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TCP-CCC: single-path TCP congestion control coupling

draft-welzl-tcp-ccc-00

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Motivation

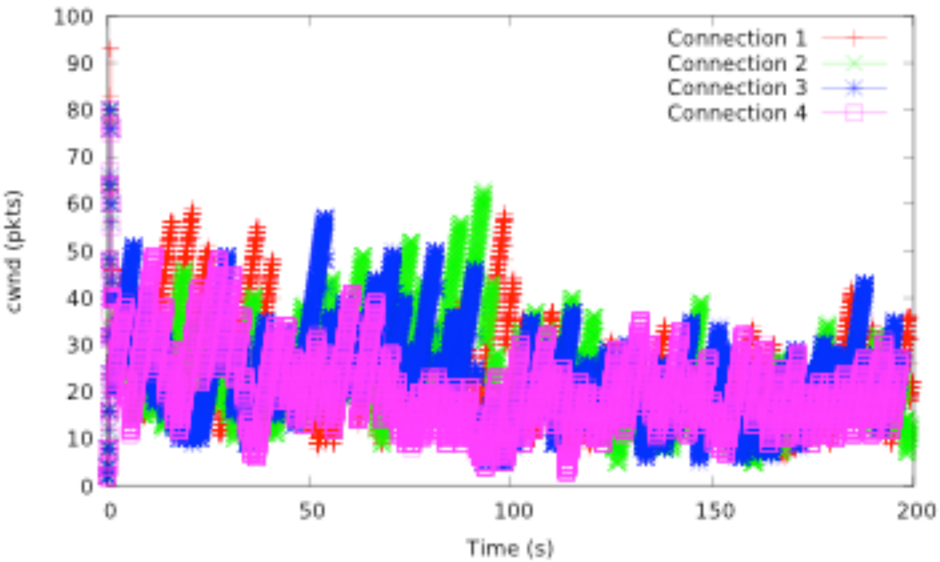
- <u>Parallel TCP connections between two hosts:</u> Combining congestions controllers can be beneficial
  - <u>Very</u> beneficial: short flows can immediately use an existing large cwnd, skip slow start; also avoids competition
  - Can divide available bandwidth between flows based on application needs
- Previous methods were hard to implement + hard to turn on/off (Congestion Manager)
- General problem with this: do parallel TCP connections follow the same path all the way?
  - Not necessarily, because of ECMP, etc.

Ensuring a common bottleneck

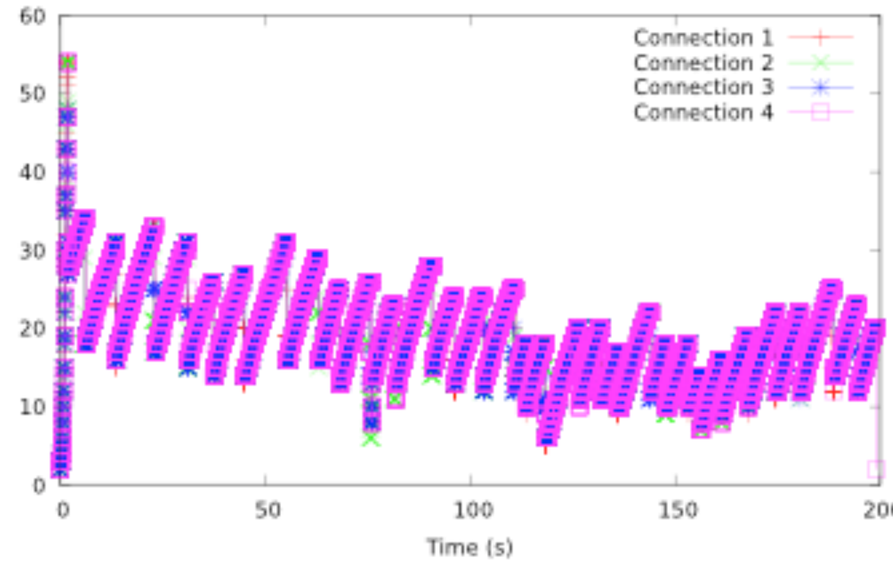
- Via configuration, e.g., app hint
  - Bottleneck is known, e.g., common wireless uplink
- Measurements can infer whether (long) flows traverse the same bottleneck [draft-ietf-rmcat-sbd]
- Encapsulation
  - VPNs, Generic UDP Encapsulation, TCP-in-UDP (TiU) …

Motivation (from IETF 95)
(ns-2 using TCP-Linux, kernel 3.17.4)

- 4 Reno flows, 10 Mb bottleneck, RTT 100ms; qlen = BDP = 83 Pkts (DropTail)
- TMIX traffic from 60-minute trace of campus traffic at Univ. North Carolina (available from the TCP evaluation suite); RTT of background TCP flows: 80~100 ms



- Link utilization: 68%
- Loss: 0.78%
- Average qlen: 58 pkts



- Link utilization: 66%
- Loss: 0.13%
- Average qlen: 37 pkts

Requirements

- Simple to implement
  - minimal changes to TCP code, avoid bursts
  - Correctly share TCP states

Requirements

- **Simple to implement**
- Correctly share TCP states

Design

- Basic idea similar to FSE in *draft-ietf-rmcat-coupled-cc*
  - *To emulate one flow's behavior (... but easy to tune)*
  - Keep a table of all current connections c with their priorities P(c); calculate each connection's share as P(c) / Σ(P) * Σ(cwnd); react when a connection updates its cwnd and use (cwnd(c) – previous cwnd(c)) to update Σ(cwnd)

Basic TCP changes

- The required changes to TCP:
  - This function call, to be executed at the beginning of a TCP connection ‘c’ :

    register(c, P, cwnd, sshtresh);

    returns: cwnd, ssthresh, state
  - This function call, to be executed whenever TCP connection ‘c’ newly calculates cwnd:

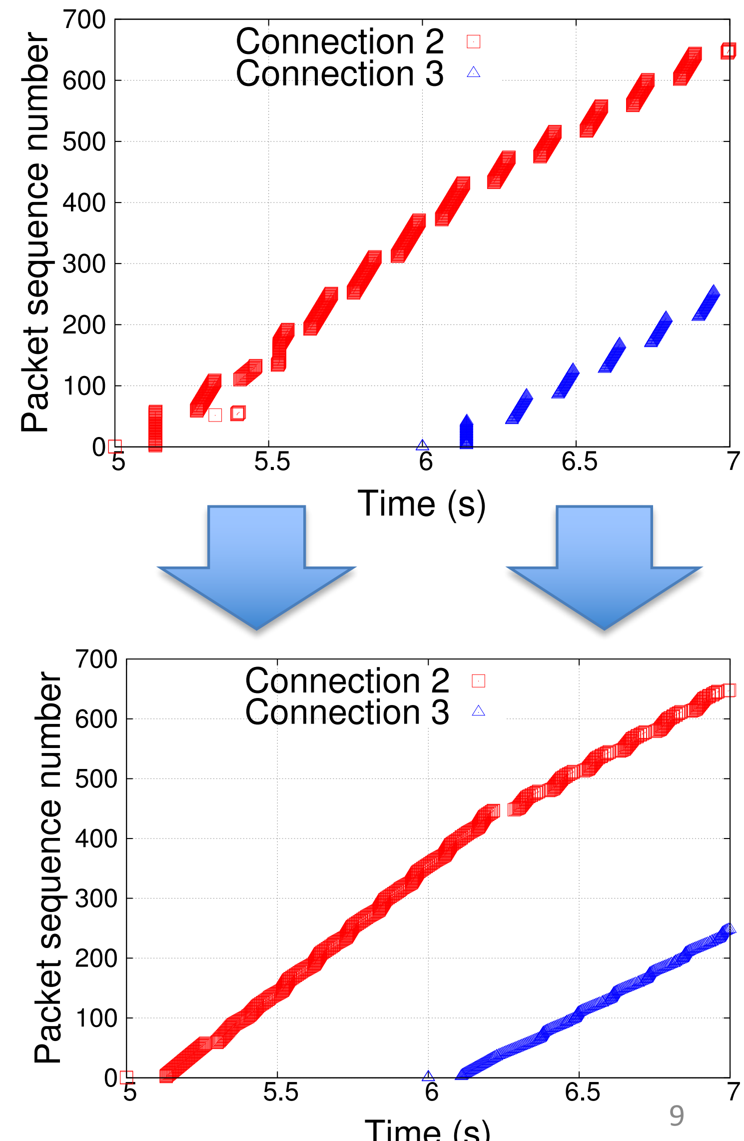
    update(c, cwnd, sshthresh, state);

    returns: cwnd, ssthresh, state
  - This function call, to be executed whenever a TCP connection ‘c’ ends:

    leave(c)

ACK-clocking to avoid bursts

- *A flow joining with a large share from the aggregate can create bursts in the network*
  - *If* ***not paced***
- *Our approach:*
  - *Maintain the ack-clock of TCP*
  - *Using the ACKs of conn 1 to clock packet transmissions of connection 2 over the course of the first RTT when connection 2 joins*
  - *Similarly, we make use of the ACKs of connections 1 and 2 to clock packet transmissions of conn 3*
  - *Requires slightly more changes to the TCP code*



[1] Safiqul Islam, Michael Welzl: *Start Me Up: Determining and Sharing TCP's Initial Congestion Window*, ACM, IRTF, ISOC Applied Networking Research Workshop 2016 (ANRW 2016), Berlin, Germany, 16 July 2016.

Requirements

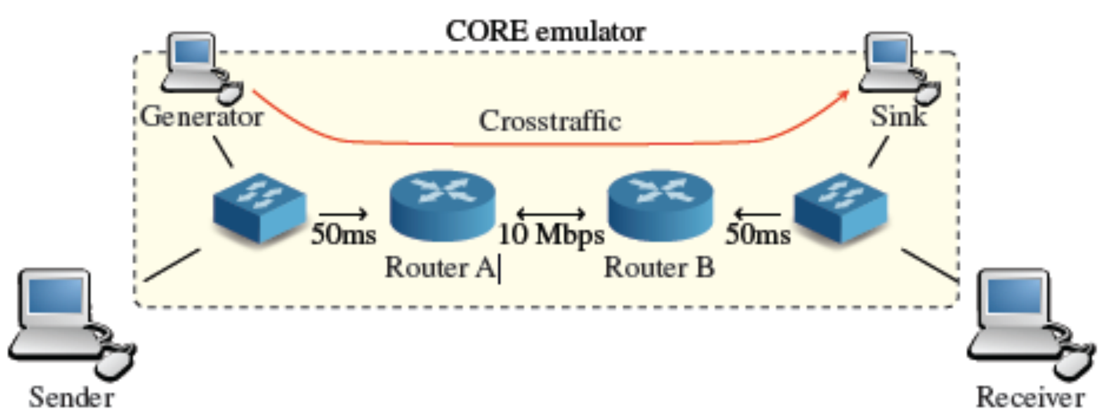
- Simple to implement
- **Correctly share TCP states**

TCP states

- Once in CA, Slow-Start(SS) shouldn't happen as long as ACKs arrive on any flow ➔ only SS when <u>all</u> flows are in SS
- Avoid multiple congestion reactions to one loss event: *draft-ietf-rmcat-coupled-cc* uses a timer
  - TCP already has Fast Recovery (FR), use that instead

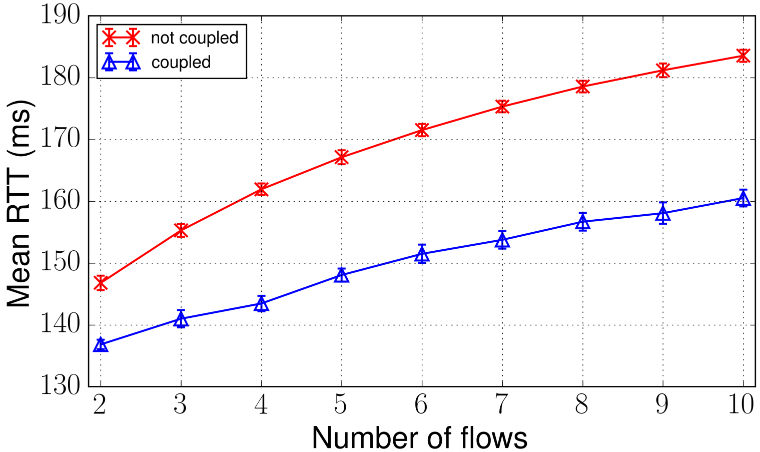
More results (FreeBSD implementation)

- Evaluations were repeated 10 times with randomly picked flow start times over the first second
- We generated internet traffic bursts using D-ITG to occupy 50% of the bottleneck capacity on average

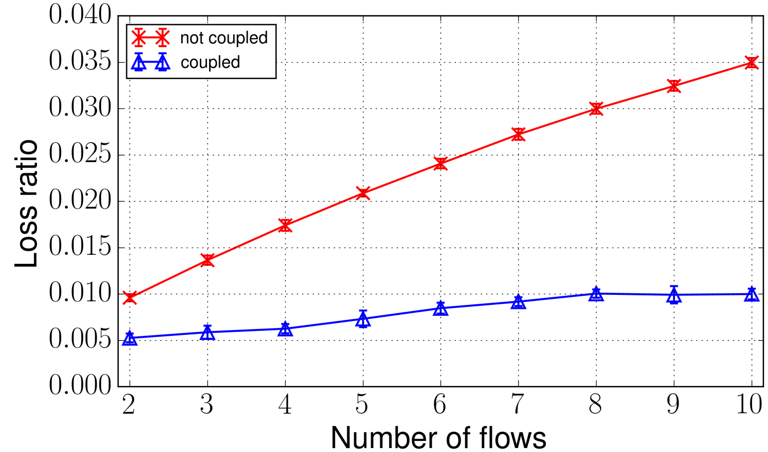


More results (FreeBSD implementation)

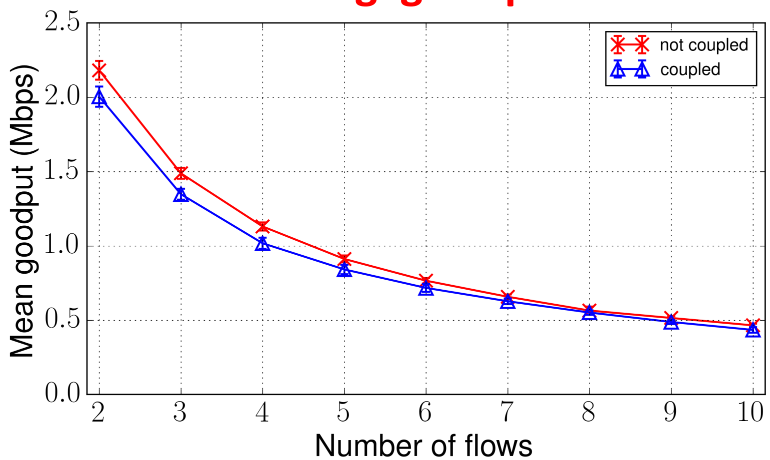
Avg. RTT



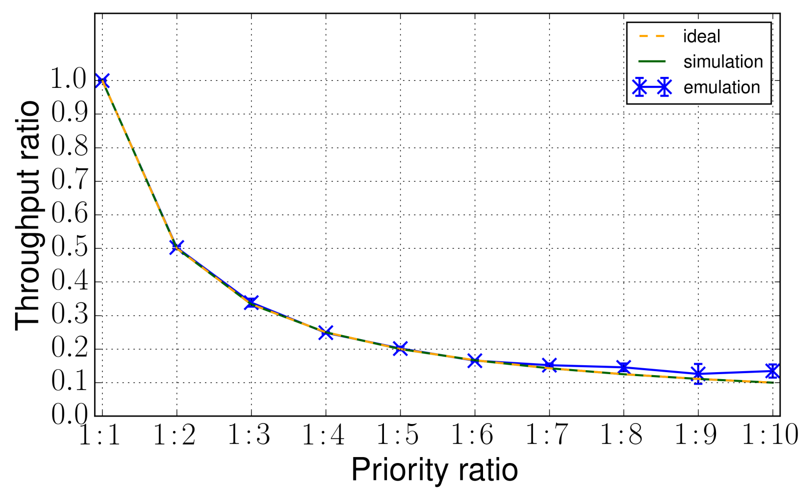
Loss ratio



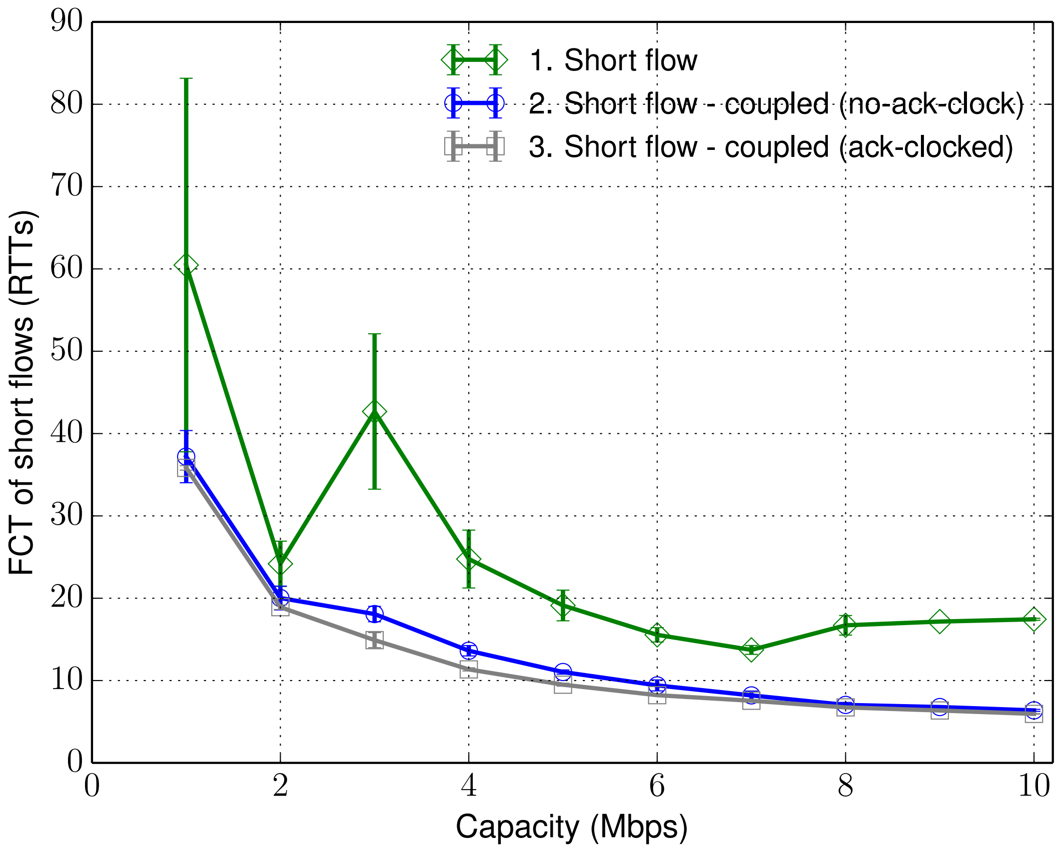
Avg. goodput



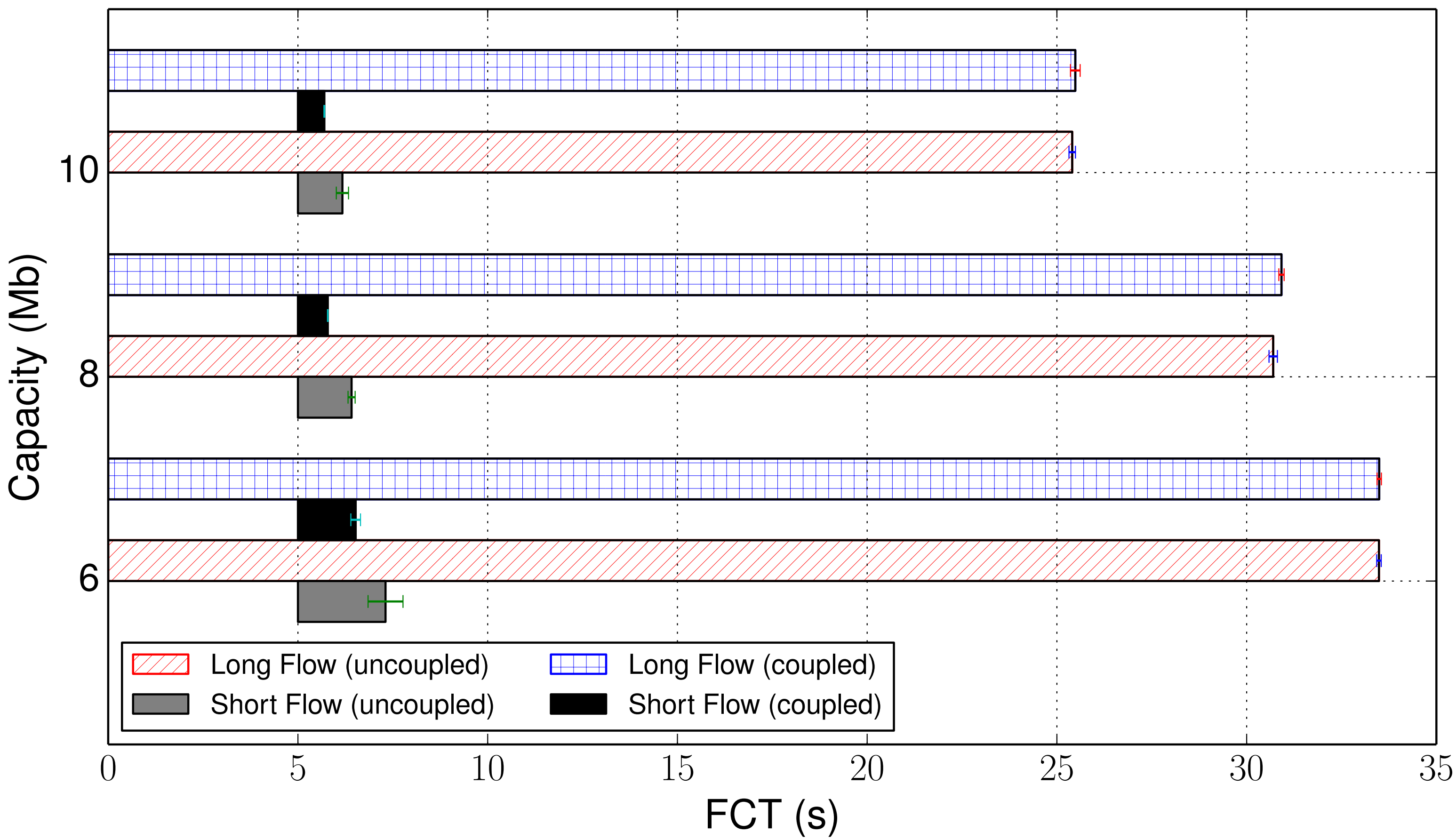
Prioritization



More results (simulation – FCT of a short flow competing with a long flow)



More results – Flow Completion Time (FCT) (FreeBSD implementation)



Questions?