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MRE Criterion in WSNS: A Study

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Abstract-Data aggregation is a very vital section of a wireless sensor network. Data aggregation in a clustered network depends on the choice of cluster head. Proper selection of a cluster head enhances the lifetime of the network thereby improving the overall performance. There are various factors based on which a cluster head is selected. MRE (Maximum Residual energy) criterion is one of the widely used criteria for cluster head selection. In this paper I have studied and analyzed various features of MRE criteria combined with clustering aspects and demonstrated some interesting conclusions. Simulations are performed using MATLAB and have concluded that MRE factor is not a good criteria for cluster head selection but when it is combined with Backup cluster head and Clustering concept it produces better results.

Keywords- Clustered network, MRE, Back up Cluster head, Cornering Effect, Data Aggregation.

I. INTRODUCTION

Wireless sensor network (WSN) consists of hundreds and even thousands of small tiny devices called sensor nodes distributed autonomously to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure and motion at different locations.[1][2] Energy plays an important role in
Wireless sensor networks because nodes are battery operated. Consequently many protocols have been proposed in order to minimize the energy consumption of these nodes. Each node in a sensor network is typically equipped with one or more sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, since in most Wireless sensor network applications the energy source is a battery, energy plays an important role in wireless sensor network, and preserving the consumed energy of each node is an important goal that must be considered when developing a routing protocol for wireless sensor networks.[3][4] A wireless sensor network is typically made of many sensor nodes used to detect accuracy and scalability of sensing areas.

In a sensor network data from the sensor nodes are sent to the base station where the user can access the required information. These nodes vary in their location from the base station so if individual sensor nodes transmit data directly to the sink node then energy consumption by individual nodes will be very high thereby the overall energy consumption in the network will be very high thereby reducing the lifetime of the sensor network. So instead of sending data directly to the sink node if these nodes can relay and pass their respective data to some intermediary nodes and these intermediary nodes can collect the data combine its own data with them and perform aggregation using some aggregation functions then the distance of transmission can be significantly reduced and the amount of data can be reduced so that resulting data sent to sink node will be minimum thereby reducing the load in the network and maximizing the overall network lifetime. This process is called as Data Aggregation. There are various network architectures based on which data aggregation task can be performed. Centralized, Decentralized, Grid based, Tree based, Clustered architectures are some of them.

II. PROPOSED WORK

The Clustered based network architecture is a very well known and widely used model for data aggregation in wireless sensor networks. A Cluster based architecture is comprised of several sensor nodes arranged into a fixed number of clusters. Every cluster consists of some sensor nodes that join a cluster based on some criterion. Among the member nodes of a cluster a cluster head is selected based on some algorithm. During the process of data aggregation every member nodes send their corresponding data to their respective cluster head and this cluster head is responsible for performing data aggregation task, It collects data from all sensor nodes of its own cluster combines them and aggregate them using some aggregation function and finally send this aggregated data directly to the base station so that the user can view the desired data. One of the most crucial issues in Clustered network architecture is the selection of cluster head which acts as the leader node within a cluster. The cluster head selected should be able to collect data from maximum number of sensor nodes and data collected should be accurate filtering redundant and inconsistent data. The performance of a sensor network depends on the choice of the cluster head in every round of data aggregation.

There exist several criteria for efficient selection of cluster head so as to maximize the reliability of the network thereby enhancing its overall performance. One of the well known and popular criterions to choose a cluster head is MRE (Maximum Residual Energy) criterion. Cluster head selected based on MRE criterion is considered to be a good factor by researchers.[5][6] Many cluster based protocols like LEACH, TREEPSI etc implement MRE criterion to select a cluster

head. The mechanism of this MRE criterion is quite simple. A cluster is comprised of several sensor nodes and among these nodes one node is selected as the cluster head. According to this criterion after the completion of one round the individual nodes send their local data to the cluster head. Besides this they also send a residual energy list to their respective cluster head. This residual energy list includes the residual energy level retained after the completion of a round. Then the respective cluster heads send the aggregated data as well as this residual energy list to the base station. For the subsequent rounds the nodes with the maximum energy retained are selected as the cluster heads by base station. This is considered a very popular and dynamic way to select cluster head since there is equidistribution of energy within the network and the cluster does not die out of energy very soon. Many times this has proved to be a good factor to choose cluster head. I have done an extensive study on this criterion (MRE) and have explored some important observations. Let us consider a worst case scenario where MRE criterion is used to find the cluster head for subsequent rounds. It is observed that it works well for only first few rounds but as the number of rounds are increased its performance starts degrading. As the number of rounds increases it is observed that the cluster heads are gradually pushed towards the corner of the cluster and is driven outwards in the respective clusters. So as a result of this in a cluster the respective cluster heads are moved outwards towards the periphery. This is termed as "Cornering Effect" in a cluster. Due to this the energy consumption will be very high since individual sensor nodes will need more energy to transmit their individual data to the cluster heads which are located far away from them. So this will reduce the overall network lifetime. Thus this MRE criterion works well only for initial rounds but as the number of rounds increases it tends to degrade the performance of the network. In some clustered based architecture a backup cluster head is also implemented to make the

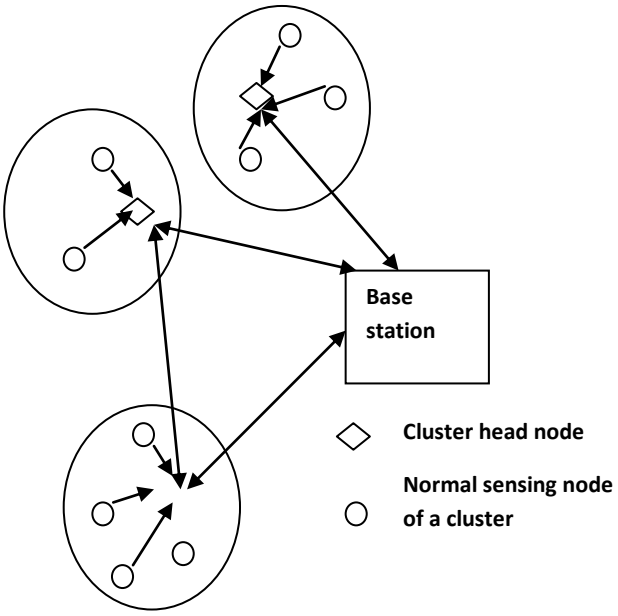


Fig. 1 A Cluster based wireless sensor network

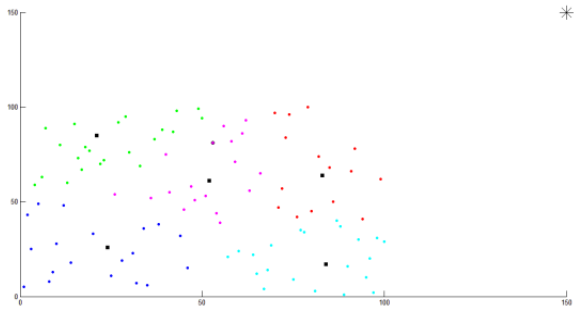
Network more reliable and fault tolerant so that in case due to any reason the main cluster head fails then the backup cluster head can perform the role of data aggregator. This backup cluster head is generally selected based on the least Euclidean distance from the main cluster head. Now as I just highlighted one of the major pitfalls of MRE criteria it is to be mentioned that this MRE criteria though performs poorly after some rounds of data aggregation but when the Backup cluster head concept using Euclidean distance criteria is applied then it is observed that because of this Backup cluster head concept the "Cornering Effect" of cluster heads gets subdued to some extent so that when some Cluster heads gets driven away in the network boundary region then due to the presence of backup cluster head other cluster heads are selected that lies within the network based on the least distance criterion. Thus in worse case scenarios selection of cluster heads based on MRE criterion will yield good results provided there is a backup cluster head in place.

Thus pure MRE criterion is not a very ideal choice in realistic scenario and will degrade the performance of a wireless sensor network after certain rounds of good performance. To improve upon this MRE factor for selection of cluster heads another vital factor is the requirement and this factor is known as Clustering. It is a key technique for discovering the inherent structure in any given data set. It partitions a given data set into subsets (clusters), so that the data in each subset share some common trait - often proximity according to some defined distance measure**.** The goal of any clustering technique is to discover 'natural' groupings in a set of patterns, points, or objects, without prior knowledge of any class labels. Formally, clustering is an unsupervised process of grouping a given set of unlabeled patterns into a number of clusters such that similar patterns are assigned to one cluster. Now if this clustering technique is implemented with MRE criteria for deciding the Cluster head for subsequent rounds the performance is significantly enhanced because clustering helps to select the mean point in a given cluster which lies at the center of the cluster thus that point is more or less equidistant from other points in that particular cluster. So if the sensor nodes are located at nearly same distance from the cluster head in a cluster then the energy consumption in transmitting data remains almost the same hence is balanced.

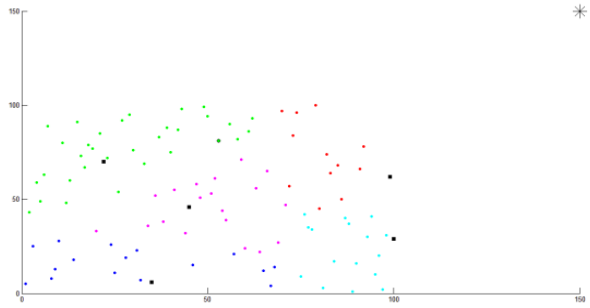
III. PERFORMANCE ANALYSIS

In the discussion it is highlighted that in a clustered based wireless sensor network architecture that uses MRE criterion to choose cluster head is not a very good factor for selection of cluster heads since it degrades the performance of the network significantly. To verify this fact this network is simulated in MATLAB environment. The entire operation of data aggregation is performed and the simulation is done for 33 rounds of data aggregation and all nodes are supplied with 2kjoules of initial energy. The result is demonstrated and illustrated diagrammatically below.

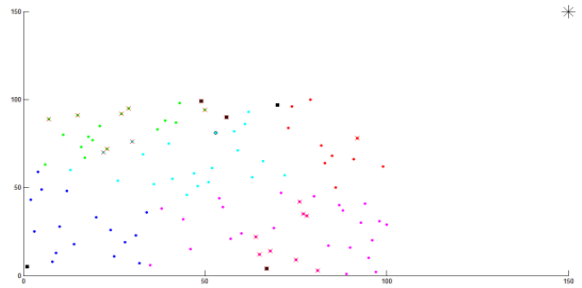
For round 1:



For round 2:



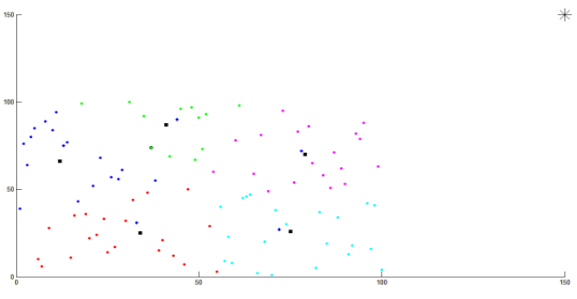
For round 5:



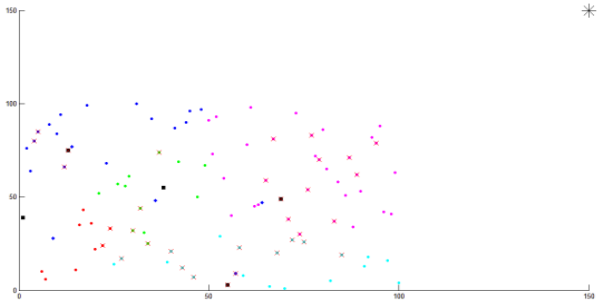
Here the entire network topology is shown consisting of a total 100 sensor nodes that are arranged into 5 clusters. Every cluster is comprised of a cluster head which are highlighted in these figures as distinguishable bright spots. As it is observed here for the first round the cluster heads were selected randomly and from next round onwards it is selected based on the MRE criterion. As a result the cluster heads are pushed towards the periphery of the network topology thus producing "Cornering Effect" thereby maximizing the energy consumption in the network.

Now this "Cornering Effect" can be minimized by combining the MRE criterion with Clustering and Backup cluster head mechanism. The reason behind this is Backup cluster head uses least Euclidean distance criteria from the main cluster head and since MRE also uses the same factor thus the Cluster head for next round is pushed back into the interior of the network topology thus Clustering with BCH reduces this "Cornering Effect". It can be verified as below.

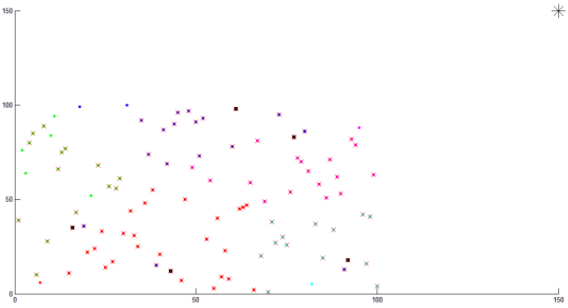
For round 1:



For round 3:



For round 5:



Thus it is demonstrated and seen that combination of MRE and Clustering enhances the performance clustering always select the CH at centroid so this draws the CH towards the center thereby mitigating "Cornering Effect".

IV. CONCLUSION

Thus we presented and analyzed various aspects of wireless sensor networks and introduced some new factors for energy retention in energy sensitive wireless networks. These factors include MRE criterion, Choice of backup cluster head combined with MRE criteria, Significance of Clustering in choice of Cluster heads etc. We demonstrated and studied negative aspects as well as positive aspects of MRE criterion and highlighted its behavior when combined with backup cluster head and clustering concept and concluded that pure MRE factor is a nonoptimal energy retention criterion is thus verified.

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