PERFORMANCE IMPROVEMENT OF CLUSTERED NETWORK THROUGH DATA REPLICATION AND SECONDARY CLUSTER HEAD SELECTION

K. Lakshmi Joshitha, A. Gangasri

Sri Sai Ram Engineering College, Chennai, India.
lakshmijoshitha@yahoo.com, srivedhu@yahoo.com

ABSTRACT

The objective of the proposed system is to augment the efficiency of the clustered wireless sensor network using Game theoretic approach. In WSN the Cluster Head (CH) has the responsibility of gathering data from the members of its group and transmitting it to the sink. In this approach CH is selected by taking into consideration the residual energy. A periodical change of the head happens when the CH energy drops below the energy of other nodes present in the same cluster. Data replication is done if either CH fails to work or the link between CH or sink gets disconnected.

Index Terms— data replication, Cluster Head (CH), Candidate CH, cluster, sink, residual energy.

I. INTRODUCTION

Clustering in Wireless Sensor Network, groups the sensor nodes deployed into particular sets [1]. The traffic load can be handled efficiently if there is a Cluster Head (CH) is required for each group which is responsible for collecting the data from the cluster it belongs to and then forward it to the sink. The goal of the Game theoretical method [2, 3, 4] is to elect Cluster Head based on energy and providing the role of CH in a cyclic order. This approach is like giving chance to effective players in the game to win the game. The characteristic of cluster leader is that it should be the fittest one with sufficiently higher energy to handle in flowing data and properly forward it to sink. Addition to this if the link between Cluster head of any group and the sink fails, data replication is performed to avoid network disconnection. Thus, data replication guarantees the enhancement of the lifetime of the nodes and networks.

II. RELATED WORK

The work of [5] gives the details about the replication of data in a network of clustered fashion for reliable data exchange when the network is partitioned. But here sensor nodes can communicate only with stable neighbors. Moreover, the provision of path for the intra cluster node is also reduced in this technique. The Low Energy clustering technique of [6], Group of nodes has its head for a particular round elected in a random manner. Then the selected Cluster Head will advertise itself to all the other nodes belonging to that cluster by sending the ADV message. After receiving the ADV message the nodes check the message and based on the strength of this message the node is accepted as the head. Then, participating nodes send the Join-Request message to the particular cluster head which is selected randomly for this round in order to show its acceptance. But in LEACH method only fixed amount of cluster heads are available for any size of network and this is not an efficient method for large scale network. CH may concentrate in specific area of the network and hence it cannot be selected just randomly. The existing Density-based clustering method [7], certain points are selected as core point to form a cluster if there exists a minimum -points in E-neighborhood distance else it is called as noise point. The data points which are at density reachable distance of the main point and not yet participating in any other clusters are getting added to the cluster. Repeated such process is carried on until the cluster has data points otherwise the same procedure will be continued for the rest of the data points to form more clusters to cover all the data points existing in the network. But this approach need predetermined criterion which makes it highly impossible to deal with the high dimensional data from scenarios of real time. In existing K-Means clustering [8], groups are formed by allocating the participating nodes to the nearest centroid. Hence this method requires K centroids. Calculation of the centroid is done again repeatedly if any changes occur in the deployment scenario. But in case of the death of the central node the entire functioning of the network is disrupted. In addition to this drawback, if there is any dropping of packet during exchange of information between the central node and participating node then that node will not be considered in network further. The group head of the cluster is selected using the fuzzy rule in [9], considers Rate of recurrent communication (RCSN) as a main parameter to select the cluster head which is the frequent communication between candidate nodes and sink. In addition to the RCSN few other parameters such as, Power of sensor nodes, Degree of nearby nodes, Distance between node and sink, Speed of nodes and mobility of the nodes are also taken into consideration. For example, if we consider Speed of sensor nodes as a selection parameter, then the slow moving nodes are having more chance to be opted for being a cluster leader because the fast moving nodes may lose their energy drastically. In existing Node density based Allocation of cluster and Routing for lengthening of the Lifetime of Networks [10], distribution of node density of a network is used to increase the its lifetime. The nodes which are nearer to the base station are usually responsible for transmitting very large amount of data. Hence those nodes are likely to consume excess of energy and are to be put to sleep when not in use to conserve its energy.

III. MATHEMATICAL MODEL

Initially consider the deployment of N nodes which undergoes clustering using iteratively done Linear Regression (ILR) based clustering. Here the highest energy node is likely to get the responsibility of being a head. Energy consumed by the node at times of packet transmission (ETx) is calculated as given below.

$$ETx(l,d) = \begin{cases} lE_{elec} + l\epsilon_{fs}d^2, d < do \\ lE_{elec} + l\epsilon_{mp}d^4, d \geq do \end{cases} \quad (1)$$

Energy consumed during the packet reception (ERx) is calculated using equation (2).

$$ERx(l) = lE_{elec} \quad (2)$$

The Table I. Shows the terms used in the equation. The value of do is 1 to 10m for the indoor application and is taken as 10 to 100 m for any outdoor applications.

TABLE I. PARAMETERS

Parameters	Description
do	Reference distance greater than the Fraunhofers distance
d	Distance over which the packet is transmitted
L	Represents the Number of bits per packet.
d^2	Refers to the power loss of free space channel model
d^4	Power loss of multi path fading channel model.
E_{elec}	Amount of energy getting dissipated during transmission or reception
$l\epsilon_{fs}$	Transmission efficiency.
$l\epsilon_{mp}$	Condition of the channel.

There may be chance for drop in energy in cluster head after some time. At this period the node which has next highest residual energy is selected as candidate cluster head. Data replication is performed by copying the data of cluster head to the participating nodes to avoid disconnection in link between the CH and sink.

IV. ALGORITHM

1. Deploy Number of nodes.
2. Form clusters based on ILR clustering.
3. Calculate the residual energy of the nodes using equations (1) and (2).
4. Select the node which has maximum residual energy as Cluster Head which collects data from Participating nodes and send it to the sink.
5. If Cluster Head fails else its energy get dropped, select Candidate Cluster Head based on energy using equations (1) and (2).
6. If the link between Cluster Head and sink fails perform data replication on candidate CH.
7. To prove the lift in the lifetime of the Network, the throughput graph of network for with and without data replication.

V. PROPOSED SYSTEM

The flow of the work is given in Fig.1. The nodes are initially deployed randomly. They are formed as clusters using ILR clustering technique. The heads of each group is provided with the role of heading based on its left out energy which follows equation (1) and (2). Then the role changes periodically using Game theoretic methodology in case CH energy drops or it fails to work. To avoid network disconnection data replication is performed.

A. Game theoretic approach of cluster head selection

This approach is used in applications such as Environmental monitoring, Military and Surveillance applications, Healthcare, Robotics, Landslide detection, Weather monitoring and Forest fire detection [11]. As shown in Fig.4 the node that forms itself as the fittest one based on the good amount of energy is chosen as head for each formed cluster. Here nodes 1, 3, 4, 5, 10, 12, 14 and 16 acts as Cluster Heads. Consider node 14 heading the group and is elected using the game methodology. The cost to declare value of different cluster leaders in the work has been evaluated as shown in Table II. Initially node 14 has the peak value of energy as 390J. As the energy is lost, the CH role needs to be changed to one of other participating node which has next best energy level belonging to the same cluster. In this cluster node 17 has high energy of 367J which is capable of playing the CH role compared to all other nodes (players). Hence node 17 acts as Candidate CH for further transmission and its given in Fig.5.

In the proposed to work we follow cooperative game theory approach. This is a game where the players cooperate to increase the utility of their group. The algorithm of the work is mentioned below from equations (3) to (10).

1. Define the game as $G = < N, S, U >$ (3)

   N - Set of sensor nodes acting as players

   S - Set of available strategies

   U - Utility function

Number of players taken for simulation setup is 19 as shown Fig.2.

2. $S = \{D, RD\}$ (4)

   D -Strategy to declare as CH

   RD–strategy of Refusal of declaring as CH

3. $cD = nCHi\ ERx + E\ aggr\ ETx(CHi, sink)$ (5)

$$cRD = ETx(si, CHi) \quad (6)$$

cD and cRD are cost of the node to declare as CH and to refuse.

$nCHi$ Number of nodes belonging to the cluster CHi

4. Utility function of the node is given by,

$$Ui(S) = \begin{cases} v - cD\ if\ Si = D \\ v - cRD\ if\ Si = RD \\ 0\ if\ Si = RD \end{cases} \quad (7)$$

v - Denotes payoff

5. Let P possibility of declaring as CH and 1-p Probability of refusing.

6. Utility function of playing D,

$$UD = v - CD \quad (8)$$

7. Utility function of playing RD

$$URD = (v - cRD)(1 - (1 - p)N - 1) \quad (9)$$

$$P = 1\ (cD - cRD/v - cRD \quad (10)$$

B. Data Replication in clustered Network

Data Replication in clustered Network is the process where the information of Cluster heading node is

replicated by the supporting CH while the CH fails to work or if there is any disconnection of link between CH and sink. In the simulation setup node 5 which is a CH of particular cluster is considered as failed to work at this condition Data replication is implemented on node 8 which has copy of information present in node 5 and continue further transmission as shown in Fig 5. Hence life duration of the network is maintained by avoid disconnection of links and CH failures. The disconnection of link to the sink leads to the selection of the candidate node that replicates CH's data. The node with highest bids is elected as candidate CH.

$$Bki = Eresiduali / Rki . csinki \quad (11)$$

$$Bki = Eresiduali / rki \quad (12)$$

Where, $Rki = rki . Cki$ (13)

Rki - Cost for i to replicate data in its CH

rki - Data access frequency

Cki - Transmission cost to its CH

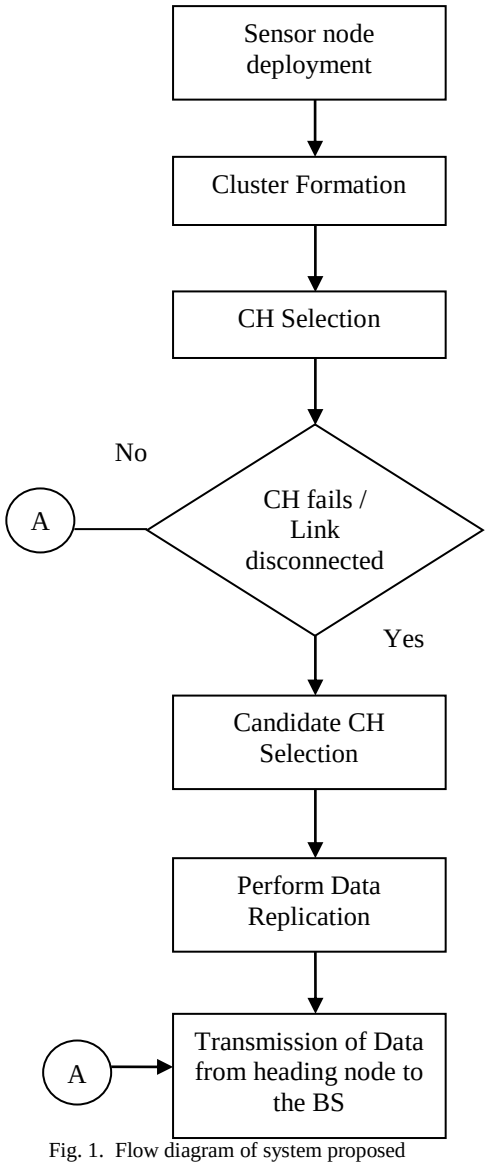

Fig. 1. Flow diagram of system proposed

Table II: Cost Function Evaluation

CH ID	Energy(J)	Cost function
17	212	848
14	110	440
13	343	1372
15	133	532

VI. Simulation Result

The deployment of nodes, cluster with the heading node using the linear regression methodology, augmenting the life of network using the data replication, candidate Cluster leader selection are simulated and the outputs are shown in Fig.2 to Fig.5.

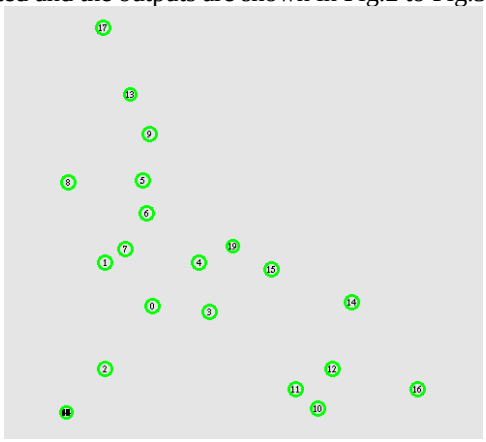

Fig. 2. Deployment of nodes

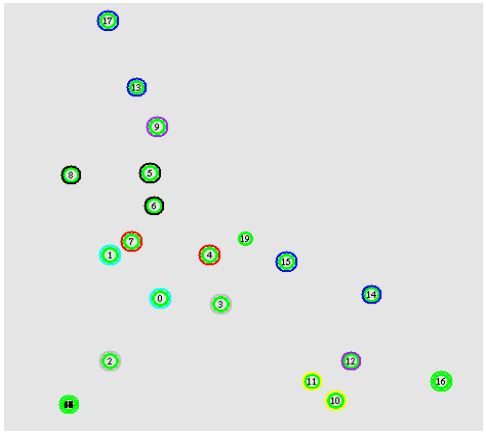

Fig. 3. Cluster Formation based on ILR clustering technique

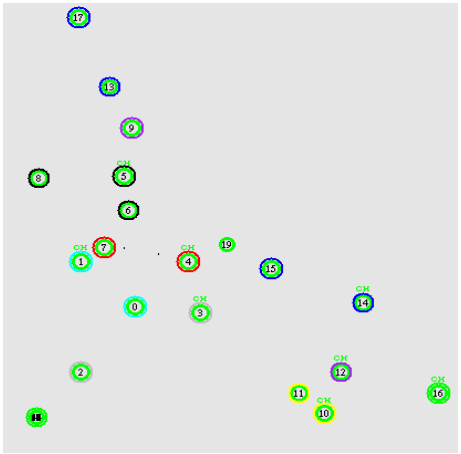

Fig. 4. Cluster Head selection

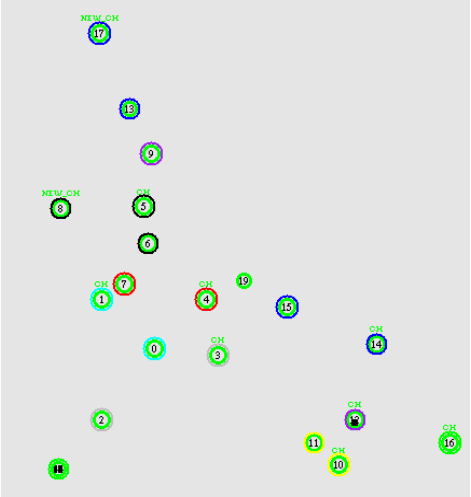

Fig. 5. Candidate CH selection and implementation of data replication

VII. Performance Evaluation

The performance of the system is evaluated in terms of throughput using Xgraph and is given in Fig.6 to Fig.8. It proves that the network is improved in its performance with data replication.

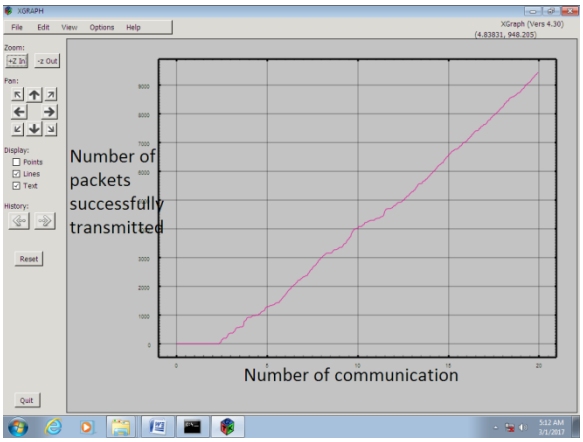

Fig. 6. Performance of throughput without data replication

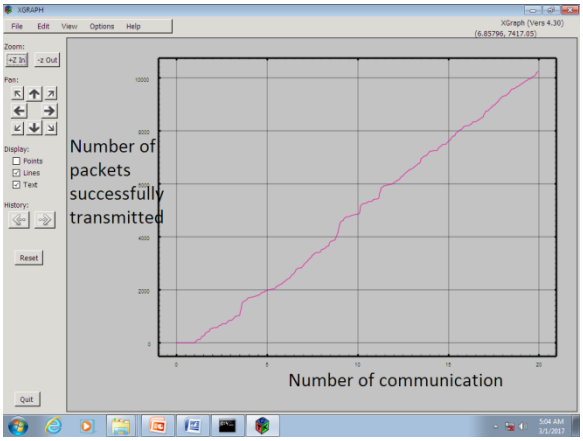

Fig. 7. Performance of throughput with data replication

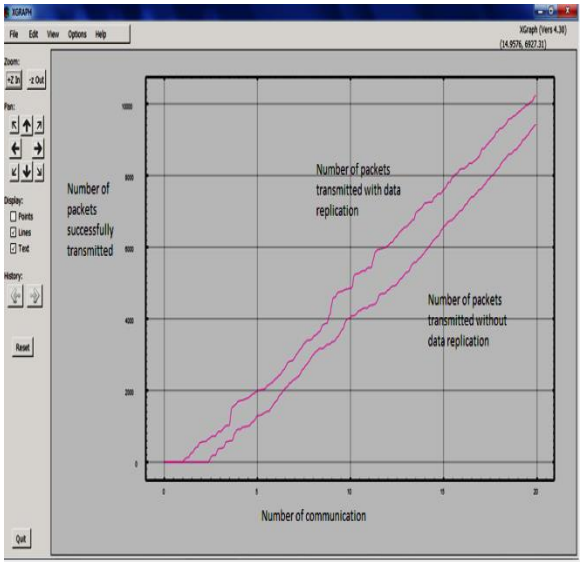

Fig. 8. Comparison of throughput for with and without data replication

VIII. Conclusion and Future Work

Cluster Head selection using Game theory is done. In case of CH failure candidate CH is elected using data replication to improve network lifetime. The future work of the cluster formation and replication method is to have some sort of scheduling for the selection of head. Moreover, the unintended node which acts selfishly not disclosing its energy to become a CH is to be identified for the formation of CH. Further the hardware implementation of data replication and the selection of candidate cluster head are to be done.

References

[1] Akyildiz, I. F., Su, W., Sankarasubramaniam, Y. & Cayirci, E., Wireless Sensor Networks: A Survey. Computer Networks 38: 393-422 (2002).

[2] Shi, H. Y., Wang, W. L., Kwok, N. M. & Chen, S. Y., Game theory for wireless sensor networks: a survey. Sensors 12(7): 9055-9097 (2012).

[3] Dasgupta, S. & Dutta, P., A Novel Game Theoretic Approach for Cluster Head Selection in WSN. International journal of Innovative Technology and Exploring Engineering (IJITEE) 2(3): 2278-3075 (2013).

[4] Xu, Z., Yin, Y., Chen, X. & Wang, J., A Game-theory Based Clustering Approach for Wireless Sensor Networks. NGCIT, ASTL Pp.58-66 (2013).

[5] Zheng, J., Su, J. & Lu, X., A clustering-based data replication algorithm in mobile ad hoc networks for improving data availability, International Symposium on Parallel and Distributed Processing and Applications Pp. 399-409 (2004).

[6] Yadav, L. & Sunitha, C., Low Energy Adaptive Clustering Hierarchy in Wireless Sensor Network (LEACH). International Journal of Computer Science and Information Technologies 5(3): 4661-4664 (2014).

[7] Amini, A., Wah, T. Y., & Saboohi, H., On density-based data streams clustering algorithms: A survey. Journal of Computer Science and Technology 29(1): 116-141 (2014).

[8] Sasikumar, P. & Khara, S., K-means clustering in wireless sensor networks, Computational intelligence and communication networks (CICN), 4th International Conference Pp. 140-144 (2012).
Natarajan, H. & Selvaraj, S., A Fuzzy Based Predictive Cluster Head Selection Scheme for Wireless Sensor Networks. Proceedings of 8th International Conference on Sensing Technology.

[9] Tarng, W., Lin, H.W. & Ou, K.L., A Cluster Allocation and Routing Algorithm based on Node Density for Extending the Lifetime of Wireless Sensor Networks. International Journal of Computer Science & Information Technology (2012) .

[10] Hemavathi, N. & Sudha, S., A Novel Regression Based Clustering Technique for Wireless Sensor Networks. Wireless Personal Communications 88(4): 985-1013 (2016).

[11] Prabhu, S.B. & Sophia, S., Real-world applications of distributed clustering mechanism in dense wireless sensor networks. International Journal of Computing, Communications and Networking 2(4): (2013).