Impact of Asymmetric Path Characteristics

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Default TCP ACK Policy

Senders release new data based on ACKs : ACK Clocking

A TCP receiver sends an ACK every 2* MSS of received data

At the start: ACK every segment to increase CWND (DAASS)

Loss in the transfer: ACK every segment while in recovery

*Note: not all CCs rely on ACK clocking (BBR, TCP Vegas)

TCP and Asymmetric Paths

ACK traffic can constrain forward link throughput

- Capacity can be different “up” and “down"
- TCP does not know

Reduce ACK traffic

- Compress (ROHC)
- Deploy ACK thinning (Filter,Decimate)
- Compact/Compand, Expand
- Deploy ACKs-first scheduling, etc

[RFC3449]

TCP and Asymmetric Paths

ACK traffic can constrain forward link throughput

Technology can be different “up” and “down"

TCP does not know

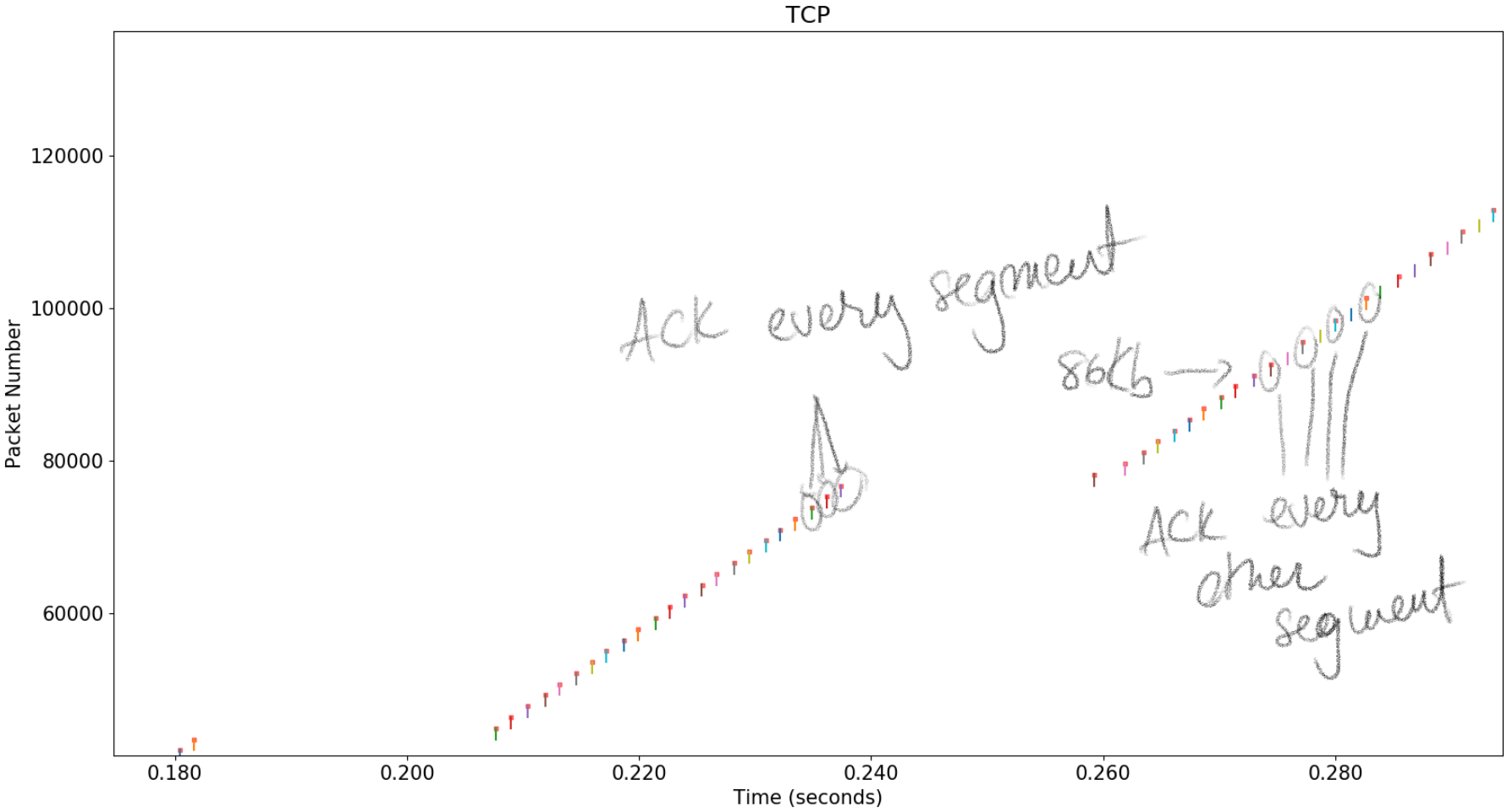
ACKs can use contention resources, assigned capacity,…

ACKs can be expensive (RRM allocation, LTE scheduling)

Deploy ACK thinning (Filter,Decimate)

… reducing the ACK rate could also benefit high-speed wired networks (e.g., reducing costs in receiver offload)

TCP DAASS - client view



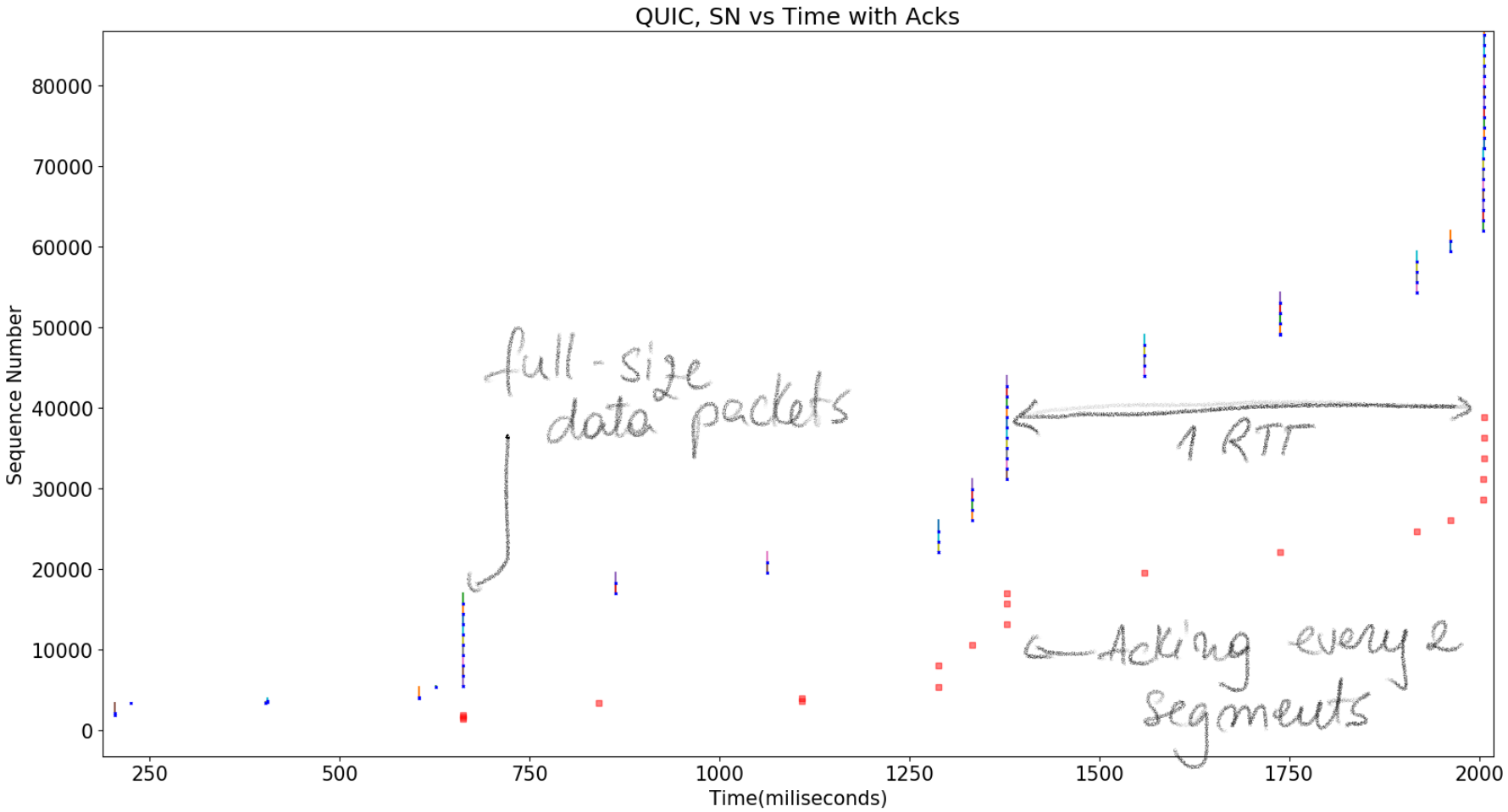
Default QUIC ACK Policy

ACKs every 2 packets (mimics TCP)

- There is an ACK delay interval (set to 25ms in Quicly)
- After loss, receiver ACKs every packet, for 1/8 of a RTT
- No DAASS (not needed)

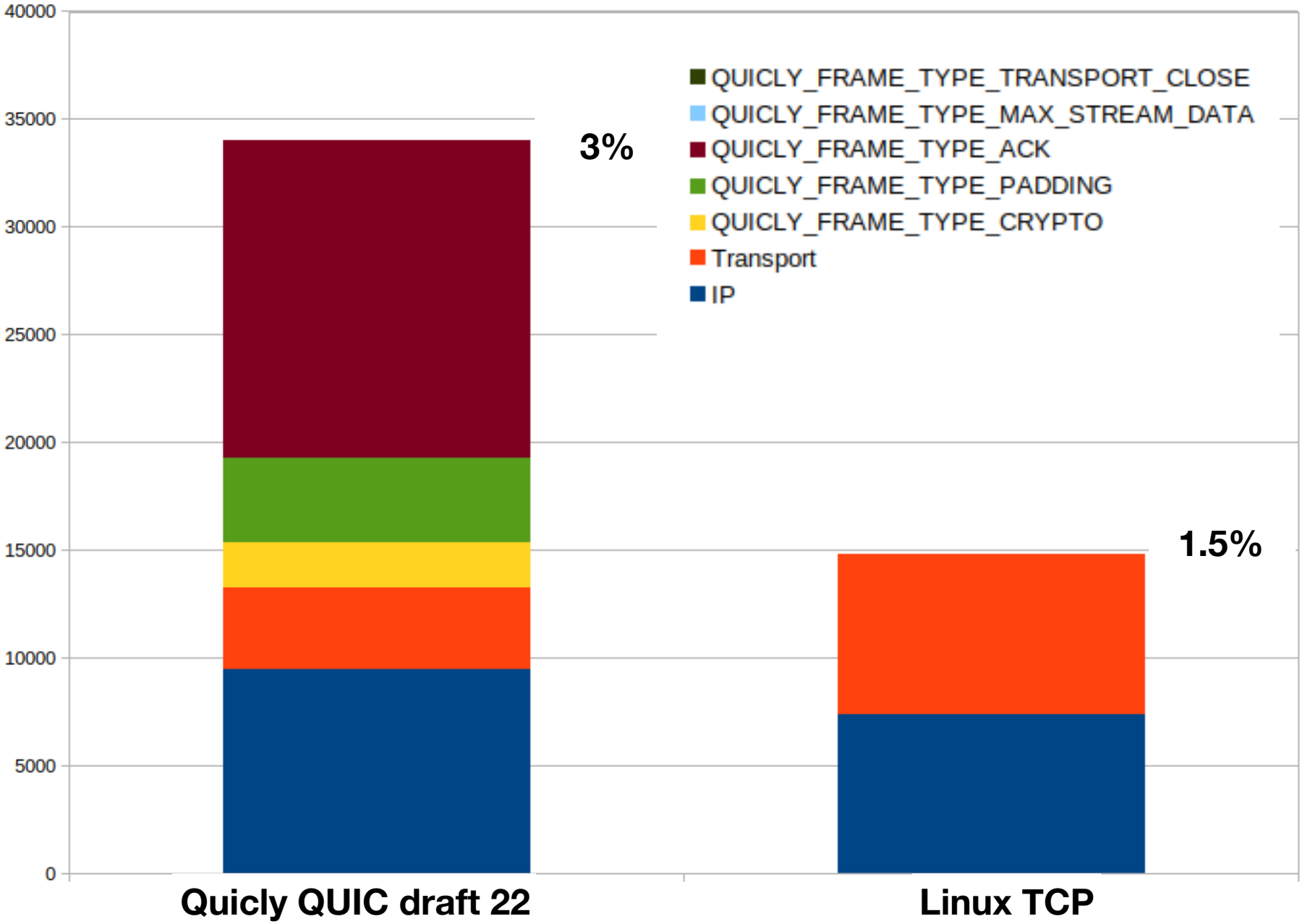
Can’t use a PEP for this encrypted traffic

QUIC - Sender View



ACKs Bytes for a 10MB download

satellite path



Could include TCP TLS 1.3 overhead.

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)

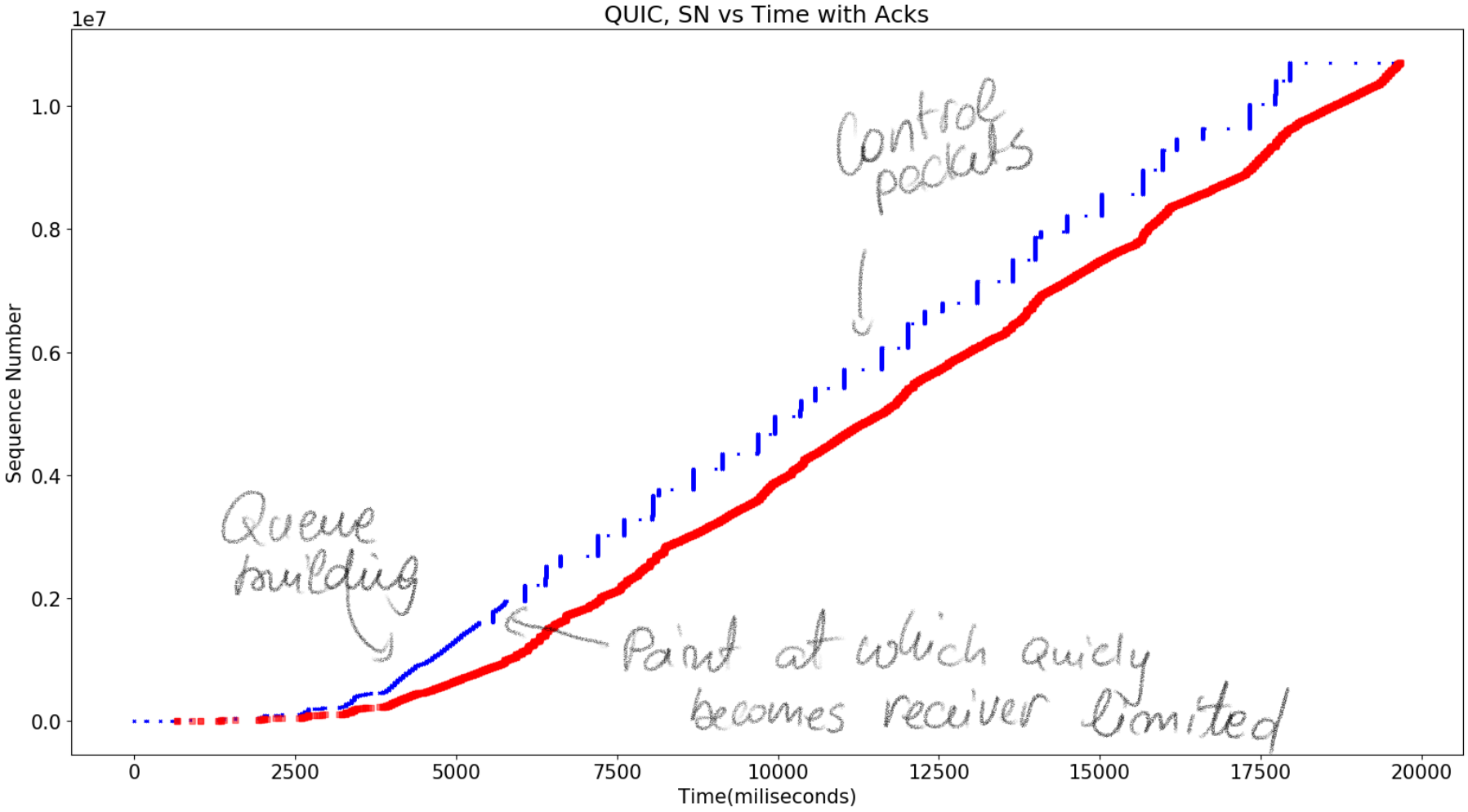
We performed 10MB downloads ACKing every 2 segments

We repeated the download ACKing every 10 segments

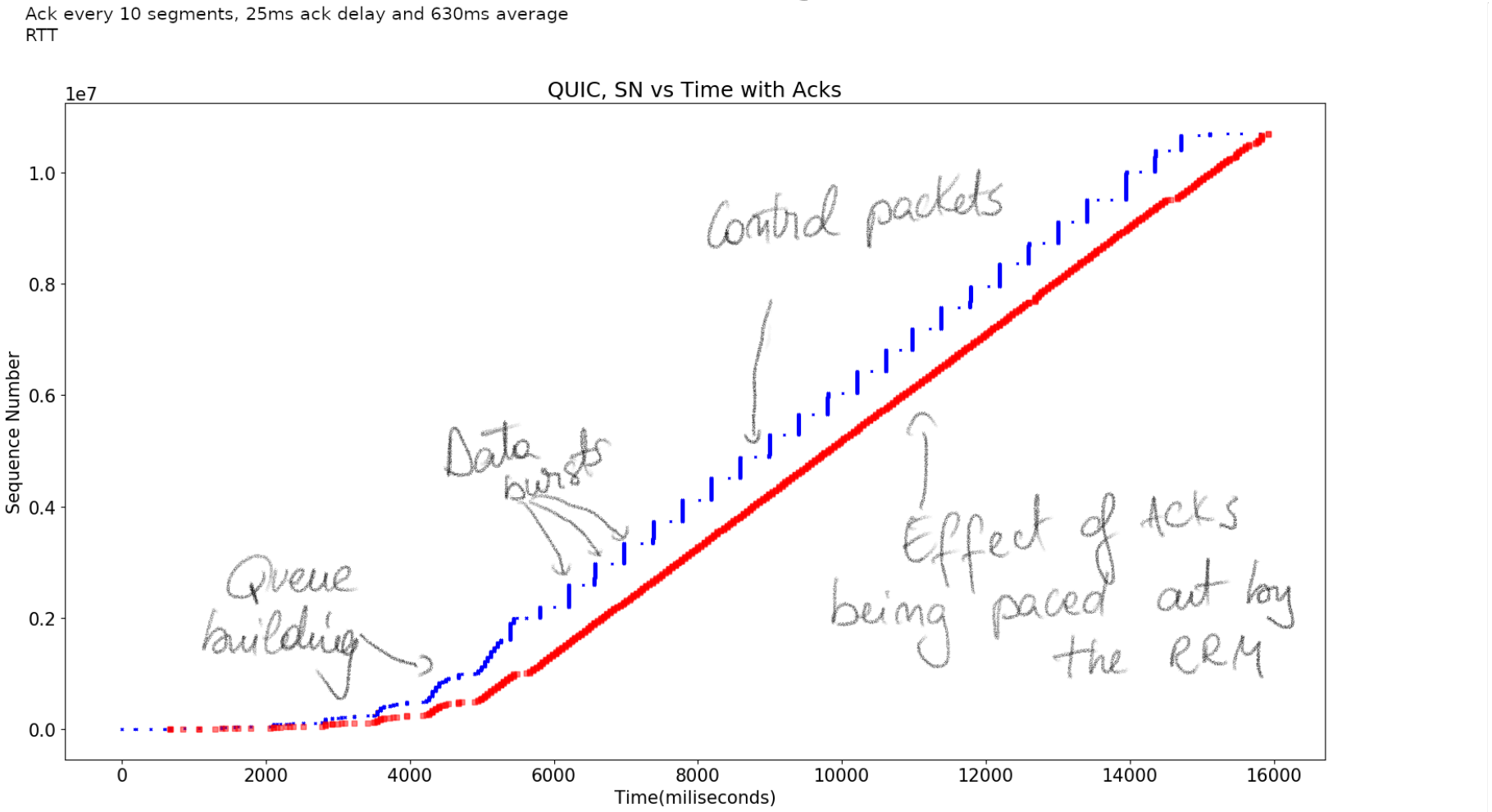
Effects on congestion control evaluated in PN over Time plots

Satellite:
QUIC ACKs every 2 packets

Ack every 2 segments, 25ms ack delay and 630ms average RTT



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

Conclusion

If we knew the path's capacity/resources had asymmetry we could know what to do.

We don't. There is no signal.

We need to determine this at the transport.

Or, expect the transport does the right thing.

We could remember problems and adapt - ACK-CC, etc.

Questions

TCP vs QUIC Measurements

- Real satellite link (with PEP for TCP)
  - Capacity 8.5 Mbps/2 Mbps.
- Captured PCAP files and QUIC logs at the sender and receiver
- Transfers of 100KB and 1MB