LT-Sync: A Lightweight Time Synchronization Protocol for P2P Networks based on IEEE1588

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1. Introduction

- Fast increasing demand of high data rates implies new concepts for an efficient usage of available resources
- Deployment of overlay-based network structures enables exchange of control and steering data between involved entities
- Rapidly changing data, like spectrum usage information requires a method for time synchronization
- Transmission delays between nodes cause unpredictable deviations
- IEEE 1588 offers solution for calculating transmission delays

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2. Concept and System-Architecture

- **LT-Sync has been designed for Chord-based DHT Networks**

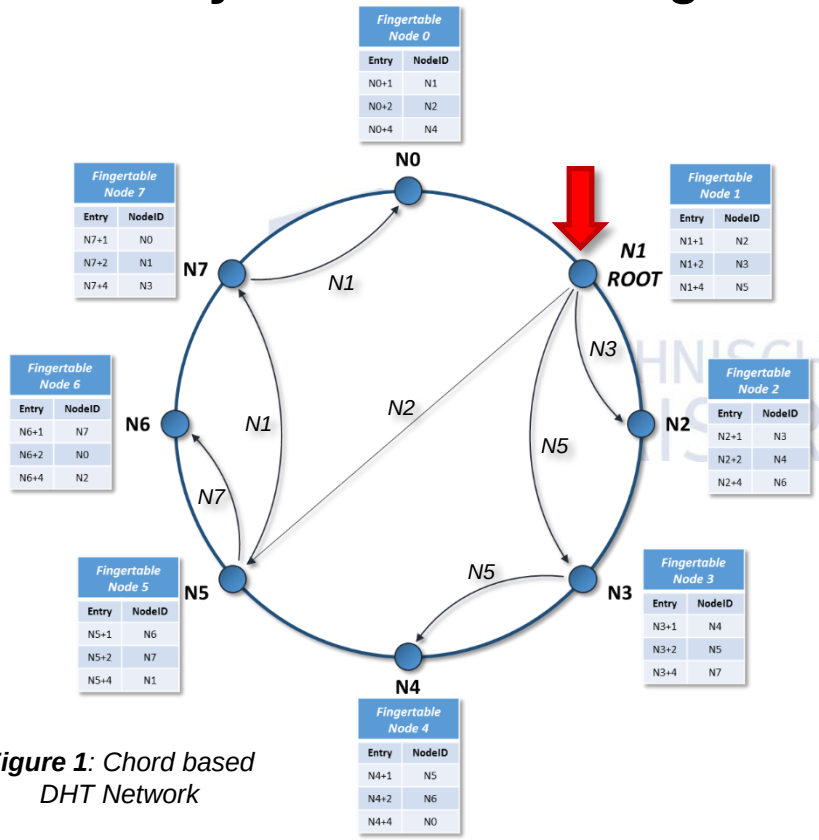

***Figure 1**: Chord based DHT Network*

- Synchronization is based on PariSync
- Synchronization will be initiated by a Root Node
- Maximum Number of hops and limit ID avoid infinite loops

$$limitID = NodeID(i+1)$$

$$ownID < limitID < \#Entry(i+1)$$

$$hops = 10$$

2. Concept and System-Architecture

- Resulting message tree

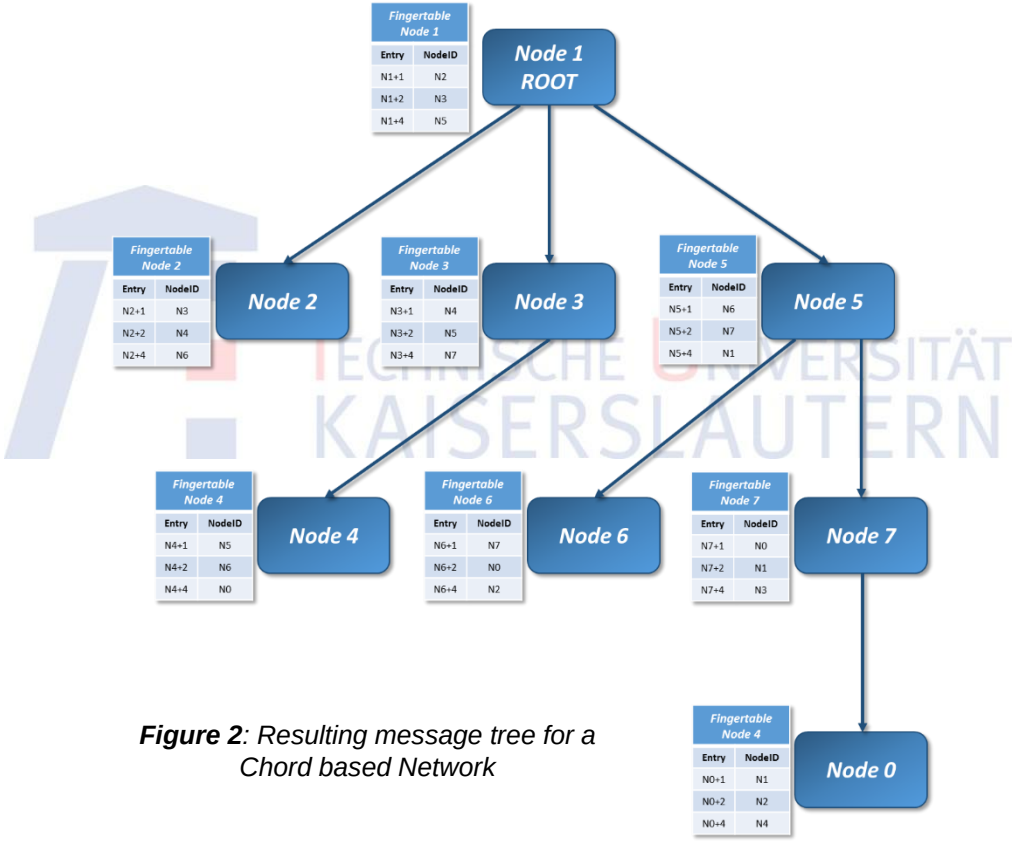

***Figure 2**: Resulting message tree for a Chord based Network*

2. Concept and System-Architecture

- Root Node should be able to provide data with high accuracy
  - DCF77 Receiver
  - NTP Connection
- Isolated Systems define own “reference time“
- Each Node is responsible for synchronizing its clients

2. Concept and System-Architecture

- Time Synchronization based on IEEE 1588

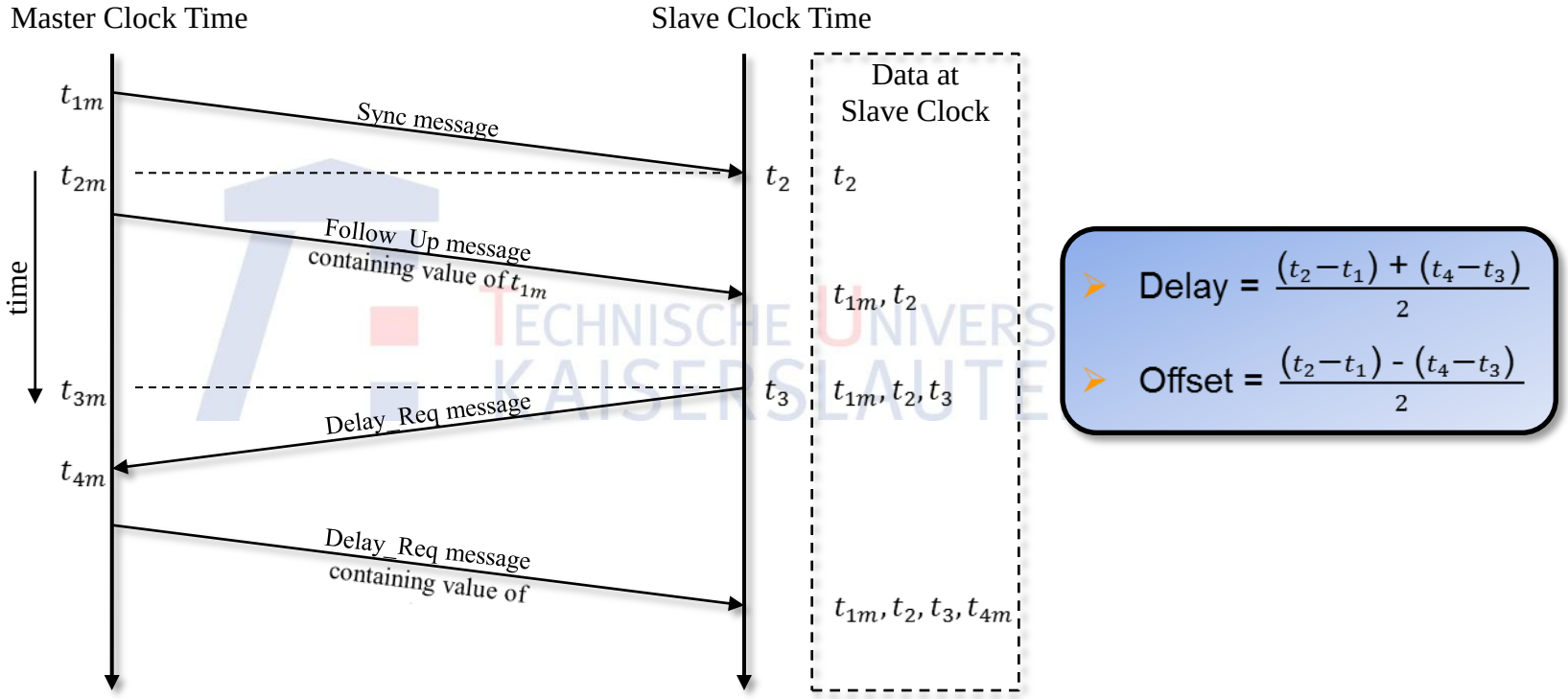

***Figure 3**: IEEE 1588 message flow*

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3. Simulation and Results

- *Assumptions*
  - Chord network with 50 nodes
  - Each Node starts with an
    - Individual deviation

$$-60\frac{\text{min}}{\text{year}} \leq \Delta t \leq 60\frac{\text{min}}{\text{year}}$$

    - Individual offset up to several hours
  - Uniform distributed transmission delay up to 5 seconds

3. Simulation and Results

- Deviation of five nodes (randomly chosen)

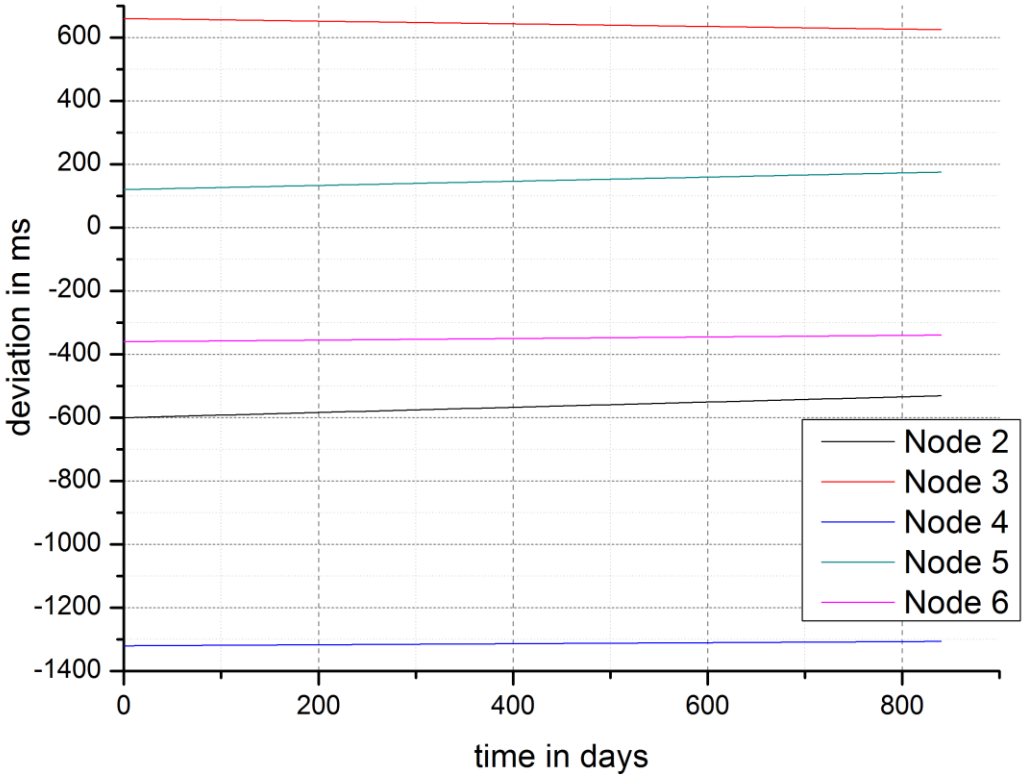


***Figure 4**: Deviation of 5 nodes with 1 hour sync interval*

3. Simulation

- Deviation of five nodes (randomly chosen)
  - First synchronization after six hours

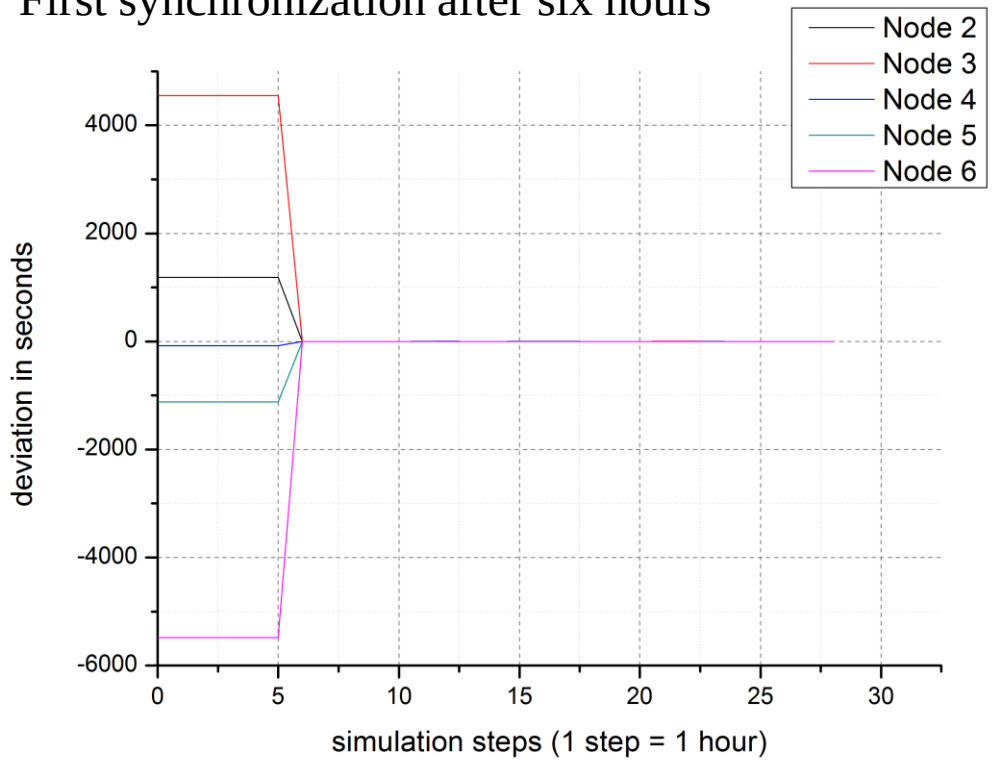


***Figure 5**: Deviation of 5 nodes with 1 hour sync interval*

3. Simulation and Results

- Deviation of five nodes (randomly chosen)

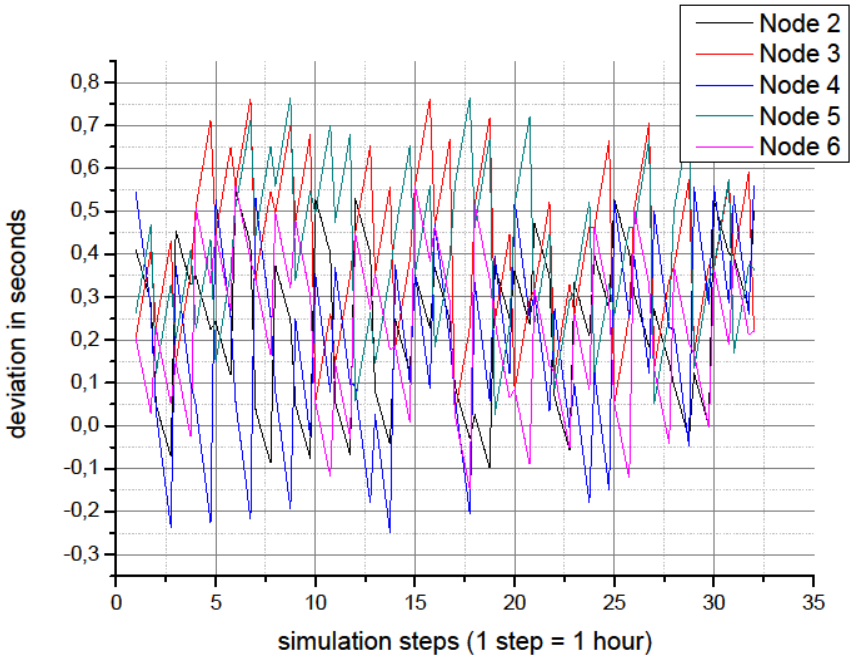


***Figure 6**: Deviation of 5 nodes with 1 hour sync interval*

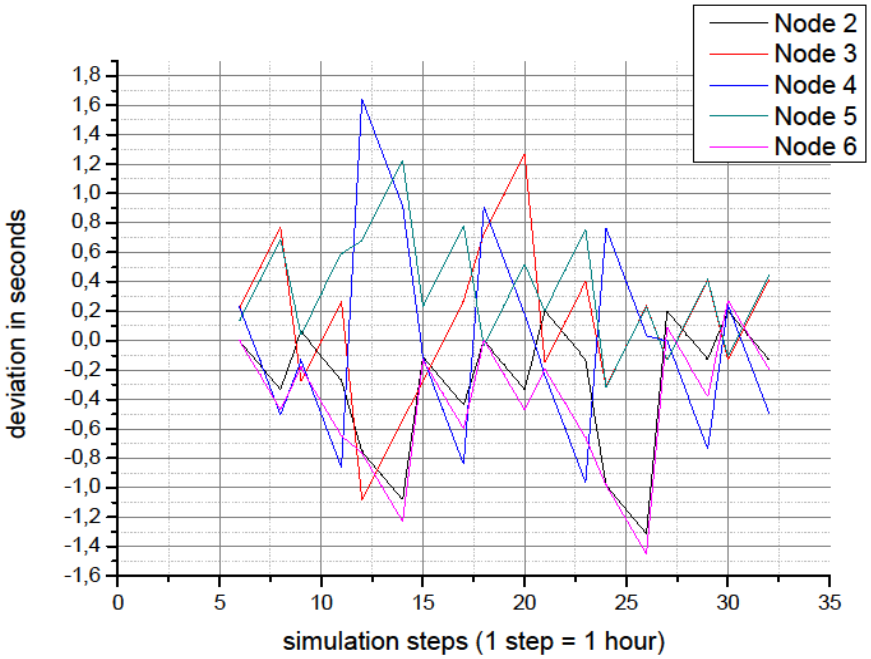


***Figure 7**: Deviation of 5 nodes with 3 hours sync interval*

3. Simulation and Results

- Deviation of five nodes (randomly chosen)

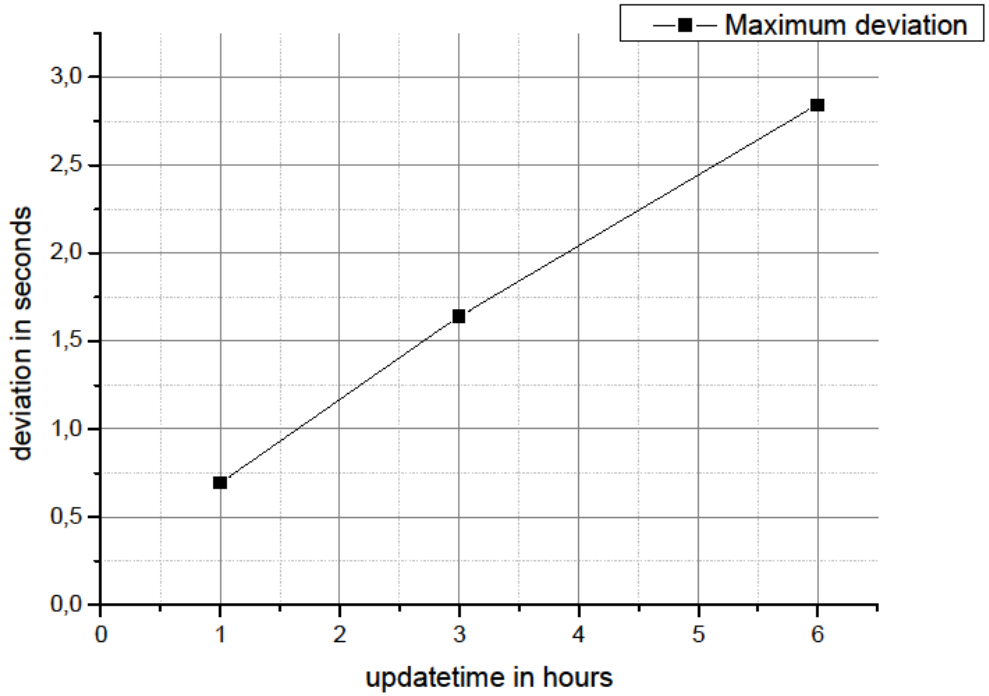
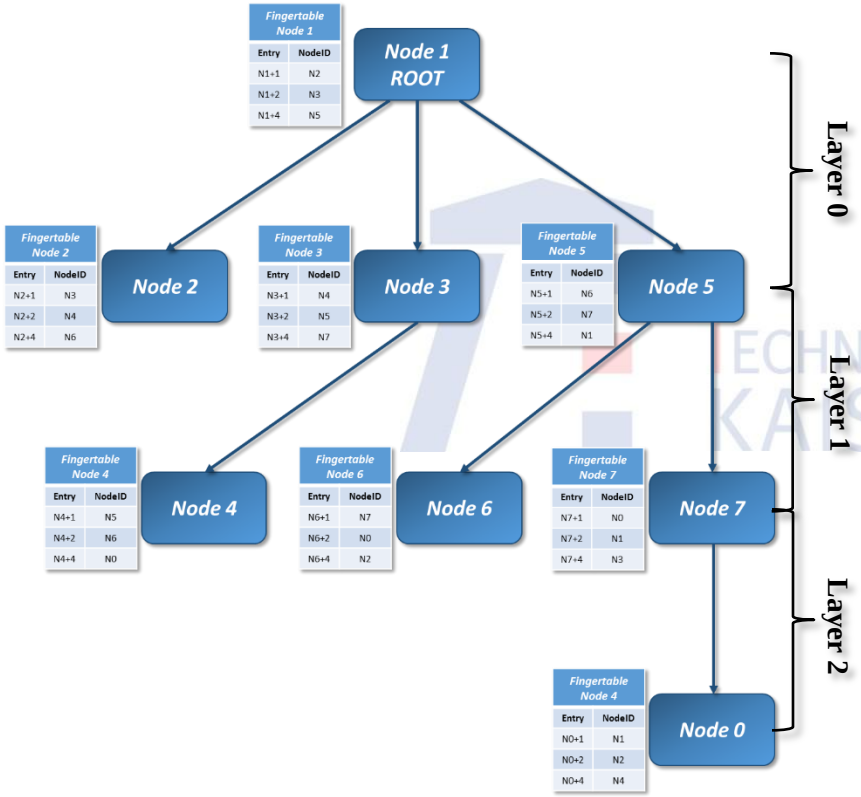


***Figure 8**: Deviation of 5 nodes with 1 hour sync interval*

3. Simulation and Results



- Each synchronization process causes an additional error
- Error for each synchronization depends on the disproportion between up- and downlink delay
- Error will sum up with the number of Layers

$$error = error_{Layer\ 1} + error_{Layer\ 2} + \cdots + error_{Layer\ N}$$

$$error = \sum_{m=0}^{m=N} error_{Layer\ m}$$

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4. Conclusion and future work

- The introduced system offers a prospect for an efficient time synchronization in peer-to-peer networks
- Simulation results have shown that:
  - Depending on the number of layers, errors less than 1 second can be achieved for one hour update interval
  - The total error can be calculated as the sum of errors caused by each layer
  - The update time and resulting error are linearly related
- Test with real systems should verify the simulation results

Thank You for your attention!

Questions?