Multilevel modeling for short TCP Transfers

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Motivation

➔ A TCP connection inevitably timeouts if the sender does not receive three duplicate ACKs.
➔ RFC2988: Conservative value of RTO is chosen (1 sec.). Hence RTO has a very harmful effect on the TCP Latency.
➔ A single packet loss provokes a timeout if
   ➔ Congestion Window is small.
   ➔ One of the last three packets is lost.
Calculation of the TCP latency

The expected latency for the document size of $n$ packets is calculated by conditioning on the number of losses.

$$L(p, RTT, n) = \sum_{k=0}^{\infty} p(k \mid n) \cdot L(p, RTT, n \mid k)$$

where $L(p, RTT, n \mid k)$ is computed recursively and

$$p(k \mid n) = p^k (1-p)^n \binom{k}{n+k+1}$$
Average Transfer time

3500 bytes and shortest propagation delay link

- Experimental data
- Cardwell et al.
- Sikdar et al.
- Fixed point approach

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Non-Monotonicity of the transfer time
Calculation of the packet loss probability: Fixed Point Approach

Average sending rate

TCP Layer \[\rightarrow\] IP Layer

Packet drop probability

\[\rho_0 = \frac{E[doc\_size] \sum_{i=1}^{N} \lambda_i}{C_{\text{link}}}\]

\[\rho = \frac{\rho^K (1-\rho)}{1-\rho^{K+1}}\]

Proposition: If \(\rho_0 < 1\) the solution of the system exists and is unique
Study of the Packet Arrival process

We simulate with NS:

- Files arrive as Poisson.
- File size exponential and Pareto.
Study of the Packet Arrival process

If
$$C_{ac} \approx \frac{2C}{N},$$
inter-arrival time distribution is close to exponential,

However the correlation is not negligible.

Bottleneck 100 Mbps,
100 access links, load 0.6

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Conclusions

Simulation analysis of the arrivals of TCP packets to a router:

- Approaches exponential when the access links are slow compared to the bottleneck (traffic spread at the access before arriving at the bottleneck).
- Correlation is not negligible under any parameter setting.

To avoid the harmful effect of RTO, the Early Retransmit mechanism calls for lowering the duplicate ACK threshold when:

- The amount of outstanding data is small.
- No unsent data are queued.

M. Allman, K. Avrachenkov, U Ayesta, J. Blanton,
« Early Retransmit for TCP and SCTP » IETF I-D, work in progress.