Multi-Objective Clustering Technique with Guaranteed delivery in Wireless Sensor Networks

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Abstract- Clustering is an essential requirement in large scale and dense deployment of sensor nodes in a target area. Many techniques have been explored for clustering which ensures coverage and connectivity and may not be focused on the guaranteed delivery of data from the cluster head to sink. The main objective of this paper is two-fold: to bring the uniform cluster size with guaranteed delivery and to route the data with minimum power symmetric connectivity. A distributed, dynamic clustering algorithm is built to unite the sensors in the field and combined greedy and chain based routing is applied to bring the guaranteed delivery of data. The results obtained are verified with the stochastic geometry to reduce the energy consumption in the sensor network and produced paramount results of packet delivery ratio.

Keywords – Clustering, Guaranteed Delivery, Wireless Sensor Networks, Routing

I. INTRODUCTION

The rapid advancement of wireless communications technologies brought the low cost sensors with tiny size and extremely good signal processing capacity. Compared to wired devices, the sensors are deployed easily with less cost. The sensors are used in number of applications such as Chemical Industries, Oil and Gas Refineries, Target tracking surveillance, Weather forecasting etc[1][3].

The advancement of technologies brought the threat also in equal weight. Issues in Physical and MAC layers, Positioning of the cluster head, Localization, Routing and Transport protocol issues etc. A cross layer design is the suitable choice for implementing an effectual network platform with sensors[4].

The rest of the paper is organized as follows. Proposed Clustering and Routing algorithms are explained in section III. Experimental parameters are presented in section IV. Concluding remarks are given in section V.

II. RELATED WORKS

Many algorithms have been implemented with the objective of minimum number of clusters in the network with at most **k** hops distance. If the sensors are deployed at a large scale or dense deployment is required if in case of forest fire detection, communication paves the essential role with guaranteed routing techniques.

The clustering techniques can be classified in many ways. One way is to classify based on the cluster size that is one hop clustering and multi-hop clustering. In one hop clustering [1], the nodes communicate can directly with their corresponding cluster head (CH) whereas in multi-hop clustering [2], the nodes tends to communicate via several hops to reach its corresponding cluster head.

The Cluster Head is a node where the data are collected from all its members and send it to the sink. The algorithms LEACH [1], HEED [3], TEEN and PEGASIS are hierarchical network protocols designed for sensor networks. A randomized Cluster Head (CH) selection is done in these algorithms. Some factors like the information of average network energy, the node location, delay etc were been considered to select the CH. The algorithm EDIT [4] also considers both the energy and the delay as a factor. The algorithms such as UCR (Unequal Clustering Routing)[5] will helpful in load balancing.

Routing is a process of selecting the best path to transmit the data in the network. Routing techniques includes the various geographic routing algorithms which changes between greedy mode and recovery mode based on the network topology. Greedy routing is a technique that forwards the message to a neighbor which is nearer to the destination. In greedy mode, there are many algorithms such as GPSR (Greedy Perimeter Stateless Routing) [6], MFR (Most Forward within Radius) [7] and Cartesian routing [8].

III. PROPOSED WORK

The major contributions of our proposed work are as follows:

The clusters formed are of uniform size.
2. The uniform sized clusters will help in the routing process.
3. The routing process in turn helps in guaranteed delivery of the data.
4. The guaranteed delivery helps to balance the load.

The sensor nodes are uniformly distributed in the sensor field. Each node in the network will have fixed transmission power. The network is fragmented into fan shaped clusters as described in Fig. 1. The sink node will be located at the center of the network. The network field is divided into concentric rings. The width between the layers should be equal and the width between the sink node and the first layer should be greater than the remaining layers. Then each layer is divided into clusters with equal sized node. This can be achieved using (2*i-1) where i represents the layer to be partitioned. Then the nodes in field will identify its position in which cluster its belongs to. The nodes identify its position using GPS (global positioning system) present in each node.

Routing is a process of identifying the path that is best suitable to transmit the data. Here in fan shaped clustering techniques, the data are transmitted from above layer to the sink node via next lower layer node but there is no predefined path to pass the data. If the data are passed in next lower layer without any predefined path then transmission of data between the nodes will be high. This causes the high amount of dissipation of energy. So there is a need to route the network for traversing the data to the sink. To undergo routing process, we implement a technique using the below specified algorithm.

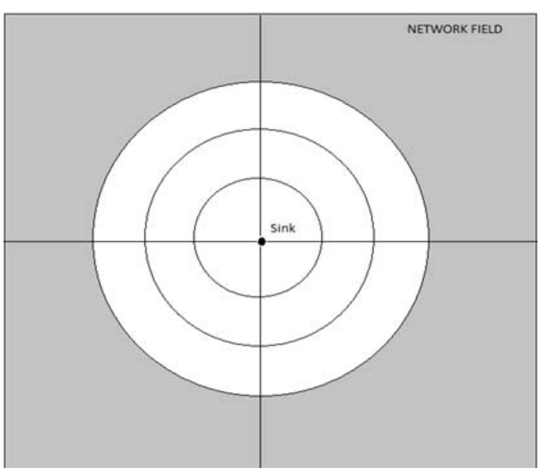

Fig.1.Partitioned Network

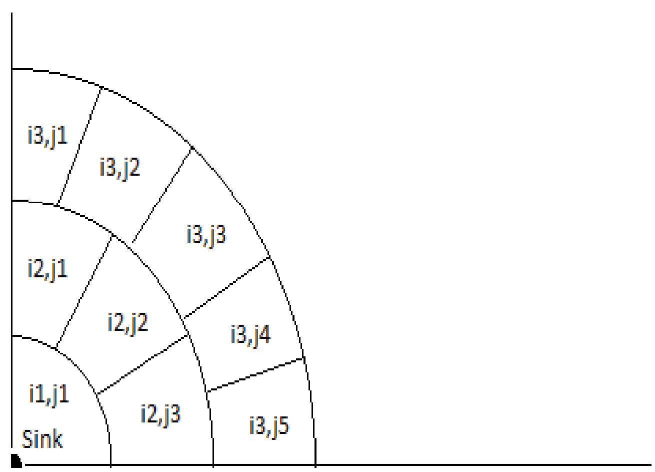

Fig.2.Partitioned layers

1. CLUSTER HEAD SELECTION ALGORITHM

1. Find the nearby nodes of each node x with the degree d as

   $d=\sum (dist(x, x') < range)$
2. Compute the difference of degree, $\Delta_x = | d - t |$, for every node r.
3. Compute the sum of the distances D with all its nearest neighbor's as

   $D=\sum \{ dist(x, x') \}$
4. Compute the average of the running speed for each node which gives measures of mobility and is given by

   $$M=\frac{1}{T}\sum\sqrt{(X(t) - X(t-1))^2 + (Y(t) - Y(t-1))^2}$$

   Where X and Y are coordinates of the node x at the time t and (t-1)
5. Compute the cumulative time T for which the node x acts as a cluster head. T denotes how much power has been consumed.
6. Calculate the combined weight W for each node r where

   $W=w(1) *\Delta_x+(w(2)* D)+(w(3)*M)+(w(4)*P)$

   where w(1),w(2),w(3),w(4) are the weighing factors for the system parameters.
7. Select the node with the smallest W as the cluster head. Remaining nodes are not allowed to participate in the election procedure.
8. Repeat the steps 2-7 for each node to elect the cluster head for the clusters.

For Clustering process, the weighted means which combines the system parameters with certain factors is taken. In our system, the number of nodes that a cluster head can handle is given by t. This component will ensure the CH is neither heavily loaded nor the efficiency decreased and the system is maintained at the most expected level. The above procedure is invoked at the activation of the system and also the set is not able to cover all the nodes. Whenever the algorithm is called, it is not necessarily that all the CH are replaced with the new ones. If the nodes in the cluster get detached from the current CH and get attached to other CH then the CH's needs to update their new members.

The component $w(1) *\Delta_x$ will be helpful to handle the number of nodes in the cluster for the efficient functioning. The goal of D is to conserve the energy. The power will be consumed in large amount if the communication takes place at a longer distance. It would be more appropriate to use the sum of the squares of the distances due to the power required to support a link increments faster than linearly with distance. The next component is W is for the mobility of the nodes because less mobility is a good choice for a cluster head. The final component P is used to measure the cumulative time for the node to be a cluster head. These components will gradually increases the performance of the cluster head and select the efficient cluster head.

2. ROUTING ALGORITHM

1. If i(k) is located at right of the current node r

   then set the rule as clockwise rule.
2. Else

   Set the rule as anticlockwise rule.
3. Endif
4. set r=i(k+1), then repeat.
5. let i(k) i(k+1) be the edge next to i(k) r according to the rule
6. loop it until i(k) i(k+1) doesn't intersect the straight line
7. set b1 to the rule
8. set n1 to i(k+1)
9. set b2 to the opposite of the rule

10. set n2 to r
11. If i(k+1)==sink then the data is sent.
12. Else loop the process.

For routing techniques, it is sufficient to check the nodes that are nearer the sink to pass the information. So we used two rules as Clockwise rule and Anti clockwise rule. The message sending along the edge which is located next in Anti clockwise direction is called anticlockwise rule whereas sending the message which is located next in clockwise direction is called clockwise rule. Consider the node r be the cluster head of the clusters and i(k) be the kth node's information.

Initially the node i(k) is checked to identify whether it is located right or left of the cluster head. For a given i(k) and the edge between the i(k) and the node r is on left hand side if the angle between them in anticlockwise direction is smaller than 180° otherwise if the angle is in clockwise direction is smaller than 180° then it is said to be right hand side. When the message is sending along the intersected edge then the traversal of the next has to be according to the clockwise rule if the sink node is on right hand side. Otherwise traversal should be on the anticlockwise if the sink is at the left hand side.

The loads in a cluster is handled by the cluster heads depends on the number of nodes supported. The maintenance of balanced load at each cluster is difficult which is mainly due to the attachment and detachment of the nodes in the cluster heads. So a parameter called load balancing actor were used. The loads of the cluster head is represented by the cardinality of the cluster size and the variance of the cardinality will tell about the load distribution which is given by

$$\text{Load Balancing Factor} = \frac{n}{\sum_i (x(i)-\mu)^2}$$

where n represents the number of cluster heads and x(i) is the cardinality of the cluster i and $\mu = (N-n)/n$ is average number of the neighbors of the cluster head. It also helpfulin guaranteed delivery of the data.

IV. PARAMETERS USED

The Clustering and Routing algorithm is being implemented using MATLAB 2011 version. The parameters used to implement the algorithm are given in Table 1.:

PARAMETERS	**VALUES**
Diameter of the simulation area	800m
Number of nodes	2500
Node's initial energy	2.5J
Energy Threshold	0.3J
Weights	w(1)=0.6 w(2)=0.25 w(3)=0.07 w(4)=0.08

Table 1. Parameters Used

V.CONCLUSION

The proposed work is under implementation using MATLAB simulation. The network field is defined in a concentric ring. The sink is assumed to be located at the center of the area. At first, the clustering strategy will significantly reduce the signaling cost. The CH selection method proposed can optimize the intra communication cost and also reduces the frequency of the re-clustering.

Followed by clustering, the routing procedure will improve the performance and also provides the best path to route. It also gives a new procedure for balancing the load which implies in guaranteed delivery of the data. In future, the direction will be considered as one of the parameters to improve in routing procedure.

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