Congestion Control in TCP

Antonio Carzaniga

Faculty of Informatics
University of Lugano

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Outline

- Intro to congestion control
- Input rate vs. output throughput
- Congestion window
- “Congestion avoidance”
- “Slow start”
- “Fast recovery”

Understanding Congestion

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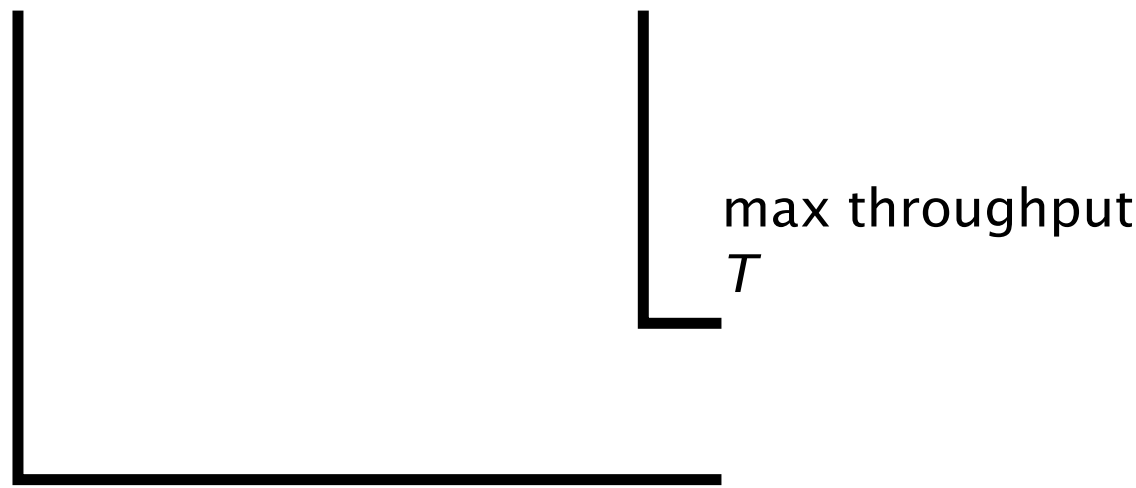

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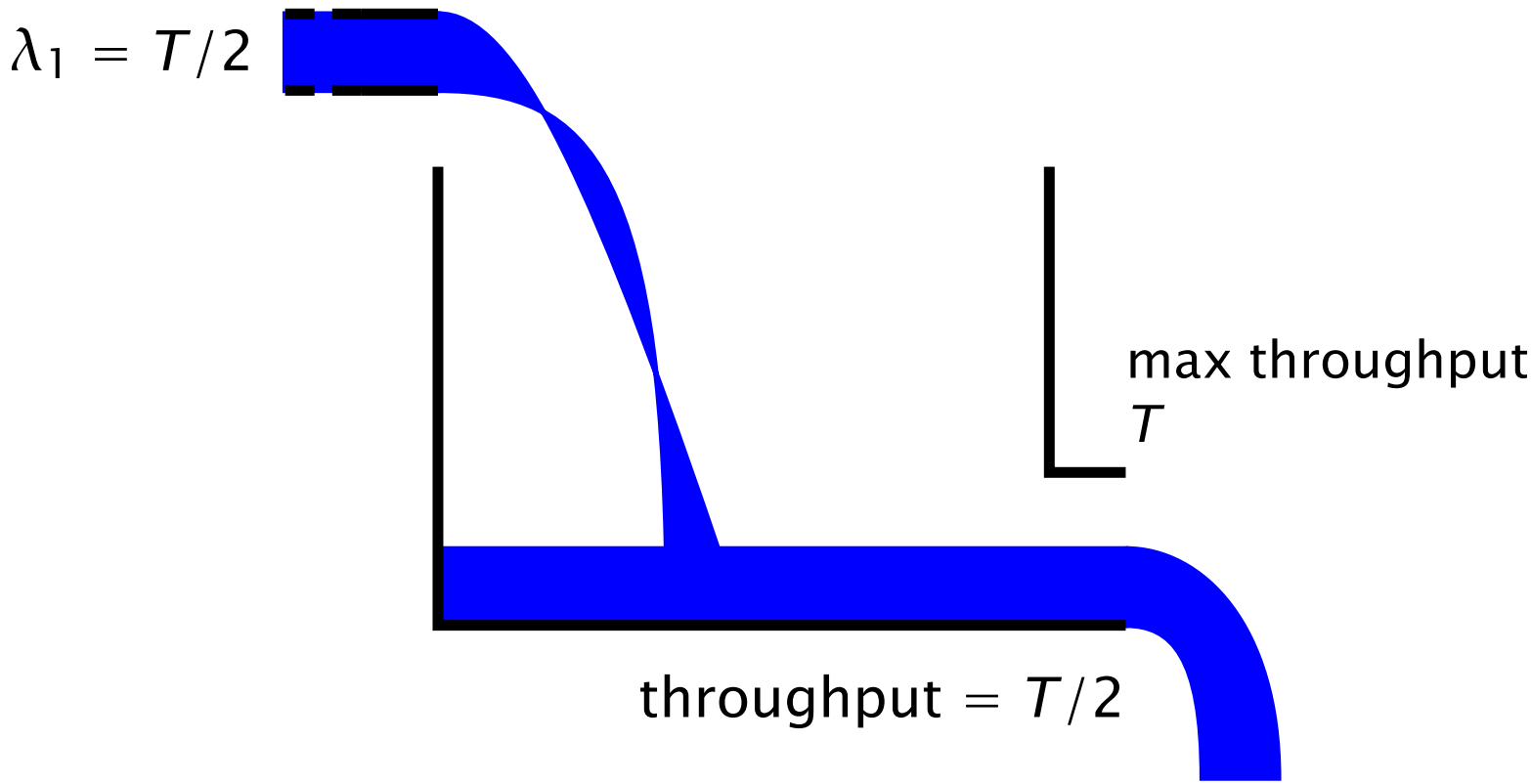

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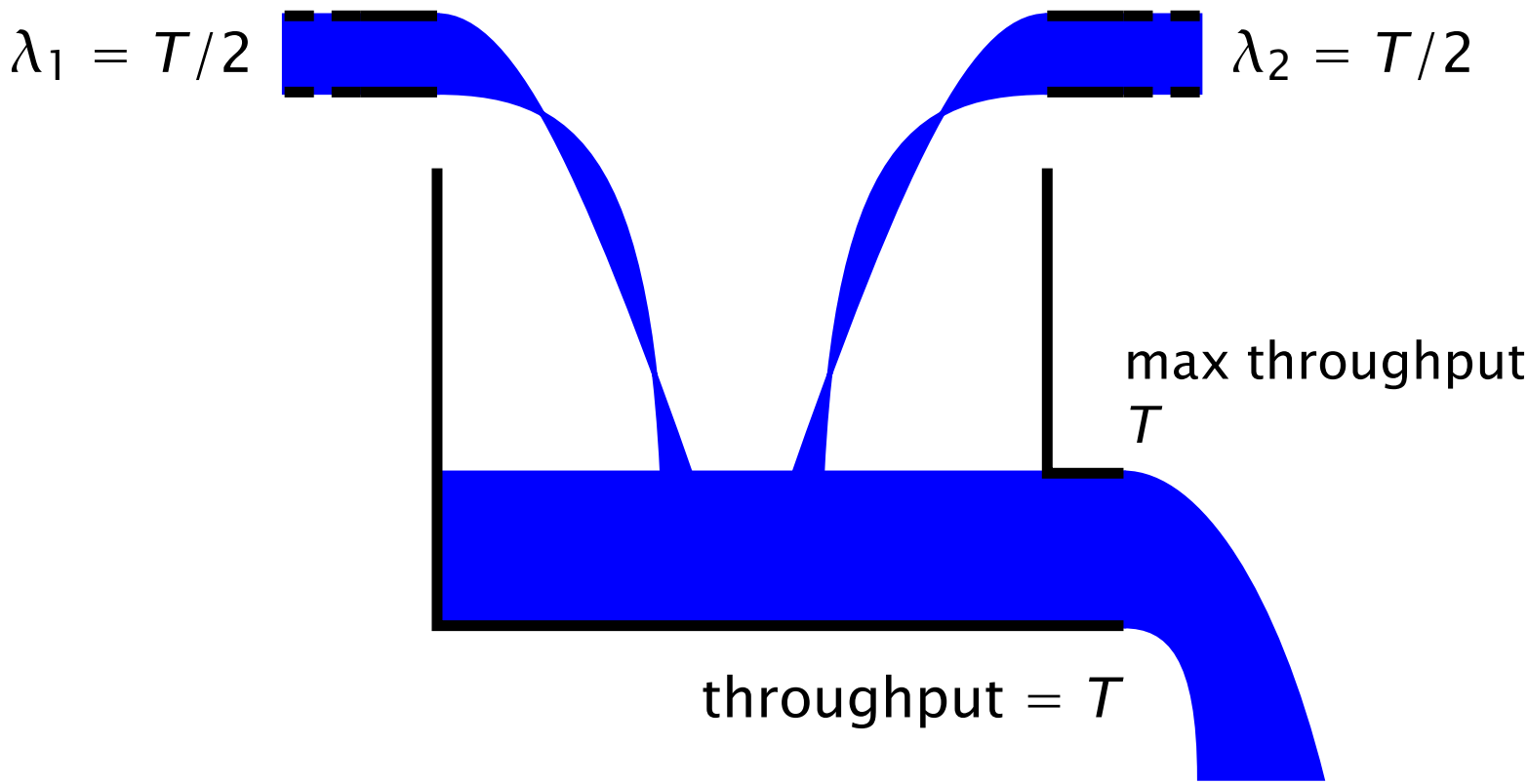

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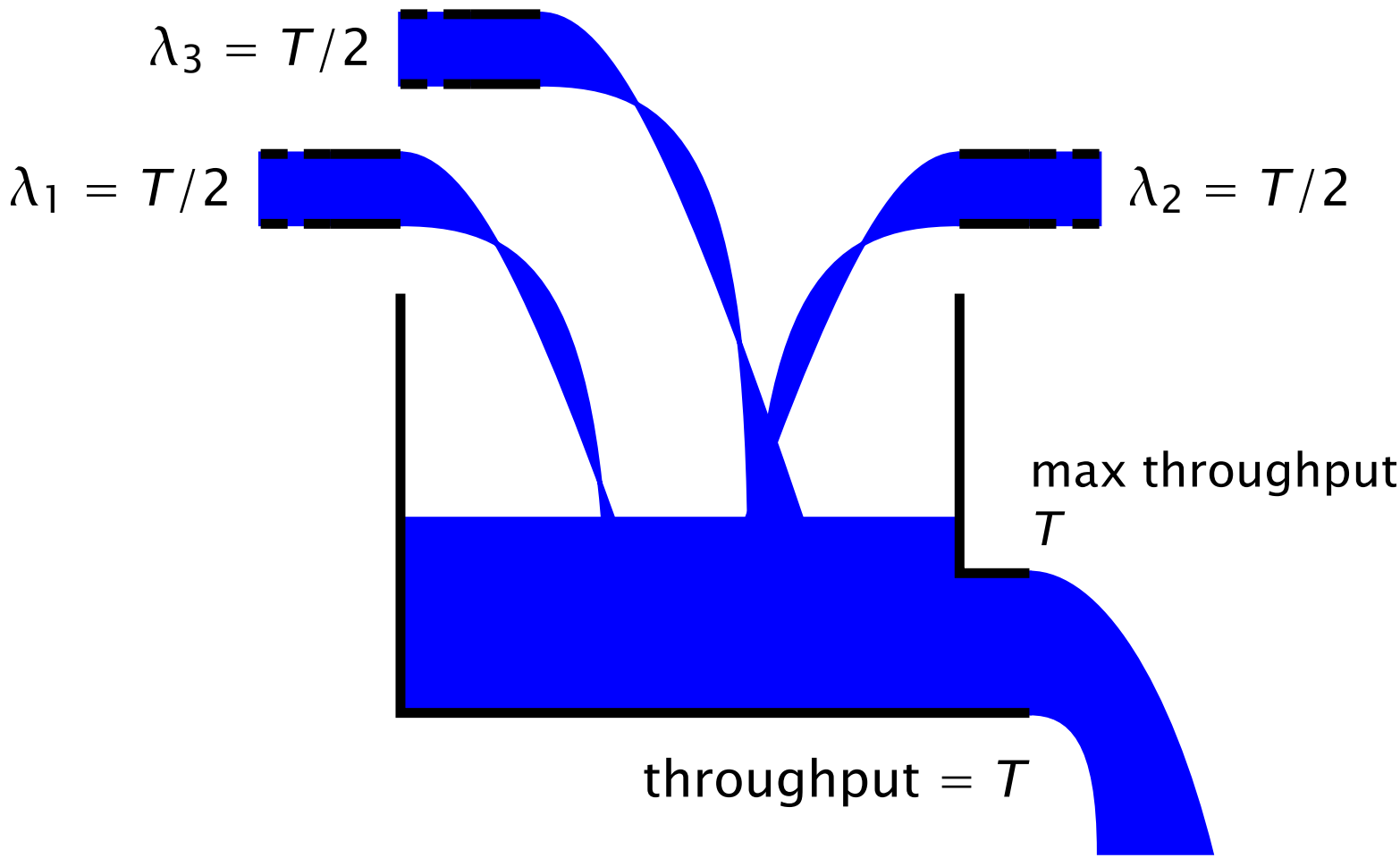

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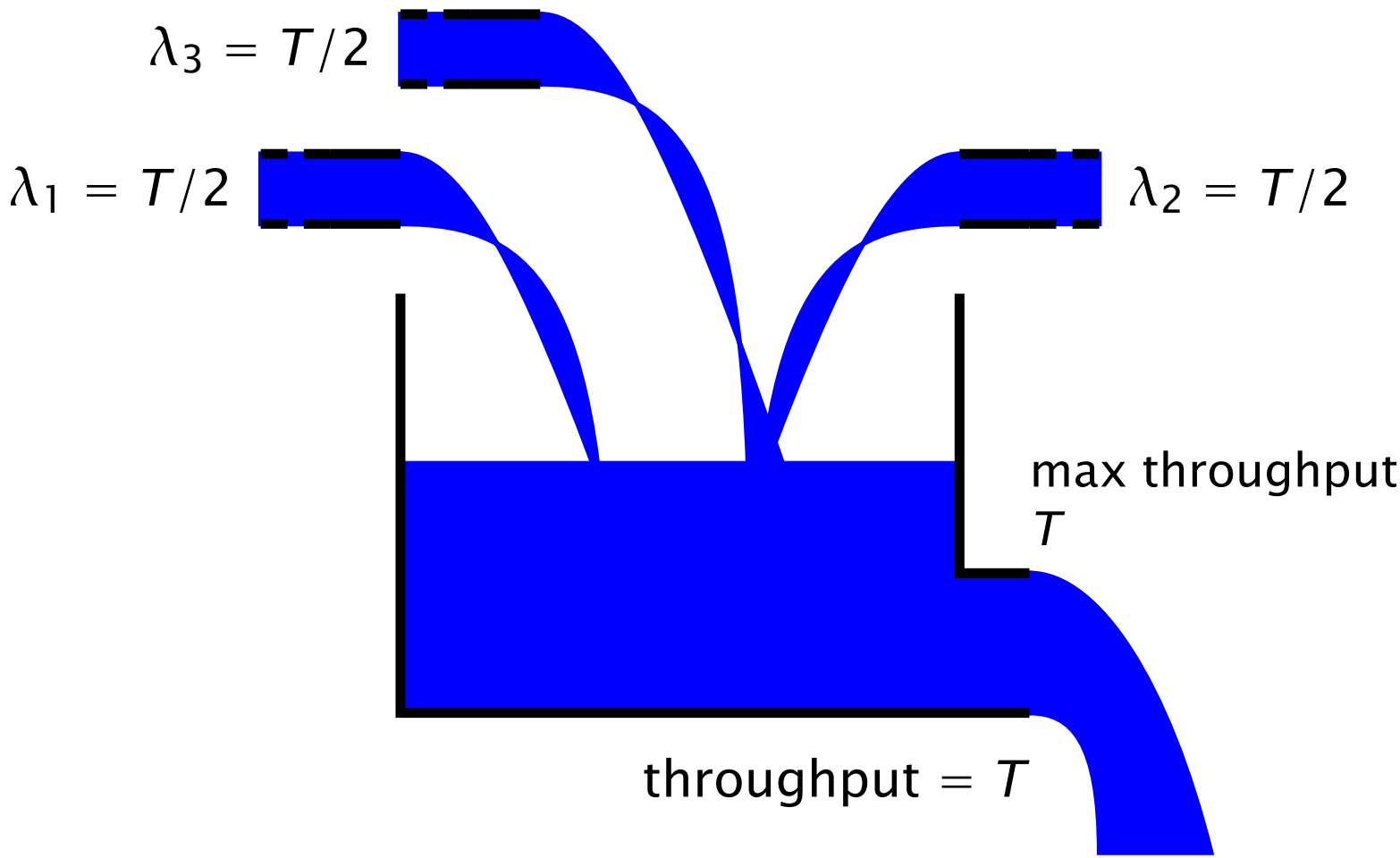

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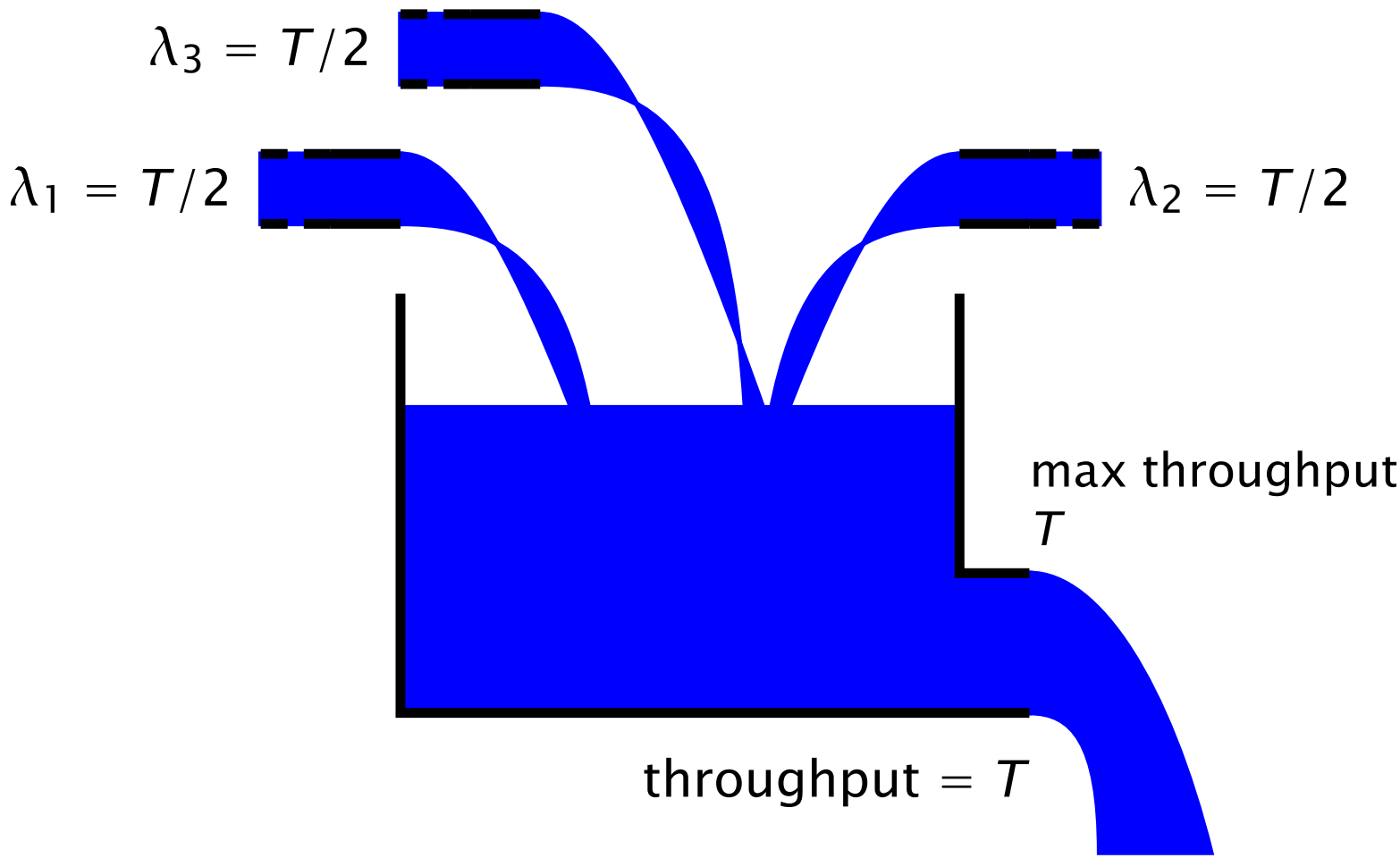

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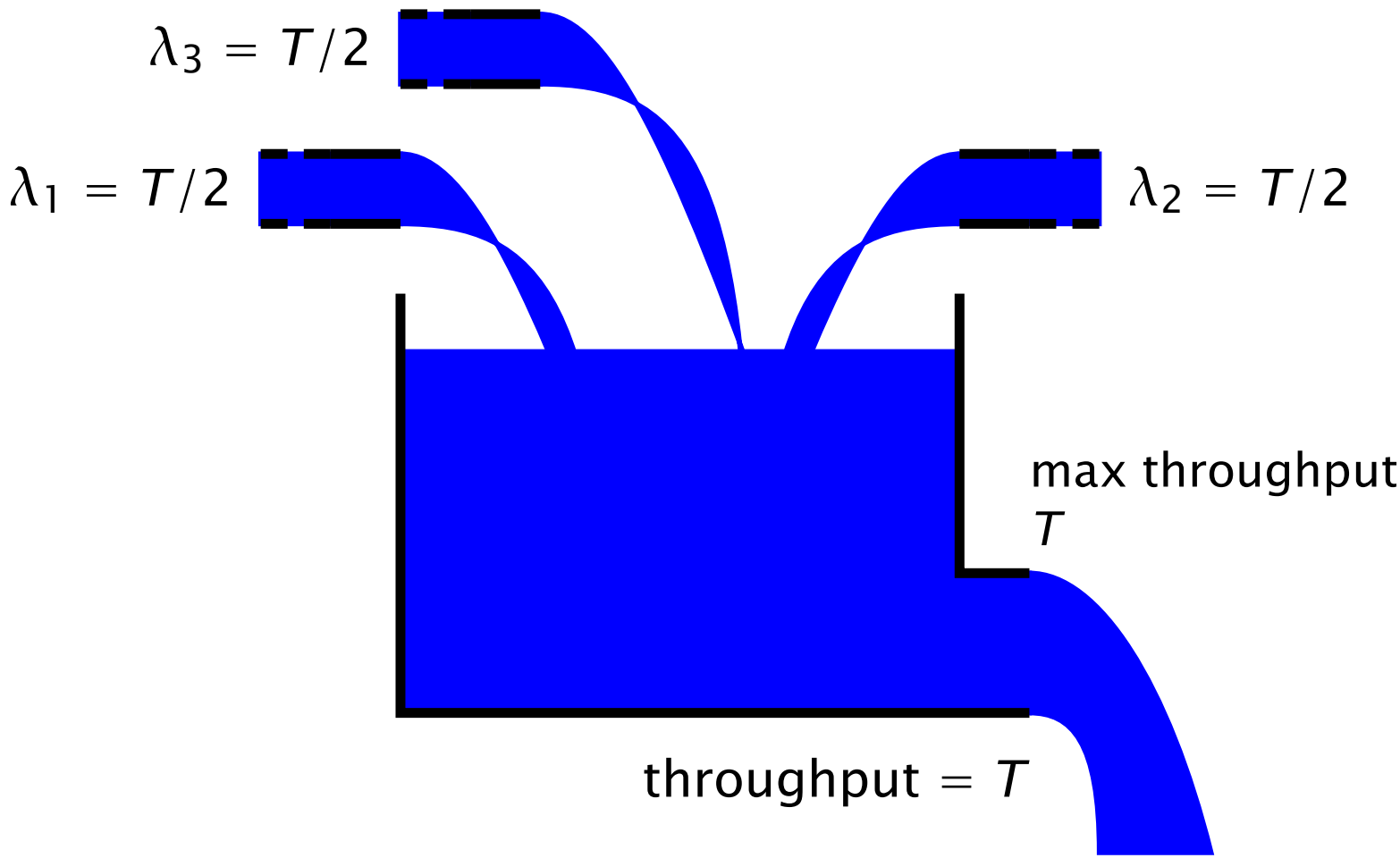

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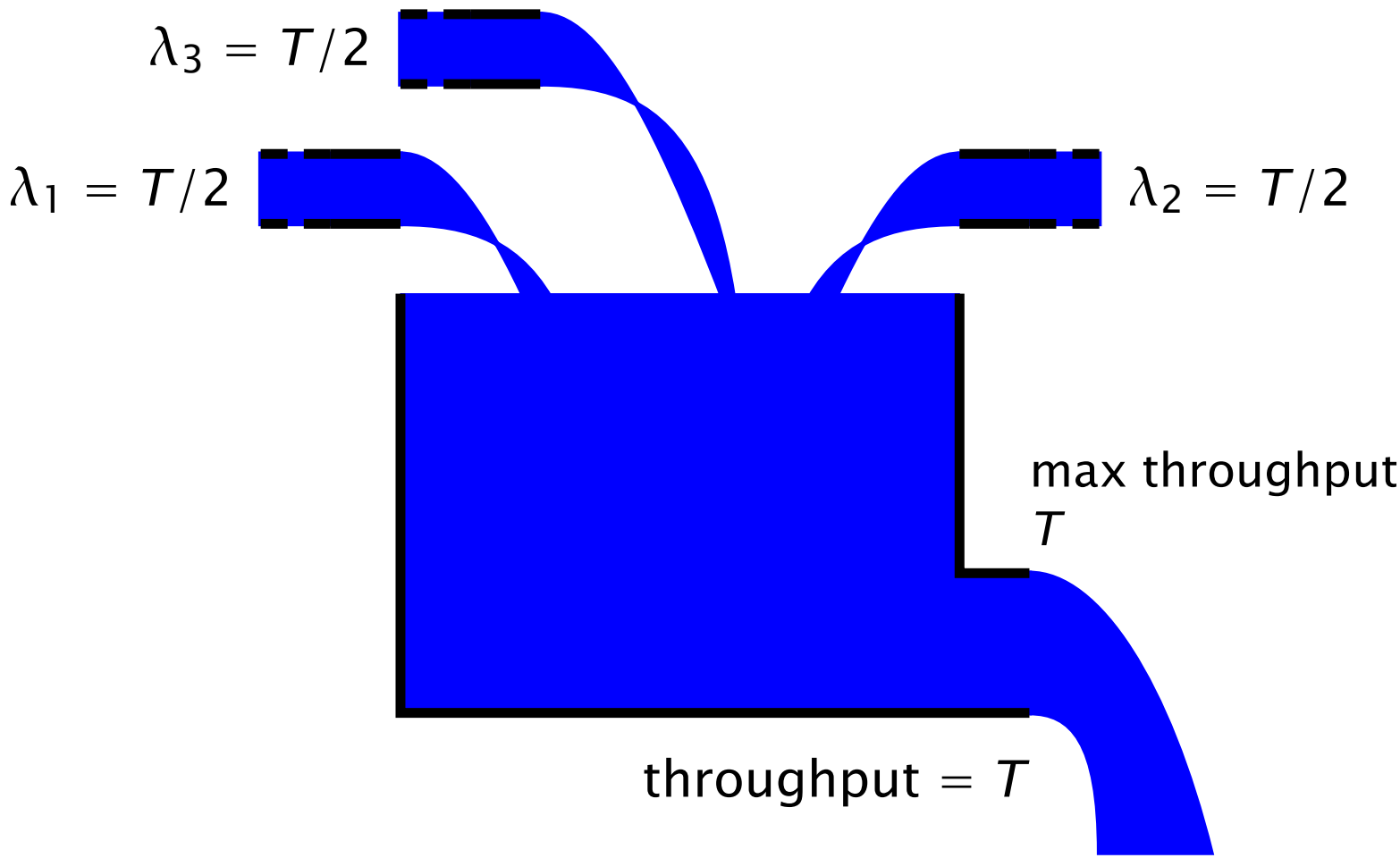

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  In this case $|q| = (\lambda_{in} - T)t$ and therefore

$$\Delta_q = \frac{\lambda_{in} - T}{T} t$$

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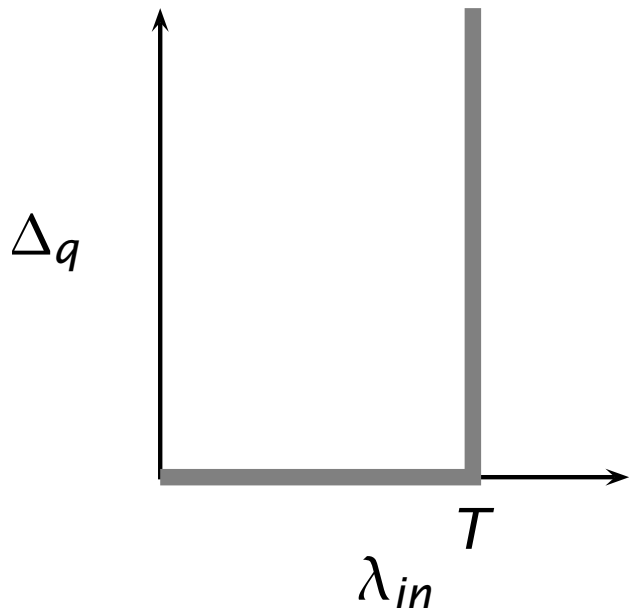

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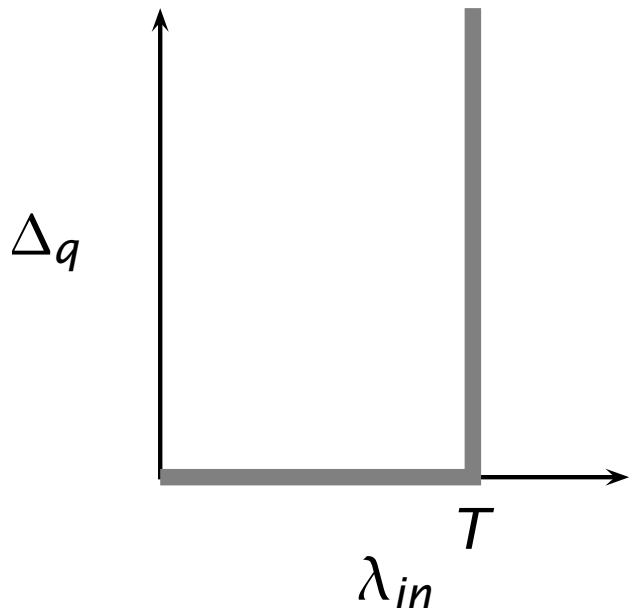

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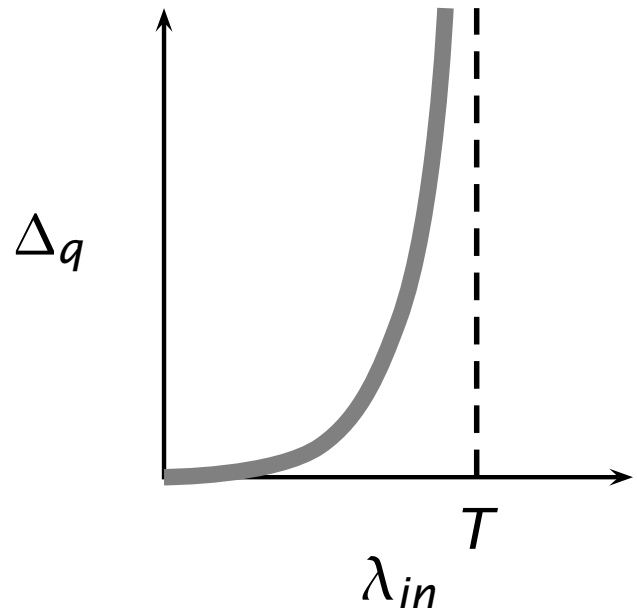

realistic input flow
λ_{in} variable

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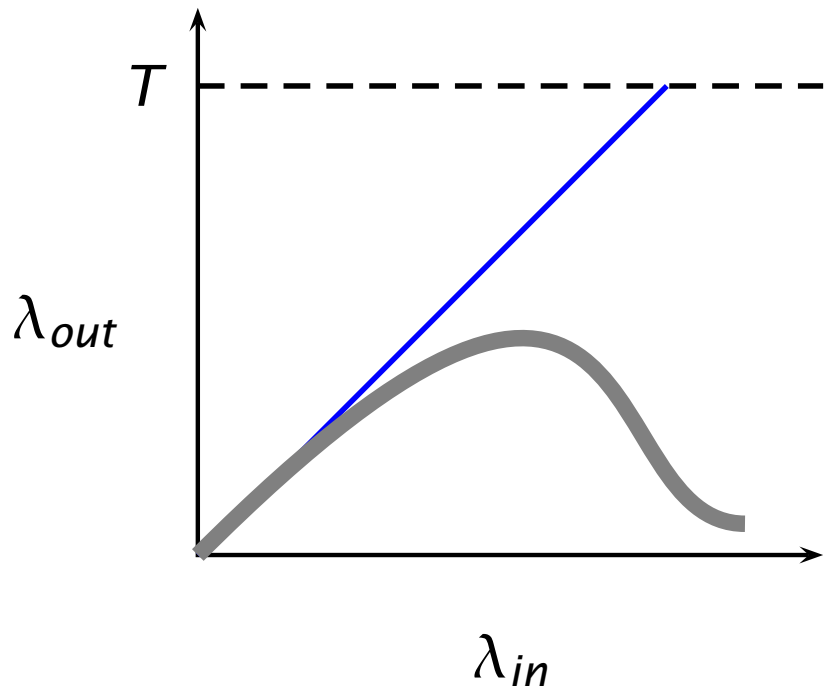

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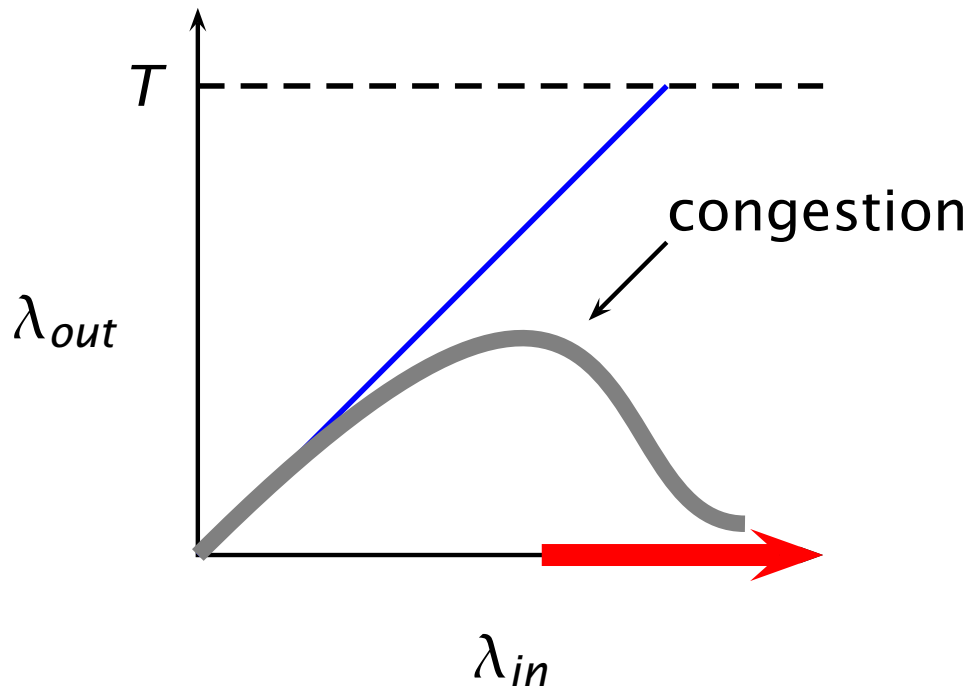

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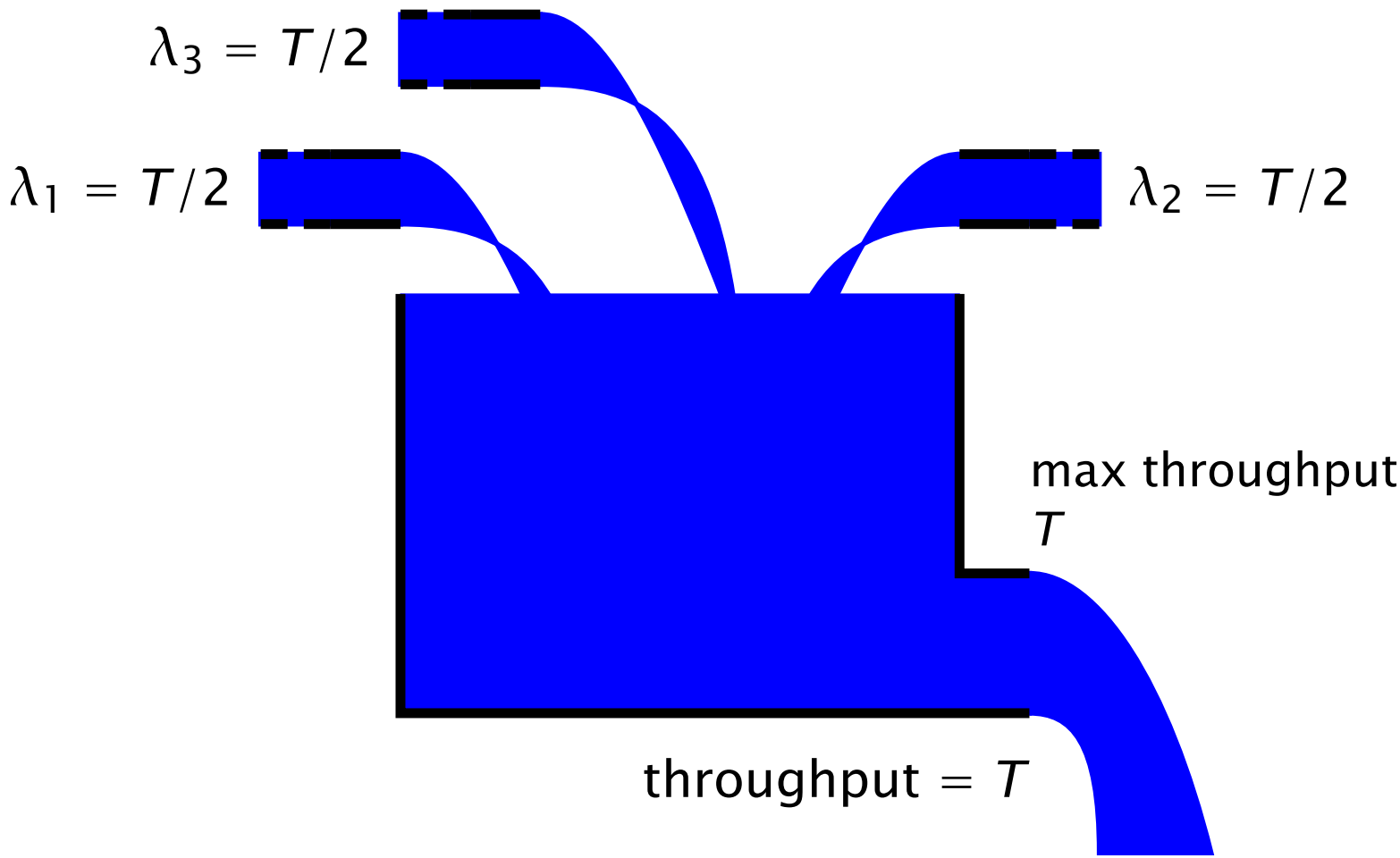

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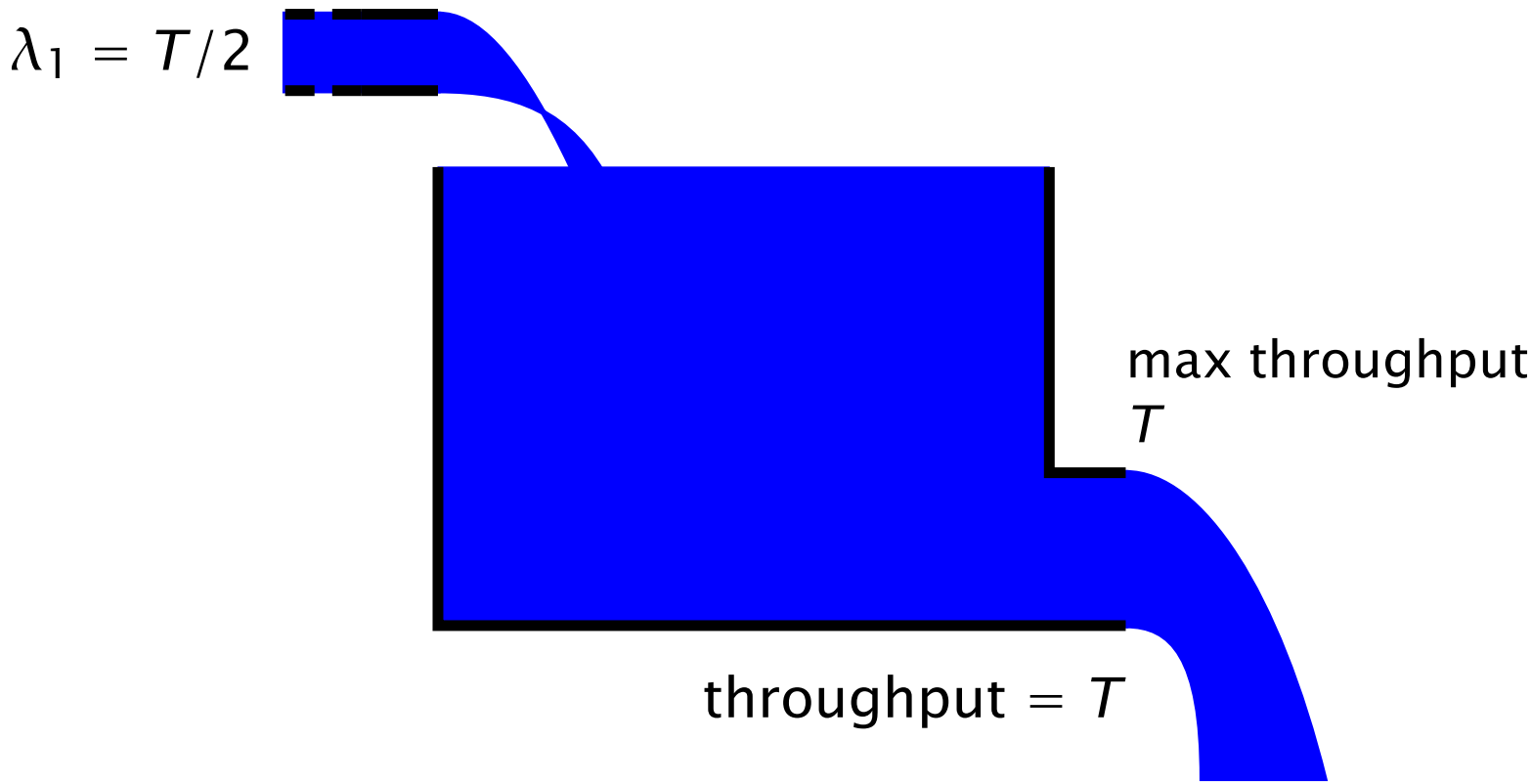

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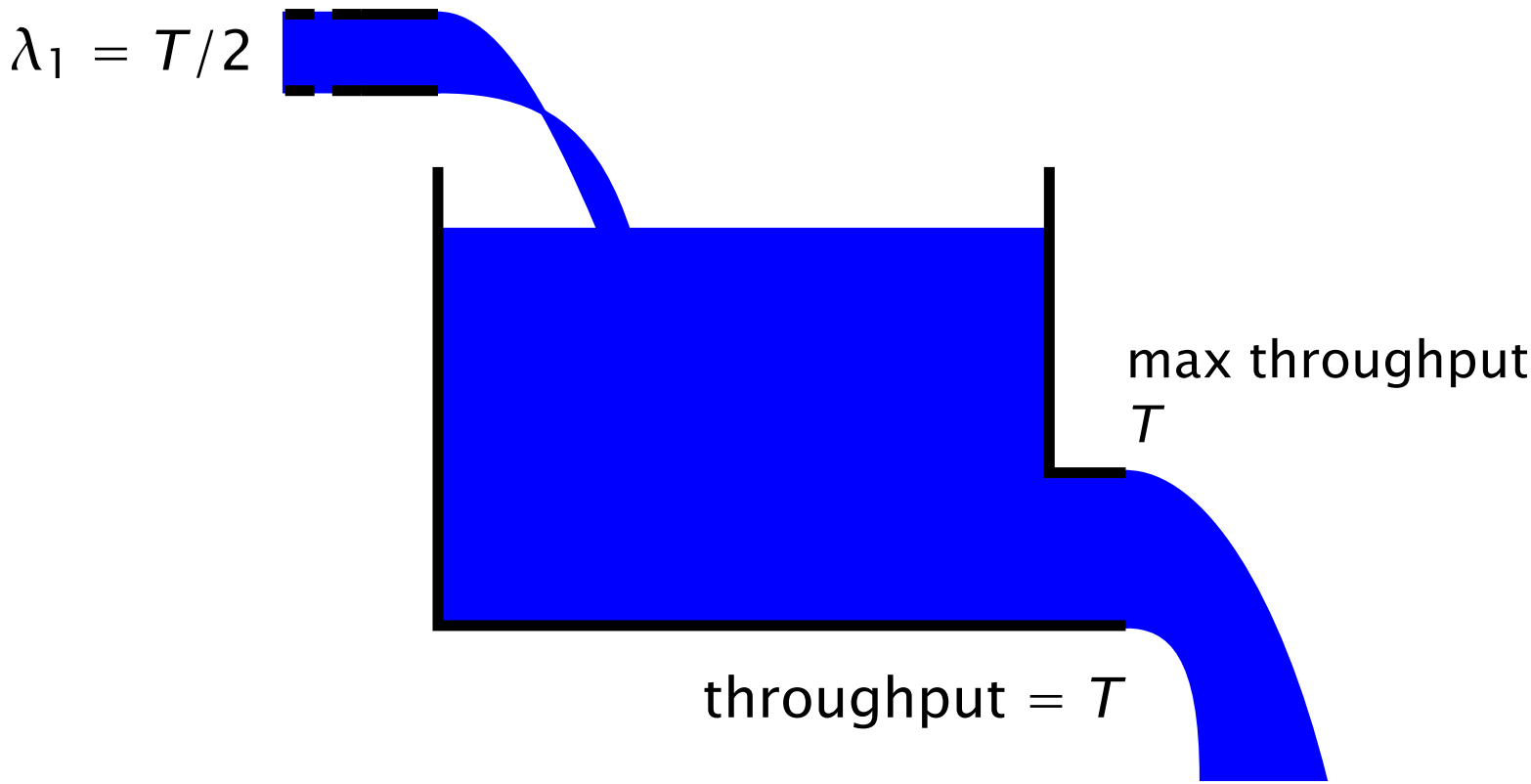

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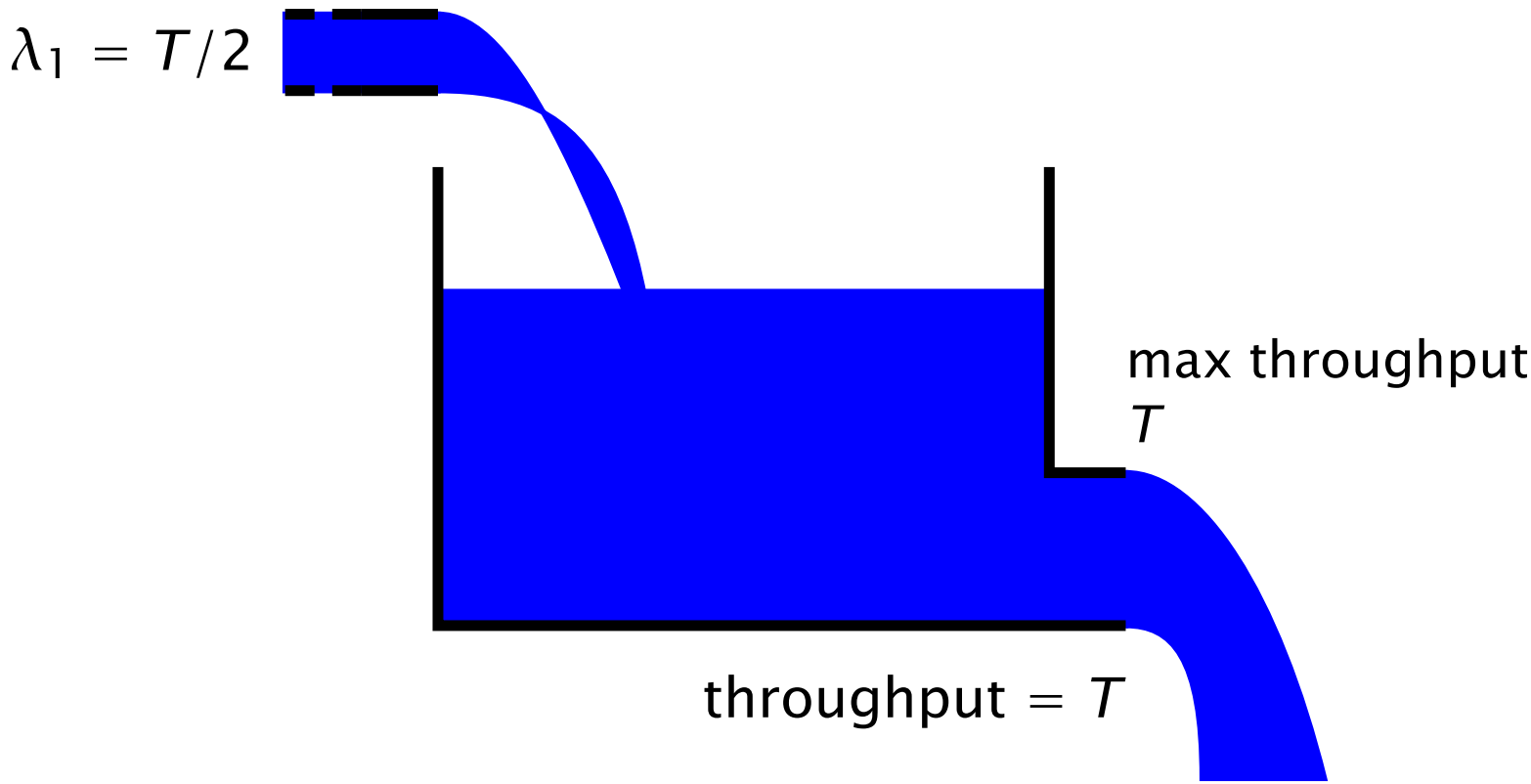

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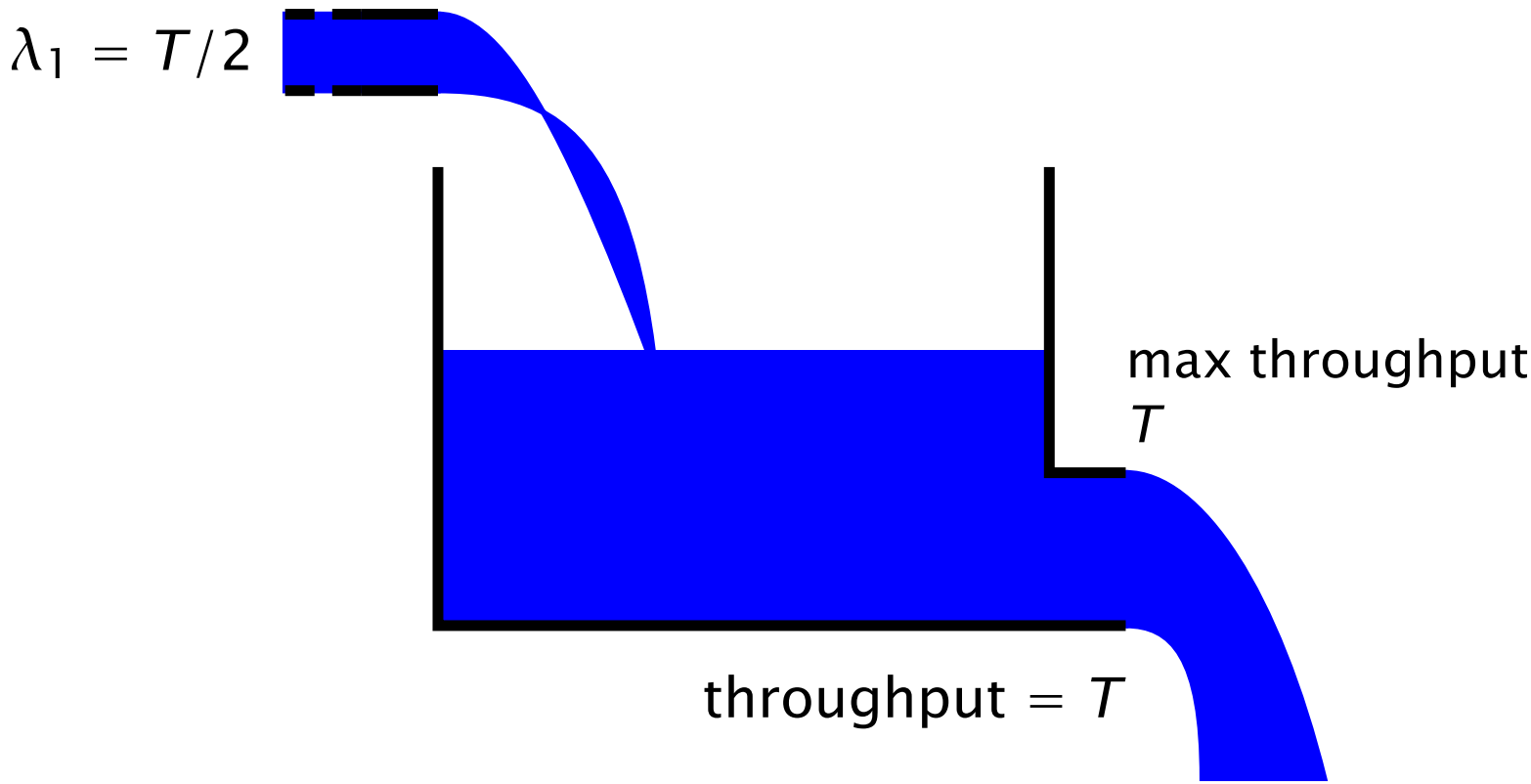

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  - how should the sender "modulate" its output rate?
    - i.e., what algorithm should the sender use to decrease or increase its output rate?

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  - the visible effect is that some segments are dropped
- Therefore the server assumes that the network is congested when it detects a segment loss
  - time out (i.e., no ACK)
  - multiple acknowledgements (i.e., NACK)

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- The resulting maximum output rate is roughly

$$\lambda = \frac{W}{2L}$$

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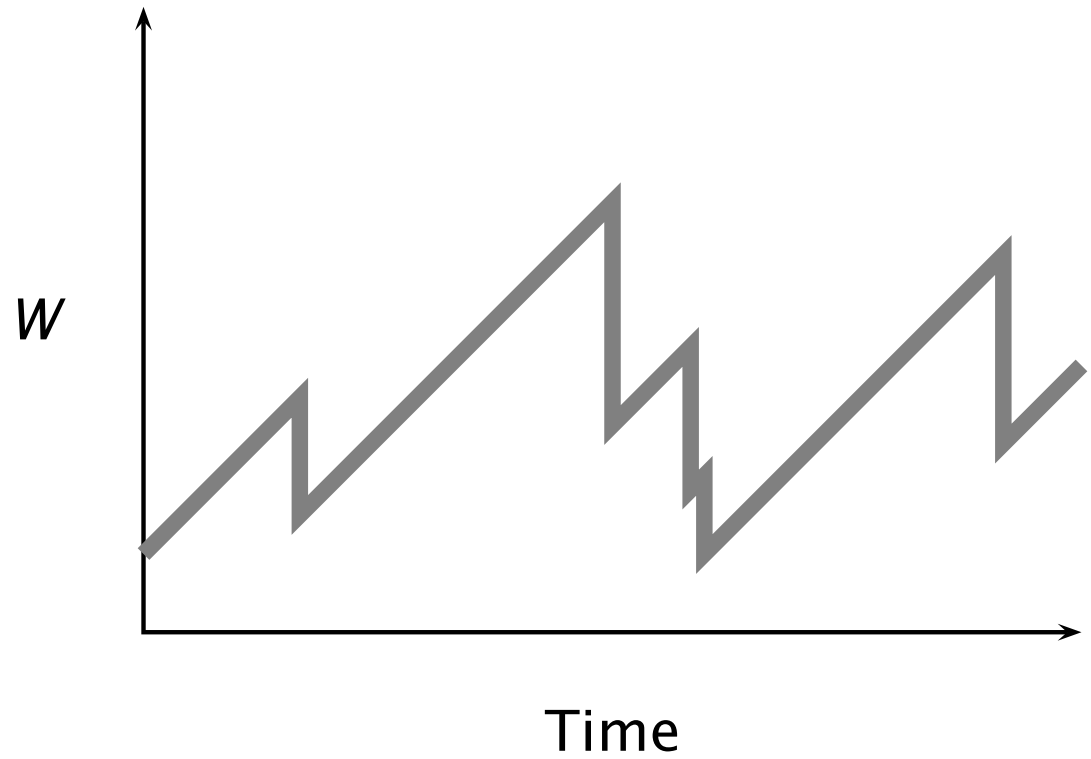
- Window size W over time



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- This process is called “slow start” because of the small initial value of *W*

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- So, TCP reacts differently to a timeout and to a triple duplicate ACKs

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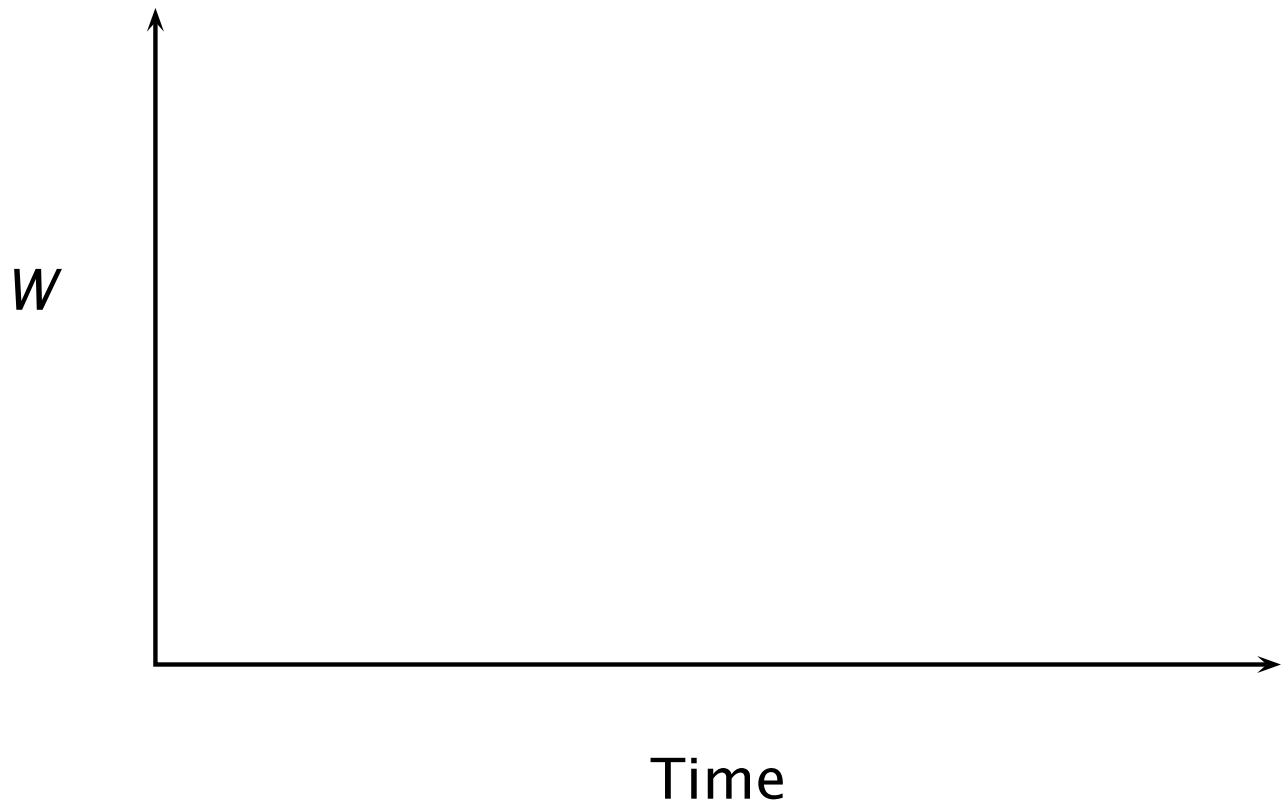
- *NACK* (i.e., triple duplicate-ack)
  - set $ssthresh = \overline{W}/2$
  - cut W in half: $W = \overline{W}/2$
  - run *congestion avoidance*, ramping up W linearly
  - This is called *fast recovery*

Sender Behavior



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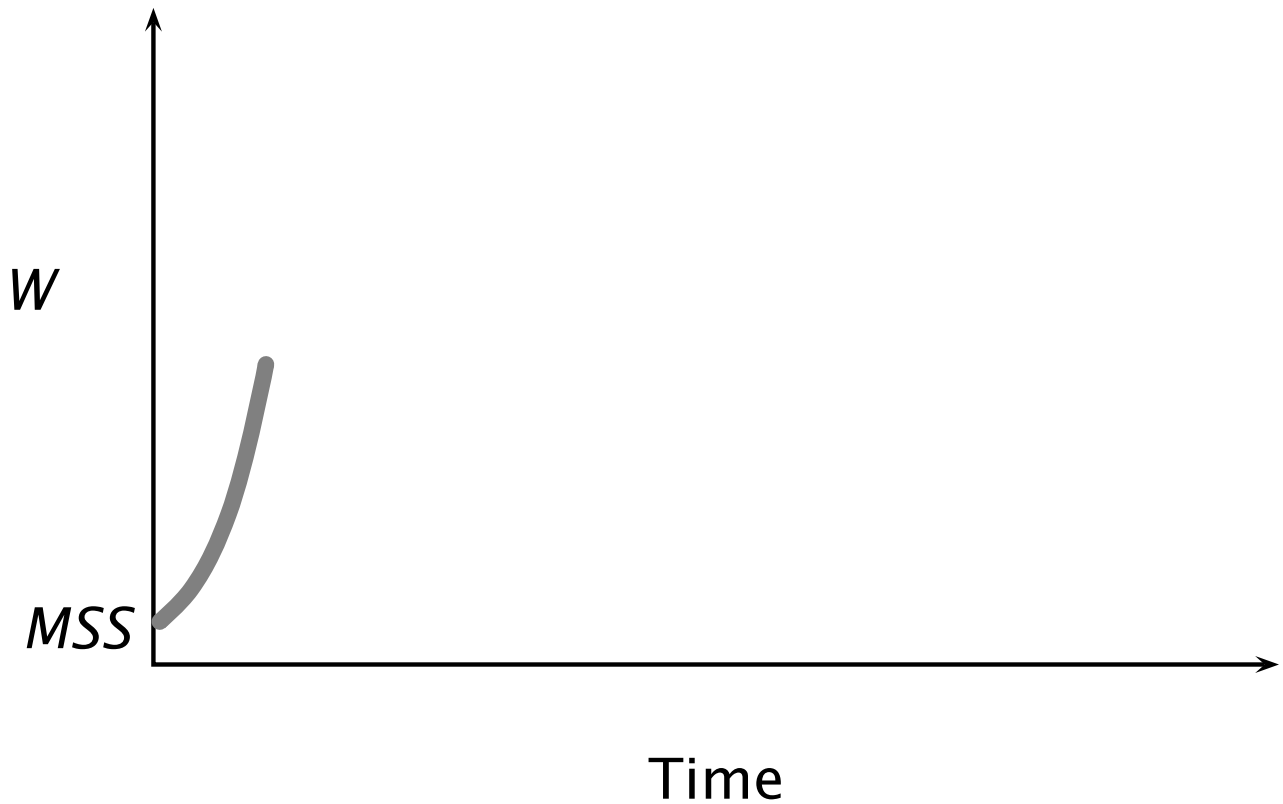

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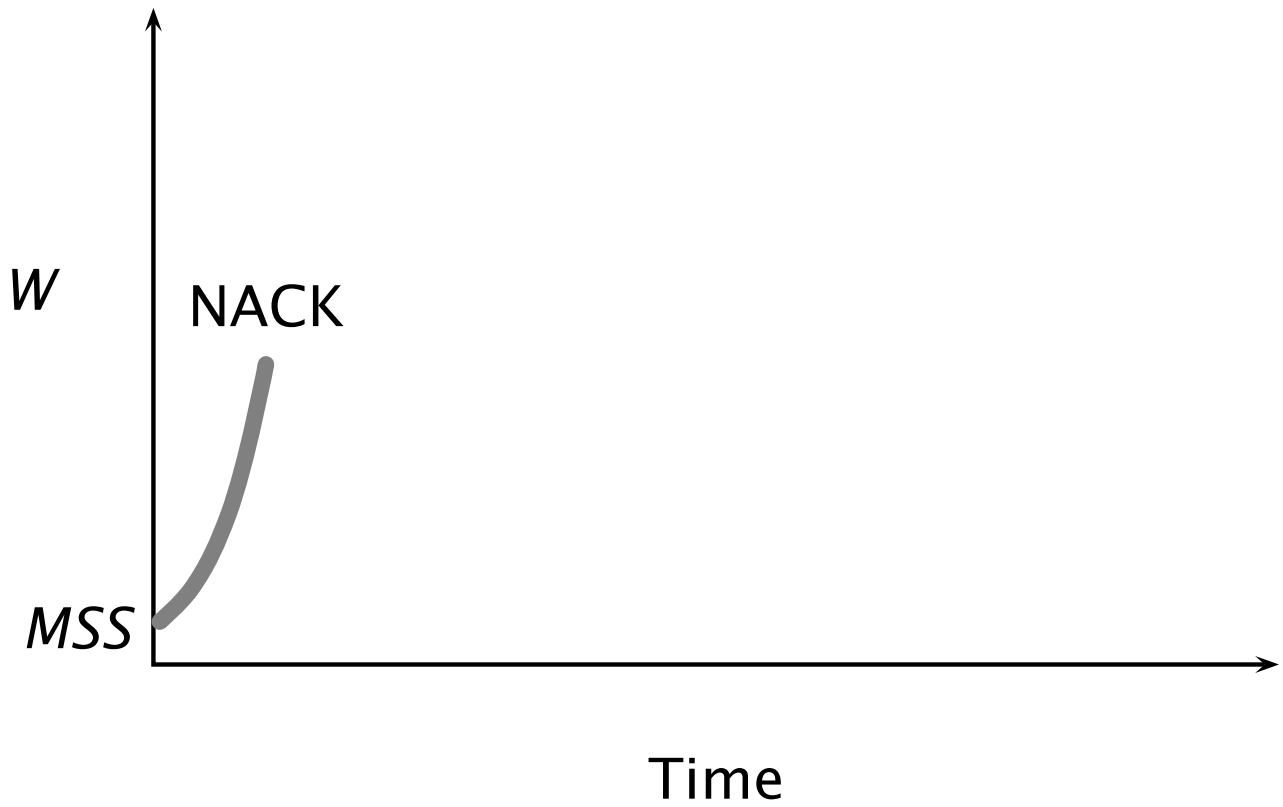

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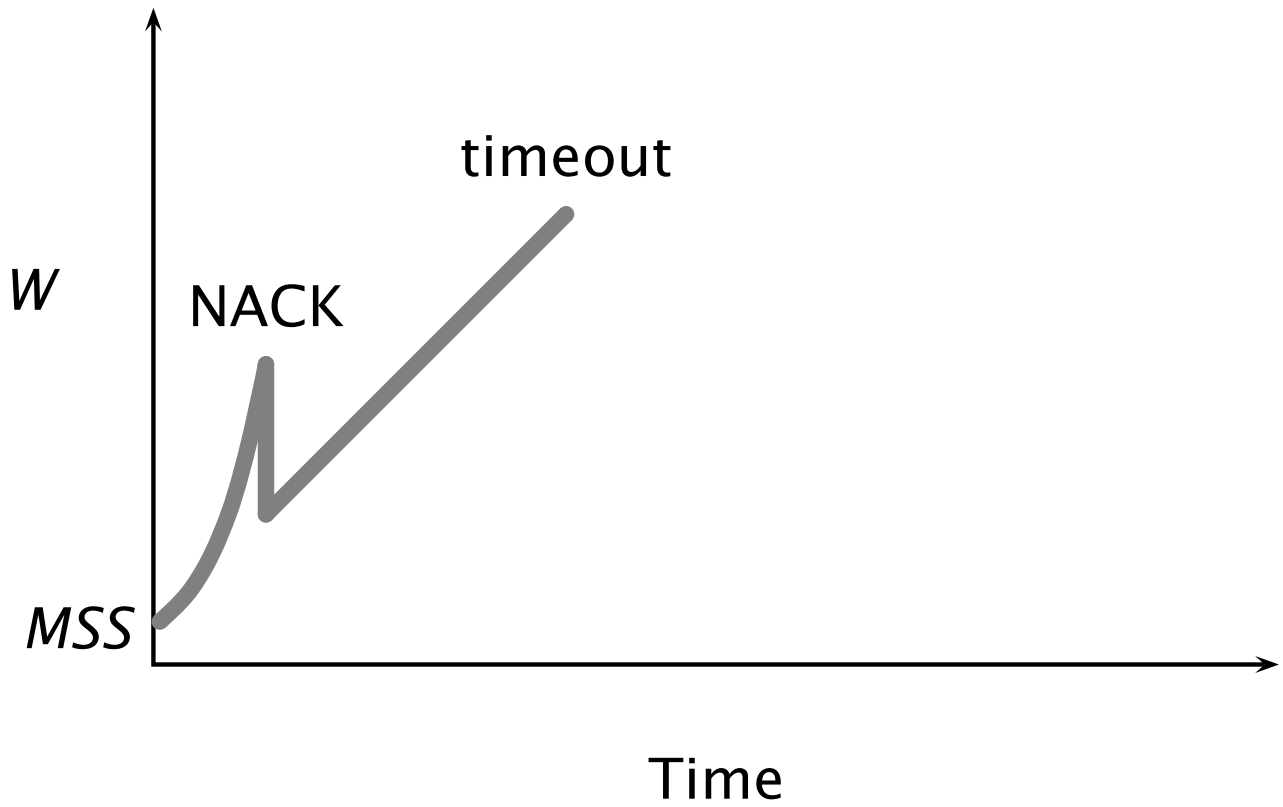

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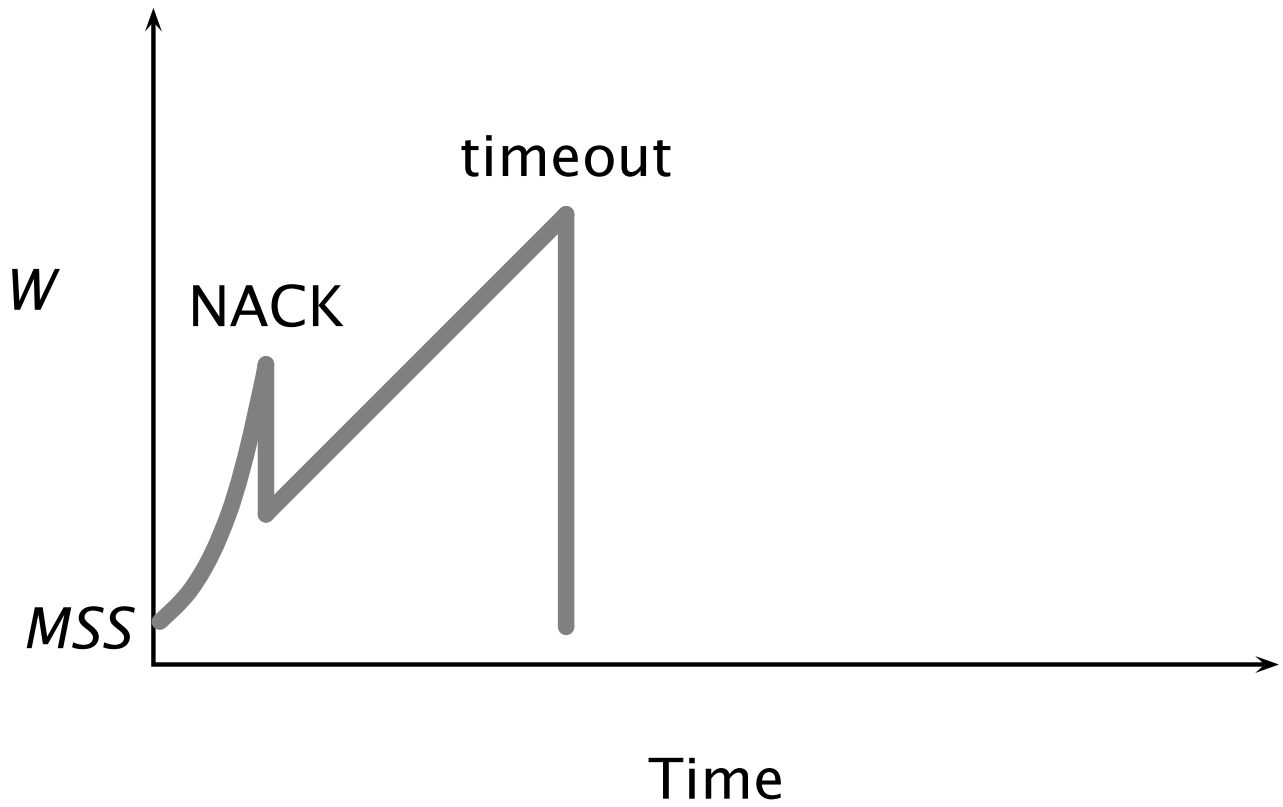

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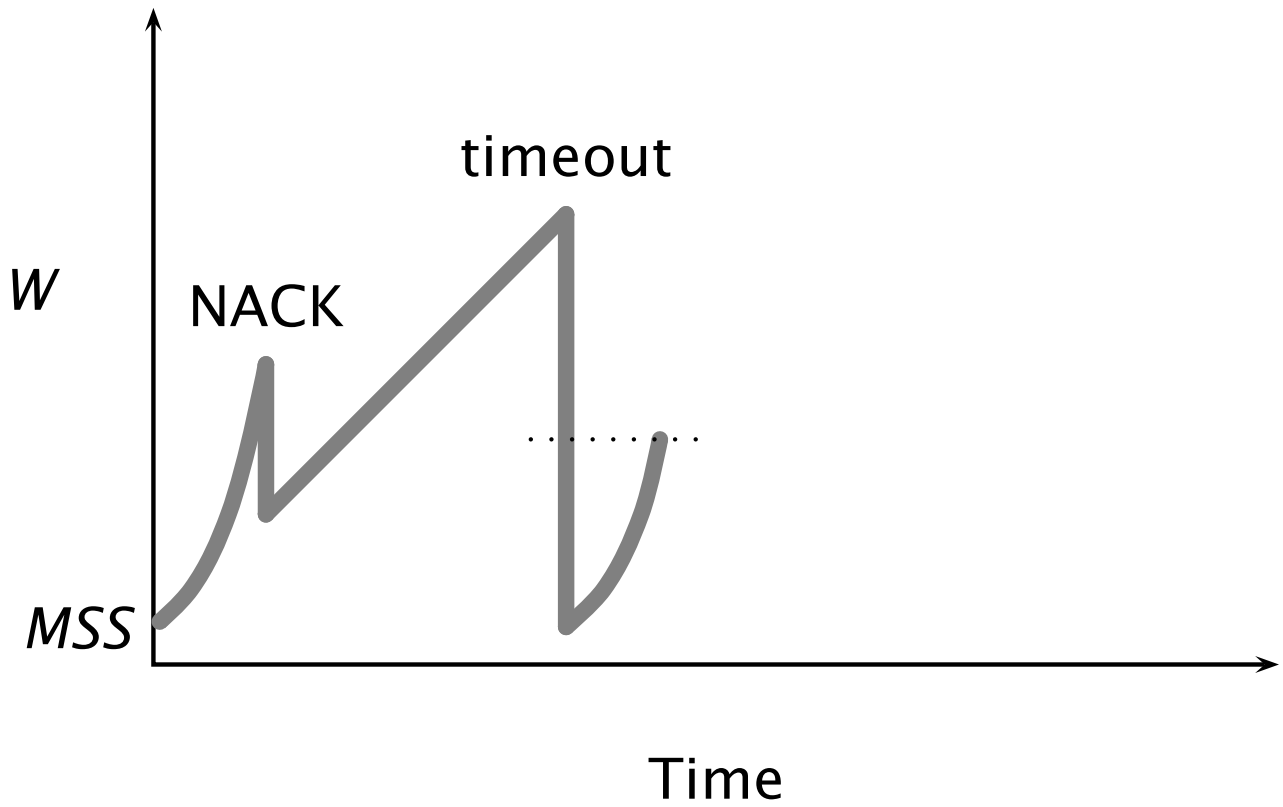

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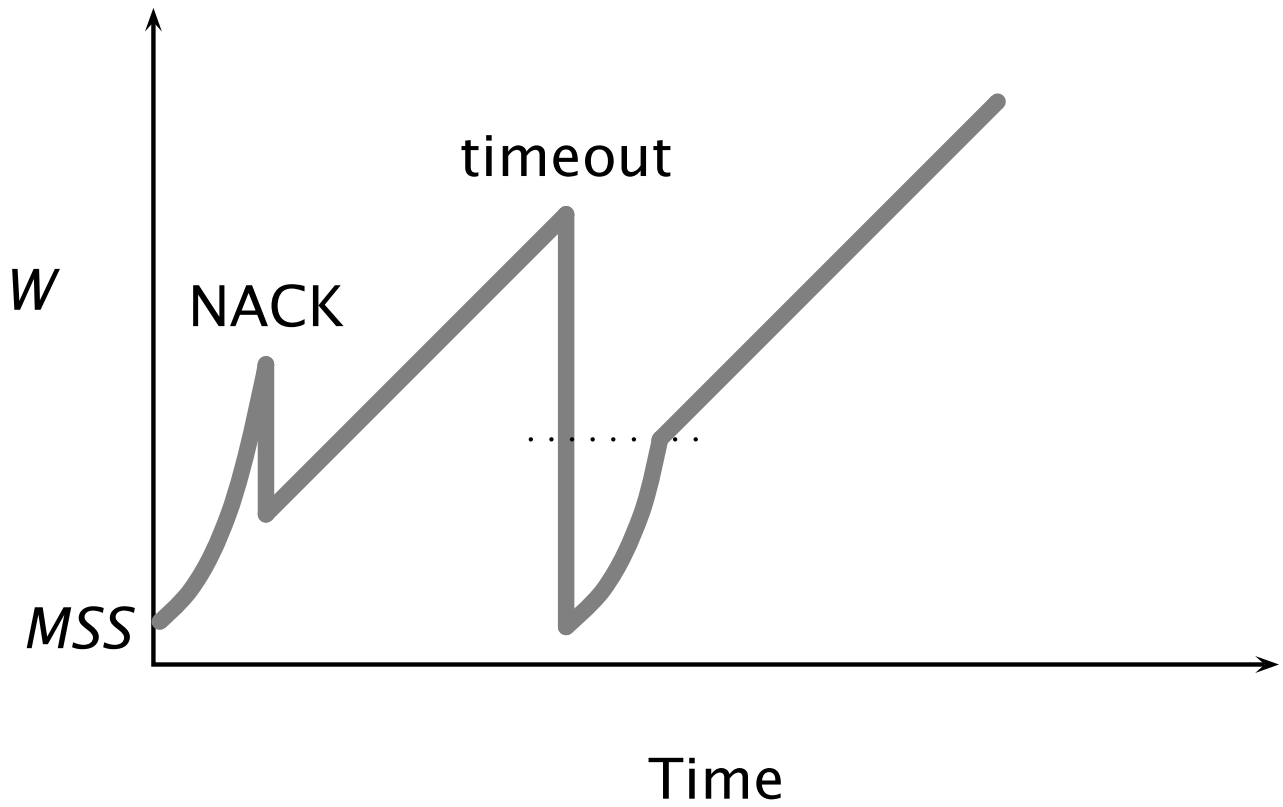

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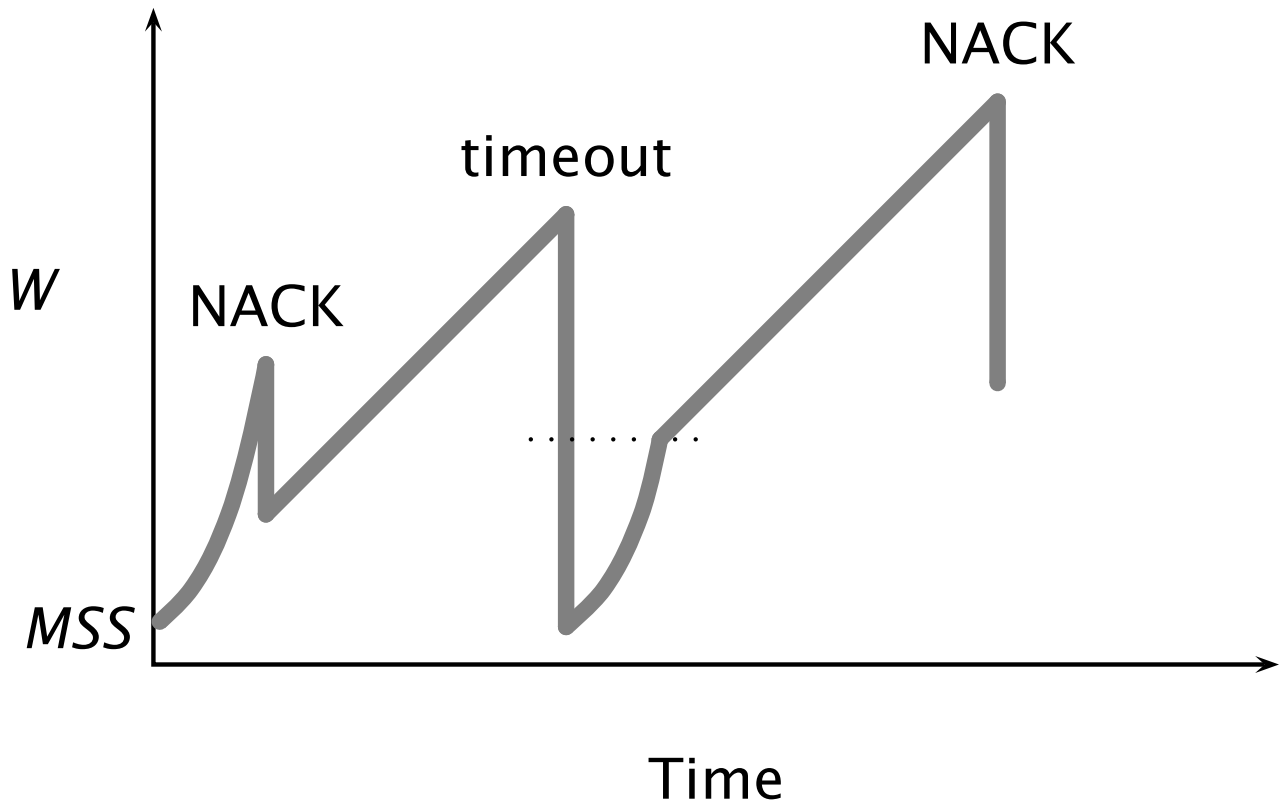

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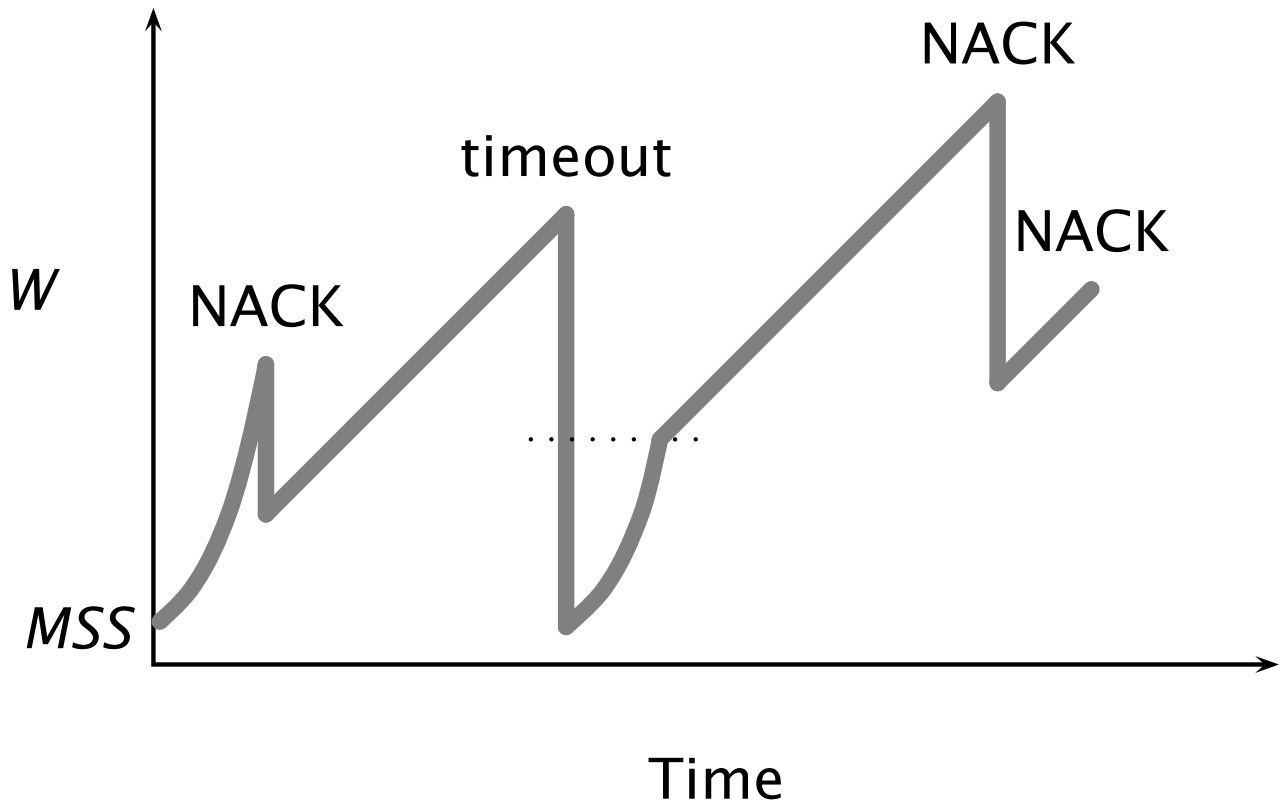

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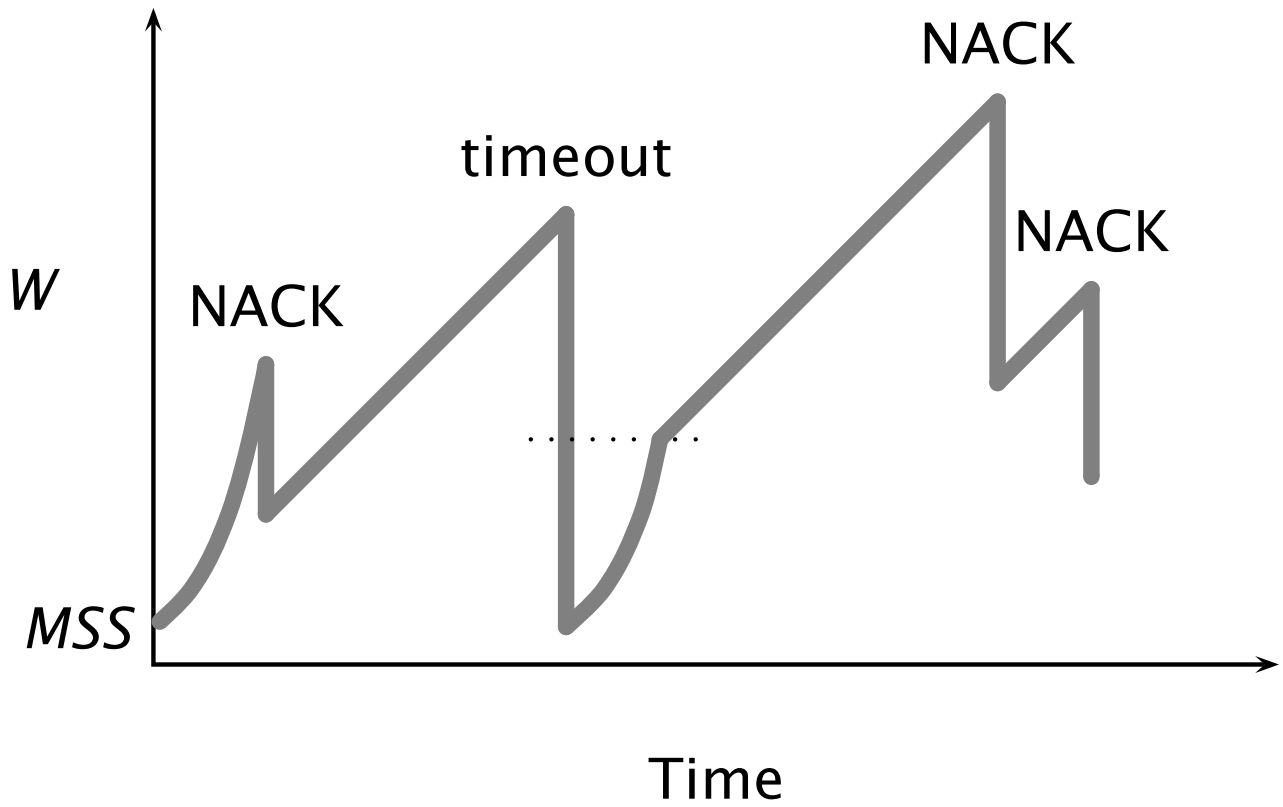

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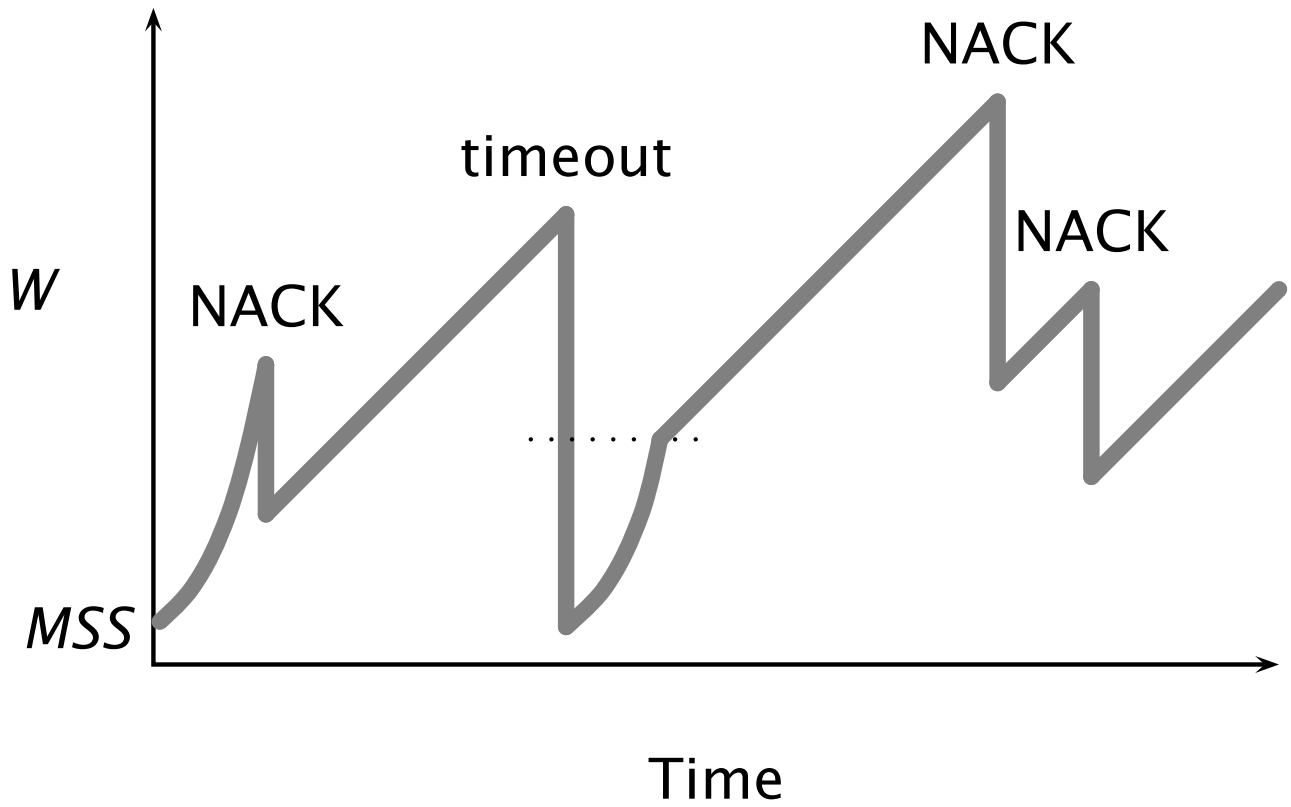

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