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Node Heterogeneity for Energy Efficient Synchronization in Wireless Sensor Network

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Abstract

The energy of the node in the Wireless Sensor Networks (WSNs) is scare and causes the variation in the lifetime of the network. Also, the throughput and delay of the network depend on how long the network sustains i.e. energy consumption. One way to increase the sustainability of network is the introduction of heterogeneous nodes regarding energy, and the other is to synchronize the local clock of the node with the global clock of the network. In this context, the paper proposes Node Heterogeneity aware Energy Efficient Synchronization Algorithm (NHES). It works on the formation of cluster-based spanning tree (SPT). In the initial stage of the algorithm, the nodes are grouped into the cluster and form the tree. The nodes in the cluster and cluster heads in the network are synchronized with the notion of the global time scale of the network. Also, clock skews may cause the errors and be one of the sources of delay and energy consumption. To minimize the energy consumptions and delay, NHES synchronizes the time slots using TDMA based MAC protocol. The results show that level by level synchronization used in NHES is energy efficient and has less delay as compared to the state-of-the-art solutions.

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1. Introduction

Time and clock synchronization are an important services for the collaborative and coordinated operations in WSNs. Time synchronization in the WSN is mainly affected by low-cost clocks, frequent topological changes, error

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sources during communication, node failures and the resource constraint nature of the nodes. For instance, network protocols such as time division multiple access (TDMA) strictly demands synchronization among sensor nodes. The unsynchronized clocks in the network take more time to send the packet to sink and hence consumes more energy. The nodes used in the formation of the network are scare of energy, and cannot sustain for a long time. Also, some part of node energy is utilized in the synchronization of activities of the nodes. To increase the lifetime and solve the problem, some percentage of the nodes with varying energy are added to the network. The energy consumption of the synchronization algorithm is minimized by matching the global clock of the sink and the local clock of the node[1,2].

The activities of the node are scheduled according to the time frame, and all the slots are synchronized with the global clock of the network. The unusable network conditions and scare resources of WSN make it essential to develop a time and clock synchronized protocol that can sustain the network long time with reduces energy consumption. The spanning tree mechanism used operates level by level reducing the multi-hop communication restricting the requirement of large network bandwidth. The improper scheduling and synchronization of the packets generated from the lower layer of the network to the upper layer cause more energy consumption. Also, retransmission delay is caused due to the variation in the clock skews and improper slot allocation to transfer the aggregated packets.The efficient way to reduce the retransmission delay is scheduling MAC protocol to manage the time slots of nodes and cluster head (CH) with global time scale. The data propagation from node to sink may be in one–hop or multi-hop, it depends on the depth of the spanning tree formed in intra and inter-cluster communication. The packet scheduling activities of the nodes are dependent on the availability of the channel, at least, equal to the synchronization time [2]. The neighboring node will synchronize their schedules periodically to prevent long term clock drift. Timing-Sync Protocol for Sensor Networks (TPSN) [3], considers the traditional approach of two-way message exchange between sender-receiver synchronization with an increase in sync errors and energy consumption. The traditional protocols are not energy efficient and difficult to implement for WSN. Due to the constraints of energy supply and processing ability, the current time synchronization mechanisms like RBS, NTP and GPS could no longer serve WSNs well, and need to be modified or redesigned.

The paper focuses on the addition of controlled node heterogeneity to minimize the energy consumption with reduced delay. The nodes used are heterogeneous regarding energy that helps to increase the network lifetime. The clustered architecture forms the spanning tree with non-ideal clocks. The frequency of each clock is assumed to fixed.The level by level synchronization used in SPT improves the network performance than a structured algorithm.

The paper has different sections as; Section 2 focuses on the present work related to synchronization algorithms. Section 3 presents the required assumptions and network model. Section 4 briefs about the NHES, Section 5 discuss simulation setup and results, and section 6 conclusion along with the future scope.

2. Related works

This section provides the idea how one can improve the QoS of the network by use of synchronizing the clocks of the node and sink. In [2] Synchronized Data Aggregation (SDA) algorithm considers the spanning tree mechanism to improve the energy consumption as compared with TPSN. It shows the reduced sync errors and energy consumption. [4] Defines a time synchronization protocol based on spanning tree. A spanning tree formed by the nodes is divided into multiple sub-trees. The sub-tree synchronization process helps to minimize the synchronization errors by adjusting the clock time within the level. In [5] Clustered Time Synchronization algorithm and energy model is presented, that conserves the energy beside accuracy while synchronizing the WSNs. Reference Broadcast Synchronization Protocol (RBS) [6] uses the synchronization between two receivers by the intermediate node within the listening range of the sender and receiver. The intermediate node sends the message for recording the time hence saves the energy in clock updates. The major disadvantage of the protocol is that the energy is wasted in synchronizing the reference sender. [7] Proposes the distributed clustering data aggregation algorithm with consideration of mobile and heterogeneous nodes into the clusters. The mobility of node frequently changes the structures and accordingly consumes more energy. In [8] Author considers the network with heterogeneous nodes regarding energy with a mobile sink. It shows improvement in throughput and network lifetime. Due to the mobility of sink control overheads are increased and consumes some part of node energy. [9] Consider hybrid