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Improvement of Energy Aware Routing Protocol: LEACH

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Abstract: This paper discusses about Wireless Sensor Network (WSN) that are widely used now-a-days in various fields to monitor some activities or to control some machinery such that no hazard take place. In this paper, first Wireless Sensor Network and their working has been discussed. After that their goals, how they play an important role in various fields by providing life critical systems, their physical and logical architecture, the issues regarding WSN and how data is sent from one node to another using various routing techniques has been discussed. The improvement over LEACH protocol has been discussed. This improvement enhances the LEACH algorithm in terms of energy consumption.

1. Introduction

In this research, we have made an attempt to make LEACH (a traditional and widely accepted routing protocol in WSN) more energy efficient to keep more number of sensor nodes alive for the prolong period of time by enhancing the selection of cluster head technique of the classical LEACH. The network life of sensor network is directly proportional to the number of nodes alive in that network.

LEACH was the first cluster based routing protocol and widely accepted across the globe till now for its energy efficient communication between sensor nodes and base station. LEACH is a two phase working protocol where first phase is known as set up phase and the second phase is known as steady phase. In set up phase, the formation of clusters take place and cluster head is chosen while in the second phase gathering of data is carried out.

Since LEACH has been accepted widely as a general structure for clustered routing protocol, it contains various deficiencies; some of which have been overcome by various authors in their works. After studying and analyzing the LEACH protocol we conclude that the nodes acting as cluster head depleting their energy quickly. The cluster head in LEACH is responsible for:

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i. Time division multiple access (TDMA) schedule table is created and manipulation is done by its member nodes to get information about when to send data packets.
ii. Data coming from different nodes are collected.
iii. Redundancy is diminished by aggregation and then transmission take place to BS.

The cluster head selection is done randomly in LEACH. This cluster-head random selection and assigning random number of member nodes may result either in balanced clusters (approximately equal member sensor nodes by each cluster) or in un balanced clusters (uneven distribution of member nodes). Here the main problem arises in LEACH when there is uneven distribution of member cluster nodes. Each cluster-head aggregates and compress all the data collected from each member node and deliver it to base station. So, consumption of energy in cluster head is directly proportional to total number of member nodes in that cluster. This means that larger the nodes in a cluster; the more energy will be consumed. So, in the case of uneven distribution of clusters, the cluster head with more member nodes will be dead soon. This uneven distribution leads to more energy consumption of the cluster heads which have larger number of member nodes. So energy conservation becomes importance in this case which can be achieved by selecting cluster head intelligently. So here our problem can be formulated as

"Enhance the clustering technique of the classical routing protocol LEACH"

2. Literature Review

Shio kumar et. al. (2010) has done a survey of all the available routing protocols in WSN. According to them, the previous routing protocols have several drawbacks that exist due to the energy-constrained essentiality of available networks. They discuss various traditional (eg. flooding) and modern routing protocols (hierarchical and cluster based routing protocols) and analyzes the performance of both in WSN. They discuss how the traditional routing protocols support reliability but not the energy aware while sending data. Whereas the modern routing protocols mainly focus on energy concern.

C. Patra et. al. (2010) discusses the energy issue in WSN due to which the development of an energy efficient routing mechanism becomes a concerned matter. Jamal and Ahmed (2006) discusses different routing techniques available today in WSN. They give main focus on the routing protocols depending on their applications and network architecture.

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The work of R.V.Biradar et. al. (2006) investigated the issues of design in sensor networks and represents a grouping (classification) and correlation of different routing protocols. This examination uncovers the significant highlights that need to be considered while structuring and assessing novel routing protocols for wireless sensor networks.

According to G. Nivetha et. al. (2012), Wireless Sensor Networks (WSN) comprises of little hubs with detecting, calculation, and remote correspondences capacities. Sensor systems are "information driven" networks and are application explicit. Neighboring nodes may have comparative information and there is a requirement for correspondence between nodes about the information to be sent. This examination uncovers the significant highlights that should be thought about while structuring and assessing new routing conventions.

Heinzelman (2000) discussed about the hierarchical clustering algorithm named as “Low Energy Adaptive Clustering Hierarchy” for homogeneous wireless sensors networks. This is a cluster-based protocol. The cluster head reduces the communication energy by minimizing the data. The minimization is done by applying aggregation, fusion and fusion of the all the data gathered from all the member nodes of a single cluster. Since cluster head does more processing than just sensing and sending data, its energy depletes quickly.

Mohta et. al. (2011) have proposed an extension of LEACH protocol which is based on energy of sensor nodes in LEACH protocol and proposed a new protocol named ALEACH. Thakkar et. al. (2012) has proposed an improvement over LEACH protocol called CVLEACH (Coverage based LEACH) which overcomes drawbacks of cluster selection algorithm by creating the non-overlapping clusters.

3. Research methodology

The improved-LEACH (LEACH-C) has done a modification to the selection of cluster head to reduce energy consumption. The following assumptions are made for this methodology:

i. The base station (BS) is immobile.
ii. All network nodes are homogenous and have minimum energy with an identify ID.
iii. The communication with nodes can be done and are able to reach BS.
iv. The role of Cluster heads are: data aggregation and compression.

In this improvement, clustering ideology is used in hierarchical manner and one round is divided into a set-up and steady-state phase. After selection of cluster heads in the set up

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phase, a check round will be initiated in which we determine whether a cluster head is balanced or not. This can be measured by comparing the actual number of nodes with the average number of nodes. The steps of the algorithm can be given as:

Step1: Start the set up phase same as in LEACH phase.

Step2: Wait for cluster selection process to end.

Step3: Calculate the average number of node as

$$Avg_{nodes} = \frac{All\ alive\ non\ cluster\ nodes}{num\_cluster}$$

Step4: Compare the number of member nodes in each cluster with theAvg_{nodes} .

Step5: If number of member nodes under a cluster head is more thanAvg_{nodes} then discard that cluster head and call to the cluster head selection process. Cluster head selection round will be repeated only for those member nodes.

Step6: Repeat step5 until there is no dispute about cluster head. In this way a balanced scenario will be created for all the clusters.

4. Results and Discussion

In this research, modified protocol is implemented using NS2 protocol. The area of 100m*100m is chosen and 100 nodes are deployed in this area. The main parameters are listed below:

Table 1: Simulation Parameter

Simulation Parameter	Value
Number of nodes	50 nJ/bit
Network size	5 nJ/bit/signal
BS location	10 pJ/(bit/m2)
Radio speed	0.0013 pJ/(bit/m4)
Data size	86.2 m
Initial node power	2 J
Numbers of CH	5
simulation stop time	3600 s
switching time	20 sec

For the comparison of proposed method with the original algorithm, three metrics are used for comparison:

i. Numbers of dead nodes on simulation time
ii. The sensor node energy consumption over simulation time

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iii. The energy consumption in cluster heads over simulation time

3.1 Rate of nodes becoming dead

The table 2 shows the rate data of ***leach.alive*** file of the simulation which can be found in ***leach_sims*** folder. This file contains the number of nodes that are becoming dead over the simulation time. After referring the table we can comparatively say that in existing LEACH protocol all the nodes become dead up to 470 seconds while in our proposed method nodes last till 530 seconds which is an improvement of approx. 60 seconds from the existing one. It can be easily seen from the graph drawn below in Figure 1.

Table 2: Number of dead nodes in network

Time	Number of dead nodes(Existing LEACH)	Number of dead nodes(Improved LEACH)
330	3	8
350	7	9
370	17	22
390	26	30
410	38	41
430	73	48
450	93	54
470	All dead	58
490	All dead	70
510	All dead	85
530	All dead	95

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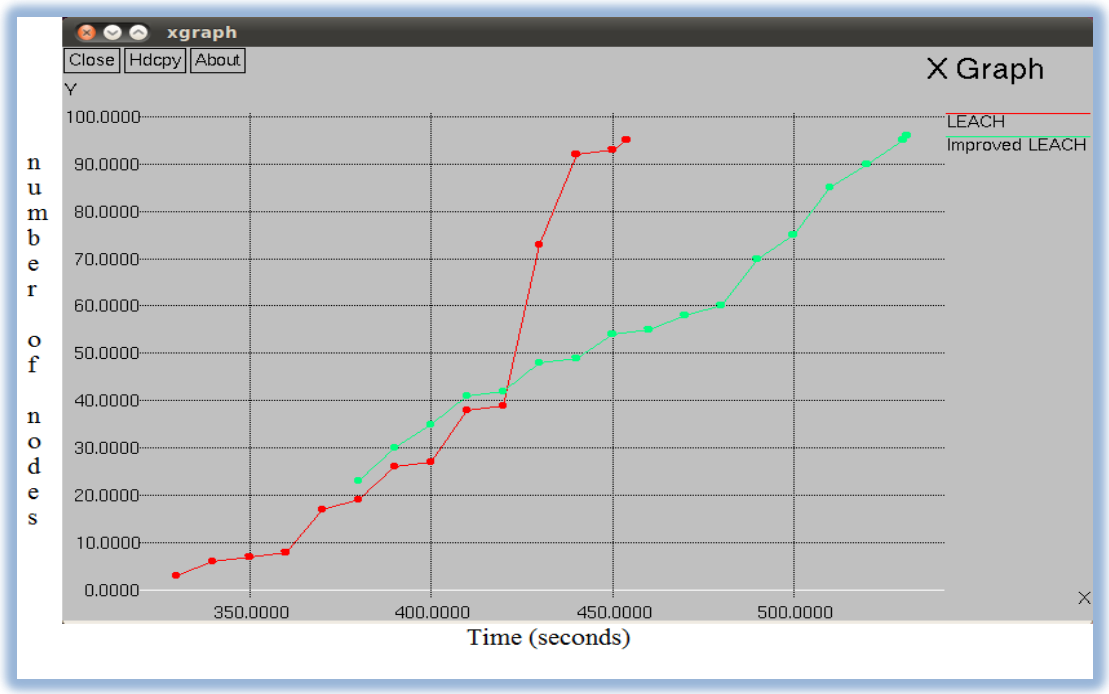

Figure 1: Dead nodes in network Vs. Time

3.2 Energy consumption in sensing nodes over the time

The second parameter we have taken is the rate of consumption of energy in all the sensor nodes that are sensing data and sending it to the cluster head. The less the energy consumed the more the network life will be. The data from the file ***leach.energy*** has been given in the table 3 for easily comparison. Based on this data the respective graph has been shown in Figure 2.

Table 3: Node energy consumption over simulation time

Time	Energy consumption in nodes (Existing LEACH)	Energy consumption in nodes (improved LEACH)
10	0.012248742899729171	0.015073960472709352
50	0.12206273553317606	0.11034525762897303
100	0.25196931871727229	0.19896987364473251
150	1.2579031273400989	0.29325175604246179
200	1.4302211810597782	0.42518443451550575
250	1.5063289087846037	0.47862384631635335
300	1.5941670503848344	0.56563204057630712
350	1.6881653963247181	1.5854838609946076
400	1.7949582859773174	1.6510317437750583
450	2.5155816139997866	1.7424351160849185
500	All nodes are dead	1.8570787079711746

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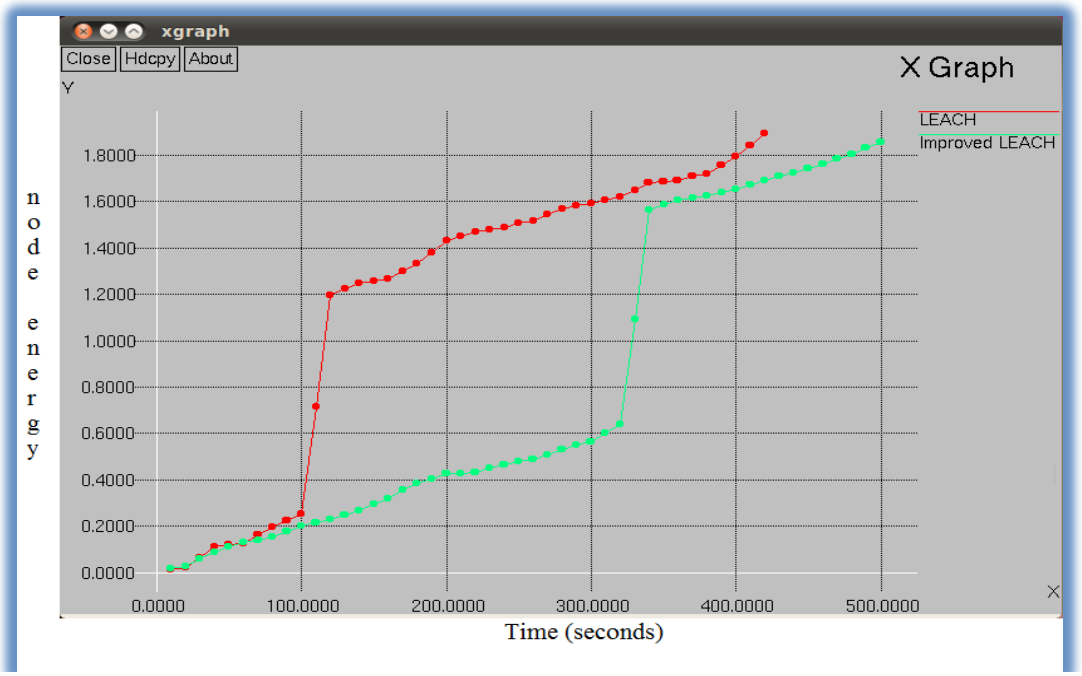

Figure 2: Node energy Vs. Time

3.3 Energy consumption in cluster heads

This is the third parameter which has been taken into consideration. The information about current energy in the cluster heads can be found out from the file ***cluster.energy*** file. Energy over the simulation time has been presented in table 4 and the graphical comparison has been discussed in the figure 3.

Table 4: Energy consumption in cluster nodes over time

Time	Energy consumption in cluster heads (Existing LEACH)	Energy consumption in cluster heads (Improved LEACH)
0	2	2
50	1.96299	1.96217
100	1.90625	1.92482
150	1.82403	1.88347
200	1.70929	1.84971
250	1.64683	1.78357
300	1.55302	1.75055
350	1.45628	1.70926
400	1.21473	1.58749
450	1.1304	1.47176
500	No adequate energy	1.31848
550	No adequate energy	1.16128

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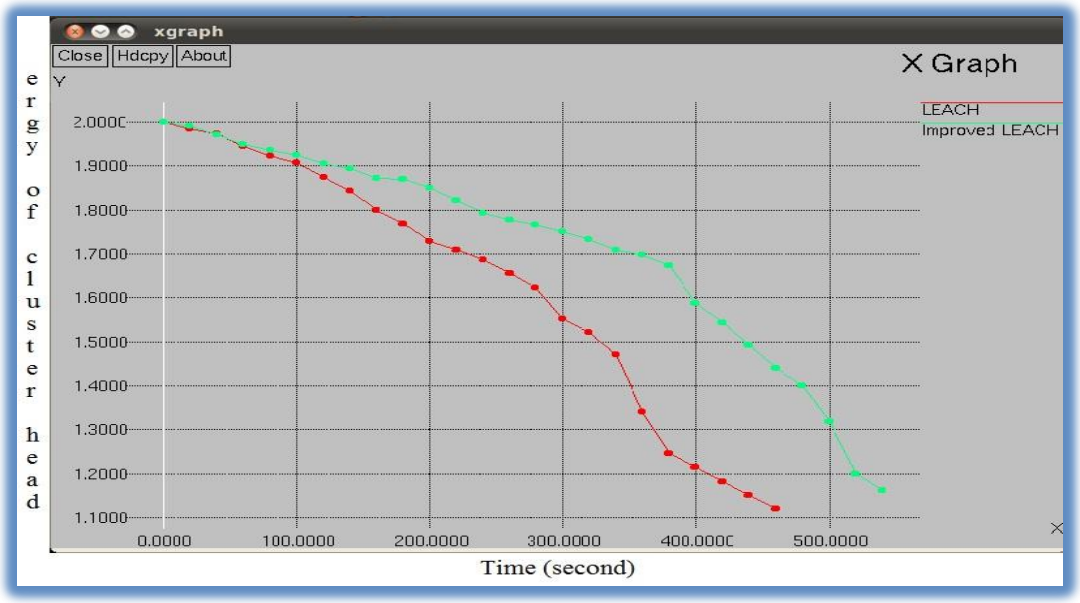

Figure 3: Energy consumption in cluster heads Vs. Time

5. Conclusion and Future Scope

In this research, a detail study of LEACH has been done and new algorithm has been proposed in the cluster selection phase. This algorithm evenly distribute the load on each cluster in the sensor nodes which leads to the less energy depletion rate in the cluster heads resulting in the longer network life time. We have shown the performance of the improved LEACH protocol by comparing it with the traditional LEACH through simulation. Thus we can conclude that the improved LEACH performs better than the traditional LEACH.

In the proposed algorithm, we are balancing the load over each cluster at the time of set up phase. The load balancing at the cluster head can be extended as another improved process of splitting those clusters that have heavy load compared with all the clusters.

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