A NOVEL ROUTING PROTOCOL WITH LIFETIME MAXIMIZING CLUSTERING ALGORITHM FOR WSN

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***Abstract*—** Wireless Sensor Network consists of tiny, battery enabled sensor nodes. In the recent years, the most important problem in WSN is to improve the life time of Network. Network life time depends on the residual energy of the sensor nodes. Most of the energy in the sensor node is used for data transmission. So, we should employ the routing protocols which can consume the energy of nodes efficiently. Already, many energy efficient routing protocols have been suggested by the researchers, among which Hierarchical Protocols achieve the better performance. In this paper, a novel routing protocol has been proposed which introduces new clustering algorithm and constructs the routing tree for efficient data transmission. The objective of this algorithm is to consume less energy, distributing energy consumption equally among all nodes and finally, extends the network lifetime. The simulation results show that this protocol consumes the energy of the nodes efficiently and improves the life time of the network. For a set of 100 nodes, the proposed algorithm gives 31% better performance than LEACH, 18% better performance than LEACH-C and 15 % better performance than TL-LEACH in terms of network life time.

Keywords: *Network lifetime, WSN, Cluster Head, Life time Maximizing Cluster*

I. INTRODUCTION

Due to the recent technology advances, manufacturing of small and low-cost sensors has become technically and economically feasible. Continued advances of wireless communication technologies have enabled the deployment of large scale wireless sensor networks (WSNs)[1]. Each sensor node is equipped with a limited battery supplied energy, which makes energy consumption a critical issue. Most of the time, the sensor nodes spent its energy in forwarding the data. Innovative techniques are highly required to improve the routing algorithm and thereby increase energy efficiency and prolong the lifetime of WSNs. There have been many sensor network routing protocols proposed to solve various kinds of problems, demanded in sensor networks. Presently, widely suggested routing techniques are distributed among different classes which are: flat, hierarchical, and location-based techniques. Many energy-efficient solutions have been put out. An approach that is likely to succeed is the use of a hierarchical structure [2].

To facilitate large scale deployments, complex and critical issues like, energy efficient operation, channel contention, latency, and management of WSNs have to be addressed. Cluster-based organization of large sensor networks is the basis for many techniques that address these issues. Applications that span large sensor fields and/or support data aggregation are prime candidates for cluster-based configuration. Clustering is particularly useful in collaborative sensor applications that perform different tasks

and deployed in the same physical area [13]. In general, the network is decomposed into a set of clusters, for example, for administrative or communicating purposes, with each cluster formed by grouping a set of nearby nodes. A designated node, namely, the cluster head (CH), manages each cluster. With many solutions based on clustering, the nodes within a cluster communicate only with their CH. The CHs are responsible for coordinating both inter-cluster and intra-cluster communication. Communication among CHs can be via either single or multiple hops.

Although many clustering solutions have been proposed [16], only a few combines clustering with a data routing scheme that is appropriate for large-scale WSNs [10,12,14]. Hierarchical topologies are attractive for such large networks because of the scalability.

II. RELATED WORKS

Many different traditional clustering algorithms for wireless sensor network have been proposed. Low Energy Adaptive Clustering Hierarchy (LEACH) Protocol was proposed by [8]. This protocol is one of the most famous hierarchical routing algorithms for energy efficiency in WSNs. Other algorithms developed thereafter were based on this algorithm. The operation of LEACH protocol is divided into rounds. Each round consists of set up phase and steady state phase. Sensor nodes are organized into different clusters based on the received signal strength and cluster heads are selected for each cluster as routers to the base station.

A two two-level LEACH (TL-LEACH) algorithm was proposed in [15]. It was enhanced to the LEACH algorithm. They adopted the same method of cluster heads selection and clusters formation. The algorithm elects two sensor nodes in each cluster as cluster heads, one node as primary cluster head and the other as the secondary cluster head. Both the primary and secondary cluster heads can communicate with each other and secondary cluster heads communicate with nodes in their sub-clusters.

A cluster tree can be formed using either a top-down or a bottom-up approach. In top-down approach, a designated root node first forms its own cluster. It then selects some of its neighbors (CHs) to form their own clusters, which in turn causes some of their neighbors to form the next level of clusters, and the process continues until the entire sensor field is covered. The cluster tree is formed by keeping track of the parent-child relationship among CHs and it is guaranteed that new child CHs are selected from neighbors of existing CHs. The IEEE 802.15.4 cluster tree follows this concept [16].

In bottom-up approach, individual clusters are formed independently and later combined together to form a higher-level structure. For example, nodes probabilistically elect themselves as CHs at different levels of the hierarchy and form their own clusters [17]. The hierarchy is then formed by directly connecting a set of CHs at level i to a CH at level i+1. TEEN [10] follows a similar concept. The physical distance between CHs of adjacent levels increases as we go up the hierarchy [3]. Thus, upper level CHs become hotspots, as they have to relay traffic from lower layers and require higher transmission energy levels. Power balanced unequal cluster formation [4, 12, 13] overcomes this issue by forming many smaller clusters closer to the sink and making them larger as the distance to the sink increases. However, clusters are more likely to become arbitrarily large as they farther from the sink. Therefore, schemes in [4, 10, 12, 17] cannot guarantee CH-to-CH connectivity in geographically large networks because the inter cluster distance is not bounded.

III. The Proposed Approach

In this paper, we propose a novel clustering algorithm and tree based data forwarding algorithm which utilize the energy of the node efficiently. Clustering is a method in wireless sensor networks (WSNs) for effective data communication and towards energy efficiency [5]. It involves grouping of sensor nodes together, so that nodes communicate their sensed data to the CHs. CHs collect, aggregate and transmit the aggregated data to the processing centre called base station for further analysis. Clustering provides better resource utilization and minimizes energy consumption in WSNs by reducing the number of sensor nodes that take part in long distance transmission. The functioning of the proposed approach is given below.

For Simulation, we make the following assumptions:

- There are M nodes in the sensor field.
- Number of clusters is *K*.
- Average number of sensor nodes in each cluster is N where

$$N = M / K \qquad (1)$$

After N rounds, each of the nodes must have been a cluster head (CH) once.

We assign each node a unique identifier N_i, for all i = 0,1,2,3,4……..M-1

A. Algorithm for Cluster Heads Selection

Originally, all nodes are the same, *i.e.* there is no CHs in each cluster, $j = 0$ where j is CHs counter. A node q_i is selected among all nodes and it continuously executes the following steps:

Firstly, q increments i by 1 and check if i is even, if yes, that node is selected as the CH for that round and announces its new position to all member nodes in the cluster; else, if i is odd, it cannot be a CH for that round and it will wait for the next round and be ready to receive advertisement message from the new CH. A predetermined value is set (threshold value) for the new CH to transmit for that round. When the value has reached the threshold, j will be incremented by 1 and the process of selection of new CH begins. It tests if the following two conditions hold.

1. A sensor node has not become cluster head for the past (1 / p) - 1 rounds.
2. The residual energy of a node is more than the average energy of all the sensor nodes in the clustering.

Thus, the probability of a node becoming new cluster head is given as

$$P_i = \frac{Erem(i) * K}{Eavg(i) * N} \qquad (2)$$

Where, $E_{rem}$is the remaining energy in node (i), E_{avg} is the average energy of all the nodes in a cluster. It continues until $j = K$. The algorithm stops when $j = K$. The new CH collects the sensed data from member nodes, aggregate them, and transmit the compressed data to the next cluster head or base station.

B. Cluster Formation

The next step in the clustering phase is cluster formation after CHs have been elected. Below gives the description of new cluster formation.

Step 1: The new cluster heads broadcasts a low cost control messages (INIT) message to all non-cluster nodes in the network using Carrier Sense Multiple Access/Collision Detection (CSMA/CD) MAC Protocol.

Step 2: Based on the RSS (Receiver Signal Strength) each sensor node determines which clusters it will join, by choosing CH that requires minimum communication energy.

Step 3: Each non-cluster node uses CSMA/CD to send message back to the CHs informing them about the cluster it wants to belong.

Step 4: After CHs have received messages from all nodes, It fix the cluster boundary and constructs the spanning tree (the procedure for spanning tree construction is given in next section).

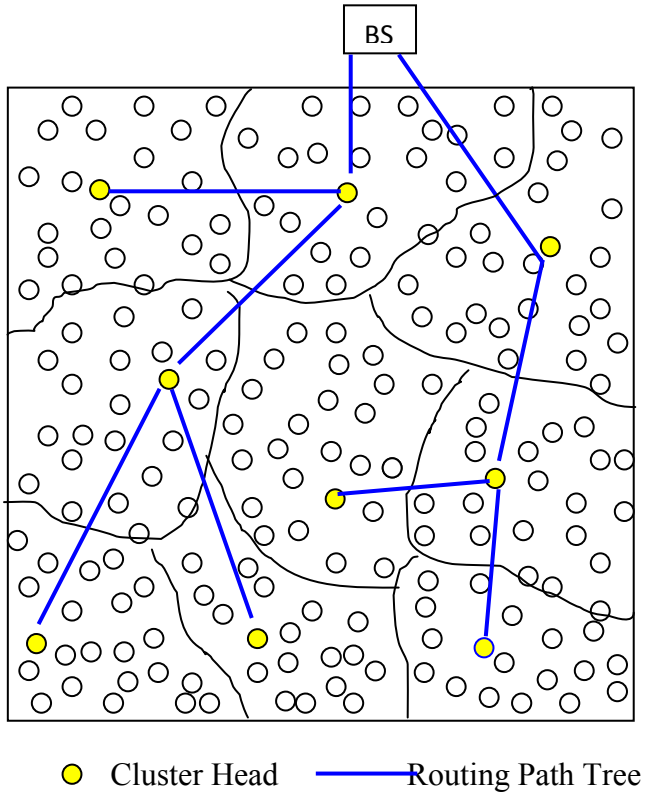


Fig.1 The Proposed Algorithm

C. Routing Tree Construction

For constructing the spanning tree the following assumptions are made:

All nodes have global knowledge about other nodes. After cluster formation all the cluster heads transmits the *Ready message* to the sink node. After certain amount of time the sink node will start the tree construction by broadcasting a *init_tree* message to the CHs. Each CHs receives this message will store the sink information in its neighbors table and after a short period, it will send an *t_accept* message to the sink which contains node residual energy and its location. The *t_accept* message has two purposes: request for a parent, and request for an ID. On receipt of t_accept messages, based on the energy and the distance sink select the parent of the tree. Sink send a message to the parent node and the parent node send the short range broadcast message to the other cluster heads. CHs reply with the create_child message. The parent node accepts the CHs as a child if number of child less than Cmax. Otherwise it forwards the request to one of its child. This procedure repeats until all the CHs entered in to the routing tree.

D. Data Collection and Data Forwarding

Step 1: The CH prepares Time Division Multiple Access (TDMA) scheduling table and send it to all nodes in the cluster. This message contains time allocated to each node to transmit to the CH within each cluster.

Step 2: Each sensor node uses TDMA allocated to it to transmit data to the CH with a single- hop transmission and switch off its transceiver whenever the distance between the node and CH is more than one hop to conserve energy. To avoid a single node transmitting data multiple times in one round, we set a threshold value *G*. *G* is the total time of all nodes in the cluster forwarding their data to the CH in one round.

Step 3: CHs will issue new TDMA slots to all nodes in their clusters when allocated time for *G* has elapsed, for each node to know exact time it will transmit data to avoid data collision during transmission that can increase energy consumption.

Step 4: CH transceiver is always turn-on to receive data from each node in its cluster and prepare them for transmission to the sink.

After all data has been received, the CH performs data fusion function by removing redundant data and compresses the data into a single packet.

IV. SIMULATION RESULTS AND ANALYSIS

In order to evaluate the performance of our proposed approach, we simulated LEACH, LEACH-C, TL-LEACH and the proposed protocol using MATLAB. We used 100 sensor nodes randomly distributed between (0, 0) and (100, 100) m and the base station is located at 50,150. We follow the same energy model as in [7], the node requires ETx(k,d) to send k bits message to destination at distance d, and ERx(k) to receive k bits message. ETx(k,d) and ERx(k) are defined as:

$$E_{Tx}(k,d) = E_{Tx\text{-}elec}(k) _ E_{Tx\text{-}amp}(k,d)$$
$$= E_{elec} * K + \varepsilon_{amp} * k * d^2 \quad (3)$$
$$E_{Rx}(k) = E_{Rx\text{-}elec}(k)$$
$$= E_{elec} * k \quad (4)$$

Where E_{elec} = 50nJ/bit and ε_{amp} 0.015 pJ/bit/m2

Energy dissipation by transmitter amplifier depends on distance *d* between sender and receiver.

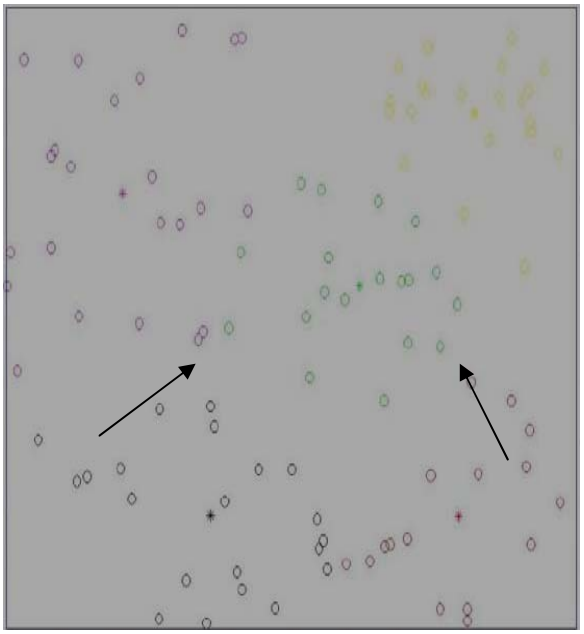


Fig. 2 : Network Deployment of 100 Nodes (After Cluster Formation)

Fig.2 shows the simulated Network in MATLAB and the arrow point outs the cluster head. In our simulation the Network is divided in to 5 clusters (each cluster is given with a separate color). The Parameters used for Simulation are given here.

TABLE1. SIMULATION PARAMETERS

Number of Sensor Nodes	**100**
Network Dimension	100 m × 100 m
Location of the Sink	50,150
Nodes initial energy (K)	0.5 J
Data Packet size	100 bytes
Broadcast Packet size	20 bytes
Maximum child per Node	3
Transmitter circuitry dissipation ($E_{Tx\text{-}elec}$)	50 nJ/bit
Amplifier dissipation multipath (E_{amp})	25 pJ/bit/m2

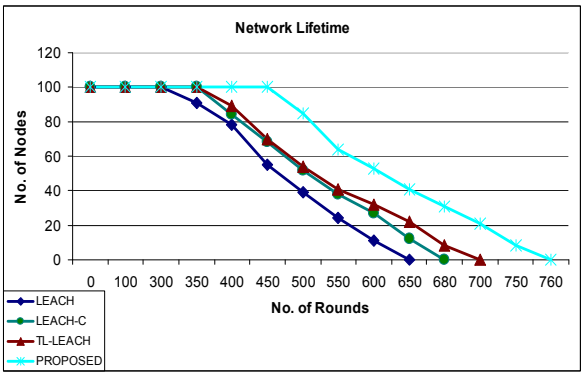


Fig.3. Network Lifetime (No. of Rounds Vs No. of Nodes still alive)

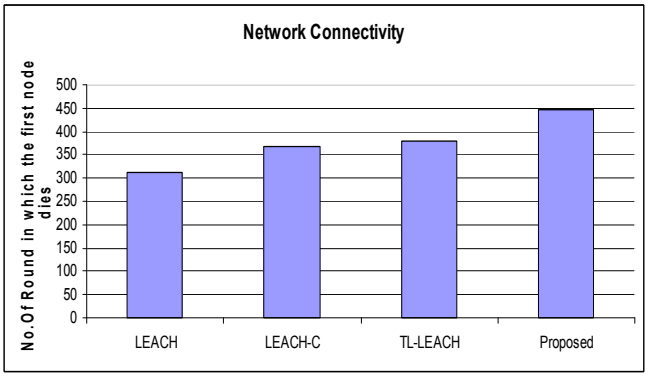


Fig.4. Network Connectivity (Round in which the first node dies)

The Fig.3 shows the network life of the simulated network. It shows a number of nodes still alive over number of rounds. As compared with other algorithms, the proposed algorithm give the better performance and extend the life time of the battery. The Fig.4 shows the network connectivity of the simulated network. It shows the round in which the first node dies. The simulation result, shows that in LEACH first node dies in 312, in LEACH-C -368, in TL-LEACH -380 and in the Proposed algorithm the first node dies in 446th round.

V. CONCLUSIONS

In this paper, we propose a new novel routing protocol for prolonging the network life of a wireless sensor node. Our algorithm Divides the sensor field into different clusters and elects a node as the cluster head for each cluster and constructs the routing tree for data forwarding to the sink node. Each node within the cluster sends its data to the cluster head with single hop transmission and cluster heads aggregates the received data and transmits it to the base station via Routing tree. The proposed method conserves energy dissipation of sensor nodes in the clusters. For a set of 100 Nodes the proposed algorithm gives 31% better performance than LEACH, 18% better performance than LEACH-C and 15% better performance than TL-LEACH in terms of network life time.

VI. REFERENCES

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