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An Improved Approach in Clustering Algorithm for Load Balancing in Wireless Sensor Networks

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Abstract: Wireless sensor networks represent the next generation of sensing machines and structures. Inherent limited energy resource is the one of the limitations of wireless sensor nodes. In order to distribute the energy dissipated throughout the wireless sensor network, data load of the sensor nodes must be balanced. Clustering is one of the key mechanisms for load balancing. Clustering algorithms may result in some clusters that have more members than other clusters in the network and uneven cluster sizes negatively affect the load balancing in the network. In our proposed work we improve a cluster algorithm for load balancing in clusters. Efficiency of WSNs measured by the total distance between nodes to the base station and data amount that has is transfer. Cluster–Head which is totally responsible for the creating cluster and cluster nodes may affect the performance of the cluster. The purposed algorithm we choose a Master Node and vice master node for regions and sub regions. To find out the master node we partition the region and find out the centered of region, by which we select the master node. For every partitioned region again portioned if required and much like depend on master node and nodes in that partitioned area. Our purposed algorithm we can find the better lifetime and energy efficiency.

Keywords: Wireless Sensor Networks, Leach Protocol, E-Leach Protocol, Load Balancing, Cluster Based Routing, Omnet++.

1. Introduction

Sensor nodes [1] [2] are energy constrained because they carry a limited energy. Because nodes are deployed randomly in a harsh environment so replacement or recharging of battery is not quite possible. Energy consumption in transmission is directly proportional to the square of the distance between transmitter and receiver.

Communications being the major energy consuming process, design of data centric wireless sensor networks [1] [2] [3] [4] focus on energy efficient data gathering. Clustering [1] of nodes is a scalable and energy efficient process for wireless sensor networks. In conventional clustering, network is divided into small group of nodes called cluster. One node from each cluster is selected as a cluster head [1, 3]. All the remaining nodes in the cluster send their data to their respective cluster head. Cluster head aggregate the data and sends to the base station. This scheme works far better than direct transmission but network depends on lifetime of cluster head and cluster head consumes more energy than other nodes and may die early.

Low Energy Adaptive Cluster Hierarchy (LEACH) [5] suggests rotation of role of cluster head among nodes randomly. A node will be a cluster head for a round and after which re-clustering is done with a new cluster head for each cluster. Every node has the possibility of being a cluster head. Because cluster had selection is done randomly, energy load balancing is achieved among the sensor nodes in the network.

An improvement over LEACH (E-LEACH) [6] [19] [20] suggests selection of cluster head by their remaining energy when the energy level of nodes drops below 50% of the initial energy. Node having maximum energy is selected as cluster head. However clustering schemes do not guarantee exactly equal number of nodes as cluster head during different rounds and clusters do not have equal number of nodes. Due to this toothed cluster formation, nodes of smaller cluster have smaller TDMA schedule than the others. So these nodes send more data frames to their respective cluster head over a round. As a result, cluster head of that cluster has to send more aggregated data to the base station. So all nodes of a smaller cluster transmit larger number of data, causing contains deplete their energy faster as compared to others. This makes overall consumption of network uneven.

The rest of this paper is prepared as follows segment 2 briefly describes the literature of clustering for the WSN in different areas, Segment 3 describes the detailed study of the related research. And the proposed algorithm is discussed. Segment 4 discusses the simulation and its results and lastly concludes the paper.

2. Literature of Clustering For WSN

Communication of data is the most energy consuming process of nodes. Clustering of nodes in a cluster is an energy efficient approach [20] by avoiding the long distance communication of nodes. In static clustering scheme, clusters are fixed and one node acts as a cluster head for each cluster. Cluster head is responsible for gathering data of nodes in the respective cluster and for sending the data o base station located at far distance. A cluster head node is consuming more energy than other nodes and hence is more prone to energy failure. Cluster head node failure results in loss of data of that cluster.

2.1 LEACH

LEACH scheme does the selection of cluster head randomly among the nodes during each round. Operation of LEACH [6] [19] is carried out in two phases during a round: *set-up phase* and *steady phase*. During the set-up phase, a sensor node chooses a random number between 0 and 1. If this random number is less than the threshold T (n), the sensor the sensor node is a cluster-head. T (n) is calculated as in equation (1)

$$T(n) = \begin{cases} \dfrac{P}{1 - P*(r \bmod \frac{1}{P})} & if \quad n \in G \\ 0 & otherwise \end{cases} \qquad (1)$$

Here P is the desired percentage to become a cluster head; r, the current round; and G, the set of nodes that have not being selected as a cluster head in the last 1/P rounds. After the cluster-heads are selected, the cluster-heads advertise to all sensor nodes in the network that they are the new cluster-heads.

Once the sensor nodes receive the advertisement, they determine the cluster that they want to belong based on the signal strength of the advertisement from the cluster heads. The sensor nodes inform the appropriate cluster head that they will be a member of that cluster. Afterwards, the cluster head assigns the time on which the sensor nodes can send data to the cluster-heads based on a TDMA approach.

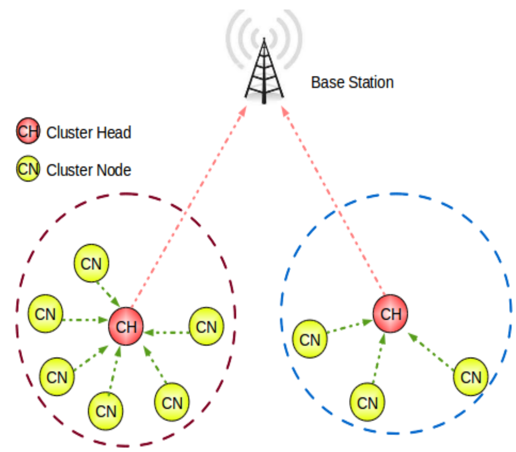

Figure.1: LEACH Protocol with Cluster Head and Cluster Nodes

During the steady phase, the sensor nodes transmit data to their respective cluster head. Each node sends data to respective cluster head during its time slot and minimizes the consumption of energy by entering into sleep mode for remaining time period. Cluster head aggregates data and sends to the base station. After a certain period of time spent on the steady phase, re-clustering is done.

ESCAL [7] uses LEACH as its base but the cluster heads do not send the aggregated data directly to the base station. A Cluster head send the data to nearby cluster head that is close to the base station and conserve the energy by not sending the data to a long distance.

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2.2 Energy-LEACH

One of the disadvantages of the LEACH is that the cluster head rotation does not take into account the remaining energy of sensor nodes. A node may not have sufficient energy to carry out the whole round and can be selected as a cluster head. E-LEACH [6] [19] [20] applies both LEACH and new approach for cluster head selection. When the remaining energy is larger than 50% of the initial energy of a node, the LEACH algorithm is applied as in equation (1). Otherwise a new approach which considers the remaining energy in each node is applied as in equation (2).

$$T(n) = \begin{cases} \dfrac{P}{1 - P * \left(r \bmod \dfrac{1}{P}\right)} * 2P * \dfrac{E_{residual}}{E_{init}} & if \quad n \in G \\ 0 & \text{otherwise} \end{cases} \qquad (2)$$

Here P is probability to become a cluster head, Eredidual is remaining energy of node and Einit is initial energy of a node. If value of T(n) is larger than a number between 0 and 1 it becomes a cluster head.

After selection of cluster head, cluster formation is done. A cost is calculated by each node to join a cluster, which includes the remaining energy and signal power strength of Cluster head. A node joins the cluster head of largest cost value.

Cost (i) = CH (i) remaining energy + CH (i) signal strength

Here CH (i) remaining energy and CH (i) signal strength are remaining energy and signal strength of Cluster Head (i). Nodes calculate the cost value and join the cluster head with maximum cost value by sending the join message to cluster head.

Each cluster head decides a TDMA time schedule and informs the member nodes about the schedule. The nodes then transmit the sensed data to the cluster head during its timeslot. A sensor node sends data to cluster head only when a certain condition is satisfied such as "Does the temperature exceed 30 degree?" If condition is not satisfied, nodes go to sleep mode to reduce energy consumption.

3. Conception of Improved Cluster Algorithm For Load Balancing

Wireless sensor networks represent the next generation of sensing machines and structures. Inherent limited energy resource is the one of the limitations of wireless sensor nodes. In order to distribute the energy dissipated throughout the wireless sensor network, data load of the sensor nodes must be balanced. Clustering is one of the key mechanisms for load balancing. Clustering algorithms [20] may result in some clusters that have more members than other clusters in the network and uneven cluster sizes negatively affect the load balancing in the network. In our proposed work we improve a cluster algorithm for load balancing in clusters. Efficiency of WSNs measured by the total distance between nodes to the base station and data amount that has is transfer. Cluster–Head which is totally responsible for the creating cluster and cluster nodes may affect the performance of the cluster. The purposed algorithm we choose a Master Node and vice master node for regions and sub regions. To find out the master node we partition the region and find out the centered of region, by which we select the master node. For every partitioned region again portioned if required and much like depend on master node and nodes in that partitioned area. Our purposed algorithm we can find the better lifetime and energy efficiency.

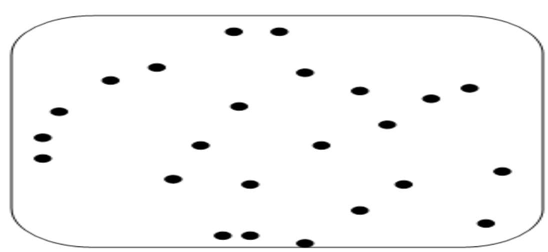

Figure.2: Random Formation of Nodes in Network

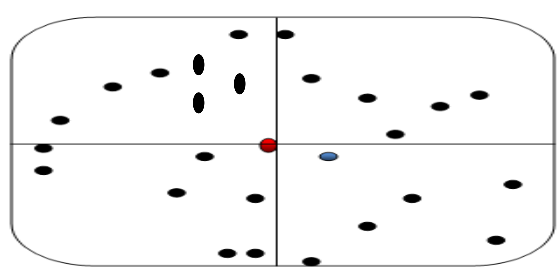

Figure.3: Division of region and selection of Master and Vice Master Node of Cluster (top layer)

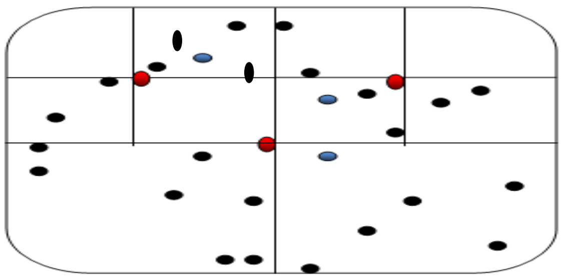

Figure.4: Division of sub region and selection of Master and Vice Master Node of Cluster (middle layer)

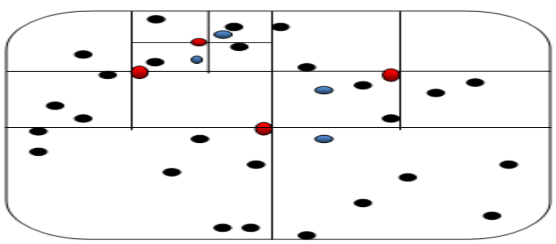

Figure.5: Division of sub region and selection of Master and Vice Master Node of Cluster (bottom layer)

Figure 2 shows the random deployment of nodes in a network; Figure 3, Figure 4 and Figure 5 shows how cluster are formed with master node and vice master node by region division. Region division helps us to make cluster balanced.
When the master node will be dead the vice master node act as a master node. After finishing the setup phase the steady state phase will start and nodes transmit data. When all the nodes within the cluster finish sending data the master nodes performs some computation on it and sends it to base station using multi-hop communication.

PROPOSED ALGORITHM:

Setup Phase:

1. First randomly generated the nodes and Measure the region and find the centre of region.
2. Find nodes as close as centre is called set of master node, store the set and specify a master node from the set on the basis of energy level of the node.
3. ID of master node is stored in to the table of previous master node and vice versa.
4. This master node broadcast a message to the all node of that region and receives **reply message [a]** from the node.
5. If the location or distance and no of node is more than the **efficiency [b]** of master node then partitioned the region into four equal sub regions and go to step 6.

Else
Go to step 7.

6. Find the centre of region and repeat step 2.

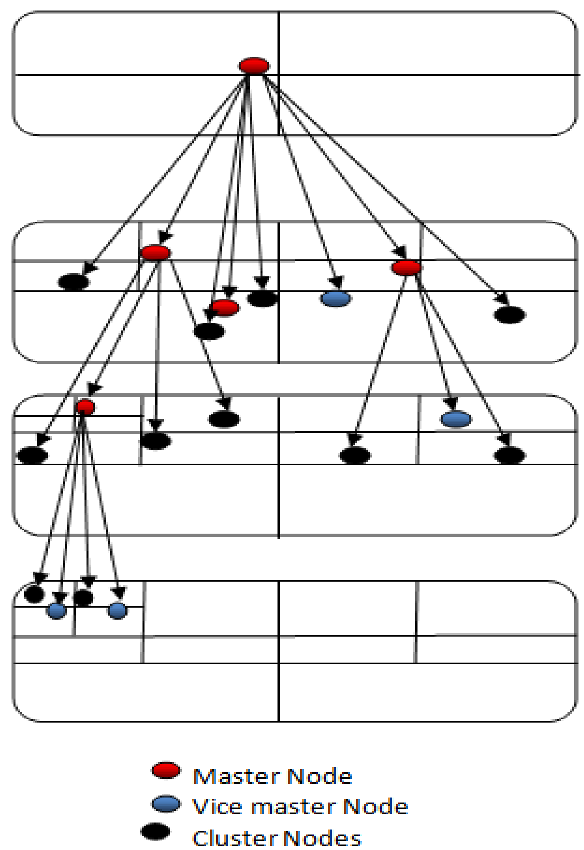

Figure.6: Hierarchical Structure of Cluster in proposed Work

7. The node id is stored in the master node and , (The master node sends a message about the information of all neighbor nodes of that region to the node,
Or
Node sends a hello signal to the neighbor nodes). Update the neighbors table.

Steady State Phase:

8. **Node to master node communication:** Nodes sensing and transmitting data to the immediate master node in their allotted time slot. The master node collects data and processes the data. After that the master node transmission is start. All master nodes do the same task.

When the data reach to base station the **steady state** is repeated,

a. Reply message contains the energy level.

b. Efficiency of master node is measured by the master node energy level, signal receiving time and delay of access.

4. Implementation and Simulation

This section describes the simulation results obtained during the investigation phases of the simulation. We used OMNeT++, is an object-oriented modular discrete event network simulator [16] to implement our improved cluster algorithm for load balancing in WSN.

4.1 Simulation Parameters

The parameter used in simulating and implementation of the simulation for improved cluster algorithm for load balancing is given in table 1 below.

Simulation parameters	Values
Simulation time	1200 sec
Number of nodes	100
Channel type	Channel/wireless channel
Node distribution	Randomly distributed
Network topology	Loss topology (900x900 m^2)
Number of trials	10 times
Initial node power	2 joule
Simulator	Omnet++

Table.1: Summery Of the Parameters Used In the Simulation Experiments**.**

4.2 Simulation Result

Death Rate is the measurement of number of node dead in the field with time. A node death can be some physical damage or a node might be out of energy. A network is reliable if the node death rate is low. A reliable network will have a better data gathering rate i.e. units received at base station will also be high.

The Results of the simulation are shown in the Table 2, which shows the Analysis of the dead nodes with varying network load and Table 3, which shows the Analysis of the remaining energy consumption by various algorithm.

Time	No. of Dead Nodes		
	Proposed Algorithm	E-LEACH	LEACH
10	2	4	7
15	4	7	12
20	5	9	17
25	7	11	19
30	7	11	22
35	8	13	27
40	10	15	31
45	12	17	34

Table.2: Analysis of Dead Nodes Comparison

Time	Remained Energy		
	Proposed Algorithm	E-LEACH	LEACH
10	298	284	249
15	295	270	225
20	289	258	202
25	280	236	186
30	275	221	172
35	271	209	159
40	263	193	143
45	257	182	137
50	249	178	132

Table.3: Analysis of Remaining Energy Consumption Comparison

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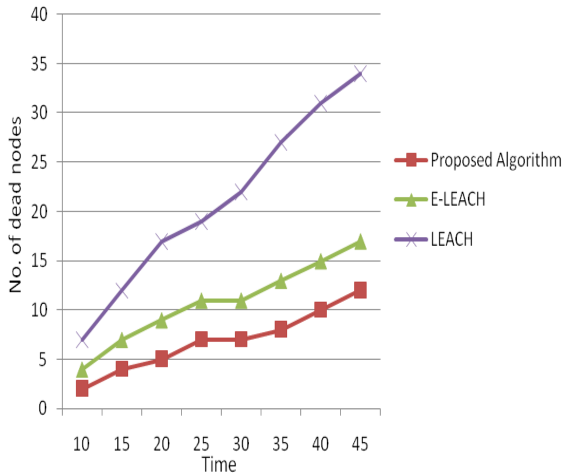

Figure.7: Dead node comparison in network

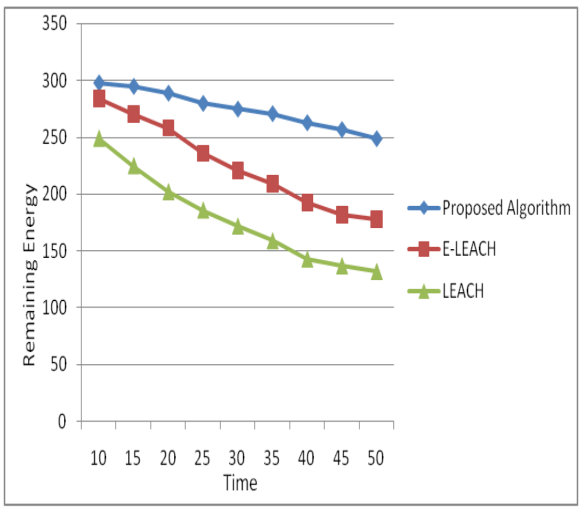

Figure.8: Remaining Energy Consumption Comparison in Network

Figure 7, shows the simulation graphs for analysis of number of dead nodes occur in different algorithms and Figure 8 shows the simulation graph for consumed energy for the nodes in different algorithms respectively. Our goals in conducting the simulation are as follows: Compare the performance of the different algorithms Vs. Lifetime of a node (dead nodes), No. of different clusters algorithms Vs. Energy consumption.

5. Conclusion and Future Work

The overall conclusion is that improved cluster algorithm for load balancing is best choice to move towards a network with less energy consumption as it involves energy minimizing techniques like multi-hop, clustering and data aggregation.

From the simulation results, we can draw a number of conclusions. Firstly the, number of dead node is less than the previous technologies. Then secondly, if number of dead node occurs by the new version are less that means the network energy remaining using improved cluster algorithm for load balancing is more than the remaining network energy using the previous techniques. We prove that in figure 8, which means the improved version of cluster algorithm for load balancing, outperforms the previous version of clustering algorithms.

However there are many more issues, which are to be considered related to minimizing the power usage and the network life time in this. We can still minimize the energy consumption and extend the network life time by improving the clustering technique.

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