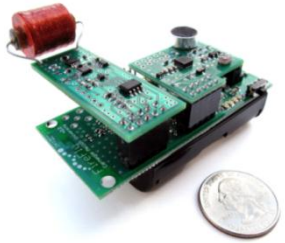
Clock Synchronization

Clock Synchronization in Networks

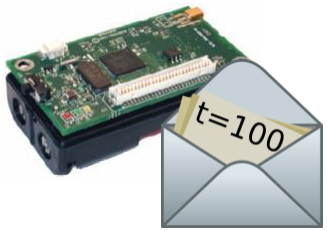
Global Positioning System (GPS)

Radio Clock Signal

AC-power line radiation



Synchronization messages



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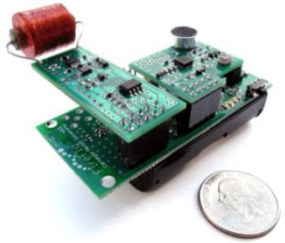

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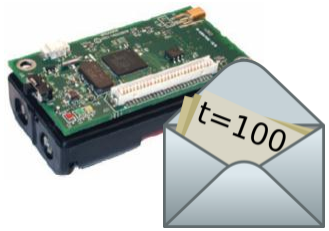
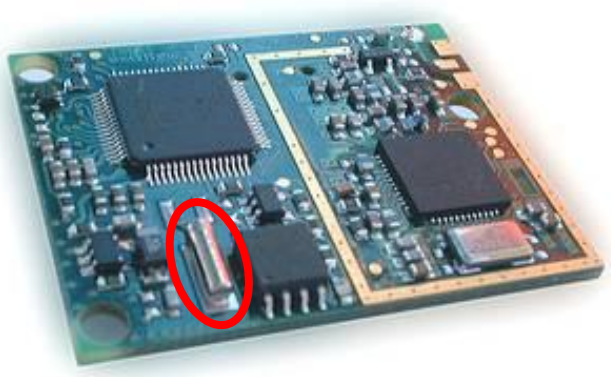
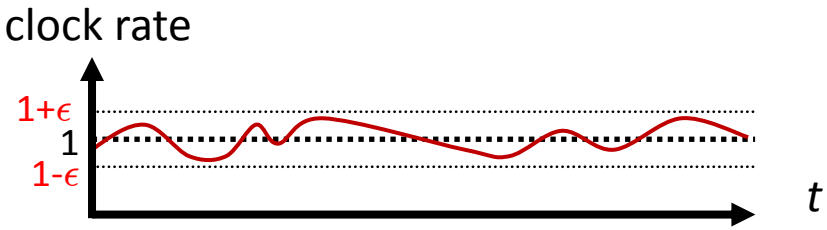
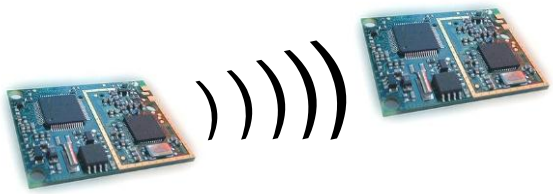


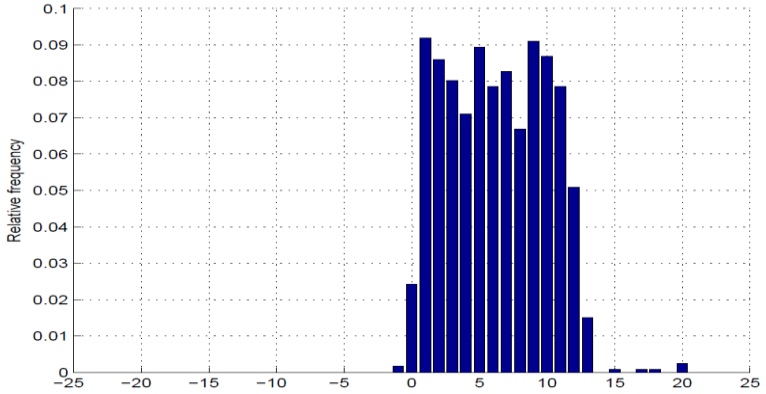
Problem: Physical Reality







message delay

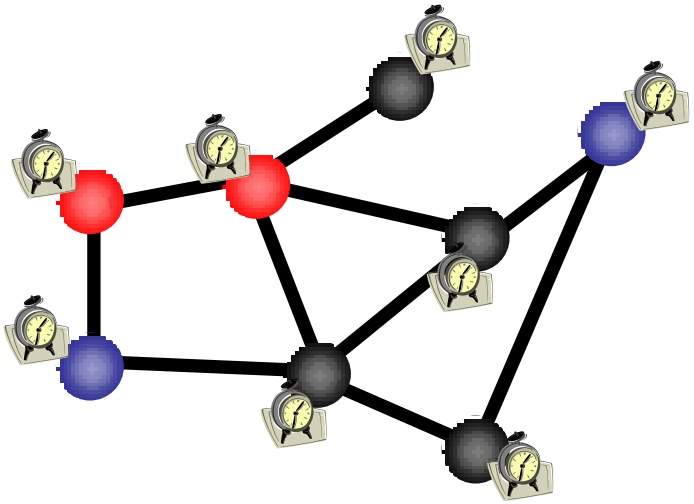


Clock Synchronization in Theory?

Given a communication network

1. Each node equipped with hardware clock with drift
2. Message delays with jitter

worst-case (but constant)



Goal: Synchronize Clocks (“Logical Clocks”)

- Both global and local synchronization!

Time Must Behave!

- Time (logical clocks) should not be allowed to stand still or jump

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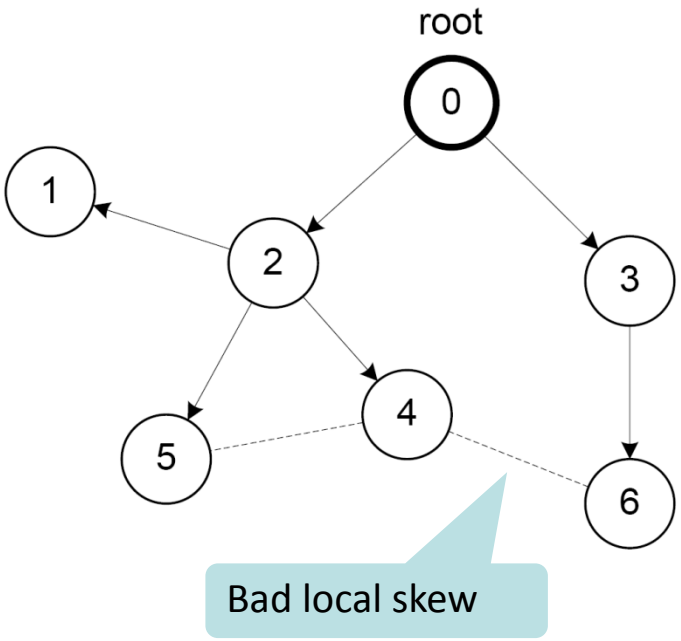
- Let's be more careful (and ambitious):
- Logical clocks should always move forward
  - Sometimes faster, sometimes slower is OK.
  - But there should be a minimum and a maximum speed.
  - As close to correct time as possible!

Local Skew

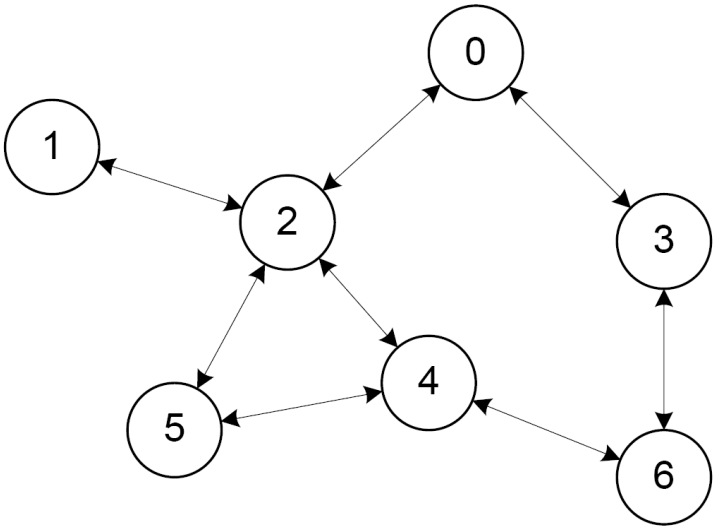
Tree-based Algorithms

e.g. FTSP



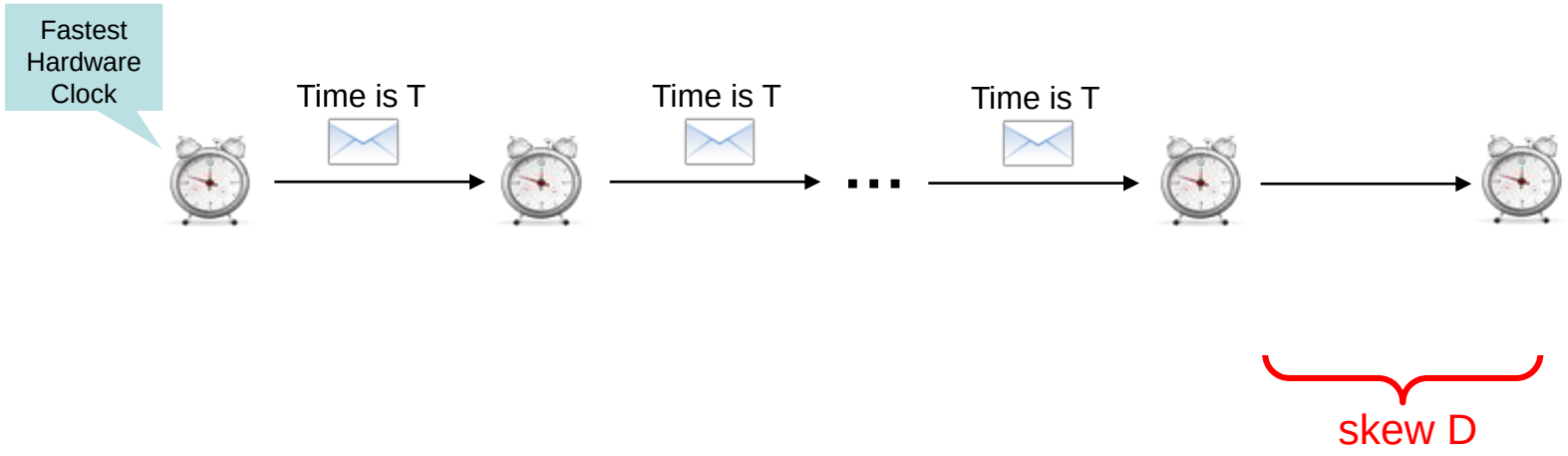
Neighborhood Algorithms

e.g. GTSP

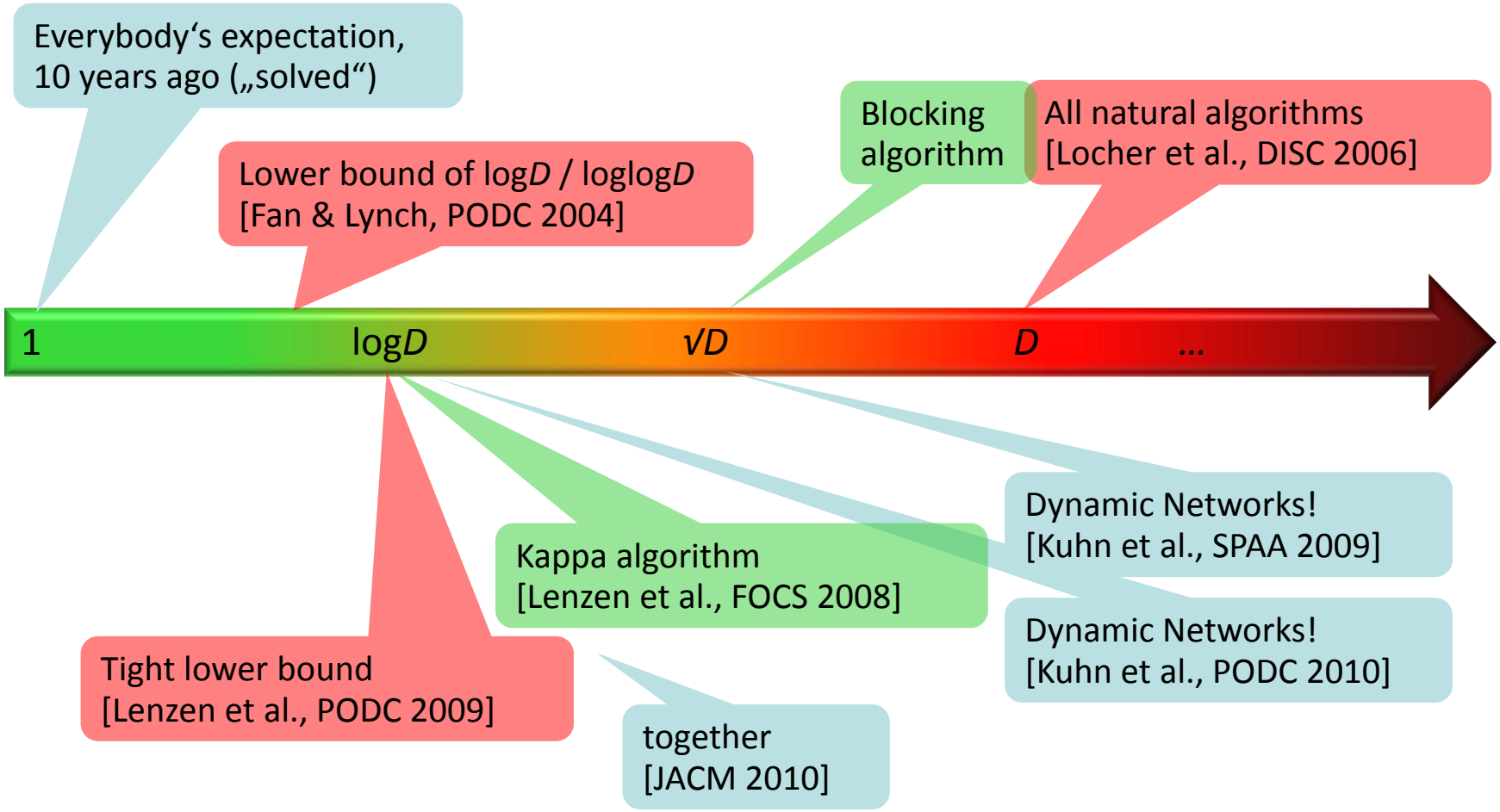


Synchronization Algorithms: An Example ("A^{max}")

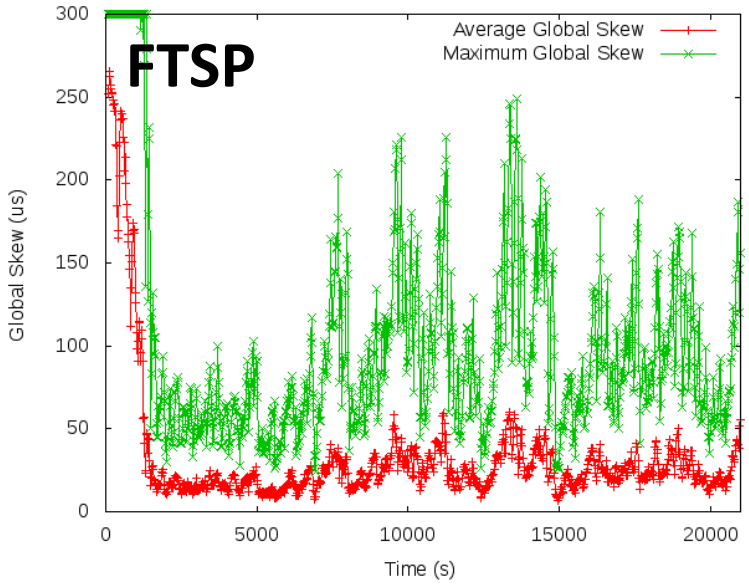
- Question: How to update the logical clock based on the messages from the neighbors?
- Idea: Minimizing the skew to the fastest neighbor
  - Set clock to maximum clock value you know, forward new values immediately
- First all messages are slow (1), then suddenly all messages are fast (0)!

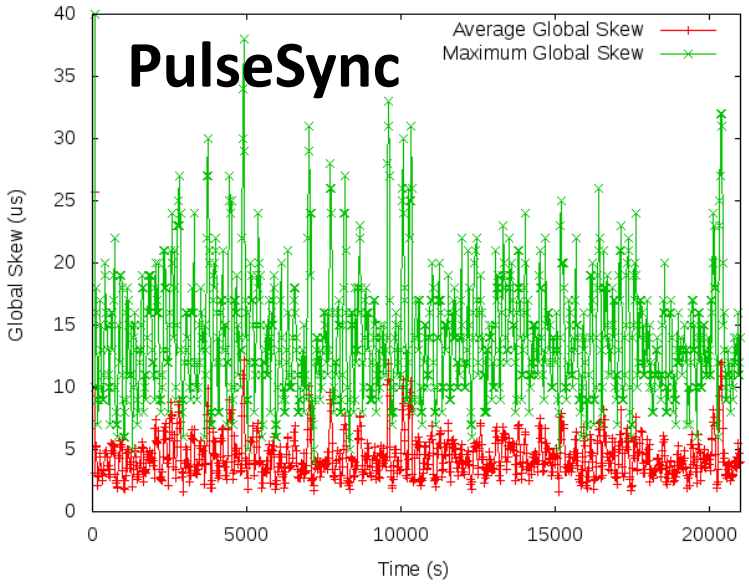


Local Skew: Overview of Results



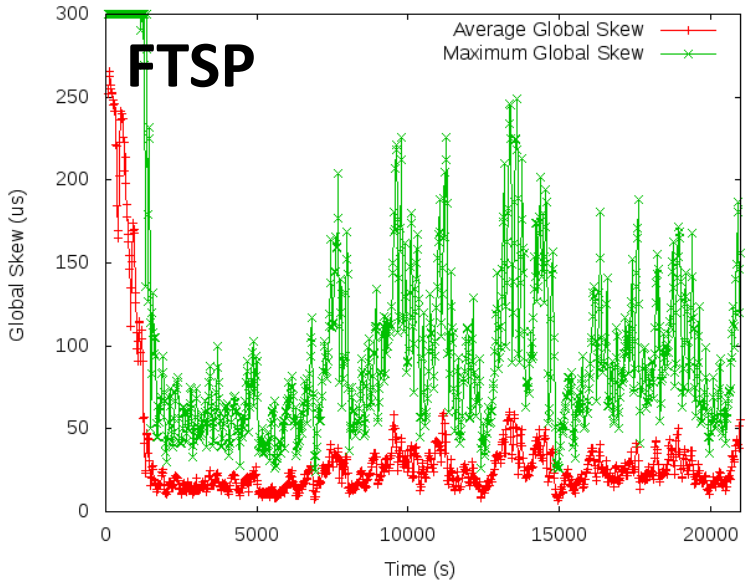
Experimental Results for Global Skew

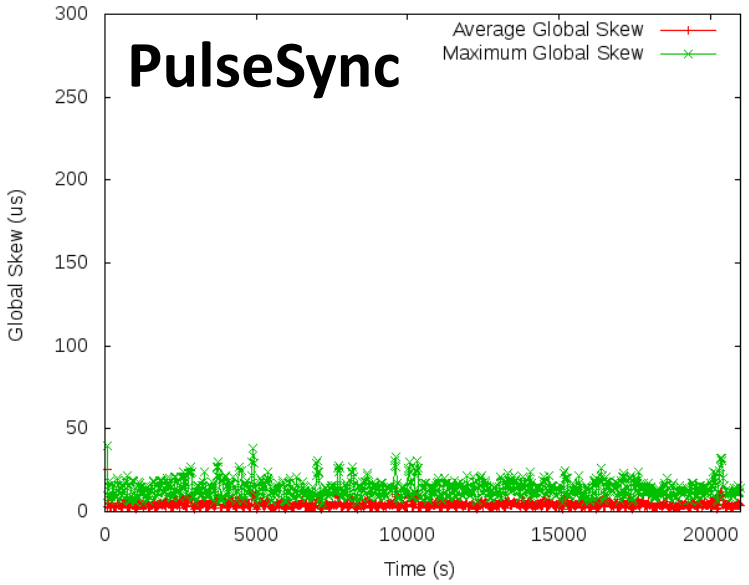




[Lenzen, Sommer, W, SenSys 2009]

Experimental Results for Global Skew





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Clock Synchronization vs. Car Coordination

- In the future cars may travel at high speed despite a tiny safety distance, thanks to advanced sensors and communication

Clock Synchronization vs. Car Coordination

- In the future cars may travel at high speed despite a tiny safety distance, thanks to advanced sensors and communication

- How fast & close can you drive?

- Answer possibly related to clock synchronization
  - clock drift ↔ cars cannot control speed perfectly
  - message jitter ↔ sensors or communication between cars not perfect