Is the Round-trip Time Correlated with the Number of Packets in Flight?

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Motivation

- Some Congestion Avoidance Techniques implicitly use the correlation between RTT and the number of packets in flight.
  - TCP-Vegas
  - Z. Wang and J. Crowcroft “A New Congestion Control Scheme: Slow Start and Search (Tri-S)”
  - Raj Jain “A Delay-based Approach for Congestion Avoidance in Interconnected Heterogeneous Computer Networks”
What can we do

- Sample coefficient of correlation

\[ \rho(C_l, x_i, y_i) = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \]

- \( x_i \): RTT
- \( y_i \): the number of packets in flight
Notations and Terms

\[ W_i = 1 \]
\[ PT_0 \]
\[ PF_0 \]
\[ PW_0 \]
\[ P_0 \]

\[ 0 \]
\[ RTT_0 \]

\[ 1 \]
\[ 1 \]
\[ PT_1 \]
\[ PF_1 \]
\[ PW_1 \]
\[ P_1 \]
\[ P_2 \]

\[ \text{i-th packet} \]

\[ 2 \]
\[ RTT_2 \]

\[ 3 \]
\[ 4 \]
\[ 5 \]
\[ PT_2 \]
\[ PF_2 \]
\[ PW_2 \]
\[ P_3 \]
\[ P_4 \]
\[ P_5 \]

\[ \text{Ack} \]

\[ 4 \]
\[ \text{time} \]

Tails
Fronts
Monitored
All
Data Collection

- Data is based on Dr. Vern Paxon’s PhD thesis “Measurements and Analysis of End-to-End Internet Dynamics”
- *Tcpdump* traces collected over 37 sites, 14,218 TCP connections span 737 paths
Slow Path & Fast Path

Frequency Distribution of Connections by Bottleneck Link Speed (Dr. Paxon)

64 KBytes/s
Correlation between RTT and W

(0.8, 0.26)

(0.8, 0.11)
\[ \rho(C_l, x_i, y_i) = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \]

\[ \rho_{\delta v}(C_l, x, y) = \frac{\delta RTT_i}{|\delta RTT_i|}, \frac{\delta W_i}{|\delta W_i|} \]
Correlation in Direction of Change

![Correlation in Direction of Change](image-url)
Coefficient of Correlation on a Path?

Coefficient of correlation for RTT and W for slow path

Coefficient of correlation for direction of change for slow path
Conclusion and Future Work

- No strong correlation between the variation of RTT and the variations of congestion window size.
- Most of TCP connections have positive correlation in the direction of change of RTT and W.
- Updating data collections
Resources

http://www.eng.auburn.edu/users/sbiaz/tech99-006.ps