Scientific Journal Impact Factor (SJIF) : 1.711
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

ENERGY EFFICIENT CLUSTERING ON FILTERED SENSOR NODES BASED ON RESIDUAL ENERGY

Sandra Jose[1] , Tintu Alphonsa Thomas[2]
[1]*CS Department &MG University, 2CS Department &MG University*

Abstract— Clustering in Wireless Sensor Networks is one of the many approaches to enhance the lifetime of the network. In clustering one sensor node will be chosen as the cluster head, whose main purpose is to transfer the sensed data from different cluster members to the sink node. The selection of cluster heads is different for different clustering protocols. In our paper, we propose a method where the member having the highest residual energy will be chosen as the cluster head. Members those who satisfy the threshold energy are able to participate in cluster header selection.
Keywords— Clustering, Cluster head, Wireless Sensor Networks, LEACH, sensor nodes

I. INTRODUCTION

Wireless Sensor Networks are nowadays used in many fields due to their ease of applicability. Sensors can be deployed in the field within the range and they are meant for sensing the changes in environment like pressure, temperature, humidity or any parameter that varies depending on the condition. The sensed data are then required to be passed to the sink node or what we call the base station. Base station is responsible for further processing of collected data. The positioning of the base stations in WSNs is discussed in [2].

The sensor's energy in almost all cases are met by the solar source, but there are cases where energy of sensor nodes are met by batteries. There are many limitations to the energy of WSNs: the sensor nodes after using their energy to the extreme point, demands recharging. Networks deployed in remote areas, or in situations that cannot find a recharging option, will let sensor nodes to die. Obviously, the life time of wireless sensor networks is dependent on the lifetime of sensor nodes. Many protocols have been proposed to enhance the network lifetime such as bringing changes to the routing in WSNs. The changes to routing are discussed in [3][4]. Clustering is the technique that we are discussing. LEACH [1] is the basic clustering protocol in which cluster heads are elected randomly for each round. Several modifications of LEACH has been introduced thereafter like advanced LEACH [10], improved LEACH [11].

Our method is also based on the clustering in LEACH protocol to make the clustering process more energy efficient and reducing the overhead. Rather than selecting the cluster head randomly, the nodes having higher residual energy is elected as the cluster heads. A filtered set of nodes having energy greater than the threshold value is first obtained. Of the filtered set, the one having higher energy will be chosen as the cluster head. Clustering deals with the transmission of aggregated data to the sink node thereby reducing the number of nodes taking part in transmission. Therefore communication overhead is greatly reduced in clustering. The sensor nodes deployed in WSNs are grouped together to form different clusters. A cluster consists of cluster member nodes and cluster heads. The member nodes collect the sensed data and they transmit it to the cluster head. The cluster head aggregates the data and they transmit it to the base station. This is the basic working of clustering and the pictorial representation is provided in figure 1.

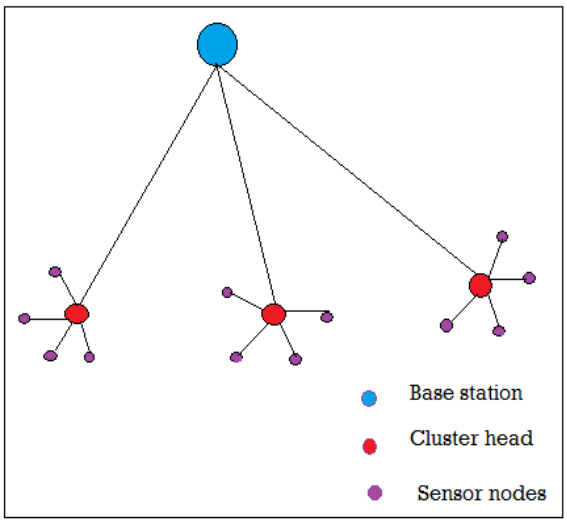

Fig 1 Architecture of Clustering Protocol

II. RELATED WORK

There emerged many proposals for the clustering protocols. The main or central concept regarding the clustering in wireless sensor network is LEACH protocol which is discussed in [1]. In the clustering protocol papers, the concept is being compared with the Leach protocol for evaluation. Leach selects the cluster head randomly for each round of the network lifetime. The SEECH protocol [6] introduced the concept of relay nodes to reduce the overhead of cluster head nodes in transmitting data packets from higher level of network to the base station. In Mobile based clustering protocol [7], the selection of cluster head is not only dependent on the residual energy of nodes, but also dependant on the speed of the nodes. In LEACH-ERE protocol [9], the probability of being elected as the cluster head is depended on the calculated values of expected consumption energy, residual energy and expected residual energy. The Fuzzy concept is applied here to calculate the chance of node to be cluster head. In [8] a survey, the different stability and energy oriented clustering is being discussed in detail. In SEEC protocol discussed in [5], the number of cluster head in wireless sensor network is dependent on the number of sensor nodes in the network. Also, a network model is described based on the location of base station [2].

III. LEACH

Leach is the technique in clustering where the cluster head selection takes place randomly. LEACH stands for Low Energy Adaptive Clustering Hierarchy (LEACH). The main aim of the protocol is to form clusters which would enhance the lifetime of a wireless sensor network. For each round in Leach, any one among the cluster members will be chosen as the cluster head.

Once a node has become cluster head, the node cannot become cluster head for P rounds, where P is the desired percentage of cluster heads. After each round, the member nodes will select the closest cluster head and joins that cluster. The schedule for each node is created by the cluster head, is then given to each member node. The schedule determines the time to send data packet by the sensor node.

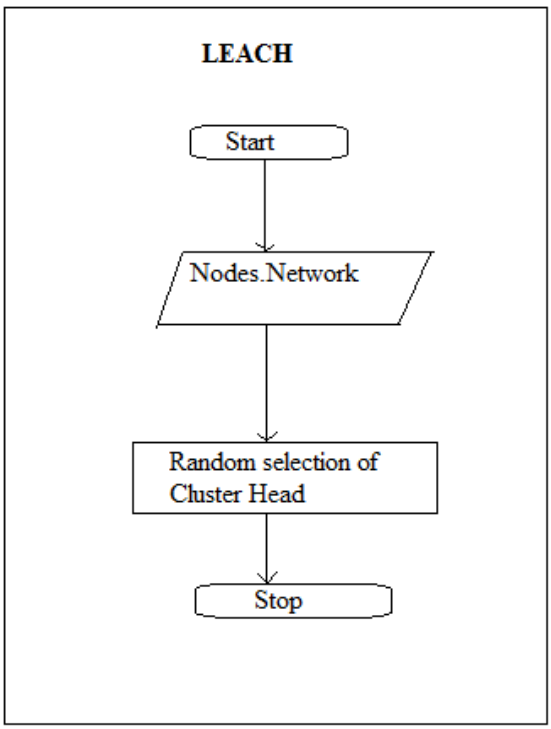

Fig 2 Flow chart-LEACH Operation

Like in all clustering protocols, the operation is divided into two phases, setup phase and steady state phase. During setup phase, the clusters are formed and cluster head are selected and schedule for each cluster member is transmitted. During steady state phase, the transmission of data takes place.

A. LEACH OPERATION

During the setup phase of clustering, each node chooses a random number between 0 and 1. A threshold value T(n) is first calculated to determine the desired percentage to become a cluster head for the current round. If the number chosen by the node is less than the threshold value, the node becomes cluster head for current round.

A predetermined value of p nodes can become cluster head for the round. The threshold value is given by

$$T(n) = \begin{cases} p/(1-p*(r \bmod 1/p)) & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

where G denote the set of nodes that have not been elected as a cluster head for last 1/p rounds. Once the cluster heads are selected, they broadcast messages to other nodes in the network showing they are the new cluster heads. The receiver nodes decides to which cluster they need to stick on to the current round, based on the received signal strength. The nodes inform the cluster head about their participation. After receiving from all nodes, the cluster head forms the TDMA schedule and it is sent to each cluster member. The schedule assigns a timeslot for each node to transmit data. During the steady state phase of clustering, the cluster members senses the data and they transmit to the cluster head. Cluster head aggregates the data and sent it to the base station.

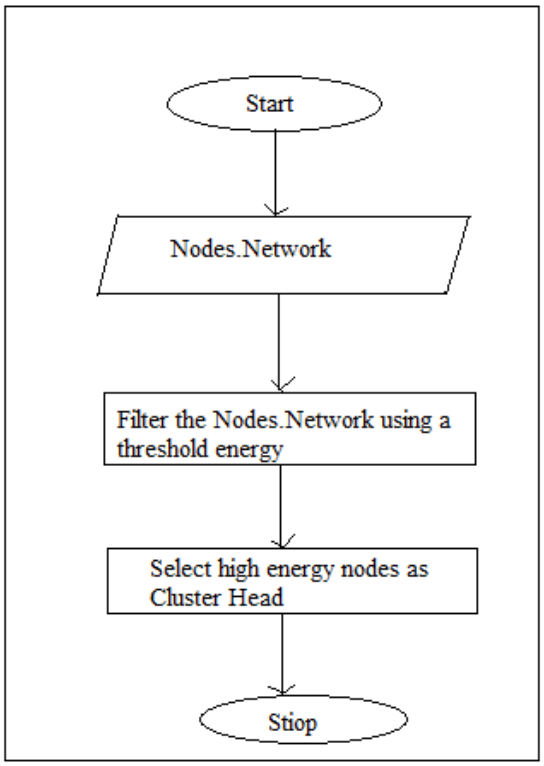

Fig 3 Flow chart – MLEACH operation

IV. MLEACH:PROPOSED METHOD

Extending the stability period and life time of wireless sensor networks are the two objectives of every researcher in the field. Increasing the lifetime of sensor nodes implies increasing the stability period of wireless sensor networks. Leach protocol has been discussed in detail in above section. Now let us look into the new method of clustering.

The lifetime of sensor networks is divided into different rounds. For each round, clusters will be formed preceded by the selection of cluster heads. A desired percentage of cluster heads is selected like LEACH. But before forming the cluster head, the network nodes are filtered to get a group of sensor nodes that satisfy a minimum threshold energy. The filtered set consists of nodes that have residual energy higher than the threshold value. From the above filtered set, the highest residual energy nodes are to be elected as the cluster head for each round.

So unlike LEACH, the search for the cluster head must be done within a set that satisfy the criteria. The probability of nodes to get elected as the cluster head is given by

$T(n) = p/(1-p*(r \bmod 1/p))$ if $n \in F$

0 otherwise

Where F(E) is the set of filtered nodes that have not been cluster head for p rounds. In Leach protocols random selection of cluster heads, low energy sensor nodes can get elected as cluster head. The cluster head consumes higher energy compared to the normal sensor nodes. So, the low energy node get depleted of energy sooner and they will die. The stability period comes to an end. So, by our approach we aim for the prolonging life period and stability period of wireless sensor networks. Nodes that satisfy a minimum value is assigned as cluster heads and lower energy nodes are only assigned the duty of sensing.

Algorithm

1. Input: Network consisting of sensor nodes
2. Divide the network in to different clusters.
3. For each round of the network life time,
   (a) For each cluster
      i. Filter the nodes that satisfy minimum threshold energy.
      ii. Of the filtered set, find the highest energy node.
      iii. Assign the highest energy node as the cluster head.
   (b) End For Each
4. End For Each
5. Steady State Phase.

Fig 4 Algorithmof MLEACH

V. IMPLEMENTATION

For the simulation of wireless sensor network for our proposed scheme we used ns 2.29 version with mannasim patch.

A.NS2

Basically, Ns2 stands as a tool to simulate what we find or experiment in network scenarios. Simulation scripts are written in the OTcl(object oriented Tcl) language, an extension of the Tcl scripting language. It runs on GNU/Linux, FreeBSD, Solaris, Mac OS X and Windows versions that support Cygwin.

B.MANNASIM

Patches are the source codes that are developed to test various scenarios in network using NS2. Mannasim Patch developed for NS 2.29 version implements the clustering algorithm for wireless Sensor Networks. Nam is not supported when using Mannasim with NS 2.29 version. All we get is the trace file, from which we could generate the graph for our analysis part.

C.CONFIGURATION

The configuration for the simulation is to be implemented through the tcl script. The UDP protocol is used as transport protocol. Depending on the scenario we use routing protocols like AODV, LEACH, MLEACH. For MAC we use 802.11 and in physical layer Crossbow Mica2 sensor node is used. The antennae configuration is omni directional antenna which is 1.0 metres above the ground level. The antennas are centred in the node. The transmitter antenna gain and receiver antenna gain is value 1. The radio propagation model is used in the project is TwoRayGround. The project uses DropTail model as interface queue. Mannasim Battery model is used. IFQ length used is 200. The number of sensor nodes in the project is twenty nodes and one node is chosen as the cluster head.

Three scenarios where created for simulating AODV, LEACH and MLEACH. The mannasim patch provides the AODV and LEACH core code which helps as to run the first two scenarios.

1) Graph: Energy Vs Time : The graph 5 shows the energy versus time graph of all the sensor nodes involved. It compares AODV, LEACH and MLEACH. From the graph, it is clear that the AODV graph get depleted sooner. But MLEACH performs better compared to the LEACH protocol. Depending on the energy model we used, energy utilization of the sensor nodes varies as per sensing process. The AODV routing protocol is apt for very wide area sensor networks. But for small networks AODV performance is poor. Since the cluster head selection takes place only on a filtered set rather than on the entire networks MLEACH energy utilization is lower compared to the LEACH. The fact leads to the more extended lifetime of wireless sensor networks.

2) Graph : Temperature versus Time : The graph 6 shows the temperature versus time of a specific node. As per the implementation the user got the chance to enter the sensor node. The sensing value is not much dependant on the energy utilization of sensor node.

3) Graph :Energy versus Time : The graph 7 shows the energy versus time graph of a specific node. The red line shows the energy depletion of sensor node that runs on LEACH protocol, whereas the green line shows the energy depletion of sensor node running on MLEACH protocol. But the graph is different for different sensor node and we cannot come to a fact depending on the energy utilization of a single sensor node. For a lifetime of the network, a node can be elected as a cluster head or simply it can perform as a normal sensor node.

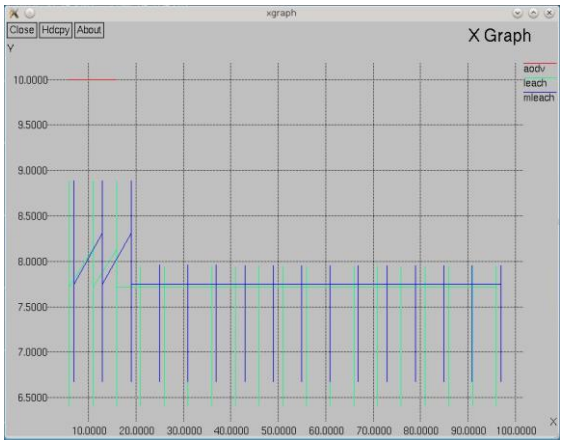

Fig 5 Graph between energy consumption versus time.

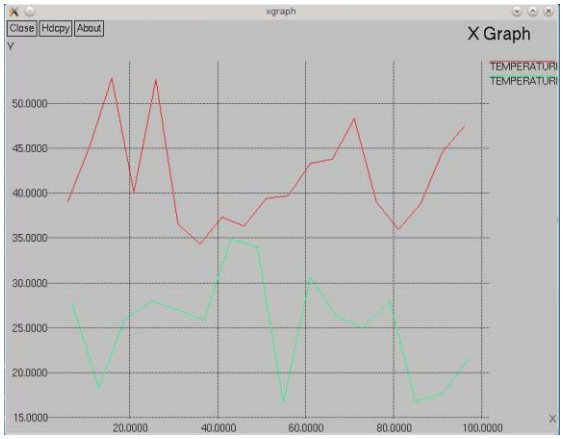

Fig 6 Graph between temperature and time for a specific node

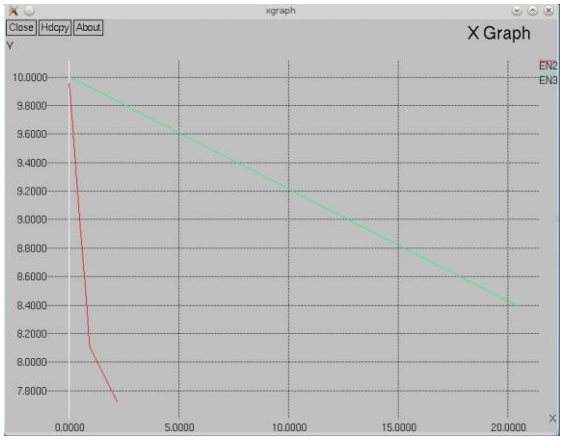

Fig : 7 Graph of Energy consumption of a specific node.

VI. CONCLUSION

From the experimental analysis done with the help of the simulation, cluster head selection based on the highest energy nodes from the filtered set of nodes that satisfy a minimum energy is better compared to the random cluster head selection in LEACH. The energy level in the sensor nodes remains higher in the former case. The reserved energy in the sensor nodes leads to the extended life time of entire wireless sensor networks. More energy preservation could be done by studying the placement of sensor nodes in network which opens us a scope for future research.

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