# Performance Evaluation of Genetic Based Dynamic Clustering Algorithm over LEACH Algorithm for Wireless Sensor Networks

**D. Srinivasa Rao, B. J. M. Ravi Kumar**

***Abstract*— A wireless sensor network (WSN) is a wireless computing devices network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, motion, intrusion or pollutants, at different locations. The purpose of designing these networks is gathering information from the environment and sending them to the sink node. One of the most important issues in these kinds of networks is energy efficiency. The longer the communication distance, the more energy will be consumed during transmission. So, clustering is a way to reduce energy consumption. In this paper, we propose a dynamic clustering algorithm using genetic algorithm. This algorithm takes different parameters into consideration to increase the network lifetime. The results of the conducted simulations show the high efficiency of the proposed algorithm.***

***Index Terms- Wireless Sensor Networks, Clustering, Genetic algorithm, Energy Consumption.***

## I. INTRODUCTION

Wireless Sensor Networks (WSN) consists of a large number of sensor nodes which are low-power, low-cost and energy limited with constrained communication and computational capabilities [12]. WSN is employed in monitoring a specific region specially places that are hardly accessible such as battlefields [13] and volcanoes [14], detection of fire events in forests and jungles [15], measuring temperature and humidity in specific places [16] and many other applications. Considering the fact that replacing or recharging the energy supplies of the nodes is barely possible, energy consumption of the nodes becomes a major source of concern. As communication protocols have an essential role in efficiency and increasing the network lifetime, it is essential to design efficient protocols that balance the energy consumption [1]. Hierarchical protocols reduce energy consumption in the networks by clustering.

## II. RELATED WORK

LEACH is a cluster-based routing protocol, and uses the following technologies to achieve its energy-saving: 1) random, self-adaptive, self-organization clustering method; 2) local control of data transmission; 3) low-energy consumption of the MAC protocol; 4) information processing technology. The LEACH protocol occupies an important position in WSN routing protocols, and other cluster-based routing protocols have been developed from the LEACH one. Its proposer later improved it, proposing the LEACH_C [11] protocol. The main improvement was that during the clustering nodes no longer compete for cluster heads, but nodes first send their own data to the sink node, and then the sink node determines the location of cluster heads according to their location, energy and cycle. The advantage of doing so lies in that we get a reasonable distribution of clusters through a reasonable arrangement of cluster heads, reducing the energy consumption due to the non-ideal random location or numbers of clusters in the original LEACH algorithm. For now, the LEACH_C and LEACH protocols may be considered generally equivalent cluster routing protocols. However, the LEACH_C network protocol has its own inherent shortcomings. Because the number of nodes in WSNs is large, the density coverage is also high, and the data collected by a single node are certainly highly related with those collected by the entire WSN, and what users need is not the data collected by all nodes (including redundant data), but rather a description of incidents the situation of events taking place in observed regions through the analysis of the set of network.

## III. PROPOSED METHOD

Having control over the position and number of cluster heads and also the number of cluster's member is always a challenge. In the clustering of the sensor network, solving this problem requires efficient clustering algorithm regarding energy consumption and balancing the energy. Dynamic nature of the network makes the problem more complex due to repetitive change in the clusters and cluster heads which can't be modeled by the mathematic methods. In the other hand, genetic algorithm is very flexible in solving such a dynamic problems. In this paper, we try to determine clustering and the place of the cluster heads using genetic algorithm in a way that there will be minimum energy consumption while attending the network coverage.

### A. Problem Representation

In the proposed algorithm, binary representation is used in which each bit corresponds to one sensor node. A "1"means that corresponding sensor is a cluster head and a "0" means that it is a regular node.

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### B. Genetic Algorithm Operators

This algorithm begins its work by randomly generated population of chromosomes. Each regular node finds its nearest cluster head and joins to it. Then the algorithm applies the genetic operators.

#### *1. Crossover Operator*

In this paper, we use one-point crossover. Crossover is a genetic operator that combines (mates) two chromosomes (parents) to produce a new chromosome (offspring). The idea behind crossover is that the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents. Crossover occurs during evolution according to a user-definable crossover probability. Consider the following 2 parents which have been selected for crossover. The "|" symbol indicates the randomly chosen crossover point.

Parent1:11001|010
Parent2:00100|111

After interchanging the parent chromosomes at the crossover point, the following offspring are produced:

Offspring1:11001|111
Offspring2:00100|010

After applying the crossover operator, a regular node may become a cluster head. If so, all other regular nodes should check if they are nearer to this new cluster head. If so, they switch their membership to this new cluster head. This new cluster head is detached from its previous cluster head. If a cluster head becomes a regular node, all of its members must find new cluster heads. Every node is either a cluster head or a member of a cluster head in the network.

#### *2. Mutation Operator*

The mutation operator is applied to each bit of an individual with a probability of mutation rate. After mutation, a bit that was "0" changes to "1" and vice versa. In fact, it is possible that a regular node becomes a cluster head and a cluster head becomes a regular node. Individual before mutation: 0 1 1 **1** 0 0 1 1 0 1 0 individual after mutation: 0 1 1 **0** 0 0 1 1 0 1 0

#### *3. Selection*

The candidate individuals are chosen from the population in the current generation based on their fitness. The individuals with higher fitness values are more likely to be selected as the individuals of population in the next generation.

#### *4. Fitness Function*

As the purpose of this algorithm is optimizing energy consumption that results in increasing the networks lifetime, so we have to consider the residual energy of the nodes as a main parameter for selecting the cluster head. The second parameter that is considered is the required energy to send a message toward the sink node. The lower the communication distance, the less energy will be consumed during transmission. Finally, since cluster heads use more energy than other nodes, reducing the number of cluster heads has a considerable effect on decreasing the energy consumption. Each individual is evaluated by the following fitness function:

$$\text{Fitness} = RE + (X * (SE) + (1- X) * (N - CH)) \quad (1)$$

$0 <= X <= 1$

In this function, RE represents the sum of residual energy in the cluster heads, N is the total number of nodes, CH is the number of cluster heads and the SE is calculated as

$$SE = \sum_{i=1}^{M} (RS_i - (RH_i + HS)) \quad (2)$$

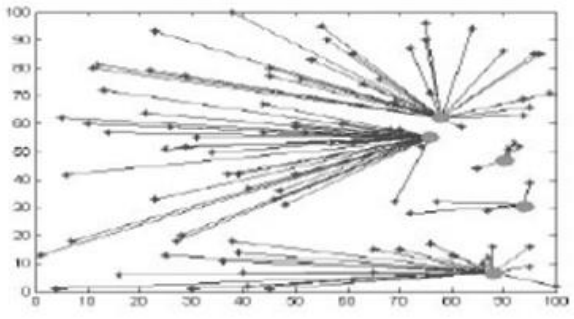
Where $RS_i$ represent the sum of required energy for sending one message from all regular nodes toward the sink node, $RH_i$ represents the sum of required energy for sending one message from all regular nodes toward their cluster head and HS represents the sum of required energy for sending one message from all cluster heads toward the sink node. The value of x ($0 \leq X \leq 1$) indicates which factor is more important to be considered: required energy (that is related to the distance) or the cost incurred by cluster-heads.

## IV. SIMULATION RESULT

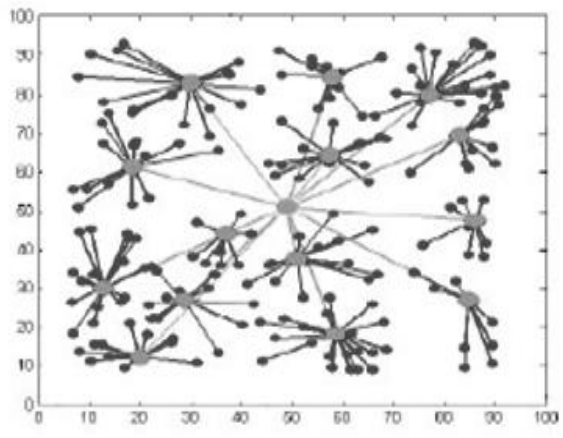
We have simulated the proposed clustering algorithm using MATLAB software and compared it to LEACH protocol. The list of the used simulation parameters and their values are shown in table 1:

| Parameters | Values |
|---|---|
| N | 100 |
| Sensing range of nodes | 10m |
| Network Dimensions | 100m * 100m |
| Initial energy of each node | 1 J |
| Packet size | 53 byte |
| Primary population | 150 |
| Crossover rate | 0.5 |
| Type of crossover | One-point |
| Mutation rate | 0.006 |
| Number of generation | 400 |

In the first experiment, the distribution of the cluster heads in the proposed algorithm is compared to LEACH protocol. Figure 1 shows the result of this comparison.



**a) Improper distribution of the cluster heads in LEACH Algorithm**



**b) Proper distribution of the cluster heads in the proposed Algorithm**

**Figure1. Comparing the cluster heads distribution**

As shown is this figure, randomly selection of the cluster heads in the LEACH algorithm may causes unbalanced distribution of them. This distribution is improved in the proposed algorithm. In the second experiment, we compared the sum of residual energy of nodes in the proposed protocol and LEACH protocol during different rounds. As can be seen in Figure 2, the proposed algorithm consumes energy uniformly and so, prolongs the network lifetime.

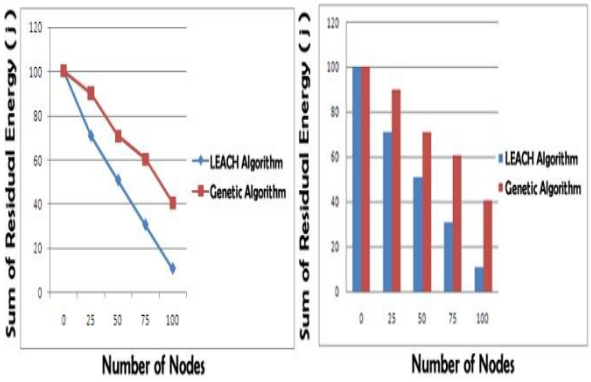



**Figure 2. Comparing sum of residual energy**

In the third experiment, we compared the number of alive nodes in our protocol and LEACH protocol during different rounds. The results of this experiment are shown in Figure 3. It can be observed that the proposed protocol has considerably more number of alive nodes in each round in comparison with the LEACH protocol.

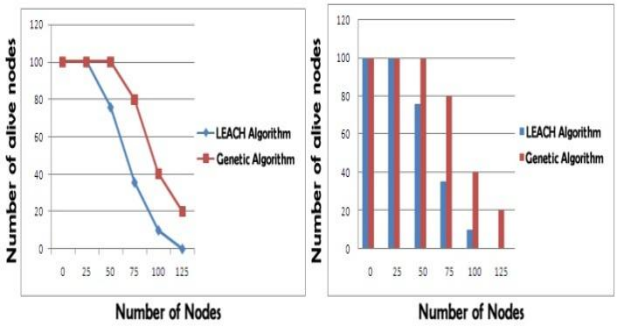



**Figure 3 . Number of alived nodes in different rounds.**

## V. CONCLUSION

In this paper, we proposed a clustering algorithm based on genetic algorithm. The proposed algorithm takes different parameters into consideration to increase the network lifetime. This parameters are residual energy of the nodes, required energy to send a message toward the sink node, and number of cluster heads. In order to evaluate our algorithm, we simulated our protocol and compared it to LEACH protocol. The results of the simulations show the effectiveness of the proposed mechanism.

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