Distributed Systems

Lecture 14: Time in Distributed Systems

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Outline

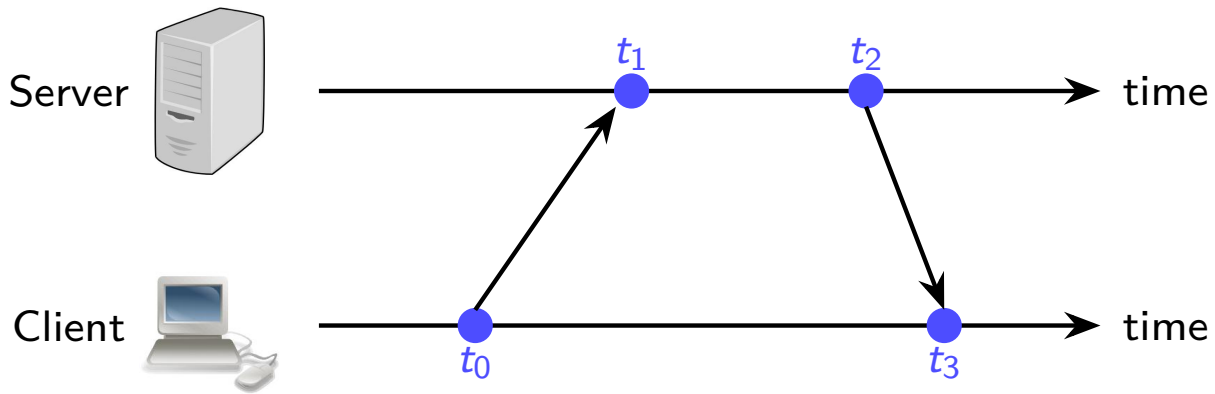
- Challenges in distributed systems
  - Consistency
  - Concurrency
- Physical and logical time
  - . . . and how to distribute it
- Time synchronization
  - Skew and drift
  - Cristian's algorithm
  - Berkeley algorithm
  - NTP and PTP
- Logical clocks
  - Relations
  - Lamport clock
  - Vector clock

Synchronization and drift

- Goal: All hosts should have the same time
- Challenges
  - Clocks can have different start times
    - $t_{\text{clock\_a}} \neq t_{\text{clock\_b}}$
    - Called **skew**
  - Clocks can run at different speeds
    - Called **drift**
    - Ideal: $dC/dt = 1$
- Drift example
  - Let $p =$ the maximum deviation
    e.g., given by the manufacturer, such that
    $1 - p \leq \frac{dC}{dt} \leq 1 + p$
  - Question: What is the maximum difference of two drifting clocks after Δt time units?
  - Answer: $2p\Delta t$

Message delays (cont'd)

- How to get (and calculate) message delays?



- Approximation

$$OWD_{\text{approx}} = \frac{t_3 - t_0 - (t_2 - t_1)}{2}$$

- Question: What is the maximum error?