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H-SATS- Simple Hierarchical Time Synchronization Algorithm for WSNs

Outline

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1. Motivation
2. Existing synchronization schemes
3. H-SATS
4. Experimental Setup
5. Results
6. Discussion

Motivation

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1. Time Synchronization Protocols (TSPs) give a common reference of time for a distributed network like WSN
2. Essential for data-fusion, TDMA based communication, power management protocols
3. Different levels of Time-synchronization
4. Cannot do it using GPS or standard protocols like NTP used for traditional networks

Motivation…

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1. Clustering technique is an important and energy-efficient technique especially for data-gathering, fusion, etc.
2. Most of the TSPs are simulation based works
3. Effectiveness for practical WSNs questionable
4. cannot give a complete picture
5. make many assumptions at a high level of abstraction, do not consider packet loss and its effect on synchronization accuracy
6. Also do not state the Line-of-Sight (LOS) conditions in which the experiments are performed
7. LOS conditions can have significant effect on the performance of TSP

Existing schemes for clustered WSN…

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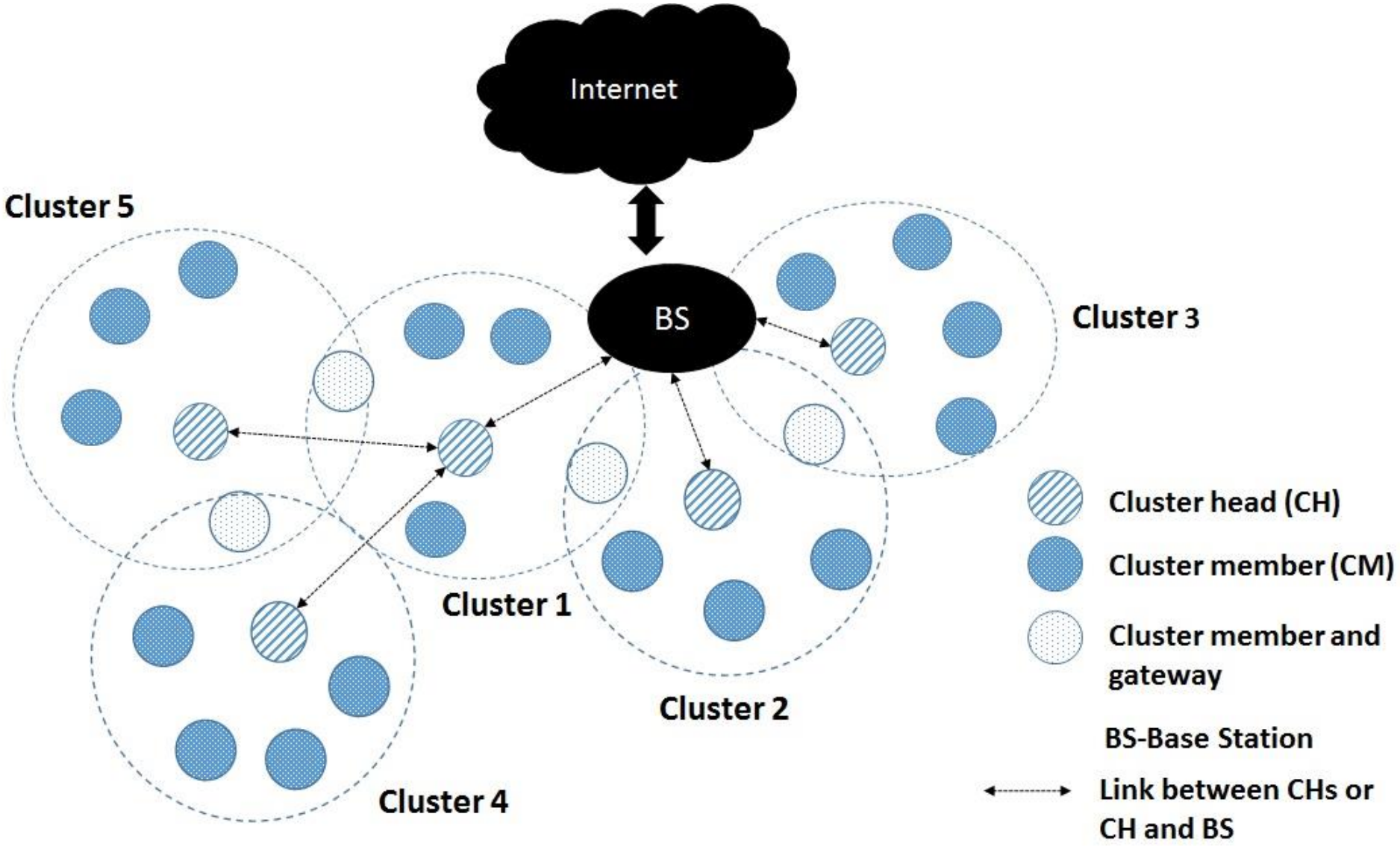
1. SLTP, L-Synch- Regression based schemes
   low accuracy, simulation based works, do not account for deterministic and non-deterministic delays
2. PC-Avg-takes average
   poor synchronization accuracy
3. CCTS, CMTS- high accuracy, but high overhead

H-SATS


Internet
BS
Cluster 5
Cluster 3
Cluster 1
Cluster 2
Cluster 4
Cluster head (CH)
Cluster member (CM)
Cluster member and gateway
BS-Base Station
Link between CHs or CH and BS

H-SATS

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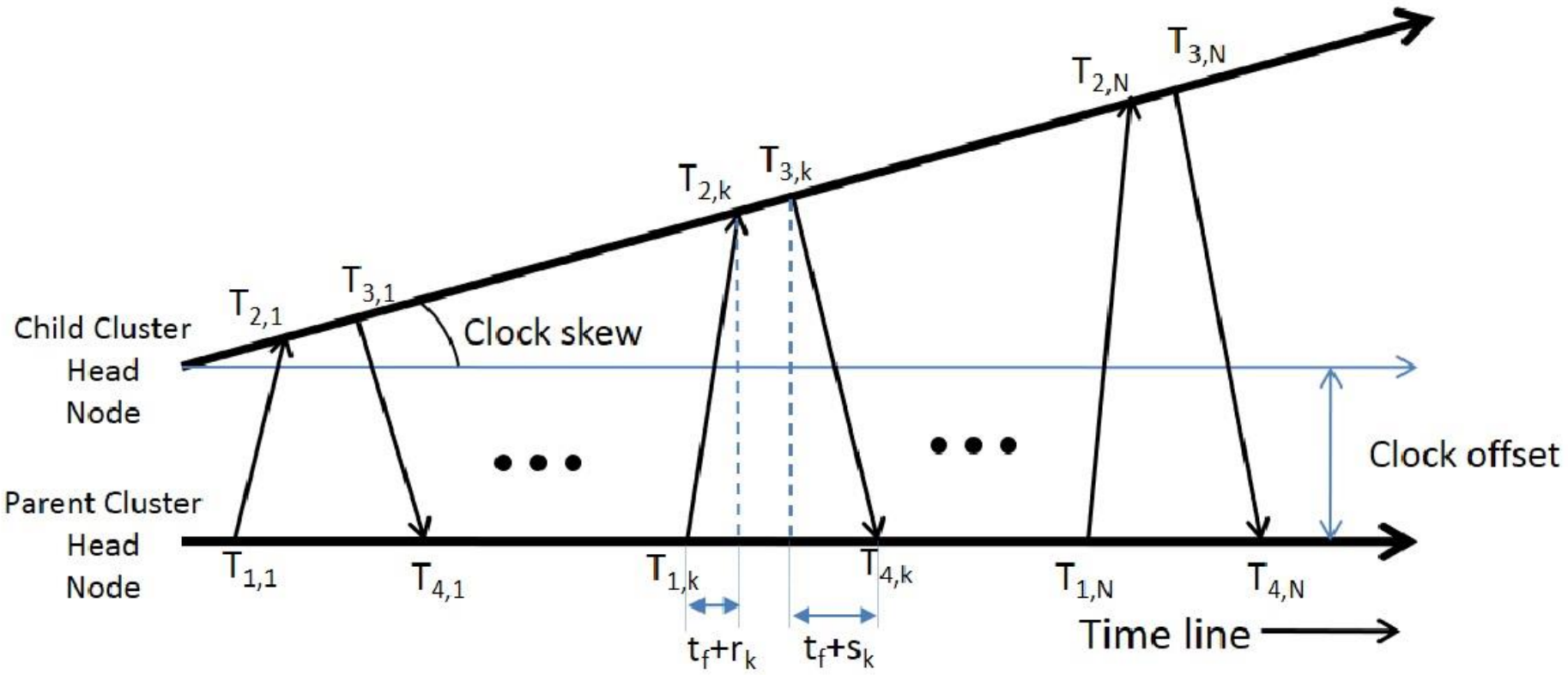

Mathematical Basis

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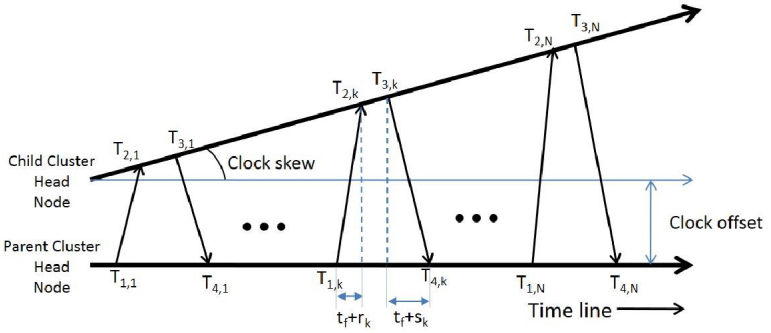
1. Clock Model

$$C_i(t) = \alpha_i\, t + \beta_i,$$

β_i: offset

α_i: skew

$$C_{ih}(t) = \alpha_{ih}\, C_h + \beta_{ih},$$



2. For a two-way exchange we can write

$$T_{2,k} = \alpha_{ih}(T_{1,k} + t_f + r_k) + \beta_{ih}$$

$$T_{3,k} = \alpha_{ih}(T_{4,k} - t_f - s_k) + \beta_{ih},$$

t_f: Det Delay

r_k, s_k: Non-deterministic delay

$$T_{2,k} = \alpha_{ih} T_{1,k} + \beta_{ih} + \alpha_{ih}(t_f + r_k)$$

$$T_{3,k} = \alpha_{ih} T_{4,k} + \beta_{ih} - \alpha_{ih}(t_f + s_k).$$

H-SATS

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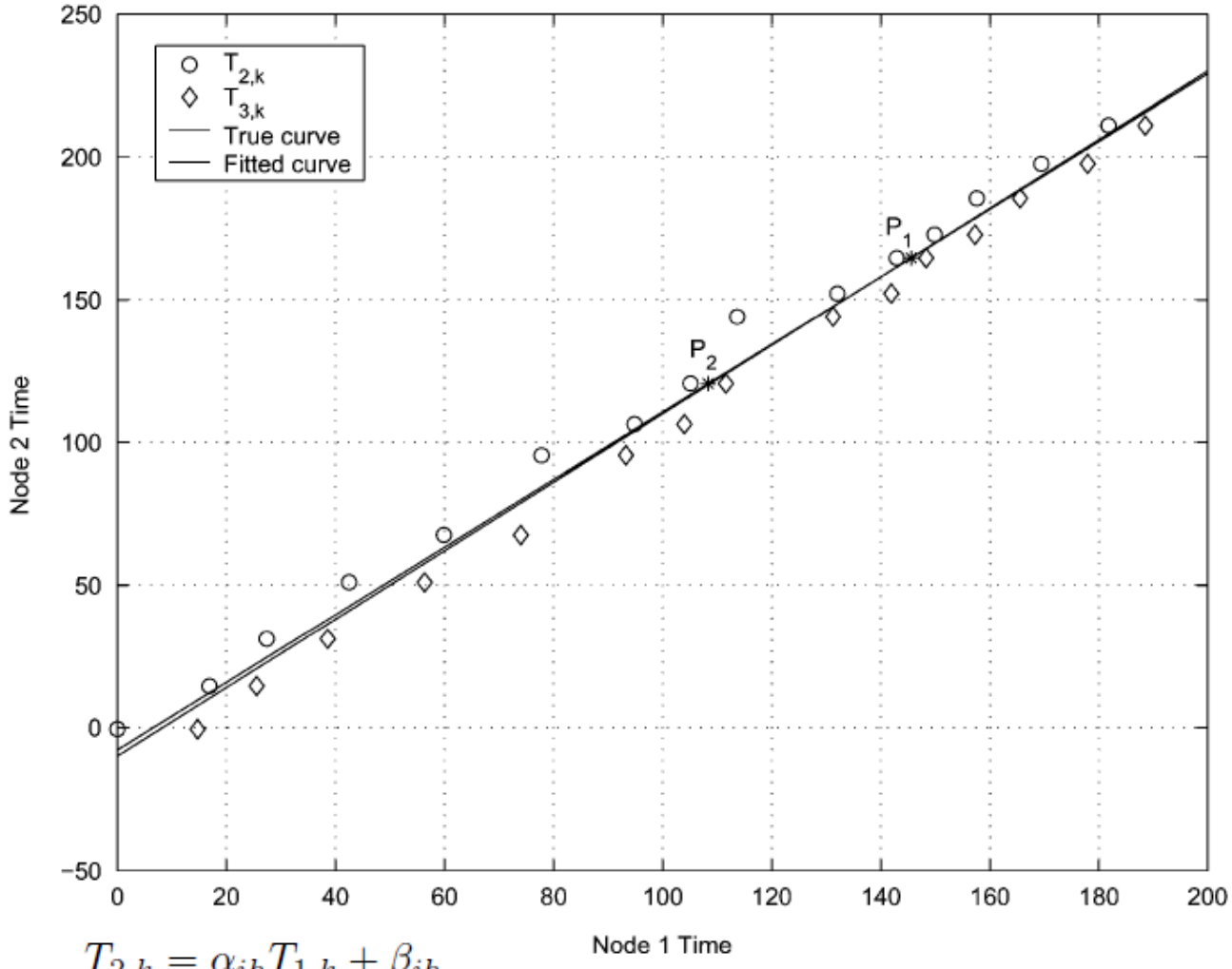

$$T_{2,k} = \alpha_{ih} T_{1,k} + \beta_{ih}$$

$$T_{3,k} = \alpha_{ih} T_{4,k} + \beta_{ih}$$

H-SATS vs regression method

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Algorithm Complexity for additions and multiplications

Algorithm	Additions	Multiplications
Regression method	O(N)	O(N)
SATS	O(N)	1

Experimental Setup

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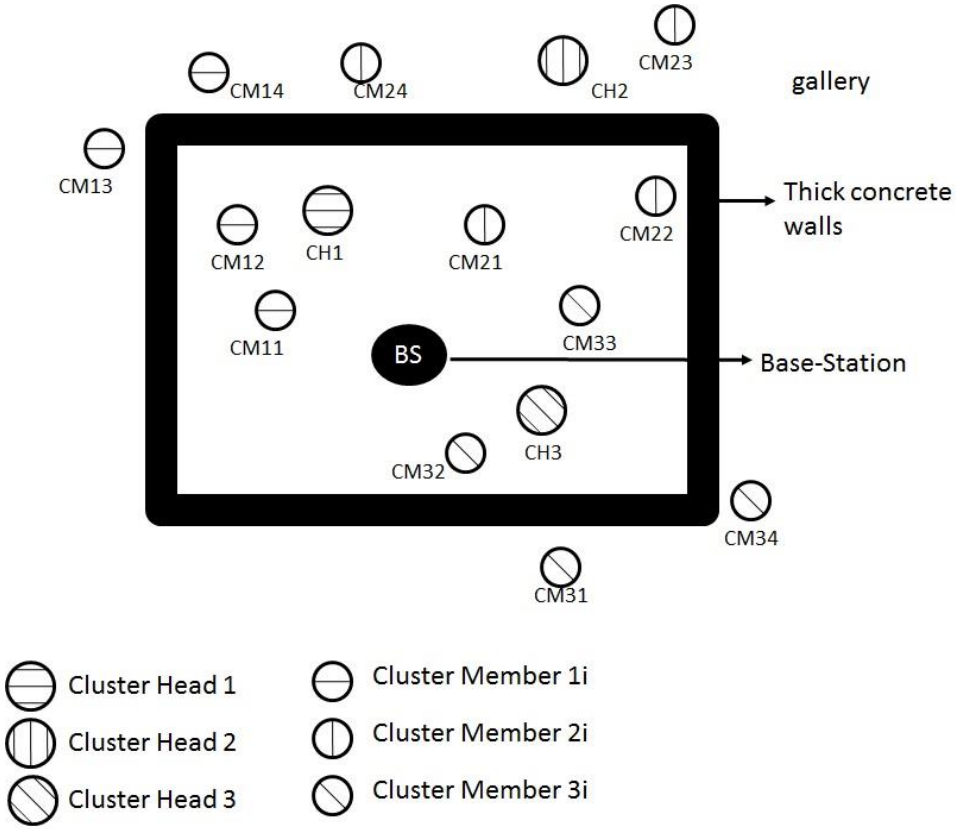
Experimental Setup



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Base Station collecting the data

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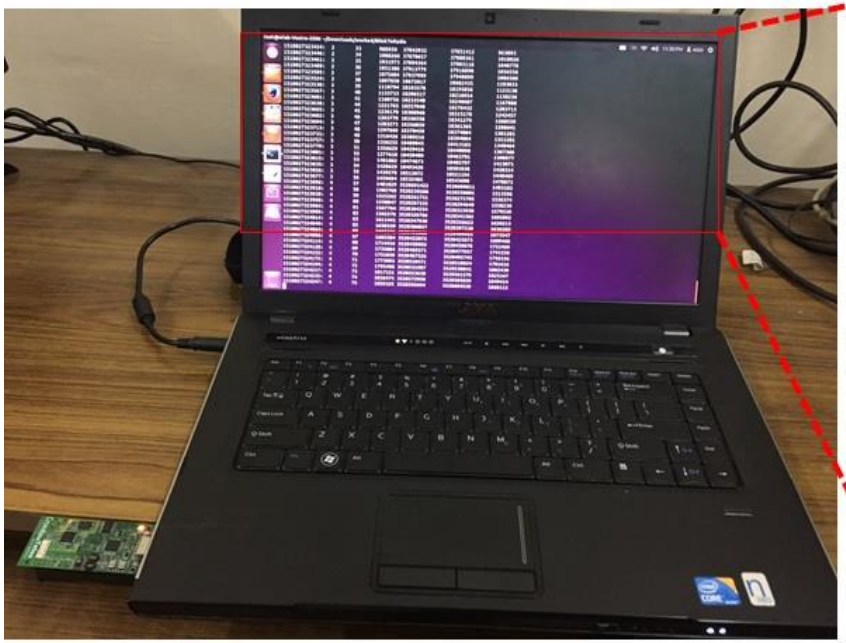

4 time stamps of a two- way exchange

Base Station collecting the data

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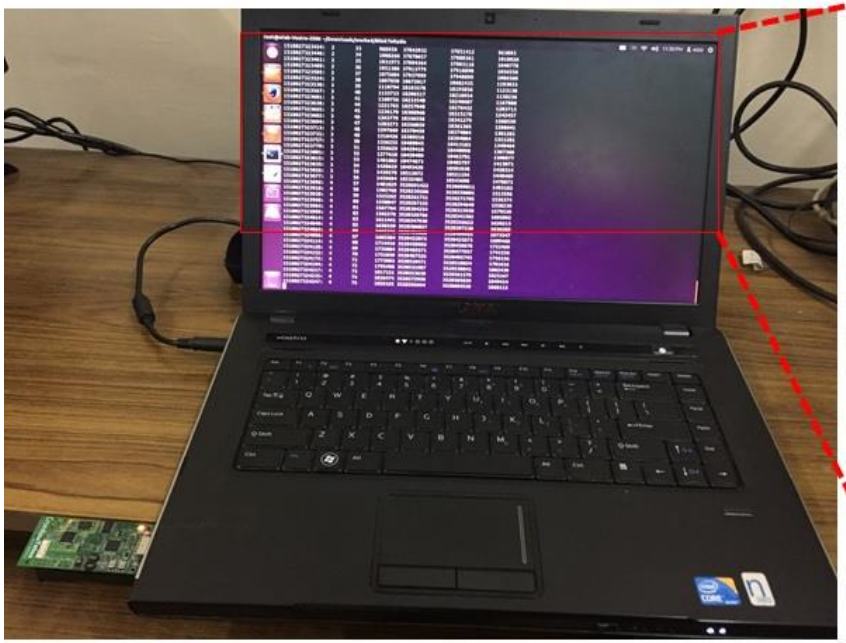

4 time stamps of a two- way exchange

Results-LOS

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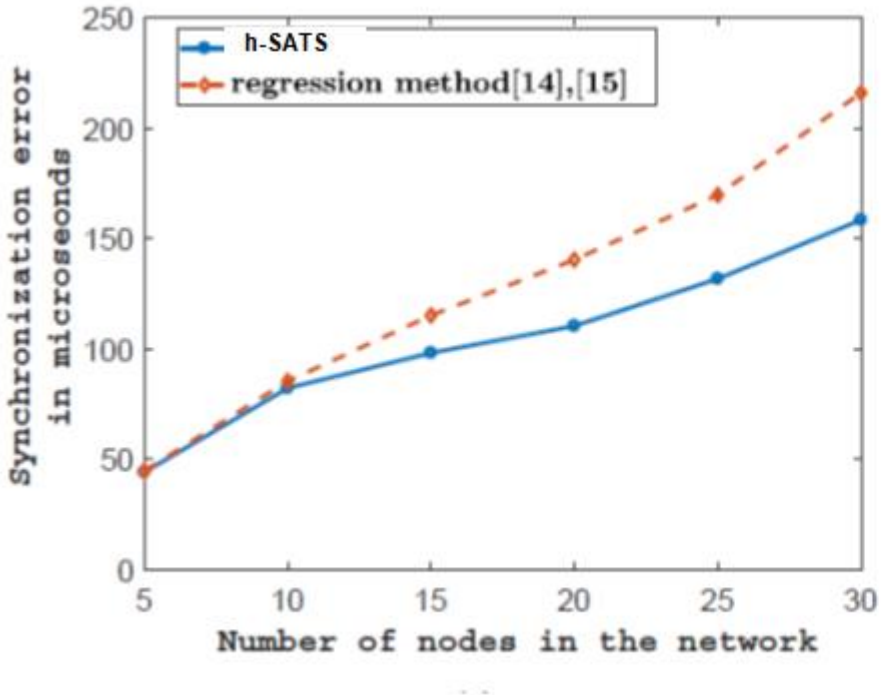

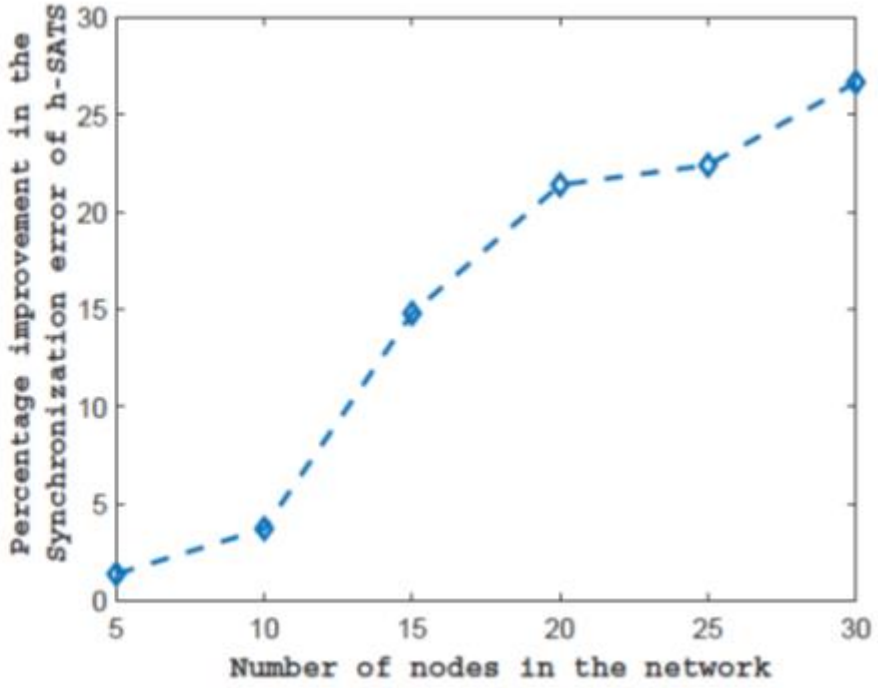

Results-mixed-LOS

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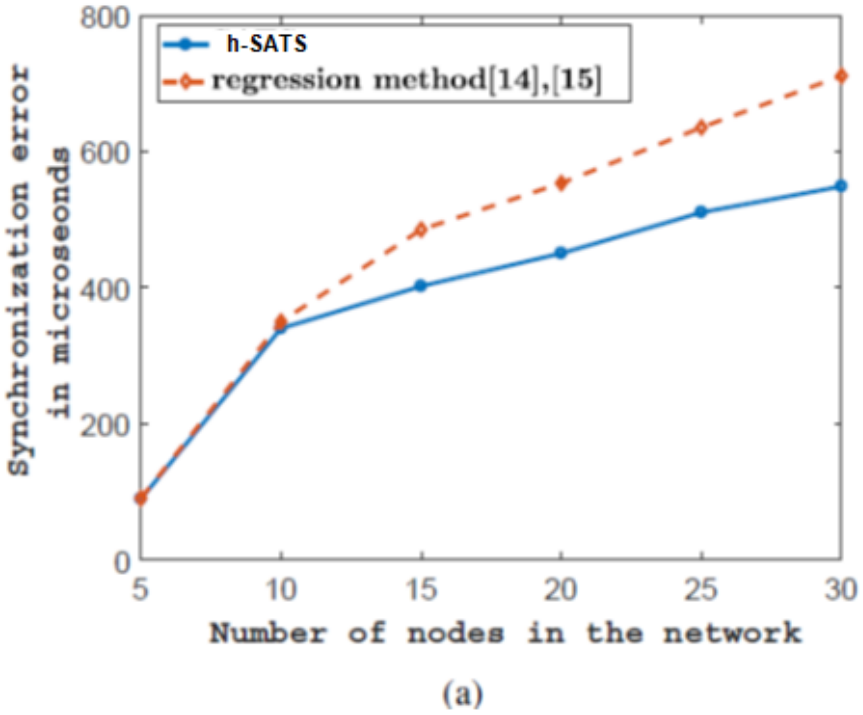
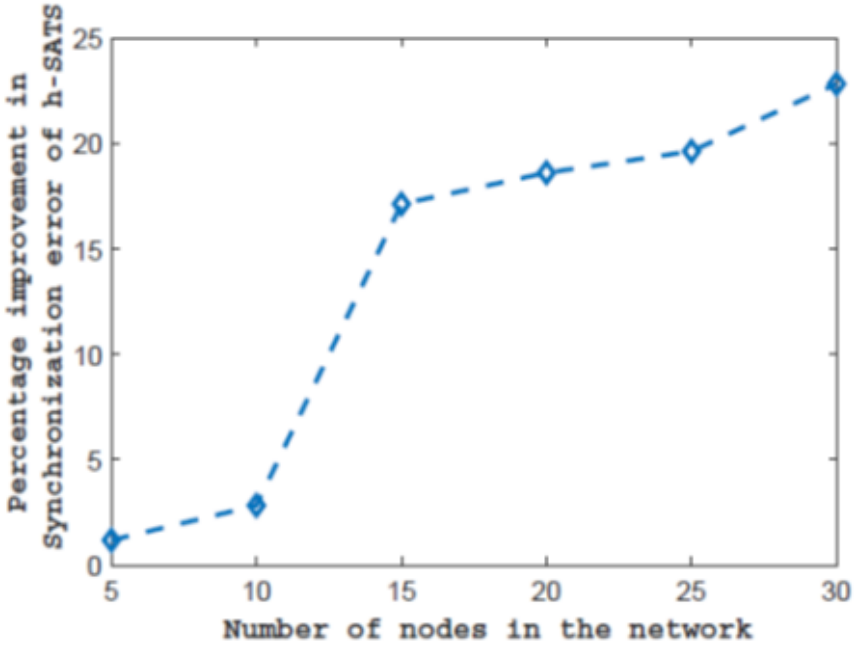


(a)



(b)

References

Chalapathi, G.S.S., Manekar, R., Chamola, V., Anupama, K.R. and Gurunarayanan, S., 2016, November. Hardware validated efficient and simple Time Synchronization protocol for clustered WSN. In *Region 10 Conference (TENCON), 2016 IEEE* (pp. 2162-2166). IEEE.

Other works are submitted to Journals for publication