Energy Distributed Clustering for Improving Lifetime of Wireless Sensor Network

Vaibhav V. Deshpande, A. R. Bhagat Patil

Abstract— Clustering is an efficient way to improve lifetime of wireless sensor network. To enhance lifetime of sensor network this paper proposes to have multiple cluster heads within the cluster of sensor nodes. At a given time one cluster head (CH) from the cluster acts as a leader of the cluster and the leadership is rotated among the cluster heads based on the energy levels. The experimental results show the efficiency of proposed algorithm in terms of residual energy, total alive nodes and the execution time as compared to the cluster with single cluster head and LEACH protocol.

Keywords— Clustering, Cluster heads, Lifetime, Wireless Sensor Network

I. INTRODUCTION

A wireless sensor network consists of spatially distributed autonomous sensors in the region of interest. This region of interest can be remote areas where the human intervention is not possible. Once deployed in such regions if the sensor node goes down due to battery supply it is hard to replace or recharge the battery which is main source of energy. Advancement in sensor technology sensors facilitated low cost sensors however resources like battery supply (energy), processing power, and storage still remain challenges in the design of sensor network. Applications of wireless sensor network include military surveillance, environmental monitoring, health monitoring, structural monitoring etc.

Various algorithms have been proposed to prolong the lifetime of wireless sensor network considering the resource constraints. Network lifetime is the key characteristics used for evaluating the performance of any sensor network [7]. Clustering is one of the mechanism to improve energy consumption of sensor of network and thereby the network lifetime. In clustering whole sensor network is divided into group of clusters. High energy node within the cluster is nominated as cluster head.

Some of the advantages of clustering are [18]:

It reduces the size of the routing table stored at the individual nodes. The CH can extend the battery life of the individual sensors and the network. CH can perform data aggregation in its cluster and decrease the number of redundant packets. By scheduling the activities within the cluster CH can reduce the rate of energy.

Manuscript received May, 2013.

Vaibhav V. Deshpande, Department of Computer Technology, Y.C.C.E, Nagpur, India.

A. R. Bhagat Patil, Department of Computer Technology, Y.C.C.E, Nagpur, India.

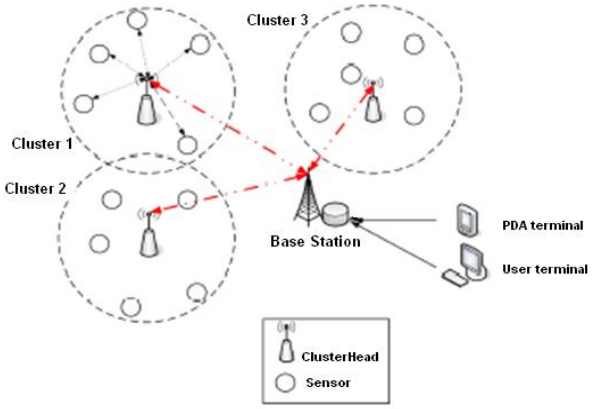

Fig. 1 Clusters with single cluster head [16]

Sensor node within the cluster sense the data, data is collected by cluster head and then passed cooperatively to the base station or sink. Cluster head is responsible for inter-cluster and intra-cluster communication hence life of the cluster head is utmost important. Failure in cluster head due to energy depletion halts the functioning of cluster and has major impact on the lifetime of the sensor network.

To improve energy consumption of the cluster head the approach is to use multiple cluster heads within the same cluster. The reminder of the paper is organized as follows. In Section II review of the literature is discussed. In Section III life extension of wireless sensor network using multiple heads within the cluster of sensor nodes is proposed and explained. Experimental setup and results are presented in Section IV. Section V concludes the paper with the conclusion and future work.

II. RELATED WORK

Lifetime extension of wireless sensor network [1] uses two cluster heads and hierarchical routing. In this paper an algorithm Two Cluster Head Energy efficient Wireless Sensor Network (TCHE-WSN) is proposed to improve the lifetime. The use of two cluster heads analogy reduces the overhead of single cluster head, avoids packet collision and improves reliable data transmission.

In Energy Balanced Clustering in Wireless Sensor Network [2], algorithms for energy balanced cluster formation, cluster head selection, intra cluster and inter cluster communication are proposed to prolong lifetime of wireless sensor network. The performance of energy balanced clustering algorithm is compared with LEACH and EEMC protocol. In Energy Adaptive Cluster-Head Selection [3], optimization of LEACH's random cluster-head selection algorithm is proposed. It ensures that energy depletion over the whole network is balanced to prolong the network lifetime.

Energy Consumption and Lifetime Analysis in Clustered Multi-hop Wireless Sensor Networks [4] uses the probabilistic cluster-head selection mechanism. In this paper a novel energy model is proposed to estimate the energy consumed in a multi-hop WSN.

Fault tolerant clustering of wireless sensor network [5], uses two phase detection and recovery from failures. In this paper an approach is proposed to recover sensors from the failed gateways without shutting down or re-clustering the system.

In Energy Efficient Clustering Scheme [6] a novel scheme (EECS) for single-hop wireless sensor networks is proposed to suit the periodical data gathering applications. The paper has discussed an approach to elect cluster heads with more residual energy in an autonomous manner using local radio communication. It achieves good cluster head distribution and also balances the load among the cluster heads using a novel distance-`d method.

Energy-Efficient Communication Protocol for Wireless Micro-sensor Networks [7] describes LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol. It utilizes randomized rotation of cluster-heads to evenly distribute the energy load among the sensors in the network. Distribution of energy among the nodes in the network reduces the energy dissipation and improves life time of wireless sensor network.

In Energy Efficient Hierarchical Clustering Algorithm [8] a distributed, randomized clustering algorithm is proposed. The algorithm generates hierarchy of cluster heads. It has been observed that the energy savings increases with the number of levels in the hierarchy.

Load balanced clustering [9] algorithm has been proposed to balance the load among cluster heads. This algorithm tries to cluster sensor nodes close to cluster head. Load balancing increases the sensor network stability and improves the communication between different nodes in the sensor network.

A novel cluster-based routing protocol [10] has been proposed to extending lifetime of cluster head. This paper discusses approach that allows sensors to vote for their neighbours to elect the cluster heads. It utilizes hybrid protocol that combines the cluster architecture with multi-hop routing for the reduction of the transmission energy.

Distributed energy-efficient clustering [11] approach selects cluster heads based on their residual energy. Sensor nodes join clusters such that communication cost is minimized. The approach exploits the availability of multiple transmission power levels at sensor nodes.

In, A Routing Protocol for Prolonging Lifetime of Wireless Sensor Networks [12] U-LEACH algorithm is proposed to address the problem in LEACH. Algorithm uses uniform distribution technique for selecting CHs and their corresponding clusters to prolong the lifetime of the network.

In, On Life Time of Sensor Network [13], a general formula for the lifetime of wireless sensor networks is discussed. Using the formula a medium access control protocol has been proposed which exploits both the channel state information and the residual energy information of individual sensors. It tries to maximize the minimum residual energy across the network in each data collection.

Energy efficient clustering scheme [14] for single-hop wireless sensor networks elects cluster heads with more residual energy in an autonomous manner through local radio communication. In this paper a novel distance-based method is discussed to balance the load among the cluster heads.

In, Hybrid Energy Efficient Distributed Protocol for Heterogeneous Wireless Sensor Network [15] an algorithm H-HEED has been proposed to improve lifetime. It considers different levels of heterogeneity in sensor nodes and identifies the impact of heterogeneity in terms of node energy in wireless sensor networks.

III. PROPOSED APPROACH

One of the important factors to improve lifetime of wireless sensor network is the design of network. Proposed clustering algorithm is divided into three phases; initialization, setup phase and steady state. Our proposed approach is explained using these three phases:

A. Initialization

Sensor nodes with varying energies are randomly distributed on the flat area. Random deployment is achieved by choosing the random locations in coordinate system.

B. Setup phase

The setup phase consists of cluster formation and cluster formation. The flat area is divided into the equal parts, nodes belongs to the same part forms the cluster. Cluster head having highest energy is nominated as leader cluster head. The responsibility of the leader cluster head is to communicate with all the sensor nodes within that cluster, gather the sensed data and communicate it back to the base station.

C. Steady State:

In this phase, once the leader among the cluster heads is identified, it takes the ownership of the communication and other cluster heads in the same cluster set off to sleep mode. Sensor nodes communicate with the leader cluster head based on TDMA schedule and in turn it communicates with sink. After each round of communication based on the energy levels of cluster heads leadership is rotated. Rotation of the leadership allows balancing of the energy consumption among the cluster heads and prolongs life of cluster thereby sensor network.

Algorithm:

1. Initialization Phase

1.1 Form the cluster based on the x,y location of the grid
1.2 Select more than one high energy node as Cluster Heads (CH1, CH2) within the cluster.
1.3 Nominate highest energy node as Leader
1.4 Leader sends join request message to all the sensor nodes within the given cluster.

2. Setup Phase

2.1 Leader(CH) = CH1
#CH1 highest energy node among the other cluster heads
2.2 The sensor nodes within the cluster communicate the sensed data to the CH in the allotted time using TDMA schedule.
2.3 Check the energy of the cluster head
If energy (CH1) < energy (CH2)
Leader(CH) = CH2

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

3. Steady State

3.1 CH collects the data from all the nodes in its cluster.

3.2 CH transmits the data to the Sink node.

IV. EXPERIMENTAL RESULTS

Life time of wireless sensor network is evaluated by considering the cluster with single cluster head over single hop. For simulation NS-2 is used. NS-2 [17] is a tool that provide rich environment for simulation of wireless sensor network at different layers. Following are details of the experimental setup and collected result.

A. Experimental Setup

Simulations are conducted with sensing area of size 300 m X 300 m and with 30 sensor nodes deployed randomly. Random deployment is achieved by choosing the (x,y) locations of the sensor nodes randomly. Simulations are carried out by running proposed algorithm. For finding out the effectiveness of usage of more than one cluster head same algorithm is run with single cluster head. Residual energy of sensor network is evaluated over the time period.

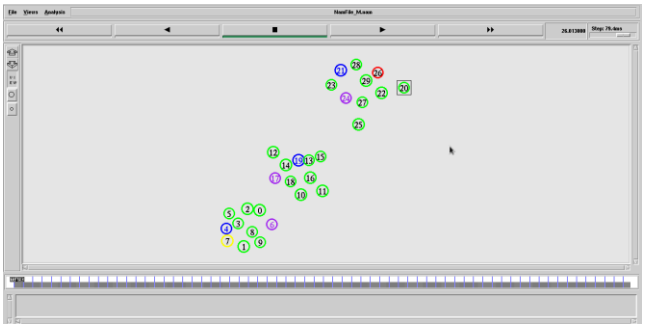

Fig. 2 Cluster with multiple cluster heads

Figure 4 shows three clusters, each with two cluster heads and the leader of the cluster of the clusters are node no. 6, 7 and 24.

B. Result

Simulations are carried out and results are obtained. Results obtained are compared with the cluster with single cluster head and LEACH protocol.

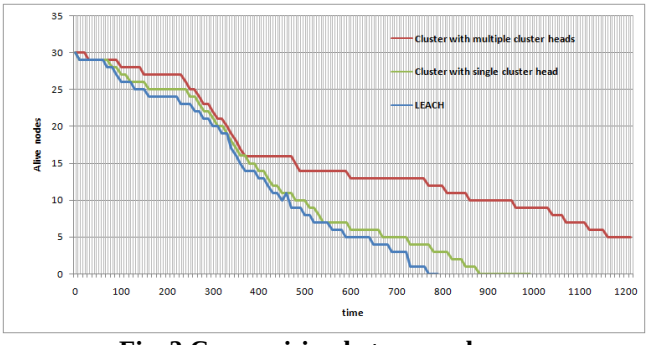

Fig. 3 Comparision between schemes

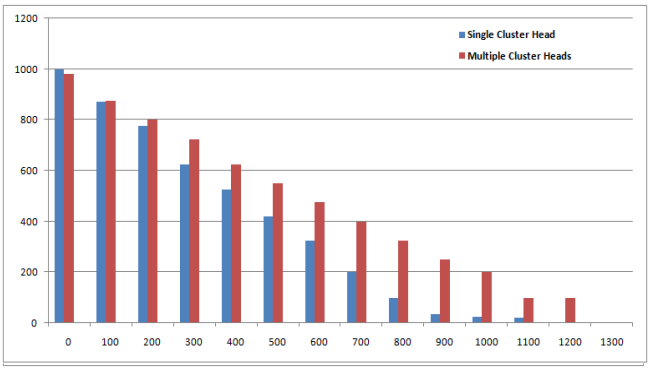

Fig. 4 Residual energy over time period

Lifetime of wireless sensor network is evaluated in terms of alive sensor nodes over the time period and residual energy of sensor network. From the figure it is observed that the proposed clustering algorithm achieves better network life time as compared to the LEACH protocol.

V. CONCLUSION

In this paper, clustering algorithm with multiple cluster heads within the cluster of sensor nodes is proposed to improve lifetime of wireless sensor network. Simulation results demonstrate that proposed clustering algorithm using multiple cluster heads is more effective in prolonging the lifetime of sensor network than using single cluster head and LEACH algorithm. In proposed algorithm energy utilization is distributed among the cluster heads which makes it work longer than the cluster with single cluster head. Also in case of cluster head failure due to the energy depletion, other cluster head continues to work without affecting the topology of the sensor network thus maximizing the network lifetime.

In the future, the clustering algorithm which is developed can be extended to incorporate dynamic selection of sensor node as cluster head, when energy levels of the existing cluster head within the cluster of cluster heads deplete below level as compared to the other sensor node in the same cluster. In addition to the balancing energy, algorithm can enhanced to incorporate load balancing among the cluster heads based on the parameter like traffic.

REFERENCES

1. B. Meenakshi, P. Anandhakumar, “Lifetime extension of wireless sensor network by selecting two cluster heads and hierarchical routing”, IEEE International Conference on Advances in Computing, Communications and Informatics, 2012.
2. Babar Nazir, Halabi Hasbullah, “Energy Balanced Clustering in Wireless Sensor Network”, IEEE International Conference on Information Technology, 2010.
3. Ying Liang, Haibin Yu , “Energy Adaptive Cluster-Head Selection for Wireless Sensor Networks”, IEEE International Conference on Parallel and Distributed Computing, Applications and Technologies, 2005.
4. Jinchul Choi, Chaewoo Lee, “Energy consumption and lifetime analysis in clustered multi-hop wireless sensor networks using the probabilistic cluster-head selection method”, IEEE International conference on Wireless and Mobile Networking, 2011.
5. Gaurav Gupta, Mohamed Younis, “Fault-Tolerant Clustering of Wireless Sensor Network”, IEEE International Conference on Wireless Communications and Networking, 2003.
6. Mao YE, Cengafa LI, Guihai Chen, Jie WU, “Energy Efficient Clustering Scheme in Wireless Sensor Networks”, IEEE International Conference on Performance, Computing and Communications, 2005.

7. Wendi Rabiner Heinzelman, Anantha Chandrakasan, Hari Balakrishnan, “Energy-Efficient Communication Protocol for Wireless Microsensor Networks”, IEEE Hawaii International conference on System Sciences, 2000.
8. Seema Bandyopadhyay, Edward J. Coyle, “An Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks”, Twenty-Second Annual Joint Conference of the IEEE Computer and Communications, 2003.
9. Gaurav Gupta, Mohamed Younis, “Performance Evaluation of Load-Balanced Clustering of Wireless Sensor Networks”, IEEE International Conference on Telecommunications, 2003.
10. Jalil Jabari Lotf, Mehdi Nozad Bonab, Siavash Khorsandi, “A Novel Cluster-based Routing Protocol with Extending Lifetime for Wireless Sensor Networks”, IEEE International Conference on Wireless and Optical Communications Networks, 2008.
11. Younis, O., “HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks”, IEEE Transactions on Mobile Computing, 2004.
12. Nazia Majadi, "U-LEACH: A Routing Protocol for Prolonging Lifetime of Wireless Sensor Networks", International Journal of Engineering Research and Applications, Volume 2, Issue 4, 2012.
13. Yunxia Chen, Qing Zhao, “On life time of sensor network”, IEEE Communications Letters, Vol 9, No. 11, 2005.
14. Mao YE, Chengfa LI, Guihai CHEN, and Jie WU, “An Energy Efficient Clustering Scheme in Wireless Sensor Networks”, Ad Hoc & Sensor Wireless Networks, Vol. 3, 2006.
15. Harneet Kaur, Ajay K. Sharma, “Hybrid Energy Efficient, Distributed Protocol for Heterogeneus Wireless Sensor Network”, International Journal of Computer Applications, Vol 4, 2010.
16. D. J. Dechene, A. El Jardali, M. Luccini, A. Sauer, “A Survey of Clustering Algorithms for Wireless Sensor Networks”, Information and Automation for Sustainability, 2008. ICIAFS 2008. 4th International Conference , Publication Year: 2008 , Page(s): 295 – 300.
17. Network Simulator-2 (NS-2) - http://www.isi.edu/nsnam/ns
18. Vivek Katiyar, Narottam Chand, Surender Soni, “Clustering Algorithms for Heterogeneous Wireless Sensor Network:A Survey”, IJAER, volume1, No 2, ISSN-0976-4259, 2010.