TCP-Friendliness of SCTP and Concurrent Multipath Transfer (CMT)

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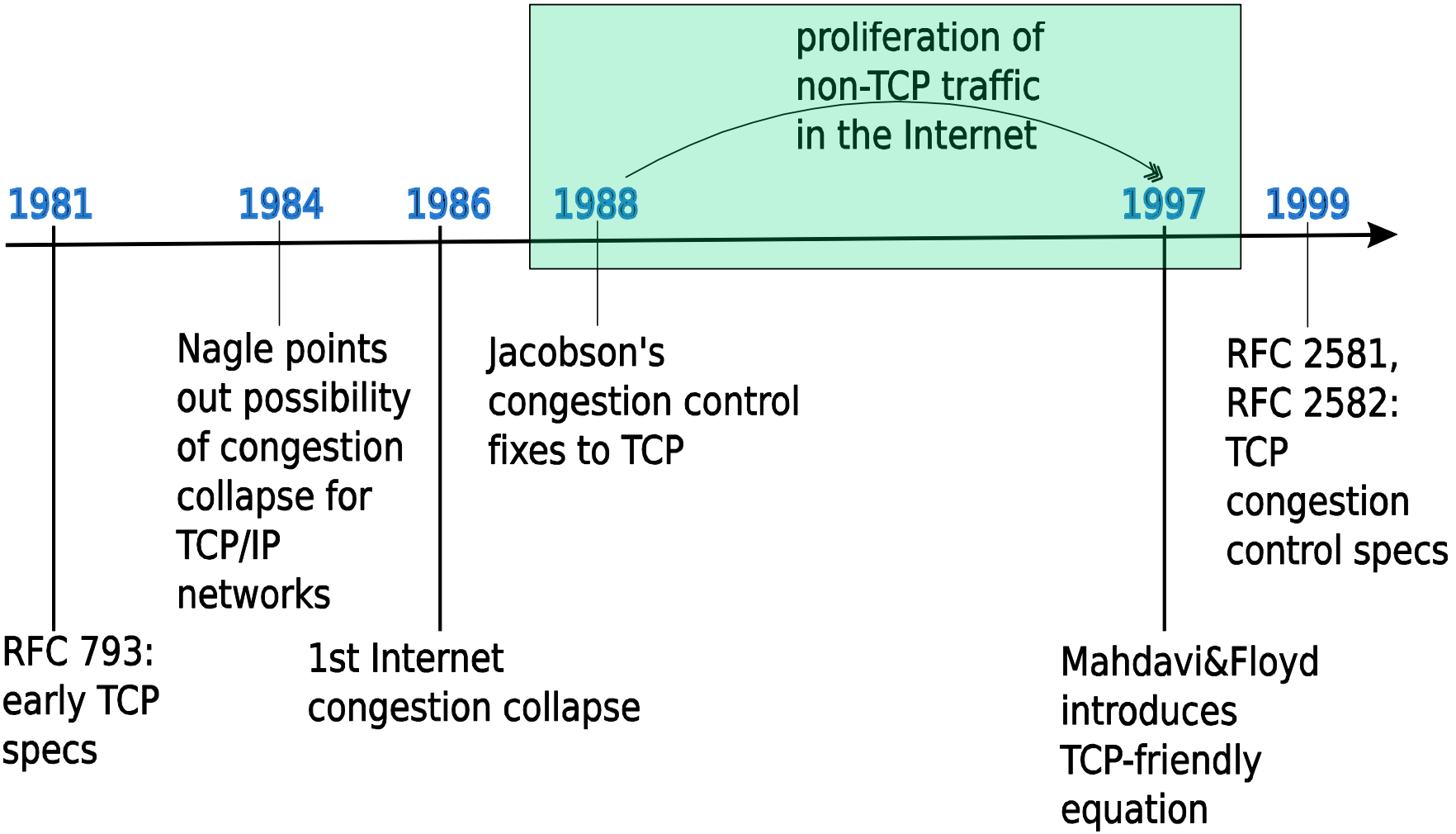
Outline

- Background on TCP-Friendliness (TCP-F)
- TCP-F of single-homed SCTP
  - Motivation, SCTP vs. TCP mechanics
  - Experimental Framework
  - Results and Analysis
  - Conclusions
- TCP-F of SCTP-based CMT
  - Motivation
  - Experimental Framework
  - Results and Analysis
  - Discussion and Conclusions

Background: TCP-Friendliness (TCP-F)



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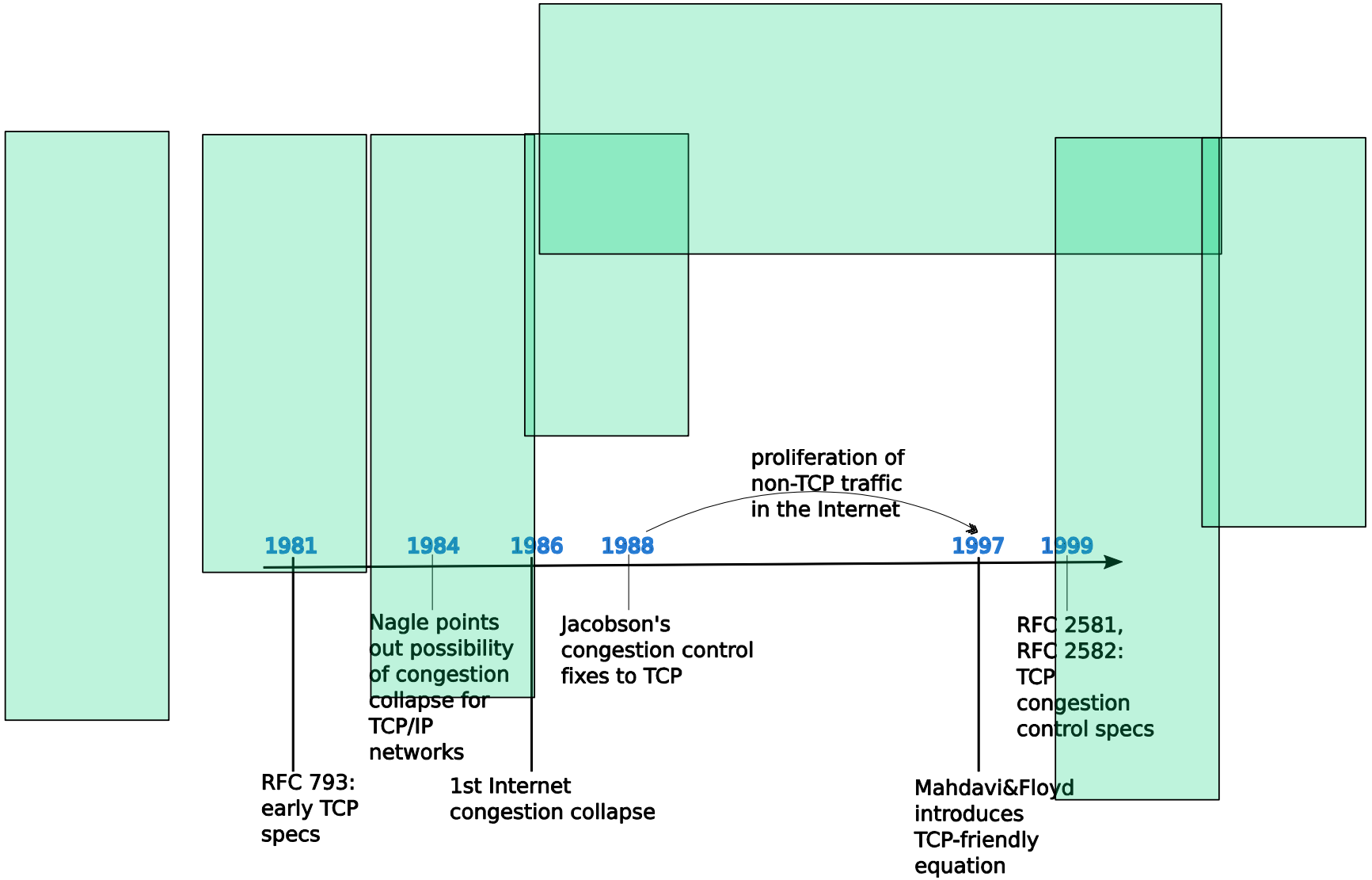


TCP-Friendliness (TCP-F)

- **"definition":** a non-TCP flow should not consume more resources than a confirming TCP flow under the same conditions + implement some form of congestion control mechanism

Bandwidth consumed by a TCP flow*
= 1.22 x MSS / RTT x sqrt(loss)

* by Mahdavi and Floyd (1997), revised by Padhye (1998) and others later on

SCTP QualNet Module

- Comprehensive SCTP simulation module for the QualNet simulator

DEGAS networking group

TCP-Friendliness of single-homed SCTP

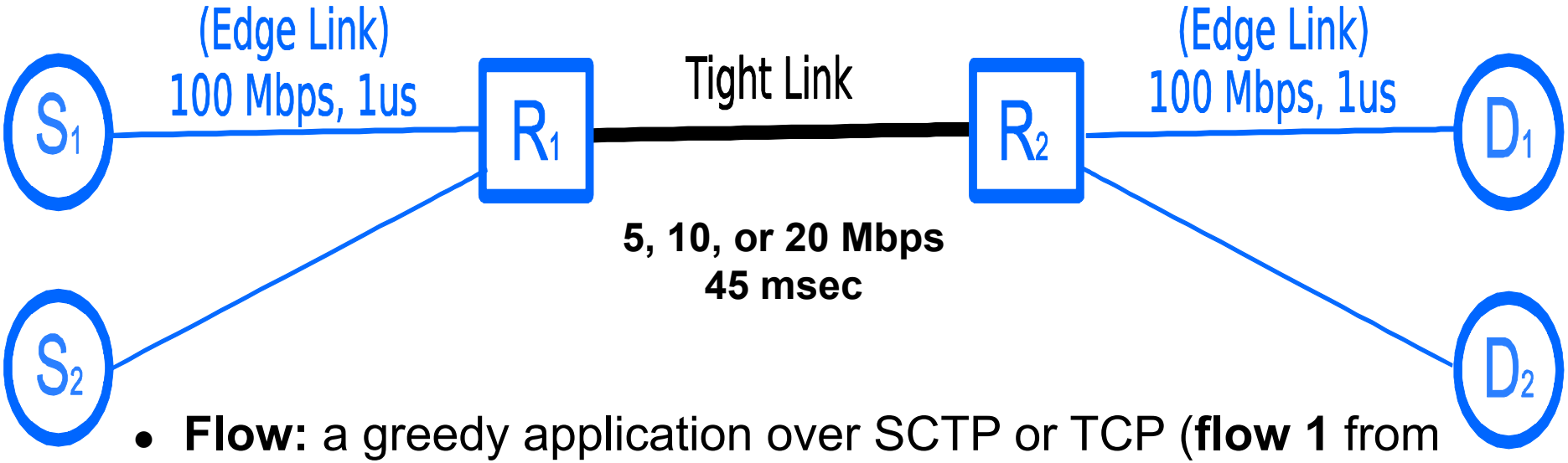
SCTP vs. TCP Mechanics

- Transport Protocol Overheads
  - Transport PDU headers
  - Message-based (SCTP) vs. byte-based transmission (TCP)
  - Transport ACKs
- Congestion Control Mechanisms
  - SCTP is “similar” to TCP but already has some of the TCP enhancements (SACK, ABC, initial cwnd size, …)

Hypothesis:

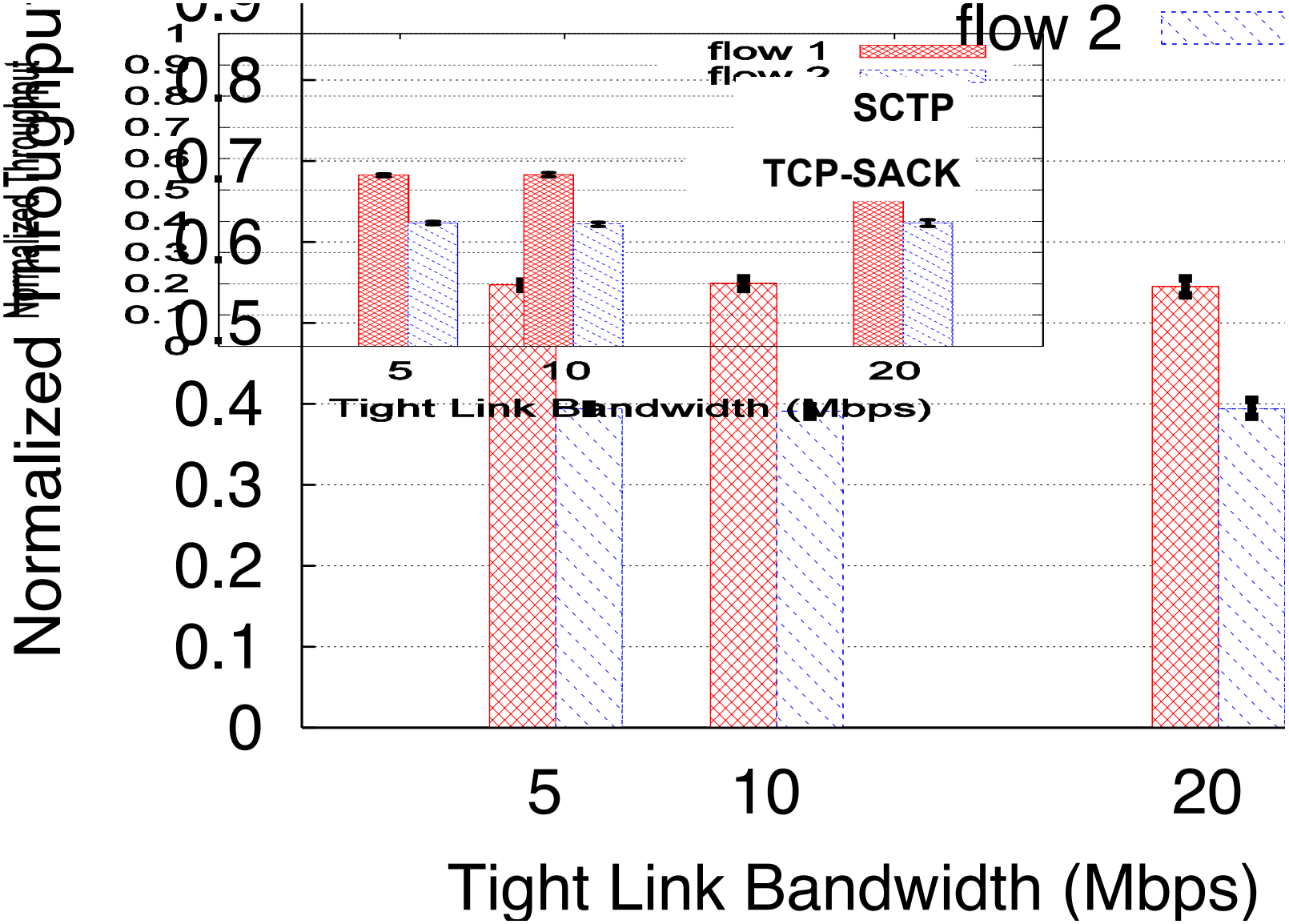
SCTP throughput may be better than TCP’s under the same conditions.

Experimental Framework

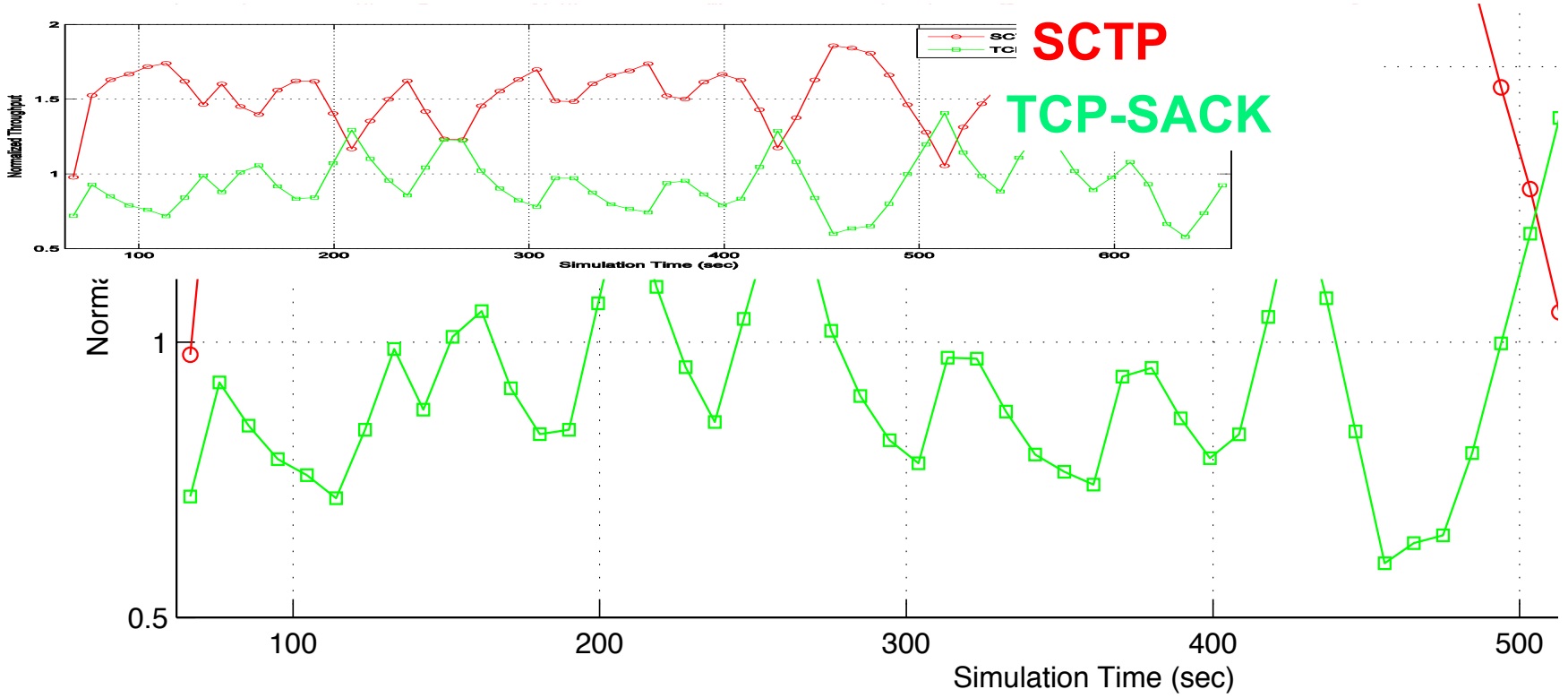


- **Flow:** a greedy application over SCTP or TCP (**flow 1** from S1 to D1, **flow 2** from S2 to D2
- **Case-I**: Two flows start at the same time *(how two flows grow together?)*
- **Case-II**: Latter flow starts after the earlier is at steady-state *(how one flow gives way to another flow?)*
- **Metrics**: Throughput, Transport Load, Goodput, Fairness Index, Link Utilization, System Utilization

Flows Start at the Same Time



TCP-SACK and SCTP flows grow together



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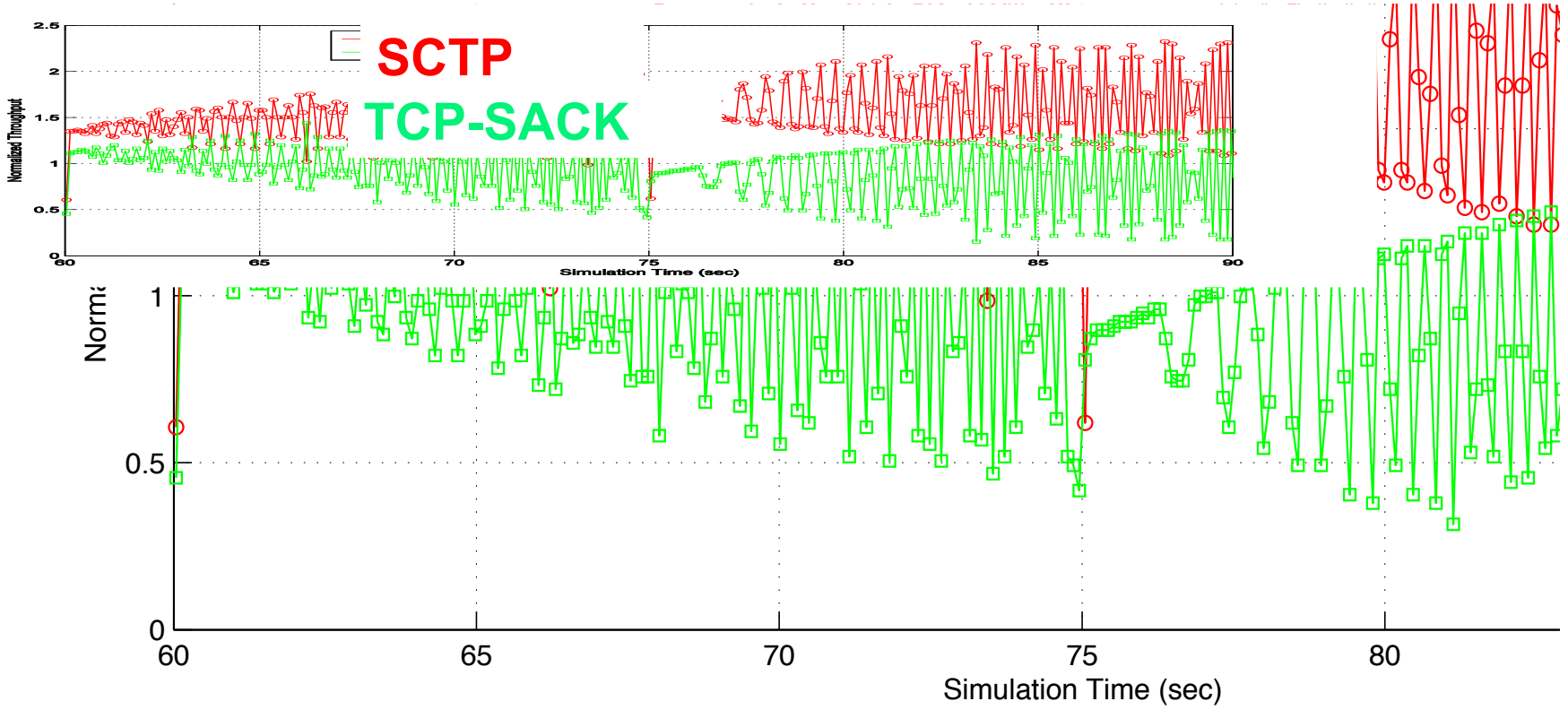
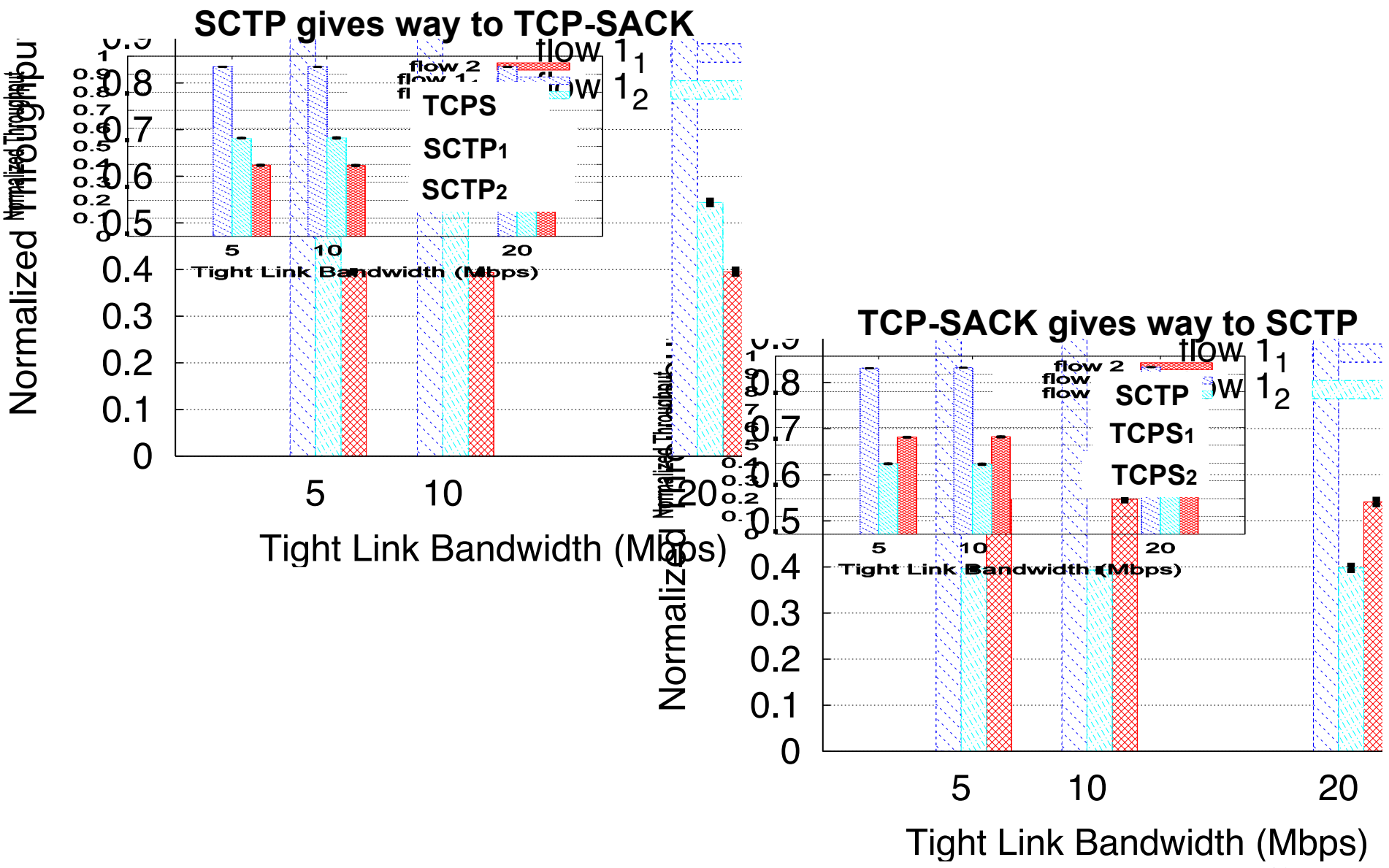
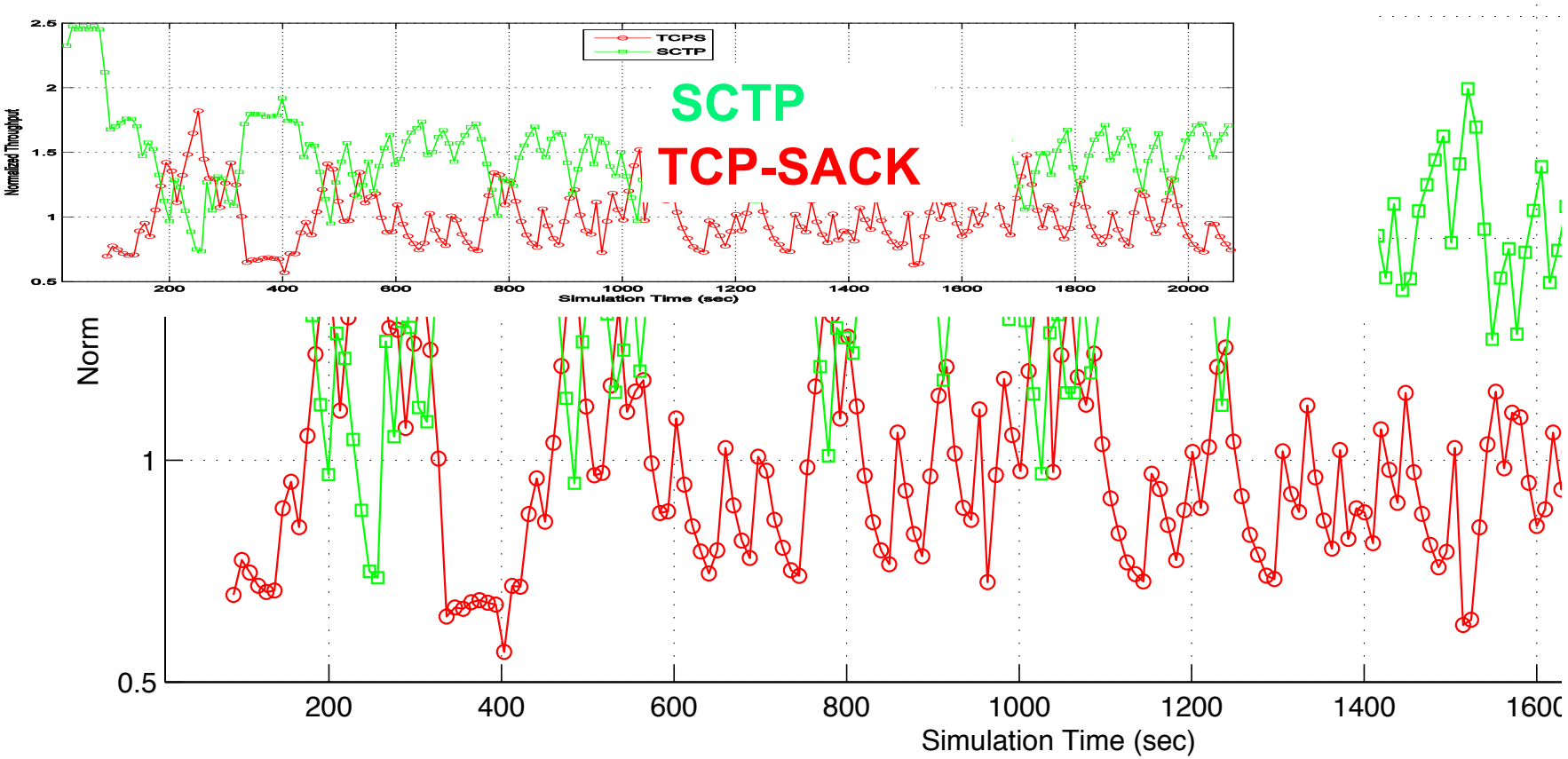


One Flow gives way to another Flow



SCTP gives way to TCP-SACK



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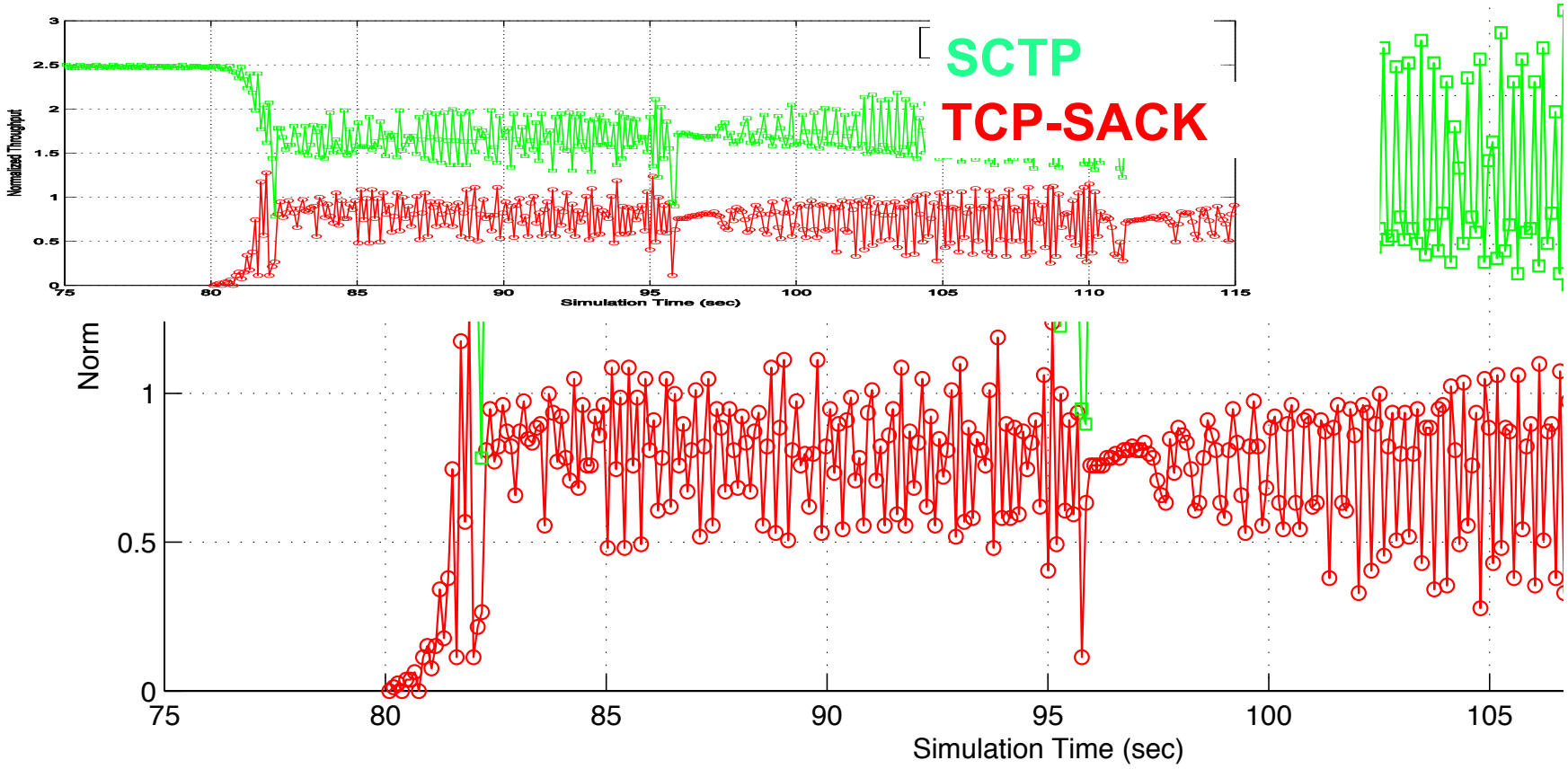
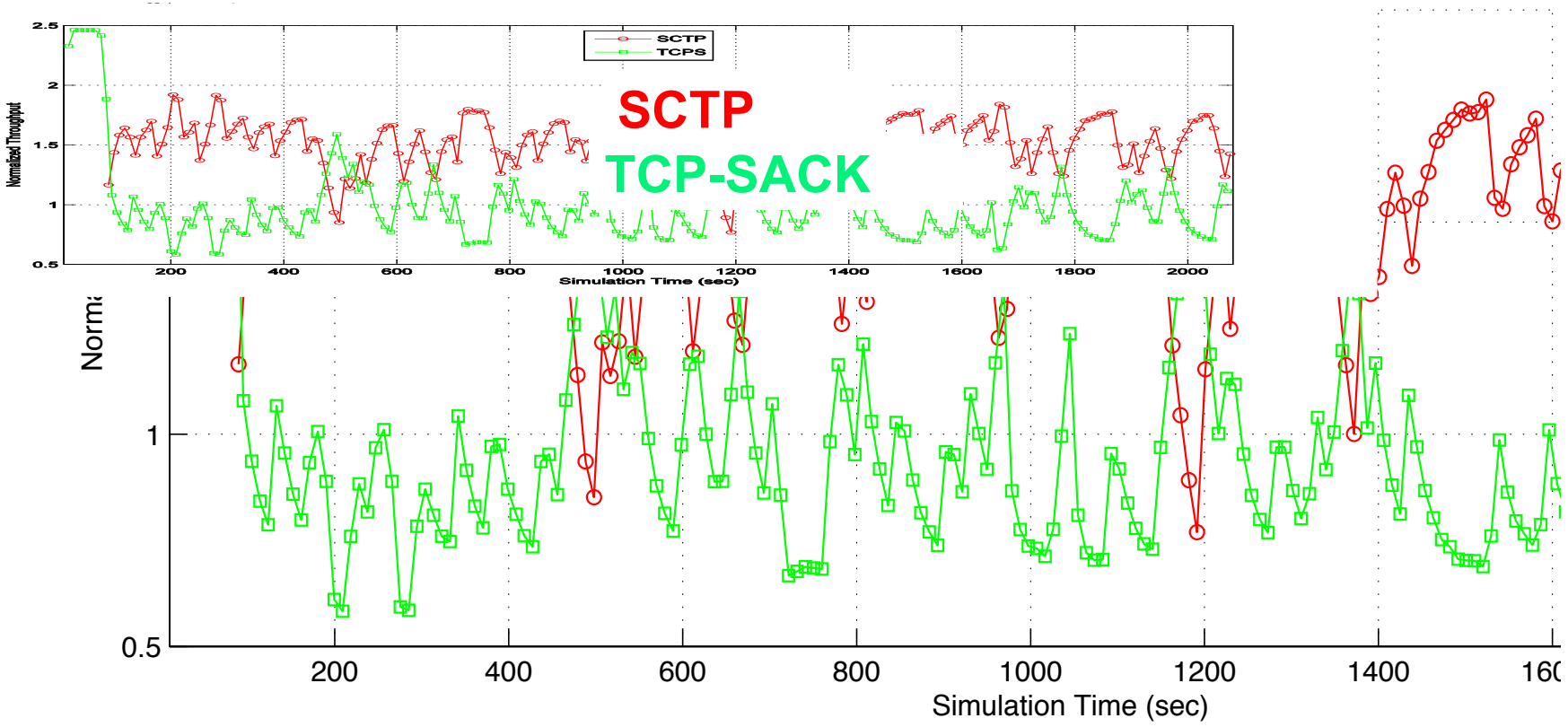
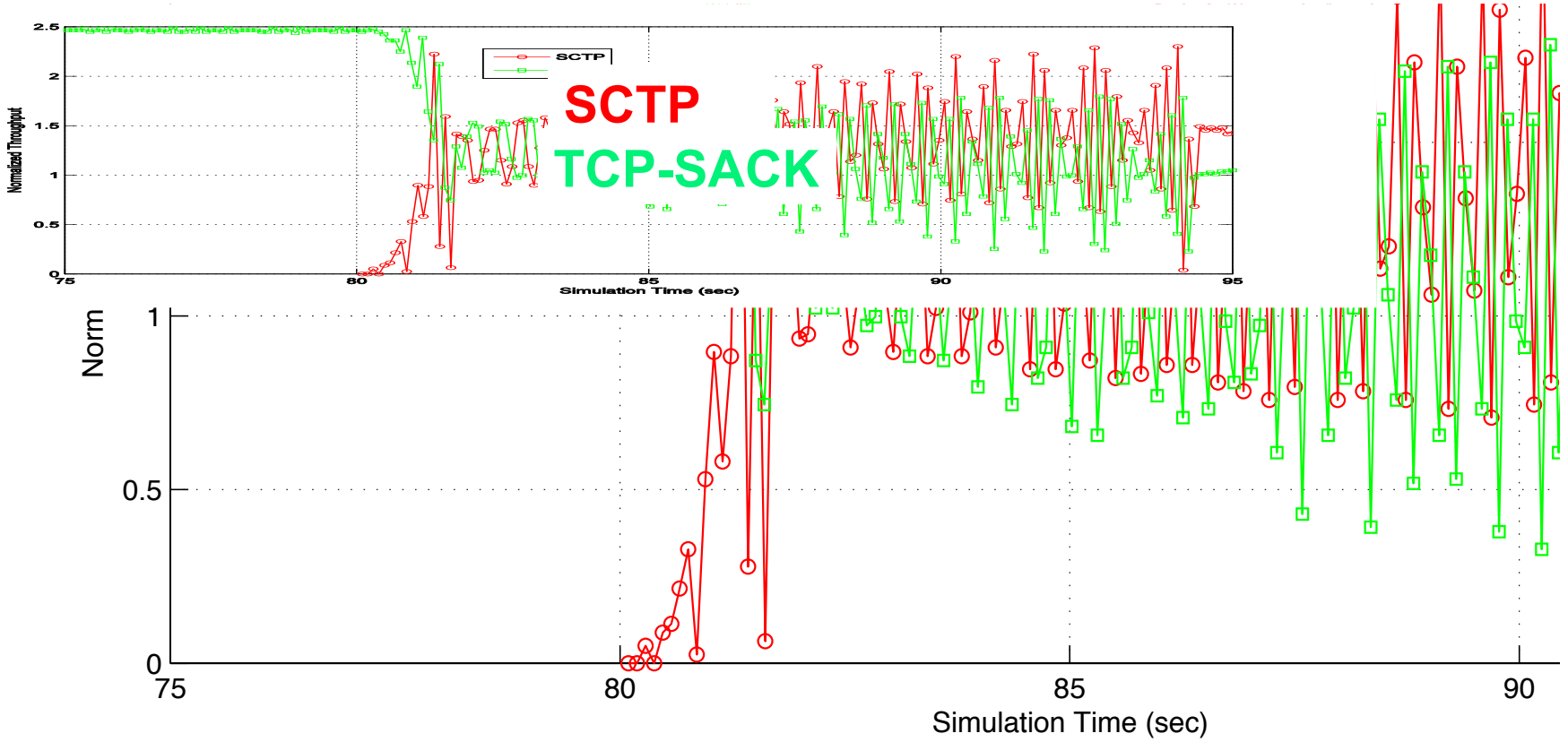


TCP-SACK gives way to SCTP



TCP-SACK gives way to SCTP



Conclusion

Single-homed SCTP is TCP-friendly though it achieves higher throughput than TCP just as TCP-SACK or TCP-Reno perform better than TCP-Tahoe

TCP-Friendliness of CMT*

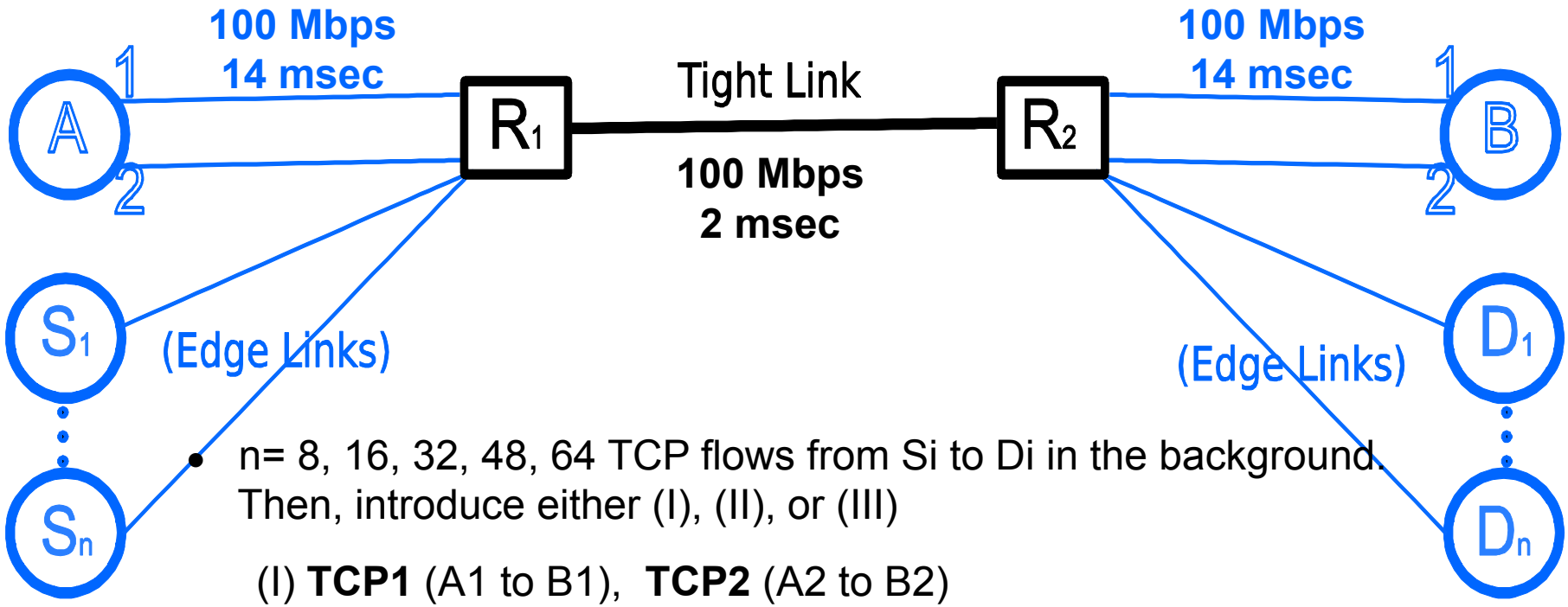
* Experimental extension to SCTP (J. Iyengar, PEL @Univ. of Delaware, 2006)

Motivation

- TCP-F is defined for end-to-end transport connections over a *single-path*
- J. Iyengar et. al. studied performance of CMT with the assumption of *bottleneck-independent* topology

How does CMT behave **when the *tight link is shared*** between the CMT subflows and other TCP flows?

Experimental Framework



- n= 8, 16, 32, 48, 64 TCP flows from Si to Di in the background. Then, introduce either (I), (II), or (III)

  (I) **TCP1** (A1 to B1), **TCP2** (A2 to B2)

  (II) **SCTP1** (A1 to B1), **SCTP2** (A2 to B2)

  (III) **two-homed CMT** where CMT-sub1 (A1 to B1), CMT-sub2 (A2 to B2)

- **RED queue** @ tight link with minth= 5pks, maxth = 3*minth, wq = 0.002, maxp = 0.02, buffer size = BWxDelay

- **Metrics**: Per-flow Throughput, Avg. flow Throughput, Fairness Index

Research Questions

- What is *the bandwidth share* of two-homed CMT compared to two independent TCP or SCTP flows?
- What is *the cost* of introducing one two-homed CMT flow into the network compared to two independent TCP or SCTP flows?

Hypotheses

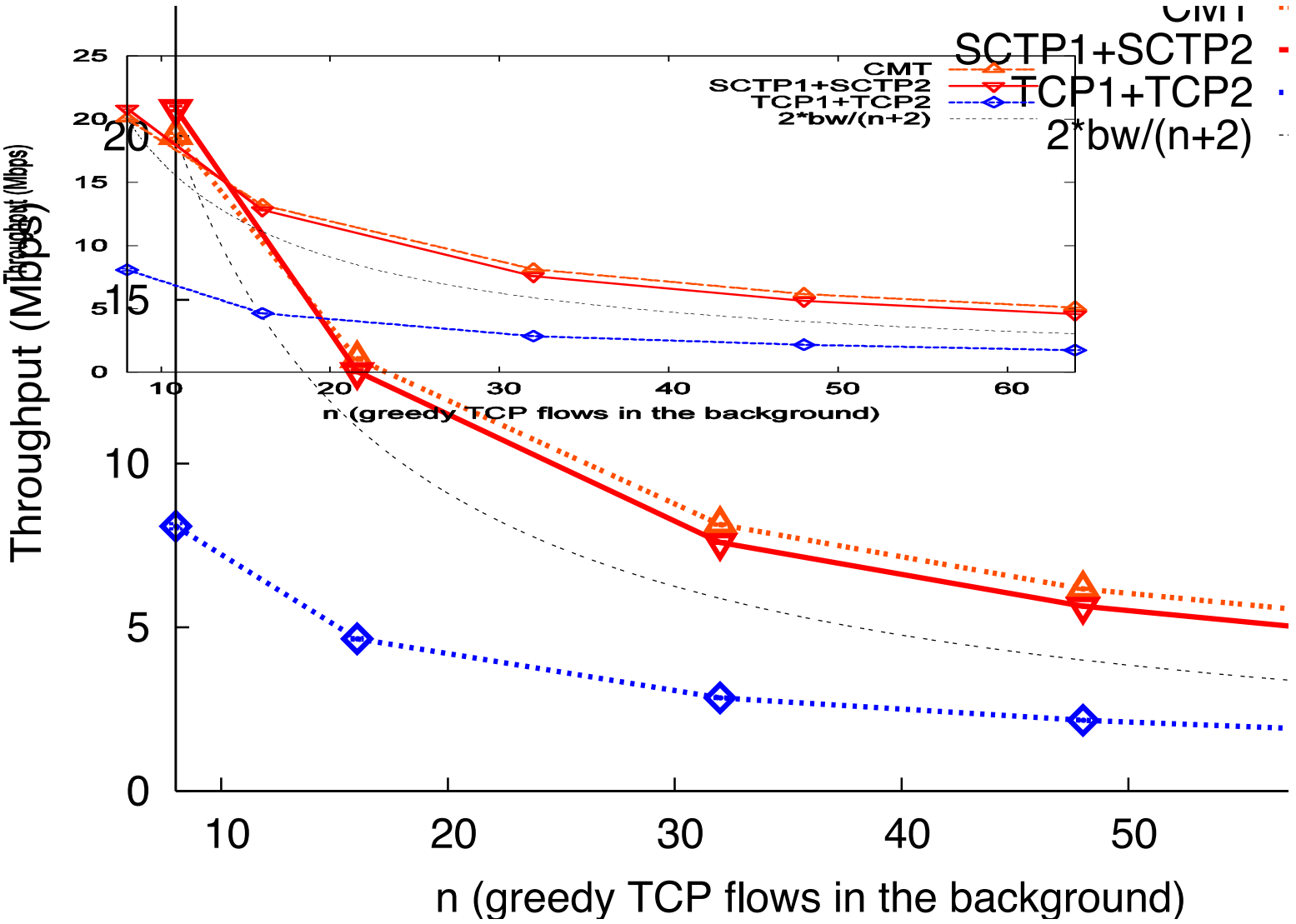
(I) Introducing two TCP flows: all TCP flows get an equal share of the bandwidth.

(II) Introducing two SCTP flows: SCTP flows get >= share of the bandwidth compared to TCP flows.

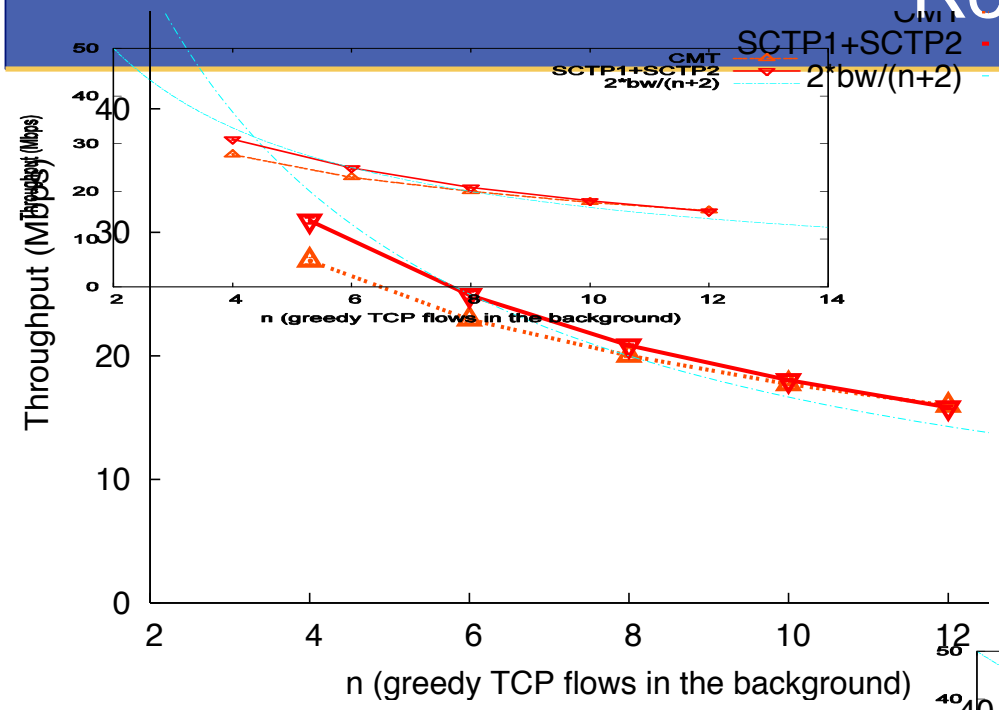
(III) Introducing one two-homed CMT flow*: CMT flow gets >= share of the bandwidth compared to two TCP or SCTP flows

*CMT shares TSN space and ACK and more resilient to losses (J. Iyengar, 2006)

Results

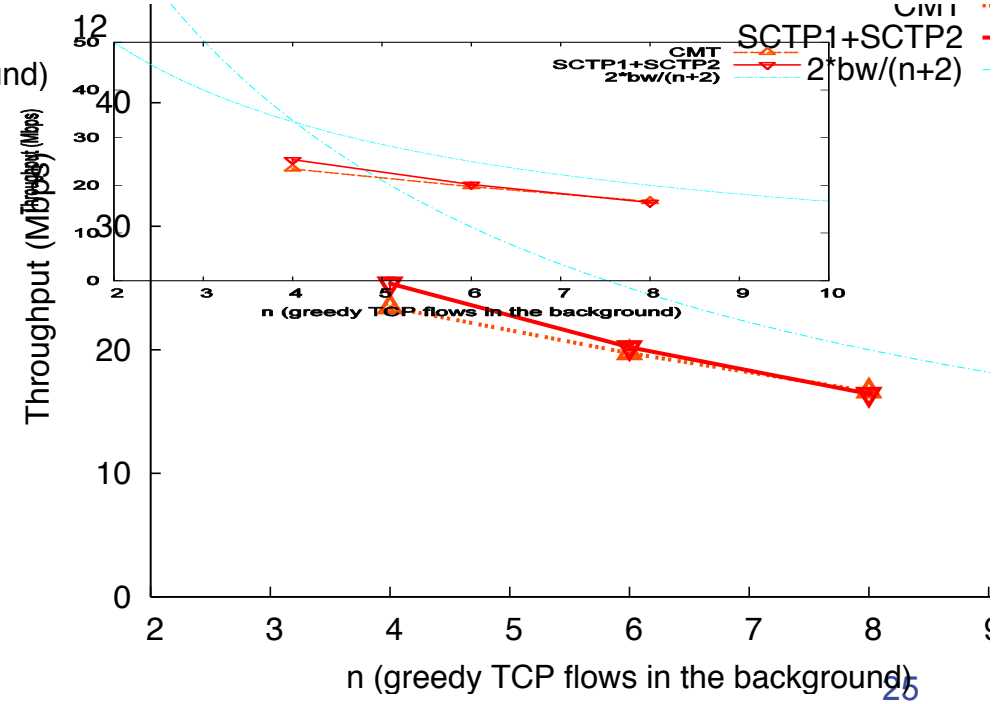

CMT
SCTP1+SCTP2
TCP1+TCP2
2*bw/(n+2)
Throughput (Mbps)
n (greedy TCP flows in the background)
0
5
10
15
20
25
10
20
30
40
50
60

Results



wq= 0.002

wq=0.001(RED reacts less aggressively on bursty traffic)



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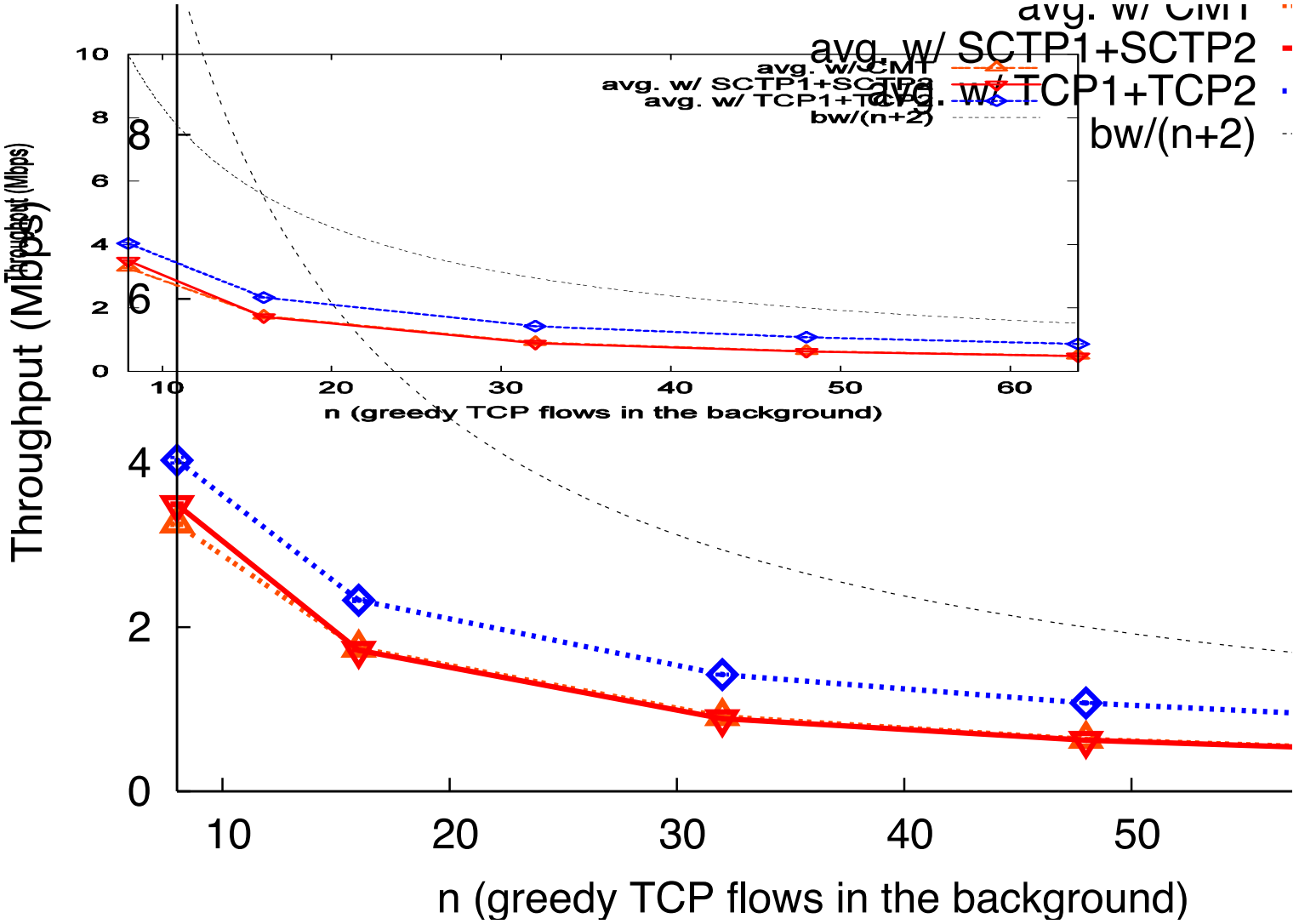
avg. w/ SCTP1+SCTP2
avg. w/ TCP1+TCP2
bw/(n+2)
Throughput (Mbps)
n (greedy TCP flows in the background)
0
2
4
6
8
10
20
30
40
50
60

Conclusion

Two-homed CMT is TCP-friendly though it achieves higher throughput than two TCP flows just as two TCP-Reno flows would outperform two TCP-Tahoe flows

Discussion and the End…

- **Other CMT-like schemes (CP, MulTFRC, mulTCP, MPAT, PA-MulTCP, MPTCP, …)**

- **Criticism to TCP-Friendliness (i.e, Flow-Rate Fairness) – Cost Fairness (B. Briscoe)**

- **TCP-F (or another fairness criteria) should include multihoming and CMT!**