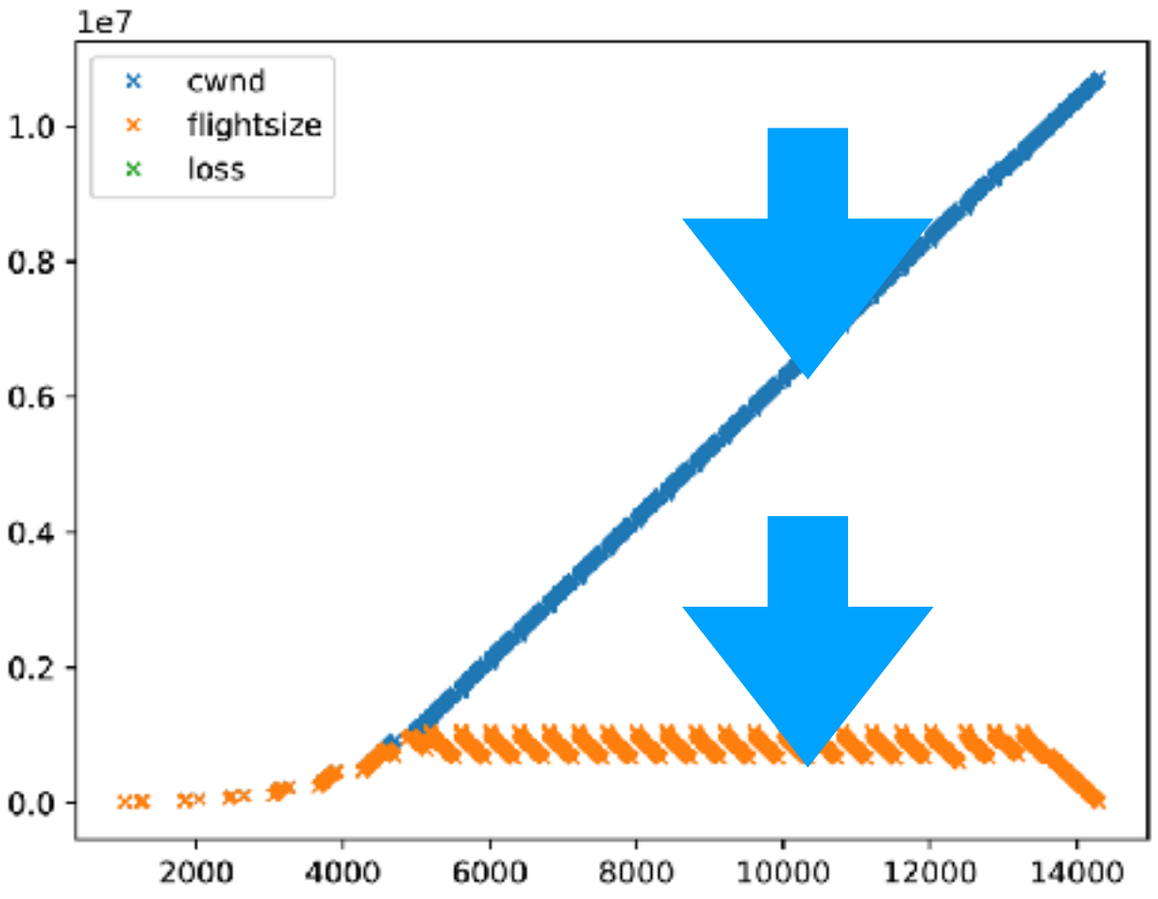


- Reduces total time of transfer (Throughput from 4 Mbps to 5 Mbps)
- Reduces number of ACKs by a factor of ~5

ACK every 10 packets



Flow Control for QUIC :-(



- Flow control limits performance:
  - Lower throughput because no PEP
  - H3 delegates flow control to QUIC
  - Uses periodic updates (compared to TCP rwnd updates)
  - Credit updates should not be delayed for a large RTT
  - Set a minimum update period
    - (e.g., at least every 50ms?)

Conclusion

- ACK rate can limit forward data rate/consume resources
- Changing ACK policy (1:10 segments) helps
- We need to do more work on this topic
  - Need to know when to use a 1:2 or 1:10 ACK Policy
- We believe this can be fixed for QUIC
- Finally, flow control complicates this!

Questions

ESA