A Comparison of Equation-Based and AIMD Congestion Control

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Outline

- Introduction
- AIMD
- TCP vs. AIMD
- TFRC vs. AIMD
- Related Work
- Conclusions

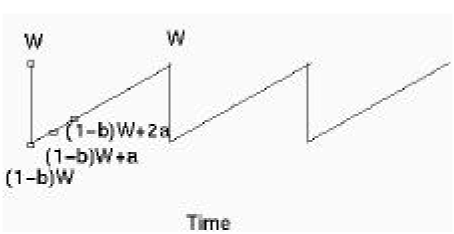
Introduction

- TCP halves sending rate upon congestion
  - MM likes smooth rate
- TFRC uses equation to make more smooth
  - 5 RTT's to reduce by half
  - Increase .28 packets per RTT
  - Still "TCP-friendly"
- TCP better modeled, understood than equation-based
- There are other AIMD protocols besides TCP
  - Find one that is more smooth than TCP
  - Make sure "TCP-friendly"

Additive Increase Multiplicative Decrease

- AIMD(*a*,*b*), with window size *W*
  - Increase parameter *a*, Decrease parameter *b*
- Each RTT increase window to *W*+*a*
- Upon loss event decrease to (1-*b*)*W*
- TCP uses AIMD(1, ½)
  - Increase by 1 every RTT
  - Decrease by ½ upon loss
- Smoother should have *b* < ½
- TCP-friendly should then have *a* < 1

Deterministic AIMD



- With *a* < 1, *b* < ½ will have "stretched" line
  - Fewer drops, too, at steady state

$$p \approx \frac{2a}{b(2-b)W^2}.$$

Alternate AIMD

- Response function, *T*, as a rate: $\hat{T} = \frac{\sqrt{2-b}\sqrt{a}}{\sqrt{2b}R\sqrt{p}}.$
- TCP then is: $\hat{T}_{1,1/2,R,p} = \frac{\sqrt{1.5}}{R\sqrt{p}}.$
- For TCP friendly, want: $\hat{T}_{a,b,R,p} = \hat{T}_{1,1/2,R,p}$

$$\frac{\sqrt{2-b}\sqrt{a}}{\sqrt{2b}R\sqrt{p}} = \frac{\sqrt{1.5}}{R\sqrt{p}}.$$

- Equivalent to: $a = \frac{3b}{(2-b)}$
- Thus: AIMD (3/7, ¼) and AIMD(1/5, 1/8)
  - Should all be TCP friendly and *smoother*

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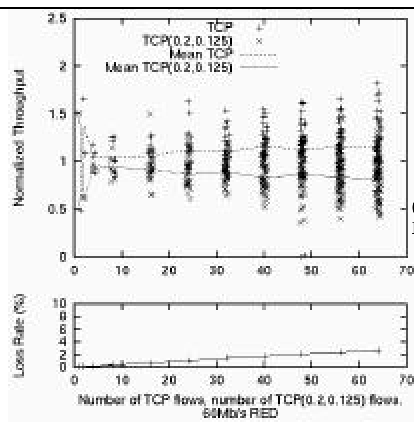
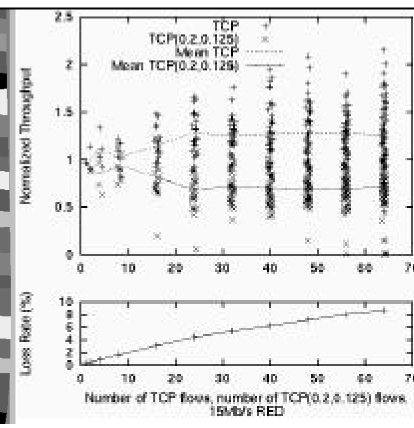
Evaluation of TCP vs. AIMD

- Run simulations in NS
  - Topology not noted, but probably "dumbbell"
- SACK TCP vs. SACK TCP(1/5, 1/8)
- Normalize so 1 is fair share



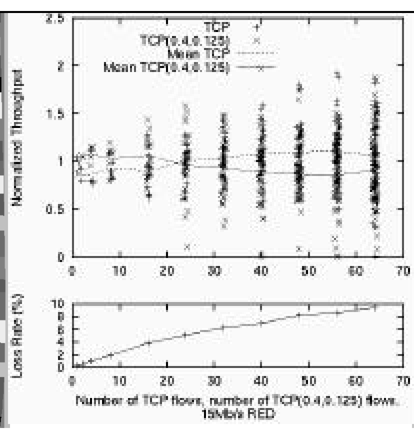
TCP vs. AIMD

(TCP gets More)



TCP vs. AIMD

(Worse with more drops)



TCP vs. AIMD

- TCP (2/5,1/8) about the same
- Maybe model too simple?

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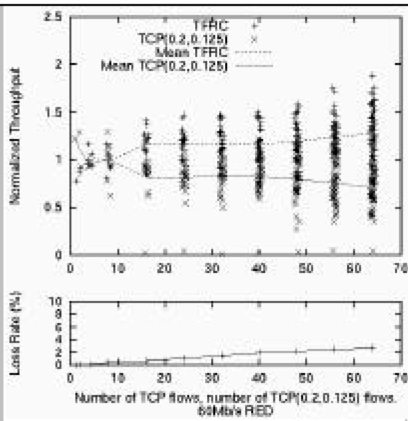
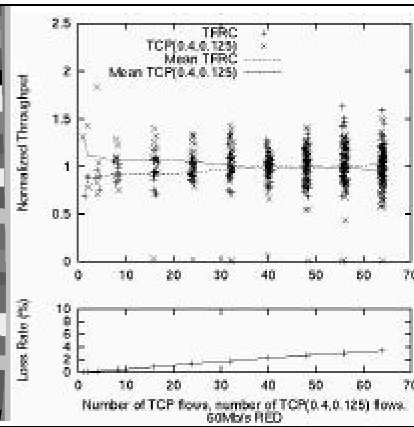
TFRC vs. AIMD



- TCP (1/5,1/8) also less
-Same as for TCP

TFRC vs. AIMD

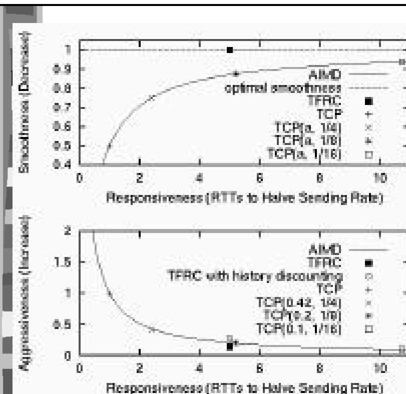


- TCP (2/5,1/8) about right

Transient Response

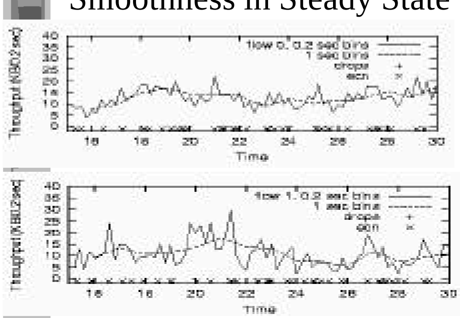
- Can determine reaction at congestion
- TCP(*a*,*b*) takes $\log_{1-b}$ 0.5 RTTs to ½ rate
  - *b*=1/8, then 5 RTTs to ½ rate
  - *b*=1/4, then 3 RTTs to ½ rate
- TFRC takes 5 RTTs to ½ rate
  - Thus, like TCP(*a*, 1/8)
- One way of comparing *responsiveness*
  - RTTs to ½ rate
- *Aggressiveness* based on *a*
  - Largest increase in rate during 1 RTT
- Smoothness based on *b*
  - Largest decrease in rate during 1 RTT

vs. Smooth and Responsive vs. Aggressive



Next up
- larger time scales
- simulation

Smoothness in Steady State

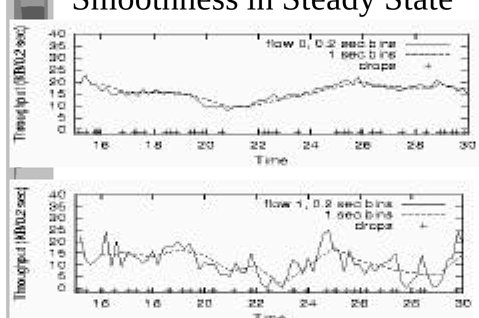


TCP (2/5,1/8)

TCP

16 flows, ECN and RED

Smoothness in Steady State



TFRC

TCP

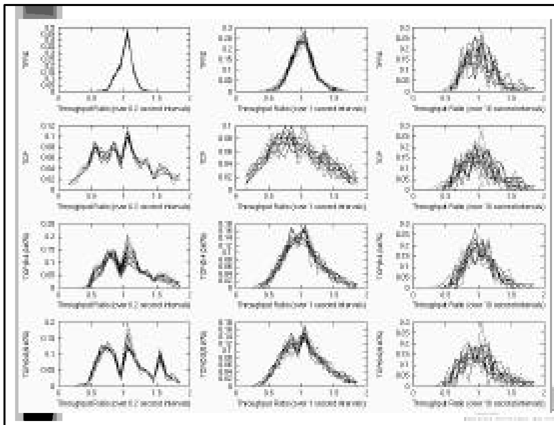
16 flows, RED

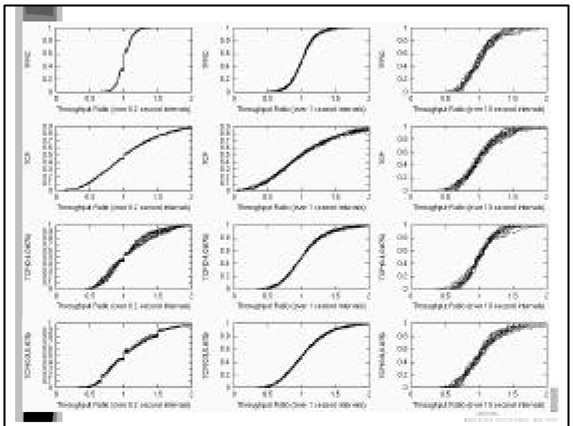
A Measure of "Burstiness"

- Throughput Ratio for *i*th interval

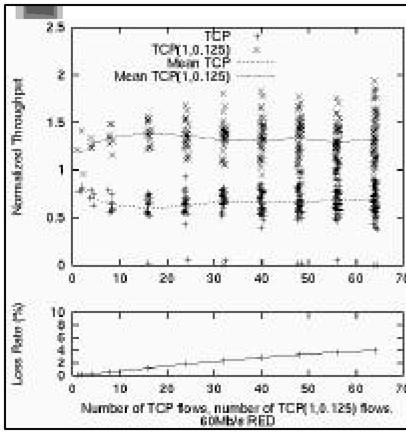
$$\frac{T_i}{T_{i-1}}$$

- 1 means rate was same
- < 1 means decreased
- > 1 means increased
- Look at fixed number of long-lived flows





TCP-Friendly AIMD



- To make TCP smoother
  - Make $b < ½$, keep $a = 1$
- 2.2 times more bwidth
- 5x more loss
- (Smooth?)

Conclusion

- Family of AIMD (a,b)
- Comparison of those like TCP
  - (1/5, 1/8) - theoretical
  - (2/5, 1/8) – actual
  - Smoother over some time intervals
- Comparison with TFRC
  - TFRC smoother than all

Future Work

- "Burstiness" in the face of
  - Bursty traffic (here, all steady state)
  - Higher drop rates (here, only 4%)
- Adaptive AIMD (Hari Kannan)
  - At steady state, decrease *a* and *b*
  - Upon bursy congestion, increase *a* and *b*
    - + Maintain TCP friendly
  - When bursty, like TCP
  - When steady, smooth and no drops

Evaluation of Science?

- Category of Paper
- Science Evaluation (1-10)?
- Space devoted to Experiments?