Energy Efficient by Removing Redundant and forming Dynamic Clustering of Nodes in Wireless Sensor Network

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ABSTRACT

In the development of various large scale sensor networks, a challenging problem is how to increase the lifetime of the sensors and to save the energy. In this paper, we solve this problem by using EERRDC protocol (Energy Efficient by Removing Redundant and using Dynamic Clustering), first by removing the redundant node and then clustering the sensor nodes. Here we compare the energy of the random nodes and the clustered nodes. The simulation results shows that the clustered nodes after turning off the redundant nodes takes only less amount of energy when compared to random nodes.

Keywords - clustering, energy, network lifetime, redundant nodes, wireless sensor nodes.

1. INTRODUCTION

A wireless sensor network consists of low power, thousands and hundreds of small size sensor nodes. These sensor nodes are battery powered. The sensor nodes collect the data and transmit it to a base station, referred as sink node. The base station collects data from all the nodes and analyzes this data to draw conclusion about the activity in the area of interest [1]. These wireless sensor networks has innumerable applications including weather monitoring, security, military surveillance, environmental monitoring, forest fire detection, healthcare monitoring and so on.

Many studies on WSN have been carried out [2] [3] [4]. Incase of a network with high density of sensor nodes, some problems may arise such as intersection of sensing area, redundant data, communication interference, and energy waste. The main key issue in the wireless sensor network is the energy. Since the nodes are battery powered, main researchers are still going on to improve the lifetime of the sensor. This occurs when there is energy difference to some threshold between an individual sensor and its neighbors, either due to the introduction of new sensor or re-energization of sensor nodes, or by any changes in the network settings which may be needed for any applications. An inefficient use of the available energy will lead to poor performance and short lifetime of the network.

2. RELATED WORK

Wireless sensor networks have attracted much research in recent years. In order to minimize the energy consumption in WSN's several energy efficient routing protocols and routing algorithms has been developed [5] [6]. A node scheduling scheme was developed and described by D.Tian and N.D. Georganaa [7]. In their approach, nodes take turn in saving the energy without affecting the service provided. The node scheduling scheme turns some nodes on or off but still some redundancy occurs. Sleep/wake scheduling has been proposed to reduce energy consumption in sensor networks [8][9]. The basic idea is to put the radio to sleep

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state during idle and wake it up before transmission. But it requires fine-grained synchronization between the sender and the receiver, so that they can wake up at the same time to communicate with each other.

The authors B.Chen, K.Jameson, H.Balakrishnan, R.Morris in article [10], proposes an algorithm to turn off the nodes based on the necessity for neighbor's connectivity. It intends to reduce the system energy consumption without significantly diminishing the connectivity of the network. The research article [11], proposes a schema in which energy is conserved by turning off their nodes when they are not involved in sending, forwarding or receiving any data.

Lien et al [12] focused on increasing the total data capacity by only considering the energy spent on the data transmissions. A clustering protocol is Power Efficient Gathering in Sensor Information System [PEGASIS], in which each node can only talk to it neighbors and can talk directly to the base station. This protocol assumes that each node has the capability to link directly to the base station, which is not possible in most cases. PEGASIS also expects that every node has a database to store the data about the location of it neighboring nodes which leads to greater demands for memory and power. In the research article [14], the authors proposes a technique to distribute the role of cluster head among some of the wireless sensor nodes based on the weight value containing the remaining energy of the node.

3. Proposed Work

The proposed work in this research paper is divided into two sections. In the first section, the redundant nodes are turned off. Later, the nodes are clustered.

A. Removing Redundant (RR)

In this section, we will present the system model, define a schema for node scheduling in our work. The figure 1 shows the system model that we use. The data from the nodes are sent to the base station. Some problems may arise if the network has a high density. Generally, the node scheduling problem is of two sub problems. First in what basis that each node should follow to determine whether it should turn off or on? Second, when the node should be turned off.

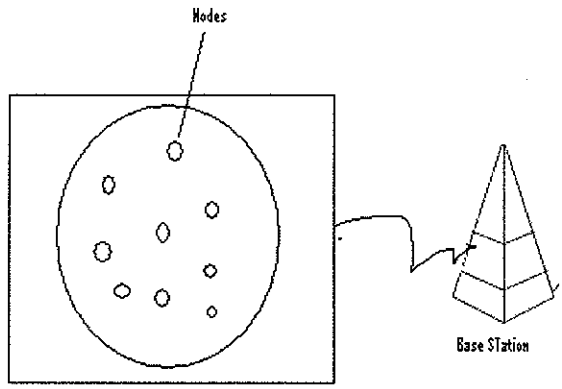

Figure 1 : Sensor Network

A large number of sensor nodes in a sensor area make it infeasible to collect redundant detailed state of information from each individual sensor node, given energy and communication constraints. Reducing redundant sensing information is an important task in a wireless sensor network which helps to save energy and can increase the lifetime of the nodes. Consider the figure 2. Suppose if both nodes N1 and N2 is sensing the same area and collecting the same information (redundant data arises), then any of the nodes can be turned off.

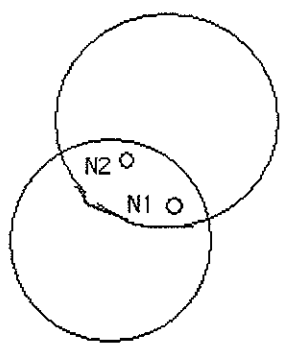

Figure 2 : Example of redundant node

The RR-SPIN protocol is used to identify the redundant node. The idea behind this protocol is, before transmitting the data, nodes negotiate with each other to overcome implosion and overlap. The useful information alone can be transferred. Among the nodes in the network one of the node act as a META node which collects the observed data from the entire region.

The RR-SPIN protocol works on two different messages namely ADV and REQ. During any process, the sink can send queries to certain regions and can wait for the data from the sensors located in the selected region. Before transmitting, the metadata send an ADV message to all the nodes about the information of its data. So when any of the nodes doesn't have the data, it can retrieve it by sending an REQ message to the metadata. If it doesn't give any REQ message, it shows that the corresponding node has collected the same information as metadata. This confirms that it has done a redundant collection and that node can be temporarily turned off.

Consider the figure 3, let N5 act as a metadata. When N5 advertises to all other nodes, if any of the nodes has the same data as N5, then that node acts as a subset of N5. Suppose if N4 has similar data as N5, then N4 acts as a subset of N5 and N4 can be turned off, so that collecting redundant information is avoided. There is more chance for a node to act as a redundant node when both the nodes are placed in the same range. By turning off the nodes temporarily, the energy used by those nodes are saved.

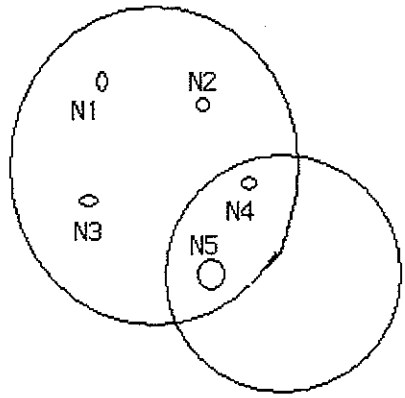

Figure 3 : System Design

After turning off the redundant node, the clustering process starts. All the nodes in the network act as a sensor nodes collecting information from the environment, apart from that they can act as a cluster head, forwarding the information to the sink, interconnecting different clusters. The entire network area can be divided into various regions or clusters with each cluster having a cluster head (CH) and all other nodes act as its members. The nodes within the clusters can communicate through the CH to the sink in an effective way.

1) Selection of CH:

The desired characteristics to identify a cluster head are

- The nodes are randomly divided into clusters.
- In each clusters, which node has the highest energy can act as the cluster head (CH).
- If the current CH is loosing out too much of energy, then the next node which has the higher energy, can take up the role of CH, thereby providing reliable transmissions.

After the clusters are formed, the network starts its normal operation. Like LEACH (Low-energy adaptive clustering hierarchy), in order to reduce the probability of collision among joint REQ messages during the setup phase, CSMA (Carrier Sense Multiple Access) is utilized as the MAC layer protocol [15].

In this section we propose the model, in which, the clusters will be formed after removing the redundant node. Initially when the clusters are to be formed, each node checks its residual energy. Since the clusters are formed randomly, there can be a chance of more nodes in one cluster and less nodes in another cluster. So to avoid this, each CH from the clusters sends a message to other CH's stating how much nodes are there in their region and about their energy. If any of the nodes has more energy than any of the CH, then that node is moved into that cluster group and elected as CH and the current CH becomes as a member.

The cluster table (CT) is formed at each cluster head, which have all the details of each cluster members in the corresponding cluster. During transmission of the data, to reduce the energy, the nodes which are not involved in sending any data can be turned off. In the CT, it has to maintain which nodes are active and which are sleep. After each round of sending the data from the source to the destination, each CH checks its energy level whether it has fallen below the threshold value. If so, it changes its role and hands its control to the next node which has highest energy. This change has to be updated in the CT and message it to other CH also.

4. Simulation Results

To validate the performance of this, we simulated with a network of about 100 nodes. In the first part, to remove the redundant nodes, the MATLAB is used, which is a scalable simulation library for wireless network systems while in the second part for dynamic clustering of nodes the NS2 is used.

Initially sensor nodes around 100 are uniformly distributed over a terrain range of (800,800) and with the routing protocol as RR-SPIN, the simulation time is setup to 300s. The radio transmission range is 50m.The following table shows the performance of the energy consumption after using the RR-SPIN protocol.

The initial energy consumption for 100 nodes is about 322.2 Joules. By using the proposed system after turning off 4 nodes the energy is only 282.9 J. We can see that the proposed system reduces the nodes as well as the energy is also saved which is shown in the Table 1.

Table 1: Energy consumption for whole sensor n/w

Number of nodes	Energy consumed(joules)
100	322.2
96	282.9
88	166.5
80	142.3
76	102.6

The following figure 4 clearly shows that after turning off the redundant node the energy consumed is reduced.

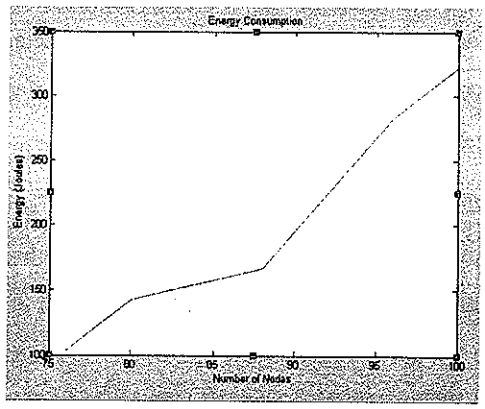

Figure 4 : Energy Consumption

In the next stage, the nodes are clustered using DC technique. The nodes are clustered into five groups with one CH in each cluster. (as shown in figure 5).

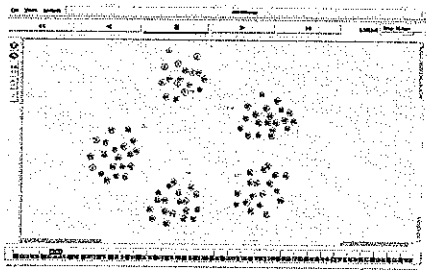

Figure 5 : Nodes are clustered

The data has been send from 14th node to the 38th node (as shown in Fig 6).

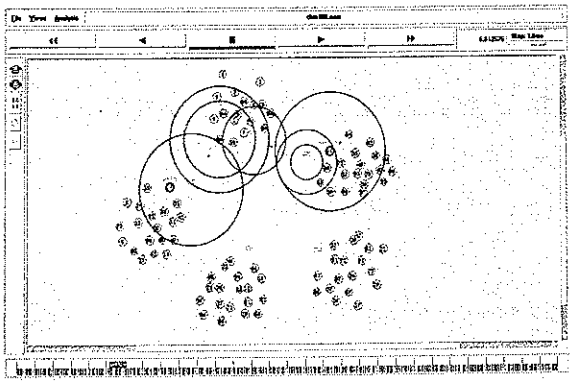

Figure 6 : Data transmission from source to destination node

The results of the proposed system are compared with randomly distributed nodes. The proposed system proves that it uses only less amount of energy while sending the data. The results of the EERRDC protocol is also shown in figure 7.

Figure 7 shows that the total remaining energy of the clustered nodes is more than the random nodes. It shows that EERRDC utilizes only less amount of energy, so that the lifetimes of the nodes are also increased.

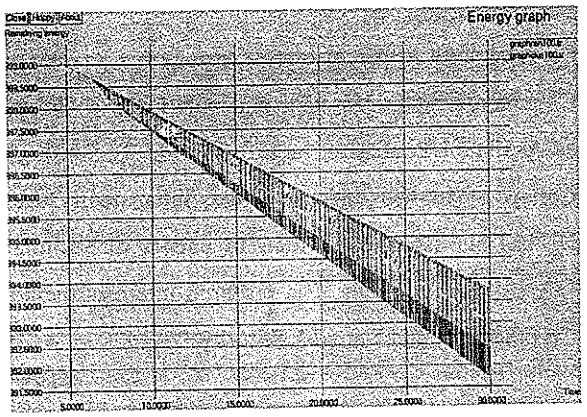

Figure 7. Random nodes Vs Clustered nodes

V. Conclusion

Here we introduced a novel way to utilize the nodes after turning off the redundant nodes, so that the energy has been saved. Other technique along with this is, using dynamic clustering of the nodes, which has also saved the energy. The energy efficiency and ease of deployment makes EERRDC a desirable protocol for wireless sensor networks. Both the simulation results show that the energy has been saved, so that the lifetime of the nodes is also increased. Our future work will be further investigating in clustering techniques.

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Manju Priya .S completed M.Sc, M.Phil in Computer Science from Bharathiar University, Coimbatore. Currently she is pursing Ph.D in Computer Science in Karpagam University, Coimbatore. She has presented more than 5 papers in the national and international conferences. Her research area includes Wireless sensor networks, network communications.

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