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RAWSN: A Routing Algorithm Based on Auxiliary Nodes to Reduce Energy Consumption in Wireless Sensor Networks

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Abstract

In this paper, an algorithm , based on genetics and auxiliary nodes, to reduce energy consumption in wireless sensor networks has been presented. In this research, by considering some parameters as energy and distance, a target function has been created, which is more optimum comparing to other methods. In this research cluster head is selected by genetic algorithm. In RAWSN algorithm a new technique of replacing auxiliary nodes when some CHs 'energies come to an end, is presented. The results of simulation show that the number of alive nodes at the end of each round increases comparing to other methods and this has led to prolongation of network lifetime.

Keywords: wireless sensor network, Genetic algorithm, routing, reduce energy consumption

Introduction

In computer networks, routing is to find a route from source node to destination node[1,12].In a computer network, there may be several routes from source node to destination node, but optimum route is a route which is optimum based on some factors . For example , in some networks one factor is the distance of one node from its previous node. therefore, optimum route is the shortest route . We can refer to routing in wireless sensor networks, as one important thing of routing in networks [2]. Wireless sensor networks constitute some nodes which receive data from their surrounding environment and transmit those data to a Base Station (BS) [3] .One important problem, in this kind of network, is finding an optimum route from common nodes to Cluster Head(CH) and from CH to BS, to transmit data [4]. In these networks, receiving data from common nodes to cluster head (CH) and from cluster head to BS causes energy consumption leading to reduce network lifetime [5,12]. This problem can be solved by using an optimum route . One way to find the optimum route in wireless sensor networks is the use of genetic algorithms(GA) [6,13]. Using GA to find optimum route leads to including all optimum and non-optimum points in each round of running an algorithm[8,6,4]. In GA, bit strands namely chromosomes are used for optimization[7]. In each round of running GA, the existent chromosomes take a genetic operation. By this operation , next generations are created and after running several generations, optimum solution is produced. In this research, a routing algorithm based on genetic and auxiliary nodes has been presented to reduce energy consumption in the networks and then to prolong the network lifetime.

Related Works

The most important algorithm, presented in routing sensory networks, can be referred to as algorithm

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LEACH[4,8,9]. In this algorithm, to be a Cluster head (CH) or not to be a Cluster Head is based on the following threshold:

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

K: the percentage of CH decision(the percentage of being CH),e.g. k=0.05.

r: current round

G: all the nodes which have not been CH in recent 1/p round.

One other algorithm can be referred to as RGWSN[4]. In this method, clustering route and finding an optimum route are done by genetic algorithm. One other way of finding an optimum route in wireless sensor networks is CRCWSN[8]. In this method, a new technique of re-clustering by GA has been used. Also, one other way of energy optimization in genetic- based sensor networks , is a method presented by Jianming Zhang, Yaping Lin, Cuihong Zhou, Jingcheng and Ouyang[10]. In this method, by considering energy parameters by GA, the network lifetime has been significantly extended.

Genetic Algorithm

Genetic algorithm uses a multi- purpose search[1,4,8]. The routine work of GA is based on natural inspiration and in each round of running the algorithm, non-optimum points in the previous rounds are also included. In GA , after running each round, a generation appears. A set of solutions is called population[4,8,12]. Generations are produced by genetic operators. The genetic operators include: selection, composition and mutation .In each generation, after the operation of genetic operators on bit chromosomes a fitness value is calculated for obtained measures (populations), and then the obtained measure is compared to fitness value. By the termination of each generation , the best measure is selected as optimum population based on fitness value and it will be included in the next generation . In each generation and in selection stage, two chromosomes having higher fitness are selected as parents and in composition phase, the two selected parents compose and produce new children .Then the fitness value for children is calculated. The child having the more fitness is calculated in initial population to produce the next generation. This process is run, for several generations, to obtain an optimum solution. In general, GA can terminate under the following conditions:

- The generations reach a fixed value.
- By running GA, no recovery is obtained.
- The average fitness for several generations reaches a fixed value.
- The most fitness value shall be obtained for children.
- A combination of the above-mentioned cases occur.

Network Model and Radio Model

All the nodes in environment and base station(BS) are fixed and they can not be added or removed . The nodes' primary energies are various. The standard radio model , used in WSN, is based on the distance between sender and receiver. Within this distance the shortest distance is crossover distance. Also the transmission power equals:[12,13]

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

In which:

p_t : transmit power

G_t : gain of transmit antenna

λ : wave length of carrier signal (in meter).

When the receiver distance is longer than $d_{crossover}$, transmission power is[9,13]:

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

h_t : height of sender antenna (in meter).

h_r : height of receiver antenna (in meter).

To transmit a n-bit message in a d meter distance , the radio energy consumption equals:[4,8,9]

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

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

Also to receive an n-bit message radio energy equals[4,8,9]:

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

$\in_{fs}$ and $\in_{mp}$ are the parameters which are dependent on receiver's sensitivity and noise shape and E_{elect} is electric energy and dependent on digital code, modulation, filtering .

The New Presented Algorithm RAWSN

Each round of the new proposed algorithm composes of two steady and setup phases. In setup phase, clusters are shaped and auxiliary nodes of each grid , are introduced. In steady phase, data are transmitted to BS. The start of setup phase is by an initial message from BS accompanied by the introduction of auxiliary nodes. Initial message shows the nodes' initial energy. In the proposed method, two auxiliary nodes are considered for each grid. The environment in which the nodes are distributed are gridded and after each grid, some nodes which are likely to be optimum CHs, are selected .The selection of each grid's node is based on the nodes 'closeness to gravity center and higher energy. the closer the nodes to gravity center , the higher its initial energy and the sooner their selection . Then the selected nodes are used to include in GA as chromosome bits. In GA , a binary coding system is used. The chromosome attended in GA has 15 bits. After specifying chromosome bits, 50 populations are created randomly from initial chromosome and then we select populations randomly and binarily and compose them to produce new children. In the selection process, two populations having the highest fitness value are selected. The operations of selection, composition and mutation operators result in 100 populations. Then we apply fitness function on the created population and select several populations as optimum populations. We proceed with this process for several generations until GA stops. In the proposed method, fitness value equals mean energy consumption of the entire network which is calculated by Heinzleman model. Heinzleman has suggested , in a model, that each node, to transmit L bits of data in d distance from itself, consumes E_t energy.

$$E_t = LE_{elect} + L \in_{fs} d^2 \quad d < d_0$$

$$E_t = LE_{elect} + L \in_{mp} d^4 \quad d \geq d_0$$

In which:

d_0: the shortest crossover distance.

E_{elect}: energy required to activate electronic circuits.

$\in_{mp}$, $\in_{fs}$: parameters related to receiver's sensitivity and noise shape.

The energy necessary to receive L-bits data equal :

$$E_r = LE_{elect}$$

In this phase (setup phase), the fitness value is calculated for final population's bits and it is suggested that bits 1 indicate cluster heads(CHs) and bits 0 indicate common nodes. The fitness function or mean energy consumption of the entire network equals:

$$E_{total} = E_1 + E_2 + E_3 + E_4$$

In which:

E_1: energy necessary to send from common node to Cluster Head(CH)

E_2: Energy necessary to receive Cluster Head data from common nodes.

E_3: Aggregation energy in Cluster Head

E_4: Energy necessary to send from Cluster Head to Base Station (BS)

In this phase, after applying fitness function on the selected optimum population and specifying common nodes and CHs, E_1 is calculated for common nodes or bits 0 and E_2, E_3, and E_4 are calculated for CHs or bits 1 . In steady phase, the data transmission from common nodes to CHs is conducted in every grid and based on the transmissions, the initial energy reduces. This is done for several rounds and if in a round a CH's energy comes to an end, auxiliary nodes will be replaced . It is worthy to note that each grid can use only two auxiliary nodes to replace two CHs that their initial energy had terminated. It means that if there is more than one CH in a grid, auxiliary nodes will replace the two CHs whose energy, for the first time, comes to an end and if a CH's energy terminates again in the process of running algorithm, its value(measure) will be 0 and transmit no data. Algorithm 1 shows how to implement the proposed GA. Algorithm 2 shows the GA-proposed method.

Algorithm 3 shows how to implement the proposed Method (transfer phase).

Algorithm 1. Proposed GA

```
Function  Prop_GA
0. START
1. Nodes= Random Value of  Zero and One for Nodes.
2. Num = Number of  Generation.
3. Crom= Create Random Populations  of  Nodes
4. Sets[ ]= Rand_of(Combination(Crom)) _
single_point \\ sets is array.
5. For i=0  to set[ ]
6.    Best_Value= Fitness(Set[i])
7. End
8. If  num!=0  goto 5
9.   else
10.   Return  Best_Value
11. End.
12. End
```

Algorithm 2 **CH selection and cluster formation**

Function CH_Selection_Cluster_Formation

0. **START**
1. Definition of primary energy and auxiliary nodes
2. Networked environment
3. Node Selection of each grid
4. Create initial population
5. Create a random population of initial population
6. **Running Prop_GA**\\ call of algorithm 1 .
7. Selection optimum generation
8. running Steady phase
9. **if** round==0 go to 10

    Else **if** (CH_energy ==0)

    if (number of auxiliary nodes)!=0

    Replacement of the auxiliary nodes and go to 6

    else

    go to 10

    End if

    End if

10. **End**

Algorithm 3 transfer phase

Function Total_Transfer

0. **Call Prop_GA**;//call of 1-algorithm.
1. **Call CH_Selection_Cluster_Formation**//call of 2-algorithm.

R=Round numbers;

2. R=Round numbers;
3. for i=1 to R
4. if (transfer_Type = = Single_Hop) Then
5. **Calculate(E_1);**
6. **Else**
7. **Calculate(E_2);**
8. **END if**
9. **END For**
10. **END Function**

Simulation

The proposed algorithm has been analyzed by MALTAB software . In this analysis, some factors as alive nodes in each round, the number of grids and likely CHs in each grid ,etc, have been considered.

The proposed method has been compared to GSAGA, LEACH and RGWSN methods. Figure 1and Figure 2 shows common nodes and CHs. Figure 3 shows the number of alive nodes at the end of 1400 rounds and figure 4 shows fitness function for the proposed method.

According to the above- mentioned diagrams, it has been cleared that after running 1400 rounds, the number of alive nodes in RAWSN methods is more than that in LEACH ,GSAGA and RGWSN methods. So the network lifetime extends. Also Figures 4,5 show the number of clusters in LEACH and proposed methods.

As shown by diagrams, in RAWSN, clusters formation in different rounds is more balanced than in the LEACH Algorithm.

Table 1. Simulation Parameters

Parameter	**Value**
Network size	100*100 m
Base station location	0,0 m
Initial energy for node	rand [0.2,0.5] J
E_{elec}	50nJ/bit
ε_{fs}	10pj/bit/ m^2
ε_{mp}	0.0013pj/bit/m^4
Data aggregation energy	5nj/bit/signal
d_0	87m
Nodes number of each grid	5
Nodes number	100
Grids number	8

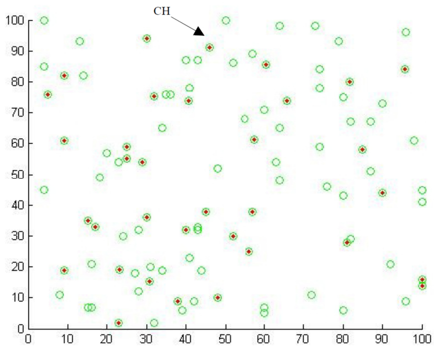

Figure 1. common nodes and CHs

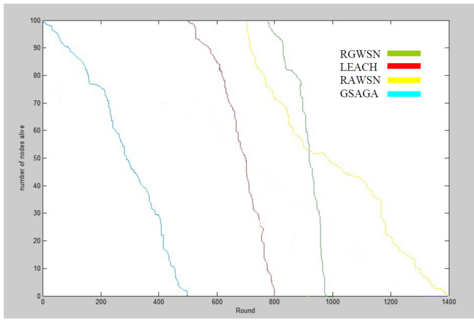

Figure 2. Total number of alive nodes in the RGWSN, LEACH,GSAGA,RCSDN and RAWSN

Results

In this research, a new technique to transmit data from the existent nodes in the environment to BS has been proposed. In this method, a technique of using

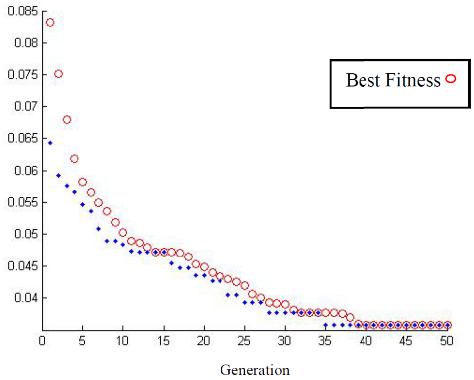

Figure 3. fitness function for the RAWSN

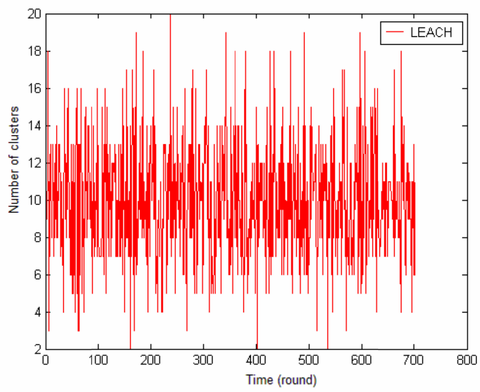

Figure 4. Total number of cluster in different round in RAWSN

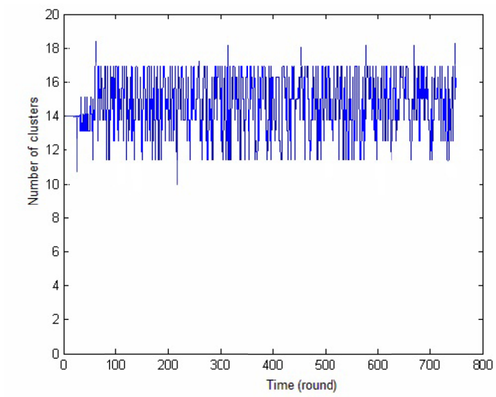

Figure 5. Total number of cluster in different round in RAWSN

auxiliary nodes when CH's energy terminates, has been applied. By various simulations we show that the proposed technique is different from previous methods and can significantly prolong the sensor network lifetime.

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