Energy Balanced Routing for Data Collection in Wireless Sensor Networks

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Abstract— Wireless Sensor Network (WSN), is a system composed of large number of micro sensors. In most of its applications, data are typically gathered by the sensor nodes and reported to the data collection point called the sink or the Base Station (BS). The sensor nodes have limited battery power and battery replacement is not easy for these networks, with thousands of physically embedded nodes. Hence efficient use of battery is very important to maximize the lifetime of the network. And this is achieved by a tree based energy balanced routing protocol, which builds a routing tree using a process where for each round the BS assigns a root node and broadcasts this selection to all sensor nodes in the network. Subsequently each node selects its parent by considering only itself and its neighbour’s information. Thus making it a dynamic process. The comparison with the existing protocol is also performed to show the improvements.

Keywords: BS, MEMS, CH

I. INTRODUCTION

The WSN is considered to be latest trend of Moore’s law towards miniaturization. Recent advances in micro electro mechanical systems (MEMS) and low power and highly integrated digital electronics have led to the development of micro sensors. The capabilities of sensor nodes include sensing, computation and wireless communication. Such sensors are equipped with the sensing subsystem for data acquisition from the physical surroundings, the processing subsystem for data processing and the wireless communication subsystem for data transmission. Along with these the storage and battery are present. The figure below shows the basic block diagram of any sensor node.

These networks have a wide range of potential applications to security, agriculture, industry, health, environmental monitoring etc. Energy being a very important resource of any sensor network needs to be managed efficiently, as to extend the lifetime of any network. The lifetime of a wireless sensor network is defined in two completely different ways.

1) Time elapsed until the first node in the network depletes all of its energy.
2) Time elapsed until the last node in the network depletes all of its energy.

The energy consumption is due to ‘useful’ and ‘wasteful’ operations. The useful operations include transmitting or receiving data, processing requests and data forwarding. The wasteful operations include idle listening, overhearing and collision.

The data is sensed by the sensor nodes and the information is transmitted in a hierarchal manner to reach the sink. In some applications there may be a need to provide security to the data that is to be transmitted. This avoids the danger of data misuse to an extent. The security concept is more needed in the military applications networks, where data has great importance.

There are two cases of data processing

1) Case 1: With data fusion, where the data received and data sensed by itself is aggregated at each node and a constant amount of data is transmitted further.
2) Case 2: Without data fusion, where the data received and data sensed by itself is summed up at each node and is transmitted further. Here no reduction or aggregation of data takes place.

II. RELATED WORKS

Sensor network nodes are limited with respect to energy supply, restricted computational capacity and communication bandwidth. Most of the attention, however, has been given to the routing protocols since they might differ depending on the application and network architecture.

There are several routing protocols which aim at extending the lifespan of the network. LEACH (Low Energy Adaptive Clustering Hierarchy), is self-adaptive and self-organizing routing protocol. It involves two stages, the setup and the steady state stage [1]. In setup stage the nodes based on the threshold value decide whether to become a Cluster Head (CH) or not. Ones the CH is selected based on the energy level and the distance each of the node connects itself to a particular CH. During steady state stage the CH collects the data from the cluster members and forwards it to the Base Station (BS) in one hop after fusing. Forming the CH reduces the amount of data directly transmitted to the BS. The selection of CH is random so as to consume energy evenly from all nodes.

In PEGASIS (Power-Efficient GAthering in Sensor Information Systems), each node communicates only with close neighbour and takes turns transmitting to the BS and thus reducing the amount of energy spent per round. In this protocol, the data is collected and gathered from nearby nodes. The PEGASIS will form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbour. Gathered data moves from node to node and get fused and eventually a designated node transmits to the base station [2]. Nodes will transmit information to the base station so that the average energy spent by each node per round is reduced. PEGASIS performs data fusion at every node except in the end nodes in the chain [3]. Each node will fuse its neighbour’s data with its own to generate a single packet of the same length and then transmit that to its other neighbour in the network. The equations below are used to calculate transmission costs and receiving costs for a k-bit message and a distance d [2].

Transmitting: \( ET_X(k,d) = ET_X - elec(k) + ET_X - amp(k,d) \)

\( ET_X(k,d) = Elec * k + Amp * k * d^2 \) (1)
Receiving: \( ERx(k) = ERx - elec(k) \)

\( ERx(k) = Elec^* k \) \( (2) \)

HEED (Hybrid Energy Efficient Distributed) protocol was designed to select different cluster heads in a field according to the amount of energy that is distributed in relation to a neighbouring node. In each cluster one node acts as a cluster head which is in charge of coordinating with other cluster heads. To increase energy efficiency and prolong network lifetime intra cluster communication is used and it communicates with other cluster heads. HEED distribution of energy extends the lifetime of the nodes within the network thus stabilizing the neighbouring node and it operates correctly when nodes are not synchronized [4]. In Hybrid Energy Efficient Distributed clustering algorithm, each node is mapped to exactly one cluster. The node can directly communicate with its cluster head (via a single hop). Each node independently makes its decisions based on local information. Clustering terminates within a fixed number of iterations. At the end of each TDMA, each node is either a cluster head, or an ordinary node that belongs to exactly one cluster. Clustering should be efficient in terms of processing complexity and message exchange or cluster heads are well-distributed over the sensor field.

### III. PROPOSED WORK

We are proposing a method to collect the data in a wireless sensor network taking care of the energy consumption. The security being one of the important factors in the WSNs application like military, the security is provided for such data. Hence making the whole of the system efficient with respect to energy consumption and security.

This particular model involves 3 stages: deployment stage, topology construction and the transmission stage. The deployment includes the placing of the nodes in the area of interest. The topology used here is the tree, and hence the tree construction for the deployed nodes takes place. Proving the path for the data transmission and then the actual data transmission takes place keeping in mind the shortest path and energy levels.

### IV. PROPOSED MODEL

The WSN consisting of \( N \) nodes is generated by random placement of nodes in the area of interest. The nodes considered here are homogeneous nodes having equal energy and fixed communication range.

As the sensors are also used in terrain regions where replacement of the battery in these nodes is next to impossible, there we cry for each bit of the energy to be utilized very efficiently. To take care of this battery utilization and increasing the lifetime of the whole network we already have protocols. These routing protocols help achieve this target, but here we can still more improve it through the proposed model.

The nodes generated in an area are connected to each other through the tree structure. This tree structure is formed based on the nearest node for transmission along with the consideration of its energy level. The data transmitted from one node to the other gets aggregated at each node and further transmitted. And the other case where only the data at each node gets added up and is transmitted further. These two cases of data fusion are illustrated below with an example of left node and intermediate node having data of 1 unit each.

![Diagram](image)

**Fig. 1: Fusion and Non-Fusion Example**

Ones the tree is constructed using these criteria’s of energy level and distance the data tries to reach its destination through the shortest path possible hence saving time and energy.

The data security is provided using the blowfish algorithm. The data that is to be sent is encrypted, using a key generated. Ones the encryption takes place the data is ready to be transmitted. The transmission takes place as explained above. The tree structure rebuilds whenever the energy levels of the nodes involved in transmission vary. Hence providing an adaptive tree structure. The other important factor in this model is that the residual energy is measured and found that only a small amount of energy is utilized.

The nodes are selected to participate in the data transmission only when their energy level is above the threshold. Ones the node depletes its energy to go below this threshold, that particular node is considered dead. The care for removing such nodes from the transmission process is taken. The adaptive tree formation takes place leaving that node. In this way the data loss that may take place at that node and energy to change the path after reaching till that node and returning back is avoided.

Here we have also compared the proposed results of first dead node with one of the existing protocol result LEACH.

### V. SIMULATION

We have simulated the proposed model with a fixed area and random placement of the sensor nodes. The algorithm is executed to show the performance of the work. In this section we discuss about the inputs provided and the corresponding parameters related.

We have considered a fixed area 200 X 200 mts. The nodes to be placed are \( N=100 \). The initial energy \( Energy\_init \) is set to 1. The other values initialized are:

- No. of cycles= 100
- Transmission energy: \( Energy\_Tx=50nJ \)
- Reception energy: \( Energy\_Rx= 50nJ \)
- Sampling Frequency energy: \( Energy\_fs=10pJ \)
- Energy for transmitter amplification: \( Energy\_Tx\_Amp= 9fJ \)
- Energy for data aggregation: \( Energy\_Data\_Agr= 5nJ \)
- Data aggregation factor: \( Data\_Aggregation= 0.75 \)
- The sink location is fixed.

The procedure to be followed: Enter the input message to be sent. The message gets encrypted with help of the key. The nodes gets deployed in the region and the tree...
construction takes place. The deployment is set different for both the fusion and non-fusion cases. Once tree structure is obtained according to the proposed model the residual energy graph and the throughput graph for both the cases is obtained.

The parameters involved are:
1) Residual energy: The energy left over after each round.
2) Throughput: The rate at which the message is delivered successfully to the sink.
3) Dead nodes: Nodes that deplete their energy and reach below the threshold and not eligible to participate in the process.

VI. RESULTS

The figure 2, shows the residual energy and the throughput for fusion and non-fusion case. The green line representing the fusion and red the non-fusion. We can see that the energy utilized is very much less in both the cases. It remains to be the initial energy 1 almost throughout. As we increase the number of nodes we can see the slight reduction in the energy level. The other side of the figure represents the throughput for both.

![Fig. 2: Residual Energy and Throughput](image)

The construction of tree takes place for the deployed nodes as shown below. Fig.3 for the non-fusion and fig 4 for the fusion. The red node in both the figures represent the sink.

![Fig. 3: Tree Construction for Non-Fusion](image)

![Fig. 4: Tree Construction for Fusion](image)

The tree rebuilds whenever there is a change in the energy level of the nodes involved in data transmission.

We can compare our performance with that of the LEACH. The fig 5 and Fig. 6 show the graphs for number of dead nodes in LEACH and the proposed model respectively with respect to rounds.

![Fig. 5: Dead nodes in LEACH](image)

![Fig. 6: Dead Node In Energy Balance Routing](image)

The graph represents the number of rounds vs. number of dead nodes. We have taken only 1000 rounds in consideration for LEACH and 2000 for energy balance routing, for better results. In LEACH the first node dies off after 570 rounds and that in energy balanced routing proposed it is 1650 rounds.
VII. CONCLUSION
In this paper, we focus on maximizing the lifetime of the wireless sensor networks by energy balanced routing. The energy utilized is less as we can note it through the residual energy graph. The throughput is satisfactory. The adaptive nature of tree construction adds an advantage. The time taken for this model is also in seconds. So adds no delays.

The comparative results of the first dead node which is also one of the definition of network lifetime is obtained. Hence the lifetime of proposed model is far better than the existing taking care of the energy utilization.

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