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CLUSTER FORMATION ALGORITHM FOR LIFE TIME MAXIMIZATION IN HETEROGENEOUS WIRELESS SENSOR NETWORKS

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ABSTRACT

Typically, a wireless sensor network (WSN) is a new technology about acquiring and processing information from environment. Wireless sensor network contains an important number of inexpensive power constrained sensors, which collect data from the environment and transmit them towards the base station. Sensor networks have limited and non-rechargeable energy resources. Saving energy and therefore, extending the wireless sensor networks lifetime, imposes a great challenge. The clustering technique is a kind of key technique used to reduce energy consumption. Many clustering protocols had designed for the characteristic of heterogeneous wireless sensor networks. In this paper we propose energy efficient cluster formation algorithm for heterogeneous wireless sensor network. Our technique differs from DEEC protocol in cluster formation phase. In our technique the member node join that cluster head which has minimum distance between member node to cluster head and minimum distance between cluster head to base station. Simulation result shows that our technique will increase the network lifetime around 25% and number of packet sent up to 10%.

Index Terms*: *Base Station, Clustering, Heterogeneous Wireless Sensor Network.

I. INTRODUCTION

Sensor nodes are often left unattended e.g., in unapproachable environments, which makes it difficult or impossible to re-charge or replace their batteries. This necessitates devising novel energy-efficient solutions to some of the conventional wireless networking problems, such as medium access control, routing, self-organization, so as to prolong the network lifetime. Since, sensor nodes are power-constrained devices, frequent and long-distance transmissions should be kept to minimum in order to prolong the network lifetime [1], [2]. Thus, direct communications between nodes and the base station are not encouraged. One effective approach is to divide the network into several clusters, each electing one node as its cluster head [3]. The cluster head (CH) collects data from sensors in the cluster which will be fused and transmitted to the base station. Thus, only some nodes are required to transmit data over a long distance and the rest of the nodes will need to do only short-distance transmission. Then, more energy is saved and overall network lifetime can thus be prolonged.

Adaptive Clustering can be done in two types of networks, homogeneous and heterogeneous networks on the basis of energy. Homogeneous are those in which nodes have same in terms of initial energy, memory and link. While heterogeneous networks are those in which nodes have different initial energy, memory and link. In this paper the discussion is to be done only energy heterogeneity. Many Clustering algorithms have been proposed for homogeneous wireless sensor networks such as LEACH [3], PEGASIS [7], and HEED [6] which does not perform well in heterogeneous networks. SEP [9] uses two types of nodes normal and advanced nodes. Advanced nodes have more energy than normal ones. It prolongs the stability period of the network lifetime. The main problem in SEP is that it does not fit for networks having more than two types of energy.

DEEC [11] is clustering-based algorithm in which cluster head is selected on the basis of probability of ratio of residual energy and average energy of the network. In this algorithm, node having more energy has more chances to be a cluster head. It prolongs the lifetime of the network. Our proposed protocol follows the same concept of DEEC but differ in cluster formation phase in our protocol clusters are form on the criteria of cluster head distance to base station and node distance to cluster head. Simulation result shows that our protocol improves the performance of network.

II RELATED WORK

For homogeneous wireless sensor networks Heinzelman, et. al. [3] introduced a hierarchical clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a cluster-based protocol, which includes distributed cluster formation. LEACH randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy load among the sensors in the network [3]. PEGASIS [7] is a chain based protocol which avoids cluster formation and uses only one node in a chain to transmit to the BS instead of using multiple nodes. PEGASIS and LEACH are designed for homogeneous Wireless Sensor Networks.

In homogeneous WSN, all nodes are same type. But in heterogeneous WSN includes different types of sensor nodes. When we apply LEACH or PEGASIS to heterogeneous WSN, they not perform well. Because in heterogeneous WSN nodes having different type of energy so low energy node will die more quickly.

SEP [9] uses two types of nodes normal and advanced nodes. Advanced nodes have more energy than normal ones. It prolongs the stability period of the network. SEP performs poorly in multi-level heterogeneous networks and when heterogeneity is a result of operation of the sensor network

To improve the SEP performance, the DEEC (Distributed Energy-Efficient Clustering)[11] algorithm was designed for multi level heterogeneous WSN. In DEEC cluster head is selected on the basis of probability of ratio of residual energy and average energy of the network.

Our Energy Efficient cluster formation algorithm scheme is based on DEEC. The difference between DEEC and our protocol is mainly in cluster formation phase in our protocol the member node join that cluster head which has minimum distance from member node and minimum distance from base station

III Energy Efficient Cluster formation Algorithm

Our algorithm is based on DEEC scheme, where all nodes use the initial and residual energy level to define the cluster heads. To avoid that each node needs to have the global knowledge of the networks, DEEC and MDEEC estimate the ideal value of network lifetime, which is use to compute the reference energy that each node should expend during each round.

3.1 Network model

In this section, we consider a network with N nodes, which are uniformly dispersed within an M×M square region. The node always has data to transmit to a base station, which is often far from the sensing area. The network is organized into a clustering hierarchy and the cluster-heads (CHs) do aggregation function to reduce correlated data produced by the sensor nodes within the clusters. The cluster-heads transmit the aggregated data to the base station directly. To avoid the frequent change of the topology, we assume that the nodes are micro mobile or stationary.

We consider the multi-level heterogeneous networks for our protocol operation. In multi-level heterogeneous networks; initial energy of sensor nodes is randomly distributed over the close set $[E_{0,} \quad E_0(1 + a_{max})]$, where E_0 the lower bound is and a_{max} determines the value of the maximal energy. Initially, the node n_i is equipped with initial energy of $E_0(1 + a_i)$ which is a_i times more energy than the lower bound E_0 The total initial energy of the multi-level heterogeneous networks is given by:

$$E_{total} = \sum_{i=1}^{N} E_0(1 + a_i) = E_0(N + \sum_{i=1}^{N} a_i) \tag{1}$$

3.2 Radio Model

We use similar energy model and analysis as proposed in [3]. According to the radio energy dissipation model [3] in order to achieve an acceptable Signal-to-Noise Ratio (SNR) in transmitting an l -bit message over a distance d, the energy expended by the radio is given by:

$$E_{tx}(l,d) = \begin{cases} l * E_{elec} + l * E_{fs} * d^2 & if\,(d < d_0) \\ l * E_{elec} + l * E_{mp} * d^4 & if\,(d \geq d_0) \end{cases} \tag{2}$$

E_{elec} is the energy dissipated per bit to run the transmitter circuit. Here both the free space (d^2 power loss) and the multipath fading (d^4 power loss) channel models were used, depending on the distance between the transmitter and receiver d_0 .is given by following formula.

$$d_0 = \frac{E_{fs}}{E_{mp}} \tag{3}$$

Energy spend in receiver circuit is given by

$$E_{rx} = E_{elec} * l \tag{4}$$

3.3 Cluster Head Selection Method

Our protocol uses the initial and residual energy level of the nodes to select the cluster-heads same as DEEC. To avoid that each node needs to know the global knowledge of the networks, our algorithm estimates the ideal value of network life-time, which is use to compute the reference energy that each node should expend during a round.the probability of cluster head selection for normal mode and advance mode is as follows.

$$P_{normal}(i) = \left\{ \frac{p_{opt}}{1 + \alpha * m} \frac{E_i(r)}{\overline{\overline{E(r)}}} * \frac{\overline{D_{BS}}}{D_{BSi}} \right.$$

$$P_{advance}(i) = \left\{ \frac{p_{opt}}{1 + \alpha * m} (1 + \alpha) \frac{E_i(r)}{\overline{\overline{E(r)}}} * \frac{\overline{D_{BS}}}{D_{BSi}} \right. \tag{5}$$

$$\overline{D_{BS}} = \frac{1}{N} \sum_{i=1}^{N} D_{BSi}$$

This means that the nodes with more energy will have more chances to be the cluster-heads than the nodes with less energy. Thus the energy of network is well distributed in the evolving process.

Threshold for cluster head selection in our protocol calculated as:

$$T(S_{nrm}) = \begin{cases} \dfrac{p_{nrm}(i)}{1 - p_{nrm}(i) * r \bmod \dfrac{1}{p_{nrm}(i)}} & if \quad S_{nrm} \in (G') \\ 0 & otherwise \end{cases} \tag{6}$$

$$T(S_{adv}) = \begin{cases} \dfrac{p_{adv}(i)}{1 - p_{adv}(i) * r \bmod \dfrac{1}{p_{adv}(i)}} & if \quad S_{adv} \in (G^{''}) \\ 0 & otherwise \end{cases}$$

Our technique implements the same strategy for estimating the average energy in the network as proposed in DEEC [6]. Since the probabilities calculated depend on the average energy of the network at round r, hence this is to be calculated. This average energy is estimated as

$$\overline{E}(r) = \frac{1}{N} E_{total} (1 - \frac{r}{R}) \tag{7}$$

Where R denotes the total rounds of the network lifetime can be calculated as:

$$R = \frac{E_{total}}{E_{round}} \tag{8}$$

E_{round} is the energy dissipated in the network in a round.

The total energy dissipated E_{round} is given by

$$E_{total} = l(2NE_{elec} + NE_{DA} + kE_{mp} d^4_{toBS} + NE_{fs} d^2_{toCH}) \tag{9}$$

Where k is the number of clusters, N nodes are distributed uniformly in an M ×M region E_{DA} is the data aggregation cost expended in the cluster-heads. d_{toCH} is the average distance between the cluster members and the cluster-head. d_{toBS} is the average distance between the cluster-head and the base station.

$$d_{toCH} = \frac{M}{\sqrt{2\Pi k}}, \quad d_{toBS} = 0.765 \frac{M}{2} \tag{11}$$

By calculating the derivative of with respect E_{total} to k to zero we get optimal number of clusters as

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\Pi}} \sqrt{\frac{E_{fs}}{E_{mp}}} \frac{M}{d^2_{toBS}} \tag{12}$$

Thus we can compute the lifetime R substituting these equations.

3.4 Cluster formation method

After election of cluster head, each HEAD node broadcasts the HEAD_AD_MSG across the network, this message consists head ID and energy of that cluster head. All normal nodes receive that message and calculate the cost function according to following formula

$$Cost = E_j * (1 / D_{ij})$$

IV RESULT AND DISCUSSION

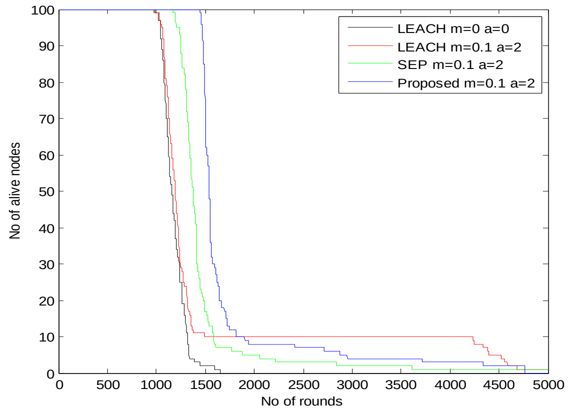
We evaluate the performance of our proposed protocol and DEEC protocol using MATLAB. Both methods simulated in multi level heterogeneous network. The basic simulation parameters for our model are mentioned in Table 1. The environment consists of 100 nodes; randomly deployed a field with dimensions 100×100.The sink is located at position. The energy of each node is distributed between $[E_0 \quad 2E_0]$ where E_0 =0.5

In WSNs, there are a lot of parameters to evaluate a clustering algorithm. In this paper, the number of nodes alive and number of data packet sent is chosen to compare the performance of our algorithm with DEEC. Without considering other external factors, if a node's energy is less than zero, we define it as a dead node.

Fig.1 Shows the results of the case with m = 0.1 and a = 2, and It is obvious that the stable time proposed method is prolonged compared to that of SEP and LEACH. Because in our proposed method the node which have more residual energy and less distance to base station have more chances to become cluster head. And normal node joins that cluster head which has more energy and less distance to base station. The performance of SEP protocol is better than LEACH because in SEP protocol advance node becomes cluster head more frequently. We also observe that the first node die of LEACH when m=0 and a=0 and LEACH m=0.1 and a=2 almost same time this shows that LEACH cannot able to take advantage of heterogeneity. The reason of this is in LEACH the cluster head election is random so normal node die more frequently and advance nod dies very slowly member join to cluster having minimum distance between member node to cluster head and distance between cluster head to base station distribute the load , so that makes network clustering more reasonable, saves energy, effectively prolongs the life cycle of the entire network.

Fig. 2 Figure 5.4 shows that rounds first node dead and half node dead of our protocol, LEACH and SEP .We see that the first node dead in our protocol is 1443 rounds is highest. Means in our protocol the network is full connected till 1443 rounds..SEP has FND at 1171 which is greater than LEACH. Because in SEP the cluster head election probability is according to initial energy of nodes. Thus advance nodes become cluster head more number of times than normal nodes. the FND of LEACH with m=0 and a=2 is almost same because in LEACH there is no criteria that advance node becomes cluster head frequently in LEACH the cluster head election is random. So LEACH cannot take advantage of energy heterogeneity

Similarly the half node dead (HND) of our protocol is 1539 which is greater than LEACH and SEP.SEP has HND at 1373 which is greater than LEACH.LEACH m=0,a=0 and LEACH m=0.1 ,a=2 has almost same HND at 1158 and 1192



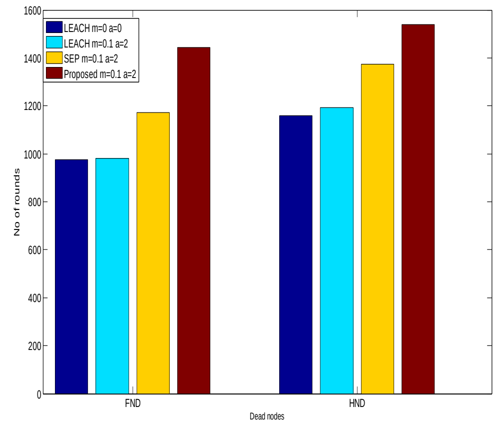


Fig.1 number of node alive vs. number of rounds. (m=0.1) **Fig.2 FND and HND when m=0.1**

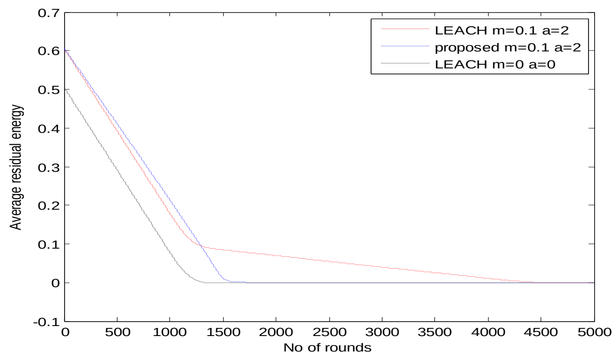
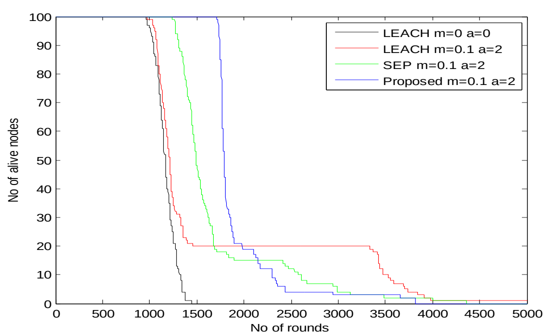


Fig.3 Average residual energy in LEACH and proposed when m=0.1



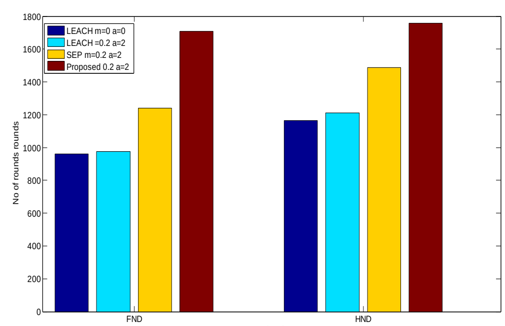


Fig.4 Alive nodes vs. rounds when m=0.2 **Fig. 5 FND and HND of LEACH, SEP and proposed method** when m=0.2

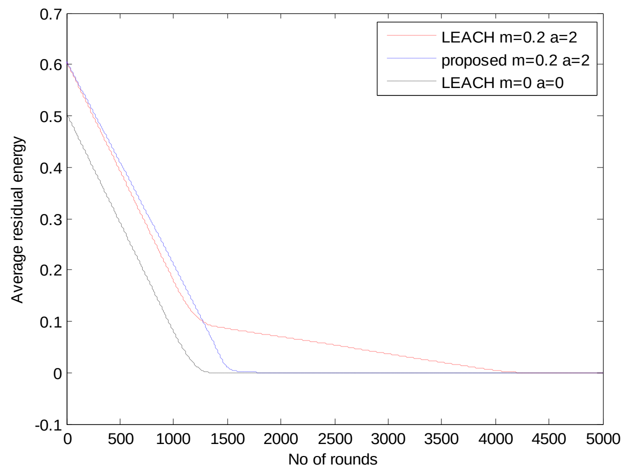


Fig.6 Average residual energy in LEACH and proposed method when m=0.2

Fig.3 shows the average residual energy comparison of LEACH and proposed protocol when m=0.1 and a=2.simulation result shows that our proposed method has more average residual energy at stable region as comparison to LEACH. Fig.4 shows the results of the case with m = 0.2 and a = 2, and It is obvious that the stable time (the first node die) in proposed method is prolonged compared to that of SEP and LEACH. Fig. 5 shows that rounds first node dead and half node dead of our protocol, LEACH and SEP. when m = 0.2 and a = 2. Fig.6 shows the average residual energy comparison of LEACH and proposed protocol when m=0.2 and a=2.simulation result shows that our proposed method has more average residual energy at stable region as comparison to LEACH

TABLE 1

PARAMETERS VALUE

parameter	Value
Network Field	(100,100)
Base Station location	(50,200)
n (No of sensor node)	100
p	0.1
E_{fs}	10nJ/bit/m2
E_{mp}	0.013 pJ/bit/m4
E_{elec}	50nJ/bit
E_{DA} (Data aggregation energy)	5nJ/bit/signal
W	0.8

V CONCLUSIONS

In this paper, the modified method for lifetime maximization for heterogeneous WSNs is proposed. In the proposed method every node select itself as a cluster head based on initial energy, residual energy and distance to base station. The epochs of being cluster-heads for nodes are different according to their initial and residual energy and distance to base station. Means nodes which have more residual energy and less distance to base station has more chances to become cluster head.

Also in our proposed scheme the cluster formation takes place using a cost function. That cost function includes energy of cluster head and distance from normal node to cluster heads. Means normal node joins that cluster head which has more energy and less distance.

The simulation result shows that in our proposed schemes the round when first node die is more that region is known as stable region. In the proposed scheme the network is full connected more number of rounds than LEACH and SEP. And the average residual energy is more in our proposed scheme.

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