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Energy-efficient Time Synchronization for Self Re-clustering Mechanism in Heterogeneous Wireless Sensor Networks

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Abstract

In Heterogeneous wireless sensor networks, scalability is one of the basic concerns, because of the huge number of sensor nodes with limited battery power at each and every node. Suppose if the huge number of sensor nodes are dynamically deployed in the network maintenance of the synchronization between the nodes is not so easy and also it effects the scalability metric..The synchronization protocol ensures that synchronization reliability does not degrade significantly when large numbers of sensor nodes are deployed. The goal of this protocol is to maintain a unique global time slot by creating self re-clustering hierarchical topology in a wireless sensor network. A Cluster head in the topology will act as synchronization head to the cluster member. The importance of this mechanism gaining and manage the effective synchronization at a large scale cluster based network when cluster head losses its local synchronization due to physical disturbances or energy depletion rather than small cluster nodes lying in a neighborhood. The proposed re-clustering works in three phases: setup phase, synchronization phase and re-clustering phase.

INTRODUCTION

Wireless sensor networks have been used for a variety of applications, globally which includes the Environmental(Flood detection, habitat monitoring, Fire monitoring, Detection of floods and earth quakes), Health(Intra patient monitoring, Tele monitoring of human physical data), Military(Nuclear detection, Attack prevention), Civilian(Hue traffic monitoring, Security in shopping malls and banks), Home and Education(Problem solving, Smart kinder garden, Intelligent home), Scientific(Study of cosmic radiation, subatomic particle, Ground sea exploration, high energy physics) **[1]**. In the wireless sensor network, a network clustering is one of the key factors to achieve energy efficiency routing, extending network lifetime, reduce energy consumption and so on. In WSN by selecting less overlapped clusters, results a high performance of the network function such as broadcasting, routing, aggregation of data, Query Processing **[2].** In the previous research work lot of algorithms have been suggested to handle the time synchronization in WSN .In this paper we mainly focus on the self-adjustable clustering mechanism when the loss of local synchronization occurs. To address the synchronization problem we proposed an energy efficient time synchronization between the Cluster Heads (CH) and Cluster Members (CMs) in order to reduce the link failures. In this proposed paper we use Convex-Hull algorithm to perform synchronization between CH and CMs, as a result is energy efficient in unreliable noisy wireless sensor networks. In Section 2, we discussed previous work along with many existed clustering methods such as Convex Hull and linear regression. Convex Hull estimated fitted line is more exact than linear regression approach. The proposed technique will be discussed in section 3 follows simulation results. In Section 4, we describe the conclusion and its future scope of the implementation.

RELATED WORK

The current and previous time synchronization algorithms and its overview of general clustering methods are discussed in this section. In general time synchronization protocols are classified in to two, one is Synthetic (Local time of a sensor node is achieved by performed a several time estimation) and Second is Non-Synthetic (by consider a sample of time estimation) is less overhead and faster, but less precise than first one. Reference Broadcasting (RBS) is a non-synthesized technique and calculates the variation between sensor nodes offset **[3]** and determines each local time along its neighbor local time. PCTS **[4],** CHTS **[5],** SLTP **[6],** and L-SYNC **[7]** all are used cluster based topology with different synchronization techniques. In SLTP initially CH continuously sends its local time to its CMs at specified time slots, by sing linear regression CMs are compares it's time intervals with CH.SLTP gives efficient performance for long span networks than RBS. The selection of the cluster heads based on ID, Degree (in terms of its neighbors) and Weight (in terms of residual energy, average distance to its neighbor members) **[8]** and **[9].**

L-SYNCng**[10]** does not change nodes clock time, instead of the clock offset and skew of each node will be calculated within its corresponding cluster head clock. In general synchronization is not effects the sensor node properties such as strength, ability and its radio transmission. The above all existed approaches are not discussed when the cluster head failure occurs how the synchronization has re-establishment in between two nodes is a key concern. This paper mainly focuses self-adjustability (re-clustering) of the cluster along with efficient time synchronization when the cluster head dies or loss of local synchronization. The existed approach uses two synchronization methods, namely Convex Hull **[11]** and linear regression. The Convex hull estimated a fitted line is more exact than linear regression approach.

PROPOSED SOLUTION

(EL-Sync) is the proposed synchronization technique which is done in between cluster members and cluster heads. Each sensor node is able to modify its role from CH to CM and vice versa. The proposed method doesn't modify the clock time of the members instead of a node clock offset & Skew will be calculated with corresponding to cluster head. The proposed method proceeds in three phases: Setup phase, Synchronization phase, Self-Clustering phase. In this **Setup phase** we discussed about the configuration of a wireless sensor network by using two clustering methods one is DCA (Weight-Based) and ACE (Degree-Based).ACE works based on the adjacent node degree and builds efficient clustering topology. This algorithm performs the iterative process to avoid collisions (each sensor node has a random interval). Initially, a sensor node not in the cluster, after certain time is elapsed it is connected to the gateway and immediately understand the network surroundings. Once the sensor node understood the network condition it calculates its degree of the neighbor and form a cluster with the node which one have a high degree and becomes cluster head.

In **Synchronization** phase, the cluster head starts to broadcast a synchronization packets (contains it's ID along with local time).Every cluster member receives synchronization packets and reply the acknowledgement (ACK) to the CH. The cluster head waits to receive all ACK messages from its cluster members as shown in the figure 1. Each ACK message having four-time stamps (T_{CHs}, T_{CMr}, T_{CMs}, T_{CHr}). The cluster head has T_{CHs}, T_{CMs} and T_{CHr}.Based on cluster member history at the end of the broadcasting cluster head estimates the minimum delay between T_{CMr} and T_{CMs} of each cluster member. Cluster heads will derive an equation in the form of $A = xB + y$, where x and y are the specific for CM and sends x, y to every CM eventually. Based on the cluster member history, cluster Head estimates the minimum delay of the each cluster member at the end of broadcasting, **[12].**

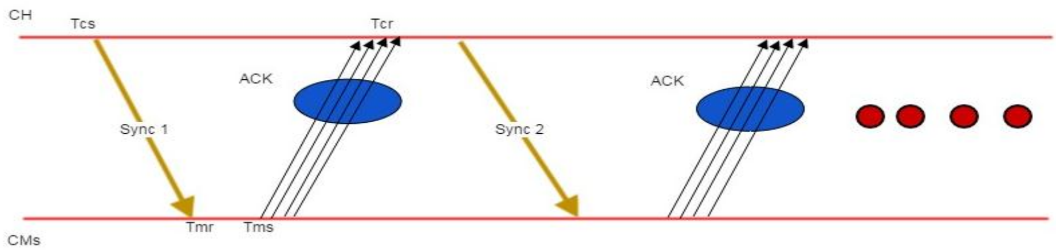

Fig.1. The Synchronization process between CH and CMs

The synchronization process may start by CH which represented in Fig.1.another method is CMs may also take initiation to perform the synchronization process by sending synchronization messages to CH. This method of the synchronization is more overhead than first one.

Dynamic Re-clustering and resynchronization phase:-

In a Cluster based wireless sensor network link failure are occur more frequently in between CH and CM or CH changes frequently due to energy depletion, loss of local synchronization between CH and it's CMs, Limited Bandwidth , so dynamic re adjustable clustering mechanism is required. When Cluster head failure is occurred , automatically the loss of local synchronization happened in between the CH and CMs until the new cluster head creation. This time discontinuity causes very serious faults like redundancy of events, missing node's deadline and so on. In our proposed algorithm performs continuous time synchronization and self-adjustable clustering to avoid all these discrepancies in the network. When CH failure is happened immediately the clustering approach form a new cluster head and then transmit the Synchronization packets to its all neighbor members (Cluster members) and wait until to receive all reply ACK from the members. The re-synchronization process happened when the cluster head failure occurs, illustrated in fig.2.

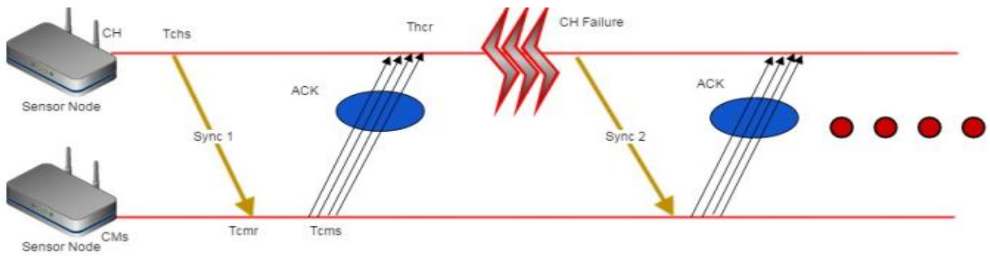

Fig.2. Re-Synchronization process when the CH failure occurs.

Test Bed Results:-

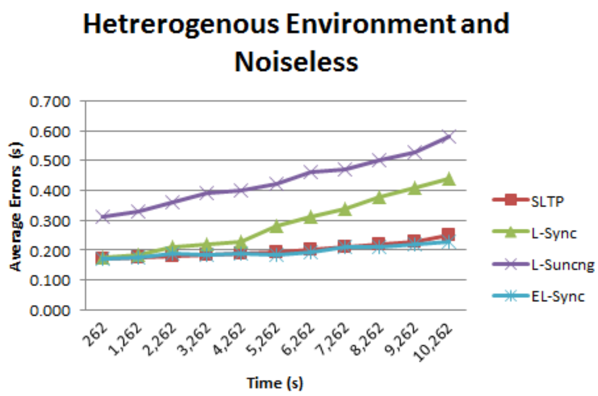

Fig.3. Error versus time comparison for EL-Sync with other approaches.

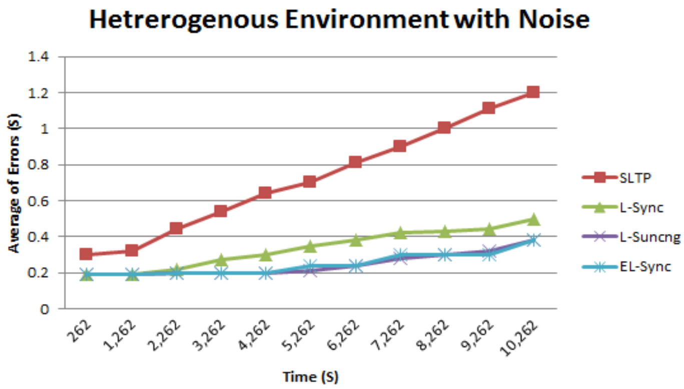

Fig.4. Error versus time comparison for EL-Sync with other approaches with noisy.

CONCLUSION

EL-Sync is a more efficient and reliable protocol for time synchronization in dynamic wireless senor networks where the nodes and clustering changes more frequently. This protocol works with weight-based and Degree-based clustering in both homogeneous and heterogeneous environments.EL-Sync can reduce the no of hops in time synchronization to process different nodes in different clusters. Moreover, EL-Sync uses the convex hull method to calculate they skew and offset in each cluster which placed in network environment. The convex hull method more capable, to calculate skew and offset intervals between each node and its related cluster head. In other words, it can remember the local time of remote nodes in the previous iterations. To estimate or evaluate the local time of the remote senor nodes, firstly we have to apply an efficient routing algorithm and afterward an exchange operation is performed in each hop. Simulation results illustrate in noisy environments synchronization accuracy is increased by the convex hull method. L-Syncng is a very useful approach to estimate synchronization in homogeneous environments and EL-Sync is for dynamic Heterogeneous environments.

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