

A non location aware version of modified LEACH algorithm based on Residual Energy and Number of Neighbors

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Abstract- A wireless sensor network consists of some sensor nodes that can be effective tool gathering data in various environments. Clustering is one of the methods used to gather information in which sensor nodes are clustered into groups and in each group all sensors communicate only with cluster heads (CHs). CHs send the collected information to a Base Station. Since the energy of the sensors is limited and sending information in each time reduces the nodes' energy, optimal selecting a CH will be notably effective in decreasing energy consumption of the nodes and therefore increases the network life time. In this paper we present a clustering method to choose the CH in an optimal way without need for information of nodes' location, based on two parameters of the energy and number of neighbors, considering the mobility of the nodes. The considerable point in the results is that the performance of our algorithm is uniformly in the three cases.

Keywords: wireless sensor network, clustering, energy efficiency, mobility, lifetime, non location aware

I. INTRODUCTION

Recent improvements in electronic science and wireless telecommunication has allowed the scientists to fulfill the idea that they have had in mind for many years. The technology of sensor networks allows us to monitor an extensive physical space intangibly and precisely [1], [2].

A sensor network consists of a large number of sensor nodes. Helping each other, these nodes can control over a vast physical space effectively, collect information from their environment and transmit them to a central point for making decision. Each node is equipped with a number of sensors (such as sound sensors, temperature sensors, infra-red sensors, tremor sensors or other kinds of sensors), a small processor, a radio sender/receiver and a power resource. The nodes of this network can be fixed on the ground, on air, in water, on human body and/or on vehicles. The sensor nodes helping each other try to gather environment information and send them to a center called sink [2], [3].

Sensor network can be used in military security applications, controlling and monitoring the traffic, industrial automation, controlling the procedures and machinery, environmental monitoring, biological and medical applications, reconstruction engineering like maintaining and controlling bridges, structures and expressways [3], [4], [5].

As mentioned before, a sensor network is constantly collecting information from the environment in order to achieve a general vision on the under-controlled environment.

Wireless Sensor Networks (WSNs) consist of some sensor nodes that have ability to process data and make wireless communication in the field of the network [6], [7]. In each time of collecting data, all sensor nodes' data must be collected and transmitted to the sink. It is supposed that the sensor network includes node of the same kind and all nodes have the ability to send information to other nodes and also to the sink [8]. WSNs have a special characteristic. Nodes, in these networks, are randomly positioned in the environment, namely the geographical locations of these nodes are unknown and they are placed in the environment massively. So they should be generated inexpensively. These nodes have limited energy resources; therefore the nodes' functions must be energy efficient. As noted, each node after happening an event, sense the information related to the event and send it to the sink. A simple way to send the information is sending the information of each node to sink directly. But as the sink may be somewhere far from the nodes, this method will reduce the energy and cause the nodes to be annihilated. This will finally decreases the network lifetime, therefore to decrease energy consumption, the number of sending information and the rate of the information sent to the sink is better to be lowered as much as possible. In this way, the more gradually and in a longer time the nodes lose the energy, the longer time the network can continue to work without any nodes [7]. Thus, the nodes are put in clusters and one node, from among the nodes of each cluster, is selected as the CH. This CH collects other nodes' information and transmits it to the sink.

Clustering is a method by which the sensor nodes in a network organize themselves in hierarchical structures. In a particular cluster aggregation and fusion are performed in the CH in order to the rate of transmission to be reduced. The way of forming

cluster is based on the remainder of the sensor nodes' energy and the distance of the node to the CH [9]. At the beginning, the nodes select their CH right after deploying and send the data to it. The role of the CH is to forward these data and its own data to the sink after aggregation and fusion the data. LEACH is one of the first hierarchical routing protocols for WSNs. The idea presented in LEACH has inspired many other hierarchical routing protocols.

In this paper an algorithm is offered for gathering information from the network in a clustering way and for optimal selecting the CHs to decrease energy consumption. This will prolong the network lifetime.

Then, the related works are reviewed in section 2. In section 3 the proposed algorithm is explained and in section 4, this algorithm is evaluated and compared with similar works in this field.

II. RELATED WORKS

So far many algorithms have been presented in the field of collecting information from networks by clustering. In [10], Low-Energy Adaptive Clustering Hierarchy (LEACH) has been proposed as one of the first methods of hierarchical clustering in which each member of the cluster randomly plays the role of the CH. LEACH must know the information about the location of each node. The CH acts as an information collector from its cluster. In [11] a Hybrid, Energy-Efficient, Distributed (HEED) clustering approach for ad hoc sensor networks has been proposed as a topology control algorithm. Most proposed algorithms in this field are distributed ones because each node makes its decision based on its location information. Therefore, distributed algorithms are more robust but more expensive. Because each sensor needs to aggregate and save the relevant information and then perform the clustering algorithm, the centralized algorithm has been proposed [12]. In [13] CHs are selected by the sink, which is called LEACH-C algorithm. This algorithm is similar to LEACH except the cluster formation phase. In this method the selection of the CH is done by the sink. During the set up phase, the sink receives some information from other CHs selected based on this information.

Selecting the CH by LEACH has some disadvantages such as:

- a) In case of selecting more than one CH in the network, because of dependence on the probable model, CH may be very close to one another.
- b) CHs are selected without considering residual energy in the nodes. On the other hand the nodes' energy in the first period of the network performance is assumed to be the same, but since the nodes' energy consumption in the next periods is not the same, the LEACH method was modified. In [14], [15] M-LEACH which is the modified version of the LEACH gives more chance to the node with more energy to become the CH. Like in LEACH, this probability is not the same for all the nodes. [16] Proposed ANTCLUST,

based on an ant model of colonial closure, to solve to solve clustering problems. Ants recognize each other by exchanging a chemical substance. If they are similar, the ant is welcomed and treated as a member of the same nest. In ANTCLUST, two randomly chosen objects meet based on their similarity, merged in one cluster. By repeating the meetings, an appropriate set of clusters is eventually formed so that similar objects are accommodated in the same cluster.

III. THE PROPOSED ALGORITHM

As discussed in the previous section, routing in LEACH algorithm is done by the way in which each member of the cluster takes the role of the CH in a random rotating way and the CH acts as an information collector from its cluster [12]. But this algorithm does not support mobility and it needs the location information of sensor nodes. In M-LEACH, it was tried to consider these cases but again there are problems.

In this paper an algorithm is proposed to solve these problems. This algorithm operates in the form of non location aware and therefore, there is no need for the nodes to be equipped with GPS that causes increase in the expense. Also there is no need for the localization methods that requires computing processing. In this method the mobility model of Random Walk with Reflection [17] is used for the mobility of the nodes. The algorithm uses the updated topology information to select optimal CH. In other words, the nodes may enter a new cluster after movements, and they should select a new cluster head to reduce the energy consumption of the network. The algorithm just uses production of the remained energy parameters and the number of each node's neighbors as the criteria of becoming cluster head.

$\text{No.neighbor} * E_{\text{residual}} = \text{selective CH}$

Because the cluster head must communicate with the sink directly, it should have high energy to receive information from the nodes of the cluster. Therefore, residual energy of each node has direct relation with selecting the node as the cluster head. We also use a new parameter of the number of the neighbors; that is, the more neighbors the node has in its transmission area, the more chance it has to become the cluster head. Because the number of the neighbors in a range causes this node to communicate with the cluster head in one hop and this generally reduces the energy consumption of the network. As mentioned above, the algorithm acts independently from the distance parameter in spite of the previous examined algorithms. Here the nodes do not give any of their own location information to collect and fusion the data. In the proposed algorithm, the sensor nodes, having received a signal, estimate the distance to the

sender of the signal based on the signal's attenuation. We use this approximate distance to make decision about selecting the optimal cluster head and determine the range of sending information from the nodes to the CH. In this approach, the nodes are put in the environment randomly. The locations of these nodes are unknown. The nodes sense the information from the environment periodically and send it to the cluster head. The cluster head, then, aggregate the sent raw information and send it toward the sink. Since the sent data has already been processed, therefore the aggregation is not a large amount of information and this reduces the energy consumption in a distributed way and also the algorithm selects the cluster heads in a distributed manner. This method in spite of the centralized methods increases the scalability.

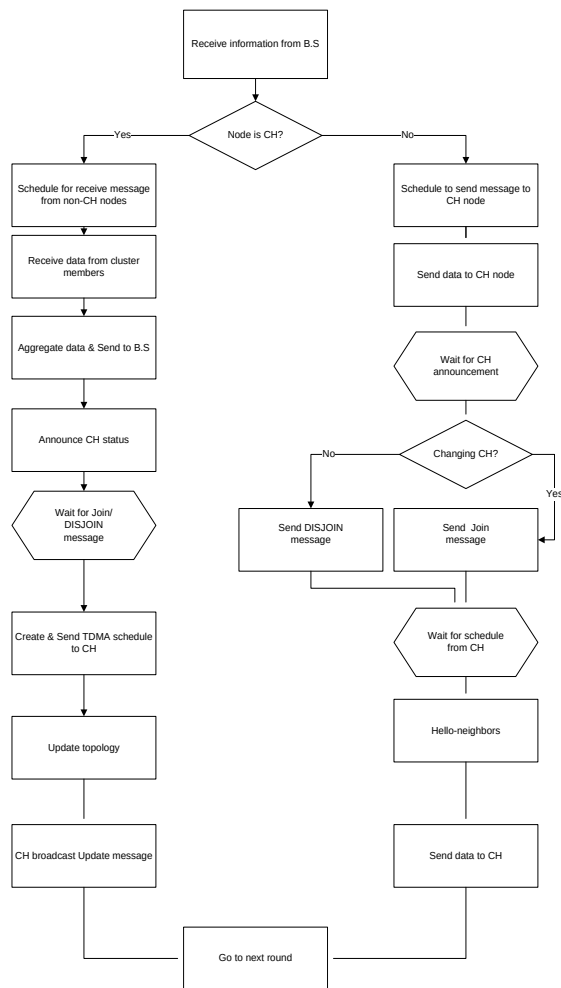


Fig 1. Flowchart for operation of proposed algorithm

Figure 1 shows the flowchart of the proposed algorithm. If a data is sent to the CH, it will be received, aggregated and sent to the BS by the CH. The members wait for the

announcement from the CH to get its status information. In each round, the topology is updated and having broadcast it by the CH, all the nodes become aware of new status for optimal selecting of the CH in next round.

IV. SIMULATION & EVALUATION

To evaluate the performance of the proposed algorithm, the simulator [18] and [19] has been used and to compare the performance of the proposed algorithm, it has been compared with LEACH, M-LEACH, ANTCLUST and HEED. 500 nodes have been randomly put in a square area in dimensions of 600m*600m. The sink is in (0, 0). The length of data packets is 320 bytes and the communication range is 25 meters. Each node begins with primary energy of 2000 J and has unbounded amount of data to be sent to the sink. The energy consumption model for sending k bits information is as follows:

$$E_{tx}(k, d) = E_{elec} * k + \epsilon_{amp} * k * d^{\alpha}$$

And the energy that the cluster head consumes to receive k bits information is as follows:

$$E_{rx}(k) = E_{elec} * k$$

In these relations α is 2 and E_{elec} is the energy consumed to trigger the sender and receiver which 100e-12nJ/b in our work, and ϵ_{amp} is the energy consumed in the amplifier of the sender which is given 100e-9pJ/b/m² in this simulation.

In this simulation, we observed the average energy consumption and compared it with LEACH, M-LEACH, ANTCLUST and HEED. The number of alive nodes in the network which works with the proposed algorithm has also been compared with the number of alive nodes in the network with the above- mentioned algorithm. In this simulation, the Random Walk with Reflection mobility model was used. The results have been averaged on 10 random topologies.

Figure 2 shows that the average energy consumption in the proposed algorithm is optimized compared with LEACH, M-LEACH and HEED. Also, from a particular round time on, it has better results in comparison with ANTCLUST. This is because of considering more neighbors in addition to more energy that has caused more nodes to become the members of the cluster and transmit information.

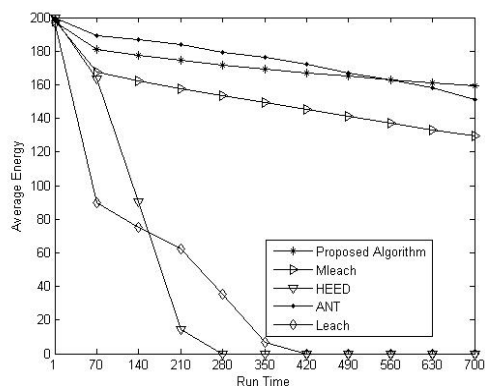


Fig 2. Average energy over round time with Random Walk with Reflection mobility

To prove the claim of reduction in energy consumption of the network, in figure 3, the maximum energy consumption of the nodes during the network lifetime has been compared with above mentioned algorithms among all of which the proposed algorithm has the highest maximum energy.

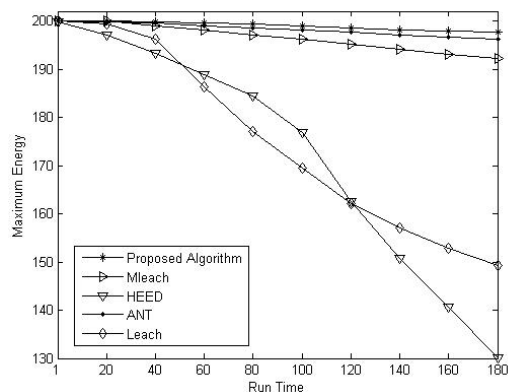


Fig 3. Maximum energy over round time with Random Walk with Reflection mobility

In the proposed method, we define the network lifetime as: the algorithm continues so long as the number of alive nodes is 90% of the primary nodes and when the number of the failed nodes becomes more than 10%, the simulation ends, namely the network has ended its work.

Figure 4 shows the alive nodes in the network. In this comparison, the proposed algorithm has better results in proportion to ANTCLUST, M-LEACH and LEACH algorithms, too. Also, from a particular round time on, it has better results in comparison with HEED. To select the cluster head in the proposed algorithm, we consider the parameter of the number of neighbors and this generally decreases the energy consumption of the network. This is because more nodes are related to the cluster head in one hop and it means the nodes send the data in a less bound; and since on one hand the nodes having more

neighbors are suitable to become the cluster head, and on the other hand, sending information related to the square of transmission distance, the shorter the transmission distance is, the less energy is consumed and proposed algorithm reduces the energy consumption of the network by using the new parameter of the number of neighboring.

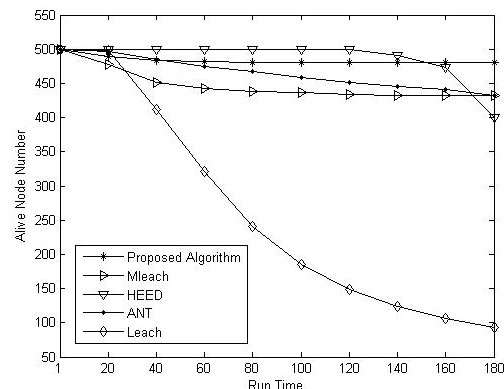


Fig 4. Number of Alive Nodes over round time with Random Walk with Reflection mobility

V. Conclusion

This paper presents an energy efficient clustering algorithm in WSNs which works with mobile nodes based on modified LEACH and without using the location information of nodes. Clustering is a method by which the sensor nodes in a network organize themselves in hierarchical structures. In a particular cluster, aggregation and fusion are performed in the CH in order to the rate of transmission to be reduced. The formation of a cluster is based on the residual energy of sensor nodes and the number of their neighbors. The results of simulation show that the presented algorithm decreases the average energy consumption notably and therefore the nodes have more maximum energy. Also proposed approach prolongs the sensor network lifetime considerably. The considerable point in these evaluations is that the performance of our algorithm is uniform in the three cases.

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