Efficient Energy and Time Synchronization in Wireless Sensor Network

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***Abstract*---Time synchronization is the indispensable part of the infrastructure in wireless sensor network. The efficient and precise operation of many applications in wireless sensor network requires synchronization time. In order to achieve network wide time synchronization, a synchronization protocol has been considered that is Timing-sync protocol for sensor network (TPSN) is a clock-sync protocol. The objective of this project is by increasing certain number of nodes simulating the TPSN protocol under different parameter using network simulator (NS2).From the parameter analysis, delay and drop of packets is reduced. Therefore from the simulated result of TPSN protocol, efficient energy and synchronization accuracy is achieved in the wireless sensor network.**

Keywords: Wireless sensor network (WSN), flooding time synchronization protocol (FTSP), Time sync protocol for sensor network (TPSN).

I.INTRODUCTION

Wireless sensor network(WSN) provide a bridge between the real physical and virtual worlds, and it has the ability to observe the previously unobservable at a fine resolution over large spatio-temporal scales WSN have a wide range of potential applications to industry, science, transportation, civil infrastructure, and security.

There are many challenges and problem domain in wireless sensor networks such as energy efficiency, time synchronization, responsiveness, robustness, scalability, systematic design, privacy and security.

One of the important problem domains in wireless sensor network is time synchronization. Time Synchronization in wireless networks is extremely important for basic communication. In sensor network there are four synchronization problems like send time, access time, propagation time, and receive time. The send time is that of the sender erecting the time message to transmit on the network and the access time is that of the MAC layer delay in retrieving the network. This could be waiting to transmit in a time division multiple access protocol

The propagation time is the time for the bits to be physically transmitted on the medium.

Finally, the receive time is the destination node, where it processing the message and transferring it to the host. The major problem in time synchronization is not only that this packet delay, but also being able to envisage the time spent on each node can be difficult. Eliminating any of these functions will greatly increase the performance of the synchronization method.

To overcome these problem synchronization protocol is used. The problem analysis in the existing system is that sensor nodes in wireless sensor networks (WSNs) equipped with cheap hardware clocks which frequently drift apart due to their low-end quartz crystals. Since the drift can be different for each sensor nodes, the hardware clocks of the nodes may not remain always synchronized although they might have been synchronized when they start up. To overcome the problem a common method is used in order to achieve network wide synchronization time synchronization, time synchronization protocol is used.

Thus simulating the time synchronization protocol under three parameters such as data rate, overhead and synchronization accuracy.BY analyzing the parameters from the simulated result, number of packets received is more compared to drop packets and delay is also reduced. Once the delay is reduced efficient energy is achieved in the sensor network.

The objective of the project is to reduce the synchronization error in the sensor network by analyzing timing-sync protocol for sensor network (TPSN) under different parameters and also increasing number of nodes to analyze the performance of synchronization error.

By analyzing synchronization protocol with different parameters, delay is reduced therefore efficient energy is obtained during the transmission of packets from sender to receiver. Therefore efficient synchronized notion of time and energy is achieved.

II. SYSTEM ARCHITECTURE

The system architecture of the wireless sensor network for time synchronization is creating certain number of sensor nodes in the sensor network. Since sensor node will frequently drift with each other tight synchronization is maintained in the network by implementing timing-sync protocol for sensor network (TPSN).

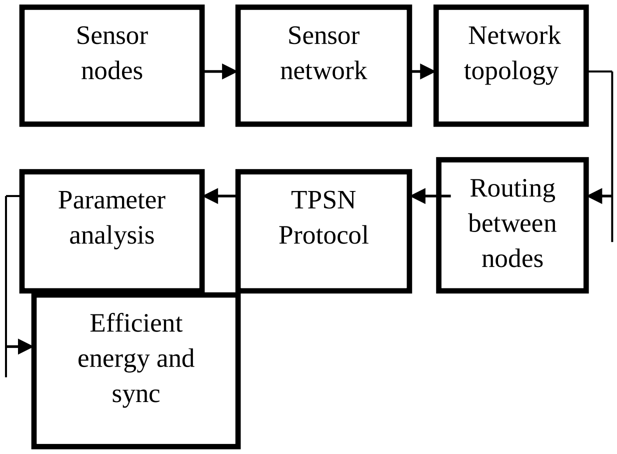

Figure 1 Block Diagram of Time Synchronization

First step is to designing networks with a certain number of nodes and then creating network topology and then setting sensor network. Next step is to establishing routing between the nodes using routing protocol. The routing protocol used here is Destination sequenced distance vector routing protocol (DSDV) routing protocol, it is a table driven routing protocol. Each entry in the routing table contains a sequence number, the sequence numbers are generally even number if a link is present; else, an odd number is used.

After providing routing between the nodes, implementing the Timing-sync protocol for sensor network (TPSN).TPSN is a clock-sync protocol and it is based on the spanning tree structure, where the leader node is selected. Final step is that simulating the timing-sync protocol under three different parameter overhead, data rate and synchronization accuracy. Thus from the simulated result drop of packets from source to destination is condensed where the delay is also reduced. By analyzing the simulated result the parameter overheads and synchronization error is reduced, while the constant packet data rate is achieved.

III. TPSN PROTOCOL MECHANISM

TPSN is a sender-receiver based synchronization that uses a spanning tree to organize the network topology. The function is divided into two phases, the level discovery phase and the synchronization phase. The level discovery phase creates the hierarchical topology of the network in which each node is assigned a level like first level of nodes and second level of nodes. Only one node resides on level zero, the root node. In the synchronization phase all *i* level nodes is selected and it synchronize with *i-1* level nodes. This will synchronize all nodes with the root node.

I. Level Discovery Phase:

The level discovery phase is run on network deployment. First, the root node (leader node) should be selected. If the node was equipped with a GPS receiver, then that could be selected as the root node, and all nodes on the network would be synchronized. The other method is that any node can be the root node and other nodes can periodically take over the functionality of the root node to share the synchronization message.

Once the root node is selected, it will initiate the level discovery method. The root node will send the level discovery packet to its neighboring nodes. The level discovery packet contains the identity and level of the sending node. The neighbor nodes of the root node will then assign themselves as first level of nodes and the process continues for the second level of nodes. This process of sending level discovery packets to all nodes will continue until all nodes have received the level discovery packet and are assign a level.

Once again all nodes in the network are assigned a level to create a tree type topology. All nodes of level *i* will broadcast the level discovery phase with all nodes of level *i-1*.

II. Synchronization phase:

In this phase is two-way communications between two nodes. It is a sender to receiver communication. The synchronization phase begins at the leader node and propagates through the network.

Figure 1 represents the two-way communication between a pair of nodes. The time T1, T2, T3, and T4 are taken. Node ‘A’ will send the synchronization pulse packet at time ‘T1’ to Node ‘B’. This pulse packet contain Node A's level and the time ‘T1’. Node B will receive the pulse packet at time T2. At time ‘T3’ Node ‘B’ sends the acknowledgment packet to Node ‘A’. Thus the acknowledgment packet contains the level number of Node ‘B’ as well as times T1, T2, and T3. Thus by knowing the drift, Node ‘A’ can correct its clock time and successfully synchronize to Node ‘B’.

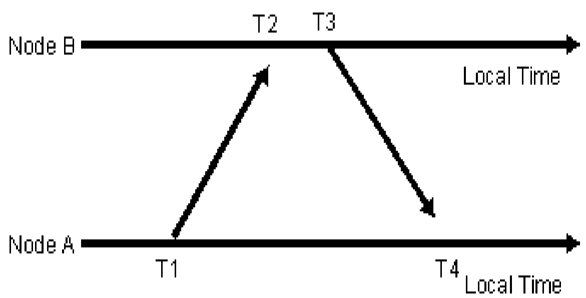

Figure 1 Two-way messaging between nodes

The root node broadcasts a time sync packet to the first level of nodes. These nodes will wait a random amount of time before it get acknowledgment packet, initiating the two-way messaging. The leader node will send the acknowledgment packet to first level nodes and that nodes will adjust their clocks to be synchronized with the root nodes.The level two nodes will be able to get the level one node communication; the level two nodes will wait a random period of time before initiating the two-way messaging with the level one node. The process continues until level *i* nodes and level *i-1* are synchronized. This process will continue until all nodes are synchronized to the root node.

IV. PERFORMANCE METRICES

In order to evaluate the performance of FTSP protocol the following two metrics are investigated:

Synchronization Error

This represents the difference between actual data generation time and estimated data generation time. The correctness of the estimated data generation time is important because it is used to infer temporal relation.

Overhead

This represents the traffic produced due to the synchronization mechanism in proportion to the total data traffic. Lower synchronization overhead implies higher throughput and efficiency of the network

Packet Data Rate

It is the ratio between number of packets received and the number of data packets which are expected to be received (the data packets sent times the number of nodes in the network).It will describe the loss rate that will affects the maximum throughput that the network can support.

V.EVALUATION VARIABLES

To compare the error and overhead of the synchronization mechanisms, scenarios are simulated with varying network size, node mobility, and data rates

Network Size

In order to fix the network density with increasing number of nodes, the grid size is varied accordingly.

Node Mobility

In the node mobility model, each node has a randomly generated target location and moves to that location with a random speed (maximum speed10m/s). To change the level of node mobility, the pause time between the target locations is adjusted from 0 to400 seconds. A smaller pause time means higher mobility.

Data Rate

To vary the data rate, we adjust the packet sending rates at source nodes; higher data rate means higher traffic volume.

VI. SIMULATION RESULTS

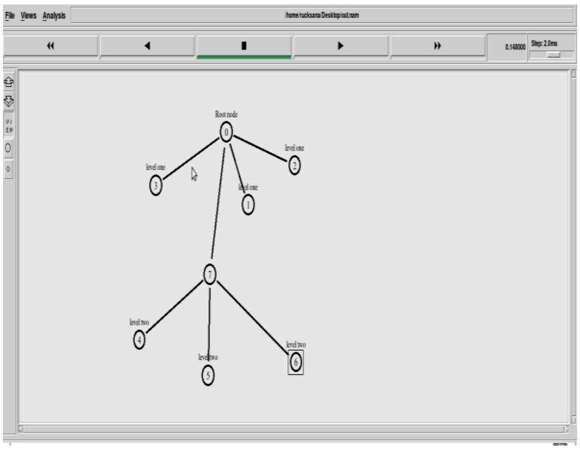

Figure 3 Level Discovery Phase

Figure 3 represent the spanning tree structure in timing-sync protocol for sensor network (TPSN).

The above figure represents the first phase that is level discovery phase. First the root node is selected, node 0 act as root node while node 1,node2 and node 3 act as level one nodes.

The node 4,node 5 and node 6 act as level two nodes, root node send the level discovery packet to level one node, once it get synchronized it will transmit that packet to the level two nodes.

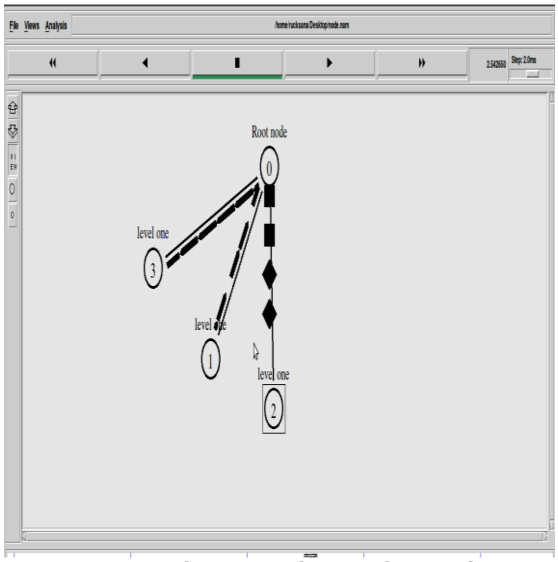

Figure 4 Synchronization Phase Level One Nodes

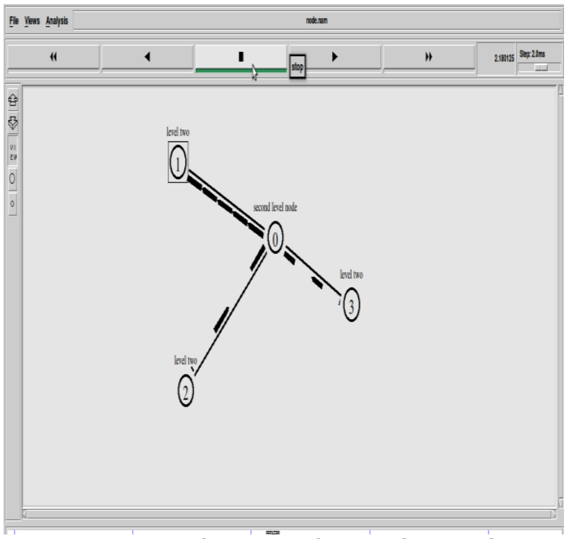

Figure 5 Synchronization Phase Level Two Nodes

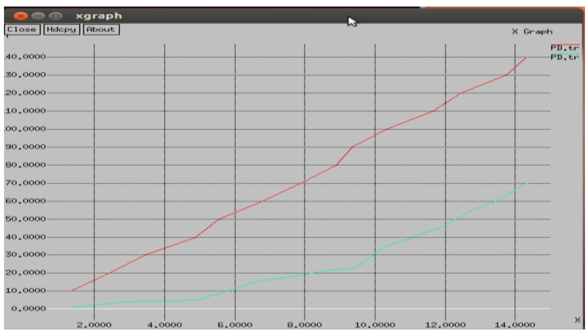

Figure 6 Xgraph for Parameter Overhead

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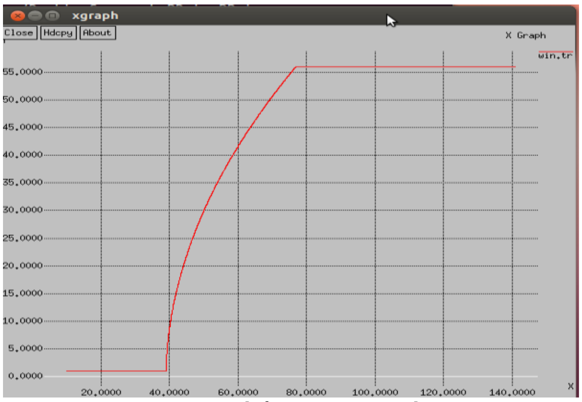

Figure 7 Xgraph for Parameter Packet Data Rate

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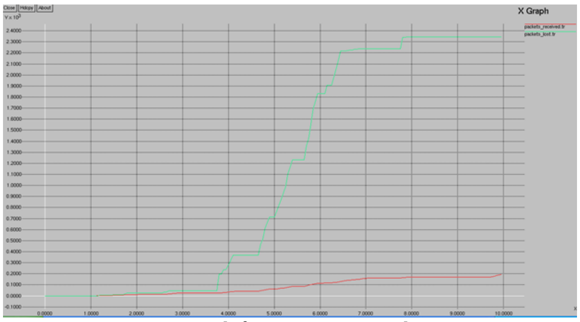

Figure 8 Xgraph for Parameter Synchronization Error

VII.RESULTS AND DISCUSSIONS

From the simulated result, figure 3 represent the level discovery phase, and the figure 4 represent the synchronization phase for level one nodes, while figure 5 represent the synchronization phase for level two nodes. In the level discovery phase root node send the level discovery packets to first level of nodes 1, 2&3.once first level of nodes get packet location it will transmit the level discovery packets to level two nodes. This process continues until all nodes receive the level discovery packet. In the synchronization phase it will transmit the sync message containing its current time, neighbor node receive that message and acknowledge to that node. Thus by knowing the drift, node 1 can correct its clock time and successfully synchronize to node 2.this process continues until first level of nodes and second level of nodes gets synchronized.

Figure 6 shows the Xgraph for the parameter overhead where the actual data generation is more than the expected data generation because of that packet drop is high compare to the packet received.
Figure 7 shows the Xgraph for the parameter packet data rate, initially packet delivery rate is high and after some time the data rate of the packet becomes constant. Figure 8 describes the Xgraph for the parameter synchronization error, where the sensor network has the synchronization of nodes because of that packet received is high compared to the drop of the packets.

VII.CONCLUSION AND FUTURE WORK

Thus the TPSN protocol under different parameter is that under the performance of overhead, actual data generation is more compared to the expected data generation. Initially the data rate is very high, after a particular time period constant data rate is achieved, thus energy consumption is reduced in the network by achieving the constant speed Number of packets received is high compared to the packet lost, thus making the synchronization error is reduced in TPSN protocol. Thus the TPSN protocol has reduced sync error, therefore efficient energy and synchronized notion of time is achieved in the sensor network. In future work, efficient TPSN protocol is improved by increasing the number of nodes to run at the same speed by employing an agreement algorithm and synchronizes them to a reference node which floods stable time for the whole network.

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