TIME SYNCHRONIZATION FOR TIME OF ARRIVAL BASED LOCALIZATION

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ABSTRACT

Location and position awareness is most important for wireless sensor networks. Many WSN applications such as environment monitoring, target tracking and rescue require location awareness and accurate location. Accurate localization and synchronization are two important factors in wireless sensor network. Location accuracy is affected due to Synchronization, noise, offset, delay clock drift, and mobility. In Range based Time of Arrival (ToA) based localization gives location information for any range while RSSI and AoA only for short range. Weak synchronization is major problem in ToA hence time based localization requires clock/time synchronization due to the drifting of the local clocks. This paper reduces the clock drift problem using proposed synchronization algorithm. The Main objective is to develop the algorithm which can minimize the Synchronization error in WSN with considering offset and the skew of clock. In proposed algorithm timing information are exchanged explicitly using periodic packets know as beacons which are used to carry timestamps. Proposed algorithm consumes less energy, gives proper synchronization, scalable and eliminates the problem (Time Synchronization) of Time of Arrival based localization.

Keywords*: *Wireless Sensor Network, Time Synchronization, Localization.

I. INTRODUCTION

Wireless Sensor network is defined as a group of special spread and recording the physical conditions of the environment and organizing the collected data at a control location. In other word the WSN is consist of a number of wireless sensor and base stations. Localization is one of the main issues in wireless sensor networks. Localization is process to determine the geographical position of sensors in a wireless sensor network. Localization is divided in two methods - Range based localization method and Range free localization method. [1] Range based Time of Arrival (ToA)[2,3] based localization gives location information for any range while RSSI [4] and AoA only for short range.Weak synchronization is major problem in ToA hence time based localization requires clock/time synchronization due to the drifting of the local clocks.Location accuracy is affected due to synchronization, noise, clock drift, offset and propagation delay. The Main objective is to develop the algorithm which canminimize the synchronization error in Wireless Sensor Network with considering offset and the skew of clock.

This paper is organized as following. Section 1 gives brief introduction of wireless sensor network and localization. In Section 2 give information about localization techniques. It also gives how to calculate distance estimation using RSSI [5, 6], AoA [7], ToA [8] and TDoA [9]. Section 3 gives brief information of proposed method. Section 4 gives Simulation result of mordent TPSN method. Section 5 gives conclusion.

II. LOCALIZATION TECHNIQUES

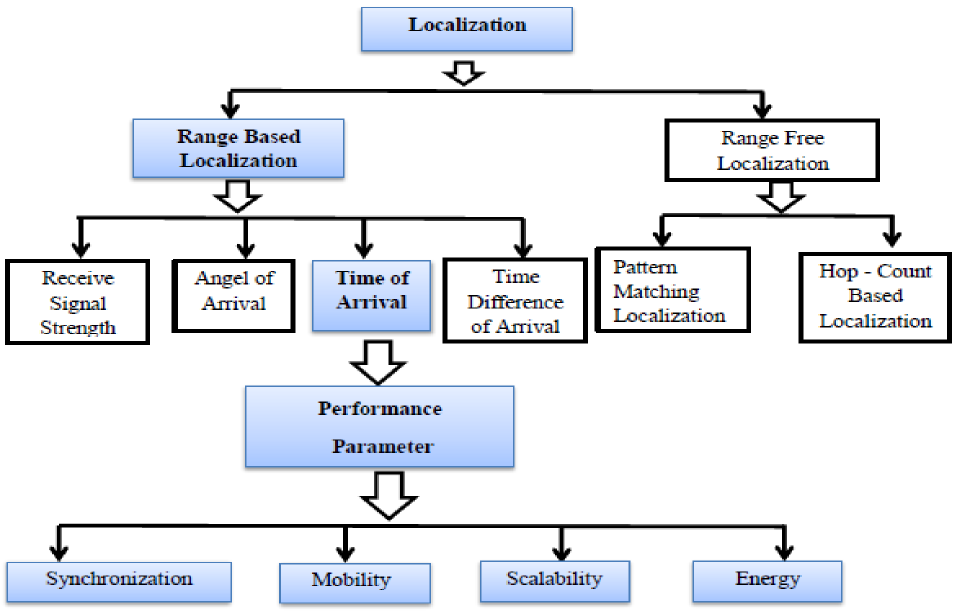

Figure 1: Localization Techniques

Figure 1 show the localization techniques. Localization method is divided in Range Based Localization and Range Free Localization. Range based method uses the measured data the angle and distance toEstimate its location. Range based method is more accurate compare to range free method. High accuracy can be obtaining using range based method. Range based method again subdivided in four type 1) Received signal strength indicator (RSSI), 2) Time of Arrival (ToA), 3) Angel of arrival and 4) Time Difference of Arrival (TDoA). Range free method uses the connectivity and hop by hop count to determine the location.

RSSI base localization is used to translate signal strength into distance. RSSI is easier and cheaper comparing to other method. Main disadvantage is accuracy is affected for large range and line of sight environment. RSSI does not work well in NLOS case because of multipath interference effects. TDoA determined the distance by using the differences in the time of arrival of signals that are transmitted from two reference nodes. Advantage of TDoA method is to overcome the limitation of Time of arrival. TDoA gives location accuracy of targeting the presence of significant noise. Main disadvantage of TDoA method is source of error is due to multipath propagation of TDoA measurement. The AOA method uses simple triangulation principle to calculate the location of a target node. Disadvantage of AoA method is if distance increase between target node and the transceiver stations accuracy of location is affected due to propagation characteristics of the received signal. To overcome this disadvantage ToA method comes in Localization. Time of arrival is the most generally used distance measurement method.

ToA measures the point to point distance between two nodes like source and receiver. In the TOA method the one way propagation time is determined and the distance between reference node and transmitter is estimated. It means the source and receiver are synchronized to measure the ToA information. The measure ToA multiply with a known propagation speed which is denoted by C, give the computed distance between source and receiver. Then it performs Trilateration to determine the location of unknown node. Advantage of ToA method is that ToA give high accuracy in position location of a target node. If the distance between two node increases do not affect the accuracy of calculation like in other method AoA and RSS method. Main disadvantage of ToA method is week synchronization is major problem in ToA. This paper overcomes the time synchronization problem of to A based localization.

III. TIME SYNCHRONIZATION FOR ACCURATE LOCALIZATION

Time synchronization in a computer science aims at providing a common time scale for local clocks of nodes in the network. All hardware clocks are imperfect or faulty. The local clocks of nodes may drift away from each other in time, hence observed durations of time intervals may different for each node in the network. Need of time synchronization for better localization performance and coordinate future event. There are different methods for time synchronization. For example Simple Network Time Protocol (SNTP), Reference Broadcast Synchronization (RBS), IEEE 1588 and Time-Sync Protocol for Sensor Networks (TPSN). Among those method TPSN give better performance compare to other method.

A.Timing-Sync Protocol for Sensor Networks (TPSN): Ganeriwal Proposed time synchronization protocol for sensor networks, which they call Timing-Sync Protocol for Sensor Networks (TPSN) [17].TPSN use hierarchical topology in the network. TPSN is scalable and the synchronization precision does not deteriorate significantly as the size of the network increases. TPSN works in two phases first is “level discovery phase" and second is “synchronization phase".Level discovery phase is run once at the network deployment. First a node should be determined as the root node. The root node is assigned a level zero and it initiates this phase by broadcasting a level discovery packet. The level discovery packet includes the identity and the level of the sender. The neighbours of root node receive packet and assign a one greater than level they have received. For example level 1. After founding their own level, they broadcast a new level discovery packet containing their own level. This process is continued and every node assigns level which node is in network. When all nodes assigned a level then a node neglect any future packet. In this phase no flooding congestion takes place. Thus a hierarchical structure is developing with only one node, root node, at level zero. A node might not receive any level discovery packet owing to MAC layer collision.In the synchronization phase is the two-way Message exchange between a pair of nodes. The authors assume that the clock drift between a pair of nodes is constant in the small time period during a single message exchange. The propagation delay is also assumed to be constant in both directions.

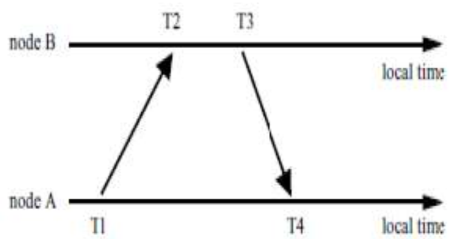

Figure 2: Two Way Message Exchange Between A Pair of Nodes.[5]

Consider a two-way message exchange between nodes A and B as shown in Figure 4 Node A initiates the synchronization by sending a synchronization pulse packet at T1 (according to its local clock). This packet includes A’s level number, and the value T1. B receives this packet at T2 = T1+ +d, where is the relative clock drift between the nodes, and d is the propagation delay of the pulse. B responds at time T3 with an acknowledgement packet, which includes the level number of B and the values T1, T2, and T3. Then, node A can calculate the clock drift and propagation delay as following, and synchronize itself to B.[18]

$$\Delta = \frac{(T2-T1)-(T4-T3)}{2}, \quad d = \frac{(T2-T1)+(T4-T3)}{2}$$

The synchronization phase is initiated by the root node's time sync packet. On receiving this packet, level 1 node initiate a two-way message interchange with the root. Before initiating the message exchange, each node waits for some random time, in order to minimize collisions on the channel. Once they get back a reply from the root node, node adjust their clocks to the root node. Level 2 nodes, overhearing some level 1 node's communication with the root, initiate a two-way message interchange with a level 1 node, again after waiting forsome random time to ensure that level 1 nodes have completed theirsynchronization. This procedure eventually gets all nodes synchronized to the root node.

IV. PROPOSED MODERATETPSN METHOD

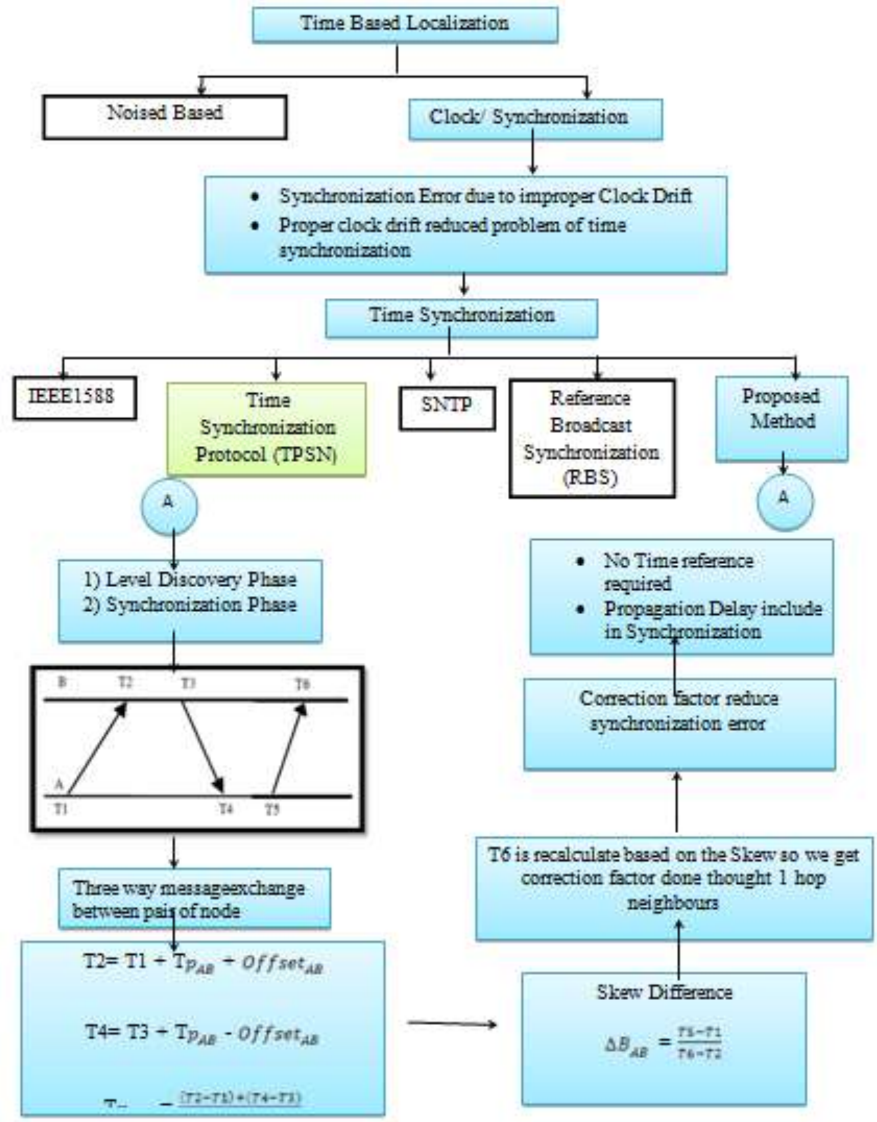

Figure 3 Block diagram of time based localization

Figure 3 show the block diagram of time based localization. Time synchronization is main problem of time of arrival method. There different type of synchronization method. For example IEEE 1588, Simple Network Transport Protocol, Reference Broadcast Synchronization and Time synchronization protocol for network here we present algorithm we reduce clock drift using Time Synchronization protocol. Following process is done between nodes to reduce drift and offset.

1. First A sends a synchronization pulse packet to B. The synchronization pulse packet contains the level number of A and the time value of T1.
2. Node B receives this packet at time, T2

   T2 = T1 + Tp_{AB} + $Offset_{AB}$

   Where Tp_{AB} = propagation delay

   T1 = Timestamp
3. At time T3, 'B' sends back an acknowledgement packet to 'A'. T4 receives acknowledgment packet.

$$T4 = T3 + Tp_{AB} - Offset_{AB}$$

$$Tp_{AB} = \frac{(T2-T1)+(T4-T3)}{2}$$

4. Skew Difference between two node calculate by following equation

$$\Delta B_{AB} = \frac{T5-T1}{T6-T2}$$

Skew difference calculation for n node

$$\Delta B_{ij} = \frac{Txj(nT)-Txj((n-2)\tau}{Trj(nT)-Trj((n-2)\tau}$$

Where

τ = Time Sampling

Txj = Time stamp of transmitter j at the message transmission time, Tp_{AB} =Propagation delay

5. T6 is recalculate based on the Skew so we get correction factor done thought 1 hop neighbours

$$T4 = T3 + Tp_{AB} + Offset_{AB}$$

$$T6 = T3 + (T6 - T3) - \Delta B_{AB}$$

$$T6' = T5 + Tp_{AB} + Offset_{AB}$$

$$Tp_{AB} = \frac{(T4-T3)+(T6'-T5)}{2}$$

Where $Offset_{AB}$ = Clock offset between two node

6. After completing the message exchange the synchronization error is produced.By calculating correction factor continuously synchronization error is reduced for static node and moving node.

V. SIMULATION RESULTS

5.1 Simulation Set Up

Simulation setup divided in two stages. First one is prime structure and second one is slot Structure. Prime structure is based on contention based IEEE 802.11 protocol. This stage usedfor non-synchronized in order to join network for synchronization. Then deterministic MAC such as TDMA used to transmit data fram synchronized node. Followingparameter used in simulation.

Table 1: Simulation Parameter

Area	**1000 * 1000**
No of Node	50
MAC	IEEE 802.11
Packet Queue	50
Antenna	Omnidirectional antenna
Propagation Model	Two Ray Ground

Result of Proposed TPSN code which is implemented network simulation 2 (NS-2) isshown in below Figure 4. Nodes are synchronized in first snapshot. In simulation we take 50 nodes. In Figure 4 green node suggested that node is not participating in synchronization process while blue node suggests that node is participating in synchronization processSimulations done in 200s.All node are static. As soon as time is increase synchronization error is decrease due to proposed algorithm add correction factor otherwise synchronization error increases.

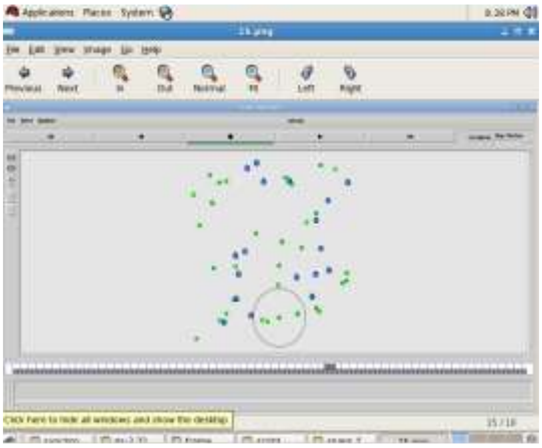

Figure 6 Node are Synchronized

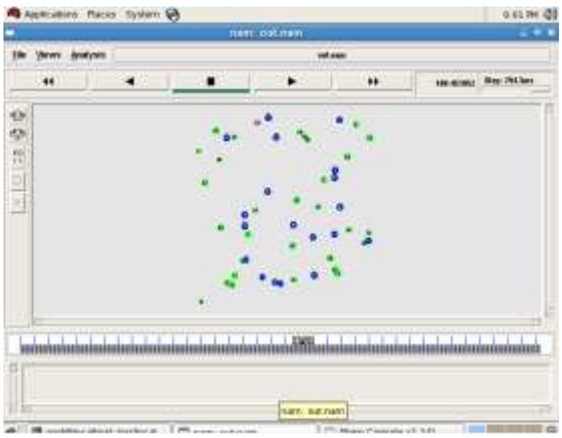

Figure 7 Node are Synchronize

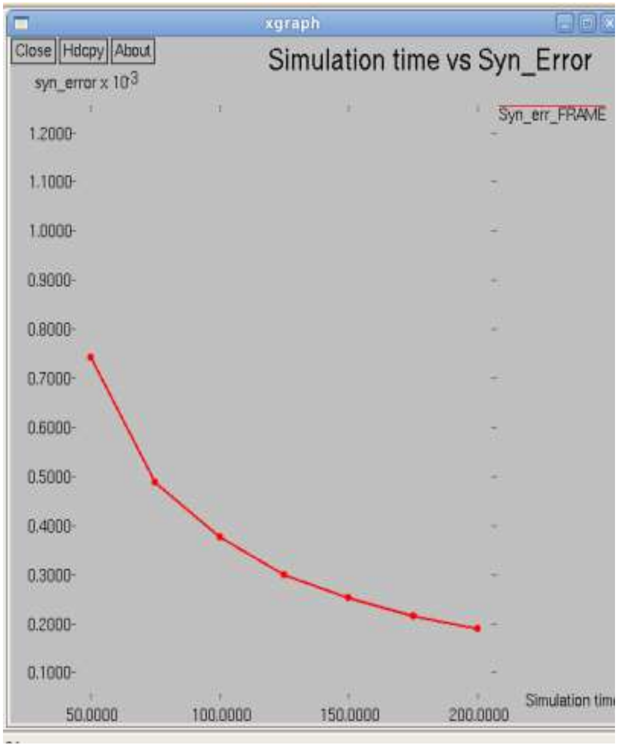

Figure 8 Simulation Time vs Synchronization Error (Static node)

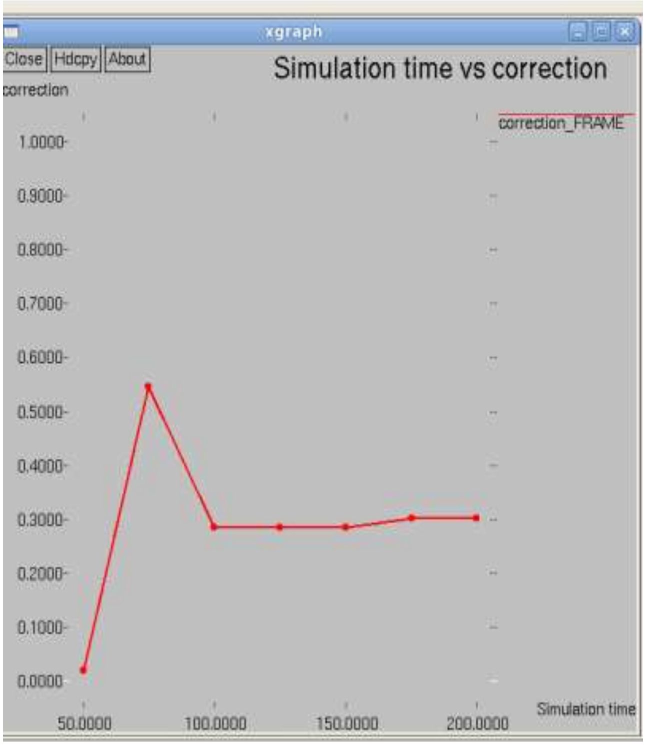

Figure 9 Simulation Time vs Correction Frame (Static node)

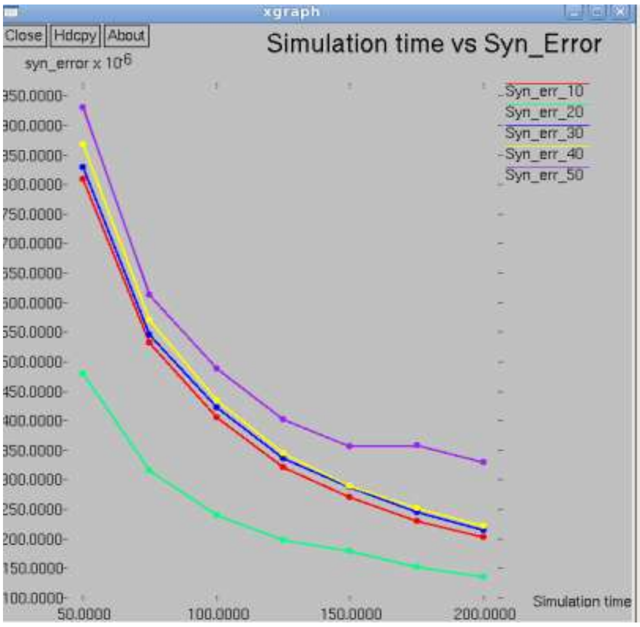

Figure 10 Simulation Time vs Synchronization Error (Moving node)

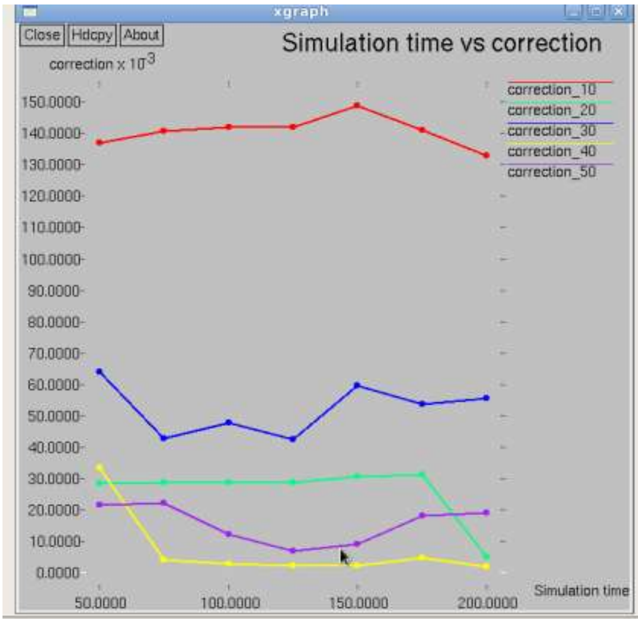

Figure 11 Simulation Time vs Correction (Moving node)

Figure 10 and 11 show the graph of synchronization error and correction. In Figure 10 we can see that for moving 10 node correction factor is more compare to 20, 30, 40 and 50 nodes. For 50 node correction factor is less that means 50 nodes has low synchronization error. In proposed algorithm we continuously added correction factor so that synchronization error is reduce. Proposed algorithm provides accurate result as node is increase.

5.2 Observation Parameter of Simulation

Table 2: Observed Simulation Parameter

Sending packets	1841	**Delay**	0.068848
Receiving packets	1841	**Throughput**	80043.5
Packet delivery ratio	100	**Jitter**	0.0999836
Normalized routing overhead	2.71103	**No of packets dropped**	0
Control Overhead	4991	**Dropping ratio**	0
Total Energy Consumption	10.2165	**Overall Residual Energy**	4889.78
Average Energy Consumption	0.208501		

VI. CONCLUSION

There are many factors that affect the location accuracy of the estimated locations are Scalability, Energy, Mobility and Time Synchronization. From comparative paper study time based (ToA, TDoA) localization error is not less than 2.5m .Time synchronization is main factor that affect the location error. Time Synchronization algorithm is more affected by offset, delay and drift. So that research is being done on time synchronization algorithm. In this paper proposed work focused to minimize skew, offset and considering propagation delay during synchronization message communication.

Proposed method of Time synchronization is provides efficient time synchronization in sensor network, even when nodes are increase. Proposed algorithm provides less synchronization error for static and dynamic nodes. Proposed algorithm consumes less energy [Table 2], gives proper synchronization and eliminates the problem of Time of Arrival based localization [II].

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