The Effect of the Initial Window Size and Limited Transmit Algorithm on the Transient Behavior of TCP Transfers

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Introduction

- A TCP connection inevitably timeouts if the sender does not receive three duplicate ACKs.
- RFC2988: Conservative value of RTO is chosen (1 sec.). Hence it 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

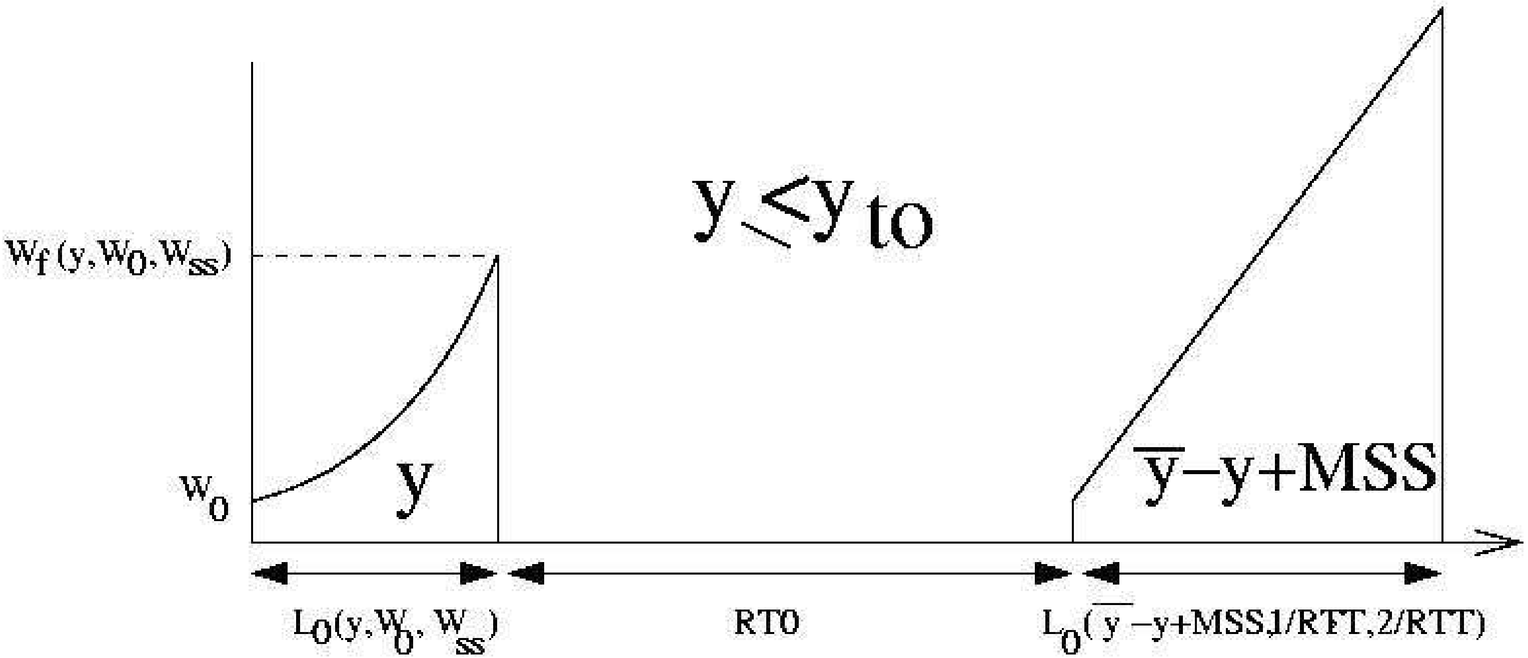
The expected latency for the document size $\bar{y}$ is calculated by conditioning on the number of losses.

$$L(p, RTT, \bar{y}) = \sum_{k=0}^{\infty} p(k \ \ losses \mid \bar{y}) L(p, RTT, \bar{y} \mid k)$$

$$L(p, RTT, \bar{y} \mid k) = \int_{y=0}^{y=\bar{y}} \left[L(p, RTT, y \mid 0) + RTO \ 1\{g(y)\} + L(p, RTT, \bar{y} - y \mid k-1) \right] dF(y)$$

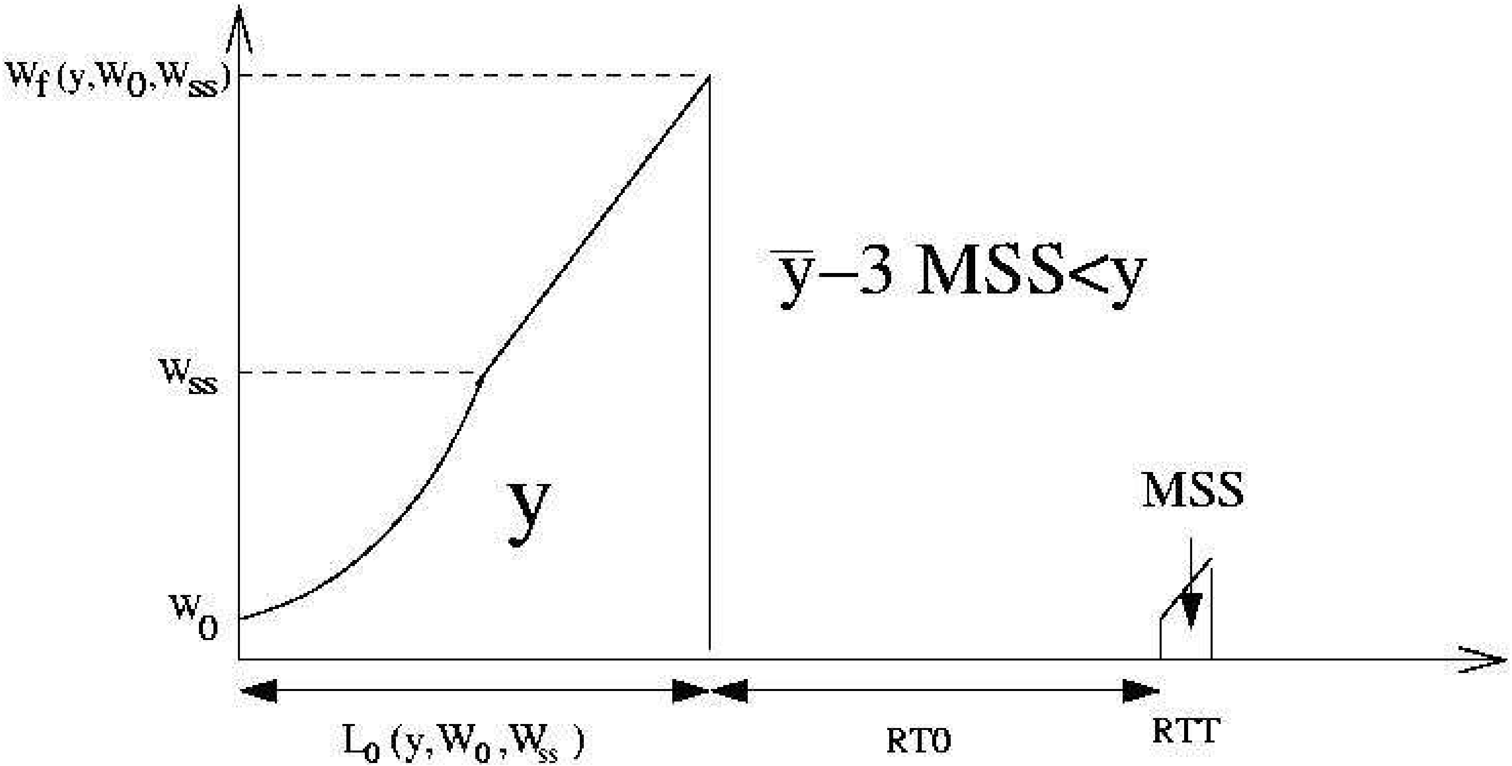
Conditional Latency for k=1

- The Small Window Effect.



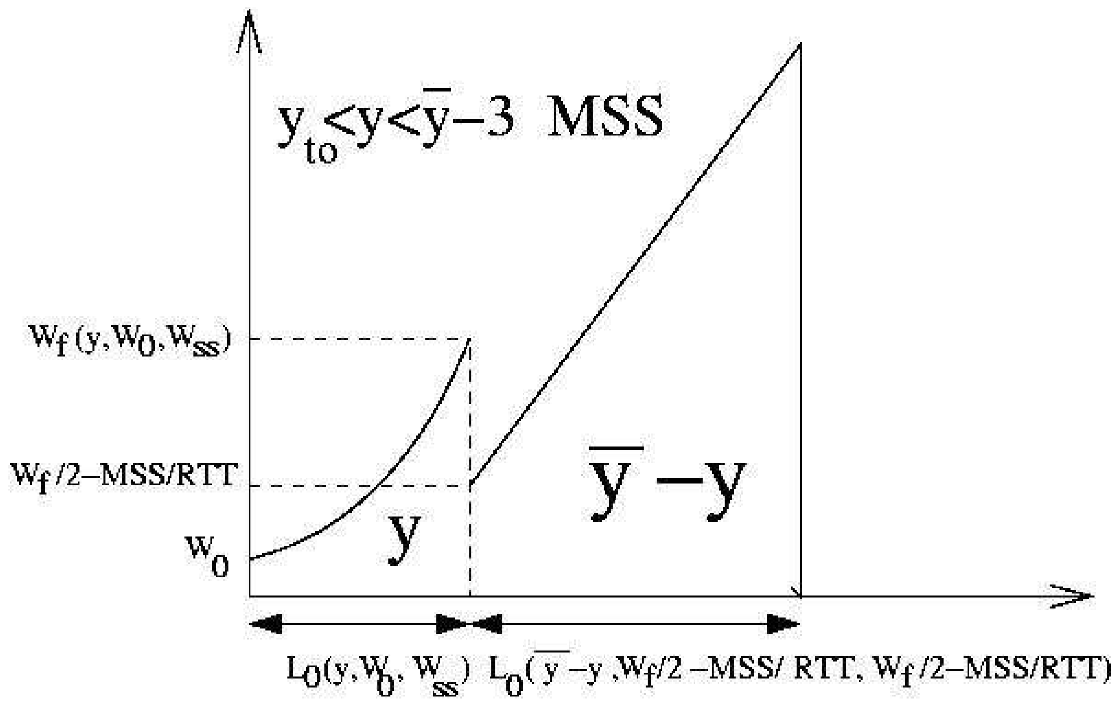
Conditional Latency for k=1

- One of last three packets is lost.



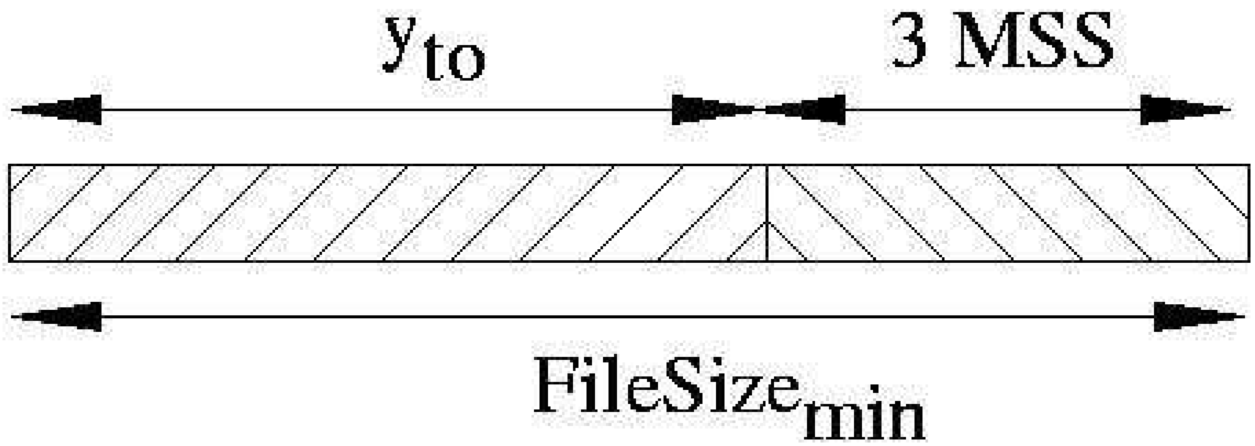
Conditional Latency for k=1

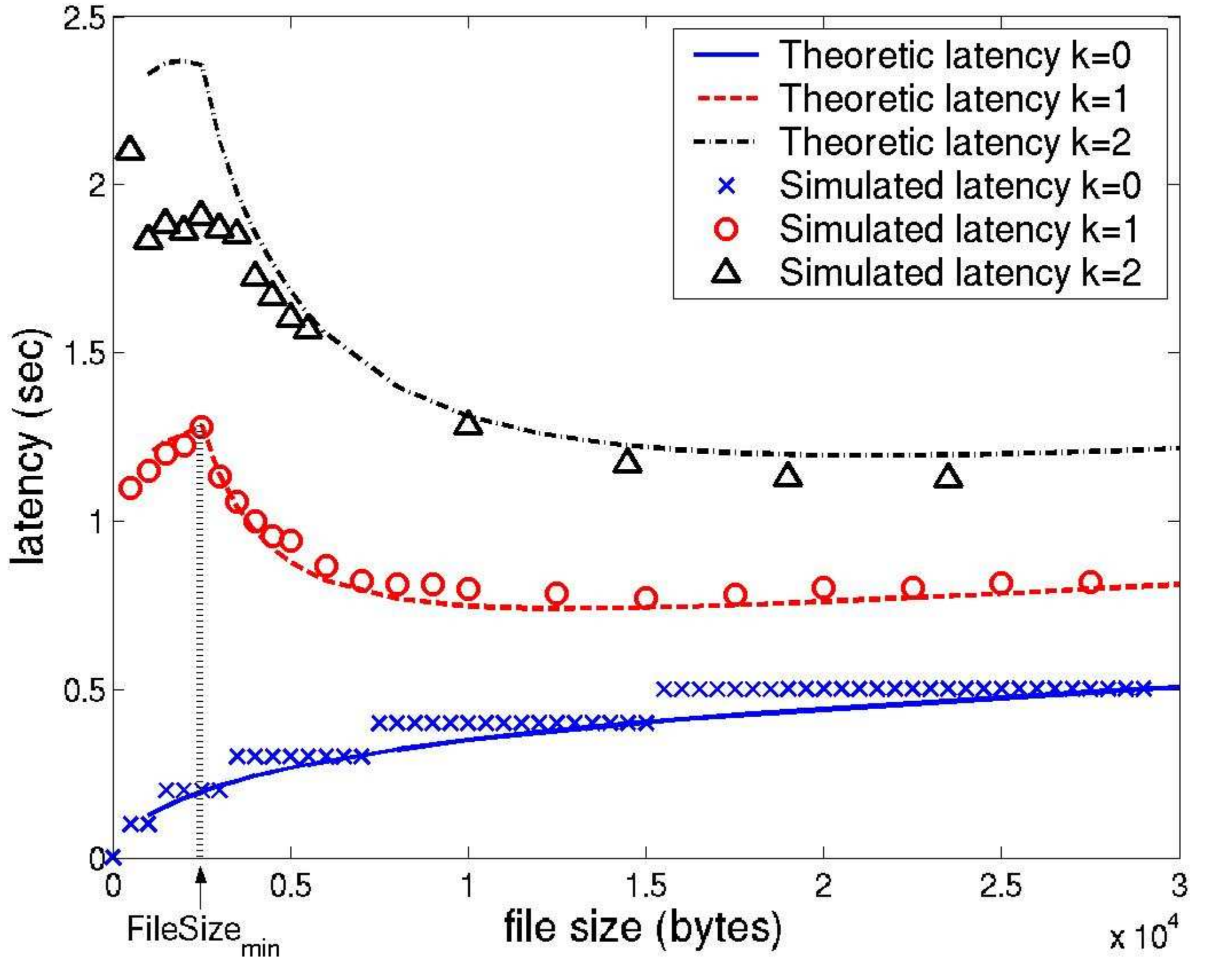
- Three dup ACKs are received.



The loss of one packet **inevitably** provokes a timeout if

$$\overline{y} \leq FileSize_{MIN}$$





Theoretic latency k=0
Theoretic latency k=1
Theoretic latency k=2
Simulated latency k=0
Simulated latency k=1
Simulated latency k=2
latency (sec)
file size (bytes)
x 10^4
FileSize_min
0
0.5
1
1.5
2
2.5
3

IW and LT proposals

- RFC 2414: Increasing TCP 's initial window.
- RFC 3042: Enhancing TCP 's Loss Recovery Using Limited Transmit.
  - Upon reception of 2 dup ACK new data is transmited.
- Both of them reduce the value of $FileSize_{min}$ diminishing y_{to}.

Values of $FileSize_{MIN}$

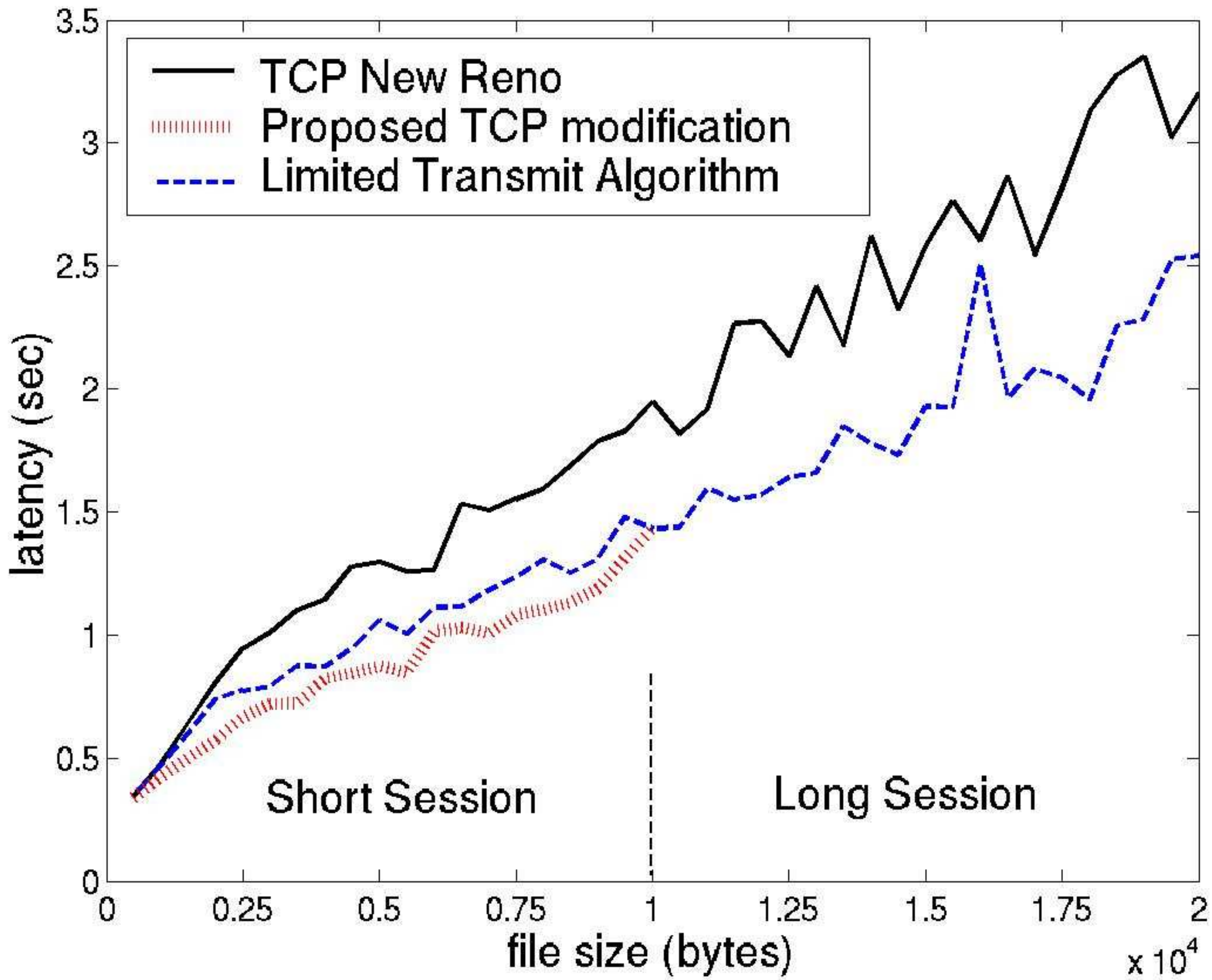
	TCP	*TCP With LT*
W_0=1	6(3+3)	5(2+3)
W_0=2	5(2+3)	4(1+3)
W_0=3	4(1+3)	3(0+3)
W_0=4	3(0+3)	3(0+3)

What can we do to improve Short TCP transfers ?

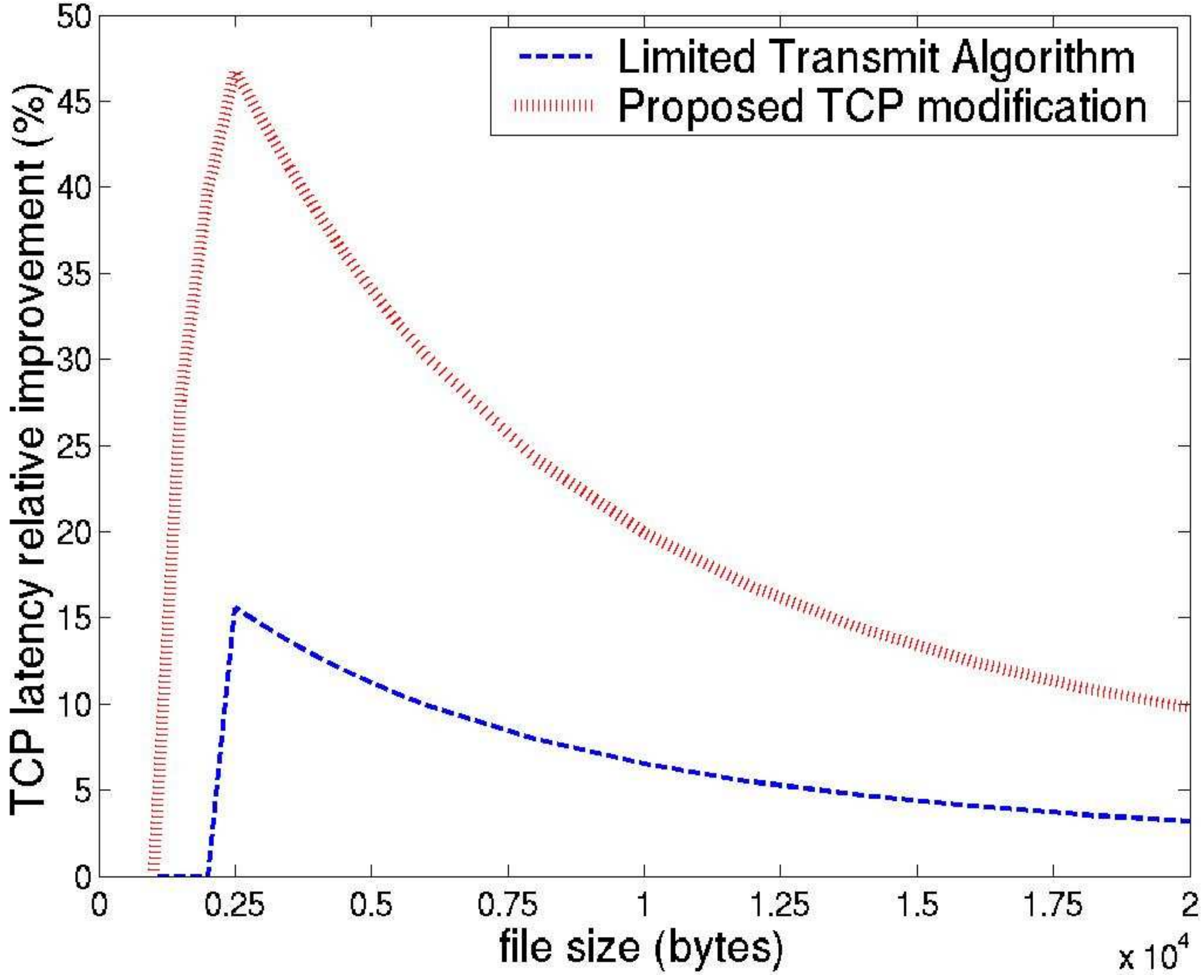
- Total contribution in data volume of Short TCP transfers to the Internet traffic is small.
- Short TCP sessions.
  - Make LT algorithm responding to one duplicate ACK.
  - Reduce the number of duplicate ACKs that trigers loss recovery mechanism.

Values of $FileSize_{MIN}$

	TCP	*TCP With LT*	*Proposed Modification*
W_0=1	6(3+3)	5(2+3)	2(1+1)
W_0=2	5(2+3)	4(1+3)	1(0+1)
W_0=3	4(1+3)	3(0+3)	1(0+1)
W_0=4	3(0+3)	3(0+3)	1(0+1)



TCP New Reno
Proposed TCP modification
Limited Transmit Algorithm
latency (sec)
file size (bytes)
x 10^4
Short Session
Long Session
0
0.5
1
1.5
2
2.5
3
3.5
0.25
0.75
1.25
1.75



Limited Transmit Algorithm
Proposed TCP modification
TCP latency relative improvement (%)
file size (bytes)
x 10^4
0
5
10
15
20
25
30
35
40
45
50
0.25
0.5
0.75
1
1.25
1.5
1.75
2

Conclusions

- In the context of Short TCP timeout event is very harmful.
- IW proposal is only beneficial in the transient state.
- LT proposal brings benefits in both transient and steady states.
- TCP can be modified to avoid timeouts in situations where it is not possible to receive three dup ACKs.

Future Research

- What is short TCP ? What is Long TCP ?
- How to chose the threshold ?
- The effect of the proposed TCP modifications on the performance of the network needs further investigation.
  - Out of order and lost packets.

References

- M.Allman, H. Balakrishnan, S.Floyd, « RFC3042: Enhancing TCP 's Loss Recovery Using Limited Transmit », January 2001.
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- S. Ben Fredj, T. Bonald, A.Proutiere, G. Regnie, J.Roberts, "Statistical Banwidth Sharing: A Study of Congestion at Flow Level", SIGCOMM 2001.
- V.Paxson, M.Allman, « RFC2988: Computing TCP 's Retransmission Timer », November 2000.

Calculation of the TCP latency

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

$$f(y) = \frac{k}{\bar{y}} \left(1 - \frac{y}{\bar{y}}\right)^{k-1}$$

Calculation of the TCP latency

$$L(p, RTT, Y \mid k) =$$

$$= \int_{0}^{\max(0,\min(y_{to},\bar{y}-dup.MSS))} \left[L(y, W_0, W_{SS} \mid 0) + RTO + L\left(\bar{y}-y+MSS, \frac{MSS}{RTT}, \frac{W_f}{2} \mid k-1\right)\right] f(y,k,\bar{y})dy +$$

$$+ \int_{\max(0,\min(y_{to},\bar{y}-dup.MSS))}^{\max(0,\bar{y}-dup.MSS)} \left[L(y, W_0, W_{SS} \mid 0) + L\left(\bar{y}-y, \frac{W_f}{2} - \frac{MSS}{RTT}, \frac{W_f}{2} - \frac{MSS}{RTT} \mid k-1\right)\right] f(y,k,\bar{y})dy +$$

$$+ \int_{\max(0,\bar{y}-dup.MSS)}^{\bar{y}} \left[L(y, W_0, W_{SS} \mid k-1) + RTO + L\left(MSS, \frac{MSS}{RTT}, \frac{W_f}{2} \mid k-1\right)\right] f(y,k,\bar{y})dy$$

$$\textit{where} \qquad f(y,k,\bar{y}) = \frac{k}{\bar{y}}\left(1-\frac{y}{\bar{y}}\right)^{k-1}$$

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