Time, Clocks, and the Ordering of Events in a Distributed System

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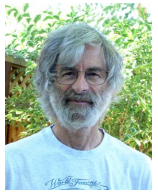
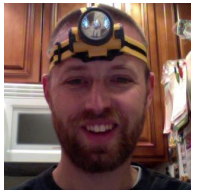


Presenter: Heath Borders



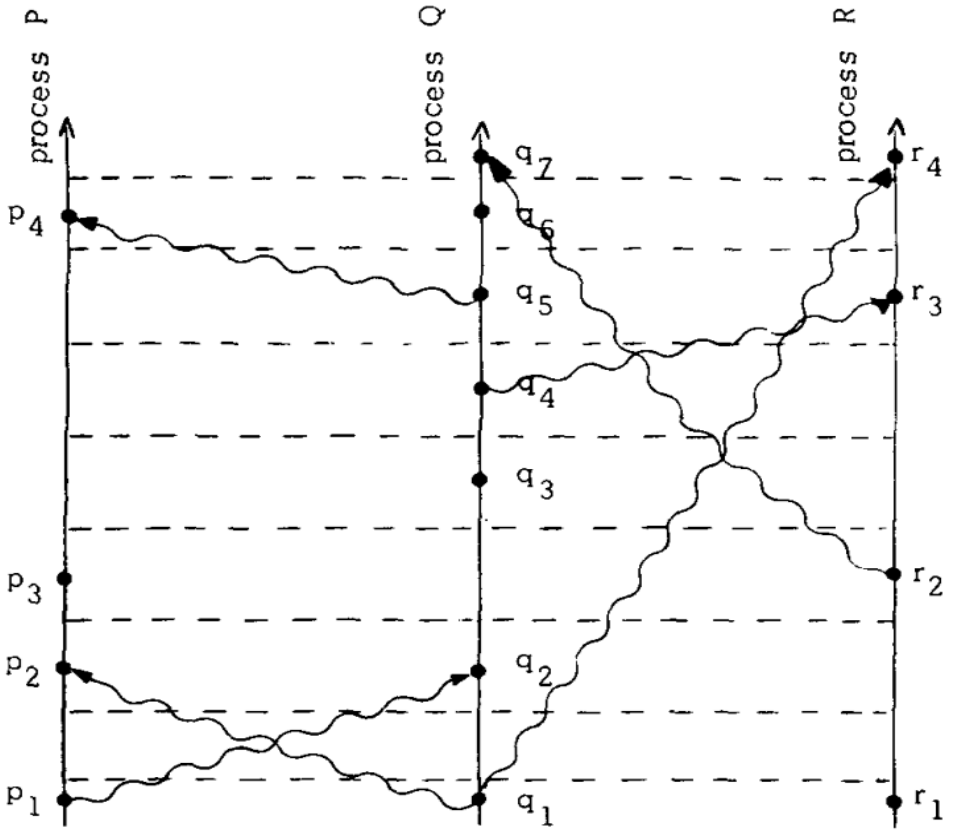
Why do we care?

- Paxos
  - http://en.wikipedia.org/wiki/Paxos_(computer_science)
- Spanner
  - http://en.wikipedia.org/wiki/Spanner_(database)

Ordering

- Partial Ordering ("Happens Before")
- Total Ordering from Partial Ordering by Sharing State

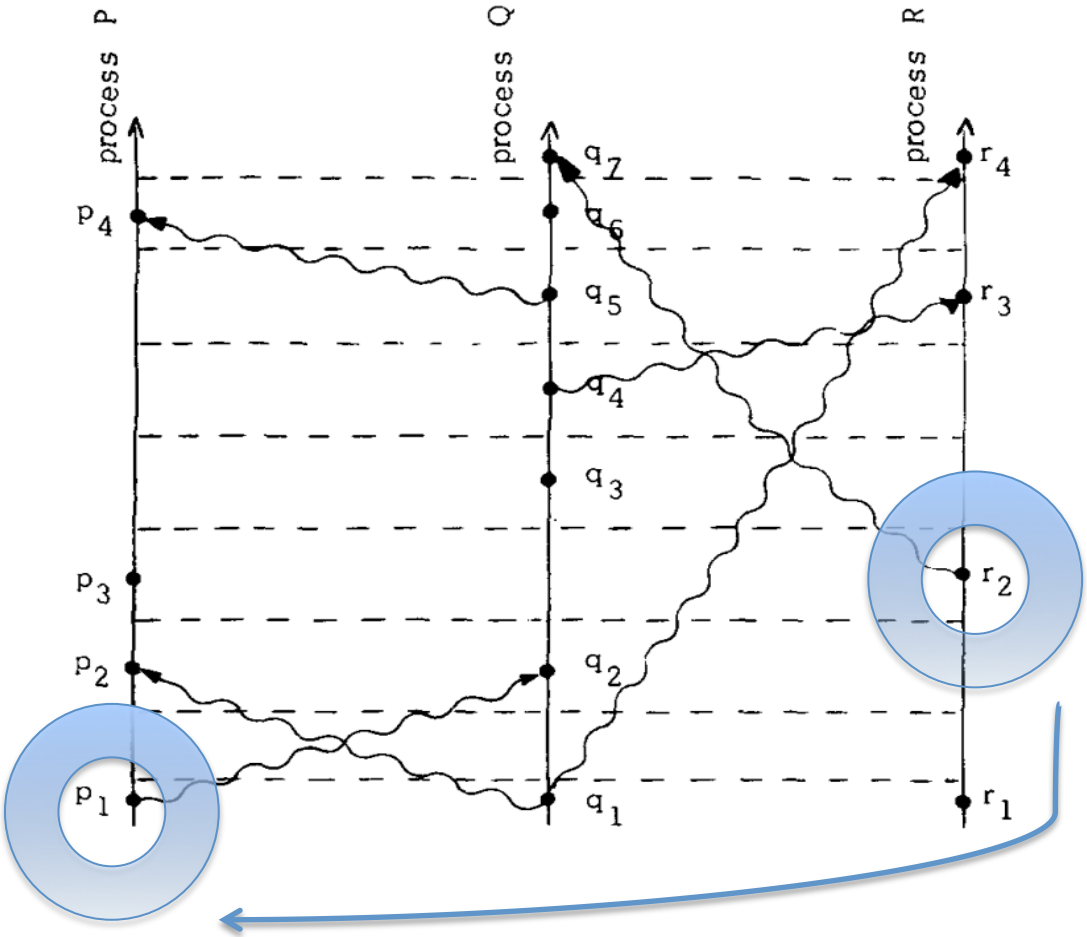
Figure 3


process P
process Q
process R
p_4
p_3
p_2
p_1
q_7
q_6
q_5
q_4
q_3
q_2
q_1
r_4
r_3
r_2
r_1

Anomalous Behavior

- What if someone sends a message between processes outside of our clock?

Figure 3


process P
process Q
process R
p4
p3
p2
p1
q7
q6
q5
q4
q3
q2
q1
r4
r3
r2
r1

Physical Clocks

- Solve Logical Clock Problems with Physics!
  - Minkowski Spacetime is Partially Ordered
  - http://philosophyfaculty.ucsd.edu/faculty/ccallender/index_files/Time%20in%20Physics.doc

Math

- Clock rate skew < E
- System event coarseness K: (T1 – T2 < K)
- Transmission Time: M

- Theorem: $E/(1-K) \leq M$

In Spanner Terms

- K = 200 μs/sec
- E = 6msec
- Thus, M is at most 6.00120024msec

- http://research.google.com/archive/spanner.html