Кластеризация сенсоров для выбора активных узлов в беспроводных сенсорных сетях с использованием генетического алгоритма

Одним из эффективных путей управления окружающей средой и контроля за ней является использование беспроводных сенсорных сетей. Обеспечение стабильной и надежной связи между узлами и по всей сети, оптимальное энергопотребление и соответствующее сенсорное покрытие среды — проблема первостепенной важности для таких сетей. Разделяя узлы сети на несколько групп, называемых кластерами, можно уменьшить потребление энергии и в результате — увеличить продолжительность жизни всей сети. В каждом кластере один из узлов выбирается главным. Основной задачей является определение количества кластеров и узлов в них, а также выбор главного узла в кластере таким образом, чтобы покрытие среды было стабильным и надежным. В статье рассматривается генетический алгоритм для решения поставленной задачи, который позволяет сбалансировать потребление энергии и продолжительность жизни сети в соответствии с результатами, полученными непосредственно на основе выполненных оценок.

Ключевые слова: *генетический алгоритм, открытие сенсорных сетей, баланс энергии, кластеризация, основная кластеризация, активные группы.*

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Nodes clustering for selection of active nodes in wireless sensors networks by using genetic algorithms

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One of the appropriate ways for monitoring and controlling environment is to use wireless sensor networks. In these networks, energy optimum consumption and environment suitable cover in terms of sensitivity are among important issues. Using network sensors division into several parts, named clusters, one can increase energy consumption and as a result can increase networks life span. In these networks, each of the clusters has a node called cluster head, and the rest of the clusters nodes are considered as clusters members. Among main challenges in this kind of clustering, to be able to cover the whole environment in terms of sensation through connecting network nodes, are number of clusters, number of members in each cluster, and place of each cluster head. In this paper, we tried to apply a genetic algorithm to solve this problem leading to providing balance in energy consumption and to increasing network life span according to results achieved through the performed evaluations.

Keywords-component: *covering sensor networks, genetic algorithm, energy balance, clustering, active groups, and cluster head.*

INTRODUCTION

Sensors connection through a wireless network has generated wireless sensor networks. Through distribution in the environment, these sensors do functions as inducing data, monitoring environmental happenings, and delivering data to sink node to collect final results [1].

In designing wireless sensor networks, the major problems are limitations as: environment suitable covers, energy consumption, and life span [2].

Researches performed so far indicate that using network groups organization and dividing them into clusters, one can get more efficiency of energy that leads to network life span increase. Time passed to death of the first or the last network node is called network life span [3]. Selection algorithm of a subset of active groups to cover the region in a sensitive way from many other groups is a np-complete issue [3, 6].

LEACH protocol [4] for clustering in wireless sensor networks is a very common method composed of two phases: set up phase, and steady state phase. In steady state phase, transporting data is performed in a single hop.

In each of the clusters, nodes called cluster head are selected. Data gathered from member groups, distributed in a uniform way, are locally processed prior to sending to base station or sink node which is in a far distance form other member nodes. Redundant data, if there is any, is deleted from that and then is sent in from of a new parcel to the base node. All groups situation is clear to the base node and ability to send the nodes is adjusted according to their distance from the receiver (fig. 1).

As energy consumption in cluster head is much more than that in member nodes, after a while their energy is ended and so using dynamic clustering in LEACH has been issued. That means that after each time of sending and receiving operations, cluster heads are changed and one of the member nodes is randomly selected as the cluster head. Due to random selection of cluster heads, it is possible that in a part of the area under covering, lots of cluster heads are accumulated and in other part there is no cluster head, i. e. they are distributed in an un-proper way in the network.

Controlling clusters number, cluster heads, and their place, also number of members in each of the clusters are considered as the main challenges with this presupposition that cluster heads are continuously altered in each time of network activity such as sending and receiving. This that how many cluster heads should be selected and where it should be done to have the best efficiency of energy consumption to lead to network high life span is a NP-hard issue. In this paper, we apply genetic algorithm to determine the cluster head place so that it has minimum energy consumption in the network.

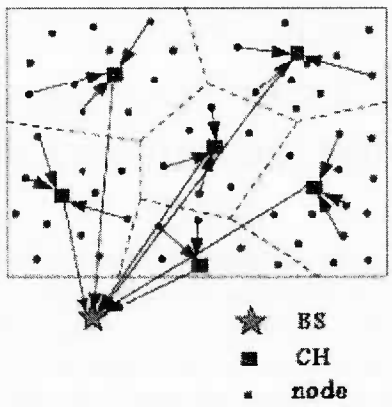

Fig. 1. Shows cluster head selection in LEACH in a random way

REVIEW OF LITERATURE

Hanizlemann provided a model on energy consumption as following [5, 10]. Each member node uses E_s energy to send L bit of data to d distance from itself, this is got by:

$$E_s = \begin{cases} LEelect + L_{\varepsilon fs} d^2 & d < d_{co} \\ LEelect + L_{\varepsilon fs} d^4 & d \geq d_{co} \end{cases}$$

where Eelect is energy required to activate electronic circuits of the sender, d_{co} is a threshold limit, ξ_{fs} and ξ_{mp} are energies for activating capacity elaying for two multi-directional and open air status. If distance from d_{co} threshold is too much, adjusting capacity relay of the sender is performed by a multi-directional model, otherwise, an open air model is used for the channel. Also, some energy is used to get this L bit in the receiver node:

$$E_r = LEelect.$$

Supposing: in each period, one cluster head from each of the nodes of its cluster receives only

one parcel, and sends all useful information of all received parcels in a unified parcel to base station in a single hop.

GENETIC ALGORITHM ESTABLISHED TO SOLVE THE PROBLEM

Genetic algorithms are methods which try to find out the best answer in problem solving space according to looking for mood space in a random way. However, this random searching is led to finding out the best answer by those agents gotten form the nature. The following figure indicates general structure of genetic algorithm (fig. 2).

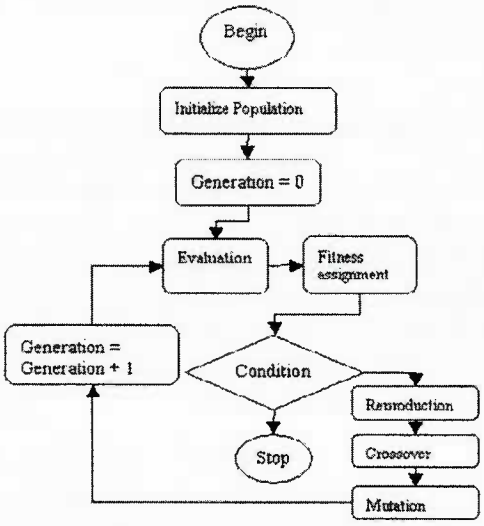

Fig. 2. The generic structure of genetic algorithms

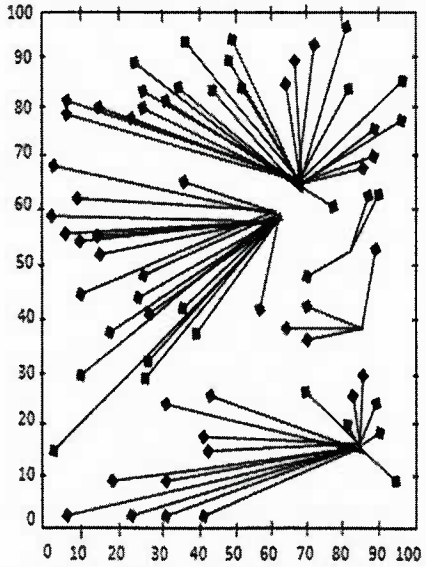

Fig. 3. Represents cluster head distribution in a uniform way with established algorithm which has been much better than LEACH

In this article supposes that all cluster composing and management operations are performed in the base station which does functions as a robust center of processing with unlimited source of energy. It can classify all network nodes situation in coordinated clusters in terms of total energy consumption, after receiving energy information in a way that structure, resulted from the nodes and cluster heads which are distributed in the network level, would have the least amount of energy consumption that is called running phase.

After clusters composition, all nodes recognize their clusters head and send data according to the TDMA[1] timetable, determined by cluster heads and sent to the nodes, that is called permanent state phase. The collection of running phase and permanent state is called a period (Rounds). At the end of each period, clustering operation is re-performed [1] (fig. 3).

A. Definition of chromosome structure

To define a genetic algorithm the first step is to define its chromosome structure. In this genetic algorithm, number of required cluster heads, determined in the base node by network designer, determines length of the chromosome. Each of genes of this chromosome is an indicator of a number of network nodes whose reminded energy is more than network energy mean. The chromosome structure is as following in which L is chromosome length and gi is ith gene:

$$chrom = \{gi / i = 1,2,\ldots,L\}.$$

Where:

S. ID reveals the indicator,

S. residual Energy reveals the node's reminded energy,

N is number of all nodes,

and Emean is network energy mean.

$$g_i = S.ID \quad ID = 1,2,\ldots N,$$

where:

$$residual\ Energy \geq Emean.$$

[1] Time Division Multiple Access

B. Evaluation function

In each genetic algorithm a definition of «better» and «wrose», provided on the basis of a function called Evaluation function, is necessary. Performing the «Cross over» and «Mutation» operations of base node, a chromosome, which provides the least amount of fitness or, in other words, the least network energy difference with the previous period, is selected and introduces the nodes in it as a cluster head to the network. If the network's achieved energy in the kth period is represented by $E^{K}_{network}$, then the evaluation function is as fllowing that must be Min:

$$fitness = \left| E^{K}_{network} - E^{k-1}_{network} \right|.$$

The new generation chromosomes are selected from those that have reduced the energy consumption by the network. According to rolling wheel, the probability of selecting the chromosome that has done too is much more than the others; the rest of algorithm phases such as providing a cluster and timetabling is matched with LEACH algorithm (fig. 4).

EVALUATION AND EFFICIENCY

For evaluation, the algorithm; suggested in MATLAB software, is simulated and compared with LEACH protocol, then the results are provided in diagrams.

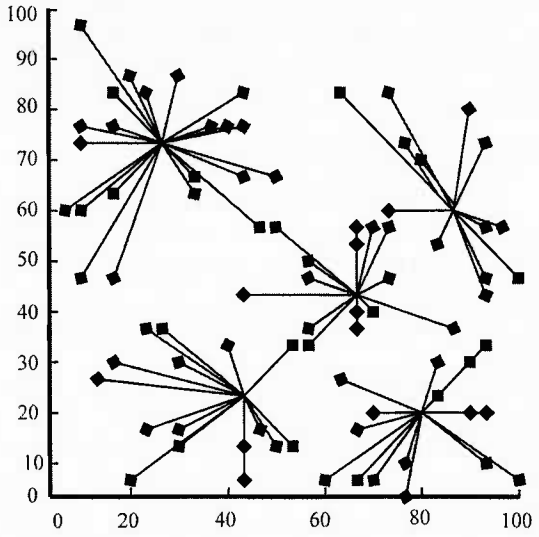

Fig. 4. Indicates reduction amount of energy consumption by the network during its life span. We compared them in 150 periods of sending and receiving of data

In this simulation, we suppose that network size is 100 m and number of the nodes is 100. The primary energy is

$$E_{elect} = 50nj / bit, 0,1j, d_{crossover} = d_{co} =$$
$$= 87m, \xi_{fs} = 10pj / bit / m^2,$$
$$E_{DA} = 5nj / bit / signal,$$

and size of the parcels is 4000 bits.

Also, parameters applied in the genetic algorithm are:

Primary population: 100
Chromosome length: 5
Cross over rate: 0,5
Mutation rate: 0,02
Iteration: 100.
Where:

Iteration amount is algorithm stop condition (fig. 5, 6).

We compared them in 150 periods of sending and receiving of data.

As it is clear, the established algorithm has considerably increased the death time of the first network node in comparison with LEACH. Even after the death of the last node, number of the passed periods is much more.

CONCLUSION

In this paper, a solution is provided through using the genetic algorithm, established in the base station center. This solution determines the cluster head place in a way that leads to the least

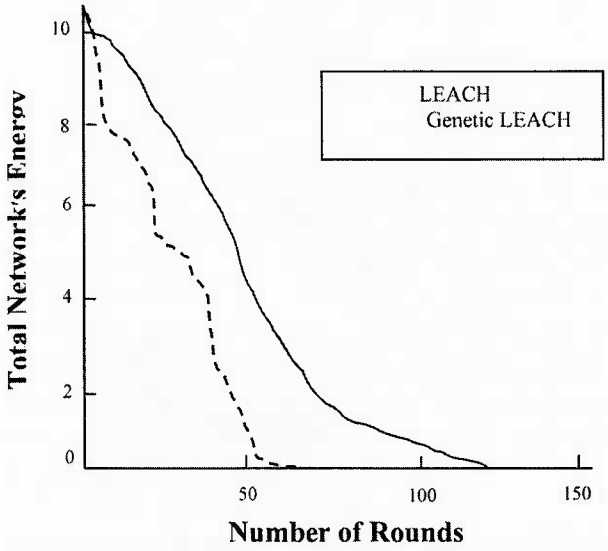

Fig. 5. Indicates reduction amount of energy consumption by the network during its life span

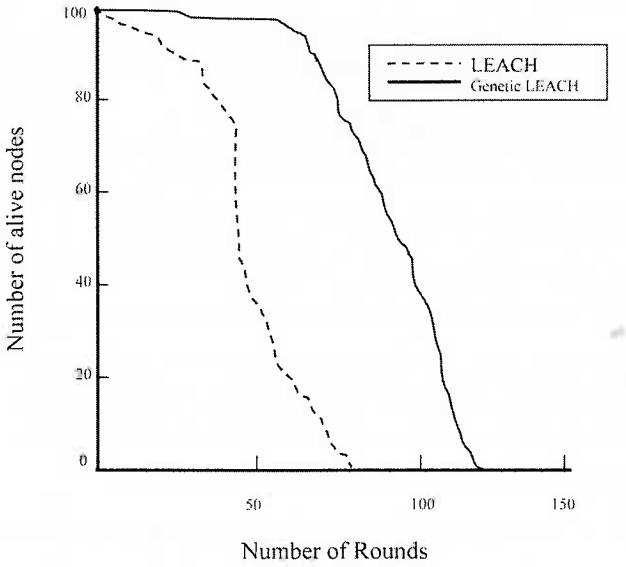

Fig. 6. Reveals sensor network life span increase compared with LEACH

energy consumption in the network which in turn results in network life span increase. As further studies, one can decrease the suggested algorithm complications using better methods for primary coding and for more appropriate evaluation function.

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