

Lifetime Enhanced Cluster Based Routing in Wireless Sensor Networks

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ABSTRACT: In Wireless Sensor Networks, data transmission is constrained by the limited battery energy of the nodes. The densely deployed sensor nodes will detect redundant and correlated data which may cause wastage of energy. In order to save resources and energy, and to enhance the network lifetime, clustering technique can be used. In cluster based networks, the cluster head performs data aggregation and routing. This paper proposes a cluster based routing method with a power saving mechanism for enhancing the lifetime. The overlapping coverage area of the randomly deployed nodes forms the basis of the power saving scheme.

KEYWORDS: Clustering, Data aggregation, Lifetime, Residual energy, Wireless Sensor Network

I. INTRODUCTION

Wireless Sensor Network consists of a large number of wireless nodes called sensor nodes and one or more base stations called the sink. These sensor nodes collect information from the environment based on their sensing mechanism. The nodes deployed in large numbers collaborate to form an ad hoc network capable of reporting to data collection sink (base station). Wireless sensor network have various applications like habitat monitoring, building monitoring, health monitoring and target tracking.

1.1. Importance of Clustering

One of the important issues regarding the WSN is the limited battery power of the nodes. In most of their applications sensor nodes are deployed in harsh environments. This makes the recharging of the batteries inconvenient or sometimes impossible. Sensor nodes consume their limited battery energy to send and receive data packets to support the function of its target application. The resource constrained nature of sensor nodes is a main challenge to the design of WSNs. Therefore, there is a need to study alternate or new techniques which enable more efficient use of scarce resources at individual sensor nodes for an application.

Clustering is an effective way to minimize the energy consumption. Objectives of clustering are to minimize the total transmission power aggregated over the nodes in the selected path, and to balance the load among the nodes for prolonging the network lifetime. The sensor nodes can be organized to clusters and each cluster is managed by a special node or leader, called cluster head (CH). The CH is responsible for coordinating the data transmission activities of all sensors in its cluster. Transmission to the base station is also performed by the CH.

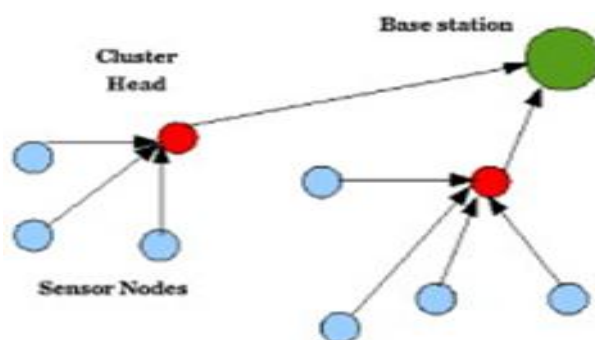


Figure 1: Basic cluster structure

The CH node selection is one of the important issues in the clustering technique. Since all the data transmission management is performed by the head node, this node should have sufficient energy. Also since the energy of the CH depletes faster than other nodes, there should be some mechanism to replace the exhausted head with a new node.

This paper studies the techniques associated with routing and data transmission in WSN which achieves energy efficiency and prolonged lifetime. The main contribution of this paper is the proposal of an energy efficient cluster based routing scheme with power saving mechanism using sleep and active scheduling. The rest of this paper is organized as follows. An overview of related works is given in section II. The proposed method is explained in section III. Section IV presents the performance evaluation and section V concludes the paper.

II. RELATED WORKS

Many clustering algorithms have been proposed for ad-hoc and sensor networks recently. LEACH [1] is the most famous application-specific algorithm that uses clustering to prolong the network lifetime. In LEACH, the nodes organize themselves into local clusters, with one node acting as the cluster head. LEACH uses a probabilistic function for selecting the cluster head which ensures every node with a cluster head role.

In Energy-Efficient Cluster Based Data Aggregation, ECBDA [2], one node is selected as a CH by using its residual energy and the communication cost factor. If the residual energy is less than the required threshold value, a new cluster head is elected from the same cluster. In Hierarchical Flow Balancing method [3] has the route construction phase, in which the sensors are grouped into clusters based on their overlapping degrees and then a hierarchical backbone network is constructed using the cluster heads with the sink at the top. In the data transmission phase, the sensors send the sensed data to their cluster heads and then the heads forwards the data to the sink. If a node loses its head and could not find a new one, isolated node reconnection phase is executed. This phase joins the isolated node to another cluster head.

Jiguo Yua et. al. [4] proposed a cluster-based routing protocol for wireless sensor networks with non-uniform node distribution which includes an energy aware clustering algorithm EADC and a cluster based routing algorithm. Clusters of even sizes are formed and the energy consumption among cluster members can be balanced well. Another method ERP-SCDS [5] employs architecture with static clusters to reduce the energy in the clustering process. To have an energy-efficient clustering mechanism and well-distributed clusters, the initialization of static clusters is handled by the sink. The multi-hop route discovery algorithm is replaced by the relay node selection mechanism to further achieve better energy efficiency.

III. PROPOSED SYSTEM

The Lifetime Enhanced Cluster Based Routing proposed in this paper mainly deals with preservation of energy of the cluster nodes. The overlapping coverage area of the nodes is the basis of this power saving scheme.

1.2. Cluster Formation

The initial cluster formation phase is based on the static clustering method [5]. Sink collects the node position information from all the sensor nodes. According to the coordinate positions collected by the sink, the nodes are provided with an id. During the cluster formation, nodes with same id will join the same cluster.

1.3. Head Election

The head election phase is based on timer mechanism initially. Every node broadcasts head advertisement messages to its neighbours. The first timed out node becomes the head. The CH for the next round of operation is selected in the current round itself. A threshold value is set for residual energy of the head nodes, which determines whether the head should be replaced or not. Further head selection is based on average value of residual energy. From the member nodes of an exhausted head, the one with highest average residual energy is selected as next head.

1.4. Route Discovery

This process involves the selection of proper routing nodes. Each cluster head transmits the data collected from its member nodes to the base station through these routing nodes. The routing node selection is based on residual energy and distance parameters. The neighbouring cluster heads exchange their energy information with each other. When a cluster head has data to send it selects from its neighbours, the one with highest energy value as its next hop. Also the distance from this node to the base station should be less than that from the sending cluster head node.

1.5. Power Saving Schedule

For transmitting data to the base station, the cluster members will first transmit the data to respective cluster heads. The data transmission is the most energy consuming task in the operation of WSN. So if the number of transmissions is reduced, it saves a considerable amount of energy.

In this paper the power saving is achieved using a sleep and active scheduling of the member nodes in each cluster. For this the randomly deployed node positions are considered. The sensors are deployed randomly

and densely. This causes the coverage overlapping of the nodes. The nodes are driven to a sleep state at which they consume only a small amount of energy. This sleep state is based on two conditions

- 1) If more than one node is deployed such that they cover the same area, then only one such node is kept active and others are driven to sleep state.
- 2) The overlapping coverage for all the nodes is calculated. The nodes with highest overlapping are made to sleep.

The first condition is based on the fact that the random deployment causes the nodes to be so closer to each other and so they will have the same area of coverage. So making one active node will preserve the energy of other nodes.

For the second condition, the overlapping coverage is calculated initially. Here the nodes within the transmission range of a particular node are called the neighbours of that node. A node whose coverage area is overlapping with all its neighbours will be having the highest overlapping. Such a node is made to sleep state because of the interference caused by the overlapping.

The position information is passed by the members to their respective CHs along with the residual energy parameter. Hence the cluster head can determine which of its members should be in sleep state. When the energy level of half of the cluster members are below the predetermined threshold, the sleeping nodes are made active and the sleep procedure is applied to the rest. This process will prolong the lifetime considerably as the scheduling is not to be repeated at each round but only when fifty percentages of nodes are below the energy constraint.

1.6. Data Transmission

The nodes in the active state will have to transmit data to their respective cluster heads. For this the CH assigns TDMA slots to the members. Each member is allowed to transmit during its own slot. The data received by the CH is aggregated and the forwarded to the corresponding routing node.

IV. PERFORMANCE EVALUATION

The method is simulated in NS2. The experiment consists of 100 nodes deployed randomly in an area of 100m x 100m. All the nodes were given the same initial energy. The operation is initiated by the sink. Also the nodes are assumed to be location aware by GPS. The simulation parameters are listed in the Table 1 given below.

Table 1: Simulation Parameters

Parameter	Value
Network field	100 m X 100m
Number of nodes	100
Initial Energy	100 J
Residual energy Threshold	25 J
Sensing radius	40 m

The performance metrics consists of two parameters, the energy consumption and the number of active nodes. The proposed method is compared with the static clustering method. The power saving scheme has increased the number of active nodes in the network after a certain number of iterations compared to the static clustering method without the sleep schedule. The total energy consumption over time is also reduced because the redundant data transmissions are eliminated by the sleep procedure.

Fig.2 given below shows the number of active nodes plotted against the number of iterations. The values show that there are more nodes alive after a certain number of iterations than the static method. Fig.3 shows the variation in total energy dissipation in the network with respect to time.

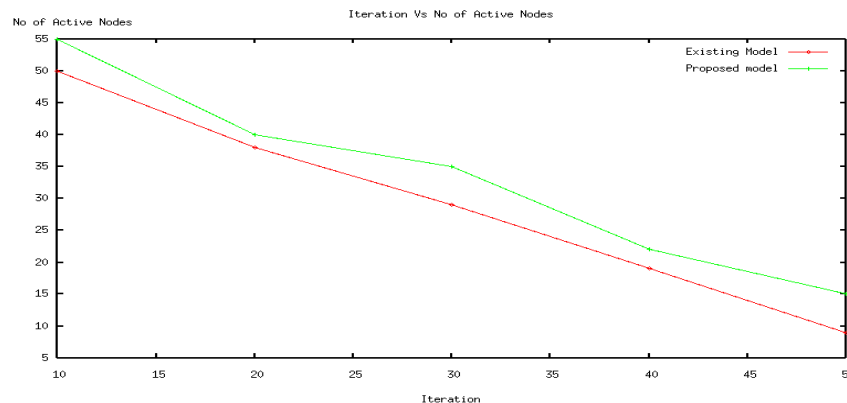


Figure 2: Number of active nodes plotted against the iterations

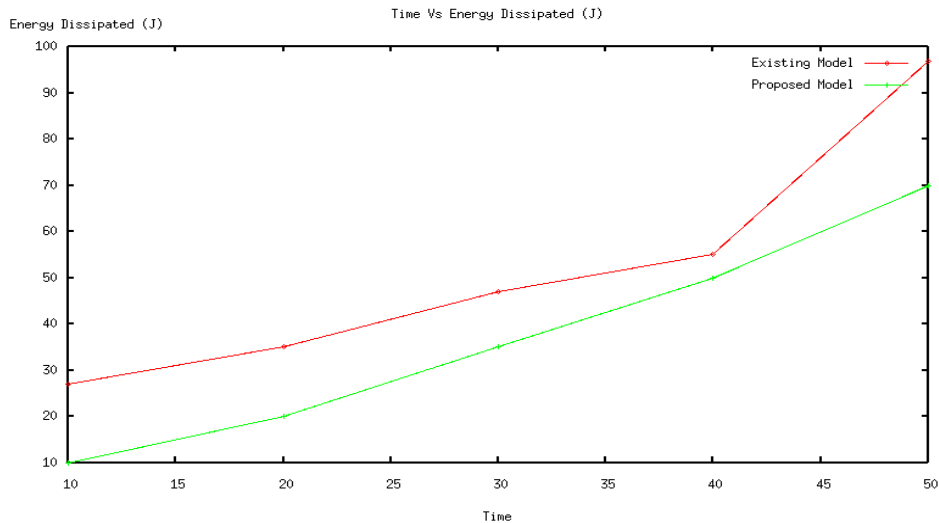


Figure 3: Total energy dissipated plotted against time

V. CONCLUSION

Clustering is the most energy efficient data transmission and routing mechanism in WSN. The aggregation of data at the cluster heads reduces the number of data transmissions and hence saves a lot of energy. The method described in this paper achieves an efficient clustering method with proper selection of cluster heads. The routing node selection is based on residual energy which makes the routing procedure energy efficient. The nodes consume a small amount of power during sleep period and hence the lifetime of entire network is enhanced. If the nodes are able to move to new clusters when they are isolated due to exhausted heads then the lifetime can again increased. This can be implemented as an extension to this work.

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