Tweaking TCP's Timers

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Context

- Researching user-level TCP for my PhD.
- Focusing on how to implement it efficiently at user level, particularly in a server room.
- Timers are a small but interesting part of that.

Historical Context

- TCP was first specified in the early 1980s
  - OS support for time was poor and costly
  - Networks were slower, so time intervals longer.
- Portability very important, all leads to...

TCP has weak requirements of the OS

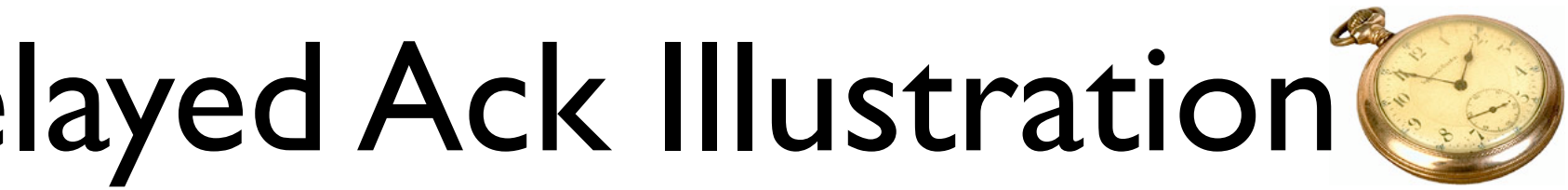
What are TCP Timers?

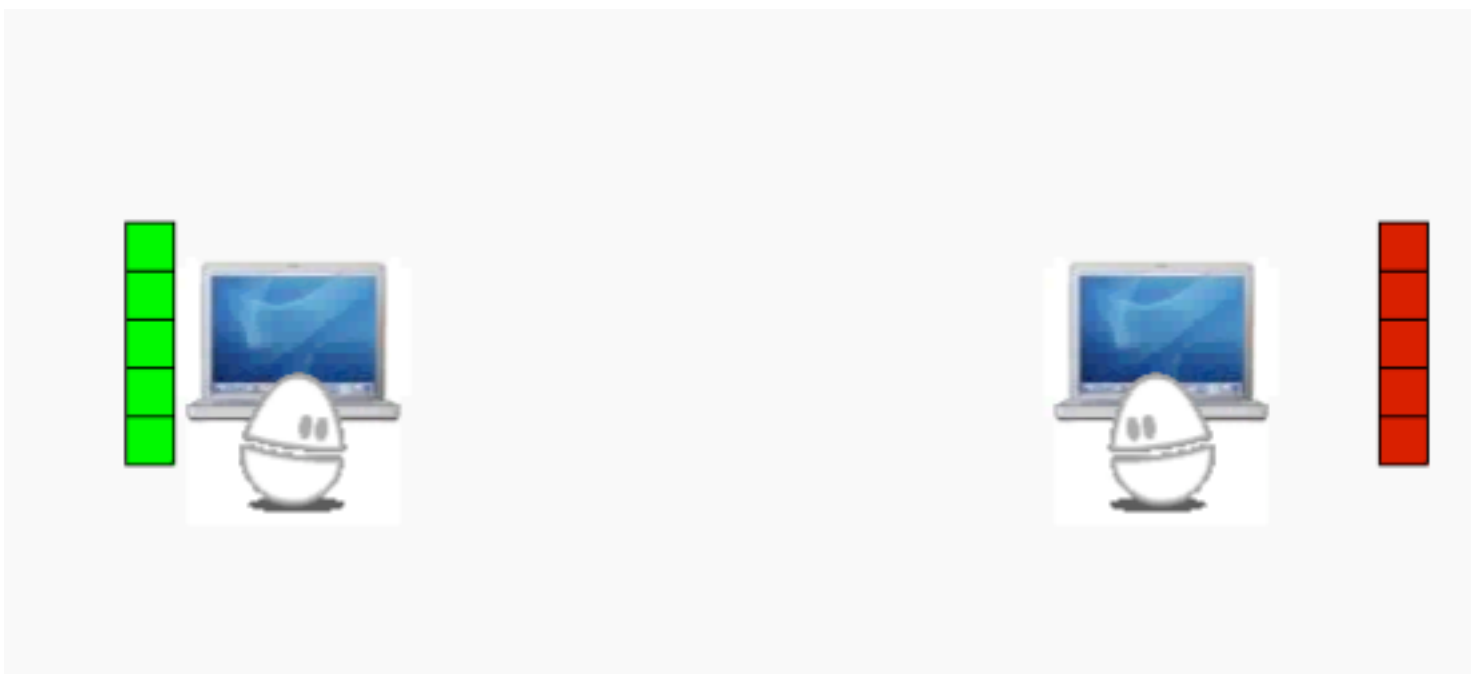
- *Not* measuring time (usually).
- Enable an action to be performed later.
- Mostly used to deal with inactivity:
  - Timer *set* when activity is expected
  - Timer *cancelled* when activity occurs
  - If timer expires, recovery action is executed.

Delayed Acknowledgments

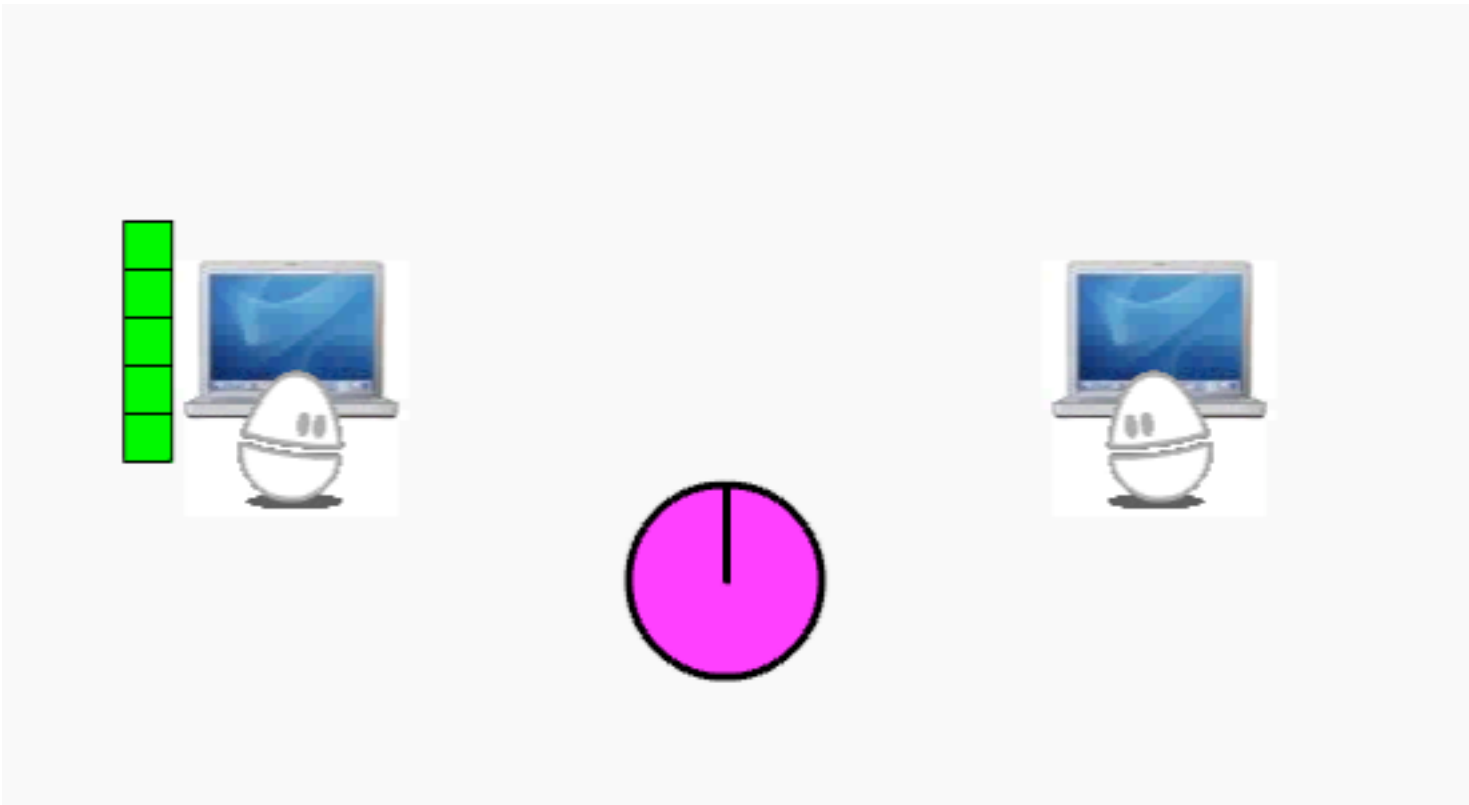
- TCP sends acks for reliability and flow control.
- Can either be a separate packet or piggyback on a data packet.
- Acks are delayed to encourage piggybacking.
- Timer used to ensure delay is limited.

Delayed Ack Illustration





Timer Ticks Illustrated



Timer Techniques

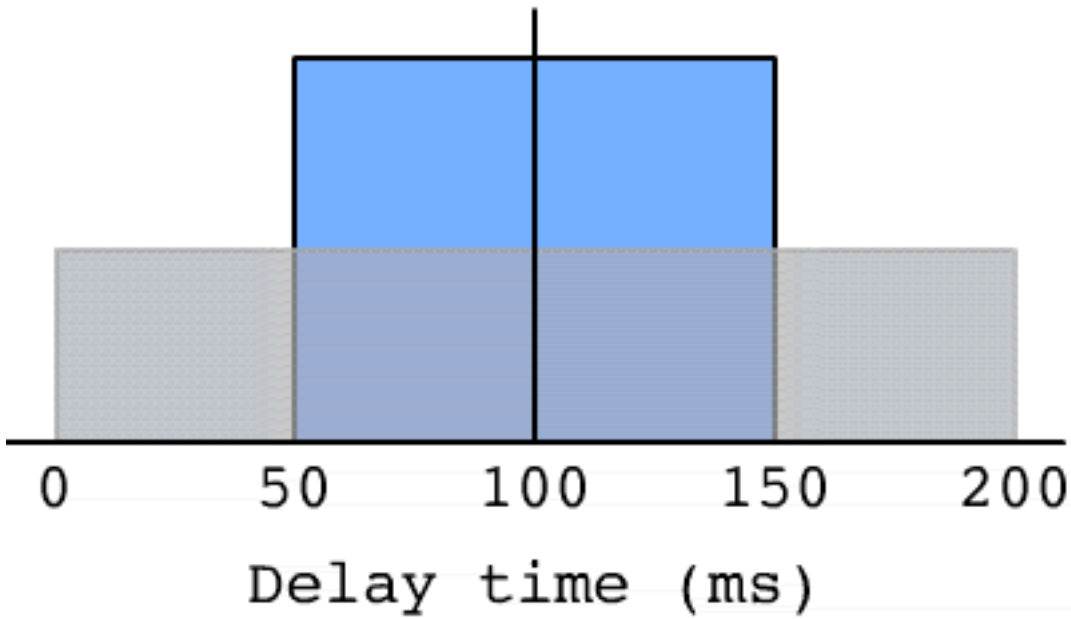
- How to implement timers?
- Trad. scheme based on 100ms clock ticks
  - Maintain flags in per-connection state.
  - Each tick, check list of connections for timers.
- Modern scheme based on hashed hierarchical timing wheel.
  - Ordered list of timers, use hardware clock to trigger the check and schedule operation.

Problems

- Inaccurate delay of acks: from 0ms to 200ms
- List of connections must be searched each clock tick.
- A busy connection will still regularly send separate ack packets.

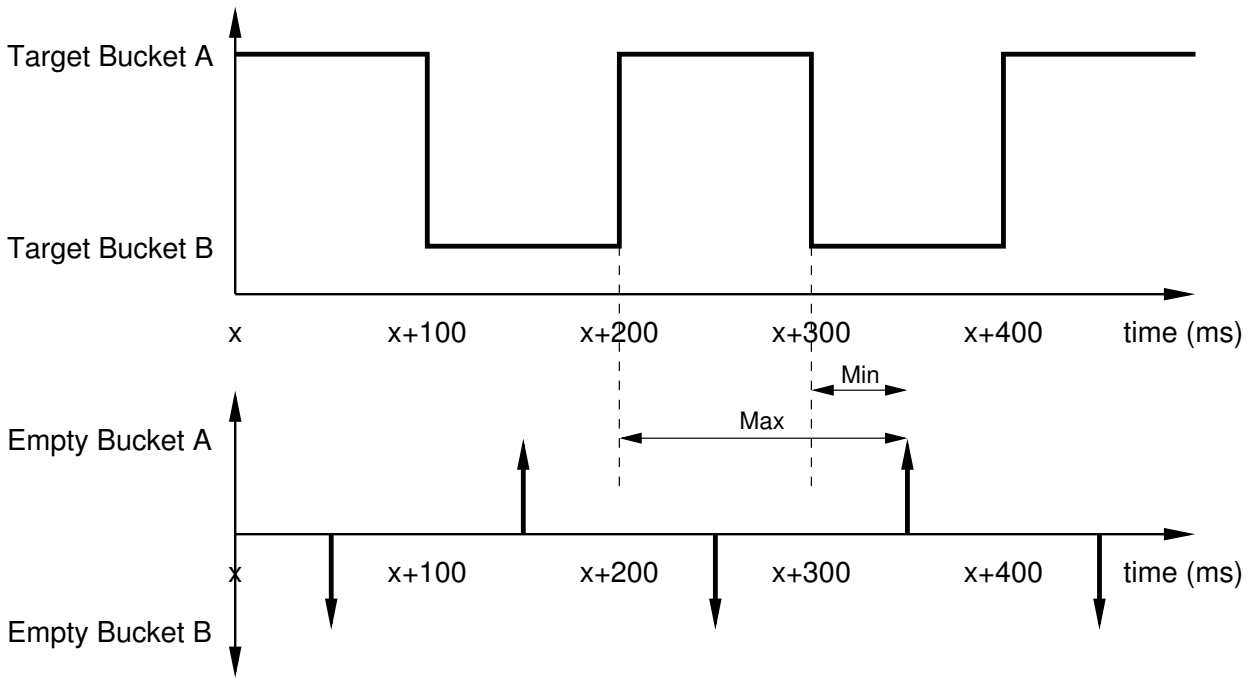
Potential Solution (i)

- Change profile of delay:



Potential Solution (ii)

- Use two timer buckets to achieve delay limits:



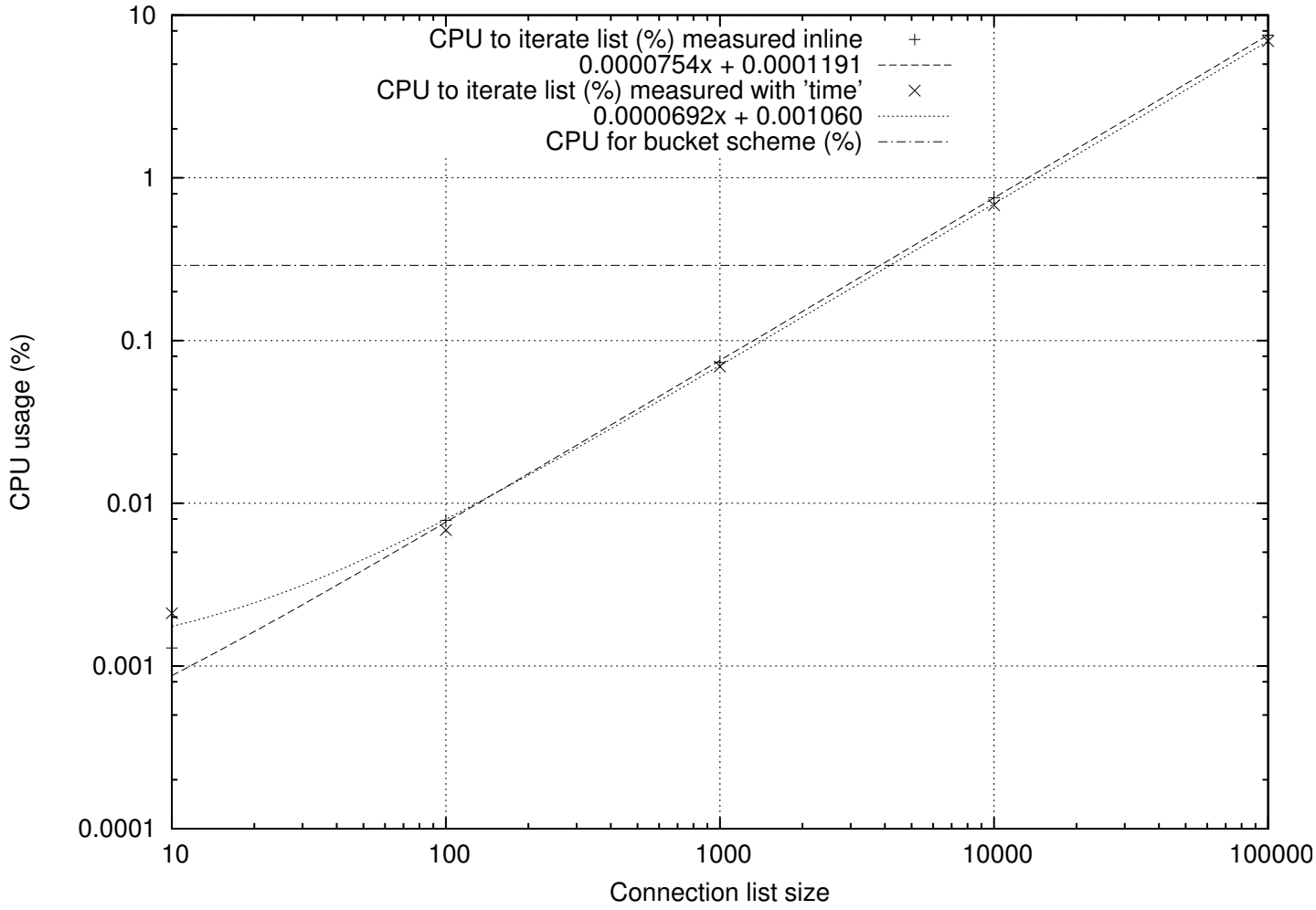
Potential Solution (iii)

- Implementation of buckets:
  - Lazy switch avoids need for scheduling.
  - Timer execution when blocking op encountered.
  - Data thread used for active connections.
  - Time checking done using “rtdsc” counter.

Potential Solution (iv)

- Handle timers for active connections from the data thread.
- Removes need for locking, other than for handing connections between threads.
- No list searching, but...
- Increased set/clear timer complexity.

CPU Usage Tradeoff



Summary

- Timers at user level can benefit from a different solution.
- Change the way timers are implemented to:
  - Give guaranteed lower, reduced upper bound;
  - Avoid locking by checking timers in data thread.
- Minor performance issue for current TCPs
  - May be more important in future.

Questions/Comments?

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