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IMPROVEMENT OF AN ENERGY BALANCE METHOD OF LEACH BASED ON GENETIC ALGORITHM

In most implementations of wireless sensor networks fixed stations used to distribute information, but it leads to high-speed energy consumption by sensors which around and also the sensors are located on high-traffic routes lose their energy. So that after some period of time network environment will be fragmented. Therefore, the use of mobile stations in Wireless Sensor Network (WSN), advantage energy balance consumption among all sensors in providing a coverage area. It will be causing to increase the lifetime of the sensors and ultimately prolonged network lifetime. This paper proposes a new improved algorithm of LEACH protocol (LEACH-TLCH) which is intended to balance the energy consumption of the entire network and extend the life of the network. The new algorithm is emulated by Opnet simulation platform; the simulation results indicate that both energy efficiency and the lifetime of the network are improved.

Keywords: *energy consumption, LEACH protocol, network lifetime, genetic algorithm, Opnet simulation.*

Introduction and problem statement

LEACH Protocol is a typical representative of hierarchical routing protocols [1]. It is self-adaptive and self-organized. In this work, by the environmental monitoring of sensors and their locations, each will be evaluated with useful data and will be used. Otherwise, the sensor which is not having sensing data will not participate in the network lifecycle and energy consumption. Now, if in WSN use more mobile stations, the higher efficiency of the method will be reached. Therefore, several mobile stations at the same time monitoring the environment and they will choose the most appropriate sensors to communicate and transfer data through to the target mobile station. That station with higher load sensing will be selected for data distribution. In this work proposal method of data distribution with the mobile station will be explained. The genetic algorithm used to choose the most appropriate mobile station and data distribution.

1. Description of LEACH algorithm

In WSN, LEACH protocol can save network energy greatly compared with the non-cluster routing algorithm [2, 12-15]. Many other clustering algorithms are proposed based on LEACH, such as TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol) [3], PEGASIS (Power-Efficient Gathering in Sensor Information Systems) [4], HEED (Hybrid Energy-Efficient Distributed Clustering) [5] and so on. The design of an energy-efficient routing protocol for WANs requires a detailed insight into algorithm design and energy management strategies. This section describes the LEACH algorithm using the network that has the following characteristics [6-10]:

- All the sensors had the same size, limited energy and distributed in a square area.
- Mobile stations are monitoring periodically with random moving.
- The mobile station has unlimited energy.
- Position and profile of sensor nodes are fixed.
- Sensors can be regular their transmitter power.

Each time when any change of stations location or pause happened implementation, data processing and dissemination are doing. Considering the above parameters for the network process of data distribution with mobile node will be explained.

In the first phase - detection covered sensors by each mobile station. After setting up the network and sensors, the mobile stations that entered to the environment should be identified itself to the sensor of the network.

Station:	Station Number	Location address of station

Replying Message by Sensor:	Sensor nodes number	Location addresses of sensor	Level of the sensor energy

Figure 1. The structure of sending by station and replying message by sensor

According to the data of each of the covered sensors, which shows its active or passive of sensing operation, record the value for it, a value of 0 for passive sensor and 1 for the sensor which actively sends data. Therefore, there will be a table for each of the mobile stations, which each sensor has one of this two parameter 0 or 1.

The second phase is the determination of the most appropriate mobile station.

2. Parameterized problem with genetic algorithms

In this work, an optimization method based on genetic algorithm will be discussed. The intended purpose is the increasing operational speed and prolonged network lifetime. This section describes and analyses the performance of this algorithm, as the main issue which is the selection of best node for transmission. Before the implementation of the algorithm some assumptions should be made:

First assumption:

Determine the structure of chromosomes, according to the wireless sensor network. Genetic algorithm starts to solve a problem with a series of random answers which called Population. The Population made up of the number of chromosomes, and each chromosome contains genes, the genes can be binary numbers. Now, to determine the initial population in wireless sensor networks assumed: Sensors within the network were developed in different places at random considered as genes, and mobile stations are being monitored environment we identified as chromosomes. This determination of parameter can be set and design environment based on genetic algorithm. After the main two parameters have been determined, one can go to the next process through the algorithm.

The second assumption - set target function:

The aim of this project is the selection of the most appropriate published stations. The function should be considered to help to choose the most appropriate, so parameter will be considered for selecting chromosomes. The best selection is to choose the most appropriate station which has the most active sensors. By this way, the transfer speed increased, and the energy consumption of the network will reduce. Parameters and objective function to determine the propriety can be expressed as follows:

$$fitnees_j = \sum_{i \in N}((p_{ij} + a + e_i) - m_i)^* y_{ij}, \qquad (1)$$

where y_{ij} – if the i-sensor in j-station is enabled, a value of 1, otherwise a value of 0 will be considered (this parameter in the mobile station table (chromosomes) showing that the sensor (gene) is enabled. (Figure 2); e_i – energy consumption by i-th sensor; p_{ij} is a cost of the i-th sensor to the j-th mobile station; a – is an energy required to power a sensor and m_i is a remaining energy of its sensor.

According to the equation of target function as a number of sensors to be more active in the desired station fitness function will be larger and therefore more chance to be also selected.

Sink 1->N9=0,N7=0,N6=9,N5=0,N4=0,N3=0,N2=1, N1=0;

Sink2->N34=0,N40=1,N35=0,N36=1,N37=0,N38=1,N39=1, N8=0;

Sink3->N16=0,N15=0,N14=0,N13=0,N12=0,N11=1,N10=0;

Sink4->N33=0,N32=0,N31=1,N30=1,N29=0,N28=0,N27=1, N26=1,N25=0;

Sink5->N17=1,N24=0,N23=0,N21=0,N22=1,N20=0,N18=0.

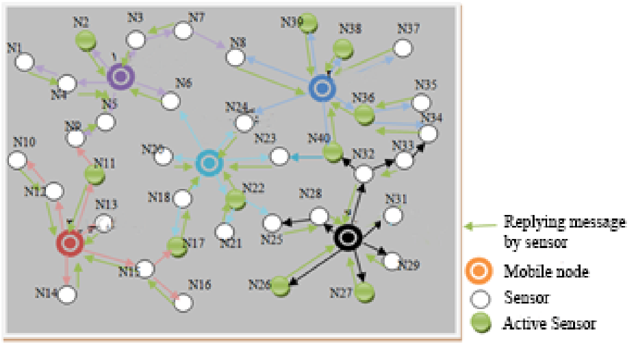

Figure 2. Identifying coverage sensor and creating binary tables of each station

Using the formula to calculate the objective function was introduced, the fitness of each mobile station can be obtained. The next step algorithm will benefit from it.

The third assumption - Selection:

Once in a generation, an individual is selected, it means that this person deserves to reproduce, or direct participation in the next generation will be. Depending on the conditions governing selection has a variety style and techniques. So after determining the fitness function for each mobile station, turn to choose the best station of derived functions, is to transmit information. Genetic algorithms are several ways to select the most appropriate target. This implementation of the method used Roulette Wheel Selection.

The performance of this method is that the probability of a hypothesis h_i for using in the next population depends on the ratio of its fitness to fitness of other members. That is:

$$P(h_i)\, fitnees\ (h_i) / \sum_j fitnees\ (h_j) \qquad (2)$$

The hypothesis is more likely to choose the most appropriate. This possibility it also fits with the hypothesis other than the opposite. In this method distance from zero to fitness, the collection will be taken into account, next the value of finesses is placed side by side on a such a distance that the distance of each is equal to its fitness. Hence, circumference is the sum of all fitness of intended mobile stations and the proportion of each of the mobile stations considered as a sector. The wheel is spun N times, where N is the number of stations. At every turn, these mobile stations wheel marker is selected and placed in the tank of next generation parents.

Therefore, the selection should be such, that selected station increase prolonged network lifetime and its productivity must be used for the next steps.

The fourth assumption - cutting (Crossover):

After the selection of a genetic algorithm, it is time to integration step. Now two mobile stations donate the number of their sensors to create the next generation. If they do not adjust (sensor does not turn off) as they are with no change will be transferred to the next generation, and the most suitable option will be selected. Crossover grade indicates how often sensors change, and the possibility of implementation will consider p = 0.5.

Assuming fifth - mutation:

Mutation is one of the phenomena of genetic science that rarely occur in some chromosomes. The role of mutations in genetic algorithms to restore lost or missing genetic material into the population. To prevent premature convergence algorithm, reach locally optimal solutions. In mutations, a series of gene randomly chosen then zero turns to one and one to zero. In implementing this functionality in wireless sensor networks where the sensor is activated during the run of the publication this process is done, and the desired gene in the chromosome (mobile station) has changed from 0 to 1 or if the cause is off marker gene will change from 1 to 0. The operation will be done taking into account the probability for each gene (p_ (mutation = 0.05)).

The sixth assumption - Finish algorithm:

After performing the steps of the algorithm, it is time to finish it; the following conditions should be considered:

Get the final answer in any particular period.

End each period in the specified time.

So, in any specified period for each stage of publication of data, sensors that are not involved different processes of algorithms remained silent, and energy will not consume. Duration of each period identified and achieved according to the network parameters and the type of sensor used in the network. At the end of the algorithm, the lifetime of the network should be considered for the entire periods and depend on the power consumption of each period calculate the total network lifetime. For this operation, regard to the energy of k-th period (E_k) total energy of network will be shown by E_t, the network remaining energy will calculate by the following formula:

$$E_r = E_t - \dots - E_{k-1} - E_1 \qquad (3)$$

3. The implementation steps of the algorithm

After parameterization, the problem with genetic algorithms in this section theoretical implementation will be discussed (Figure 3). For that there are several steps:

Step one - set up a wireless sensor network with a defined field, m mobile station and n sensors which distributed randomly.

The second step - the stations at current location start identified themselves with a broadcasting message to the sensors that around and in their next steps (In each

step the stations make a pause for some time and move at a certain speed and in random order).

Step Three – sensor station in response to the identifying message of the mobile station sends a membership message to a mobile station which closer.

Step Four – after the stations receive messages from the sensors they are as follows: (begin Genetics Algorithm).

The first step of Genetic: create the initial population:

- Each station (chromosomes) makes up a table for itself. Each sensor (gene) if enabled the value of 1 otherwise 0 will consider at their table.

The second step of Genetic: determination of target function:

- According to the following formula for each of the mobile stations a lot of metrics will be considered:

- For each of the mobile stations (chromosomes), one fitness value will be considered.

The third step of Genetic: choose the most suitable mobile station: using the method of roulette wheel choice will be done:

The collect rate of total station and the result shows as u.

- The following steps will be done n times (n number of stations)

- Select a random number(r) between 0 and u.

- The station which completes the limit can be chosen as the selected station.

The fourth and fifth steps of Genetic: mutation Cutting:

If in some period of time sensor turn off or turn on the table indicators change from zero to one or from one to zero, this leds to the new state in a station, which would be a new situation and get back to the period of determination of the objective function.

Finish the algorithm which happens in a case of the outcome the time of period or gets a result and selects the best station.

4. Simulation and Results

After describing the steps of the algorithm in a networked environment and parameterized according to the wireless sensor network, using Opnet [16] to simulate the scenario and following parameters for simulation will be considered:

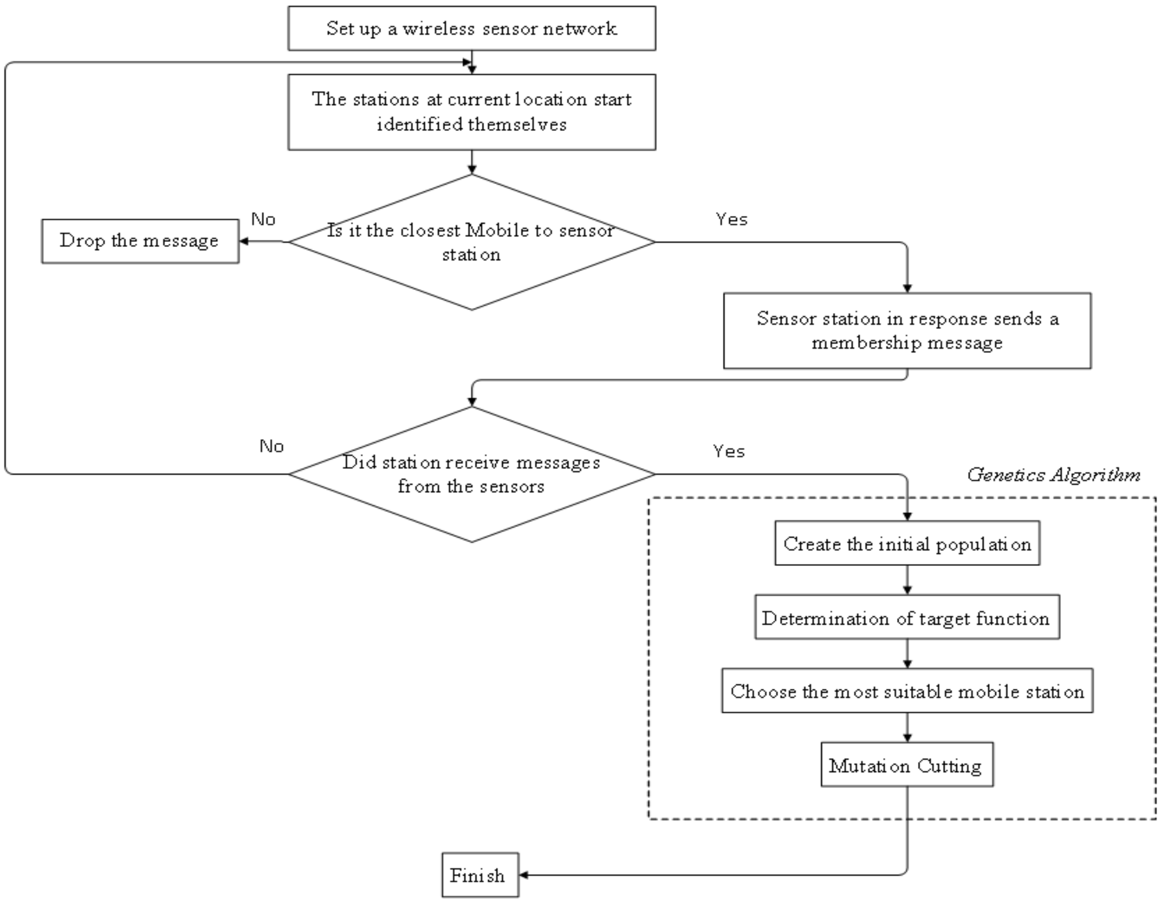

Figure 3. Genetic algorithms for selection of the best appropriate wireless sensor

Scenario: Cartesian network environment in size 100 × 100 is implemented, and position sensors and stations are integer Cartesian grid. The location of each sensor consists of two parameters that determine the location of the coordinates on the grid, which are placed just randomly.

Mobile stations are in the same way randomly located on the screen every time after running the simulation location will change randomly. In the scenario, there are 5 stations, 100 Sensors and the network size is 200*200.

Table 1 shows some of the basic parameters which used in the simulation, some of them were presented as a matrix of values in a simulation.

In the first step after the placement of sensors in a networked environment, identify their location on the Cartesian grid which plays the role of the network environment. And their coordinates and distance sensor station checked to determine the desired sensor is belonging to which mobile station in that period of time. So the shortest distance from a sensor to stations is obtained using Euclidean equation.

Table 1

Parameters For Simulation

Parameters	Value	Parameters	Value
Sensor's Energy	E(40*1)	Number Of Station	5
The energy required powering the sensor	A(40*1)	Number Of Sensors	100
i-th Sensor path cost to j-th destination	P(40*5)	Network size	200*200or * 100 100
Number of periods	Maxit=100	The sensor energy	100 j
Number of population in each period	Npop=5	The energy required powering the sensor	10 j
Rate of crossover	Pc=0.8	i-th Sensor path cost to jth destination	100 j
Rate of mutation	Pmu=0.2	Packet size	2000 bit

Table 2 shows a part of the output of this step in the simulation.

Table 2

Coordinates And Distance Sensor Of Sensors

Sensor ID	Coordinates (Cartesian)	The distance between sensor to station in order from 1 to 5	Belonging to Station No. (Assignment)
1	[148,47]	[23.70,25.17,148,62,117.38,70.02]	1
2	[147,195]	[169.29,173.01,140.94,103.23,78.05]	5
3	[174,17]	[38.07,29.42,187.10,157.03,102,83]	2
4	[73,74]	[80,88.81,73.59,57.42,88.19]	4
5	[137,120]	[94,98.32,114.28,71.84,13.34]	5
6	[158,73]	[51.47,52.63,145.77,108.75,44.72]	5
7	[41,17]	[96.42,104.12,112.45,116.70,147.92]	1
8	[155,41]	[23.43,21.47,158.09,126.57,76.16]	2
9	[78,110]	[102.64,110.69,57.87,24.18,72.33]	4
10	[46,129]	[137.44,145.77,23.02,20.09,104.69]	4
11	[97,30]	[40.19,48.66,122.80,105.65,101.87]	1
		…	
76	[162,150]	[126.49,129.12,140.73,97.86,35.11]	5
77	[24,105]	[137.87,146.73,23.02,49.39,126.57]	3
78	[65,109]	[109,87,118.19,46.09,22.02,85.37]	4
79	[80,83]	[80.61,89.14,72.62,50,77.82]	4
80	[36,51]	[104.04,112.79,78.08,85.44,131.72]	3
81	[4,185]	[207.29,215.52,60.08,82.21,161.05]	3
94	[191,89]	[82.97,81.27,172.46,131.86,49.64]	5
95	[12,174]	[193.72,201.97,47.29,69.02,149.30]	3
96	[126,71]	[46.32,52.55,117.72,84.85,51.88]	1
97	[200,45]	[65.80,59.61,195.49,159.22,87.65]	2
98	[131,121]	[95.18,99.98,108.22,65.76,19.41]	5
99	[77,28]	[60.03,68.26,113.64,103.58,115.10]	1
100	[5,84]	[144.18,153.11,47.53,77,148.70]	3

In another processing matrix for each station, location is considered, concerning the proposed plan in previews section, activation of the sensor will be determined. It can be raised so that:

- The location of each station in each period with specific coordinates on the network.

- A matrix [1*n] that represents the active (1) or inactive (0) of the sensor for that station.

For example, for the first station in this simulation in some period it is considered as follows:

Station (1,1).Cartesian = [137,26]

The distribution of this sensor for the device is shown in figure 4.

As it was shown in Table 4-2, this station has 20 active elements in its coverage area. Thus, mobile stations in each after changing locations and reached to the new coordinate they identify new coverage. And by creating a matrix and use in the next steps.

Now after determining of coverage sensors in each period of the population, it is time to execute the genetic algorithm and select the best station. For each station, we had a chromosome into account in this implementation throws to the same theory, and have assumed the number of chromosomes in the initial population algorithm equal to 5. And so this formula to get the most appropriate, for each of the chromosomes according to the proportional data value earned and will assume separately.

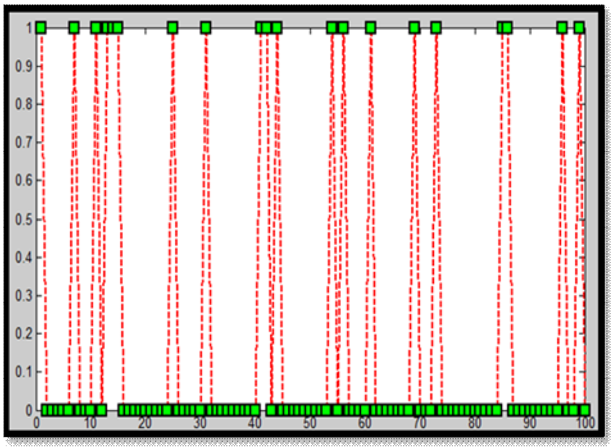

Figure 4. The sensor distribution for the first station

It's taken Implementation of the genetic algorithm for the 100 periods. In these periods at each station, a new location and new cost considered and sensors that belong changed. In each case separately calculate the cost and appropriate cost will be done. After the implementation of the 100 periods, the most appropriate of them will be selected and compared with the results of all periods. So that for each period, some amounts of the best pop will be considered, that it would be the most appropriate genes in each period at the "observed" position. For example, the distribution for the most appropriate chromosome in period seven will be as follows (Figure 5).

As well as sensors for transfer to any station within a particular period can be seen in the best pop in into assigned, which by using a matrix number of station and number of allocation sensor specified. For example, this can be seen in a period 20.

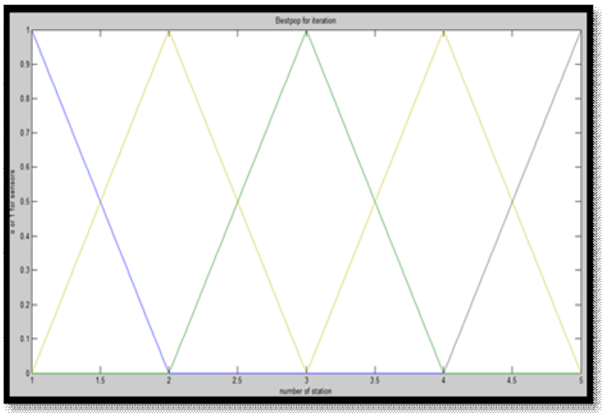

Figure 5. The distribution
for the most appropriate chromosome

[1,1],[5,2],[2,3],[4,4],[5,5],[5,6],[1,7],[2,8],[4,9],[4,10],[1,11],[2,12],[1,13],[1,14],[1,15],[3,16],[4,17],[5,18],[5,19],[4,20],[3,21],[3,22],[5,23],[5,24],[1,25],[5,26],[4,27],[3,28],[5,29],[3,30],[1,31],[4,32],[5,33],[3,34],[3,35],[3,36],[3,37],[4,38],[3,39],[5,40],[1,41],[1,42],[5,43],[1,44],[3,45],[2,46],[4,47],[3,48],[4,49],[4,50],[3,51],[3,52],[5,53],[1,54],[4,55],[1,56],[4,57],[4,58],[4,59],[4,60],[1,61],[4,62],[5,63],[5,64],[4,65],[5,66],[2,67],[5,68],[1,69],[2,70],[3,71],[5,72],[1,73],[5,74],[2,75],[5,76],[3,77],[4,78],[4,79],[3,80],[3,81],[5,82],[3,83],[5,84],[1,85],[1,86],[3,87],[5,88],[5,89],[4,90],[4,91],[5,92],[4,93],[5,94],[3,95],[1,96],[2,97],[5,98],[1,99],[3,100].

Where each row includes a vector in which the second verse of each vector represents the number of sensors and the first element of the vector display and the station number assigned to it. For example, [2.12] indicates that sensor. 12 is assigned to Station 2. In each period depending on the population that is created, there is the possibility of mutation and composition which led to the creation of new child chromosomes. These new chromosomes can be more appropriate for selecting. Thus, the time period increased or the number of searching attempt for selecting. For example, to display station number 2 in period 20, for a given sensors 150 possible permutations intended that vary depending on the mutation and composition for each chromosome. The following chart shows the distribution of these sensors at station number 2 in period 20 (Figure 6).

Thus, for each of these chromosomes, a combination value is considered, which led to the creation or non-creation of a combination of desired chromosomes. Figure 7 represents the combination in period 20 for station 2.

In determining the most appropriate chromosome in each period, one of the parameters which determine the suitability of chromosomes is select as cost. With shows in cost portion of the bestpop menu.

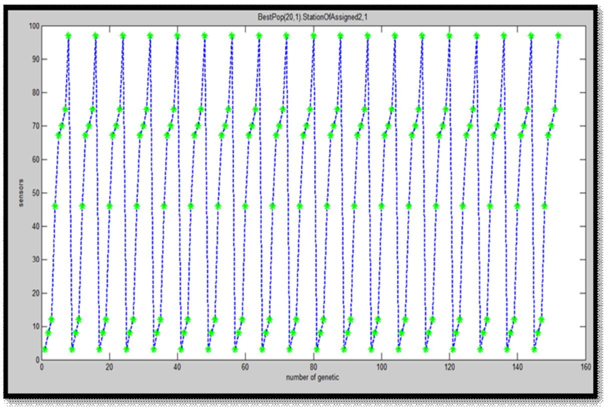

Figure 6. Distribution of the sensors
at the station number 2

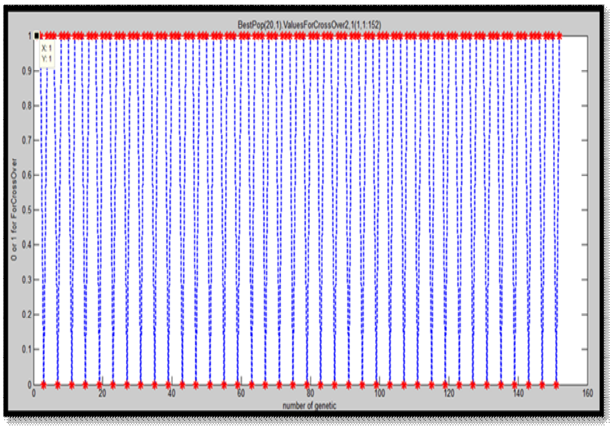

Figure 7. Combination value in period 20
for the station number 2

Conclusions

In most implementations of WSN fixed stations used to distribute information, but it leads to high-speed energy consumption by sensors which around and also the sensors are located on high-traffic routes lose their energy.

To increase the lifetime of the sensors and ultimately prolonged network lifetime proposed the method, in which using wireless sensors to distribute information. The proposed method is based on genetic algorithm for selection of the best appropriate wireless sensor. In this way, firstly parameterized problem with genetic algorithms had been done. After that theoretical implementation had been discussed.

The result shows the process of determining the most appropriate chromosome in each period. For example, for the period number 20, [19,44] was the most appropriate choice cost. By this way, instead of using fixed stations, the most appropriate wireless sensor (chromosome) used to distribute information, and it will be causing to increase the lifetime of the sensors and ultimately prolonged network lifetime.

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ВДОСКОНАЛЕННЯ МЕТОДУ ЕНЕРГЕТИЧНОГО БАЛАНСУ LEACH НА ОСНОВІ ГЕНЕТИЧНОГО АЛГОРИТМУ

Мохаммад Амін Салех

У більшості реалізацій сучасних безпровідних сенсорних мереж нерухомі вузли використовуються для розподілення інформації, що призводить до збільшеного розходу енергії сенсорами, що пов'язані з такими вузлами, а також сенсорами, що розміщені на маршрутах такого інтенсивного трафіку. Таким чином, через деякий час мережне середовище стане фрагментованим. Отже, використання мобільних станцій в безпровідних сенсорних мережах покращує енергетичний баланс серед усіх сенсорів в зоні обслуговування. Це призводить до збільшення часу життя сенсорів та, в результаті, до пролонгованого часу життя мережі. В статті запропоновано вдосконалений метод для протоколу LEACH (LEACH-TLCH), що дозволяє збалансувати енергоспоживання всієї мережі та збільшити час життя мережі. Моделювання вдосконаленого методу виконано у середовищі Opnet; результати моделювання підтвердили покращені характеристики енергоефективності та часу життя мережі.

Ключевые слова: *енергоспоживання, протокол LEACH, час життя мережі, генетичний алгоритм, середовище Opnet.*

УСОВЕРШЕНСТВОВАНИЕ МЕТОДА ЭНЕРГЕТИЧЕСКОГО БАЛАНСА LEACH НА ОСНОВЕ ГЕНЕТИЧЕСКОГО АЛГОРИТМА

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В большинстве реализаций современных беспроводных сенсорных сетей неподвижные узлы используются для распределения информации, что приводит к повышенному расходу энергии сенсорами, связанными с такими узлами, а также сенсорами, расположенными на маршрутах такого интенсивного трафика. Таким образом, через некоторое время сетевая среда станет фрагментированной. Следовательно, использование мобильных станций в беспроводных сенсорных сетях улучшает энергетический баланс среди всех сенсоров в зоне обслуживания. Это приводит к увеличению времени жизни сенсоров и, в итоге, к пролонгированному времени жизни сети. В статье предложен усовершенствованный метод для протокола LEACH (LEACH-TLCH), позволяющий сбалансировать энергопотребление всей сети и увеличить время жизни сети. Моделирование усовершенствованного метода выполнено в среде Opnet; результаты моделирования подтвердили улучшенные характеристики энергоэффективности и времени жизни сети.

Ключевые слова: *энергопотребление, протокол LEACH, время жизни сети, генетический алгоритм, среда Opnet.*