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An Enhanced General Self-Organized Tree-Based Energy-Balance Routing Protocol (EGSTEB) for Wireless Sensor Network

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Abstract: ***Wireless Sensor Network (WSN) is the network consists of large number of sensor nodes. These sensor nodes collects large amount of data and transmit it to the base station. But these sensor nodes provide a limited battery power and battery replacement is not an easy method for wireless sensor network. Energy efficient routing protocols provide longer network life time by minimizing total energy consumption and balance the network load. A General Self-Organized Tree-Based Energy-Balance Routing protocol (GSTEB) is the one of the energy efficient routing protocol, which discusses two extreme cases of data fusion that is each sensor node transmits same amount of data and different amount of data. For both cases it builds a routing tree using a process where, for each round, Base Station (BS) assigns a root node and broadcasts this selection to all sensor nodes. Each node selects its parent by considering itself and its neighbor's information. GSTEB provide an efficient energy balanced routing and longer lifetime for the network, when each sensor node transmits same amount of data or different amount of data. Although GSTEB protocol achieves it has some problems such as difficult to distribute the load evenly on all nodes in tree structure and overhead in the base station. The proposed method (EGSTEB) solves these problems by overhead and energy consumption of sensor nodes.***

Keywords: ***Wireless Sensor Network, Energy Efficiency, Hierarchical Routing Protocols, GSTEB, Sensor nodes.***

1. Introduction

Wireless Sensor Network (WSN) is an emerging technology, which contains hundreds or thousands of sensor nodes. These sensors have the ability to communicate either among each other or directly to an external base-station (BS). Basically, each sensor node equipped with sensing, processing, transmission, and power units. A base-station may be a fixed node or a mobile node capable of connecting the sensor network to the internet where a user can have access to the reported data. The important requirements of WSN are: Use large number of sensors, Low energy consumption, Self organization capability.

However, WSN provides limited power to all the sensor nodes. The energy consumption of a sensor node is either useful (transmitting and receiving data) or wasteful applications (retransmission of data, overhearing or redundant data). The battery replacement in the sensor nodes is not an effective method for energy balancing because of their deployment in the network.

Routing technique is the one of the effective method to minimize the energy consumption of sensor nodes. Based on the network structure, the routing protocols are classified in to Flat based routing protocols, Location based routing protocols and Hierarchical routing protocols. In flat based routing, all nodes are typically assigned equal roles or functionality and in location-based routing, sensor node's positions are exploited to route data in the network. The main aim of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by involving them in multi-hop communication within a particular cluster and by performing data aggregation and fusion in order to decrease the number of transmitted messages to the sink. In a hierarchical architecture, higher energy nodes can be used to process and send the information while low energy nodes can be used to perform the sensing in the proximity of the target.

2. Related works

The previous study includes several hierarchical based routing methods in wireless sensor networks.

Kuong-Ho Chen et al. [2] introduces an Energy-Efficient Chain-Based Hierarchical routing method (CHIRON). It divides the sensing are in to different fan shaped groups

based on the transmission range and direction of antenna. The nodes in each group form a chain where chain leader selected on the basis of residual energy. Each node transmits data along the chain to chain leader. To avoid longer transmission to the base station, multi-hop leader by leader transmission is applied. Here, overhead in the base station is high because of multiple number of groups are formed.

Kyung Tae Kim et al. [3] propose a Tree Based Clustering Routing Protocol (TBC). Here the nodes in the cluster form a tree with the root as cluster head, while the height of the routing tree based on the member nodes to the cluster head. Each node receives data from its children, fuses it with its data forward it to the parent node. The cluster head fuses the data and transmit it to the base station. If base station is far away, some cluster head consume more energy for longer transmission.

Bencan Gong et al. [4] propose Tree Based Routing Protocol (TRP). Here the nodes are creating a routing tree based on distance between neighbor nodes and sink and residual energy of neighbor nodes. Each node fuses the data received from children with its data and forward data to its parent. TRP is the excellent protocol but there may be communication interfere occur in between child nodes and parent node.

Sonam Palden Barfunga et al. [5] propose Energy Efficient Cluster Based Routing Protocol (EECBRP). In this protocol, the Base Station selects the Cluster Heads (CH). The selection procedure is carried out in two stages. In the first stage, all candidate nodes for becoming CH are listed, based on some parameters. The data transmission inside the cluster and from the cluster head to the base station takes place in a multi-hop fashion. The node which is nearer to base station consumes more energy.

Muhammad Inam et al. [6] suggested Hierarchical Energy Efficient Routing Protocol (HEERP). In this technique, two types of cluster head is used Independent cluster head that are nearer to base station and Dependent cluster head that are far away from base station. Dependent cluster head passes the data to base station through independent cluster nodes. The member nodes inside the cluster aggregate its data using chain strategy. The node which is nearer to base station consumes more energy.

3. Proposed work

An Enhanced General Self-Organized Tree-Based Energy-Balance Routing Protocol (EGSTEB) is the modified version of GSTEB [7] routing protocol. Like GSTEB, it discusses two extreme case of a data fusion:

Case (1): The data between any sensor nodes can be totally fused. Each node transmits the same volume of data no matter how much data it receives from its children.

Case (2): The data can't be fused. The length of message transmitted by each relay node is the sum of its own sensed data and received data from its children.

Also the operation of EGTEB is divided in to four phases, Initial Phase, Tree Constructing Phase, Self-Organized Data Collecting and Transmitting Phase, and Information Exchanging Phase. The modification is done in a tree construction phase for both cases to reduce overhead in the network.

3.1 Initial phase

Initial Phase is a significant preparation for the next phases. Base station broadcast a packet which contains beginning time, the length of time slot and the number of nodes N. Then the each sensor node compute their energy level using the equation given below and broadcast a packet contains its ID and energy level to its communication range for collecting neighbor information table. After Initial Phase, GSTEB operates in rounds. In a round, the routing tree may need to be rebuilt and each sensor node generates a data packet that needs to be sent to BS. When BS receives the data of all sensor nodes, a round ended.

$$EL[i] = residual\_energy[i] / \infty \quad (1)$$

3.2 Tree Constructing Phase

There is some difference in the tree construction in the case 1 and case2. For the first case, construct a binary a tree instead of a constructing a general tree. For second case, cluster tree topology is constructed to reduce the number of child nodes for the base station.

3.2.1 Binary Tree Construction

A binary tree is a tree data structure in which each node has at most two children, which are referred to as the left child and the right child. Base station selects a node which has highest energy as the root of the binary tree. Each node i select its parent P based on following conditions:

- P ε N[i].
- The distance between the parent node P and root R is should be less than that of node i and root.
- The parent P not has more than two child nodes.

3.2.2 Cluster Tree Construction:

The cluster formation [8] consists of three steps

- Base station collects information regarding location of all the nodes in the network. Depending on the density and geographical layout of the network, it virtually divides the network into four zones as shown in the figure. The objective behind this method is to ensure uniform selection of Cluster Heads (CHs) throughout the layout of the network.
- Initially, the node which is randomly chooses as a cluster head because each node has same energy level. After the first round the nodes which have highest energy than other nodes in each zone is become CHs.
- Once the CHs are formed, it broadcasts Advertisement message to all the other nodes in the network. The other sensor nodes send Join-Request message to nearest CH based on Received Signal Strength Indication (RSSI) from CHs.

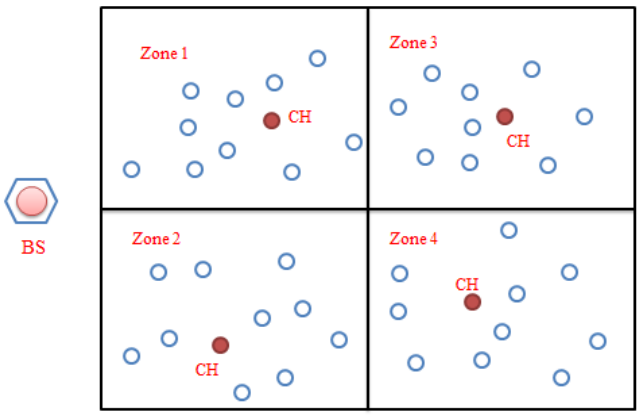

Figure 1: Cluster formation

In tree construction, the nodes within a cluster construct a tree where the cluster-head is the root of it. For tree configuration, each node select its parent based on residual energy of the node and distance information. The parent node of node i should satisfy following criteria:

P ε N[i].

The distance between the parent node P and root R is should be less than that of node i and root.

Where N[i] represents the neighbor list of node i. If node i cannot find such apparent it selects root node as its parent. After the tree construction each node transmits data to its parent in an allocated time slot. To avoid the longer transmission between cluster head and base station use three forwarding nodes. Forwarding nodes have ability to cover long transmission range. It is deployed in a location where all the nodes of each cluster are easily reachable. The forwarding node collect the data from the cluster head transmit to base station if cluster head is far away from base station. If it is nearer to base station CHs directly transmit data to base station.

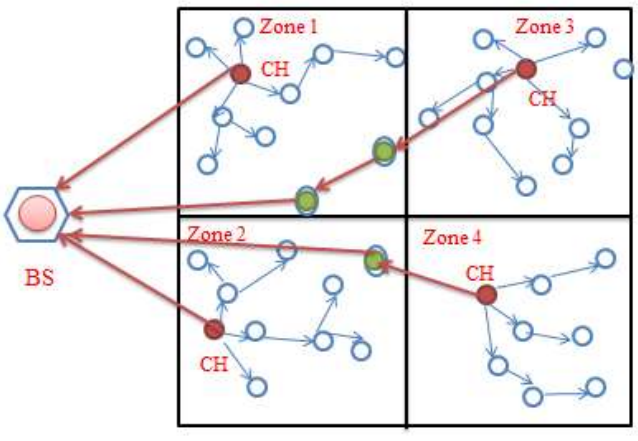

Figure 2: Data transmission

3.3 Self-Organized Data collecting and Transmitting Phase

The Self-Organized Data Collecting and Transmitting Phase are divided into several TDMA time slots. In a time slot, only the leaf nodes try to send their DATA-PKTs. After a node receives all the data from its child nodes, this node itself serves as a leaf node and tries to send the fused data in the next time slot.

3.4 Information Exchange Phase

In an information exchanging phase nodes transmit their data to their parent and each node check their energy level, if its energy level is low it generate a data packet and broadcast to its neighbor. Then neighbor update their neighbor information table.

4. Results and Analysis

Proposed method is implemented using NS2.Nodes are static. The energy of each node is calculated based on the equation specified. The proposed EGSTEB are compared with the existing GSTEB protocol based on overhead and energy. Once the modification is done it is found that the overhead involved in packet transmission is reduced slightly because of binary tree construction for case 1. The graphical results show that overhead is considerably reduced in the proposed technique since load is evenly distributed in to nodes in the network.

TABLE I
NETWORK SIMULATION PARAMETER

Parameter	Value
Number of Nodes	40
Network Area	450 m x 450 m
Nodes Type	Static
Traffic	CBR

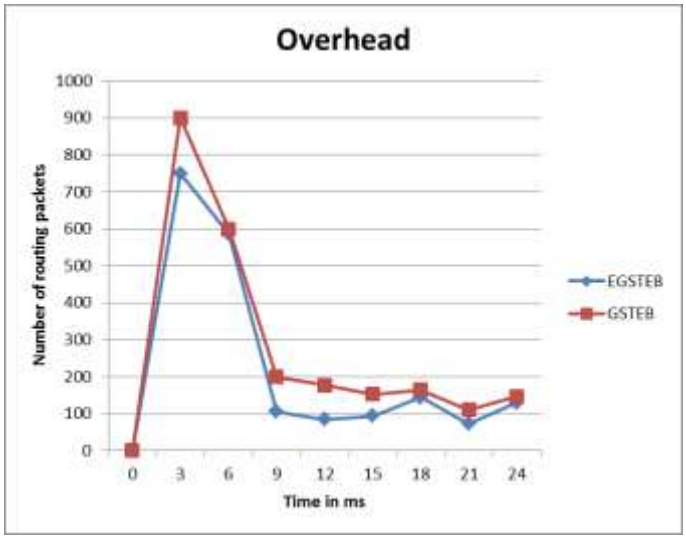

Figure 3 Overhead during transmission for Case 1(Existed Vs Proposed)

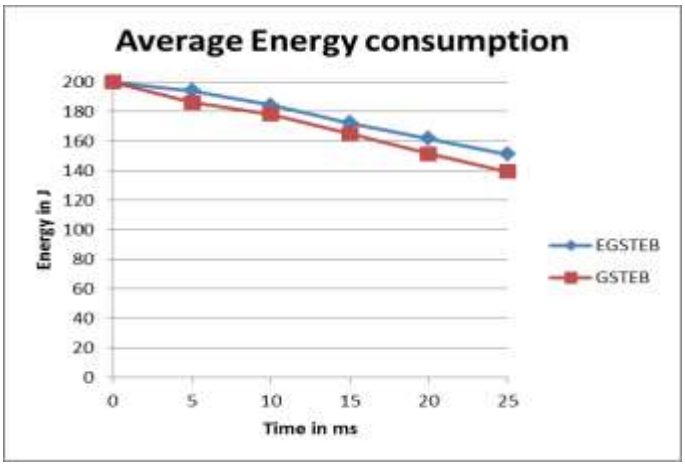

Figure 4 Average energy consumption for Case 1(Existed Vs Proposed)

For case 2, number of control packets send by the base station is reduced because of base station only need to communicate with the cluster heads. Also the longer transmission between cluster heads and base station is reduced by using forwarding nodes. The graphical result shows that overhead in the network considerably low by comparing with GSTEB.

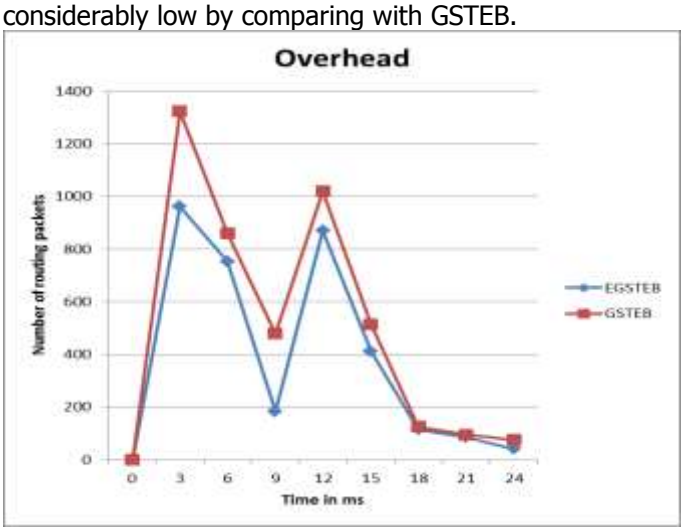

Figure 5 Overhead during transmission for Case 2(Existed Vs Proposed)

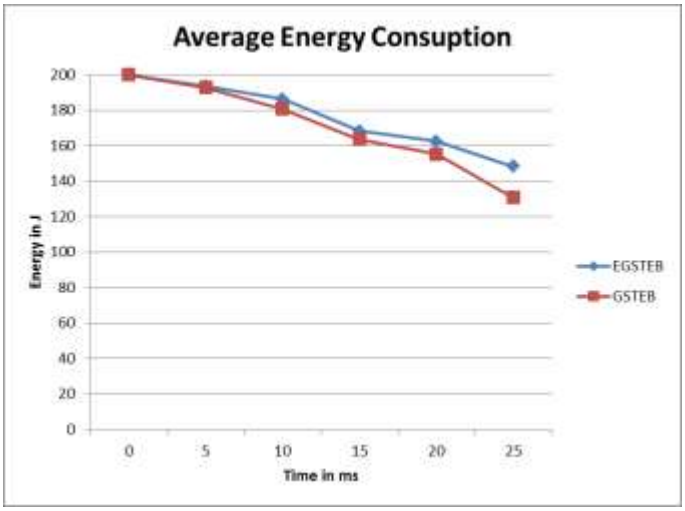

Figure 6 Average energy consumption for Case 2(Existed Vs Proposed)

5. Conclusion

GSTEB is a self-organized protocol discusses two extreme cases of data fusion. In both cases, GSTEB provides efficient energy balanced routing and longer lifetime for the network. The disadvantage of GSTEB protocol is difficult to distribute the load evenly all nodes in tree structure and overhead in the base station. To solve this problem construct a binary a tree instead of a constructing a general tree to distribute load among the sensor nodes in the first case. For second case, cluster tree topology is constructed to reduce the number of child nodes for the base station for reducing overhead and extra energy consumption in the base station.

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