CSC8980 Wireless Sensor Networks

Time Synchronization for Wireless Sensor Networks

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Outline

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Post-Facto Synchronization

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- Expected Sources of Error
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Introduction

- Time synchronization is a critical piece of infrastructure for any distributed system. WSN have unique requirements in the scope, lifetime, and precision of the synchronization achieved.

- WSN make extensive use of synchronized time: proximity detection into a velocity estimate

- Existing time sync methods need to be extended to be mindful of time and energy that they consume

- The heterogeneity of sensor network applications, the need for energy efficiency and the variety of hardware need to be taken in count when creating a new sync method.

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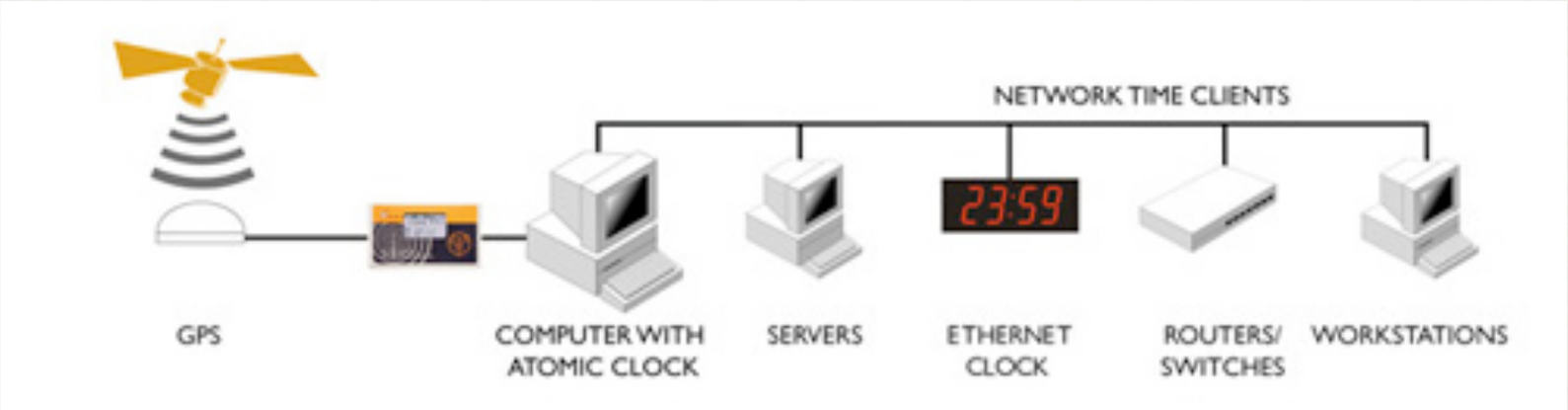
Characterizing Time Synchronization

US Global Positioning System (GPS) and WWV/ WWVB use the Coordinated Universal Time (UTC) which is the same Greenwich Mean Time (GMT)



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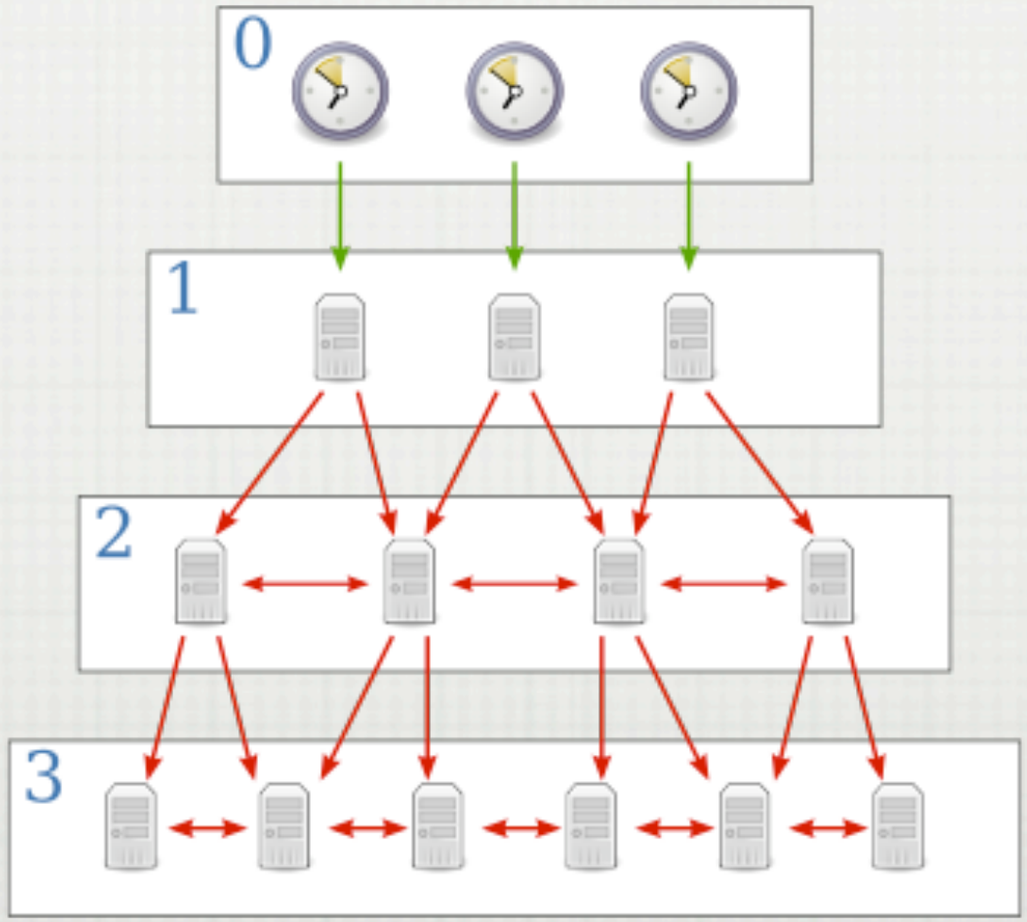
Characterizing Time Synchronization

Network Time Protocol (NTP)



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Time Synchronization Metrics

- Precision
- Lifetime
- Scope and Availability
- Efficiency
- Cost

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Sensor Network Time

Must be highly energy-efficient

Existing time sync methods are not designed with this constrain in mind. For instance NTP which is conservative in their use of bandwidth but inefficient where radios consume significant power even by passively listening for messages

It is impossible for any single sync method to appropriate in all situations. sensors should have multiple methods available. (trade precision for energy or scope for convergence time) The algorithm should be tunable.

Therefore, by modifying existing sync methods and composing them into multi-modal solution, they created the post-facto synchronization method

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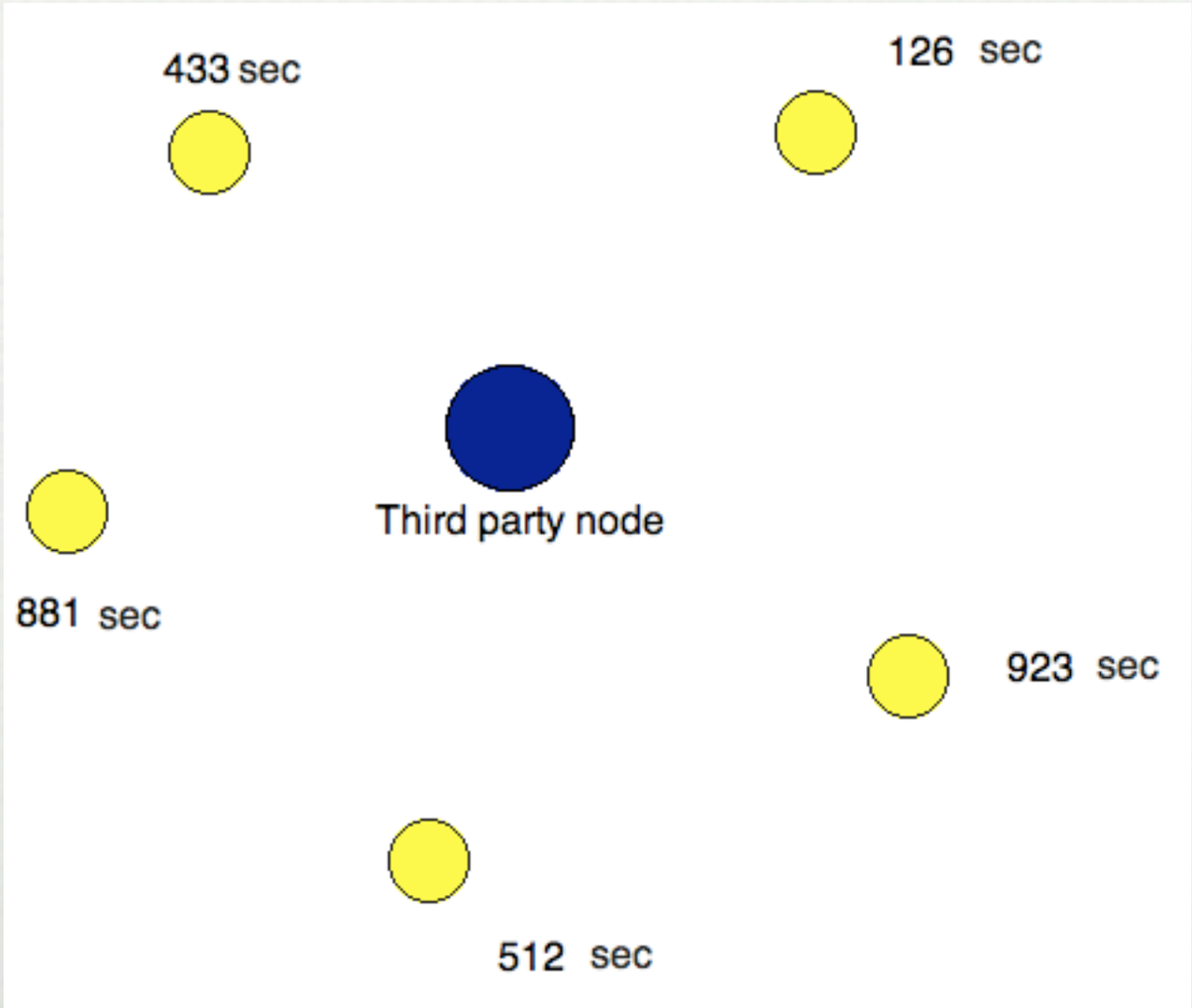
Post-Facto Synchronization

In this scheme, nodes' clocks are normally unsynchronized.



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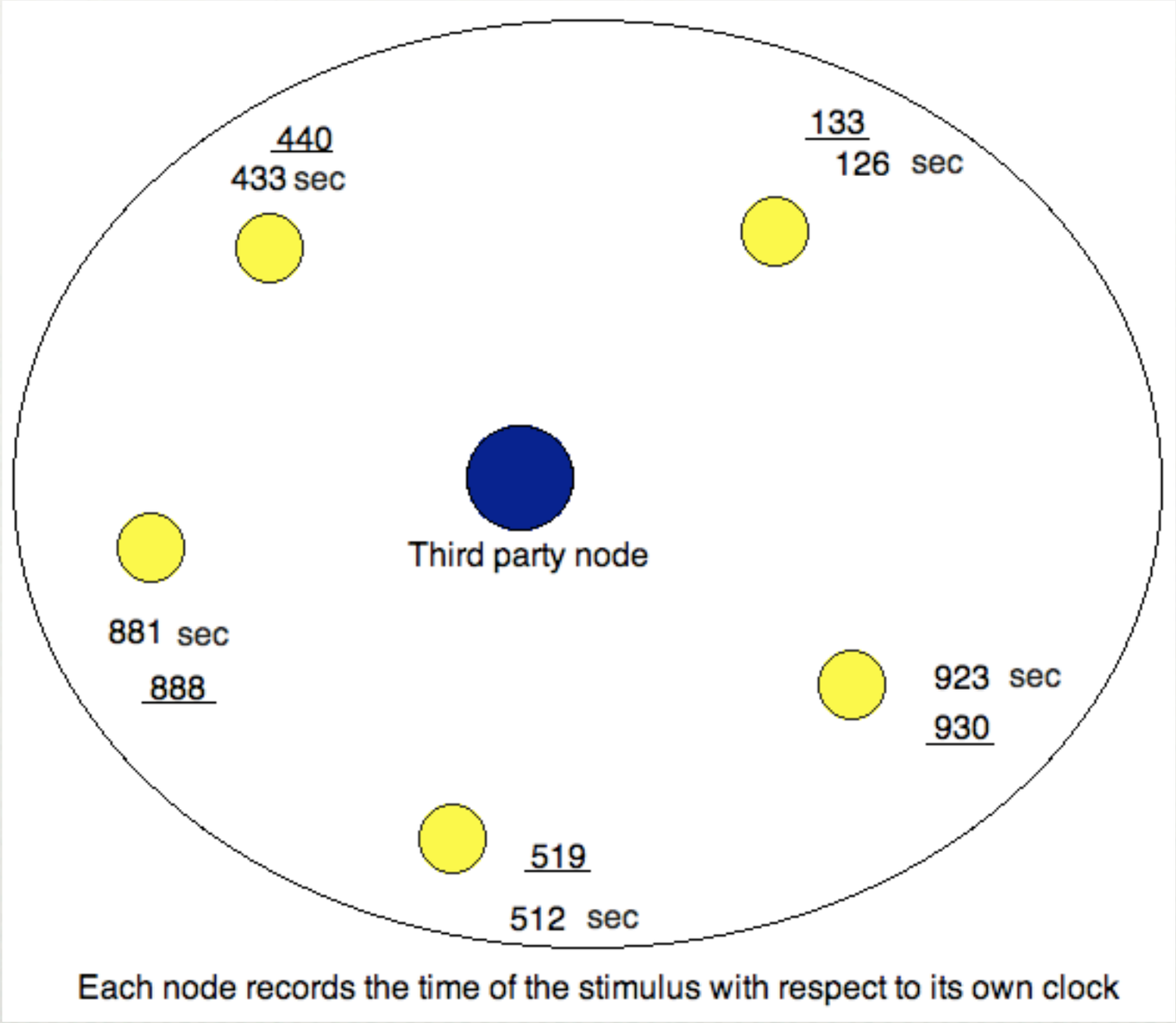
Post-Facto Synchronization



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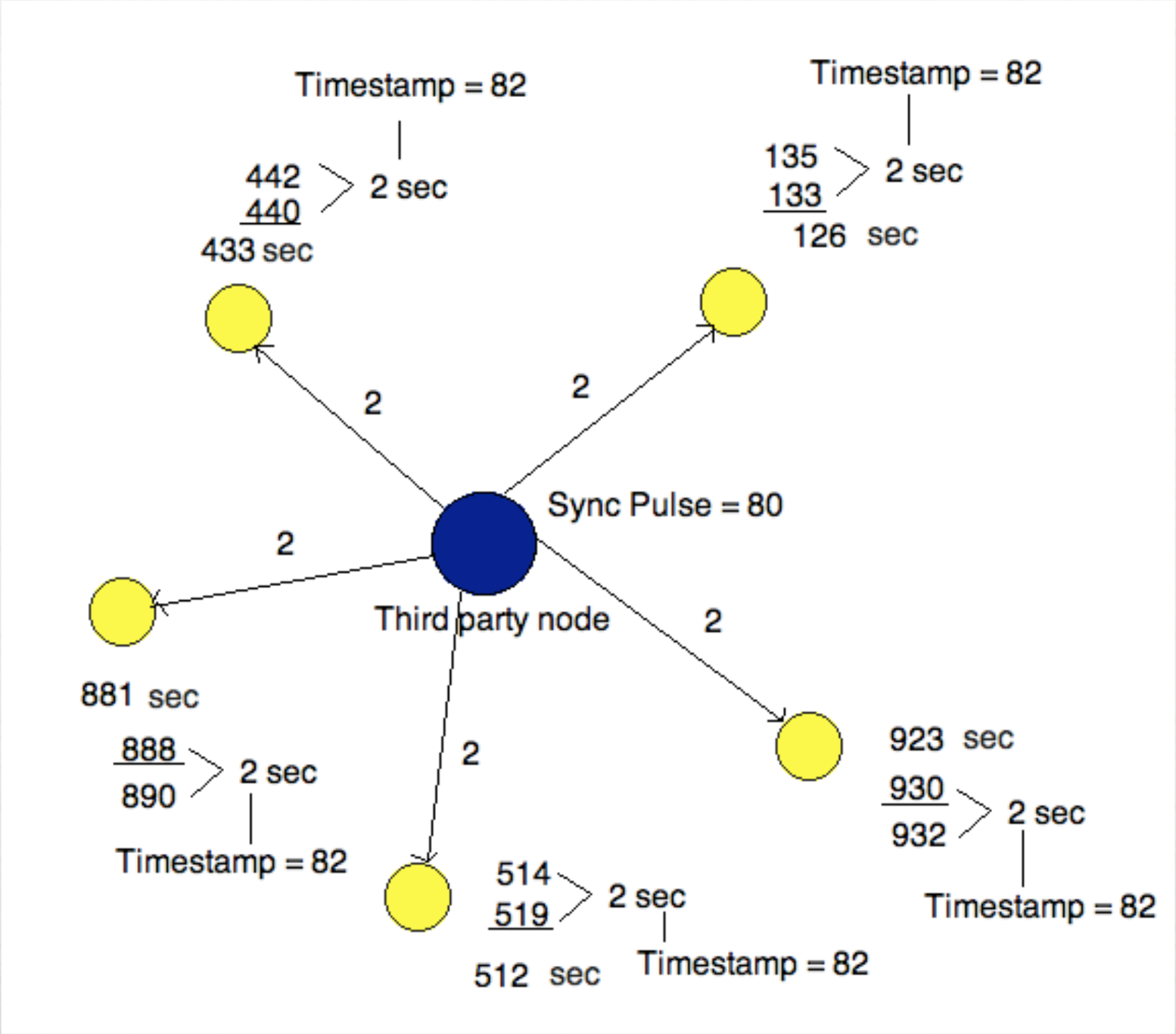
Post-Facto Synchronization



Expected Sources of Error

Skew in the receiver's local clock: nodes clock's do not run at exactly the same rate, causing error in that measurement. One way of reducing this error is to use NTP to discipline the frequency of each node's oscillator. (multi-modal sync)

Variable delays on the receivers: there is no guarantee that each receiver will detect the signal at the same instant. Variable latency can contribute to unpredictable delays.

Propagation delay of the sync pulse

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Post-Facto Synchronization Study

Ideally, if there are no variable delays in the receivers or skew among the receivers' local oscillators, the time reported for the stimulus should be identical.

In reality, these sources of error cause dispersion among the reported times to grow as more time elapses between the stimulus and the sync pulse.

The precision increases if NTP is used to train the frequency of the receiver's clock.

If the clocks are trained for a period of time (several days) and the external time source is removed, the clock's frequency will remain stable

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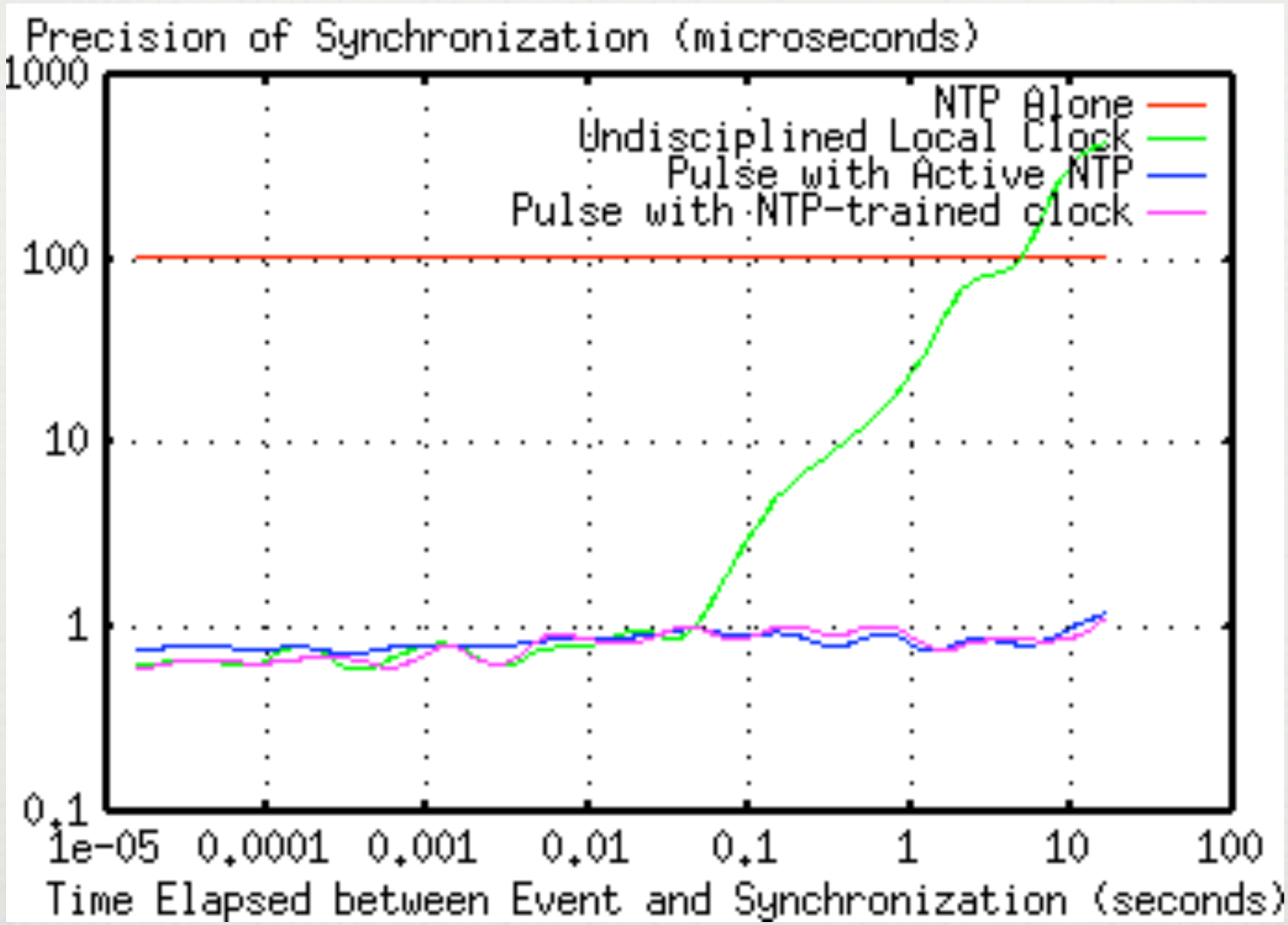
Post-Facto Synchronization Analysis



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Conclusions

1. Time sync is a critical piece of infrastructure for distributed system. WSN make have use of synchronized time

2. Post-Facto sync method combines the oscillator frequency discipline provided by NTP with an instantaneous phase correction provided by a simple synchronization signal sent by a beacon

3. Same timing precision was possible even when NTP no longer had an active external time of frequency standard, after initial period.

4. Post-Facto sync method need to be tested in real WSN

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Q&A

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