ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 6, June 2015

An Enhanced Distributed Fault-tolerant Clustering Algorithm(EDFCA) Using Grid Deployment for Wireless Sensor Network

Payal Monga

Abstract*— Energy consumption is the most popular parameter in the wireless sensor network. To reduce the energy consumption, mostly uses the clustering topology. Cluster formation should be efficient and overall overhead like routing overhead should be less. In this paper we proposed an Enhanced distributed fault-tolerant clustering algorithm(EDFCA), in which WSN is divided into grids and in each grid, there is a cluster head which manage all the nodes, mostly all the nodes of particular grid are covered by the gateway, very few nodes are uncovered due to the communication range of the gateway. EDFCA takes care about those sensor nodes which have no gateway within their communication range. In the cluster based network, cluster head uses more energy rather than other nodes due to extra workload and it can be dead earlier rather than other nodes. So EDFCA also provides the recovery of the faulty cluster head. And the experimental results show the improvement of EDFCA over the DFCA (Distributed fault-tolerant clustering algorithm).

***Index Terms*— Cluster Head, Cluster Formation, Fault Tolerance, Grid Deployment, Wireless Sensor Network.**

I. INTRODUCTION

Wireless Sensor Network is like a distributed system, in which various nodes are distributed, they coordinate with each other to reach the base station.WSN uses the various protocols for sending the data to the base station. It is consist of various nodes, the main components of nodes are sensing unit, processing unit, communication unit and the environment in which it is operated. Each sensor node collects data and send to the base station. Sensor node is also called the member node. Data is sensed by the network is routed to the base station.

In Wireless Sensor Network, the main issue is the Energy Consumption because each sensor node uses own energy for communication with the base station. WSN provides cost effective solutions for these problems. Clustering techniques are used for solving these constraints. It allows organizing the member nodes in a hierarchical manner, grouping them into clusters, in each cluster one node act as a leader node, which is called cluster head (CH) as shown in Fig.1. Cluster head is responsible for transmitting the information of whole cluster, it helps to avoids the collisions between the sensor nodes inside the cluster because they don't communicate

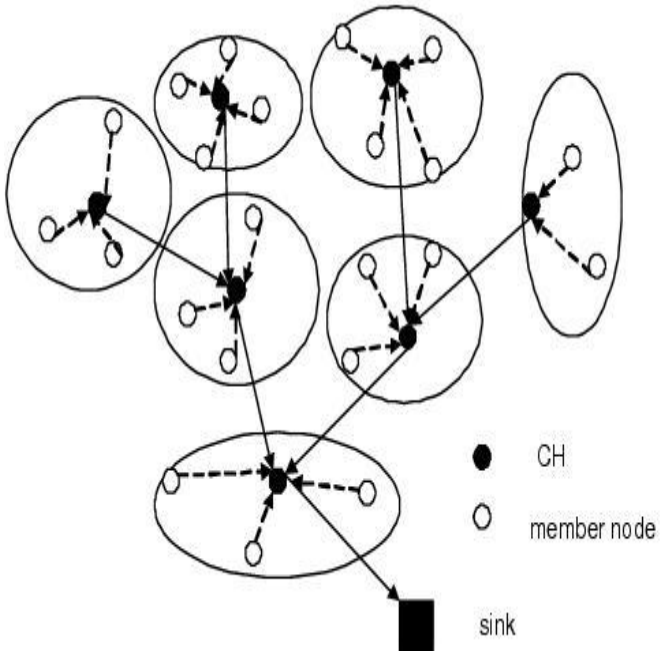

Fig. 1. A Wireless Sensor Network Model

with the other clusters nodes [1]. Cluster head manages the TDMA (Time Division Multiple Access) schedule and sending the combined data from the nodes to the base station [2]. Clustering techniques are used to achieve long network lifetime and decrease the energy consumption.

In this paper we proposed an Enhanced Distributed Fault-Tolerant Clustering Algorithm (EDFCA), there are some special nodes, which are called gateways and we also called cluster heads interchangeably. These nodes are assigned with extra energy but these nodes are also energy constrained. For long network lifetime, lifetime of gateways plays very important role. Therefore cluster formation is very important task in which nodes should be assigned to the gateways in proper way. When the nodes are randomly distributed, some nodes are uncovered by the gateways because they are not comes under the communication range of the gateways.

In EDFCA, WSN is divided into grids, in each grid nodes are distributed randomly but evenly, so there are very few nodes that have no gateway within their communication range as compared to Distributed Fault-Tolerant Clustering Algorithm (DFCA) [3]. EDFCA takes care about that nodes which have no gateway and there is less overhead due to less

uncovered nodes as compare to DFCA. There is no one Left out Node as DFCA. When the fault is detected, to recover the failure of cluster head, EDFCA avoids the re-clustering approach, it provides better fault tolerance algorithm as compared to DFCA. Results show that proposed method performs well rather than DFCA with respect to Nodes in Covered Set, Nodes in Backup Set, Left out Nodes, Remaining Energy, Routing Overhead, Number of rounds when first node dies.

II. RELATED WORK

Mostly uses the clustering techniques for reducing the energy consumption. Many clustering techniques have been developed for Wireless Sensor Network. LEACH (Low Energy Adaptive Clustering Hierarchy) is the most important clustering technique [4] that forms clusters in distributed manner. Main drawback of this technique is cluster head is selected randomly due to which node with very less energy may be selected as a cluster head which may die quickly. Therefore number of techniques have been proposed to improve LEACH such as I-LEACH [5], PEGASIS [6], MULTI-CHAIN PEGASIS [7], TSEP [8], TEEN [9], HEED [10] etc. In cluster formation, DFCA takes care about the sensor nodes that have no Gateway within their communication range and it also presents the recovery of the faulty cluster head[3]. Rehana raj T et al. [11] proposed a fault tolerant and energy efficient clustering approach in which WSN is divided into smaller cluster and sub cluster enabling a reduction of communication overhead. This paper also propose a fault tolerance method that uses matrix based error approximation method for providing the approximate sensor data of the failed node. Luciana Moreira Sa de Souza [12] present a survey of approaches to fault tolerance and detection techniques in WSNs in both theoretical and application driven research.

The main drawback of DFCA [3] is due to random deployment nodes are not evenly distributed in each cluster. Some cluster head have more sensor nodes, some cluster head have less sensor nodes and some nodes are out of the communication range of any gateway. By this, Uncovered Set has more nodes. And Second drawback of this algorithm is there are left out nodes present, which are not capable to communicate with any cluster head due to the communication range. They are communicating directly with base station, so there is too much energy consumption. When the fault is detected in DFCA, there is too much routing overhead while broadcasting messages for selecting another cluster head. We recovered all these drawbacks in the proposed work.

III. TERMINOLOGY USED IN ALGORITHM

Covered Nodes and Covered Set: Covered Nodes are those nodes which are covered by at least one gateway within its communication range. Covered Set is the collection of all covered nodes in the wireless sensor network. Covered set is represented as CO_{set}.

Uncovered Nodes and Uncovered Set: Uncovered Nodes are those nodes which have no gateway within its communication range. Uncovered set is the set of all uncovered nodes in the wireless sensor network. Uncovered set is represented as $UNCO_{set}$.

Backup Nodes and Backup Set: Backup Nodes for an Uncovered Nodes are all the Covered Nodes which are comes within the communication range of Uncovered Nodes. Backup Set for an Uncovered Nodes are the Set of all Backup Nodes of Uncovered Nodes.

Left Out Nodes: Left out Nodes are those uncovered nodes which are not comes in the Backup Set due to the problem of the communication range, these nodes are left at all, they can't communicate with any gateway.

Inactive Nodes: Inactive nodes are those nodes, which have some residual energy but due to the failure of gateway, they are unable to communicate with its gateway

IV. PROPOSED ALGORITHM

We proposed an EDFCA, Firstly here is cluster formation algorithm as shown in Fig.2. In this WSN is dividing into the Grids of same region. In each grid, nodes are distributed randomly but evenly. In each Grid there is one Gateway, that have equal number of nodes. And that is selected by following steps:

- First we select mid-points of all Grids.
- Then calculate the distance of all the nodes from these mid-points.
- Getting the shortest distance nodes from mid-points and choosing that nodes as Gateways.

After selecting the gateways in all grids, we choose the neighbors of all the gateways and after it gateways will broadcast HELLO message to all the neighbor nodes. If the node received HELLO message then it becomes the member of the Covered Set otherwise it becomes the member of the Uncovered Set. The sensor nodes which belongs to the Uncovered Set, broadcast a HELP message for backup in same grid. The sensor node which belongs to the Covered Set and also the neighbor of the Uncovered Node sends a reply and becomes an element of the Backup Set. In this algorithm, uncovered nodes are very less rather than DFCA. Left out Nodes are not present in this algorithm. Both Drawbacks are recovered in this algorithm.

We also proposed a fault tolerance algorithm as shown in Fig.3. When fault is detected in particular grid, then EDFCA recover the faulty cluster head by finding the residual energy of all inactive nodes of same grid. Then call the max function, and highest residual energy of the node selected as Gateway. By this network overhead decreases as compared to DFCA due to less broadcasting while selecting another gateway.

Algorithm: Cluster Formation

Step 1: WSN is divided into 3×3 or 9 grids, in which nodes are evenly distributed.

Step 2: Choose the one gateway per grid.

2.1: Choose the mid-points of all grids.

for i=1:9

x_{in} = mid-point of x-coordinate of i^{th}

y_{in} = mid-point of y-coordinate of i^{th}

end

2.2: Get the distance of all the nodes from these mid-points.

S_j = set of nodes in i^{th} grid

for i= 1:9

for j= 1: S_j

d_{ij} = Distance between nodes and mid-points.

end

call min

gateway= min (d_{ij} (S_j))

end

Step 3: Gateway broadcast HELLO message

G_i = set of gateways

3.1: while (S_i receiving HELLO message from G_i)

S_i becomes the element of CO_{set}

endwhile

3.2: if(timeout && no HELLO message received**) then**

S_i becomes a member of $UNCO_{set}$

endif

Step 4: if (S_i € $UNCO_{set}$**) then**

S_i broadcasts a HELP message for backup.

endif

Step 5: if (S_i € $UNCO_{set}$**) then**

5.1: S_i broadcasts a HELP message for backup.

5.2: while (S_i receiving reply from S_j)

BackupSet(S_i) = *BackupSet*(S_i) ∪ S_j

endwhile

5.3: if (*BackupSet*(S_i) ≠ 0) **then**

S_i uses S_j from *BackupSet*(S_i) as a *relay*

with highest residual energy to send the data to the CH.

endif

endif

Step 6: Stop.

Fig. 2. Cluster Formation Algorithm

Algorithm: Fault Tolerance

/* Fault is detected by the sensor node S_i and set itself as uncovered. */
Step 1: If fault is detected in any grid.

S_i = set of nodes that became inactive.
N = length of S_i
for i= 1:N
E_i = energy of S_i
end
call max
gateway= max**(**$E_i(S_i)$)

Step 2: Stop.

Fig. 3. Fault Tolerance Algorithm

V. RESULTS AND DISCUSSION

We performed the proposed algorithm using MATLAB R2013b. The experiments are performed with 100 × 100 square meter area by 91 sensor nodes and 9 gateways. Each sensor node has initial energy of 2 joules and for each gateway initial energy is 10 joules. If the energy of the node reaches to 0 joules, then that node considers the dead node. In our simulation the radio energy model is used as same as [13].

Here we compare the results of Distributed Fault-Tolerant Clustering Algorithm [3], and Enhanced Distributed Fault-Tolerant Clustering Algorithm, which is our proposed algorithm as shown in Table. 1.

Table. 1. Comparison of DFCA and EDFCA

Parameters	DFCA	EDFCA
Nodes in Covered Set	58	78
Nodes in Backup Set	27	13
Left out Nodes	6	0
Remaining Energy	41.3867	122.1173
Routing Overhead	8.7800	0.7800
Number of Rounds When First Node Dies	1	9

From these values, it is clear that proposed algorithm EDFCA provides better results than DFCA [3].

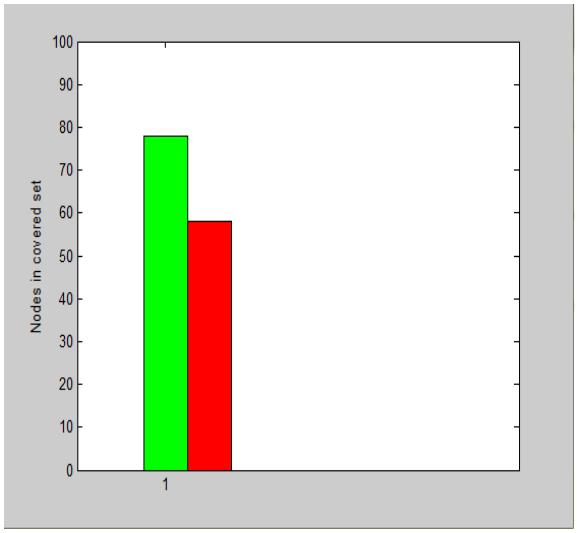

Fig. 4. Nodes in Covered Set

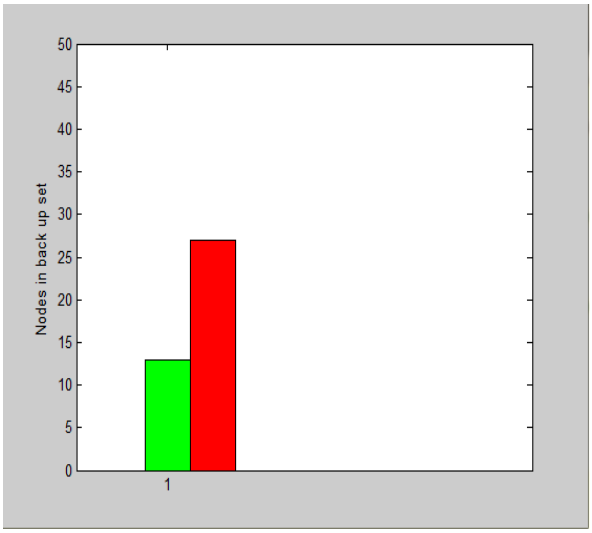

Fig. 5. Nodes in Backup Set

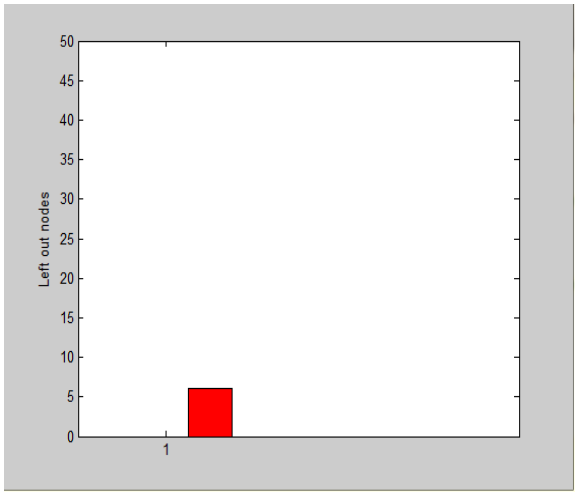

Fig. 6. Left out Nodes

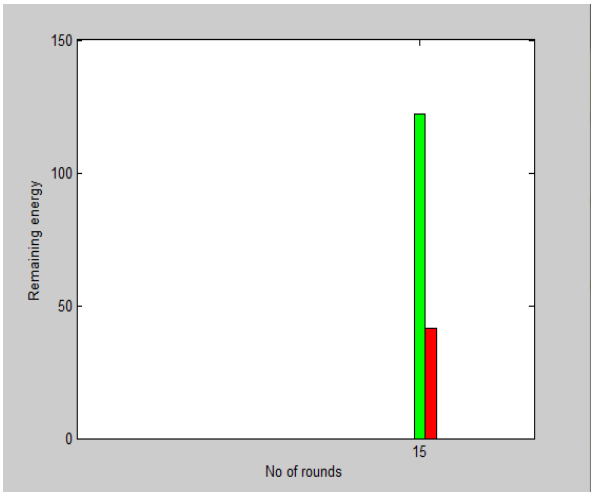

Fig. 7. Remaining Energy

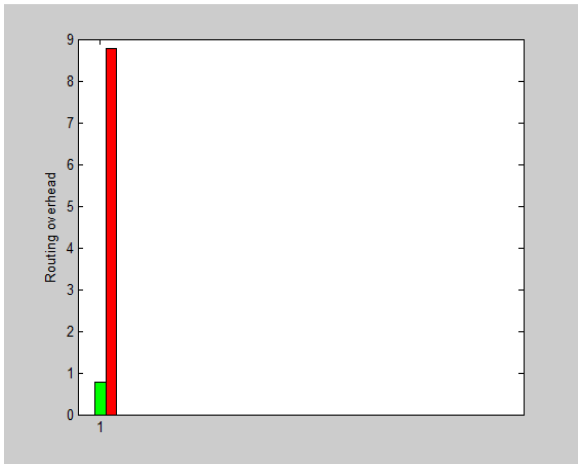

Fig. 8. Routing Overhead

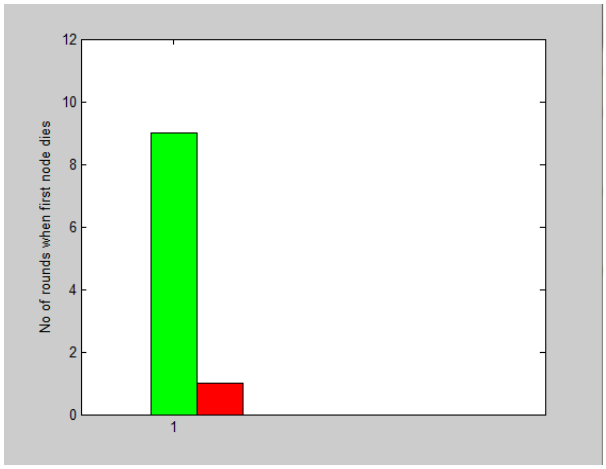

Fig. 9. Number of Rounds When First Node Dies

Fig.4,5,6,7,8,9 shows the comparison of DFCA(by bar graph of red color) and EDFCA(by bar graph of green color) in terms of nodes in covered set, nodes in backup set, left out nodes, remaining energy, routing overhead, number of rounds when first node dies respectively.

VI. CONCLUSION

In this paper, we presented Enhanced Distributed Fault-Tolerant Clustering Algorithm called EDFCA for Wireless Sensor Network. The Drawbacks of DFCA are recovered in this algorithm by using the grid deployment method, nodes are distributed randomly but evenly in each grid. Each gateway have equal no of nodes and there are very few nodes which are uncovered by the gateways rather than DFCA. And there is no one Left out Node, mostly all nodes are covered by the gateway and uncovered nodes are communicated with gateway through backup set. Recovery of faulty cluster head recover by the another cluster head in same grid. Results shows that EDFCA is more efficient than DFCA in terms of Nodes in Covered Set, Nodes in Backup Set, Left out Nodes, Remaining Energy, Routing Overhead, Number of rounds when first node dies.

ACKNOWLEDGMENT

I would like to thanks my supervisor Mr. Vishal Kumar Arora, Assistant Professor, Department of Computer Science Engineering, SBS State Technical Campus, Ferozepur (Punjab), India, for all the support he gave me, during the months I spent undertaking my field work.

REFERENCES

[1] Liliana M. Arboleda C. and Nidal Nasser, "COMPARISON OF CLUSTERING ALGORITHMS AND PROTOCOLS FOR WIRELESS SENSOR NETWORKS".
[2] M. BaniYassein, A. Al-zoubi, Y. Khamayseh, W. Mardini, "Improvement on LEACH Protocol of Wireless Sensor Network (VLEACH)",doi: 10.4156/jdcta.vol3.issue2.yassein.
[3] Md Azharuddin, Pratyay Kuila, Prasanta K. Jana, "A Distributed Fault-tolerant Clustering Algorithm for Wireless Sensor Networks", IEEE, 2013.
[4] W. Heinzelman, A. Chandrakasan and H. Balakrishnan "Application specific protocol architecture for wireless microsensor networks," IEEE Transactions on wireless communications, vol. 1, no. 4, pp. 660-670, 2002.
[5] Md. SiponMiah and Insoo Koo, *Member, KIICE* "Performance Analysis of ILEACH and LEACH Protocols forWireless Sensor Networks",J. lnf. Commun.Converg. Eng. 10(4): 384-389, Dec. 2012.
[6] Debnath Bhattacharyya, Tai-hoonKimandSubhajitPal,"A Comparative Study of Wireless Sensor Networks and TheirRouting Protocols",ISSN1424-8220,*10*,10506-10523;doi:10.3390/s10121050, *Sensors* 2010.
[7] Samia A. Ali and Shreen K. Refaay, "Chain-Chain Based Routing Protocol", IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 2, ISSN (Online): 1694-0814, May 2011.
[8] *M. B. Rasheed, N. Javaid, Z. A. Khan, U. Qasim, M. Ishfaq*, "E-HORM: AN ENERGY-EFFICIENT HOLE REMOVING MECHANISM IN WIRELESS SENSOR NETWORKS", arXiv:1303.6260v1 [cs.NI] 25 Mar 2013.
[9] Manjeshwar A. and Agrawal D. P, "TEEN: A routing protocol for enhanced efficiency in wireless sensor networks," Proc. of the 15th Intl. Workshop on Parallel and Distributed Computing Issues in Wireless Networks and Mobile Computing, San Francisco, pp. 2009–2015, 2002.
[10] Younis O. and Fahmy S, "HEED: A hybrid, energy-efficient, distributed clustering approach for Ad - Hoc sensor networks," IEEE Transaction on Mobile Computing, vol. 3, pp. 366–379, 2004.
[11] Rehana raj T, Maneesha V Ramesh, Sangeeth k "Fault Tolerant Clustering Approaches in Wireless Sensor Network for Landslide Area Monitoring".
[12] Luciana Moreira Sa de Souza, Harald Vogt, Michael Beigl, "A Survey on Fault Tolerance in Wireless Sensor Networks".
[13] R.U.Anitha, Dr. P. Kamalakkannan, " Enhanced Cluster Based Routing Protocol for Mobile Nodes in Wireless Sensor Network" Proceedings of the 2013 International Conference on Pattern Recognition, Informatics and Mobile Engineering (PRIME) February 21-22.

Payal Monga has received her M.Tech degree in the Computer Science Engineering from Shaheed Bhagat Singh State Technical Campus(SBSSTC) Ferozepur (Punjab), India, under the Punjab Technical University(PTU).