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, \(1/2\))
  – Increase by 1 every RTT
  – Decrease by \(1/2\) upon loss
• Smoother should have \(b < 1/2\)
• TCP-friendly should then have \(a < 1\)

Deterministic AIMD

\[
\begin{align*}
  & W \\
  \rightarrow & (1-b)W+a \\
  \rightarrow & (1-b)W+b \\
  \rightarrow & W \\
\end{align*}
\]

• With \(a < 1\), \(b < 1/2\) 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:
  \[
  T = \frac{\sqrt{2-b\sqrt{a}}}{\sqrt{2bR/\sqrt{p}}}
  \]
• TCP then is:
  \[
  \hat{T}_{1,1/3,R,p} = \frac{\sqrt{15}}{R\sqrt{p}}
  \]
• For TCP friendly, want:
  \[
  \hat{T}_{a,b,R,p} = \hat{T}_{1,1/3,R,p}
  \]

\[
\frac{\sqrt{2-b\sqrt{a}}}{\sqrt{2bR/\sqrt{p}}} = \frac{\sqrt{15}}{R\sqrt{p}}
\]
• Equivalent to:
  \[
  a = \frac{3b}{2-b}
  \]
• Thus: AIMD (3/7, 1/4) 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](image1)

TCP vs. AIMD

(TCP gets More)

![TCP vs. AIMD](image2)

TCP vs. AIMD

(Worse with more drops)

![TCP vs. AIMD](image3)

TCP vs. AIMD

(TCP gets about the same maybe model too simple?)

![TCP vs. AIMD](image4)

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Transient Response
- Can determine reaction at congestion
- $TCP(a,b)$ takes $\log_2 \frac{1}{b} \cdot 0.5$ RTTs to $\frac{1}{2}$ rate
  - $b=1/8$, then 5 RTTs to $\frac{1}{4}$ rate
  - $b=1/4$, then 3 RTTs to $\frac{1}{4}$ rate
- TFRC takes 5 RTTs to $\frac{1}{2}$ rate
  - Thus, like $TCP(a, 1/8)$
- One way of comparing responsiveness
  - RTTs to $\frac{1}{2}$ rate
- Aggressiveness based on $a$
  - Largest increase in rate during 1 RTT
- Smoothness based on $b$
  - Largest decrease in rate during 1 RTT

Smoothness in Steady State
- $TCP(2/5, 1/8)$
- Smoothness in Steady State
- $TCP$ and $TFRC$
- 16 flows, ECN and RED
- 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 $b < \frac{1}{2}$, keep $a = 1$
  - 2.2 times more bandwidth
  - 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 bursty 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?