# Performance of Short TCP Transfers

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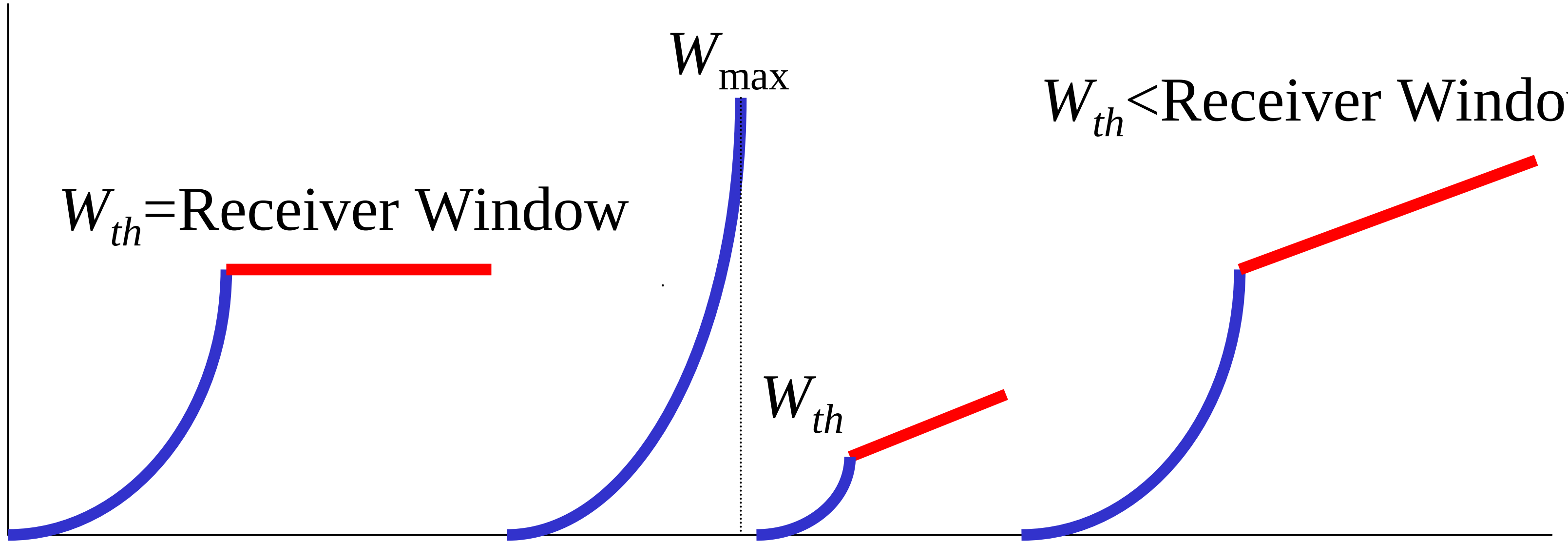
# Outline

- Studied problem: Burstiness of Slow Start.
- Questions:
  - How to increase the window during Slow Start?
  - How to set the Slow Start threshold?
- A model with some simulation results.
- A proposition that preserves the ACK clock.
- Conclusions.

# An overview of TCP Start-Up

A quick increase of the window (by one segment for every new ACK) until reaching the Slow Start threshold ($W_{th}$) or filling the network pipe ($W_{max}$).



# TCP burstiness during Slow Start

- Caused by the ACK clock and the fast window increase (i.e. packets are transmitted in a burst upon ACK receipt).
- Results:
  - Early buffer overflow and under-estimation of the available bandwidth.
  - Prohibits a faster version of Slow Start required on long delay paths (e.g. satellite links).

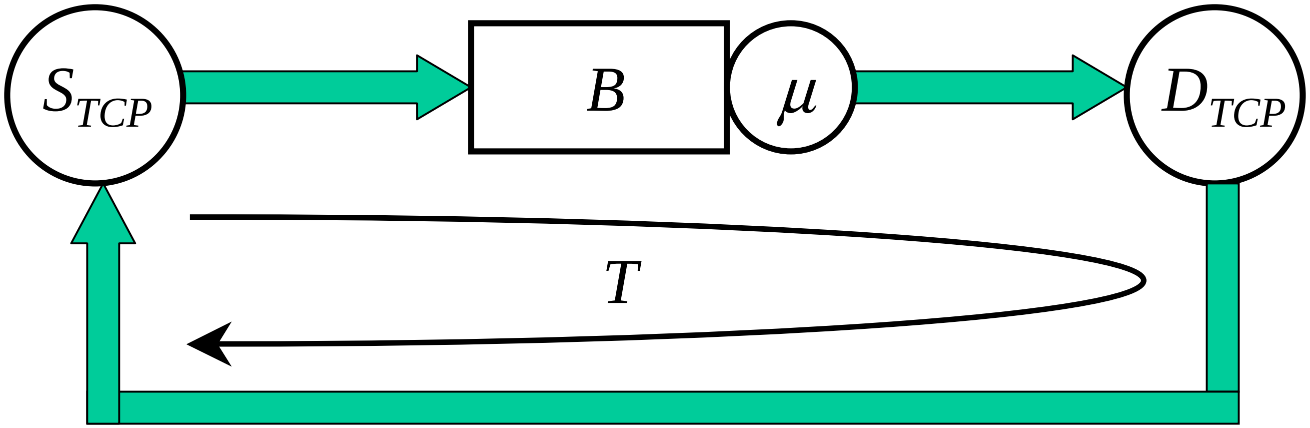
# Some questions

- How to dimension network buffers?
- How fast to increase the window?
- How to set the Slow Start threshold?
- Try to find a window increase policy that preserves the ACK clock.

# Related works

- Byte Counting : Consider the number of bytes covered by an ACK while increasing the window. Proposed to recover from the impact of Delay ACK on satellite links.
- Set the Slow Start threshold at the beginning of the connection to the bandwidth-delay product. The flow of ACKs is used for inferring path parameters.

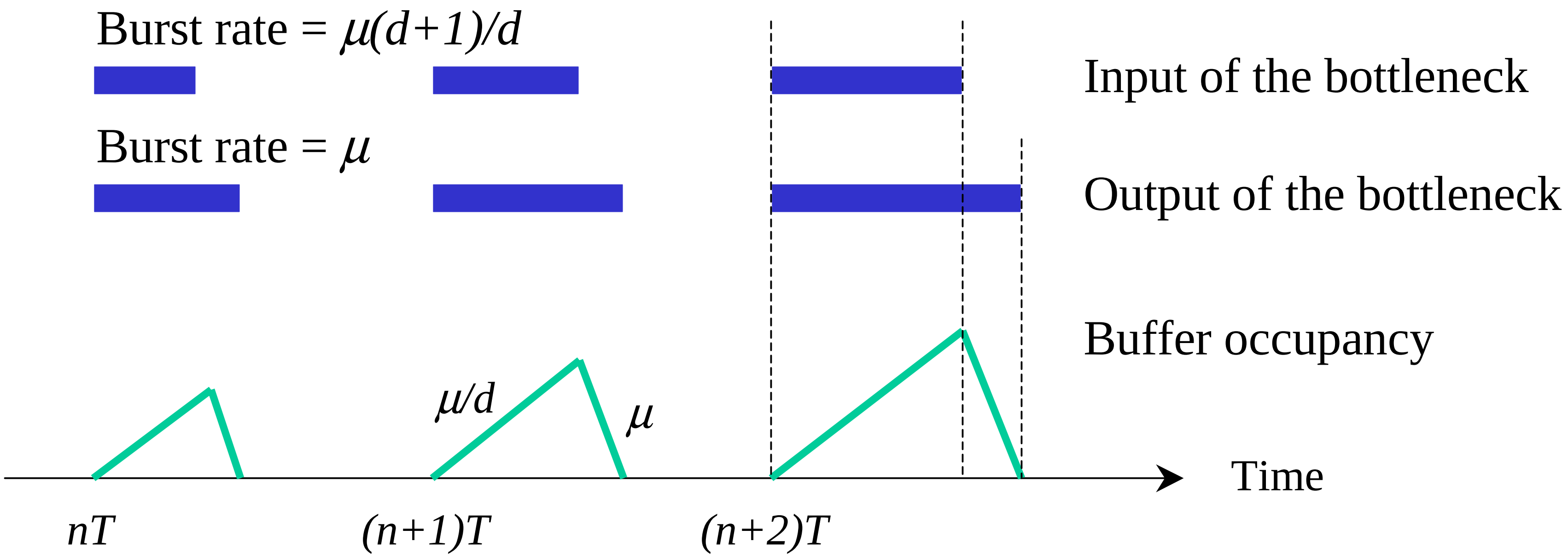
# A simple model




Define $d$ as : $W((n+1)T) = W(nT) + W(nT)/d$

**Problem:** Find the window at which $B$ overflows during Slow Start ($W_B$) assuming that $W_{th}$ is set to infinity.

# The overflow window $W_B$



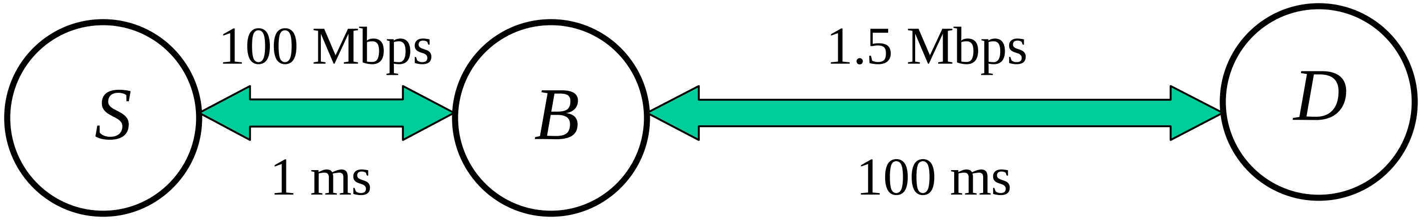

$$W_B = \min[(B+\mu T), B(d+1)] = \min[W_{max}, B(d+1)]$$

# Corollaries

- Buffer size to be set to more than $\mu T/d$ in order for Slow Start to fill the network pipe.
- The Slow Start threshold to be set to just less than $W_B$ in order to avoid losses.
- The window growth rate during Slow Start can be increased until $B$ becomes less than

$$\frac{\min[W_{th}, W_{\max}]}{d+1}$$

# A couple of simulations

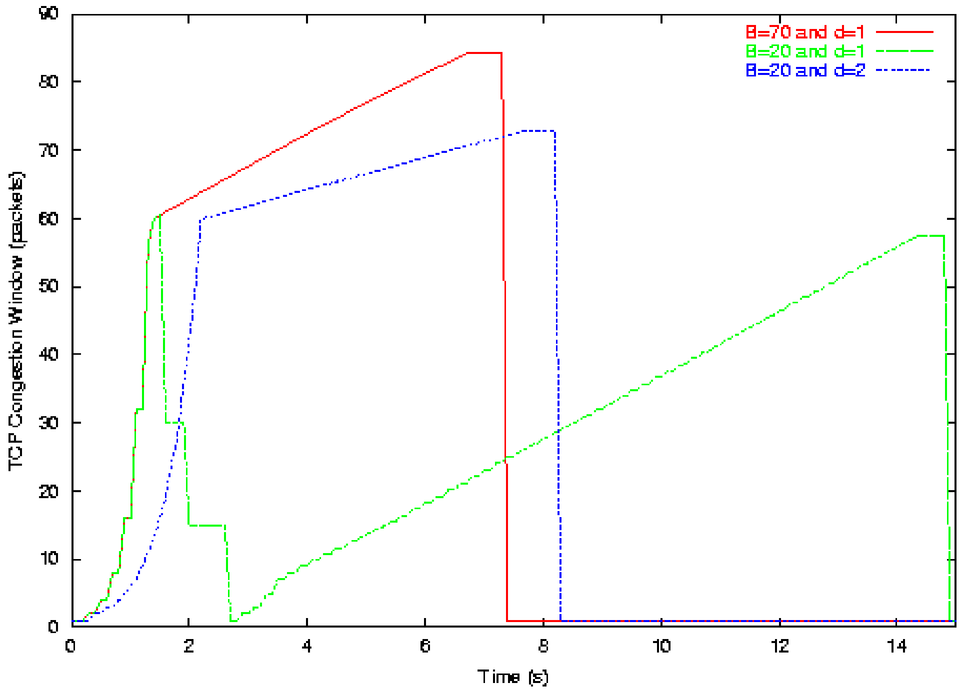



- Simulator : `ns`
- TCP version : Reno
- MSS : 512 bytes

# Impact of $B$ on $W_{th}$ choice

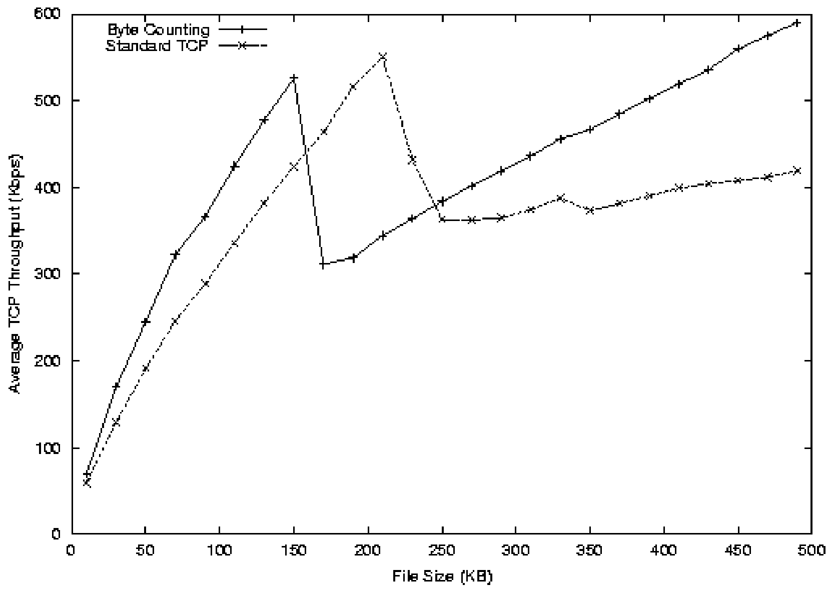
File size : 100 Kbytes.

$W_{th}$ less than the bandwidth-delay product (BDP).

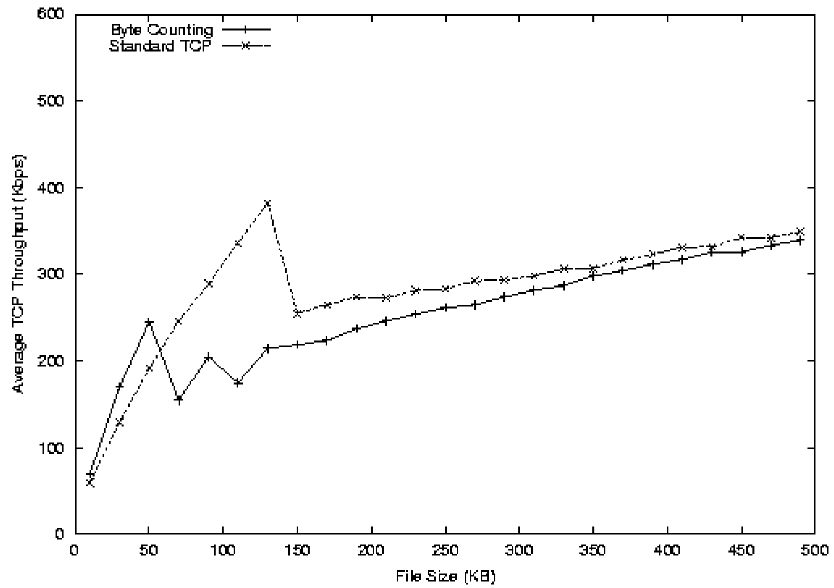


# Interaction between *d* and *B*

$W_{th}$ set to a large value.
Plot the throughput as a function of the file size.




B=70 packets




B=20 packets



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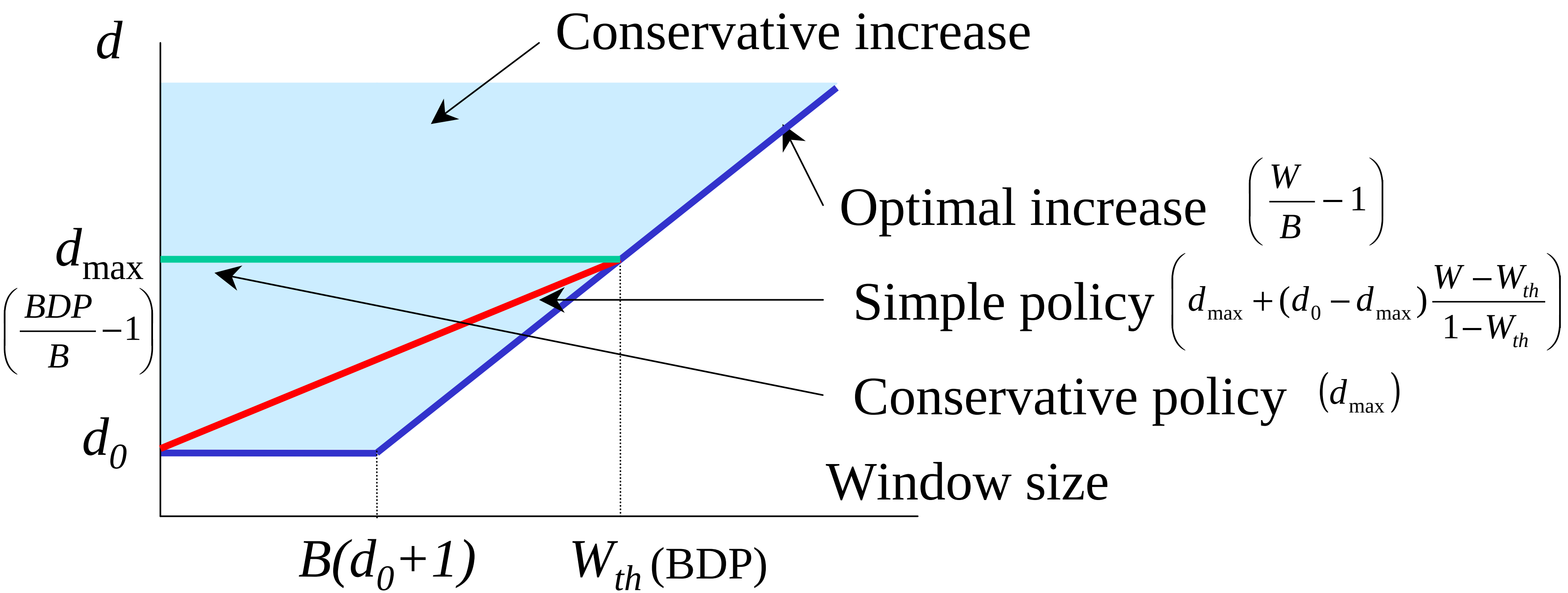
# How to increase the window?

Let $d_0$ represent the maximum window increase rate.



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# Decreasing Byte Counting

- Let $d_0$=1 and set a value for $d_{\max}$ (1,2,…).
- Upon ACK arrival at the source :
  - Standard TCP (d=2) : $W += 1$
  - Limited Byte Counting (d=1) :

$$W += \min(DataCovered, 2)$$

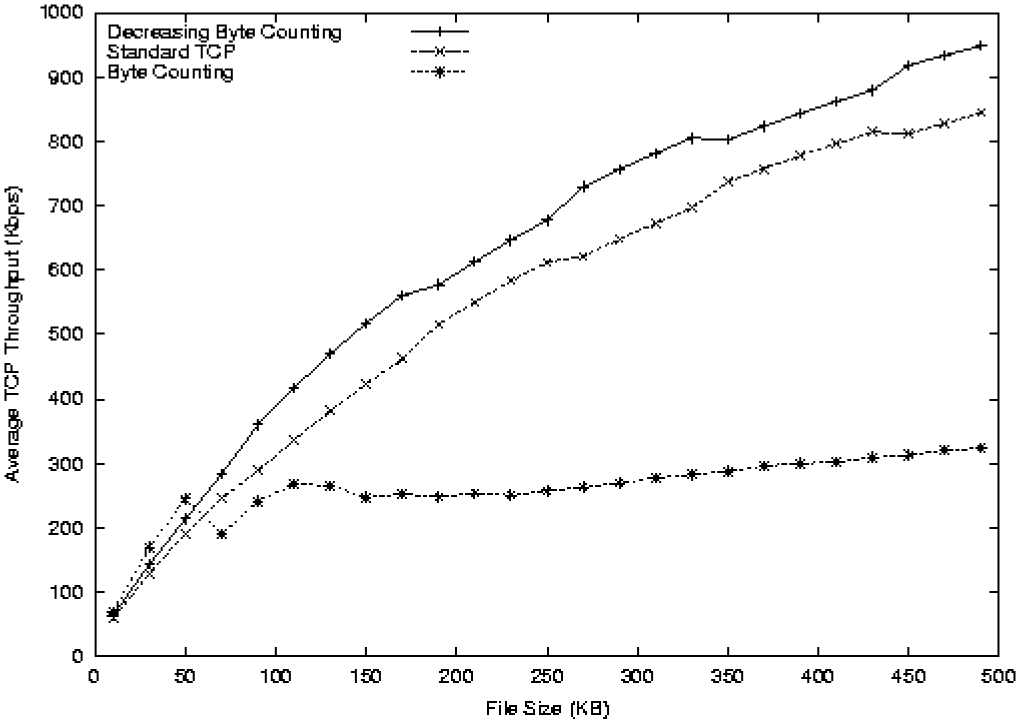
  - Decreasing Byte Counting ($d$=1 to $d_{\max}$):

$$W += \min(DataCovered, 2)\left( d_{\max} + \left(1 - d_{\max}\right) \times \frac{W - W_{th}}{1 - W_{th}} \right)^{-1}$$

# Simulation

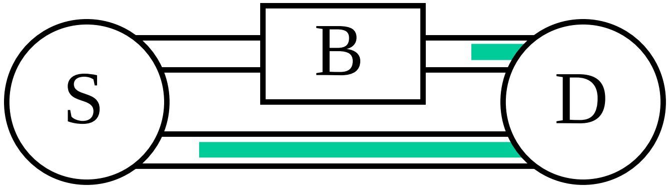
Set $W_{th}$ to the BDP.

Take *B* such that $d=2$ is not aggressive and $d=2$ is.

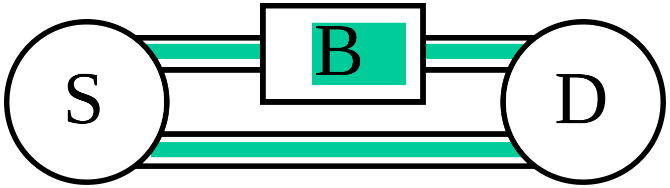


# Case of multiple connections

- Multiple connections of close RTT share the bottleneck.
- A new connection finds $N$ packets in the network where $W_{max}/2 < N < W_{max}$.




$N < \mu T$




$N > \mu T$

# The overflow window $W_B$

- Similarly to the case of a single connection

$$W_B = \min[W_{\max} - N , B(d+1)]$$

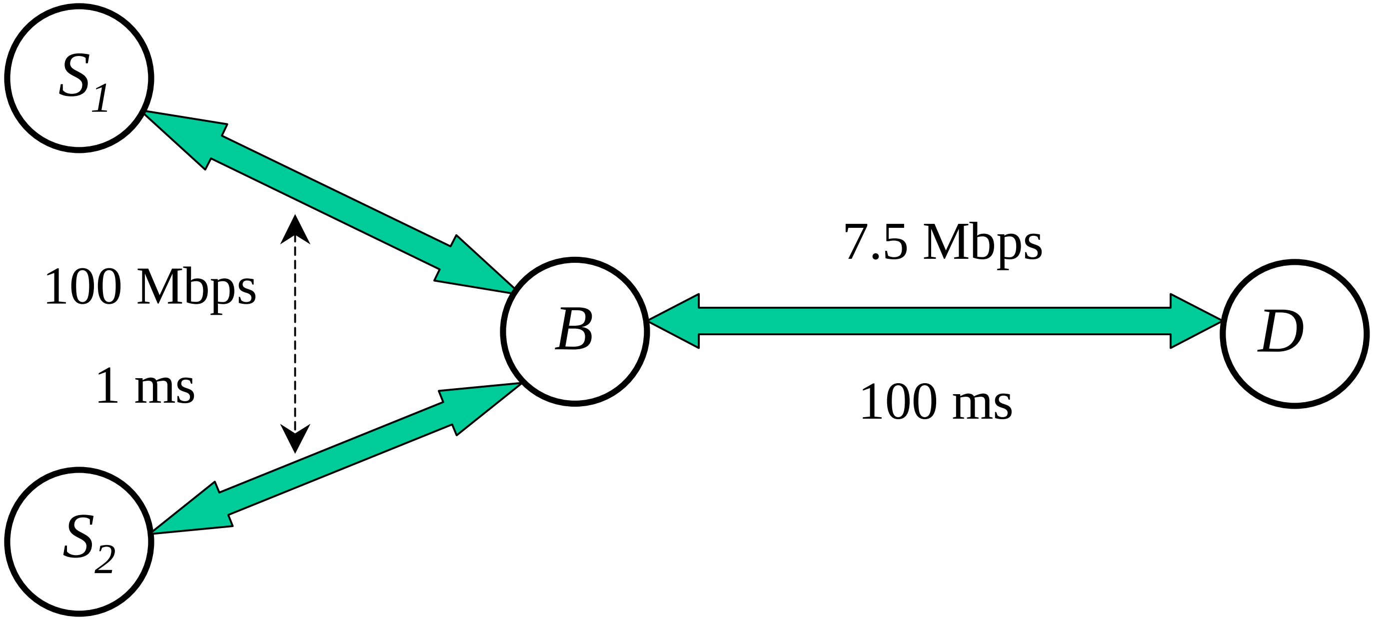
  – $W_B$ varies between 0 and $W_B^{max}$

$$W_B^{\max} = \min[W_{\max}/2 , B(d+1)]$$

  – The window growth rate during Slow Start can be increased as long as

$$B > \frac{\min[W_{th}, W_{\max} - N]}{d+1} \geq \frac{\min[W_{th}, W_{\max}]}{d+1}$$

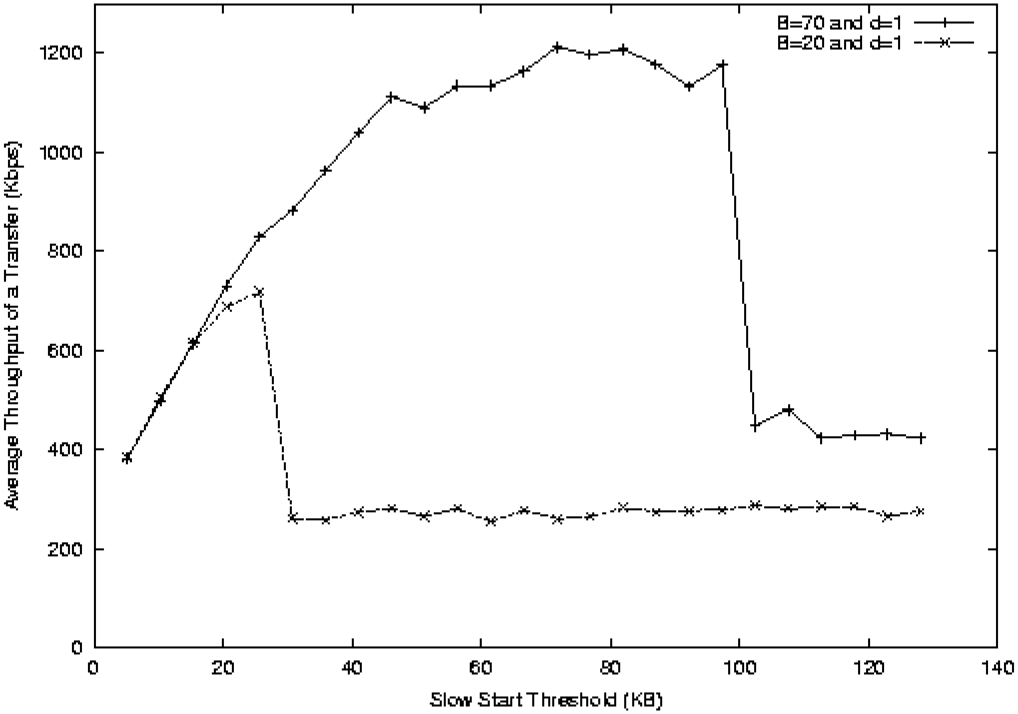
# A couple of simulations




– Multiple transfers per source.
– File size chosen randomly between 100KB and 1MB.
– 50 simulations of 50 seconds each.

# Validation of the model for $W_B$

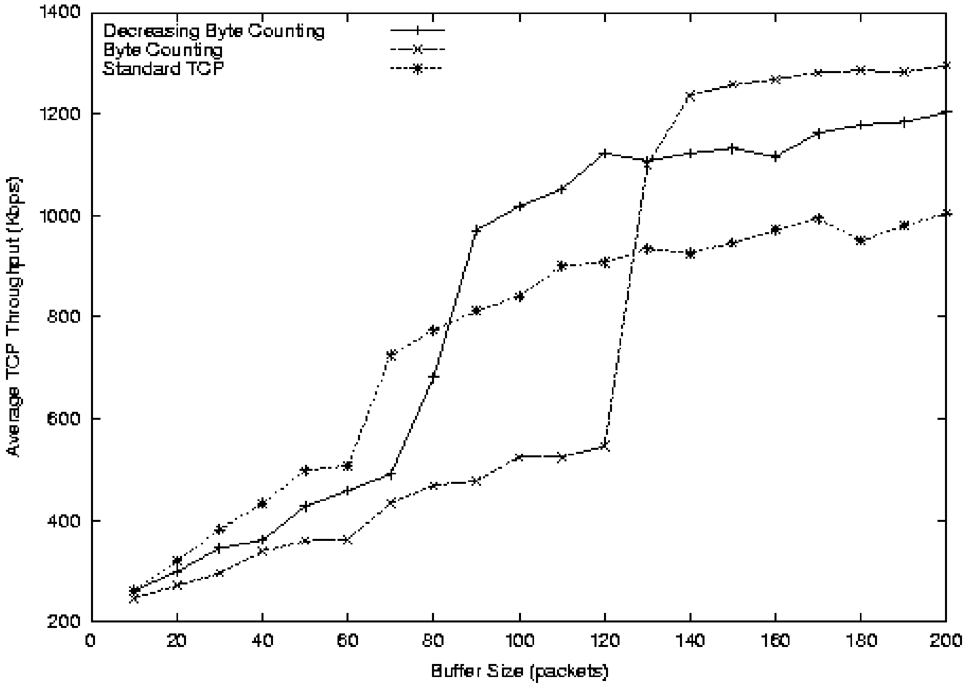
Plot the average throughput as a function of $W_{th}$.



# Decreasing Byte Counting

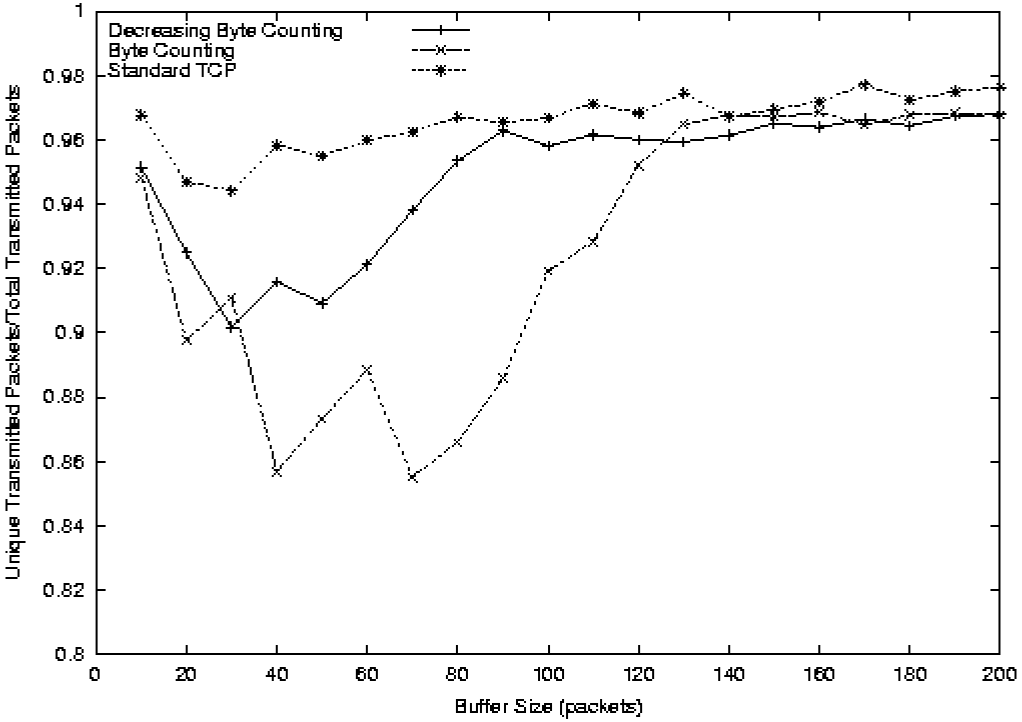
Set $d_0$ to 1, $d_{\max}$ to 2 and $W_{th}$ to the BDP.

Plot the average throughput as a function of *B*.



# Decreasing Byte Counting

Plot the retransmission ratio as a function of *B*.



# Conclusions and Perspectives

- A simple model for the study of Slow Start:
  - A problem of STCP in case of small buffers.
  - A limit on the window increase rate and thus on the duration of Slow Start.
- Decreasing Byte Counting: Reduce the burstiness as long as the window grows.
- Still have to investigate the other direction for Slow Start enhancement: *Packet Pacing*.