Improving the Stable Period of Leach Protocol in Wireless Sensor Network Using Dynamic Stable Election Protocol

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Abstract: ***In this paper different methods for clustering and cluster head selection to WSN are provided to improve energy efficiency. We tend to develop and analyse low-energy adaptive clustering hierarchy (LEACH), a protocol design heterogeneous WSNs that combines the ideas of energy-efficient cluster-based routing with data aggregation to achieve good performance in terms of system lifetime, energy efficiency. Further, we tend to modify LEACH which is one of the most prominent wireless sensor networks routing protocol as modified LEACH (MODLEACH) by introducing a protocol referred to as SEP (Stable Election Protocol. Our modified LEACH, in comparison with LEACH out performs it victimization metrics of cluster head formation, throughput and network life. Finally a brief performance analysis of LEACH and Modified LEACH (MODLEACH) is undertaken considering metrics of throughput, energy efficiency and network lifetime.***

Keywords: Wireless Sensor Network, LEACH, Stable Election Protocol

1. Introduction

Wireless sensor network (WSN) has been a center of attraction for researchers due to its characteristics like feasibility of rapid deployment, self-organization and fault tolerance, as well as rapid development of wireless communications and integrated computer electronics. Such networks are assembled by randomly but densely scattered tiny sensor nodes. As sensor nodes are susceptible to failures and also the network topology changes very repeatedly, completely different protocols have been projected to save the overall energy dissipation in WSNs. Among them, Low Energy Adaptive-Clustering Hierarchy (LEACH), first proposed by researchers from Massachusetts Institute of Technology, is taken into account to be one of the most effective protocols in terms of energy efficiency [1][5]. The LEACH protocol forms multiple clusters of nodes and designates a single cluster head (CH) node in each cluster, with the objective of minimizing the energy consumption of WSNs. In this hierarchy, CH nodes are responsible for the collection of the measurement from member nodes and the delivery of the aggregated information to the base station (BS) as illustrated in Fig. 1.

On the other hand SEP [9],[10] is a two-level heterogeneous proactive network protocol. SEP attempts to maintain the constraint of well balanced energy consumption. It assumes that each node in the network has different energy. Therefore in SEP there are two types of nodes; normal nodes and advance nodes. Advance nodes have more energy than normal nodes and the additional energy factor between advanced and normal nodes is denoted by alpha (a).

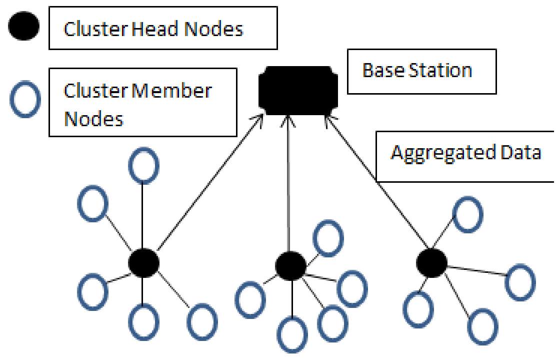

Figure 1: A WSN Model with Low-Energy Adaptive Clustering Hierarchy

Suppose that there are n numbers of sensor nodes in the network and m be the fraction of advanced nodes, which are equipped with a time more energy than the normal nodes. Let E_0 be the initial energy of each normal sensor node. Then energy of each advanced sensor node will be $E_0 = (1+a)$. The total (initial) energy of the network is equal to:

$$n \cdot E_0 \cdot (1-m) + n \cdot E_0 \cdot m \cdot (1+a) = n \cdot E_0 \cdot (1+a \cdot m) \quad (1)$$

2. Related Work

Today, most of the research is done to improve ultra-low powered WSN which is only possible if the overall network lifetime increases, energy consumption decreases and the network run with high stability and consistency. To achieve this, several algorithms have been implemented and these algorithms are called energy-efficient algorithms. These algorithms in their basic type have already been applied on numerous network protocols as well as LEACH, AODV, TEEN etc. However, these algorithms want further analysis for increase in network lifetime, energy efficiency etc. Within the LEACH protocol at the stage of cluster forming, a node indiscriminately elites a number between zero to at least one, compared this range to the threshold values $t(n)$, if the number is smaller than $t(n)$, then it became cluster head throughout this round, else it become common node [6]. Threshold $t(n)$ is determined by the following:

$$t(n)=\begin{cases} \dfrac{p}{1-p*\left(r \bmod \dfrac{1}{p}\right)} & \text{if } n\in G' \\ 0 & \text{if } n\notin G' \end{cases} \quad (2)$$

Where p is the percentage of the cluster head nodes in all nodes, r is the number of the rounds, G is that the collection of the nodes that haven't been head nodes within the initial $1/p$ rounds. Using this threshold, all nodes all nodes are going to be ready to be head nodes after $1/p$ rounds. The analysis is as follows: every node becomes a cluster head with probability p when the round begins, the nodes that are head nodes in this round will not be head nodes in the next $1/p$ rounds, as a result the number of the nodes which are capable of head node will gradually reduce, so, for these remaining nodes, the probability of being head nodes must be increased. After $1/p-1$ round, all nodes that haven't been head nodes are going to be selected as head nodes with probability 1, when $1/p$ rounds finished, all nodes will return to the same starting line. When clusters have formed, the nodes begin to transmit the inspection data. Cluster heads receives data sent from another node, the received data was sent to the access after attached. This is often a frame data transmission. In order to reduce redundant energy cost, steady stage is consisting of multiple frames and also the steady stage which is far longer than the set-up stage.

3. Proposed Work

In Proposed work, the logic of stable election protocol is added to the existing LEACH protocol for better throughput value which is calculated by the packets send to base station and lower energy consumption. In the proposed work i.e. MODLEACH nodes are more stable and survive in network for longer time and stay alive for more duration [2],[3]. SEP allot a weighted probability to every node based on its initial energy. It improves the cluster formation by decreasing the CH epoch interval of advance nodes, i.e. advance nodes get a lot of chances to become a CH. The weighed possibilities for normal and advanced nodes respectively, are:

$$p_{nrm}=\frac{p_{opt}}{1+\alpha-m} \quad (3)$$

$$p_{adv}=\frac{p_{opt}}{1+\alpha-m}\times(1+\alpha) \quad (4)$$

Another parameter into consideration is the threshold value. It depends on the probability of node. Each node generates a random number and is compared with threshold value. If the generated value is less than threshold then that node will becomes CH. The threshold calculation for normal nodes and advanced nodes are, respectively:

$$T(S_{nrm})=\begin{cases} \dfrac{p_{nrm}}{1-p_{nrm}\left(r \bmod \dfrac{1}{p_{nrm}}\right)} & \text{if } S_{nrm}\in G' \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

$$T(S_{adv})=\begin{cases} \dfrac{p_{adv}}{1-p_{adv}\left(r \bmod \dfrac{1}{p_{adv}}\right)} \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

where r is that the current round, G' and G" the set of normal nodes and advanced nodes, that have not become cluster heads within the last $1/p_{nrm}$ and $1/p_{adv}$ rounds of the epoch respectively [8],[9]. The scenario of proposed work is shown below:

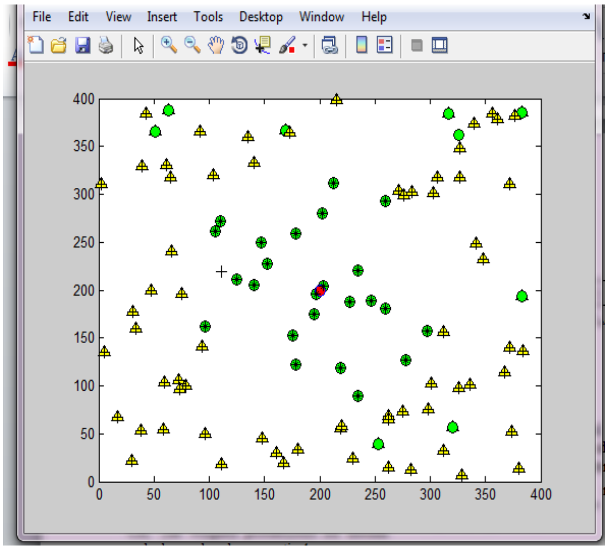

Figure 2: Scenario of the Network

3.1 Proposed Algorithm

Table 1: Various parameters used in the algorithm

Parameters	Description
p	Probability of node to be a cluster head
Distance	Distance of i_{th} node from base station

$S(i)$	Represent the node
$S(i)\cdot x_d, S(i)\cdot y_d$	Location of the i_{th} node
$S(n+1)\cdot x_d, S(n+1)\cdot y_d$	Location of the base station
ETX	Transmit energy
EMP	Data aggregation energy
Efs, Emp	Transmit amplifier energy
$R_{\max}$	Maximum number of rounds
E_{avg}	Average energy of the nodes
n	No of nodes
r	No of rounds

Algorithm

Step 1:- Create a sensor network model of varying dimensions, by deploying nodes in a static way.

Step 2:- Assign initial energy to each node, i.e. $E_0 = 0.5$.

Step 3:- Arrange the nodes based on the distance from base station as shown in equation 7.

Step 4:- For first round, initialize cluster head as per the minimum distance from the base station, number of cluster heads for round 1 is $p*n$. For further rounds no of cluster head is calculated by equation no 8 and [8].

Step 5:- For the next round r $=1:1:r_{\max}$

If $\left(S(i)\cdot E \geq E_{avg}\right)$ then // $S(i)\cdot E = E_0$

i=nominee cluster head *//nominated for Cluster head selection*

If the neighborhood of the nominee cluster head is not a cluster head then

i=cluster head *//cluster-head selected*

STEP-6:- Dead node: if $\left(S(i)\cdot E = 0\right)$ then

Dead=i *//i_{th} node dies*

n=n-dead *//n: decrease no of alive nodes*

STEP-7:- Go to step-5

STEP-8:- End

- To calculate node-distance from Base-Station the given formula is used:-

$$\text{Distance} = \sqrt{\begin{pmatrix}\left(s(i)\cdot x_d - \left(s(n+1)\cdot x_d\right)\right)\wedge 2 + \\ \left(s(i).y_d - \left(s(n+1)\cdot y_d\right)\right)\wedge 2\end{pmatrix}} \tag{7}$$

- P is the probability with which node i elects itself to be cluster head at the beginning of the round r+1, such that expected number of cluster head nodes for this round is k.

- Each node will be cluster head once in 1/p rounds.

$$temp\_round \leq \left(p/1 - p*\mathrm{mod}\left(r, round(1/p)\right)\right) * \left(s(i)\cdot E / total\_energy\right) \tag{8}$$

- Decrease the energy of the nodes chosen as cluster head by the formula as mentioned below by checking the conditions:-

  if (distance>do)

$$s(i)\cdot E = s(i)\cdot E - \begin{pmatrix}(ETX + EDA)*(4000) \\ + Emp*4000* \\ \begin{pmatrix}dis\tan ce*dis\tan ce* \\ dis\tan ce*dis\tan ce\end{pmatrix}\end{pmatrix};$$

Else

$$s(i)\cdot E = s(i)\cdot E - \begin{pmatrix}(ETX + EDA)*(4000) \\ + Efs*4000* \\ (dis\tan ce*dis\tan ce)\end{pmatrix};$$

4. Results and Comparison of Existing and Proposed Work

The graphs shown below depicts that the MODLEACH has better performance in comparison to the existing LEACH.

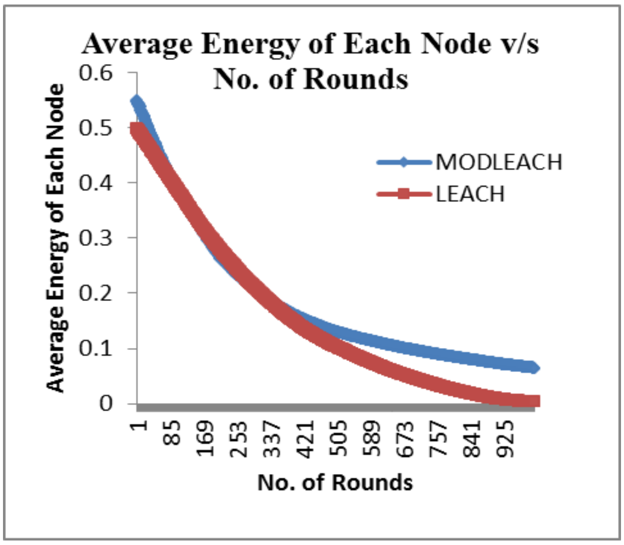

Figure 3: Comparison of Energy of Each Nodes

It was found that MODLEAH has 16% improvement in terms of energy consumption as compared to the existing LEACH.

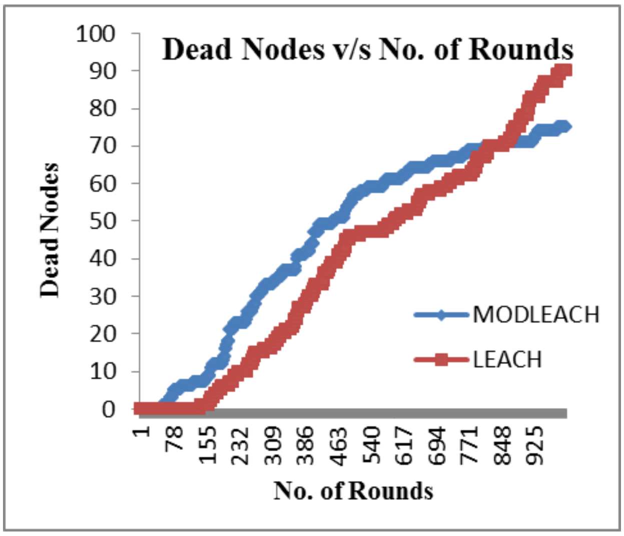

Figure 4: Comparison of Dead Nodes

It was found that MODLEACH has 14% improvement in terms of dead nodes as compared to the existing LEACH.

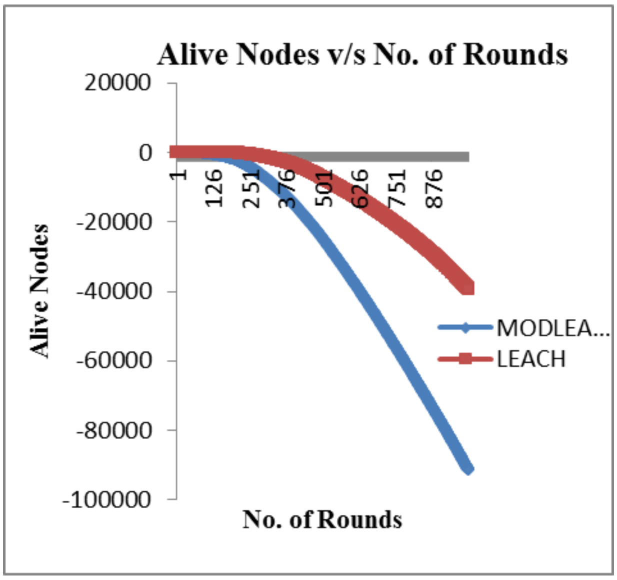

Figure 5: Comparison of Alive Nodes

It was found that MODLEAH has 64% improvement in terms of alive nodes as compared to the existing LEACH.

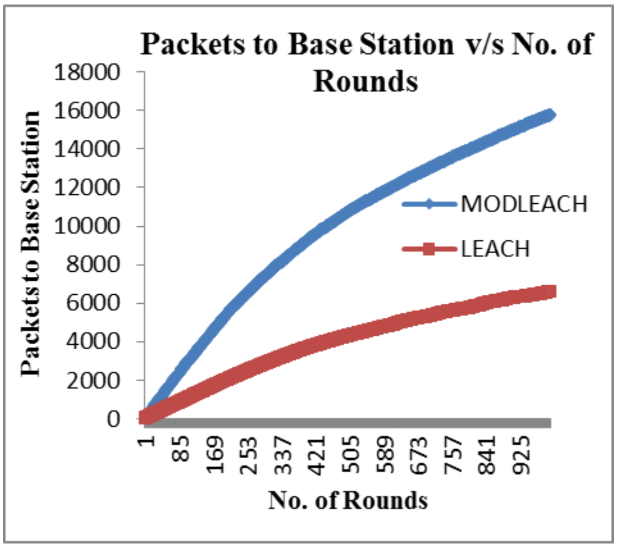

Figure 6: Comparison of Packets to Base Station

It was found that MODLEAH has 60% improvement in terms of packets send to base station as compared to the existing LEACH. MODLEACH has better throughput value in comparison to LEACH protocol.

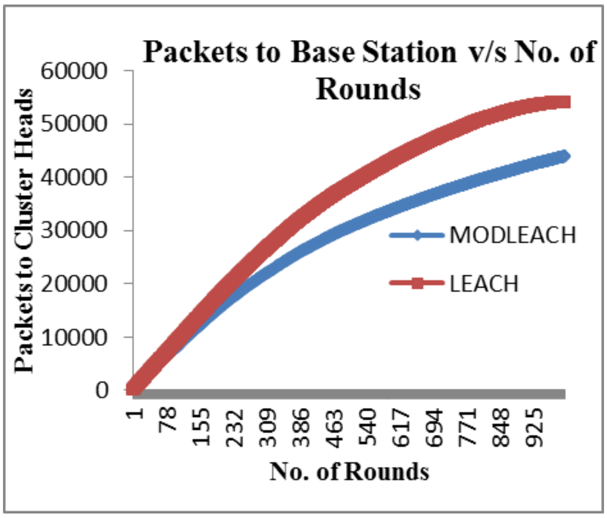

Figure 7: Comparison of Packets to Cluster Heads

It was found that MODLEAH has 25% improvement in terms of packets send to cluster head as compared to the existing LEACH.

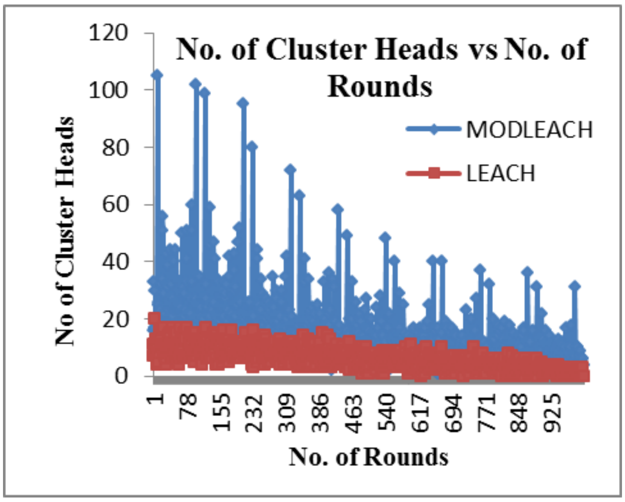

Figure 8: Comparison of Number of Cluster Heads

It was found that MODLEACH has 58% improvement in terms of number of cluster head in the network as compared to the existing LEACH.

5. Conclusion

The synthesis result confirms that the MODLEACH is suitable for energy consumption and throughput value. Better throughput value and lower energy consumption is achieved by adding the logic of Stable Election protocol. In the proposed work concept of advanced nodes is also added and has been tested to have better network lifetime and significantly less energy consumption. Again, the suggested structure showed the more stability in nodes as compared to the existing work.

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