International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:5, No:4, 2011

Design and Implementation a New Energy Efficient Clustering Algorithm using Genetic Algorithm for Wireless Sensor Networks

Moslem Afrashteh Mehr

***Abstract*—**Wireless Sensor Networks consist of small battery powered devices with limited energy resources. once deployed, the small sensor nodes are usually inaccessible to the user, and thus replacement of the energy source is not feasible. Hence, One of the most important issues that needs to be enhanced in order to improve the life span of the network is energy efficiency. to overcome this demerit many research have been done. The clustering is the one of the representative approaches. in the clustering, the cluster heads gather data from nodes and sending them to the base station. In this paper, we introduce a dynamic clustering algorithm using genetic algorithm. This algorithm takes different parameters into consideration to increase the network lifetime. To prove efficiency of proposed algorithm, we simulated the proposed algorithm compared with LEACH algorithm using the matlab

***Keywords*—**Wireless Sensor Networks, Clustering, Genetic algorithm, Energy Consumption

I. INTRODUCTION

WIRELESS Sensor Networks consist of a large number of small and cheap sensor nodes that have very limited computation capability, energy and storage. They usually monitor some area, collect data and report to the base station. Recently, due to the achievement in low-power digital circuit and wireless communication, many applications of the WSNs are developed and already it is used in military object, habitat monitoring and object tracking[1][2]. Moreover, the WSN is one of the most important research areas to provide context aware services in the ubiquitous computing environment[3].Designing the WSNs is very difficult because the sensor nodes have limited computation capability, limited power and small memory size[4][5]. Among these three factors, the energy consumption is the most important one because the battery is not changeable if once the sensor nodes are deployed. The energy is also the major consideration in designing the routing of the WSNs .Hierarchical protocols reduce energy consumption in the networks by clustering. In these protocols, nodes are divided into some clusters and some nodes that have more energy than others are the selected as cluster heads[6].The remaining of this paper is organized as follows: Section 2 gives an overview on related works reported on clustering in sensor networks. In section 3 the proposed protocol is presented. Simulation results are given in section 4 and finally Section 5 is the conclusion.

Moslem Afrashteh Mehr is with Department of Computer Engineering, Islamic Azad University Science and Research Branch, Iran e-mail:(Moslemafrashteh@gmail.com)

II. RELATED WORKS

During the last few years, many clustering algorithms have been proposed as an efficient way to organize communication and data processing in a sensor network. LEACH [7] is one of the clustering mechanisms to achieve the energy efficiency in the communication between sensor nodes. In each round, sensor nodes elect itself as a cluster head based on probability model. To elect a cluster head, each sensor node generates a random number δ between 0 and 1. If the δ is smaller than the threshold value T (n), the sensor node elects itself as a cluster head and advertises this fact to other nodes around the cluster head. The most important problem of LEACH is exchanging clusters and losing energy in comparison to other Algorithms. [8]proposes a distributed and randomized LEACH-like algorithm which provides methods to compute the optimal values of the algorithm parameters a prior and use a multi-hop technique in both intra-cluster and inter-cluster communications. ACE [9] is an emergent algorithm that uses just three rounds of feedback to form an efficient cover of cluster across the network. It uses the node degree as the main parameter to elect cluster heads. [10]proposes a clustering algorithm based on ANTCLUST [11]. Using this method, the sensor nodes with more residual energy independently become cluster heads. However, it produces much control overhead during iterations. TPC [12] is a novel two-phase clustering (TPC) scheme for energy-saving and delay-adaptive data gathering in wireless sensor networks. Each node advertises for cluster head with a random delay, and the node who overhears others' advertisement will give up its own advertisement. In such a way, the network is partitioned into clusters in the first phase. In the second phase, each member searches for a neighbor closer to the cluster head within the cluster to set up an energy-saving and delay-adaptive data relay link .With the advantages of chain topology, TPC achieves a great tradeoff between energy cost and delay. PEBECES [13] divides the network into several equally distributed sections and then categorizes them into clusters with different sizes. In this algorithm, each node is equipped with GPS and sends its position and remaining energy to the sink directly. In the method proposed in [14], clusters and cluster heads are selected dynamically using genetic algorithm. This method considers distance between nodes and the number of cluster heads as parameters for clustering but didn't consider the residual energy of the nodes. One of the main parameters for selecting the cluster heads is residual energy of sensor. Gupta in [15] used fuzzy logic to find cluster heads. In this method, during each period, the sensor that has the most chance is selected as cluster head. Three fuzzy variables are used to calculate the chance including: residual energy of the nodes, the number of neighbors of the nodes, and centrality. In this method, the base station determines cluster heads. In Algorithms proposed in [16] and [17], the selected node has higher characteristic than other nodes in its cluster or the neighbor clusters. This algorithm is improved by LCA 2 [18].

In this paper, we propose a clustering algorithm which takes several parameters into consideration for dynamic clustering. This algorithm will balance the energy consumption in the network and prolongs the network lifetime.

III. Proposed Method

Having control over the position and number of cluster heads and also the number of cluster's member is always a challenge. In the clustering of the sensor network, solving this problem requires efficient clustering algorithm regarding energy consumption and balancing the energy. Dynamic nature of the network makes the problem more complex due to repetitive change in the clusters and cluster heads which can't be modeled by the mathematic methods. In the other hand, genetic algorithm is very flexible in solving such a dynamic problems. In this paper, we try to determine clustering and the place of the cluster heads using genetic algorithm in a way that there will be minimum energy consumption while attending the network coverage.

A. *Problem Representation*

In the proposed algorithm, binary representation is used in which each bit corresponds to one sensor node. A "1" means that corresponding sensor is a cluster head and a "0" means that it is a regular node.

B. *Genetic Algorithm Operators*

This algorithm begins its work by randomly generated population of chromosomes. Each regular node finds its nearest cluster head and joins to it. Then the algorithm applies the genetic operators.

a)*Crossover Operator*

In this paper, we use one-point crossover. The crossover operation takes place between two consecutive individuals with probability specified by crossover rate. These two individuals exchange portions that are separated by the crossover point. The following is an example of one point crossover:

Individual 1: 0 1 1 1 0 0 1 1 0 1 0
↓
Individual 2: 1 0 1 0 1 1 0 0 1 0 1

After crossover, two offspring are created as below:

Offspring 1: 0 1 1 1 0 1 0 0 1 0 1
Offspring 2: 1 0 1 0 1 0 1 1 0 1 0

After applying the crossover operator, a regular node may become a cluster head. If so, all other regular nodes should check if they are nearer to this new cluster head. If so, they switch their membership to this new cluster head. This new cluster head is detached from its previous cluster head. If a cluster head becomes a regular node, all of its members must find new cluster heads. Every node is either a cluster head or a member of a cluster head in the network.

b)*Mutation Operator*

The mutation operator is applied to each bit of an individual with a probability of mutation rate. After mutation, a bit that was "0" changes to "1" and vice versa. In fact, it is possible that a regular node becomes a cluster head and a cluster head becomes a regular node.

Individual before mutation: 0 1 1 **1** 0 0 1 1 0 1 0
↓
Individual after mutation: 0 1 1 **0** 0 0 1 1 0 1 0

c)*Selection*

The candidate individuals are chosen from the population in the current generation based on their fitness. The individuals with higher fitness values are more likely to be selected as the individuals of population in the next generation.

d)*Fitness Function*

As the purpose of this algorithm is optimizing energy consumption that results in increasing the networks lifetime, so we have to consider the residual energy of the nodes as a main parameter for selecting the cluster head. The second parameter that is considered is the required energy to send a message toward the sink node. The lower the communication distance, the less energy will be consumed during transmission. Finally, since cluster heads use more energy than other nodes, reducing the number of cluster heads has a considerable effect on decreasing the energy consumption. Each individual is evaluated by the following fitness function:

$$\text{Fitness} = RE+SE+(X * (D) + (1- X) * (N - CH)) \quad (1)$$

$$0 <= X <= 1$$

In this function, RE represents the sum of residual energy in the cluster heads, N is the total number of nodes, CH is the number of cluster heads and the SE represent the sum of required energy for sending information from cluster head toward the sink node and D is the distance between sensors .

$$SE=\sum_{i=1}^{M}(RESi - (RECi + ((M-1) * CHE + CES)) \quad (2)$$

Where RES_i represent the sum of required energy for sending one message from all regular nodes toward the sink node, REC_i represents the sum of required energy for sending one message from all regular nodes toward their cluster head , CHE represents the sum of required energy for receiving M messages from all cluster members and finally CES represents the sum of required energy for sending one message from cluster head toward the sink node.

$$D=\sum_{i=1}^{M}(DRSi - (DRCi + DCS)) \quad (3)$$

Where DRS_i represent the sum of distance from all regular nodes toward the sink node, DRC_i represents the sum of distances from all regular nodes toward their cluster head and DCS represents the sum of distances from all cluster heads toward the sink node.

The value of x ($0 \le X \le 1$) indicates which factor is more important to be considered: required energy (that is related to the distance) or the cost incurred by cluster-heads.

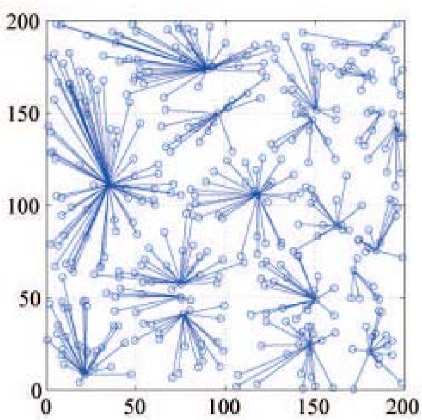
IV. Simulation Result

We have simulated the proposed clustering algorithm using MATLAB software and compared it to LEACH protocol. The list of the used simulation parameters and their values are shown in table 1:

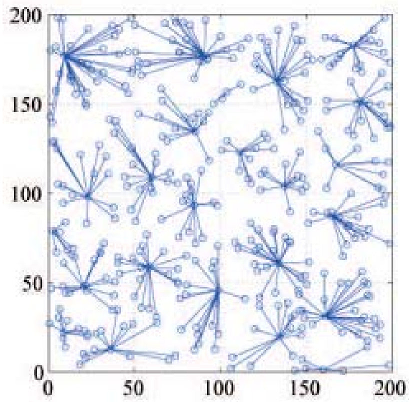
TABLE I
THE VALUES OF THE SIMULATION PARAMETERS

parameters	Values
N	100
Sensing range of nodes	10 m
Network dimensions	200*200 m^2
Initial energy of each node	1 Jules
Packet size	64 Byte
Primary population	200
Crossover rate	0.6
type of crossover	One-point
Mutation rate	0.007
Number of generation	500

In the first experiment, the distribution of the cluster heads in the proposed algorithm is compared to LEACH protocol. Fig.1 shows the result of this comparison.



a) Improper distribution of the cluster heads in LEACH algorithm



b) Proper distribution of the cluster heads in the proposed algorithm

Fig 1 Comparing the cluster heads distribution

As shown is this figure, randomly selection of the cluster heads in the LEACH algorithm may Causes unbalanced distribution of them. This distribution is improved in the proposed algorithm.

In the second experiment, we compared the sum of residual energy of nodes in the proposed protocol and LEACH protocol during different rounds. As can be seen in Fig 2, the proposed algorithm consumes energy uniformly and so, prolongs the network lifetime.

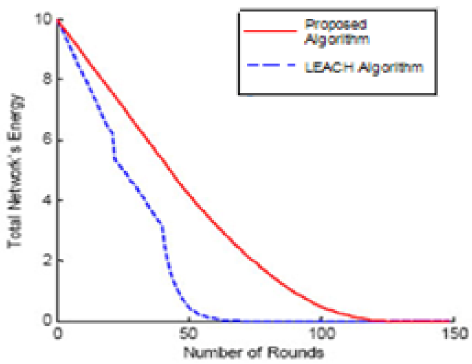


Fig. 2 Comparing sum of residual energy

In the third experiment, we compared the number of alive nodes in our protocol and LEACH protocol during different rounds. The results of this experiment are shown In Fig 3. It can be observed that the proposed protocol has considerably more number of alive nodes in each round in comparison with the LEACH protocol.

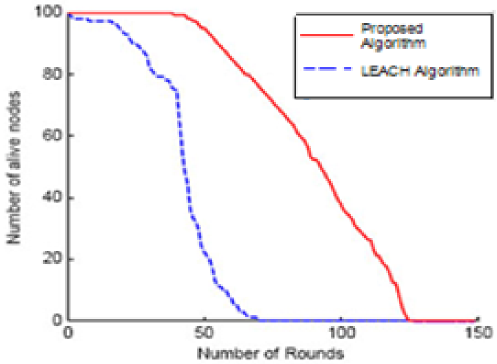


Fig. 3 Number of alived nodes in different rounds

V. Conclusion

In this paper, we proposed a clustering algorithm based on genetic algorithm. The proposed algorithm takes different parameters into consideration to increase the network lifetime. This parameters are residual energy of the nodes, required energy to send a message toward the sink node, and number of cluster heads. In order to evaluate our algorithm, we simulated our protocol and compared it to LEACH protocol. The results of the simulations show the effectiveness of the proposed mechanism.

References

[1] A. Cerpa, J. Elson, D. Estrin, L. Girod, M. Hamilton, and J. Zhao,“Habitat Monitoring: Application Driver for Wireless Communications Technology”, In Proceedin gs of the ACM SIGCOMMWorkshop on Data Communications in Latin America and the Caribbean, San Jose, Costa Rica, 2001.

[2] C. Shen, C. Srisathapornphat, and C. Jaikaeo, “Sensor Information Net-working Architecture and applications”, IEEE Personal Communications,pp. 52-59, August 2001.

[3] S.H. Park, J.S. Cho, S.M. Jung, Y.J. Han, and T.M. Chung, “Architecture of Context-Aware Integrated Security Management Systems for Smart Home Environment” , APNOMS2007, LNCS 4773, pp. 543-546, October 2007.

[4] I.F. Akyildiz, W.Su, Y. Sankasubramaniam, and E. Cayirci, “Wireless Sensor Networks: A Survey”, IEEE Communications Magazine, pp. 102-114, August 2002.

[5] J.N. Alkaraki and A.E. Kamal, “Routing Techniques in Wireless Sensor Networks: A Survey”, IEEE Wireless Communication, pp. 6-23, Decem-ber 2004.

[6] Y. Ossama and M. Srinivasan, "Node clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges", IEEE Network (Special issue on Wireless Sensor Networking), Vol. 20, issue 3, pp.20–25, May 2006.

[7] W.B. Heinzelman, A.p. Chandrakasan and H. Balakrishnan, "An Application Specific Protocol Arthitecture for Wireless Microsensor Networks", IEEE Transaction On Wireless Comunication , 660-670 April 2002.

[8] Bandyopadhyay,S, and Coyle , E. (2003) "An Energy-Efficient Hierarchical clustering algorithm for Wireless sensor networks".Proceeding of IEEE INFOCOM03.

[9] Chan, H. and perrig, A. (2004). ACE :An Emergent Algorithm for Highly Uniform Cluster Formation. Proceeding of the first European Workshop on sensor Networks(EWSN).

[10] Kamimura, J., Wakamiya , N. and Masayuki , M. (2004). Energy-Efficient clustring Method for Data Gathering in Sensor Networks.Proceeding of the Annual International conference on broadband Networks.

[11] Labroche, N., Monmarche, N. and Venturini , G. (2002). A new clustring algorithm based on the chemical recognition system of ants.proceedings of ECAI 2002.

[12] Choi, W., Shah, P.and Das, S.(2004).A Framework for Energy-Saving Data Gathering Using Two-Phase Clustering in Wireless Sensor Networks.*Proceedings of the First*Annual International Conference on Mobile and Ubiquitous Systems: Networking and Services (MobiQuitous’04).

[13] Y. Wang, T.L.X. Yang, D. Zhang, "An Energy Efficient and balance Hierarchical unequal clustering algorithm for large scale sensor network", Inform. Technol.Journal, 28-38,8(1), 2009.

[14] S. Jin, M. Zhou and A.Wu , "Sensor Network Optimization Using a Genetic Algorithm", School Of EECS, University of Central Florida,Orland ,FL 32816.

[15] G. Riordan and S. Sampalli, "Cluster- Head Election Using Fuzzy Logic for Wireless Sensor Networks",In Proceedings of IEEE Communication Networks and Services Research Conference , Pages 255-260,May 2005.

[16] O. Zzitoune, M . aroussi, Rziza, D. Aboutajdine, "Stochastic Low Energy Adaptive Clustring Hierarchy", ICGSTCNIR, volume(8), Issue(1), pp 47-51. 2008.

[17] H. Junping, J. Yuhui and D. Liang, "A Time-base Cluster-Head Selection Algorithm for LEACH", in proceeding of IEEE Symposium on computers and communication 2008 (ISCC 2008), Marrakech ,Morroco. July 6-9 , 2008

[18] W. Ye, J. Heidemann, and D.Estrin , "An Energy - Efficient MAC Protocol for Wireless Sensor Networks " , in proceeding o the 21st International Annual Joint Conference of the IEEE Coputers and Communication Societies (INFOCOM 2002), New Yok, NY , USA , June, 2002.