Volume 1 No. 2, June 2011
International Journal of Information and Communication Technology Research

http://www.esjournals.org

A Coverage aware Clustering Scheme for power constrained Wireless Sensor Networks

[1]Namrata S. Baghele, [2]K.N. Hande
Computer Sci. And Engg.Department
G.H.Raisoni College of Engg. Nagpur.India
[1]bnamrata09@gmail.com, [2]kapilhande@gmail.com

ABSTRACT

This paper evaluates the Clustering as energy and coverage enhancement approach for WSN.The paper includes the proposed scheme which is an amendment to LEACH protocol and involves a unique node scheduling and a fitness function to enhance coverage in each round. The algorithm employs a distinct rotation of cluster heads in order to ensure balance in energy consumption and coverage requirements which can ultimately lead to enhancing the quality of service (QoS) related to the surveillance which in turn leads in maximizing lifetime of network.

Keywords: *Coverage, clustering, energy balancing, power consumption.*

1. INTRODUCTION

A wireless sensor network is a network having collection of nodes embedded with simple process, fewer memory, tiny sensing material, and energy-limited battery. The accuracy of sensing information depends on the coverage quality in the monitoring region. On the other hand due to energy limitation there should be optimum energy consumption while improving coverage efficiency.

A lot much attention has drawn towards two basic problems in WSN namely power balancing and coverage efficiency. There are so many coverage based routing algorithms designed to face traditional problem of energy conservation in WSN

Coverage and connectivity are also prime concerns in WSN along with energy conservation. To have satisfactory sensing coverage is one of the major issues in Wireless sensor networks. Moreover due to energy constrained environments a lot of challenges are supposed to be faced in order to enhance coverage range. An efficient method for coverage optimization should enhance coverage with optimal balancing of power consumption among sensor nodes.

Sensor nodes in a WSN are characterized by limited power and computational capabilities, and are expected to function for extended periods of time with minimal human intervention. The life span of such networks depends on the efficient use of the available power for sensing and communication. The paper addresses the clustering approach in wireless sensor networks in order to enhance coverage in power constrained environment.

2. RELATED WORK

A lot many algorithms have been proposed for improving energy efficiency in WSN .Some of them are emphasizing over coverage aspect too.

2.1 Overview of clustering protocols

LEACH [15] is of a kind, a basic clustering protocol applied in wireless sensor networks, works with two-phase mechanism based on the random number each node generates. However, LEACH causes cluster-head nodes less evenly distributing in the network.

In LEACH (***Low-energy adaptive clustering hierarchy***) [1] algorithm is divided into rounds and each round separated into two phases, the set-up phase and the steady-state phase. In the set-up phase, each node decides whether or not to become a cluster head for the current round. This decision is based on the threshold T (n).

$$T(n) = \frac{p}{1-p*(r \bmod (1/p))} \quad \text{if } n \in G \qquad (1)$$

Where p is the predetermined percentage of cluster heads (e.g., p = 0.05), r is the current round, and G is the set of nodes that have not been cluster heads in the last 1/p rounds.

HEED [16] **adopts** corresponding cost types (e.g., minimum degree cost, maximum degree cost, and average reachability power) towards cluster formation.

Under the category of Non Randomized algorithms which are commonly classified into three branches: Weight-based, Topology-based and Heuristic-based algorithms. In Weight-based distributed Clustering algorithm [17] cluster selection depends on combined weights of neighboring nodes.

PEGASIS [18] is a topology-based clustering approach. It improves the performance of LEACH and prolongs the network lifetime significantly using a chain topology. Heuristic based algorithm decides cluster selection based on lowest and highest degree of node.

Teen [19] is another cluster based routing protocol based on Leach. This protocol is basically for time critical applications to respond to sudden changes in the sensed data.

In general, the *k*-coverage problem has been discussed when coverage control for WSNs is considered [7, 8].

All of the above algorithms don't support multilevel adaptive clustering i.e. level of clusters cannot be changed depending on different situations. This kind of fixed level clustering may be in efficient in the scenario where the sensing area changes dynamically.

Different cluster head election techniques with coverage preservation are studied in [12].

CoCMA [13] which encompasses optimization for initial deployments using a MA and a wake-up scheme. The CoCMA turns off the redundant nodes according to the MA-based schedule for nodes in order to save energy.

3. CLUSTERING APPROACH FOR ENERGY CONSERVATION

Clustering used for energy conservation involves:

i. Cluster Formation:

It comes with cluster head selection and selecting member nodes in cluster.

In real application scenario, it leads clusters to overlap each other seriously. Some gaps may hold the space among two or more close neighboring clusters. To attain uniform clustering distribution, remedial measures should be taken according to different clustering status like if node is a cluster head, when node is in non-clustered status, if node *is* a member node, it is just obedient to its cluster head [5].

ii. Steady-state phase:

In the steady-state phase, member nodes transmit the sensing information (e.g. the acoustic and seismic signal, light intensity, temperature, or pH value, etc) to their cluster heads. Next, cluster heads aggregate the data and relay them to the base station. Since base station may be far away and the data messages are large, this is a high-energy transmission. Therefore, to be a cluster head will consume much more energy than member nodes. To take full use of node's conserved energy and to extend the system lifetime, rotating head position is introduced into proposed clustering scheme.

The basic problem that the proposed scheme attempts to solve is to cover all the area by the entire network during its lifetime by employing the remained energy of the nodes to recognize their sensing range.

4. PROBLEMS WITH EXISTING SOLUTION:

The nodes die rapidly using PEGASIS, LEACH-Coverage-U and LEACH methods, since they do not have node scheduling strategies. Node-scheduling strategies that save much energy, so the longer network lifetime can be obtained.

5. THE PROPOSED SCHEME

The proposed energy and coverage preserving scheme is an extension of LEACH. Just in addition it adapts a unique node scheduling scheme followed by cluster formation and steady state stage.

It checks the coverage preservation in each round by analyzing convergence.

5.1 Cluster head selection

1. Each node conveys the energy level and its degree of neighbors to the base station.
2. BS decides the node with highest energy level and optimum degree as a cluster head. It again uses geographic information available with it.
3. BS multicast the information of CH to other nodes.

5.2. Energy Model

The node-scheduling scheme should save energy, therefore, increase system lifetime by comparing the energy consumption per node in the original and extended LEACH. If the cost of the node-scheduling phase dominates the overall energy consumption in each round, it is better protocol, energy is mainly consumed in two parts: data transmission for clustering forming (*Ec*) and data gathering (*Eg*). While in the extended LEACH, extra energy is needed in node scheduling phase.

The same energy parameters and radio model as discussed in [10], which indicates that the transmission energy consumption is

The transmitter dissipates *ETx* (*l*, *d*) J energy to run the radio electronics and the power amplifier. The equations used to calculate transmission costs for an *l*-bit message and distance *d* are shown below:

$$ETx = \begin{cases} l*E_{elec} + l\epsilon_{frissamp} d^2 & d < d_{crossover} \\ l*E_{elec} + l\epsilon t_{worayamp} d^4 & d >= d_{crossover} \end{cases} \quad (2)$$

where *l* is the message length in bits; *Eelec* represents the electronics energy; *d* is the distance between the transmitter and receiver; ε *frissamp* and ε *tworayamp* are propagation loss factors as inversely proportional to *d* 2~4 ; *dcrossover* depicts the threshold distance for Friss and two-ray ground attenuation models.

5.3 Coverage preserving node scheduling

To extend LEACH with the node-scheduling scheme, a straightforward way is to insert the self-scheduling phase of our scheme before the LEACH cluster set-up phase.

At the beginning of each round, all the nodes self-determine whether to turn themselves off or not and off-duty nodes will not participate in the cluster forming and steady-state phase followed. The advantage of such timeline is that our node-scheduling scheme is embedded into the LEACH seamlessly without any modification of its original.

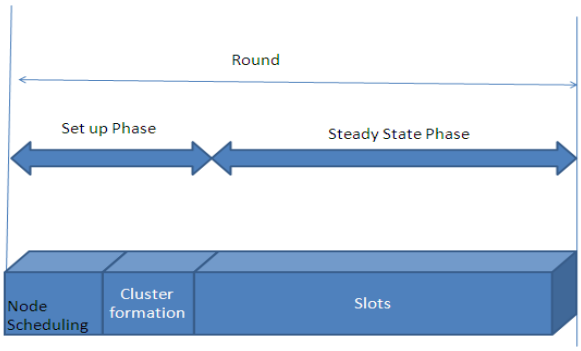

Figure 1

5.4 Fitness function

The goodness of schedule for active sensor nodes is regarded as the fitness function the higher fitness implies a better energy efficiency schedule for nodes.

5.5 The Idea of Algorithm

The proposed algorithm is based on finding the optimum number of nodes which ensures the coverage. Each node confirms its situation by collecting information of all neighbours. By gathering all of this information it ensures whether the neighbors can contribute to cover all of the area. The node scheduling is implemented in such a way that if any other node on the path ensures about the full coverage the original node can be made off.

5.6 Rotation of Cluster heads

In order to deal with coverage preservation in power constrained environment cluster head selection should be done very carefully. Cluster head should be selected in such way that it ensures the maximum coverage area.

In addition, to ensure that energy level of each cluster head can evenly degrade, it is crucial to rotate cluster-head node dynamically to increase transmission reliability.

To balance energy consumption, eligible nodes take turns to be elected to the cluster heads. The scheme performs better than existing clustering algorithms in term of conserving energy and meeting coverage requirement.

In addition, this technique is independent of time synchronization, which will restrict clustering practical application.

6. SIMULATION RESULTS

Simulation for the above mentioned scheme has been performed using NS 2 as a simulation tool. The simulation scenario involves following parameters

Simulation Time -4.1 min
Maximum Energy level -10 J
Distance Unit -Feet
MAC Scheduling -S-MAC
Network Size (Nodes) -28
Cluster Head -Node 0(BS)
Broadcast ID- 65535
Geographical Area- 650*650

The results clearly shows the cluster head rotation performed based on threshold.

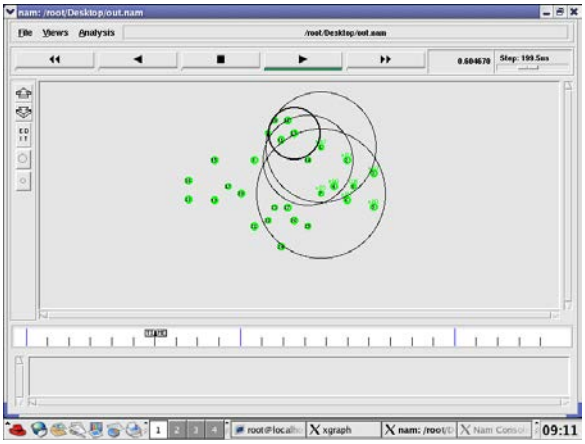

Figure 2

Entire network is divided into no. of clusters each of which is governed by cluster head. As in simulation window the rightmost cluster acts as an active node for the duration and capable of covering the entire network coverage.

The following graph obtained shows the energy decay of each node with time which clearly reflects uniform energy degradation of all nodes including cluster head (as all lines are parallel).

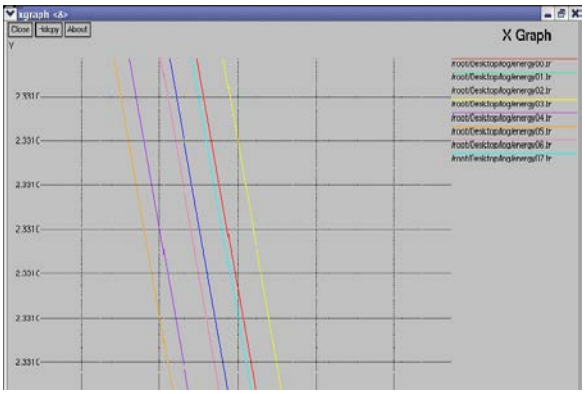

Figure 3

6.1 Comparison with DSDV

Though the implemented protocol is amendment to LEACH, here we are mainly emphasizing on minimizing routing overheads in order to reduce and balance power consumption. Thus we compared the results with well known and efficient routing protocol DSDV. The following graph shows how implementation of same scenario with DSDV reflects uneven energy degradation of every node.

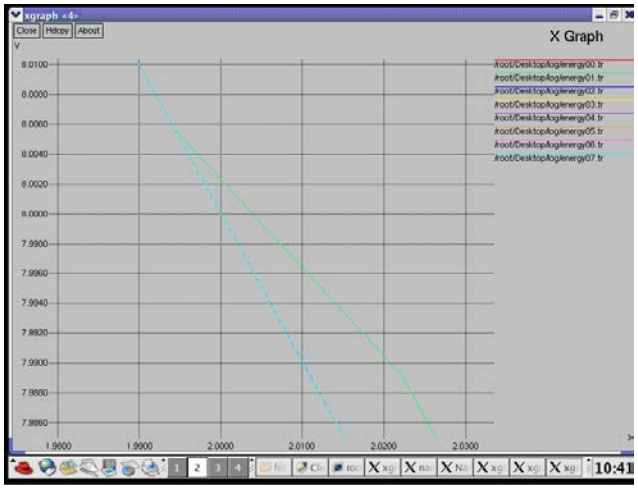

Figure 4

Even it can be seen from the animation clearly that with there are great extent of packet loss and nodes tend to lose energy rapidly.

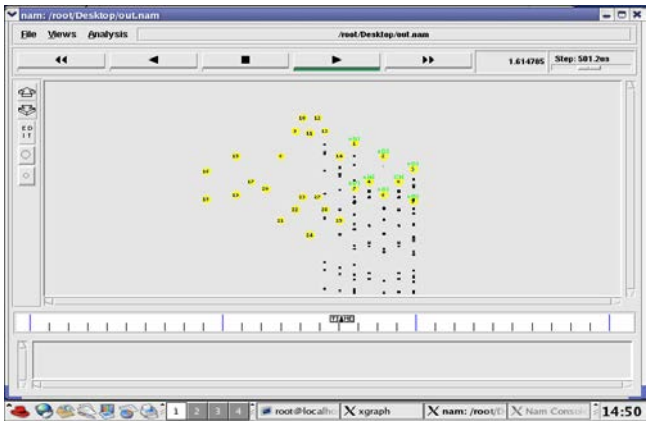

Figure 5

The yellow color of nodes shows 50% of energy loss in the animation. These packet losses are not at all found with our algorithm.

6.2 Comparision with LEACH

Efficiency of our protocol if compared with LEACH, it shows really better performance which can be summarized in following two tables.

Parameter	LEACH	CACS
Avg. energy decay	24%	9%
Throughput	71%	87%
Avg.packet delay	26%	10%
Avg No.of packets	113	84
Packet Size	400	400

6.3 Comparison with clustering attributes

Parameter	LEACH	CACS
Cluster Stability	Moderate	High
Balanced clustering	OK	GOOD
Node Mobility	No	Possible
Convergence time	constant 0(1)	variable 0(n)

7. CONCLUSION

In this paper, we proposed a clustering method with coverage-preserving node-scheduling scheme, which can reduce energy consumption, therefore increase system lifetime, by turning off some redundant nodes.

We have considered the parameters that include: number of packets sent in the network, energy consumed by the network, remaining energy level of nodes at specific time and network lifetime of the network. Experimental results show that enough redundancy still remained although some nodes were turned off. We implemented this scheme as an extension to the LEACH protocol, which is an existing data communication protocol for wireless sensor networks. We compared the energy consumption in the original LEACH and the extended LEACH and analyzed the effectiveness of our scheme in terms of energy saving. Preliminary simulation results in the radio model and energy parameters proposed by the LEACH designer show the potential of such energy saving and system lifetime increase.

REFERENCES

[1] A.P. Chandrakasan, A. C. Smith, W. B. Heinzelman, An Application –Specific Protocol architecture for Wireless Microsensor Networks. *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660-669, 2004.

[2] Nauman Israr and Irfan Awan" Coverage Based Intercluster Communication for Load Balancing in Wireless Sensor Networks" 21st International Conference on advanced Information Networking and Applications Workshops2009 IEEE.

[3] Mihaela Cardei My T. Thai Yingshu Li Weili Wu," Energy-Efficient Target Coverage in wireless Sensor Networks" IEEE INFOCOM 2005

[4] S. Slijepcevic and M. Potkonjak. Power efficient organization of wireless sensor networks. In Proc. Of the IEEE Int. Conf. on Communications (ICC), June 2001.

[5] Liang Xue Xin-Ping Guan Zhi-Xin Liu Qing-Chao Zheng "power and coverage aware clustering scheme for WSN" International Journal of Automation and Computing 2009 , Mouth 20××, range of pages

[6] Guoliang Xing; Rui Tan; Benyuan Liu; Jianping Wang; Xiaohua Jia; Chih-Wei Yi" Data Fusion Improves the Coverage of Wireless Sensor Networks" MobiCom'09, September 20–25, 2009, Beijing, China.

[7] Chen, J.; Koutsoukos, X. Survey on coverage problems in wireless ad hoc sensor networks. In *Proceedings of IEEE southeastCon*, Richmond, VA, USA, 2007.

[8] Huang, C.F.; Tseng, Y.C. The Coverage Problem in a Wireless Sensor Network. In *Proceedings Of the 2nd ACM international conference on Wireless sensor networks and applications*, San Diego, CA, US.

[9] A. P. Chandrakasan, A. C. Smith, W. B. Heinzelman, An Application –Specific Protocol Architecture for Wireless Microsensor Networks. *IEEE Transactions on Wireless Communications*, vol. 1, no. 4, pp. 660-669, 2004.

[10] A. Molina, G.E. Athanasiadou, A.R. Nix, "*The Automatic Location Of Base-Stations For Optimised Cellular Coverage: A New Combinatorial Approach*," IEEE 49th Vehicular Technology Conference, vol.1, pp. 606-10, May 1999.A, September 19, 2003; pp.115-121.

[11] Liang Xue Xin-Ping Guan Zhi-Xin Liu Qing-Chao Zheng "power and coverage aware clustering scheme for WSN" International Journal of Automation and Computing 2009, Mouth 20××, range of pages.

[12] K. Lieska, E. Laitinen, J. Lahteenmaki, "*Radio Coverage Optimization With Genetic Algorithms*," IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, vol.1, pp. 318-22, Sept. 1998.

[13] S.Soro, W.B. Heinzelman, (2008) "Cluster Head Election Techniques for Coverage Preservation in Wireless Sensor Networks", Ad Hoc Networks.

[14] Joe-Air Jiang, Chia-Pang Chen, Cheng-Long Chuang , Tzu-Shiang Lin , Chwan-Lu Tseng , En-Cheng Yang and Yung-Chung Wang "CoCMA: Energy-Efficient Coverage Control in Cluster-Based Wireless Sensor Networks Using a Memetic Algorithm"Sensors, *22 June 2009.*

[15] H. Karl, and A. Willig, "Protocols and architectures for wireless sensor networks", John Wiley & Sons, UK, 2005.