Journal of Theoretical and Applied Information Technology
30th November 2011. Vol. 33 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AN EVOLUTIONARY APPROACH TO IMPROVE THE LIFE TIME OF THE WIRELESS SENSOR NETWORKS

[1]B.BARANIDHARAN, [2]B.SANTHI
[1] Assistant professor, School of Computing, SASTRA University, Thanjavur, India.
[2] Professor, School of Computing, SASTRA University, Thanjavur, India.

E-Mail: [1] baranidharan@it.sastra.edu, [2] shanthi@cse.sastra.edu

ABSTRACT

Energy efficiency in the wireless sensor networks is the major factor which determines its usability in applications like military surveillance, environmental monitoring, and health care monitoring. Improving Energy efficiency through evolutionary computing algorithms is the latest research phenomena for wireless groups all around the world. Mostly, due to the dense deployment of sensor motes in a monitoring area redundant data will be given to the sink nodes. In the recent works done in this NP-hard problem routing activity is only concentrated much to conserve the energy within the network. Here in our proposed work genetics operators are applied in such a way to reduce the redundant information to the sink station and conserve its energy reserves.

Keywords: *Sensor, Energy Efficiency, Clustering, Genetic Algorithm, Life Time*

1. INTRODUCTION

Wireless sensor networks (WSN) revolution had made this world to become global village. The information technology revolution has its impact on the sensor field as it becomes the reliable information source to the pervasive computing environment. Nowadays, WSN has become the integrated component in the military surveillance, medical diagnosis, weather forecasting, fire detection alarming systems, etc… Though its application is unlimited its implementation in certain fields like precision agriculture, water management is difficult due to its energy constraints. In the environmental monitoring systems the researchers are expecting it to run un attend for at least a year.

In the recent years more concentration is done only on the energy conservation in WSN through selecting optimal path in the routing. Although it gives the desired result, frequent rearrangements within the network like addition of new nodes, death of energy depleted nodes urges the WSN again to form the new routing schemes. Here, in our proposed work the energy conservation is achieved through the efficient clustering through genetic algorithm approach. In clustering we are following two approaches, (i) Distributed clustering, where the nearby nodes form their own clusters without any central entity involvement but in (ii) Centralized clustering, the clusters are formed by the base station by considering the residual energy level of the nodes and elect the nodes which are having higher energy than threshold level as the cluster head nodes. During data transmission phase multi hop reduces the transmission energy than the long distance single hop communication. Generally in multi hopping following approaches are followed,

MHRM: Minimum Hop Routing Model [1, 9], in which the routing path is chosen based upon the minimum hop between the node and the base station.

MTEM: Minimum Transmission Energy Model [1, 9], in which the data are forwarded from node **a** to node **b** in such case node **b** is closer to the base station than node **a**.

2. RELATED WORKS

When the wireless sensor network replaced the single macro sensors, it gained advantage in extended range of sensing, fault tolerance,

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

improved accuracy and lower cost than its predecessors. But as the number of nodes increases in the WSN to increase the coverage range and accuracy, energy management becomes a major constraint since all these nodes are battery powered. Till date number of protocols has been designed to improve the energy management schemes, there is ample scope in this area for betterment.

LEACH [9], Low energy adaptive clustering hierarchy has been proposed by Heinzelman to support the self configuring and robust nature of WSN. In order to reduce the amount of data transmission from node to Base station, data correlation among the nearby node is used. Data from the nodes is initially transmitted to the cluster head nodes, where it is aggregated and sent to the base station. During aggregation the redundant data are eliminated to reduce the amount of data transmission. If a same node acts as the CH nodes for the longer period of time its energy gets depleted faster than other nodes, so LEACH provided a CH rotation mechanism in which in each round of data collection a new CH is elected to distribute the energy dissipation in the network. Though LEACH can be made application specific random selection of CH is a major drawback.

PEGASIS [10], Power efficient gathering in sensor information system proves to be more robust than the LEACH. In PEGASIS instead of cluster formation data from a node is transmitted to any one of its 1-hop neighbor node where it is aggregated and passed on in the similar manner. In real time applications PEGASIS proves to be more reliable than LEACH.

In EECPL [5], Energy Efficient Clustering Protocol the role of CH node is to generate the TDMA schedule for its member nodes. Each cluster member node transmits its data to its 1-hop neighbor where it is aggregated and passed on to the next node. Finally the aggregated data is sent to the base station from cluster sender node. Since the TDMA scheduling and data transmission is done by different nodes, it reduces the rapid depletion of energy in the CH nodes.

In ADRP [3], Adaptive Decentralized Reclustering Protocol centralized approach is followed. The base station will collect the residual energy level of each node and elect the CH nodes and future CH nodes which are having energy level higher than the threshold level. If the current CH node collapses the next CH node will become the CH node.

In [1] Ataul, etc al has used the heterogeneous wireless sensor network to find the optimal solution. Relay nodes which are having higher energy level than the remaining nodes will act as the CH node. As on average they have increased the energy efficiency of the networks by 200%.

In [2] Bara'a etc al has used evolutionary approach for clustered heterogeneous wireless sensor network. In fitness function of the chromosomes they have included both intra cluster communication distance and inter cluster communication distance. By choosing the improved fitness function optimal path can be obtained from the vast space of suitable solutions.

3. LIFE TIME OF SENSOR NETWORKS

The lifetime of the wireless sensor network [12] is the time period during which the sensor gives useful information to the specific application needs. Network lifetime of the sensor network is being evaluated in the following ways,

- Network lifetime based on number of alive nodes.
- Network lifetime based on sensor coverage
- Network lifetime based on coverage and alive nodes.

The first way is also called as n of n nodes. But lot of variants is available in this approach of evaluating the lifetime of the network. The simple model in it takes the time period till the death of first node in the network as the lifetime of the network. Another variant evaluates lifetime till the death of 'k' out of 'n' nodes in the network. But Hellman and Colcgrosso in their work divides the network into critical and

Journal of Theoretical and Applied Information Technology
30th November 2011. Vol. 33 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

non-critical nodes. The lifetime is the time period till the death of 'k' nodes from 'n' nodes in non-critical nodes and no death in critical nodes. This approach is called as m-in-k of n lifetime.

The second way used to define the lifetime of the network based on the coverage of region of interest. If all the points within a region of interest is covered, it is called as volume coverage. When a specified number of target points is covered, it is called as target coverage. Barrier coverage refers to the probability of undetection of mobile target due to barrier in sensor nodes. In most of the related works the region of interest is covered at least by one sensor.

The third type of metrics is commonly found in Ad-hoc networks. Here, lifetime is defined as the time period during which most of the nodes are connected with each other. Since in wireless sensor network each node has to communicate with base station, this metrics can't be applied as it is. Another variant of this metric is that the life time is based on the total number of packets transmitted to the sink. But in most of the related works where aggregation is used this metrics become invalid. By aggregating packets in the cluster head nodes in the network the same quality of information can be given to base station with very lesser number of packets than non-aggregated packets.

4. OVERVIEW OF GENETIC ALGORITHMS

Genetics Algorithm (GA) is a heuristic based optimization technique which produces many fruitful results in engineering field. It is structured yet randomized search technique which primarily works based upon the following three genetic operators called *Reproduction*, *Crossover* and *Mutation.* Let us have a look at genetics algorithm terms,

Chromosomes: The initial possible solutions or population to the problem are called chromosomes or individual. All the chromosomes should have the same length and the elements in it are called as genes or alleles.

Fitness function: Fitness function is used to evaluate the chromosomes fitness values and the higher valued chromosomes would produce more offspring than others. Here in our paper the fitness value corresponds to the network lifetime.

Reproduction: It is the basic genetic operator which reproduces the chromosomes with higher values to the next generation.

Crossover: Crossover selects two parent chromosomes and makes them to swap part of their genetics information with each other and produces the next generation chromosomes.

Mutation: After crossover, mutation operator is applied to the chromosomes. It prevents the GA approach from pre-mature convergence. It is used to search the solution from whole new place instead of searching from the current better ones.

5. EXPERIMENTAL SETUP

Many protocols have been using evolutionary approach for prolonging the lifetime of the network. In our work we evaluate the lifetime of the network as the number of data gathering rounds till the death of first node in the network. In most cases after the death of first node the network loses its reliability. The sensor nodes are randomly deployed in 100 x 100m area as in Figure 1.

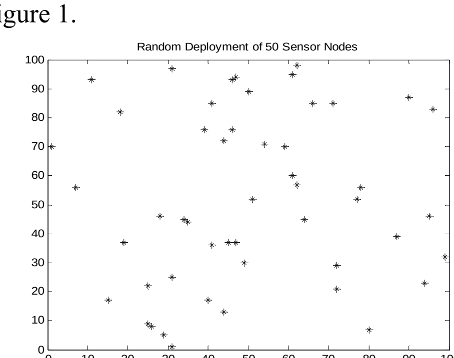

Figure 1 – random deployment of sensor nodes

5.1 Initial population and fitness:

Since we have used 50 sensor nodes in our experiment the length of the chromosome is set to be 50. In the randomly generated initial

Journal of Theoretical and Applied Information Technology
30th November 2011. Vol. 33 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

chromosomes, we are allowing 10% of the nodes to act as cluster head nodes. The cluster head nodes are represented by bit '1' and member nodes are represented by bit '0'. Also the network satisfies the following attributes,

i. For each chromosome, the member nodes calculate its distance with the cluster head node and attach itself with the nearby cluster head node.
ii. Since the number of cluster head and member node are fixed each cluster is having equal number of member nodes.
iii. Each member node transmits its data to its cluster head, where the aggregation takes place and again the aggregated packet is sent from CH node to the base station.

The fitness function of the chromosome is equal to the number of data gathering round till the death of first node in the network.

5.2 Reproduction operator:
The chromosome having the higher fitness value is having more probability to reproduce itself in the next generation. For this we used roulette wheel selection mechanism.

5.3 Cross over:
When we are applying reproduction operator only, we are only giving a chance for higher valued chromosomes to increase its number in the successive generation which leads to pre-mature convergence. To avoid this situation, we are using cross-over where the sub-strings in the previous generation higher valued chromosomes to swap and produce new off-spring in the next generation with same fitness function or more than it. In our experiment we have only used single point crossover.

Chromosome 1 …100000 | 001000…
Chromosome 2 …000100 | 000001…
Off-spring 1 …100000 | 000001…
Off-spring 2 …000100|001000…

5.4 Mutation:
Mutation is the other basic genetic operator to make the variety in the population of chromosomes in the particular generation. Whenever the same chromosomes dominate the population more than 20% in it, mutation operator is applied to maintain diversity in the population. Here, in our experimental setup we have used mutation operator in the sense to reverse the particular sub-set of string.

…10001000…
↓mutation
…00010001…

Genetic Algorithm:
Choose a random initial generation of population;
Evaluate the fitness function of each chromosome;
Till termination condition is not arrived {
Reproduce best individuals in next generation;
Perform single point cross over;
Apply mutation to generate diverse individuals;
Evaluate fitness function of the offspring;
If fitness function of offspring is less than it's
Parent's, then chromosome is repeated
;}

6. SIMULATION AND SUMMARY

6.1 Radio communication model:
As already described, the network was configured in the 100 x 100 meters with randomly deployed 50 nodes. The base station is located at the point (150, 50). We followed the same radio model as Heinzelman [9], etc...
The transmitting energy is calculated by the equation,

$E_T(l,d) = lE_{elec} + l\varepsilon_{fs}d^2$.
Where l = number of bits, d = distance between the nodes, E_{elec} = Electronics energy and ε_{fs} = free space dissipation energy.

The energy required to receive l-bits is,
$E_R(l) = lE_{elec}$.

Data aggregation energy is,
E_{AG} = 5 nJ/bit.

In our simulation we assumed that the l = 4000bits,
E_{elec} =50 nJ/bit and ε_{fs} = 10 pJ/bit/m^2

6.2 Simulation results:

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

We analyzed the network lifetime with respect to number of rounds which is suitable for many type of applications. In the figure 2 we showed the comparison between the Direct Transmission (DT) method and GA based routing. Obviously GA based routing outperform the DT in terms of number of data gathering rounds. Also in the clustering approach we can reduce the redundant data to be sent to the base station.

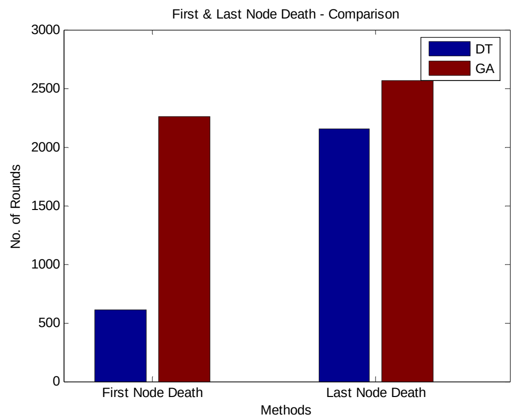

Figure 2 – Comparison of first and last node death between DT and GA

Since we have much more concentrated on the stability period of the network, in the GA based approach after the death of first node all the nodes communicate with the base station directly. In the last node death also GA outperform DT due to its clustering approach up to stability period.

In the figure 3 we can see the gradual degradation of the network for the above two approaches. After the death of first node the difference between the GA based approach and DT decreases gradually and it may converge at a point if the number of sensor nodes is increased in our experiment.

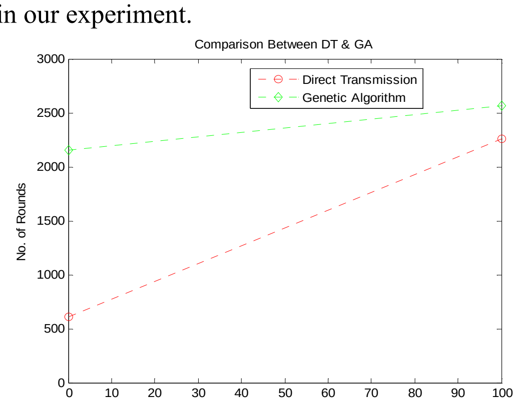

Figure 3 – Comparison between DT and GA

7. CONCLUSION AND FUTURE WORK

Life time of the sensor network can be evaluated through different metrics like coverage, number of alive nodes, etc… In this paper, number of data collection rounds before the death of first node is concentrated since it directly affects the stability period of the network. The experimental results have shown that our evolutionary algorithm performs better than the direct transmission in both first node death and last node death. Our future research direction would be around using better fitness function to analyze the wireless sensor network in depth.

REFERENCES:

[1]. Ataul Bari, Shamsul Wazed, Arunita Jaekel, Subir Bandyopadhyay.: A genetic algorithm based approach for energy efficient routing in two-tiered sensor networks, Ad-Hoc Networks 7, pp 665-676 (2009).

[2]. Bara'a A.Attea, Enan A.Khalil.: A new evolutionary based routing protocol for clustered heterogeneous wireless sensor networks, Applied Soft Computing.J.(2011), doi: 10.1016/j.asoc.2011.04.007.

[3]. Fuad Bajaber, Irfan Awan.: Adaptive decentralized re-clustering protocol for wireless sensor networks, Journal of computer and Systems sciences, doi:10.1016/j.jcss.2010.01.007.

[4]. Yi-hua zhu, Wan-deng wu, Jian pan, Yi-ping tang.: An energy efficient data gathering algorithm to prolong lifetime of wireless sensor networks, Computer Communications 33, pp. 639-647 (2010).

[5]. Fuad Bajaber, Irfan Awan.: Energy efficient clustering protocol to enhance lifetime of wireless sensor network, Journal of Ambient Intelligence and Human Computing 1, pp. 239-248 (2010).

[6]. N.Dimokas, D.Katsaros,Y.Manolopoulos.: Energy-efficient distributed clustering in wireless sensor networks, Journal of Parallel and Distributed Computing 70, pp. 371-383 (2010).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[7]. Kemal Akkaya, Mohamed Younis.: A Survey on routing protocols for Wireless Sensor Networks", Ad Hoc Networks 3, pp. 325-349 (2005).
[8]. O.Younis, S. Fahmy.: HEED: A Hybrid,Energy-Efficient, Distributed clustering approach for Ad Hoc sensor networks, In: IEEETransactions on Mobile Computing 3 (4), pp. 366–379 (2004).
[9]. W.B. Heinzelman, A.P. Chandrakasan, H.Balakrishnan.: Application specific protocol architecture for wireless microsensornetworks. IEEE Transactions on Wireless Communication, Vol 1, Issue 4, pp. 660-670 (2002).
[10]. S.Linday, C.Raghavendra,"PEGASIS: Power-Efficient Gathering in Sensor Information Systems," IEEE Aerospace Conference Proceedings, Vol.3, No.9-16, pp 1125-1130 (2002).
[11]. Manjeshwar, D.P. Agarwal.: TEEN: a routing protocol for enhanced efficiency in wireless sensor networks, In: 15th International Parallel and Distributed Processing Symposium (IPDPS'01), vol. 3, pp. 2009-2015 2001.
[12]. Isabel Dietrich, Falko Dressler,"On the Lifetime of Wireless Sensor Networks", ACM Transactions on Sensor Networks, Vol.5, No.1, pp.1-38(2009).

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AUTHOR PROFILES:

B.Baranidharan received his M.Tech in Computer Science and Engineering from SRM University, Chennai, India. He is a research scholar of SASTRA University, India. Currently he is working as Asst. Professor, School of Computing in SASTRA University. His area of interests are Wireless Sensor Networks, Ad hoc Networks, pervasive Computing.

Dr. B.Santhi received her M.Tech, Ph.D in computer science stream from SASTRA University, India. Currently she is working as Professor, School of Computing in SASTRA University. Her area of interest includes Image Processing, Ad hoc Networks, Wireless Sensor Networks.