论文分享 - TECC: Towards Efficient QUIC Tunneling via Collaborative Transmission Control

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TL;DR

Background

QUIC-in-QUIC (mostly H3-in-H3) might be desirable:

- Application Gateway
- Load balancer
- VPN / Private Relay

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rfc9297 & rfc9298 “MAS**Q**UE” : Multiplexed Application Substrate over **QUIC** Encryption

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Datagrams travels inside the tunnel in two modes:

- Each connection = 1 stream
- Directly sent as unreliable QUIC datagram

Background a.k.a. The Problem

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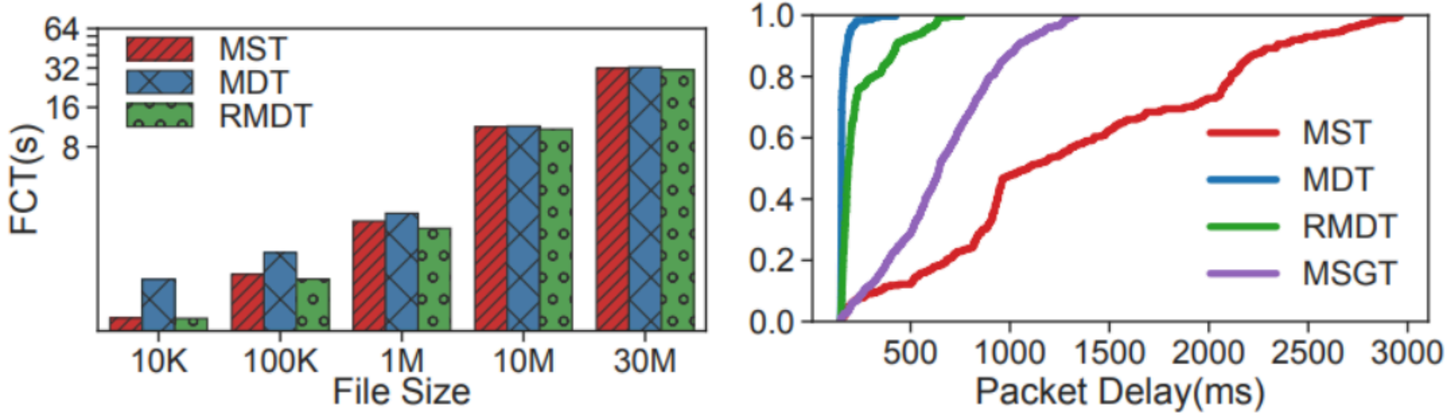
Problem:

- **Retransmission**: can happen at both level, outer retransmission messes with inner congestion ctrl.
- **Congestion control**: inner and outer congestion ctrl may behave differently.

Retransmission or not?



(a) FCTs of E2E transfers (b) CDF of E2E packet delay

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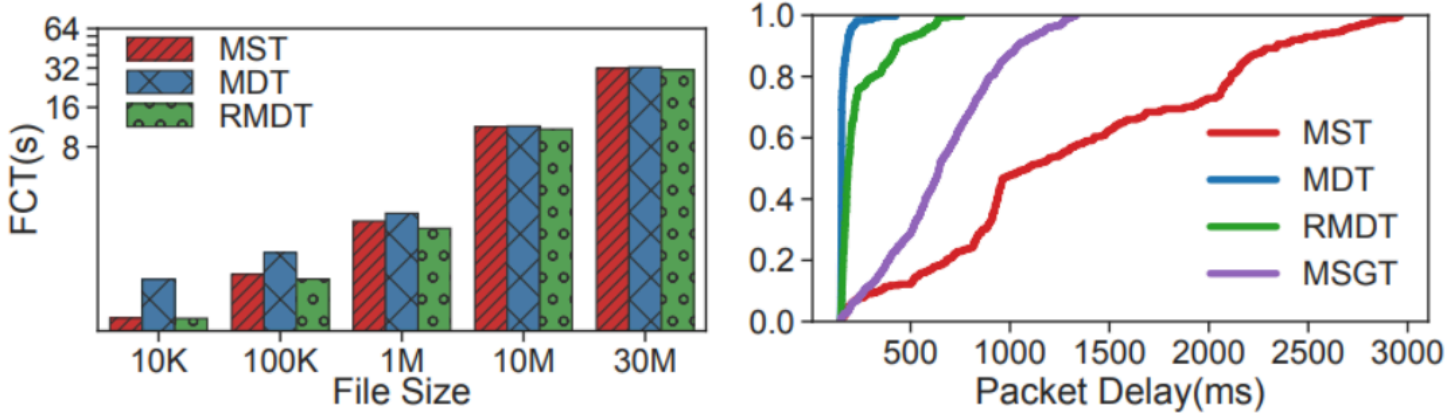

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Datagram mode with retransmission works the best.

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Less congestion $\Rightarrow$ Faster E2E time?

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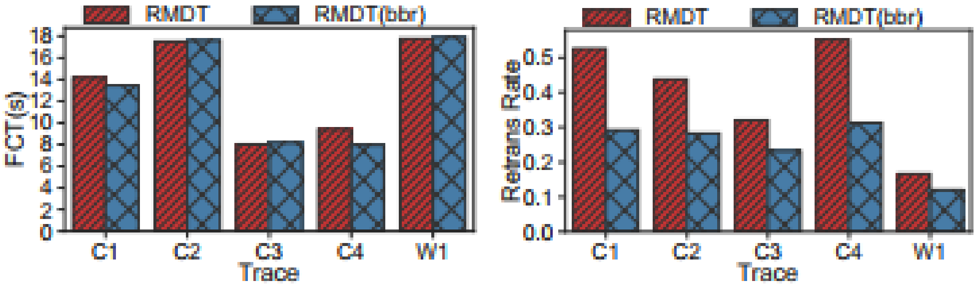
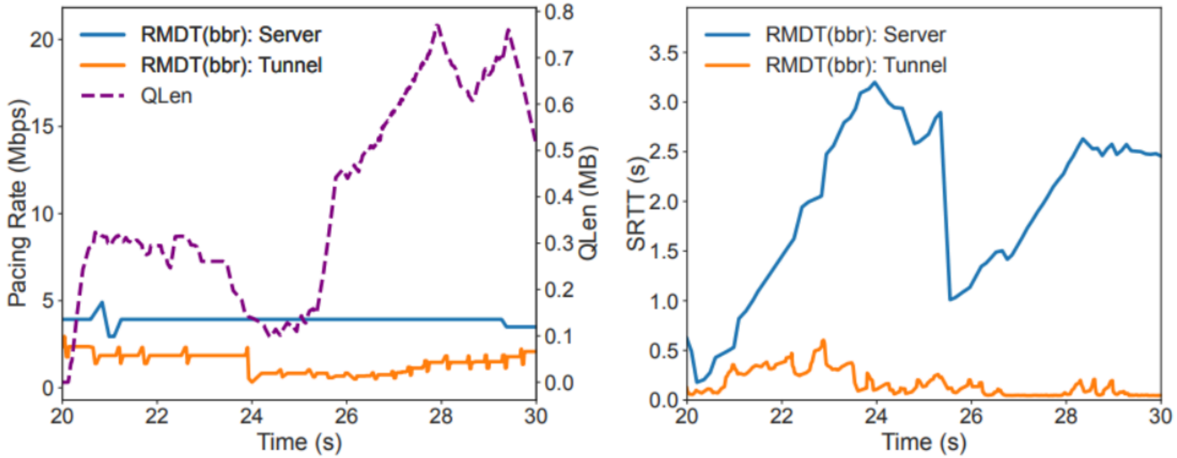


(a) FCT (b) Retransmission rate

Figure 3: The comparison between RMDT with and without CC

Nested Congestion Control



(a) Pacing rate (b) SRTT

Figure 4: The impact of nested CC: the pacing rate and SRTT of the tunnel and E2E connection are depicted.

A Dilemma

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-

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- No retransmission on tunnel $\Rightarrow$ Long flow completion time(FCT) on short messages
- Has retransmission on tunnel $\Rightarrow$ **Packet drops becomes invisible to E2E server!** Inner congestion control lags behind

TECC

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- Enable collaborative congestion control

1. Tunnel send **bandwidth** and **queue** information to server
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Servers don’t use local data to do CC!

TECC

- Matching sending rates at server and tunnel egress
- Penalize large queue usage for fairness

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Finally: Exponentially Weighted Moving Average to dampen the reports

TECC

Algorithm 1 Sender algorithm

Data: Tunnel Server Feedback: $Tr(t)$, $q(t)$, T_t

Result: Server: $Sr(t)$

function `UpdateSenderRate()`:

$e(t) \leftarrow \frac{q(t)+\delta r(t)Tr(t)}{\theta Tr(t)}$

$U(t) \leftarrow \max\{1-e(t), 1-max\_pf\}$

$U \leftarrow (1-ewma\_weight) \cdot U + ewma\_weight \cdot U(t)$

$Sr(t) = U \cdot Tr(t) + \frac{MSS}{T_s}$

return $Sr(t)$

Questions Unanswered by the Paper

1. Parameters θ, T_s depends on **real RTT**, is this approximated in runtime by smoothed detected RTT?
2. Is using server data to assist in CC able to produce some better result?
3. A lot of parameters are set based on experimentation. Can it be explained?

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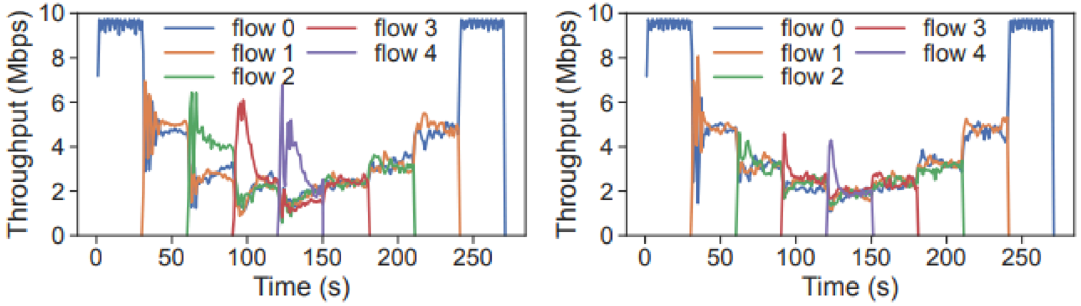

(a) TECC w/o AI (b) TECC with AI

Figure 15: Fairness among competing tunnel flows

In realworld…

	mean	p95	p99	p999
MST	2.7%	1.9%	6.0%	17.5%
TECC	3.9%	4.5%	13.3%	36.0%

Table 3: Improvements of MST and TECC