Energy Efficient Cluster Head Selection for Data Aggregation in Wireless Sensor Networks

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Abstract--- Wireless sensor network consists of several distributed sensor nodes. It is used for several environmental applications, military applications and health related applications. However, a WSN is a power constrained system, since nodes run on limited power batteries which shorten its lifespan. Battery unit determines the lifespan of the sensor network. Energy consumption is therefore one of the most crucial design issues in WSN. To prolong the lifetime of the sensor nodes, designing efficient routing protocols is critical. Most of the research in energy efficient data gathering in data centric applications of wireless sensor networks is motivated by LEACH (Low Energy Adaptive Clustering Hierarchy) scheme. It allows the rotation of cluster head role among the sensor nodes and tries to distribute the energy consumption over the network. Selection of sensor node for such role rotations greatly affects the energy efficiency of the network. Some of the routing protocol has a drawback that the cluster is not evenly distributed due to its randomized rotation of local cluster head. We have surveyed several existing methods for selecting energy efficient cluster head in wireless sensor networks. We have proposed an energy efficient cluster head selection method in which the cluster head selection and replacement cost is reduced and ultimately the network lifetime is increased. Using our proposed method, network life time is increased compared to existing methods.

Keywords: - WSN, CH, BS, LEACH, LEACH-B

I. INTRODUCTION

Wireless Sensor Network is an emerging field with lot of applications. Due to its wide applications in the field of defense security, civilian applications and medical research, there is lot of research going on. One of the advantages of wireless sensors networks (WSNs) is their ability to operate unattended in harsh environments in which contemporary human-in-the-loop monitoring schemes are risky, inefficient and sometimes infeasible. Therefore, sensors are expected to be deployed randomly in the area of interest by a relatively uncontrolled means, e.g. dropped by a helicopter, and to collectively form a network in an ad-hoc manner [1, 2].

Since WSNs consist of battery-powered devices, the energy efficient network protocols must be designed. Due to large network size, limited power supply, and inaccessible remote deployment environment, the WSN-based protocols are different from the traditional wireless protocols. Due to the short range communication and the fact that consumption of energy is proportional to the square of the distance making communication multi hop instead of direct node tries to perform computation of data locally so data to be forwarded is reduced, because computation is less expensive then data transmission in WSNs. This network protocol operation varies from application to application. One routing algorithm might be good for periodic monitoring while it may not perform well where it will have continuous data sensing.

Data aggregation in WSN is a data transfer technique where multiple data packets from sensor nodes are gathered to a certain sensor node and combined into a less number of packets. This technique is essential in the wireless sensor environment because the reduction of data packets enables less usage of wireless transmission modules, reducing energy consumption, increase network lifetime, and decrease end-to-end delay. Efficient data aggregation techniques can provide these advantages by ensuring quick and high data aggregation rates, while avoiding excessive use of control packets. The rest of the paper is organized as follow: Section II describes various existing methods for energy efficient cluster head selection in wireless sensor networks. Section III describes our proposed method. Section IV describes results and analysis. Finally conclusion is presented in section V.

II. RELATED WORK

In this section we have focused on the related work that has been done previously by several researchers. Energy Efficiency for prolonging the WSN has received much focused attention. The various existing methods are described as follows.

A. Low Energy Adaptive Clustering Hierarchy [5]

Low Energy Adaptive Clustering Hierarchy (LEACH) protocol has attracted intensive attention because of its energy efficient, simplicity and load balancing properties. LEACH is a cluster based protocol. The numbers of cluster heads and cluster members generated by LEACH are important parameters for achieving better performance. LEACH organizes nodes into clusters with one node from each cluster serving as a cluster-head (CH). It randomly selects some predetermined number of nodes as cluster heads. CHs then advertise themselves and other nodes join one of those cluster heads whose signal they found strongest (i.e. the CH which is nearest to them). In this way a cluster is formed. The CH then makes a Time Divison Multiple Access (TDMA) schedule for the nodes under its cluster. The communication between different clusters is done through CHs in a Code Divison Multiple Access (CDMA) manner. The CHs collect the data from their clusters and aggregate it before sending it to the other CHs or base station (BS). After a predetermined time lapse, the cluster formation step is repeated so that different nodes are given a chance to become CHs and energy consumption is thus uniformly distributed.

B. Random competition based clustering (RCC) [6]

The RCC algorithm applies the First Declaration Wins rule, in which any node can ‘‘govern’’ the rest of the nodes in its radio coverage if it is the first to claim being a CH. After hearing the claim which is broadcasted by the first node, neighboring nodes join its cluster as member and give up their right to be a CH. To maintain clusters, every CH in the network broadcast a CH claim packet periodically. Since there is a time delay between broadcasting a claim packet and receiving it, concurrent broadcast can possibly create a conflict. Since random timer is not a complete solution, RCC resolve further the concurrent broadcast problems by using the node ID. If the conflict persists, node having lower ID will become the CH. Although frequent node mobility still has direct effect, RCC is shown to be more stable than conventional clustering schemes.

C. PEGASIS: Power-Efficient Gathering in Sensor Information System [7]

By this author proposed algorithm PEGASIS that is a chain based protocol provide improvement over LEACH algorithms. In PEGASIS, each node communicates only with a close neighbor and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Using greedy algorithm, the nodes will be organized to form a chain, after that BS can compute this chain and broadcast it to all the sensor nodes. Energy saving in PEGASIS over LEACH takes place by many stages: First, in the local data gathering, the distances that most of the sensor nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, only one node transmits to the BS in each round of communication. PEGASIS outperforms LEACH by limiting the number of transmissions, eliminating the overhead of dynamic.

D. EECS: Energy Efficient Clustering Schemes [8]

Authors proposed an algorithm in which cluster formation is different from LEACH protocol. In LEACH protocol cluster formation takes place on the basis of a minimum distance of nodes to their corresponding cluster head. In EECS, dynamic sizing of clusters takes place which is based on cluster distance from the base station. The results are an algorithm that addresses the problem that clusters at a greater distance from the sink requires more energy for transmission than those that are closer. Ultimately it provides equal distribution of energy in the networks, resulting in network lifetime. Thus main advantage of this algorithm is the full connectivity can be achieved for a longer duration.

E. Energy Efficient Chain Based Routing [9]

The proposed protocol organizes sensor nodes as a set of horizontal chains and a vertical chain. In each chain, a node is selected as chain head. For selecting the chain heads in horizontal chains, EECRP considers residual energy of nodes and distance of nodes from the header of upper level that does not need to reselect leader of the vertical chain. This causes time and energy saving. In each horizontal chain, sensor nodes transmit their data to their own chain head based on chain routing mechanism. EECRP also adopts a chain based data transmission mechanism for sending data packets from the chain heads to the base station.

F. Distance Based Cluster Head Selection Method [10]

The author [10] has proposed an algorithm that selects cluster head as per the following algorithm.

- Step1. Let we have a set S of n nodes in a cluster viz.
- Step2. Calculate the distance of one node to all nodes.
- Step3. Calculate the sum of all distance from one to all nodes.
- Step4. Calculate distance from BS to each node for all nodes.
- Step5. Calculate the net distance with base station for each node
- Step6. Select the cluster head based on all NDBS values.

G. Mst-Pso: Minimum Spanning Tree-Pso [11]

Authors proposed a minimum spanning tree-PSO based clustering algorithm of the weighted graph of the WSNs. The optimized route between the nodes and its cluster heads is searched from the entire optimal tree on the basis of energy consumption. Election of cluster head is based on the energy available to nodes and Euclidean distance to its neighbor node in the optimal tree. Others have concluded that network life time does not depend on the base station location or residual energy of the node. Once the topology decided to then network life time becomes almost settled. Author’s shows two techniques for improving network life time: reduce the startup energy consumption of the transmitter and receiver, and optimized the network topology.

H. Balanced LEACH [12]

LEACH-B protocol adds a second selection of cluster heads to modify the number cluster-head in the set-up phase considering the node’s residual energy per round. In order to save the energy consumption and to prolong the life span of the network, the protocol needs to ensure that the partition of cluster is balance and uniform. To achieve this goal, the number of CHs needs to be dominated, and the network needs an optimal CHs amount.

I. Group [13]

GROUP clustering algorithms based on clustering algorithm that provides scalable and efficient packet routing for large-scale WSNs. Only some parts of total number of sensor nodes participate in formation of cluster heads (CHs). In this, cluster heads are arranged in a grid manner and primary sink (One of the sink), dynamically and randomly builds the cluster grid. Greed Seed (GS) is a node within a given radius from the primary sink. Any queries from sink to nodes are propagated from greed seed to its cluster heads and so on.

III. PROPOSED METHOD

In most of the energy efficient routing protocols, nodes selected as cluster heads must broadcast to member nodes of the clusters to which they belong that they have become cluster heads. As the frequency of rounding and of cluster head replacement increases, energy consumption increases due to message transmission for broadcasting

Our goal is to reducing the amount of cluster head selection and replacement cost and ultimately to extend the lifetime of the entire networks compared with the existing clustering protocols.

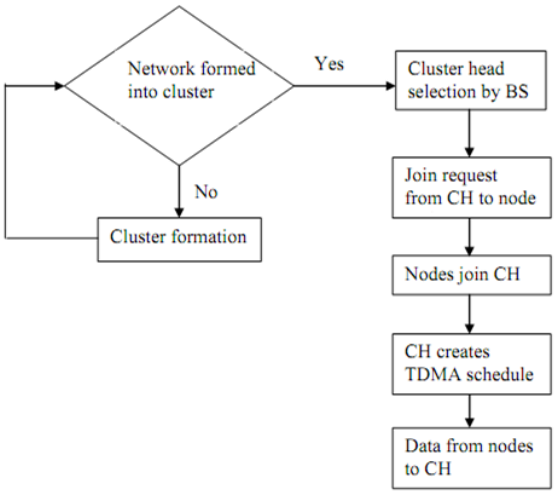

Fig. 1:

The steps in order to setup clusters and then to elect cluster heads are the following:

1. The BS creates a Time Division Multiple Access (TDMA) schedule and requests the nodes to advertise themselves.
2. Each node broadcasts a message to advertise its energy level to its neighbors. Based on this exchanged information, each node sets up a neighbor information table that records the energy level and sends this table to its neighbors. This step is repeated until the information of all the nodes in the network is sent to the BS.
3. As soon as the node advertisement is completed, the BS selects the cluster head whose energy is higher than threshold value. The overall number of nodes, which are assigned to be cluster heads, is 5% of the total number of the nodes in the network.
4. The BS broadcasts the unique IDs of the newly selected cluster heads, and their cluster members and the nodes use this information to form and enter a cluster.
5. Each cluster head creates a TDMA schedule and broadcasts this schedule to the nodes in its cluster, in order to inform each node of the timeslot that it can transmit.
6. The nodes, based on the allocated transmission time, send the data concerning the sensed events to their cluster head.
7. Every cluster head aggregates the data and then transmits the compressed data to the base station.
8. A round of data transmission has been completed, and the protocol continues from step 4 for the next round.
9. The execution of the protocol is terminated as soon as all the nodes in the network run out of energy.

IV. Result And Analysis

We have implemented our algorithm in MATLAB. Every node in the network belongs to some cluster. The various parameters we have considered for simulation are as follow:

- Network size: The size of the network will be considered as 100X100.
- No. of nodes: 100
- Node deployment: Nodes are randomly deployed in a given area.

Our aim is to prolong network life time. Network life time depends on the number of dying nodes. Here we have assigned time slot to each node before communication, and we have calculated the number of rounds after all nodes dies.

The simulations were carried out with 100 nodes for different values of node energy that are 0.25 J/node, 0.5 J/node and 1 J/node. We have measured the no. of rounds for the proposed method.

No. of Rounds when all nodes are dead

J/Node	LEACH	LEACH-B	Proposed Method
0.25	308	405	450
0.5	576	697	770
1.0	1077	1285	1398

– NO. Of Rounds Graph

A. Energy 0.25 J/Node

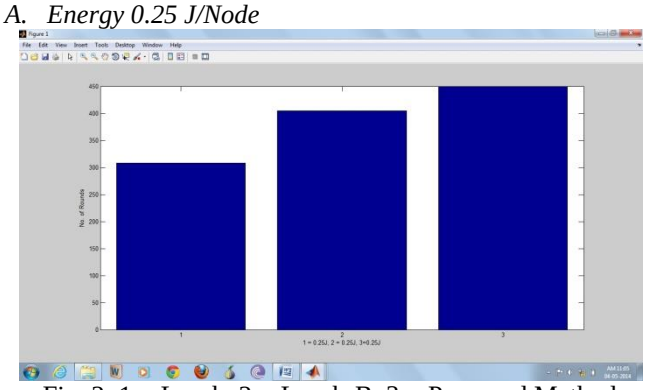

Fig. 2: 1 = Leach, 2 = Leach-B, 3 = Proposed Method

B. Energy 0.5 J/Node

Fig. 3: 1 = Leach, 2 = Leach-B, 3 = Proposed Method

C. Energy 1.0 J/Node

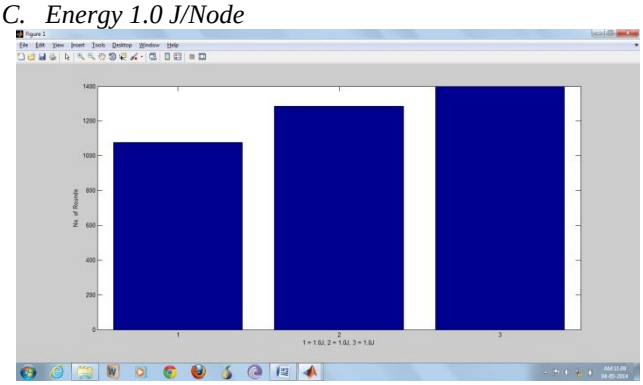

Fig. 4: 1 = Leach, 2 = Leach-B, 3 = Proposed Method

V. Conclusion

Energy Efficiency for prolonging the WSN has received much focused attention. We have proposed a simple threshold based cluster head selection method in which we reduce the amount of cluster head selection and replacement

cost. In future, we wish to improve the distance of cluster head communication with cluster member via a hierarchical tree in more efficient manner.

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