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A Clustering Approach Based on Genetic Algorithm for Leach Protocol

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Abstract—Wireless sensor networks have many nodes with limited energy that distributed in a limited geographical area and be able to monitor surroundings. The fundamental problem in WSNs protocol design and development is limited energy resources of sensor nodes in the network. In this paper an effective clustering approach for selection of cluster heads in wireless sensor network is introduce by using Genetic Algorithm for load balancing and increasing network lifetime. The approach is based on LEACH. In approach single-hop technique is used for communication within the cluster and cluster head to BS. For cluster head selection each node evaluates its density and energy, with an internal function. Simulation results show that the proposed approach effectively produces optimal cluster heads for the wireless sensor networks, and resulting in an extension of lifetime for the network.
Index Terms—*Wireless Sensor Network, Genetic Algorithm, Single hope technique, load balancing, node density.*

I. Introduction

Wireless sensor networks (WSNs), which consist of a number of small battery-powered sensors, are used to obtain various sorts of useful data from environment. These devices sense physical properties, such as sound, humidity, pressure, luminosity, temperature etc. and transmit the gathered data to a base station (BS) a powerful computer for further analysis and processing. Wireless sensor networks that consist of a large number of low power, short-lived, unreliable sensors, one of the main design challenges is to obtain long system lifetime and an energy-efficient network protocol is an important consideration in WSN applications. Many routing protocols for WSNs have been developed. In some protocols sensor nodes transmit their sensed data directly to a BS. Thus, the nodes located far from the BS will die quickly since they dissipate more energy in transmitting data packets. DT protocols are inefficient since energy levels of nodes are drained rapidly when the BS is located far. In some protocols Multi hop transmission is used for the communication. As a result, nodes located near the BS die quickly since; they end up relaying lots of data on behalf of remote nodes. Clustering is used as a tool for the energy efficient routing protocol, and in this protocol network is organized in clusters. Such a sensor network contains two types of nodes; cluster head and cluster members. All the data processing such as data fusion and aggregation are local to the cluster. Cluster heads change randomly over time in order to balance the energy dissipation of nodes. Cluster member sense the data and send to cluster head and cluster head sends the data to BS.

The paper is organized as follows. In the Section -2, LEACH protocol and its limitations are discussed, Section -3 summarizes Genetic Algorithm, Description of the proposed algorithm is included in section - 4, Section - 5 includes the simulation results and the Finally discussion is concluded in Section-6.

Ii. Leach Protocol

The LEACH protocol is one of the bench-mark protocols in the Wireless Sensor Networks. LEACH protocol has two phases: Setup phase and Steady state phase. In the setup phase, nodes are organized into clusters and in the steady state phase data is transferred from cluster head to sink via single-hop method. In each cluster a node is selected as a cluster head and the remaining nodes are called cluster-members. Data collected by the member nodes, locally processed by the cluster head. Due to local data processing and data transmission from cluster head to base station, cluster heads consume more energy than energy consumed by member nodes.

Limitations

In LEACH location of the cluster head is on random basis. This is also true for the number of cluster member in a cluster. An optimum solution for both of above mentioned issues is always required. Establish control over location of cluster heads and size of the clusters in terms of number of members always has been considered as a challenge and solving this problem requires efficient clustering algorithms in energy consumption and network load balancing. In the following section, a new approach is suggested for the optimal selection of cluster head using genetic algorithm. The approach is based in the density of nodes in the network. Following figures express the effect of density in nodes organization. Figure 1(A), shows the nodes organization just according to nodes energy and regardless of density that is not optimal in number of nodes. Figure (B); express the nodes organization according to nodes density that is more optimum location for the cluster head.

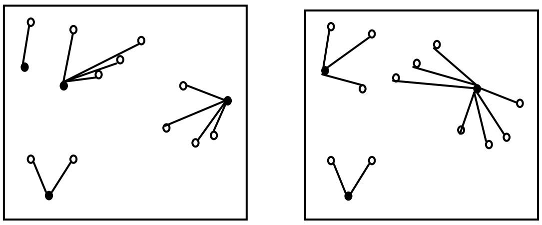

Fig1: A) Random node organization B) Node organization according in LEACH to node density

III. Genetic algorithm

Genetic algorithms are randomized search and optimization techniques guided by the principles of evolution and natural genetics. GAs perform search in complex, large landscapes, and provide near-optimal solutions for objective. Initially, the genetic algorithm begins with a primary population including random chromosomes that consist of genes. In the next step, the algorithm biases individuals toward the optimum solution through repetitive processes such as crossover and selection operators. A new population can be produced by two methods: steady-state GA and generational GA. In the first case, one or two members of population are replaced, while the generational GA replaces all the produced individuals at each generation. Proposed algorithm uses the second method so that the GA keeps the specified qualified individuals from the current generation and copies them into the new generation as part of the solution. Other individuals of the new population are obtained by crossover and mutation functions. Following steps are used in proposed genetic algorithm

Begin
1. T=0
2. Initialized population P(t)
3. Computer fitness P(t)
4. t=t +1
5. If termination criterion achieved go to step 10
6. Select P(t) from P(t-1)
7. Crossover P(t)
8. Mutate P(t)
9. Go to step 3
10. Output best and stop

End

IV. Proposed Approach for Clustering Using Genetic Algorithm

Proposed algorithm works in rounds. Each round consists of Initial phase and Steady phase. In this study, single-hop technique is used for communication within the cluster and from cluster head to BS. Network administrator selects a threshold value for the cluster head selection process. In Initial phase all nodes send the residual energy, density and probability parameters to the own internal function. Density of node means the number of nodes near the node which are in its sensing range. According to the result of internal function, the node starts a counter. The node with high result of internal function will more quickly reach to the threshold which is selected by the network administrator and notify its candidacy as cluster head to the base station. Centralized method determined optimum nodes among of candidates cluster head. The objective of the process to find the cluster heads with higher capabilities and distribute them in the network so that the total network energy consumption is minimized.

Steady State Phase

In this phase a node senses the data from the surroundings and sends to CH. Then the cluster heads aggregates the data and sends to BS.

Details of algorithm

Initial phase:

In initial phase of each round a population and fitness function is be used to select cluster head and cluster member. In first round of algorithm choose *K* initial cluster heads z_1, z_2……, z_K from the *n nodes* {x_1, x_2,……,x_n}. Than cluster member will be selected for each cluster head.

Step1: Initially all nodes have same probability to become a cluster head.

Step2: F (t) is the fitness function used to select the cluster head and defined as

F (t) =(Er * T (n) * Dr))

Where

Er=Residual energy of the node

T(n)= probability of node to become cluster head as given by LEACH

Dr= Density of node

In this equation the energy, density and probability have a direct relationship with the output of function, so increased value of inputs will produce a larger output the optimal value obtained for a particular node will be eligible to be a cluster node.

Step 3:

After calculating this built in F(t) function each node start a counter till predefined threshold value. For each network, network administrator decides number of cluster heads. The first node which reaches at a predefined threshold value will send its candidature to the sink for cluster head selection.

Step 4: Selection of Cluster Head

BS selects the cluster head and the result is sent to the network. At the BS a predefined number of nodes introduced themselves as the candidate of cluster head will determine the length of the chromosome. Each of the genes in this chromosome is identifier of number of network nodes.

The structure of chromosome is as follows

chrom = {gi|i =1,2,...,L }

Where, L is the length of chromosomes, and g_i is the i^{th} gene.

Single-point crossover from a random point in the chromosome is selected and mutation is performed, that may change a bit by leap or jump a bit state to generate one or more new chromosomes. After this base station select a chromosome that has minimum difference of energy from last round and with best probability. And all nodes in this chromosome are introduced as cluster head to network. Other nodes bind to the nearest cluster head.

The fitness function F(t) uses the density of node that increase the probability of location of cluster head in highly dense area.

Steady State Phase

After initial state each node knows its cluster head. In each period a cluster head only receive one package form each member nodes of the cluster. Cluster head aggregate the data and send to it BS

Pseudo-code of the Proposed Approach:

BEGIN

1: Specify the probability (*p*), number of nodes (n);

2: Einit(s)=E0, s=1,2, …, n;

(I)Initial Phase

1: Each node calculate Fitness Function F(t)

2: Start Counter

3: CCH{s}=TRUE; //node s be a candidate CH

4: SendToBS(IDx,) (Xx,Yx)

// The first predefine number of node reaches at threshold value will sends their candidacy to the sink for cluster head selection.

5: GAinBS

//BS perform the GA on the node which sends their candidacy for cluster and select cluster head for the network.

6: SendToCH ← BS send message to selected cluster head.

7: **if** (CH{s}=TRUE) **then**

8: BC (ADV) ← broadcast an advertisement message;

9: Join(IDi); //non-cluster head node i join into the closest CH

10: Cluster(c); //form a cluster c;

11: **end if**

(II) STEADY-STATE PHASE
1: **If** (CH(s)=TRUE) **then**
2: Receive (IDi, Data) //receive data from members;
3: Aggregate (IDi, Data) //aggregate received data;
4: TansToBS(IDi, Data); //transmit received data;
5: **else**
6: TansToCH(IDi, Data); //transmit sensed data;
7: **end if**
8: **end if**
9: } // round is completed
END

IV. Simulation Results

Simulation Parameters : following simulation parameters are used to perform simulation.

Table 1: Simulation parameters

Parameter	Value
Initial population	200
Crossover rate	0.5
Mutation rate	0.5

Table 2: The values of genetic algorithm

Parameter	VALUES
Simulation rounds	3000
Number of nodes	200+1 (Nodes + BS)
Topology Size	100 X 100
CH probability	0.5
Initial node power	0.5 Joule
Nodes Distribution	Nodes are randomly distributed
BS position	Located at 50, 175
Energy for Transmission (ETX)	50*0.000000001
Energy for Reception (ERX)	50*0.000000001
Energy for Data Aggregation (EDA)	5*0.000000001

Simulation results:

Table 3 lists the obtained simulation results using LEACH and present approach. Table 3 shows the number of rounds after which first dead node occurs in the network. The results show that the proposed approach outperforms LEACH in terms of lifetime of network.

Table 3: Number of round in which first dead node occur

Simulation Run	First dead node occur in the network) LEACH	First dead node occur in the network with new approach

Run 1	760	989
Run 2	814	1034
Run 3	782	1012
Run 4	882	1044
Run 5	698	998
Run 6	768	1093
Run 7	886	1098
Run 8	854	996
Run 9	796	1078
Run 10	875	1089

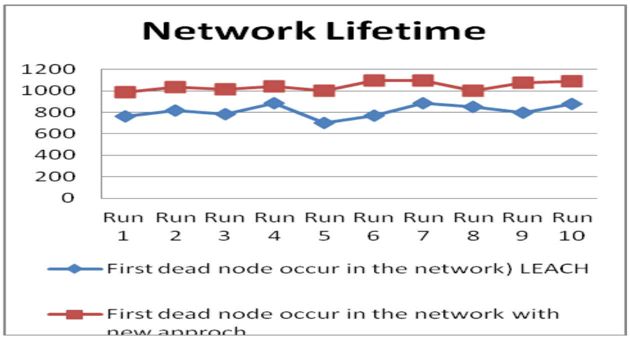

Fig 2: Number of Round in which first dead node occur

Table 4 lists the simulation results obtained using LEACH and presented approach. Table shown the number of round which last dead node occurs in the network.

Table 4: Number of round in which Last dead node occur

Simulation Run	Last dead node occur in network in LEACH	Last dead node occur in network with new approach
Run 1	1387	1890
Run 2	1456	1987
Run 3	1369	1895
Run 4	1490	1943
Run 5	1512	1967
Run 6	1496	1890
Run 7	1670	1823
Run 8	1496	1845
Run 9	1589	1904
Run 10	1586	1903

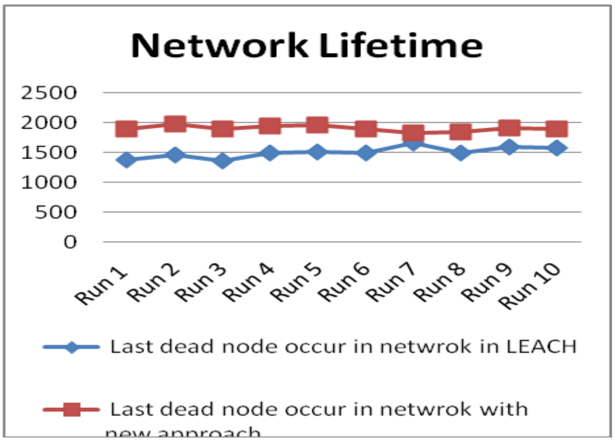

Fig 3: Number of round in which last dead node occur

IV. Conclusion

This work proposed a genetic algorithm based new approach for clustering for wireless sensor network. The LEACH protocol does not consider density of the node in cluster head selection. Proposed algorithm use node density to select candidate cluster head and BS select the cluster head from the candidate cluster head using genetic algorithm. Our proposed method outperforms LEACH in terms of network lifetime. As results shows that the number of round in which first round dead is 698(minimum) from 10 simulations with LEACH protocol is increased to 989 rounds with proposed algorithm.

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