



H-SATS- Simple Hierarchical Time Synchronization Algorithm for WSNs

Outline

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

Motivation

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...

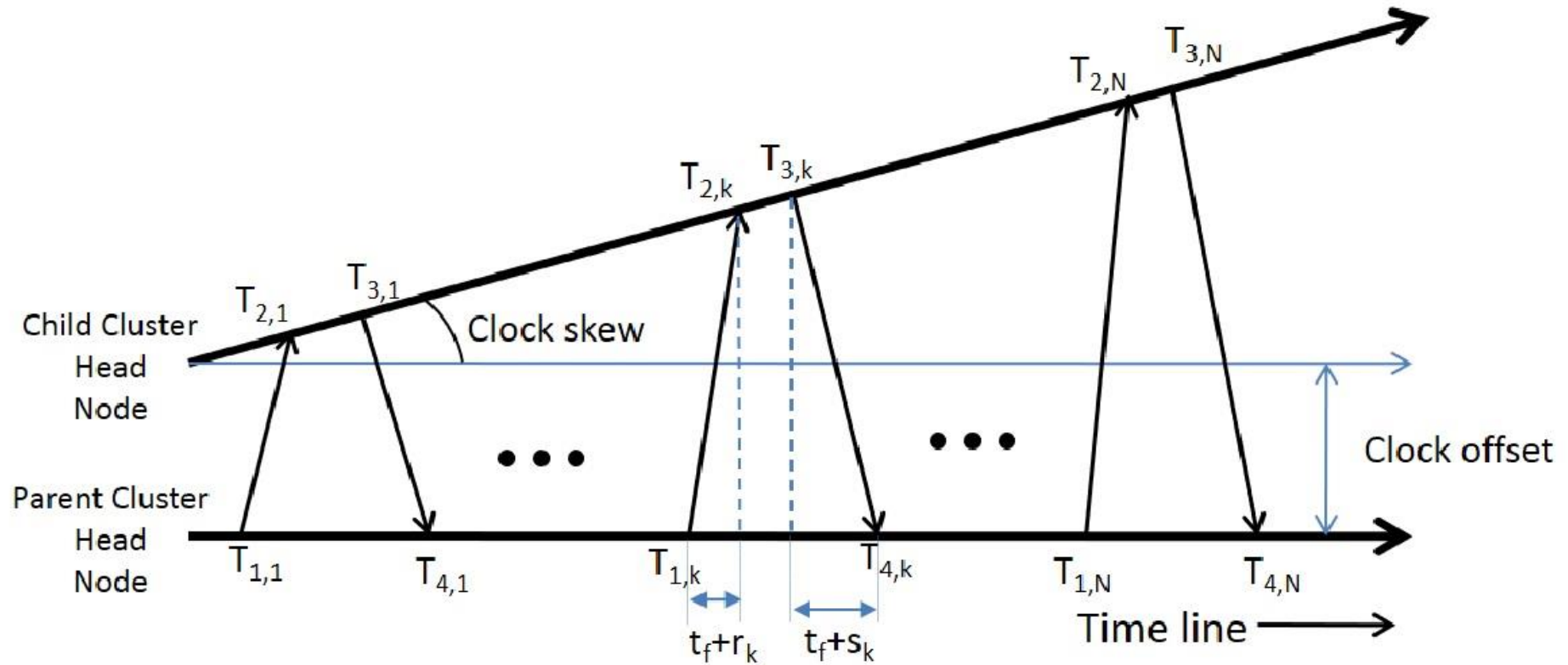
1. Clustering technique is an important and energy-efficient technique especially for data-gathering, fusion, etc.
2. Most of the TSPs are simulation based works
3. Effectiveness for practical WSNs questionable
4. cannot give a complete picture
5. make many assumptions at a high level of abstraction, 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...

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



Mathematical Basis

1. Clock Model

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

offset

skew

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

2. For a two-way exchange we can write

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

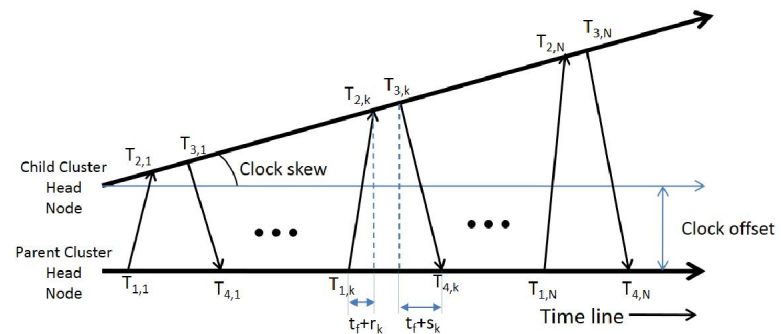
Det Delay

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

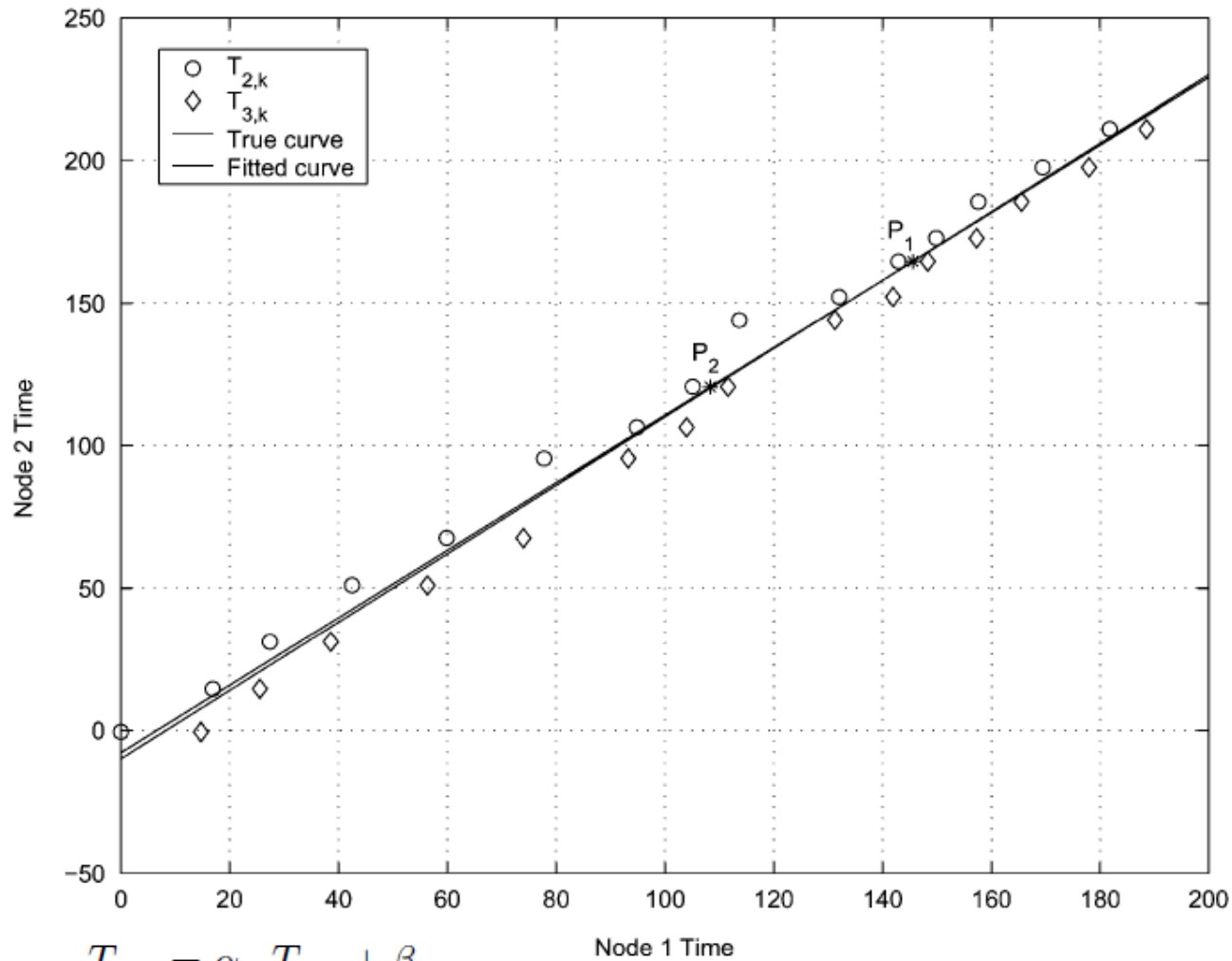
Non-deterministic delay

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

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



H-SATS



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

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

H-SATS vs regression method

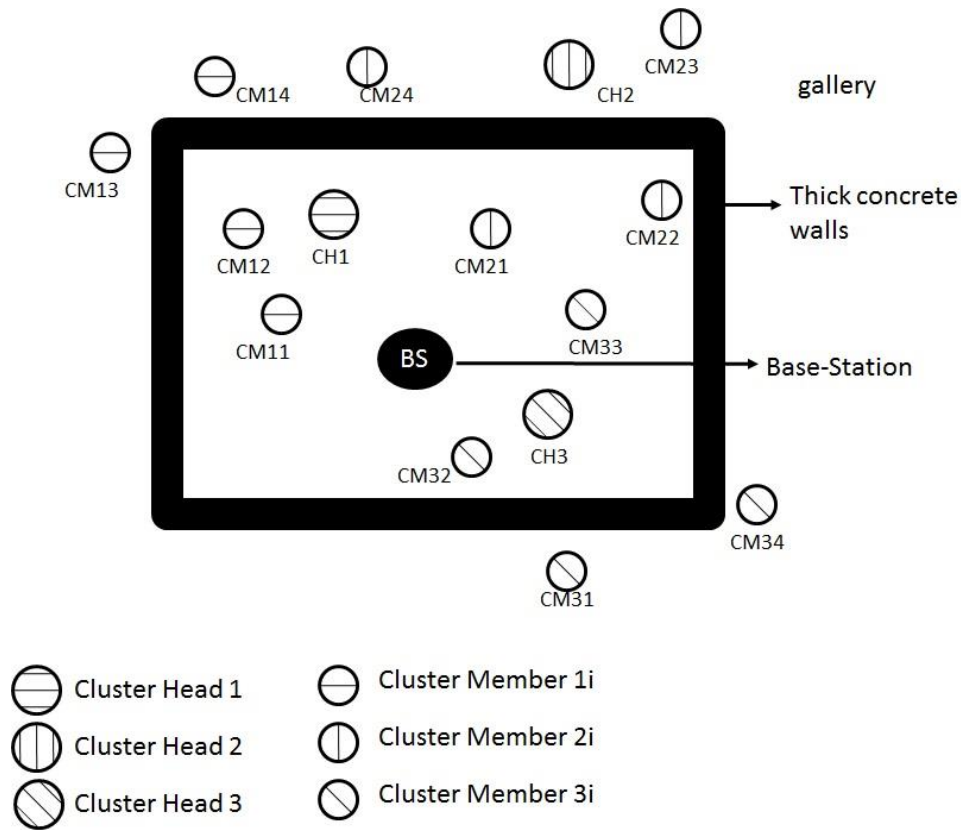
Algorithm Complexity for additions and multiplications

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

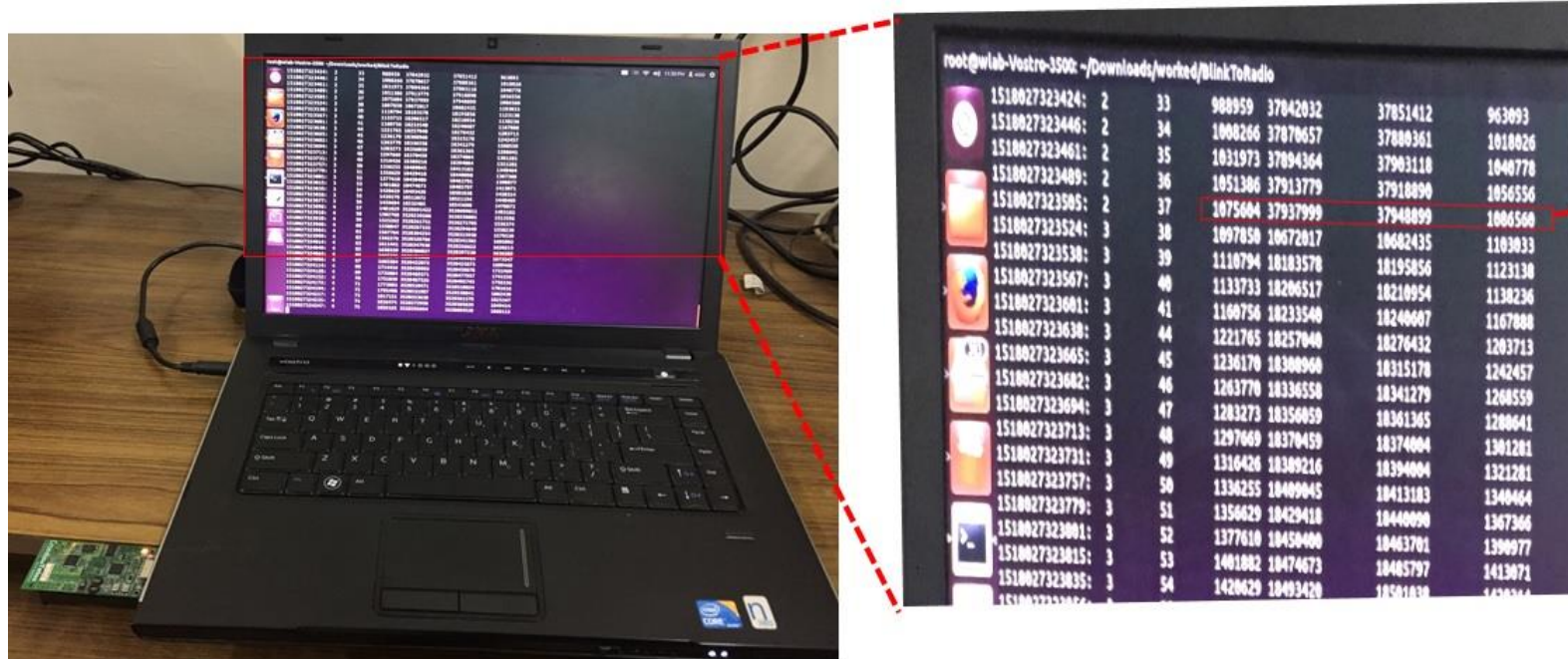
Experimental Setup



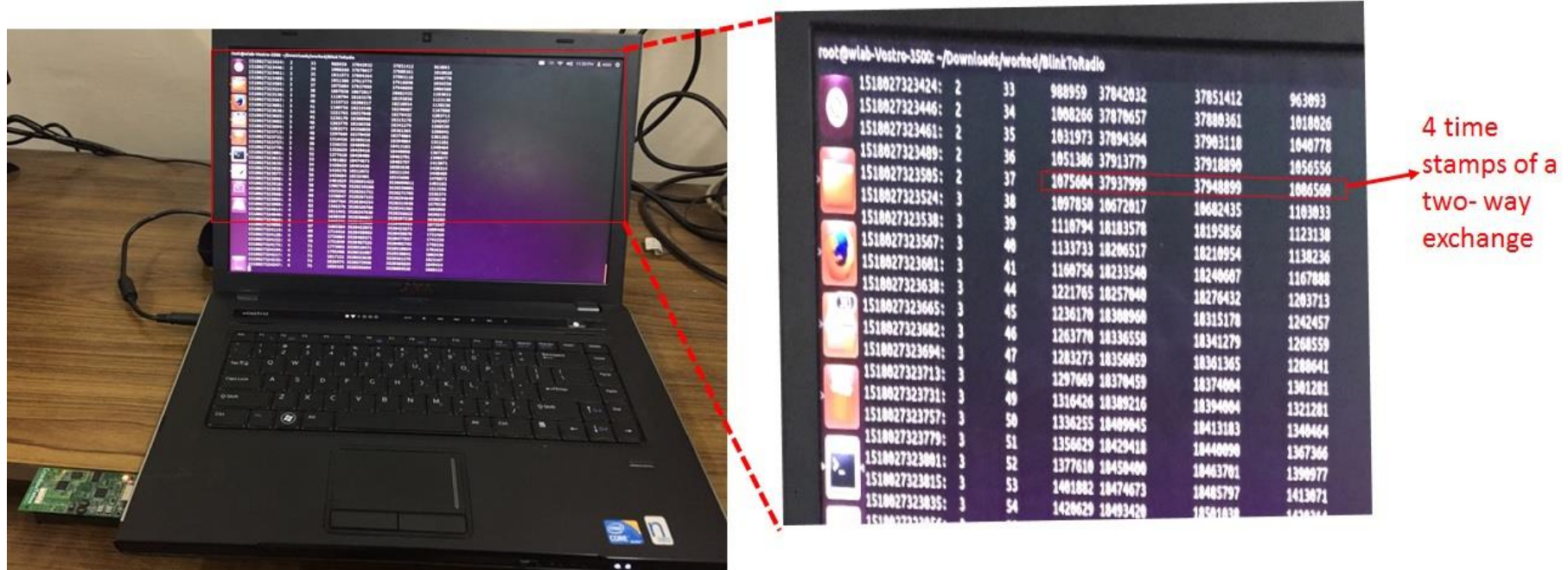
Experimental Setup



Base Station collecting the data



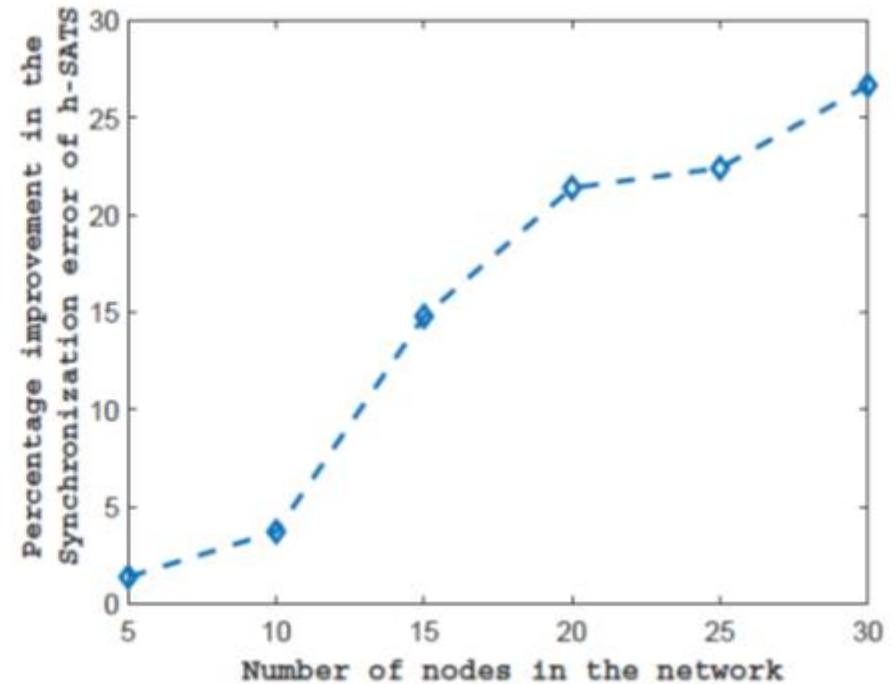
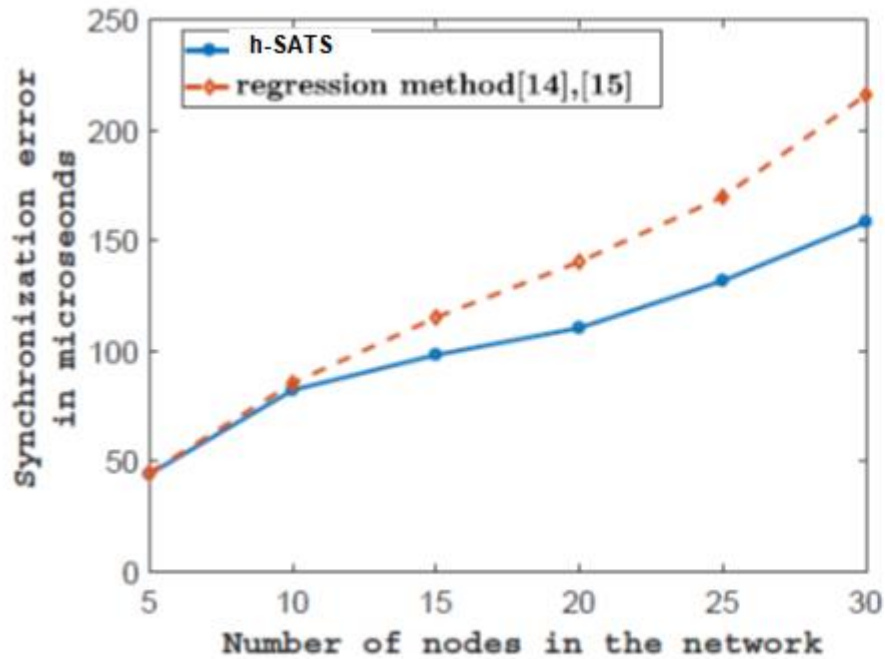
Base Station collecting the data



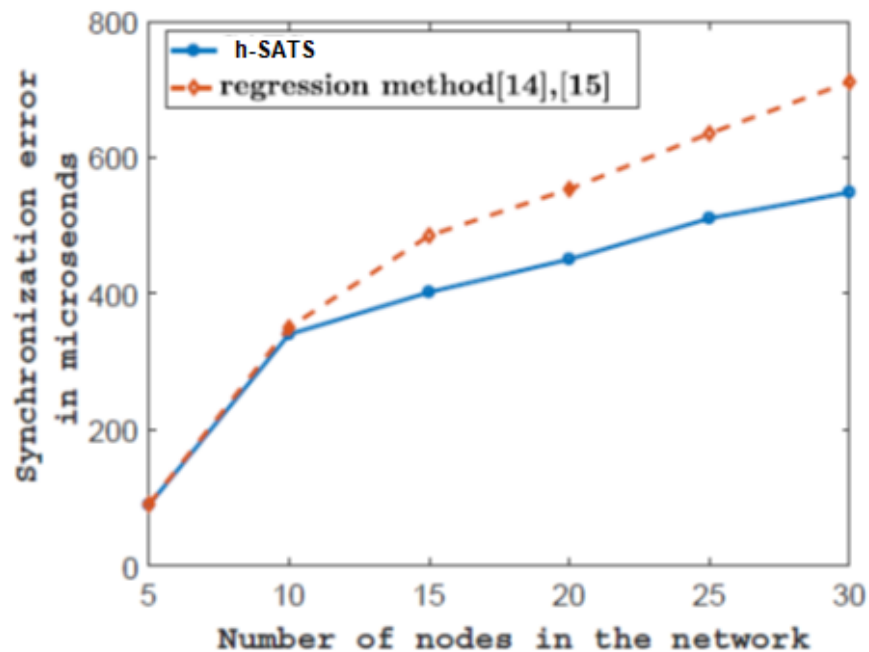
4 time stamps of a two-way exchange

IP Address	Port	Seq. No.	Len	Win	Flags	Timestamp	Window Seq. No.	Window Len	Window Seq. No.
1510027323424	2	33	900959	37042032	37851412	963093			
1510027323446	2	34	1000266	37070657	37800361	1010026			
1510027323461	2	35	1031973	37094364	37903118	1040770			
1510027323489	2	36	1051306	37913779	37910090	1050556			
1510027323505	2	37	1075604	37937999	37940099	1060500			
1510027323524	3	38	1097850	10672017	10602435	1103033			
1510027323538	3	39	1110794	10183570	10195056	1123130			
1510027323567	3	40	1133733	10206517	10210954	1130236			
1510027323601	3	41	1160756	10233540	10240607	1167800			
1510027323630	3	44	1221765	10257040	10270432	1203713			
1510027323665	3	45	1236170	10300960	10315170	1242457			
1510027323694	3	46	1263770	10336550	10341279	1260559			
1510027323713	3	47	1283273	10356059	10361365	1280641			
1510027323731	3	48	1297669	10370459	10374004	1301201			
1510027323757	3	49	1316426	10389216	10394004	1321201			
1510027323779	3	50	1336255	10400045	10413183	1340464			
1510027323801	3	51	1356629	10429410	10440090	1367366			
1510027323815	3	52	1377610	10450400	10463701	1390077			
1510027323835	3	53	1401082	10474673	10485797	1413071			
1510027323855	3	54	1420629	10493420	10501810	1430114			

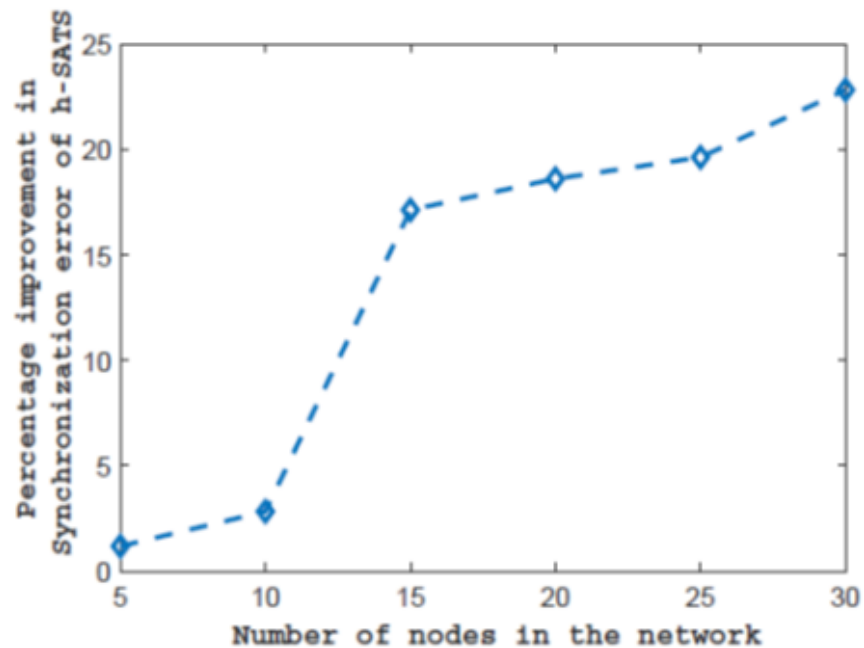
Results-LOS



Results-mixed-LOS



(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