KGAWSN: An Effective Way to Reduce Energy Consumption in Wireless Sensor Networks by K-means and Genetic Algorithms

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ABSTRACT
In this paper, we present a method by which we can significantly reduce energy consumption in sensor networks. In the proposed method, finding an optimum Cluster Head (CH) is performed by Genetic Algorithm (GA) and clustering the network environment is done by k-means algorithm. The results of simulation show that at the end of some certain part of running the proposed algorithm, the number of alive nodes increases, comparing with the same previous methods and this can lead to an increase in sensor network lifetime.

Keywords
Wireless sensor network, Genetic Algorithm, Routing, reduce energy consumption ,k-Means algorithm

1. INTRODUCTION
Undoubtedly, one of the problems in sensor networks, is energy consumption[1].This type of network is composed of several nodes scattered in the environment[2].The task of nodes is to collect environment data and send them to a Base Station(BS)[3].The nodes have limited energy. So data transmission from lower levels to higher levels can reduce energy and this can threaten network lifetime[4].One important case in this kind of network is finding an optimum route through which the nodes can transmit data to BS[5].Data transmission can be performed single hop or hop to hop[6,7]. In single hop method, after receiving environment data by common nodes and transferring them to CHs , CHs transmit data to BS. In hop to hop method, data may be interchanged between CHs before transferring to BS[8]. In the proposed method, single hop transmission has been used. Of important uses of sensor networks we can refer to control and supervision over fire accident in forest, supervision over military environments, tracing patients' conditions, and control over traffic status[9]. One effective way used in sensor networks is using GA's[5,10] .Gas use random searching for finding optimum points [5,11].The main advantage of this type of method using random searching, is that non-optimum points in previous stages can be attended in next stages[12,13]. In previous stages,

Some points may not have optimization conditions but they may have optimization conditions in next stages. In this research, a Genetic – based routing algorithm and k- means algorithm have been presented to reduce energy consumption in sensor networks.

2. K-MEANS ALGORITHM
K- means algorithm is considered as a useful way for clustering. In this method, firstly, some points are randomly attributed as clusters' centers, in terms of the required clusters[14]. Then each datum, based on similarity, is attributed to one of clusters.
In this algorithm, the following relation is used to determine the distance between points and center of each cluster:

$$j = \sum_{j=1}^{k}\sum_{i=1}^{n}\left\| x_i^j - c_j \right\|^2$$

In which c_j is the center of j-cluster.

3. GENETIC ALGORITHM
Genetic algorithm has some operators by which it can randomly find optimum points through several stages[5,10]. Genetic operators include: selection, composition and mutation[12,13,14]. After some certain run of generation by GA ,final population is obtained. GA entries are chromosomes entering as initial population[5,14,12,13]. In each generation, after running genetic operators on chromosomes' bits, the fitness value is calculated for obtained measures(populations), and then the obtained measure is compared with fitness value. At the end of each generation, the best value(measure), regarding fitness value, is selected as optimum population and is attended in next generation. In each generation, two chromosomes having higher fitness are selected as parents and the two selected parents are composed by composition operator to obtain new children. Then fitness value is calculated for children .The child having higher fitness value is attended in creating next generation. This process is performed for several generations to obtain optimum solution .

4. RELATED WORKS
One of the most significant routing algorithm in sensor networks is LEACH algorithm, being as the base of many researches. In this algorithm, the method of CH selection is totally random and based on a measure under the title of threshold as follows[3,4,5]:

$$T(n) = \begin{cases} \dfrac{k}{1-k*(r \mod \frac{1}{k})} & if \quad n \in G, \\ 0 & otherwise \end{cases}$$

In this relation, k is the probability of being CH or decision percentage. r is the current round, G is a set of nodes not being CHs in recent 1/k round. One other algorithm presented in the context of reducing energy consumption is RGWSN[5]. In this method, environment clustering and finding an optimum CH are done by GA. Of other presented methods, we can refer to BEA(BA)method[16]. In this method, clustering is based on GA.

5. THE NEW PRESENTED METHOD KGAWSN

The recommended method is based on the rounds consisting of two phases. In the first phase(form), optimum CHs and clusters are specified .In this phase, optimum CHs are determined by GA . Also the clusters are formed by k-means algorithm. In the second phase(transmission) data are transferred.

5.1 FIRST PHASE (FORM)

At the beginning of this phase , the number of clusters which shall be formed, is specified. In this method, it is supposed that the number of nodes in the entire environment and base station is fixed and nodes, after establishment, can be added or removed(network model). Also nodes' initial energy is different. In this phase, firstly some nodes are randomly considered as initial entry(initial population) to form chromosomes. The number of nodes depends on the number of clusters. In the recommended method, we consider initial population 3 times as the number of initial clusters. For example, if the number of clusters is firstly considered as 5, the number of initial populations will be 15. In this method, we use binary coding, i.e. chromosome bits are composed of 0,1. After forming initial population or initial chromosome, we select some populations randomly. Then we select populations randomly as binary and then we compose them binarily by composition operator. In the recommended method, we use the combination of two points. Figure 1 shows two- points combination.

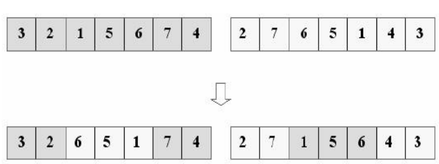

Figure 1. Two-Points combination

We use this process for some certain generations and at the end, we calculate fitness value for chromosome bits. In the produced final population, we consider bits 0 as common nodes and bits 1 as CHs. Then we form clusters by the number of CHs and based on k-means. We attribute nodes to their proportionate clusters ,i.e. the nodes selected as CHs by GA are considered, as clusters' central points in k-means algorithm. In k-means algorithm, nodes are attributed to clusters based on the distance between nodes and cluster center. Nodes attribution process continues until no change obtained in the mean distance between nodes.

5.2 SECOND PHASE (TRASMIT)

Transmit power in sensor network depends on the distance between sender and receiver. This distance equals the shortest crossover distance, $d_{crossover}$. Transmit power equals[9]:

$$p_r(d) = \frac{p_t G_t G_r \lambda^2}{(4\pi d)^2}$$

in which, p_t : transmit power

G_t : antenna transmit gain

λ : carrier signal's wave length in meter.

When receiver distance is more than $d_{crossover}$, transmit power is as follows:

$$p_r(d) = \frac{p_t G_t G_r h_t^2 h_r^2}{(d)^4}$$

h_t : transmit antenna height in meter.

h_r : receiver antenna height in meter.

When receiver is more than $d_{crossover}$, transmit power is as follows (with Heinzleman model) :

$$E_{TX}(n,d) = n(E_{elect} + \in_{fs} d^2) \quad d < d_{crossover}$$

$$E_{TX}(n,d) = n(E_{elect} + \in_{mp} d^4) \quad d \geq d_{crossover}$$

Also to transmit an n-bits message in d meter distance, energy consumption equals to:

$$E_{rx}(n) = nE_{elect}$$

Also to transmit an n- bits message from a distance of d, energy consumption equals to:

$$E_r = LE_{elect}$$

$\in_{fs}$ and $\in_{mp}$ are parameters which are dependent on receiver sensitivity(intelligence) and noise-shaped . E_{elect} is electrical energy depending on digital code , modulation, filtering and etc.

In the recommended method, 4 energies are calculated for nodes. For CHs, data transmit energy to BS, electrical energy of receiving data from common nodes and data aggregation energy are calculated. For CHs, we have:

$E_2(n,d)$: Energy required to receive information cluster head from the common node

$$E_2(n,d) = LE_{elect} \times N\_Common$$

$E_3(n,d)$: Aggregation of energy cluster head

$$E_3(n,d) = LE_{agg} \times N\_ch$$

$E_4(n,d)$: Energy required to transfer of CH to BS

$$\begin{cases} E_4(n,d) = LE_{elect} + L \in_{fs} d^2{}_{distoBs} & d_{distoBs} < d_{crosssover} \\ oR \\ E_4(n,d) = LE_{elect} + L \in_{mp} d^4{}_{distoBs} & d_{distoBs} \geq d_{crosssover} \end{cases}$$

For common nodes, only energy of data transmission to CH is calculated. It means:

$$\begin{cases} E_1(n,d) = LE_{elect} + L \in_{fs} d^2{}_{distoch} & d_{distoch} < d_{crosssover} \\ oR \\ E_1(n,d) = LE_{elect} + L \in_{mp} d^4{}_{distoch} & d_{distoch} \geq d_{crosssover} \end{cases}$$

In the above formulas, $d_{distoch}$ is the distance from common node to CH, $d_{distoBS}$ is the distance from CH to BS. E_{agg} is aggregation energy. N_ch is the number of CHs(bits 1) and N_Common is the number of common nodes(bits 0) . L is the number of bits.
In this phase, after determining the energy required by common nodes and CH, based on occurred transmissions, the initial energy of nodes is reduced, i.e. for the nodes considered as CHs in the final population, 3energy are calculated. Figure 2 shows the recommended algorithm.

6. SIMULATION

In the performed analyses, some items as the number of alive nodes, CHs selection method, the initial energy of nodes , the number of initial clusters and the number of generations are considered. Table 1 shows simulation parameters.

TABLE I. SIMULATION PARAMETERS

Parameter	Value
Nodes number	variable
Generations number	variable
Initial energy for node	rand [0.3,0.5] J
E_{elec}	50nJ/bit
ε_{fs}	10pj/bit/ m2
ε_{mp}	0.0013pj/bit/m4
Data aggregation energy	5nj/bit/signal
The number of initial clusters	5
The initial population	15
Possibility of combining	0.8
d_0	87m
Mutation probability	0.8
Network size	variable
Base station location	variable
Round number	variable

Figure 2 shows the number of alive nodes after running 1400 rounds of the recommended method along with previous methods with similar parameters. As shown by diagrams, after running 1400 rounds, the alive nodes in the proposed algorithm are more than those in LEACH, RGWSN,BA methods. So the network's lifetime increases.

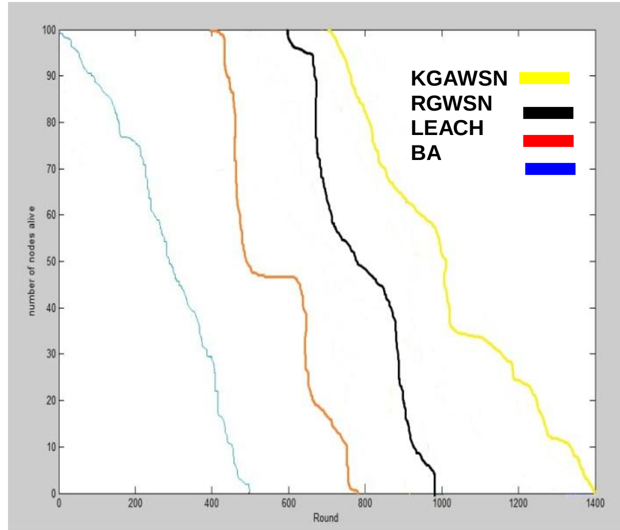

Figure 2. Total number of alive nodes in the KGAWSN, LEACH,RGWSN,BA

Figure 3 shows fitness value after running 50 generations.

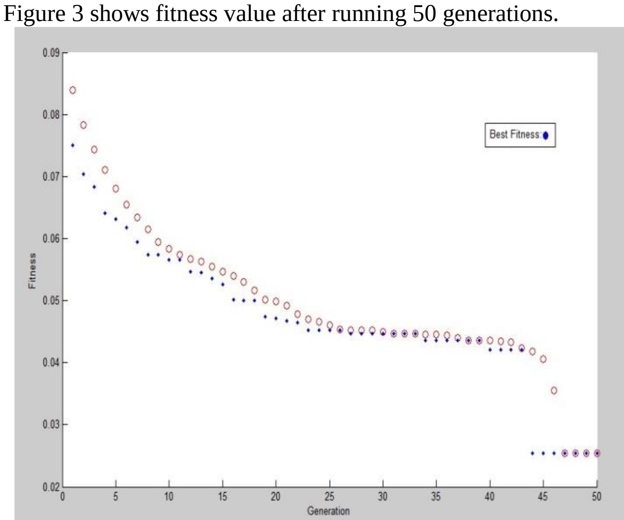

Figure 3. Running a number of generations to find the best fitnessvalue

Figure 4 shows CH selection method in different areas.

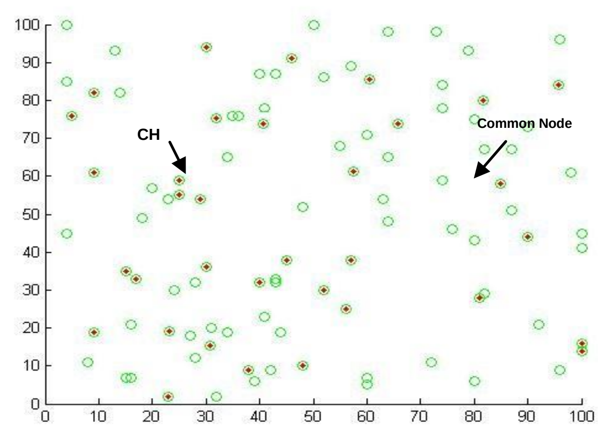

Figure 4. CH selection in different parts of network

As shown in diagram 4, the selection of CH is more in high density areas. So this method has solved the problem of CH selection in some areas with more nodes.

7. CONCLUSION

In this research, a method based on genetic and k-means algorithms has been presented for reducing energy consumption in sensor networks. In this method, a CH selection technique by GA and cluster formation by k-means algorithm have been used. By various simulations, we show that the recommended method can increase sensor networks' lifetime comparing with previous methods. We also show that the problem of CH selection in high density areas has been solved.

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