THRESHOLD SENSITIVE WIRELESS SENSOR NETWORK WITH IMPROVED LEACH

Raghuveer kajla[1],Sandip mandal[2]
[1] Department Of Computer Science, DIT University, Dehradun(Uttarakhand),India
[2]Department Of Information Technology, DIT University, Dehradun(Uttarakhand),India
[1]mohitkajla@gmail.com; [2]sandy06.gcect@gmail.com

***Abstract*- The foremost difference between the WSN and the traditional wireless networks is that sensors are extremely sensitive to energy consumption. Energy saving is the crucial issue in designing the wireless sensor networks. LEACH Protocol plays an important role in response to the uneven energy distribution that is caused by the randomness of cluster heads forming .LEACH adopts a hierarchical and adaptive approach to organize the network into a set of clusters, managed by selected CHs . Further, the proposed system improves the parent network into the most prominent wireless sensor network's routing protocol "LEACH" as TSWSN with Improved LEACH by introducing efficient cluster head replacement scheme and efficient transmitting power levels. The implementation of the clustering algorithms including the proposed advanced LEACH protocol is done using MATLAB.**

Keywords-Threshold value(tv), sensing value(sv), Threshold sensitive wireless sensor network(TSWSN), Base station(BS) , Clustering algorithms.

I. Introduction

Normally, large number of nodes are being deployed in the wireless sensor network monitoring field[1]. So, the data flow in the network is considerably large which will involve significant energy dissipation for nodes. In addition, similar types of data may be found in the closely located nodes which requires aggregation of data.[2] The energy consumption of nodes in the network is different from node to node due to locations and some other factors of the nodes in the network. Also, most of the above protocols mentioned in the related work have assumed the network environment to be homogeneous in nature i.e. all the nodes in the network are same in terms of energy level. But, these assumptions are not feasible when we talk about real life scenario.

LEACH gives birth to many protocols. The procedures of this protocol are compact and well coped with homogeneous sensor environment. According to this protocol, for every round, new cluster head is elected and hence new cluster formation is required. This leads to unnecessary routing overhead resulting in excessive use of limited energy. If a cluster head has not utilized much of its energy during previous round, than there is probability that some low energy node may replace it as a cluster head in next cluster head election process. There is a need to limit change of cluster heads at every round considering residual energy of existing cluster head. Hence an efficient cluster head replacement algorithm is required to conserve energy. In clustering protocols as LEACH, nodes use same amplification energy to transmit data regardless of distance between transmitter and receiver. To preserve energy, there should also be a transmission mechanism that specify required amplification energy for communicating with cluster head or base station. For example, transmitting a packet to cluster head with same amplification power level as required by a node located at farthest end of network to base station results in wastage of energy. One solution can be having global knowledge of network and than nodes decide how much they need to amplify signal. Locating and calculating distances with in full network topology needs lot of routing and so, this approach do not work for saving energy. To solve above mentioned problems, we propose two mechanisms. i.e. efficient cluster head replacement and dual transmitting power levels.

II LEACH Protocol

As compared to other clustering algorithms, LEACH i.e. low energy adaptive clustering hierarchy, the first clustering routing protocol, that has been proven better by W.R heinzelman et al., they proposed this distributed clustering algorithm for the first time in 2000 [3].The main objectives of LEACH, was to find a way to low consumption of energy in the cluster and to improve the life time of WSN. LEACH adopts a hierarchical and adaptive approach to organize the network into a set of clusters, managed by selected CHs. The CH carries out multiple tasks, such as periodic collection of data from the members of the cluster, aggregation of data to remove redundancy among correlated values, transmission of the aggregated data directly to the base station through a single hop method, creation and advertisement of a TDMA schedule. In the schedule created by the CH, each node of the cluster is assigned a time slot that can be used by non-CH nodes for transmission. The CHs broadcast the schedule to their corresponding cluster members. CDMA (code division multiple access) based scheme for communication is used by LEACH nodes in order to reduce the likelihood of collisions among sensor nodes.

Operations of LEACH:

The basic operation of LEACH consists of many rounds, each round being divided into two phases. The phases of LEACH are illustrated in Figure 2.1.

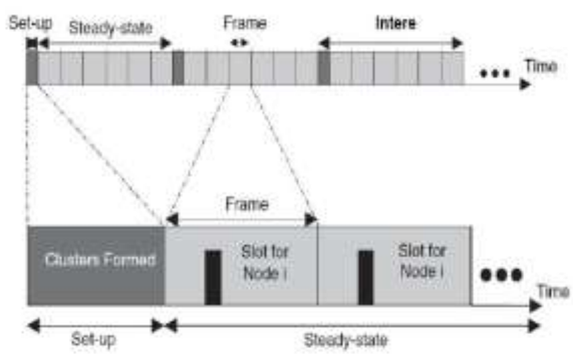

Figure 2.1: Two Phases of LEACH.

The first phase called the setup phase consists of three steps,

(i) Cluster-head advertisement,
(ii) Cluster set-up and
(iii) Transmission schedule creation.

The second phase, the steady-state phase, focuses on,

(i) Data transmission to cluster heads,
(ii) Signal processing (data aggregation/fusion) and
(iii) Delivery to the base station.

The duration of the setup phase is assumed to be relatively shorter than the steady-state phase in order to minimize the protocol overhead. At the beginning of the setup phase, cluster-head selection takes place. The role of CH rotates among sensor nodes, thereby distributing energy consumption evenly across the network nodes. To determine if it is its turn to become a CH, a node n, generates a random number x (between 0 and 1), and compares it with the CH selection threshold T(n).

$$T(n)=\begin{cases} \frac{p}{1-P*\left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \quad ...(1)$$

Where,

P is the desired percentage of cluster heads,
r is the current round and
G represents the set of nodes that have not been selected as CHs in last 1/P rounds.[4]

The node becomes a CH if its generated value, x, is less than T(n). The CH selection threshold, T(n) is aimed to ensure with high possibility that a predetermined fraction of nodes, P, should be elected as CHs at each round. Further, the threshold ensures that the nodes, those have been CHs in last 1/P rounds, will not again be selected in the current round. At the completion of the CH selection process, every node that is selected as a CH, advertises its new role to the rest of the network. Upon receiving the advertisements, each remaining node selects a cluster to join based on the received signal strength (or Euclidian distance). Then the nodes inform their corresponding CHs of their desire to become a member of the cluster. Once the cluster is formed, each CH creates and distributes a TDMA schedule that specifies the time slots allocated to each member of the cluster for transmission. CHs also select CDMA code so as to reduce inter-cluster interference, which is then distributed to all members of its cluster [5].

III Issues in LEACH

In LEACH algorithm, the energy consumption will allocate approximately uniformly among all nodes and the non-head nodes are turning off as much as possible. LEACH assumes that all nodes are in range of wireless transmission of the base station which is not the case in many sensor deployments. 5% of the total nodes play as cluster heads in every round. Time Division Multiple Access (TDMA) is deployed for better management and scheduling.[6]-[8] The problems in the traditional LEACH protocol are:

1) In LEACH protocol, cluster head node is selected randomly. One of the flaws or shortcomings in this protocol is that the probability to be selected as a cluster head, is same for each node. After several rounds, the possibility of becoming cluster head is same for the node with more remaining energy and the node with less remaining energy. Network's robustness will be affected and lifetime of the network will be shortened , if the node with less remaining energy is selected as cluster head because it will run out energy and die quickly .

2) One major problem in LEACH protocol is , the uneven distribution of clusters that is it divides the clusters in a random manner . Eventually the divided clusters may not be the best. For instance, some clusters are having either more number or less number of nodes in comparison to other clusters. Increase in energy consumption and impact on the overall performance of the network can be seen by the occurrence of some cluster heads in the relatively central of clusters, some clusters heads may be in the edge of clusters far away from the members.

3) Normally in the steady state, cluster head send data to sink data directly, but this did not take into account the distribution of cluster heads is not uniform. A large amount of energy is spent, when cluster head which is far away

from the sink communicate with the sink directly, finally leading to its crash soon because it runs out of energy. These effects are more noticeable and affect the network life seriously, when they are accompanied by the expansion of the scale of the network .

IV Our Extension Proposed: TSWSN with improved LEACH.

1. The improved threshold

For solving the drawbacks of the LEACH Protocol, energy impact factor (1 - $\frac{E_{ce}}{E_n}$) and the distance impact factor (1 -$\frac{d_n}{R_c}$) are introduced.

DEFINITION 1: E_{ce} is the remaining energy of cluster.

DEFINITION 2: E_n is the remaining energy of the node n within the cluster.
E_{ce} can be expressed as follows:

$$E_{ce} = \min(E_n).$$

2. Where E_{ce} is the minimum value of the remaining energy of every node in the cluster. .
DEFINITION 3**:** All nodes enclosed within the cluster with a minimum radius of the circle is shown in figure 3.3. R_c is the radius of this circle.

DEFINITION 4**:** The distance between node n and the centre of this circle is d_n.

Formula for the improved LEACH protocol is as follow:

$$(3)\quad T(n) = \begin{cases} \frac{p}{1-p*(r*\mathrm{mod}1/p)}*[(1-\frac{E_{ce}}{E_n})+\frac{E_{ce}}{E_n}(1-\frac{d_n}{R_c})] & \text{if } n \in G \\ 0 & \text{else} \end{cases}$$

$$(4)\quad T(n) = \begin{cases} \frac{p}{1-p*(r*\mathrm{mod}1/p)}*(1-\frac{d_n}{E_n}*\frac{E_{ce}}{R_c}) & \text{if } n \in G \\ 0 & \text{else} \end{cases}$$

Where $\frac{d_n}{E_n}$ is one of the important factor which affects the probability of normal node to become a cluster head. Only more recent from the centre of the circle and more remaining energy be lest, the node will become cluster head in the High-Probability. In this way, we can calculate the average energy consumption of all the nodes in a cluster.
The algorithm for Obtaining E_{ce} is as follows -

```
Function GETECE(S)
        Ece  = S(1).E;
        for i=1:1:n
          if ((S(i).E)< Ece )
         Ece  = S(i).E;
       end
      end
       if ( Ece  ==Eo )
           Ece  =0;
     End
     End
```

TSWSN Round Algorithm

Step 1 – Start.

Step 2 – Initiation of the network will take place.

Step 3 – Cluster Head will be elected.

Step 4 – Construction of cluster head will take place.

Step 5 – Formation of Cluster will take place.

Step 6 – After Cluster formation sensing and reporting will take place.

Step 7 – If Sensing takes place, threshold value will be compared with the sensing value.

- If sensing value will be greater than the threshold value then transmission will take place.
- If sensing value is smaller than the threshold value then transmission will not take place and we have to wait for the next sensing value. And after the next sensing value arrives then comparison between previous sensing value and arrived sensing value will take place. If the arrived sensing value is greater than the previous sensing value then the transmission will take place otherwise we have to wait for the new sensing value. And this process will be repeated till we get the sensing value greater than the previous one.

Step 8 – If Reporting takes place then the low power level or high power level will be obtained.

Step 9 – After this end of the round 1 will takes place.

Step 10 – Now if energy of existing Cluster head is less than the threshold value, Initiation of Cluster Head formation will take place.

Step 11 - If energy of existing Cluster head is greater than the threshold value, then the clusters will be utilized.

Step 12 - Both step 10 and step 11 will be fed to the next cluster head.

Step 13 – Formation of cluster head will take place in this step.

Step 14 – Here in this step cluster is formed. And from this Reporting will be fed back to the low and high power level and Sensing will also be fed back.

Step 15 – End of the process.

V Simulation Analysis

Network Life Time:

Considering network life time of LEACH and TSWSN, LEACH has lowest performance with respect to network life time and efficiency. TSWSN has greater stable period due to its efficient cluster head replacement scheme and dual transmitting power level for inter and intra cluster communication. Simulated results depicted in figure 5.1and 5.2 represent network life time by showing number of alive and dead nodes respectively.

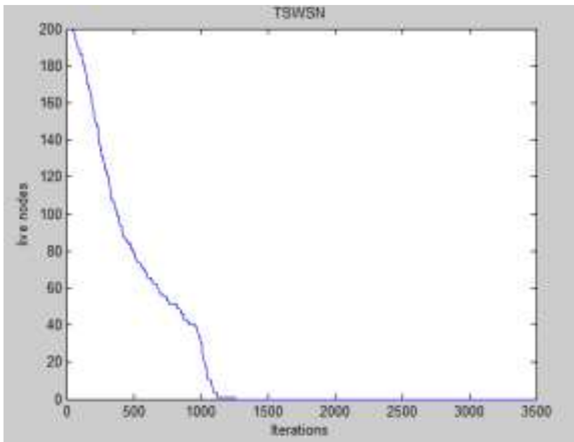

Fig 5.1 Effects on live nodes with respect to iterations in TSWSN

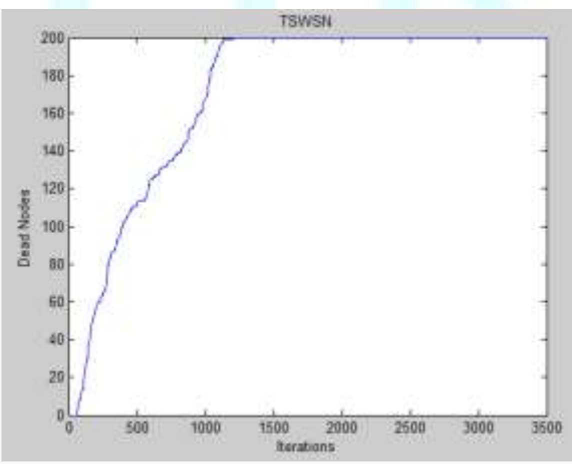

Fig 5.2 Effects on dead nodes with respect to iterations in TSWSN

Comparison of network life time of LEACH and TSWSN.

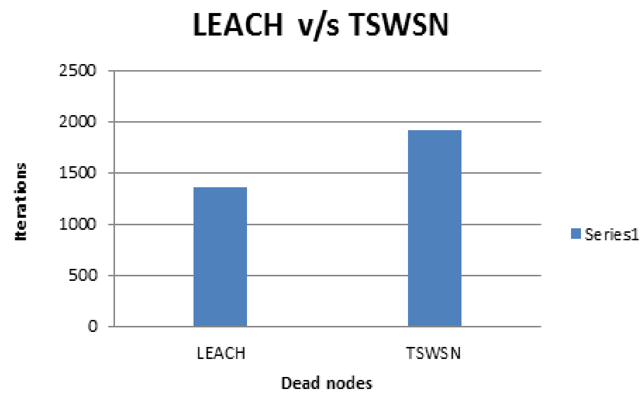

Fig 5.3 Lifetime of LEACH and TSWSN

2) Efficiency:

Besides network life time, another metric to judge efficiency of a routing protocol is its efficiency. A BS receiving more data packets confirms the efficiency of routing protocol. Efficiency depends on network life time in a sense but not always. Considering the simulated results as shown in figure 5.4 and 5.5, we deduce that, maximum efficiency is achieved by TSWSN. Improved network life time and efficient cluster head replacement mechanism are two major reasons of increased efficiency in TSWSN scheme.

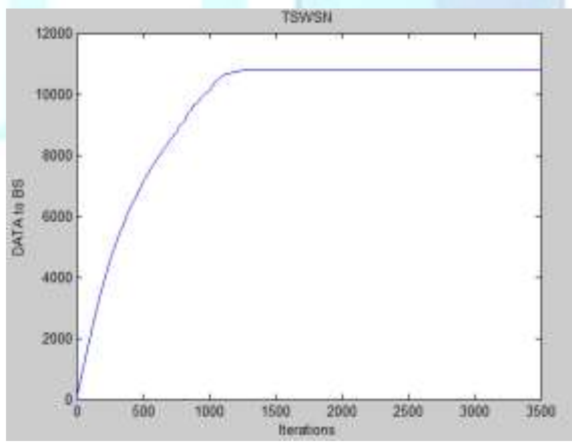

Fig 5.4 Data transferring to BS with respect to iterations.

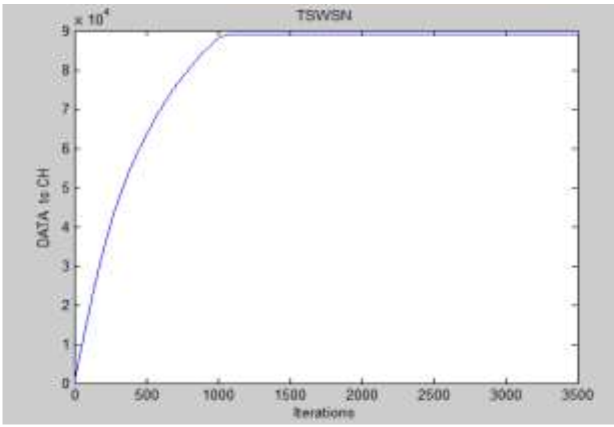

Fig 5.5 Data transferring to CH with respect to iterations.

Comparing LEACH and TSWSN with improved LEACH, TSWSN gives better efficiency due to same reasons i.e. increased network.

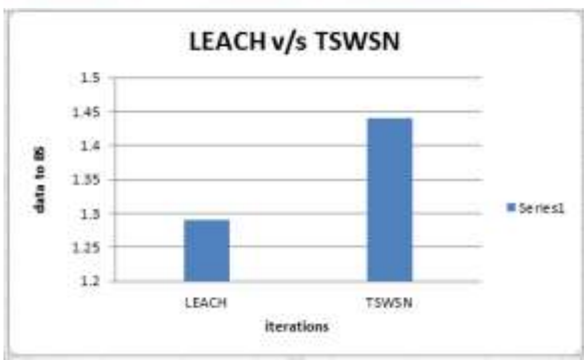

Fig 5.6 comparison of LEACH and TSWSN

VI Conclusion

Proposed work gives a brief discussion on the emergence of cluster based routing in wireless sensor networks. It also proposes the Improved LEACH that can be utilized further in other clustering routing protocols for better efficiency. In this improved LEACH is acting as a remedy to the shortcomings of traditional LEACH protocol. TSWSN tends to minimize network energy consumption by efficient cluster head replacement after very first round and dual transmitting power levels for intra cluster and cluster head to base station communication. In TSWSN, a cluster head will only be replaced when its energy falls below certain threshold minimizing routing load of protocol. Probability of each node which is to be selected as cluster head, can be solved using this technique.

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