Load Balanced Dual Cluster Heads (LBDCH) Routing Protocol in Wireless Sensor Network

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Abstract- Wireless sensor network (WSN) has been one of the most important areas of research since the revolution in the sensing industry has emerged. The capabilities of WSN are limited by the constraint of limited battery resources in its hardware modules. In the direction of efficiently utilizing the energy resources, many routing techniques utilizing the clustering, have been proposed. In this paper, the clustering is made energy efficient and load balanced by incorporating the dual cluster heads i.e. Primary Cluster Head (PCH) and Secondary Cluster Head (SCH) as compare to the traditional clustering where only single cluster head takes the responsibility of data forwarding to the base station. The selection of PCH and SCH is done on various matric namely, the ratio of residual energy to the maximum energy and distance to the base station. This helps in bringing the load balancing in the network, simulation results show that the proposed technique effectively ameliorates the stability period by 33.92 % for 100m X 100m area and by 31.39 % for 500m X 500m area as compare to the LEASE protocol.

Keywords – Dual cluster heads, clustering, load balancing, LEASE, LBDCH, WSN.

I. INTRODUCTION

Wireless sensor network (WSN) is the one of the most emerging technology in the modern times. It has been the most promising in bringing the revolution in sensing technology worldwide. WSN consists of various wireless nodes which are deployed mostly in the areas where human intervention is not possible [1]. There is huge number of applications of WSN which helps in dealing with so many attended and unattended operations [2-4].

The basic architectures of WSN and sensor node are being shown in the Figure 1 and Figure 2. Sensor nodes after their deployment collect data from surrounding and forward it to the sink which is mostly placed outside in the network in unattended applications. Sink forwards the data to the user via internet.

The architecture of sensor nodes contains four basic building blocks, namely, power unit, which is mostly 2AA battery, sensing unit sense the various attributes thereafter it forwards the sensed attribute in the digital form to the processing unit which handles all the computations, thereafter it being transmitted with the use of transceiver which helps in receiving the data as well from other nodes [5].

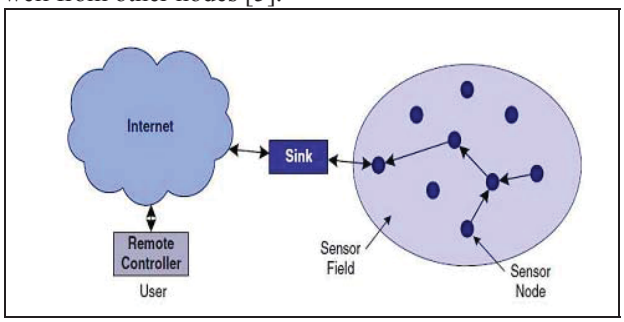

Figure 1. WSN architecture [1]

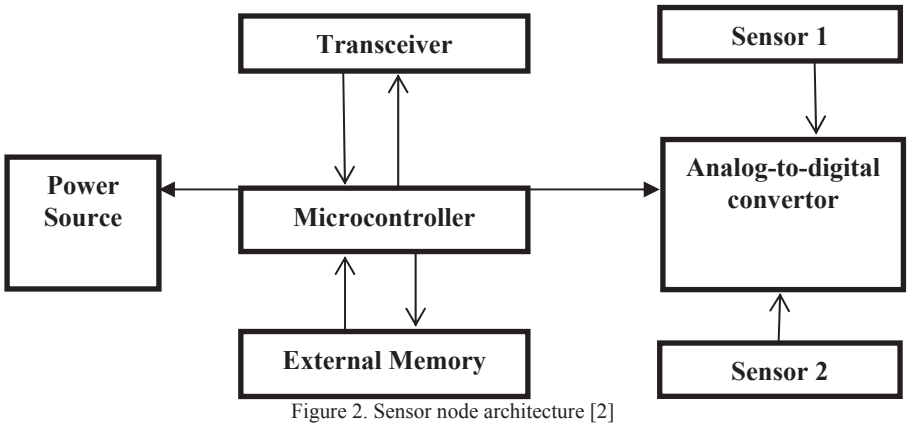

Figure 2. Sensor node architecture [2]

One of the most important concern has been the efficiently utilizing the battery resources, in achieving same, the routing among nodes becomes the most prominent [6].

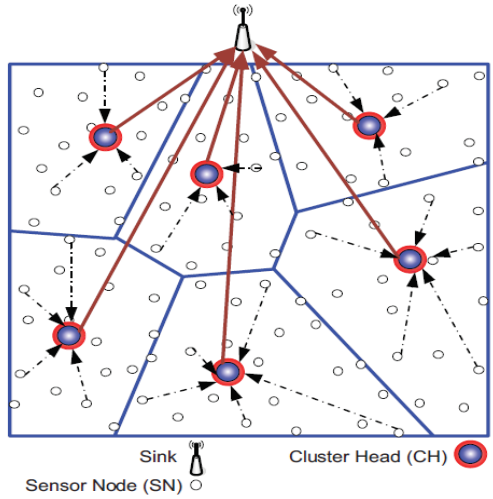

Figure 3. LEACH [7]

There are basically three types of routing techniques namely flat routing, hierarchical routing and geographic routing. Here in this paper, we have worked on the hierarchical routing which further deals in clustering topology in the network. LEACH [7] was the first protocol which gave the concept of clustering to the WSN, the concept is demonstrated through Figure 3. In clustering techniques, the nodes are grouped together to form a cluster, thereafter a cluster head is selected on some criteria which collects the data from all the nodes of the cluster and forwards it to the base station or sink [8]. In this work, the clustering has been made energy efficient by giving the much efficient approach of data collection in the clusters.

The rest of paper is organized as follows: Section 2 briefs about the related work, section 3 defines the problem of proposed work, section 4 gives the proposed protocol, section 5 results and discussion has been done after simulating the protocol, section 6 concludes the work and thereafter references and future work is being mentioned.

II. Related Work

Since the time, WSN has come into existence, huge amount of research has been focusing on the making the sensor network running for as long as possible i.e. network lifetime. It is because of the fact that nodes are equipped with non-replaceable battery resources. LEACH [7] worked on random cluster head selection and single hop communication which is not suitable on the large area network. Clustering techniques are well discussed in [9-11].

A novel double cluster-head routing policy based on clustering hierarchy routing is proposed in [12]. First and second cluster head selection is done according to balancing the number of neighbor nodes, surplus energy and distance weights. This mechanism could avoid high energy consumption in single cluster head and "false" death phenomenon. Cluster head are not periodically rotated which brings the uneven load balancing in the network.

In LEACH-C [13], the whole network is partitioned into homocentric rings and some nodes are chosen as key nodes which are similar to cluster heads in hierarchical protocol. Data is transmitted between the key node and sink in

multi-hop routes. The simulation result proved that this proposed work prolong the network lifetime as compared to LEACH and LEACH-C. In LELE protocol [14] load balancing is done by proper selection of cluster head or leader. The cluster head and leader selection algorithm considered the energy of each node and transmission distance of each node from the base station and its neighboring nodes. The author concludes that the proposed algorithm increase the network lifetime than LEACH. Double Cluster Heads Model (DCHM) [15], a novel cluster-based data fusion model is proposed by combining clustering techniques, reputation and trust systems, and data fusion algorithms for secure and accurate data fusion in WSNs. Different from traditional clustering models in WSNs, two cluster heads are selected after clustering for each cluster based on the reputation and trust system and they perform data fusion independently of each other. The technique suffers from too many overheads and computational complexities. In technique proposed in [16], two cluster heads namely main and sub-ordinate cluster heads are selected based on the parameters such as residual energy, minimum average distance from the member, nodes timer and node degree using particle swarm optimization technique. In this technique, each cluster member node sends the data to main cluster head. The aggregated data from the main cluster head is transmitted to sink through sub-ordinate cluster head. Although this technique outperform in various parameters but it is not being explored to investigate the network lifetime produced by it. In LEASE [17] cluster head selection is based on the parameters like residual energy, distance to base station and proximity to neighbors in order to balance the load among the sensors in the network. Simulation results show that proposed scheme has better stability period and balances the load of the network with prolong lifetime.

III. PROBLEM DEFINITION

In the consideration of limited battery resources the most of research is focused on the energy efficient routing techniques. In the literature survey discussed in section 2, it is cleared in clustering techniques; the major concern has been on the cluster head selection. Single cluster head has the sole load of collecting data from all the nodes and then it has to forward it to the base station or to the next cluster head which leads to the load unbalancing in the network. Too much periodical rotation of single cluster heads leads to increased overheads in the network leading to increased energy consumption. Reliability is another factor which is on the stake when it comes to the assigning the task of data aggregation and data collection to the single cluster head. DCHM has worked on the security aspects by incorporating dual cluster heads. LEASE uses CHSI (cluster head selection index) for selection of cluster head, but with the single cluster head, the load unbalancing prevails in the network. With the consideration of achieving the load balancing in the network with enhanced network lifetime, we propose LBDCH protocol which uses two cluster heads; primary and secondary cluster in the each cluster, denoted as PCH and SCH. The selection of cluster heads is proposed to be done on the basis of ratio of residual energy to the maximum energy and distance to the base station.

IV. LBDCH

In this section LBDCH protocol is discussed. The whole process can be demonstrated through the figure 4 given following:

A. Network Initialization

The network of LBDCH is initialized with same simulating environment as that of LEASE. It is being represented in the form of Table given below:

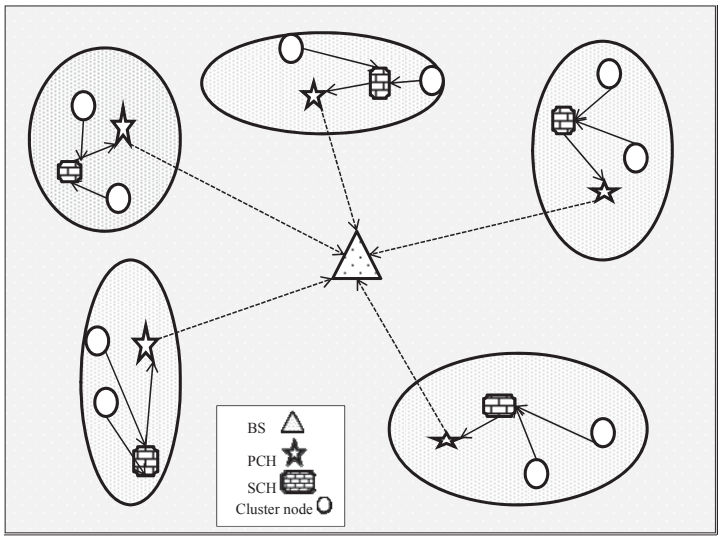

Figure 5. Data transmission in LBDH

Table 1: Simulation Parameter

Parameter	Value
Network coverage	(100,100)m, (500,500)m
BS location	(50,50)m, (250,250)m
Node Number	100, 500
Initial energy (Quantity)	In Joules 1, 0.5
E_{ELT}	50nJ/bit
E_{efs}	10pJ/bit/m^2
E_{mp}	0.0013pJ/bit/m^4
d_0	87m
E_{DA}	5nJ/bit/signal
Data packet size	4000bits

B. Data transmission in the LBDCH

In LBDCH, SCH is secondary cluster head which collects data from all the nodes in the cluster thereafter it performs data aggregation, then it forwards the data to the PCH which then forwards it to Base Station. The process of data transmission is demonstrated in the figure 5.

V. SIMULATION RESULTS

The proposed routing technique is being implemented in MATLAB software version 2013 (a).

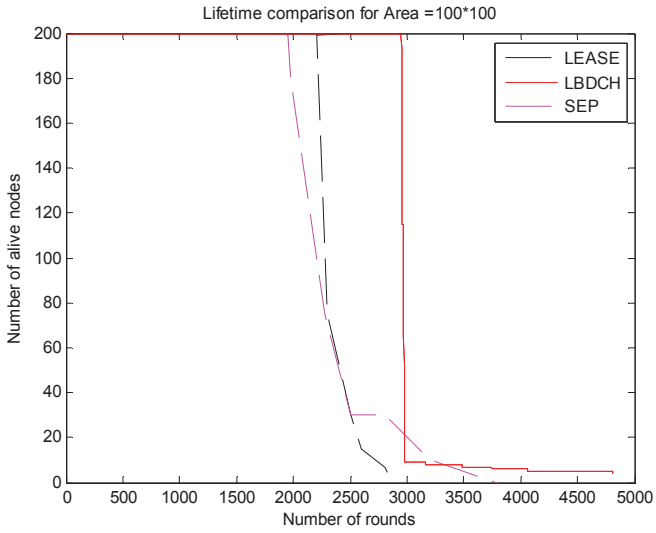

Figure 6. Network lifetime comparison

The proposed work is being discussed for two cases. Case 1 covers the area of (100 X 100) m and the number of nodes being 200 and for Case 2, the area of (500 X 500) m is taken and numbers of nodes considered are 500 in number.

There are few performance matric on which LBDCH is being investigated over the LEASE, LEACH and SEP.

A. Case 1 [Area 100 X 100 with 200 nodes]

In the first case, the area of 100m X 100 m is considered with 200 nodes deployed in the network. The performance metrics are explained as below:

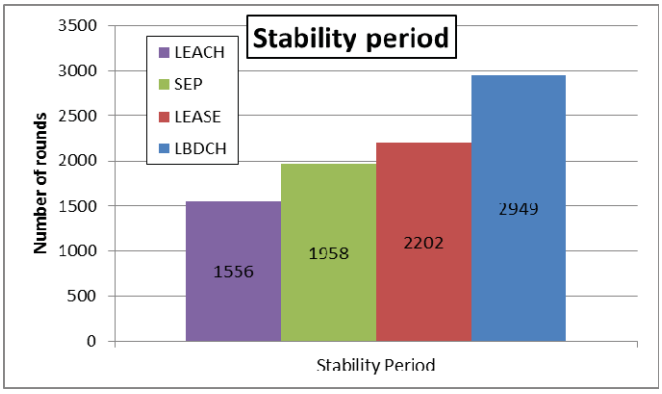

Figure 7. Stability period comparison with LBDH

1. *Stability period or First Node Dead:* It is defined as the number of rounds covered until the first node is dead. It is one of the most important metric for deciding the network stability. It can be seen from the figure 7 the stability period of LBDCH is 2949 rounds which shows the 33.92% improvement as compare to the LEASE protocol as demonstrated in Table 2.

Table 2: Percentage improvement by LBDCH

Percentage Improvement of stability period by LBDCH		
LEACH	**SEP**	**LEASE**
89.52%	**50.61%**	**33.92 %**

2. *Half Nodes Dead:*

It is defined as the total number of rounds covered till the 50% of nodes are dead. This is the metric which decides the load balancing in the network. LBDCH improves HND by 37.53% as compare to LEASE.

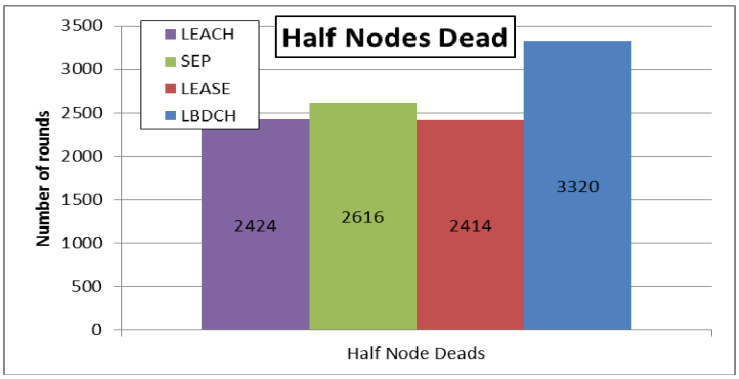

Figure 8. HND comparison with LBDH

Table 3: Percentage improvement by LBDCH

Percentage Improvement of HND by LBDCH		
LEACH	**SEP**	**LEASE**
36.96%	**26.91%**	**37.53%**

B. Case 2 [Area 500 X 500 with 500 nodes]

In the second case, the area of 500m X 500 m is considered with 500 nodes deployed in the network. The performance metrics are explained as below:

1. *Stability period or First Node Dead:*

The stability period for this case is shown in the Figure 9 and the percentage improvement is being depicted in Table No. 4.

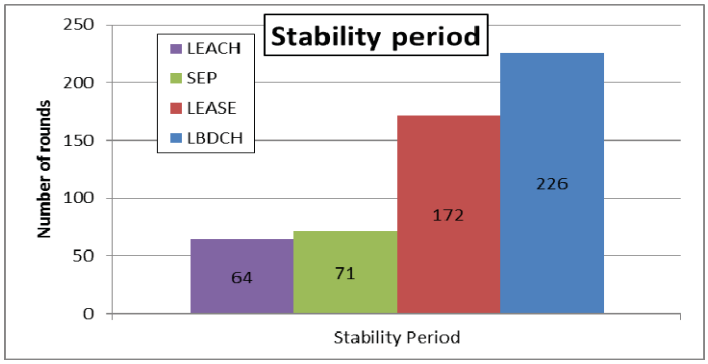

Figure 9. Stability period comparison with LBDH

Table 4: Percentage improvement by LBDCH

Percentage Improvement of stability period by LBDCH		
LEACH	**SEP**	**LEASE**
253.1%	**218.1%**	**31.39 %**

2. *Half Nodes Dead:*

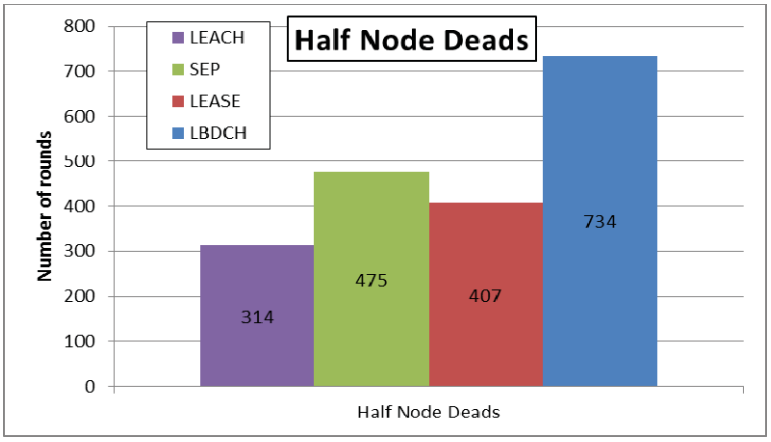

Figure 10. HND comparison with LBDH

Table 5: Percentage improvement by LBDCH

Percentage Improvement of Network Lifetime by LBDCH		
LEACH	**SEP**	**LEASE**
133.7 %	**54.52 %**	**80.34 %**

C. Conclusion and future work

There have been various routing techniques which have been focusing on making the network energy efficient. Clustering has been tremendous in bringing out scalability to the network. In this paper, dual cluster heads are introduced in each cluster, the selection of which have been on the factors of residual energy and distance to the base station. It brings the load balancing in the network. Simulation results shows that the proposed protocol LBDCH enhances stability period by 33.92 % for network area of 100 X 100 m with 200 nodes and by 31.39 % with network area of 500 X 500 m with 500 nodes. In future, this work can be extended to the scenario in which base station is mobile in nature.

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