ADAPTIVE CLUSTERING FOR ENHANCEMENT OF THROUGHPUT IN A DISTRIBUTED WIRELESS SENSOR NETWORK

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ABSTRACT

Clustered networks are of great demand today which may serve for communication in a cooperative fashion for nowadays evolving internet of things. In cases like habitat monitoring the animal may be fixed up with the sensor which becomes mobile. Especially when moving in herds or flocks the scenario is viewed as an event moving in clusters. This work aims at serving for such cases and providing an adaptive clustering with the size of the cluster being varied. As the group head dies in one cluster the cluster members are being allocated to the nearby heads based on the threshold of energy in the Cluster heading nodes. It is shown that the throughput of the network increases as the uninterrupted data collection is sustained through this residual energy scheme of member allocation to the different cluster head.

Index Terms— Cluster, cooperative communication, Cluster Head, adaptive clustering, residual energy scheme, throughput

I. INTRODUCTION

Clustering literally means formation of a group of similarly characterized points. In Sensor Network this clustering concept has its use in data gathering, distributed computing, energy conservation, reliable and simplified communication and much more. In most of the cases the cluster heading node (CH) is selected in rotation where all of the members are at least once elected as the CH. This set up is to provide the balanced life time for the nodes as the draining of the energy is on an average equal for all nodes. In case of the failure, the CH we have two options left with one being that elect a candidate CH which continues the work of the CH which is dead .The other is the allocation of the Cluster members (CM) of the failed CH to the nearby CH based on their residual energy and its distance to the CM. Adaptive clustering is the technique where the member nodes of one cluster is deputed to the nearby cluster heads when the problem arises with its own cluster head due to draining of energy and dying. The metrics evaluated shows that the adaptive clustering scheme has a better performance. The paper is organized as follows. Section II provides the relevant works in clustering concepts. Section III presents the mathematical model considered the assumptions made about the net-work. Section IV discusses the proposed work and the section V simulation results and discussions.

II. RELATED WORK

The survey about the sensor network and its characteristics are given in [1]. The mobility models for the clustering and the routing is dealt with in [2].The author in [3] deals with the parameter for the unequal clustering to prevent the generation of energy hole. [4] Works out on the distributed method of clustering and discusses the real ime applications which can be associated with the scenario. Work on Clustering in data Replication Algorithm in Mobile Adhoc networks for enhancing availability of data [5]. Formation of Clusters with variable sizes and the graph theory has been used up to equalize the energy of the different cluster heading nodes in the network. [6] is the discussion on the regression based technique of clustering or partitioning the randomly deployed nodes. The quality indices are evaluated to weigh the effectiveness of the clustering. The different types of the clustering schemes the evaluation of metrics based on the density of the cluster and the quality of cluster is discussed in [7]. The Fuzzy based predictive CH selection scheme of [8], considers recurrent communication rate as a main parameter to select the cluster leader which is the frequent communication between sensor nodes and Base Station. In addition to the technique of recurrent communication few other parameters such as, Remaining power of sensor nodes, the number of nearby nodes, Metric of distance from member node to base station, Speed of node movement is also taken into consideration. For example if we consider Speed of nodes as a CH selection parameter, then the slow moving nodes are having more chance to be selected as cluster head because the fast moving nodes may lose their energy drastically. The author of [9] indi-cates distribution of node density of a network is used to increase the network lifetime. The nodes which are nearer to the BS are usually responsible for transmitting very large amount of data. Hence those nodes consume more energy and should be put in to sleep when not in use to conserve its energy. Authors of [10, 11, 12] deals with the game theory of dealing the cluster heading operation. Each node has a payoff for the move it gives. The utility term is calculated for each move and if and only if the utility term is satisfactory the players or the nodes may abide to become the CH. There is some selfish node which shows least interest in revealing their energy level for taking part in the action. The work of [13] elaborately discusses on data replication method to overcome the link failure caused between the CH and the sink node while performing the data transmission. Sasikumar & Khara [14] shows the existing K-Means clustering. Clusters are formed by allocating the participating nodes to the nearby centroid. Hence this method requires K centroids. Cent-roid is calculated repeatedly if any changes occur in the deployment scenario. But in case of where the central node fails the entire network operation is disrupted. If there is any dropping of packet during information exchange among the nodes and CH node then that node will not be considered in network further.

III. MATHEMATICAL MODEL

The nodes are randomly distributed in the area of 1000 m x 1000 m rectangular area. All the nodes are assumed to be homogenous with an equal sensing radius of 20m.The transmission range (*n TR)* of the node is generally considered as twice the sensing range *(n SR*). Sensing range of a node covers a circular pattern of radius $n\ SR$, which is centered at its location. The antenna is assumed to be an omnidirectional one radiating radially with equal strength. The communication range of a node is a circular area of radius $n\ TR$, where $n\ TR \geq n\ SR$. Energy consumed by the node during transmission of packets (ETx) is given in equation (1). Normally the energy for the trans-mission is greater than that of the reception energy.

$$ETx(l,d) = \{lE_{elec} + l\epsilon_{fs}d^2, d < do\}$$

$$lE_{elec} + l\epsilon_{mp}d^4, d \geq do \qquad (1)$$

This variation in the energy is due to the channel condition like the fading, noise in medium of transmission, nature of the obstacles in the path, distance from the receiver to the transmitter, hardware characteristics of the transmission setup and so on. This energy consumption may be still worse in case if the event itself is moving. The parameters such as the speed of movement, the direction of movement also has an adverse effect in such scenarios.

TABLE-1: TERMS USED

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}	It is the amount of energy getting dissipated during transmission or reception
$l\epsilon_{fs}$	Transmission efficiency.
$l\epsilon_{mp}$	Condition of the channel.

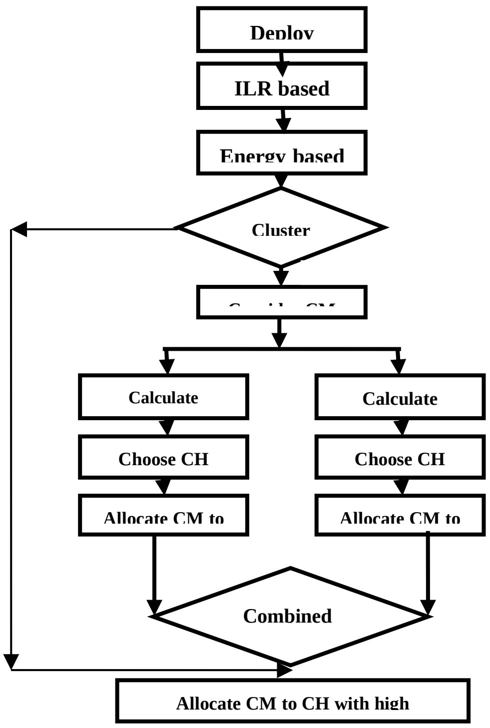

Fig.1 Flow diagram of proposed Adaptive Clustering system

Energy consumed by the node during reception process (ERx) is as in equation (2).

$$ERx = lE_{elec} \qquad (2)$$

Table 1. Shows the terms used in the equation. do Varies from 1m to 10m for the indoor application and is taken as 10 to 100m for any outdoor applications. The left out energy is the difference between the initial energy and the energy spent in exchange of the packets.

IV. PROPOSED SYSTEM

The proposed method of Adaptive Cluster Algorithm is given below. The flow diagram of the same is shown in Fig. 1.The steps in algorithm is as given below

A. Algorithm

- Nodes are deployed in a random fashion as in Fig. 2
- Form clusters based on ILR clustering as in Fig. 3
- Select cluster head by examining the energy as in Fig. 4
- If any cluster head fails, allocate the participating nodes to other cluster head based on following distance and energy conditions:

a) Calculate Euclidian distance of the cluster member (CM) and all other cluster head using the formula where coordinates of CM is (x_2, y_2) and that of the cluster head is (x_1, y_1)

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \qquad (3)$$

b) Allocate the nodes to cluster head which has distance lesser than the mean of distances which is set as threshold.

c) Calculate remaining energy of each cluster head

d) Allocate the nodes to cluster head which has residual energy greater than the threshold which is the mean of the energy of all nodes

e) The distance of the CM to the elected CH should be lesser than the threshold set that is the mean value of the distances.

- Validate the output by checking the throughput. Fig 6 and 7 shows the throughput.

V. SIMULATION RESULTS AND DISCUSSIONS

Simulation of the scenario shows 20 nodes deployed and the process of CH election done using the ILR technique. ILR is the iterative linear regression technique which is the iterative procedure to get the correct number of clusters following equations (4) to (9) as shown below for clustering.

For the horizontal clustering, we have $y = mx + c$ (4)

Where, $$m = \frac{\sum(x - x')(y - y')}{\sum(x - x')^2} \qquad (5)$$

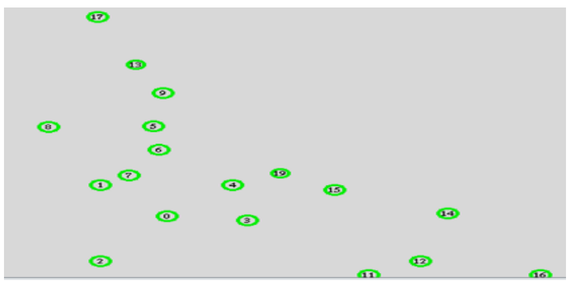

Fig.2 Node Deployment

$$c = y' - mx' \qquad (6)$$

For the vertical clustering, the equation below holds good.

$$x = my + c \quad (7)$$

$$\text{Where, } m = \frac{\sum(x - x')(y - y')}{\sum(y - y')^2} \quad (8)$$

$$c = x' - my' \quad (9)$$

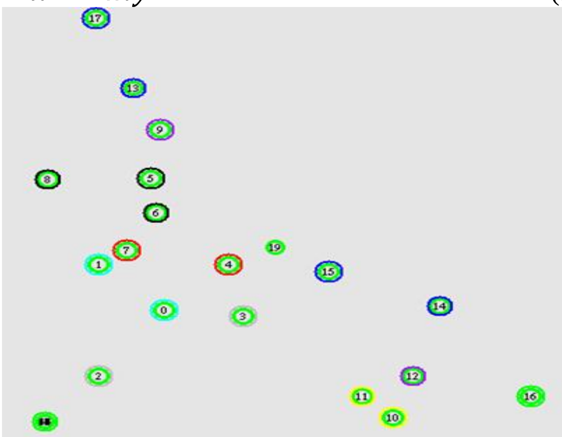

Fig.3 Cluster Formation based on ILR algorithm.

It is seen that there are 8 clusters initially formed with nodes 1, 3, 4,5,10,12,14,16 as CH. If CH 5 dies due to draining of energy, its CMs which are nodes 6 and 8 are to be allocated to any other cluster heads .The distance between nodes 6 and 8 all other cluster head is calculated. The energy component of these nodes are shown in table 2.The average distance for node 6 is 279.68m and the mean of all the nodes energy is 212J. CH that satisfies the condition of distance being lesser than 279.68m are CH1, CH2, CH3.Similarly for node 8 the mean distance is found to be 388.74m and the same CH1,CH2,CH3 satis-fies the distance criterion of being lesser than the mean value of distance. The energy constraint of CH energy being greater than the average value of 212J is satisfied by CH1, CH2, and CH7. As CH7 is of greater distance it is not considered. In the same way CH3 is of very low energy and hence not considered.

Moreover the left out heads CH1 and CH2 are considered and the best of it is selected which is CH1 that has the minimum distance and highest energy. Thus we allocate the nodes 6 and 8 of the dead CH to CH1. They prove to be the best selection of CH based on the differential residual energy and also the distance. The throughput is more for CH1 allocation than the CH2.The number of packets effectively transmitted is about 10212 by CH1 and that by CH2 is 9999 at the time of 150ms as shown in the simulated output. Fig 5 shows this alloca-tion.

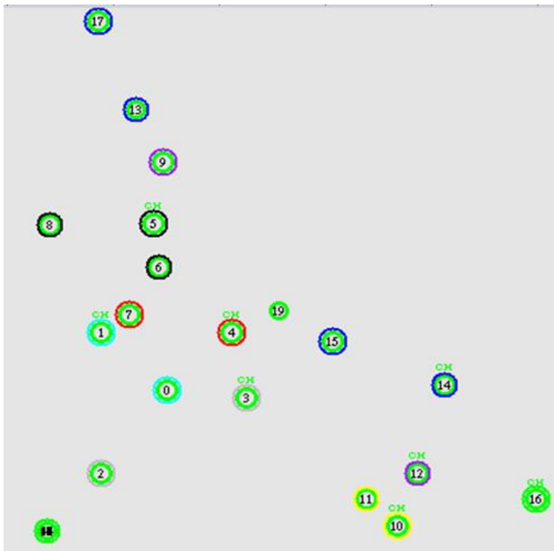

Fig. 4 Cluster Formation and CH election based on ILR clustering technique

The graph of Fig 6 and 7 shows the through put offered by the CH2 and CH1. The Simulation was done with energy, Distance and throughput as the metrics. It was proved that the intelligent allocation of the CM to the other CH when a CH fails in a network is an effective means of improving the throughput of the network. This is efficient than the energy spent in allocating the candidate cluster head that takes up the work of the cluster head.

Table 2 Energy and distance from node 6and node 8 to all Cluster head nodes

N	CH1 (N1)	CH2 (N3)	CH3 (N4)	CH4 (N10)	CH5 (N12)	CH6 (N14)	CH7 (N16)
D6 (m)	96.54	175.866	108.245	391.15	364.13	335.88	485.96
D8 (m)	133.33	288.78	231.19	507.599	486.38	462.857	611.06
E (J)	370	296	16	168	64	110	460

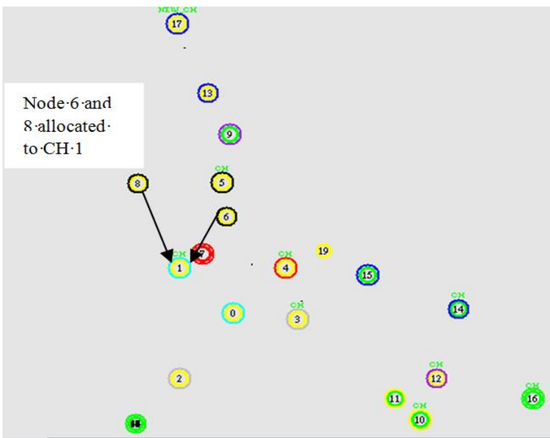

Fig.5 Node 6 and 8 are allocated to CH 1

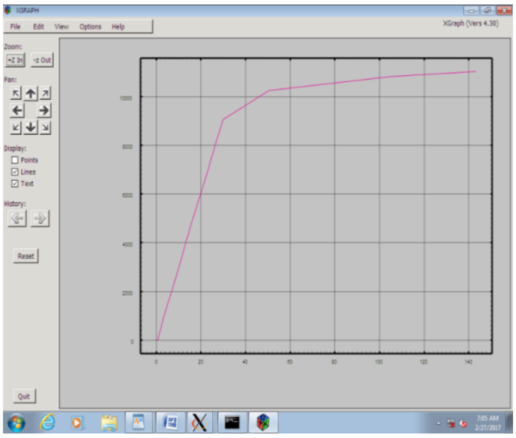

Fig 6 Throughput of cluster head CH1

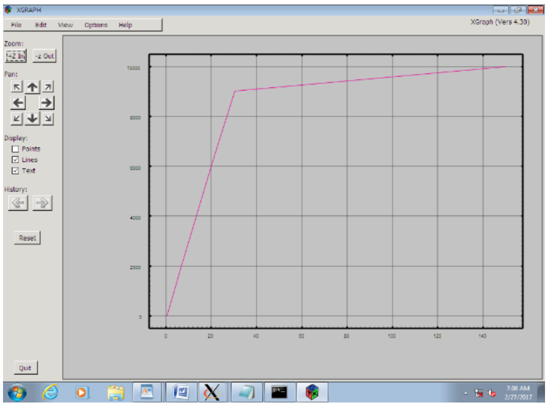

Fig.7 Throughput of cluster head CH2

VI. CONCLUSION AND FUTURE WORK

The work provides the clustering which is adaptive in nature. This proves that there is an option of selecting the best allocation scheme of the member node to the already available cluster leader nearby rather than choosing a secondary candidate cluster head in case of any CH failure. It is shown that the throughput is increased if the cluster member is allocated to the best CH based on the residual energy and distance.

Future work may have analysis on the mobility models to form the cluster where the metrics like the time taken to form the cluster for considered mobility models, its throughput, adaptive nature and the method to heal the coverage hole using the best mobility scheme will also be considered.

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