

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

A.A. Baradaran\*

Department of Computer sciences ,Faculty of sciences, Islamic Azad university,Natanz, Islamic Republic of Iran

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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

\* Corresponding author: Tel: +989133623329; Fax: +983624248735; Email: A.Baradaran24@yahoo.com

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:

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

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

$\lambda$  : 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]

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

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

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

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

$\epsilon_{fs}$  and  $\epsilon_{mp}$  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).

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**Algorithm 1.** Proposed GA

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**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

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**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( E1);
6. Else
7. Calculate(E2);
8. END if
9. END For
10. END Function
    
```

**Simulation**

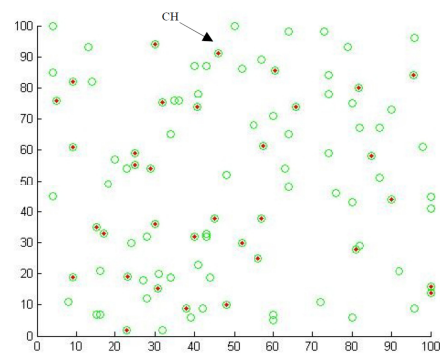
The proposed algorithm has been analyzed by MATLAB software . In this analysis, some factors as alive nodes in each round, the number of grids and likely CHs in each grid ,etc, have been considered.

The proposed method has been compared to GSAGA, LEACH and RGWSN methods. Figure 1 and 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.

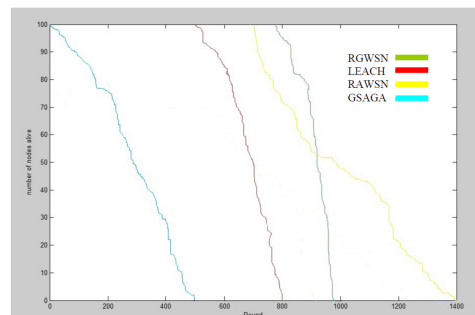
According to the above- mentioned diagrams, it has been cleared that after running 1400 rounds, the number of alive nodes in RAWSN methods is more than that in

**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                    |
| $\epsilon_{fs}$           | 10pj/bit/ m <sup>2</sup>    |
| $\epsilon_{mp}$           | 0.0013pj/bit/m <sup>4</sup> |
| 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,RCSN and RAWSN

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.

**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

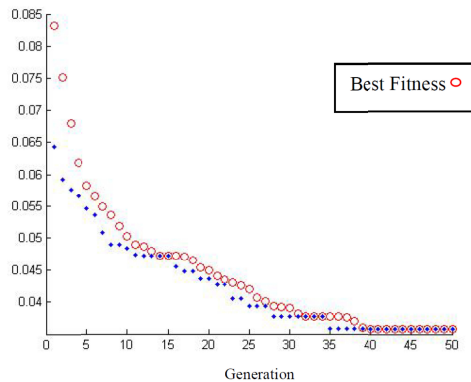


Figure 3. fitness function for the RAWSN

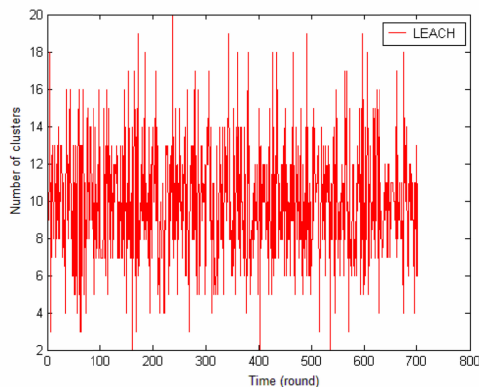


Figure 4. Total number of cluster in different round in RAWSN

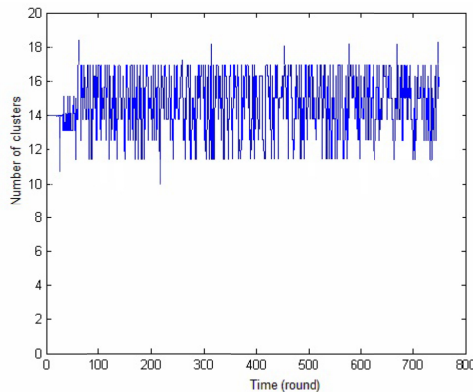


Figure 5. Total number of cluster in different round in RAWSN

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.

## References

1. Purushotham reddy V., Michael G., Umamaheshwari M., Coarse-Grained Parallel Genetic Algorithm to solve the Shortest Path Routing problem using Genetic operators. *I.J.C.S.E*, **2**:39-42 (2008).
2. Rahmani E., Fakhraie S. M., Kamarei M., Finding Agent-Based Energy-Efficient Routing in Sensor Networks using Parallel Genetic Algorithm. The 18th International Conference on Microelectronics:119-122 (2006).
3. Zhou Z., Xiang X., Wang X., Pan J., A holistic sensor network design for energy conservation and efficient. *Comput. Netw.*, **55**:131-146 (2010).
4. Delavar A. G., Baradaran A. A., Artin j., RGWSN: Presenting a genetic-based routing algorithm to reduce energy consumption in wireless sensor network. *I.J.Computer Sci*, **8**:54-58 (2011).
5. Chamam A., Pierre S., A distributed energy-efficient clustering protocol for wireless sensor Network. *Comput. Electr. Eng.*, **36**:303-312 (2010).
6. Yussof S., Razali R.Z., See O.H., A Parallel Genetic Algorithm for Shortest Path Routing Problem. International Conference on Future Computer and Communication, **5**:268-273 (2009).
7. Bari A., Wazed S., Jaekel A., Bandyopadhyay S., A genetic algorithm based approach for energy efficient routing in two-tiered sensor networks. *AD. Hoc. Netw.*, **7**:665-676 (2008).
8. Chamam A., Pierre S., A distributed energy-efficient clustering protocol for wireless sensor networks, *Comput. Electr. Eng.*, **36**:303-312 (2010).
9. Heinzelman W.R., Chandrakasan A., Balakrishnan H., Energy efficient communication protocol for wireless sensor networks. *Proceedings of the 33rd Hawaii International Conference on System Science*, **2**: (2000).
10. Zhang J., Lin Y., Zhou C., Ouyang J., Optimal Model for Energy-Efficient Clustering in Wireless Sensor Networks Using Global Simulated Annealing Genetic Algorithm. *Int. symposium on intelligent information technology application*:656-660 (2008).
11. Dimokas N., Katsaros D., Manolopoulos Y., Energy-efficient distributed clustering in wireless sensor networks, *J. Parallel and distributed computing*, **70**:371-383 (2010).
12. Delavar A.G., alirezaie A., Baradaran A.A., KGAWSN: An effective way to Reduce Energy Consumption in Wireless Sensor Networks by K-means and Genetic Algorithms, *I.J.C.A JOUR*, **48**:26-32 (2012).
13. Baradaran A. A., delavar A.G., CRCWSN: Presenting a Routing Algorithm by Using Re-clustering to Reduce Energy Consumption in Wireless Sensor Networks. *Int. J. Comput. Commun.*, **8**:61-69 (2013).



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

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A.A. Baradaran\*

Department of Computer science, Faculty of Science, Islamic Azad university, Natanz, Islamic Republic of Iran

\*E-mail: A.Baradaran24@yahoo.com

## ارائه الگوریتم مسیریابی مبتنی بر نودهای اضافی برای کاهش مصرف انرژی در شبکه های حسگر بیسیم

امیرعباس برادران\*

گروه فناوری اطلاعات و ارتباطات، دانشکده فنی و مهندسی، دانشگاه آزاد اسلامی، نطنز، جمهوری اسلامی ایران

### چکیده

در این مقاله یک الگوریتم مسیریابی مبتنی بر ژنتیک و نودهای اضافی برای کاهش مصرف انرژی در شبکه های حسگر بیسیم ارائه شده است. در این تحقیق، با توجه به پارامترهای انرژی و فاصله تابع هدفی ایجاد شده است که در مقایسه با روشهای مشابه قبلی بهتر است. در این تحقیق سرشاخه به وسیله GA (الگوریتم ژنتیک) انتخاب می شود. در روش RAWSN از یک تکنیک جدید جایگزینی نودهای اضافی به جای CH هایی که انرژی اولیه آنها تمام میشود، استفاده شده است. نتایج شبیه سازی نشان داد که تعداد نودهای زنده در پایان هر راند در مقایسه با روشهای مشابه قبلی بهبود یافته است که این افزایش طول عمر شبکه را در پی دارد.

واژه‌های کلیدی: شبکه های حسگر بیسیم؛ الگوریتم ژنتیک؛ مسیریابی؛ کاهش مصرف انرژی