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# Multiple Master Nodes based Time Synchronization Algorithm for Wireless Sensor Networks: A Review

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***Abstract*—One of the most irreplaceable & support technology for Wireless Sensor Network is Time Synchronization. Efficient Time synchronization is a well-known challenge for Wireless Sensor Network and at the same time it is a topic that has been attracting the research community in the last decade. It is significant for successful communication between nodes and to determine the sequence in which sensing data is generated. At the same time, the goal in Wireless Sensor Networks is to save the energy, which is possible only and only due to Time synchronization. This paper gives an insight on overall Time synchronization concept in Wireless Sensor Networks and overview of some traditional Time synchronization protocols. In view of the disadvantage of traditional Timing-sync Protocol for Sensor Network (TPSN), we present a newly time synchronization algorithm, in which several master nodes provide efficient network wide time synchronization between nodes over a multi hop wireless network.**

***Index Terms*— Time-Sync Protocol for Sensor Networks (TPSN), Wireless Sensor Network (WSN), Master nodes, Multi hop, Hierarchical Topology and Synchronization.**

## I. INTRODUCTION

Wireless Sensor Network are in use for the last few years, which provides a method to examine and observe unattainable environment and some other applications to control an automated system. In recent years several Wireless Sensor Network applications have been designed and introduced such as temperature, pressure, moisture and humidity [4]. Wireless Sensor Network (WSN) is made up of several nodes. In order for a node, to cooperate with each other they maintain time synchronization to complete the corresponding task in Wireless Sensor Network [1]. One of the most significant task in Wireless Sensor Network is to maintain the global time for successfully executed operations such as: Combining data analyzed and sensed via various sensor, counting informed measures and maintaining time logs amongst other things, Data fusion, node location, synchronization of dormant period and Mac link scheduling.

All of the above mentioned operations requires a unified clock. Today one of the important problem domain in WSN is time synchronization which has attracted researchers in this field. To overcome the problem of time synchronization in WSN and to achieve network wide time synchronization, time synchronization protocols have been introduced [4].

The aim of this paper is to throw some light on concepts related to time synchronization and some traditional time synchronization protocols in wireless sensor network. At the same time, we introduce some improvements

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to traditional Time sync Protocol for Sensor Network (TPSN), which is not capable to handle dynamic topology and require heavy computation.

## II. BASICS ABOUT TIME SYNCHRONIZATION IN WIRELESS SENSOR NETWORK

Time synchronization plays a vital role in wireless sensor network. The system architecture of wireless sensor network for time synchronization is created by certain number of sensing nodes in wireless sensor network. Since these sensor nodes are moving and will frequently drift with each other, thus time synchronization is maintained in network by implementing several different types of time synchronization protocol. Fig 1 represents the block diagram of time synchronization in WSN.

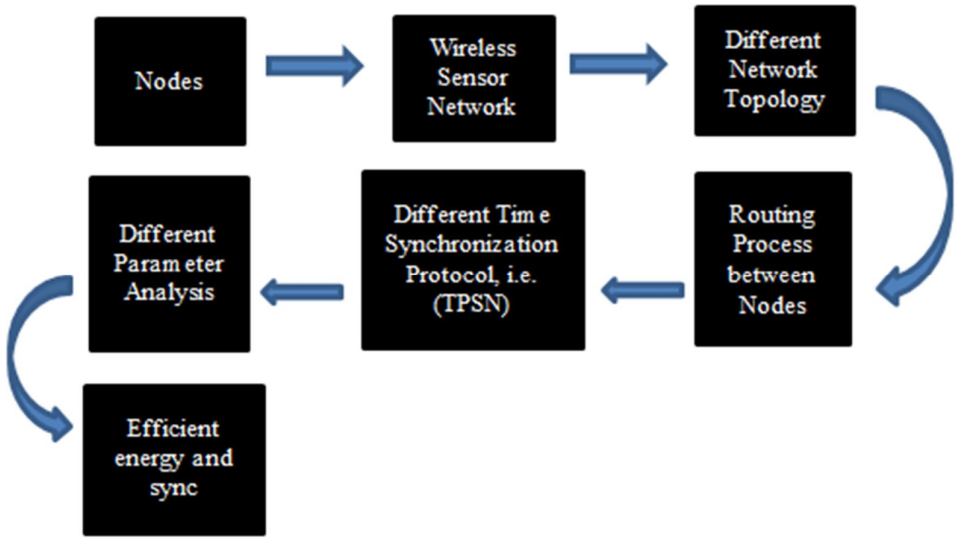


Figure 1. Block diagram of Time Synchronization in WSN [6]

In wireless sensor network several nodes are deployed and are communicating with each other to perform a task. In the above figure it shows that firstly we require sensor nodes within wireless sensor network to establish the synchronization. In next step we require different network topology so that routing process takes place within nodes. After routing process it's time for implementing time synchronization in WSN. At the result network wide time synchronization will be performed and energy will be consumed efficiently which is the main goal of WSN. Typically, synchronization is based on some sort of messages exchanges among sensor nodes. The existing time synchronization protocols used in WSN are the One-way message exchange, two way messages exchange and the Receiver-Receiver synchronization, which exchange some sort of messages.

### *A. One-way message exchange*

The one-way message exchange is said to be the simplest approach. This technique of pair wise synchronization occurs when only a single message is used to synchronize two nodes. Let's suppose that node x sends synchronization messages to node y at time T1, embedding T1 as time stamp into the message. As soon as node y receives this message, it will obtain a time stamp T2 from its own local clock. The difference between two stamps is an indicator of clock offset. The Fig 2. shows the scenario of such kind of message exchanges.

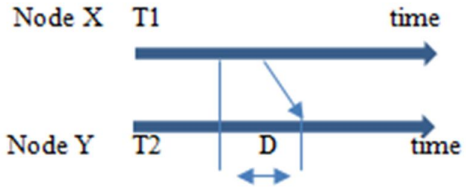


Figure 2. One-way message exchange

*B. Two-way message exchange*

As the name indicates we have to use two synchronization messages in this method. Node X will send the synchronization message at time T1 to Node Y. This message contains node X level and the time T1. Node Y will receive this message at time T2. At time T3 node Y sends acknowledgement message to node X. Thus the acknowledgement message contains the level number of node as well times T1, T2 and T3. Thus by knowing the drift, Node X can easily correct its clock time and will successfully synchronize to Node Y. The Figure 2. Shows the two-way message exchanges between nodes.

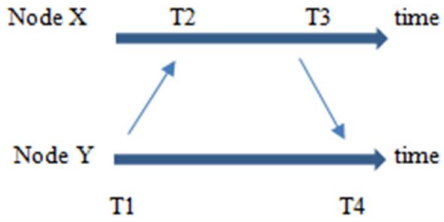


Figure 3. Two-way messaging exchange

*C. Receiver-Receiver Synchronization*

Another approach for applying time synchronization is the receiver- receiver synchronization. In this method synchronization is based on the time at which same message arrives at each receiver. Let's suppose we have a broadcast environment, the receivers obtain the message at about the same time and then will accordingly exchange their arrival time to compute an offset. In this method the arrival time of the broadcast message at different receivers are used to synchronize the receiver to each other. The below figure show the receiver-receiver synchronization method.

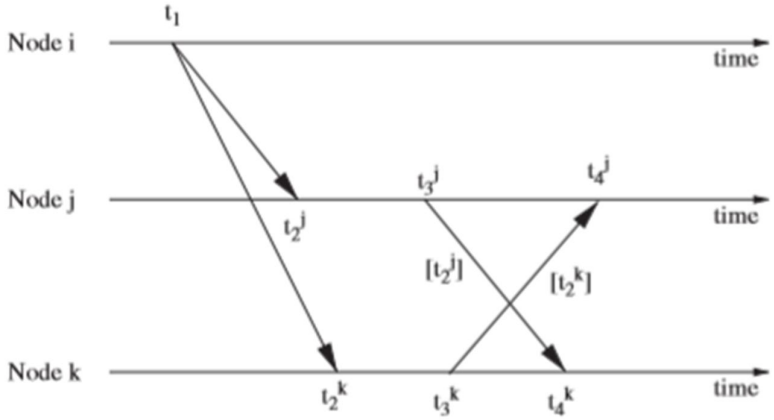


Figure 4. receiver-receiver synchronization [5]

## III. OVERVIEW OF TPSN PROTOCOL

As discussed in the previous section that several different kinds of protocols have been introduced for Time synchronization in WSN. The first time synchronization protocol is the Reference Broadcast Synchronization (RBS). In this protocol, the transmitter sends a reference packet to the receiver and then accordingly each receiver saves the Time of Arrival (TOA) of reference packet. These saved messages will be exchanged accordingly so that at the last time synchronization is performed in WSN. Another traditional protocol is the Hybrid Energy-Aware synchronization protocol. In this protocol, the process will begin from a pre determine node, which will broadcast flood packets to all other nodes. A patches of high density region along with low density regions will be established. Obviously transmitter in high density region will be observed with more number of receiver as compared to low region. Another well- known protocol is the TPSN which will be discussed briefly accordingly.

The term TPSN stands for Timing-sync Protocol for Sensor Network and was introduced by Ganeriwal in 2003. TPSN is a sender-receiver based synchronization protocol that uses the spanning tree organize the network topology. It is composed of two phases, Level Discovery phase and the Synchronization phase.

*A. Level discovery phase*

The first phase of the TPSN protocol is called the level discovery phase. This phase run on the network deployment to organize the tree structure. A hierarchical structure will be created and each node will assign a level like first level of nodes, second level of nodes and etc. It is to be mentioned that the node which will resides on level zero will be the root node or Master node. If the node is equipped with GPS receiver, then that would be the Master node, else any node can be a master node and other nodes can periodically take over the functionality of the master node. After selection of master node, it will send level discovery message (contains the identity and level of sending node) to its neighbouring nodes and will continue until all nodes within network receive it.

*B. Synchronization Phase*

The second phase in TPSN is called the synchronization phase. It is a sender to receiver communication between nodes. It will again begin from Master node which will propagate the time synchronization packets until all nodes received it within the network. Master node will broadcast these packets to the first level of nodes and it will wait a random amount of time before it acknowledgement message from maser node. It will continue until level I nodes and level i-1 nodes are synchronized. At the result within network will be synchronized successfully. The Fig 4. Shows a typical TPSN tree [7].

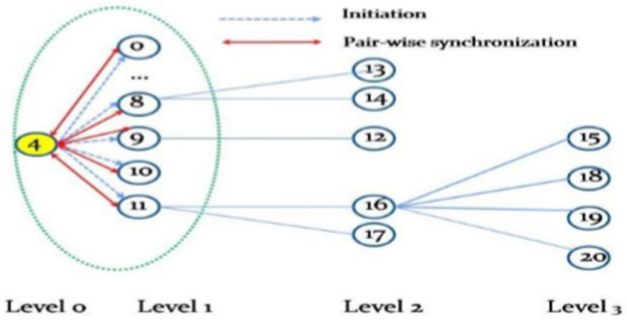


Figure 5. Typical tree uses in TPSN [7]

## IV. PROPOSED ALGORITHM DESIGN

We will propose a newly TPSN based time synchronization algorithm for time synchronization in WSN accordingly. We know that the TPSN requires hierarchical structure to organize the network topology. The more we make this tree structure efficiently, the more we will have an efficient time synchronization and at the result we will have an efficient energy based WSN. The disadvantage of TPSN is that it doesn't handle dynamic topology changes and need heavy computation.

The proposed algorithm will also work in two phases the same like TPSN, level discovery and synchronization phases. By keeping in mind the disadvantages of TPSN the newly algorithm will work efficiently and will discuss it accordingly.

*A. Level Discovery phase*

The operation of this phase will be the same like TPSN. A hierarchical structure will be made and network master node which is equipped with GPS will be specified. The network master node will broadcast level discovery packets until all nodes receive it. At the end of this phase each node will have its level and id accordingly. This phase will be completed by making network topology in which all nodes are assigned a level. We will move forward to the next stage of our algorithm which is the synchronization phase.

*B. Synchronization phase*

As mentioned early that in TPSN we have a single master node in network to respond and synchronize to all nodes within network. This method itself describes the heavy computation and traffic which is produced due to synchronization mechanism. In order to reduce the traffic, we will introduce cluster's head node within each cluster, which will act the same like master node for the nodes within a cluster. These clusters head nodes will also be equipped with GPS the same like network master node.

The synchronization will start from network master node and will move forward level by level. It means we will have level by level synchronization process. Master node will only contact with cluster head nodes, these head nodes should be in contacted with its related nodes within a specific area itself. Thus, each cluster contains a number of nodes and its head node within a specific area. It is to mentioned that not only network master node which is equipped with GPS the cluster's head node will also be equipped with GPS. At the same time, we have limited energy thus we will provide limitation for broadcasting sync packets for each cluster's head node to avoid further exchanging of packets. At a certain time, only one cluster head node which is equipped with GPS will be activated the rest of them will be in sleep mode.
During activation of cluster's head node, the synchronization process will take place and it will continue until all nodes synchronize itself with the network master node. The algorithm is shown in below chart.

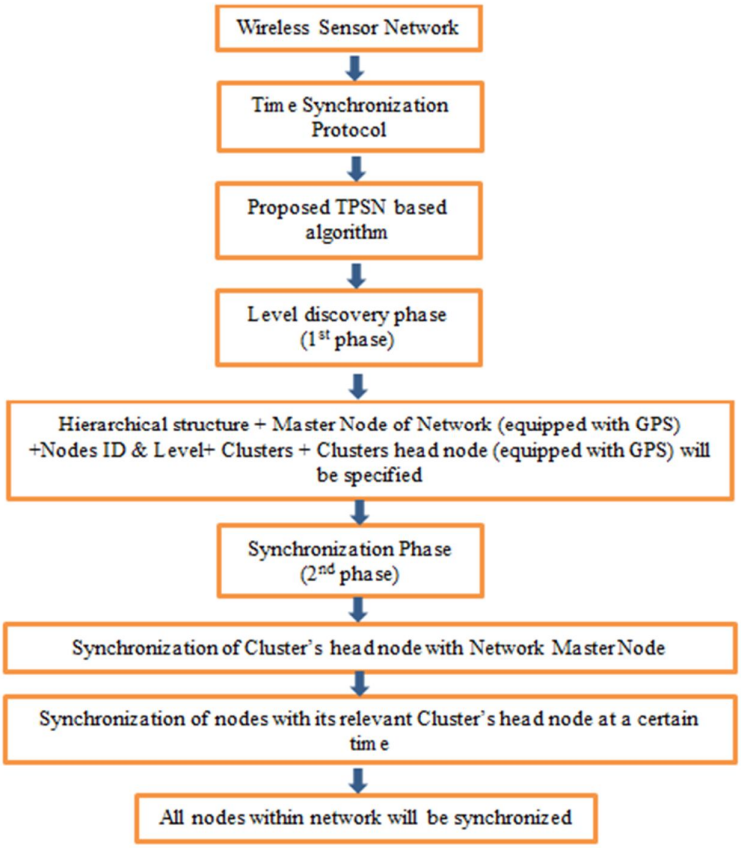


Figure 6. Flow chart of Proposed Algorithm

## V. CONCLUSION

Time synchronization plays a vital role in consuming energy and to synchronize nodes to a single time server in Wireless Sensor Network. This paper describes the overall concept of Time Synchronization and some significant traditional time synchronization protocols. At the same time, in view of shortcoming of TPSN protocol, which requires heavy computation and cannot handle dynamic topology a newly proposed time synchronization algorithm is also introduced. This algorithm reduces the propagation delay by equipping each cluster's head node with GPS and can support mostly dynamic topology as well. The more we reduce the propagation delay, the more synchronization error will be removed and at the result nodes will be synchronized efficiently. In future work, we will still further research on how to make TPSN tree structure more efficiently, so that at the result the energy and synchronization of nodes will be performed efficiently which is the main goal during design of wireless sensor network.

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