Analysis of Energy Efficient Clustering Algorithm for Wireless Sensor Networks

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ABSTRACT

Data gathering is a common but critical operation in many applications of wireless sensor networks. Innovative techniques that improve energy efficiency to prolong the network lifetime are highly required. Clustering is an effective topology control approach in wireless sensor networks, which can increase network scalability and lifetime. Clustering sensors into groups, so that sensors communicate information only to cluster heads and then the cluster heads communicate the aggregated information to the processing centre, may save energy. In this paper, we simulate a distributed, randomized clustering algorithm to organize the sensors in a wireless sensor network into clusters in MATLAB. EEHCA [1] (an Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks) achieves a good performance in terms of lifetime by minimizing energy consumption for communication and balancing the energy loads among all the nodes.

Index terms:- Clusters, EECHA, Cluster Heads

1. INTRODUCTION

Due to the increase in the development of wireless communication and MEMS technology the use of sensor networks has become more demanding and useful [3]. These sensor networks are small in size and are not expensive, as they have their own limited power supply from onboard 1 joule battery .The functions of these are sensing, signal processing and wireless communication.

Since the sensors have limited power supply, therefore to make up for the data rate and transmission range they send data to the nearest sensors and use multi hop communication to reduce energy consumption. The sensors in a given area collect information and transmit it to the sink or one more sensor which acts as the centre .To keep the cost minimum we adopt the cluster method of communication in wireless sensor networks, since the cost of transmitting a bit is higher than data

Processing one important application of WSN is data gathering, which uses techniques such as data aggregation and clustering hierarchical mechanism. The former helps in reducing redundancy and the overall communication load on sensors whereas the latter help in increasing the scalability and reducing data latency.

2. THEOREY

Wireless sensor network is a network which contains many small spatially distributed sensing devices called sensors which is shown in figure 1. These devices help in gathering information like temperature, pressure, humidity, military applications, target tracking etc. Basic features of sensor networks are self-organizing capabilities, dynamic network topology, limited power, node/communication failures, and mobility of nodes, short-range broadcast communication and multi-hop routing, and large scale of deployment.

The strength of wireless sensor network lies in their flexibility and scalability. The capability of self-organize and wireless communication enables them to be deployed in remote or hazardous location without the need of any existing infrastructure. Through multi-hop communication a sensor node can communicate to a far away node in the network. This allows the addition of sensor nodes in the network to expand the monitored area and hence proves its scalability & flexibility property.

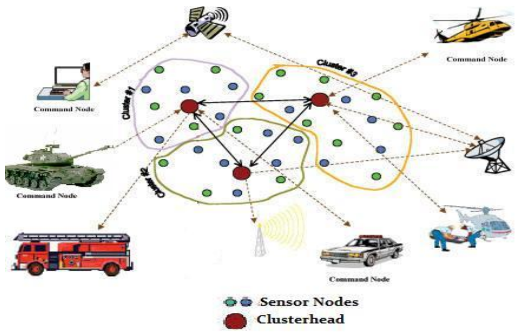

Fig.1 wireless sensor network

The amount of energy used up in transferring a bit of data is equal to many operations in sensor networks, also in an area which has a large number of sensors; transferring of data to a nearby sensor with same information will cause data redundancy.

Therefore we use the method of forming clusters. This way we can reduce data redundancy. It also helps in compressing data so that only compact data is sent, hence reducing both global and local traffic This process of grouping of sensor nodes in a densely deployed large-scale sensor network is known as clustering. With the help of its unique feature it can be used in various application such as pattern recognition, compression in images and video database.

There are three types of cluster's (CH) cluster heads, (GN) gateway node and (NN) normal node [5]. Each cluster has a cluster head which co-ordinates and controls the data that the normal node in its cluster wants to transmit. There is no direct communication between two normal nodes. They can only communicate through their respective cluster heads.

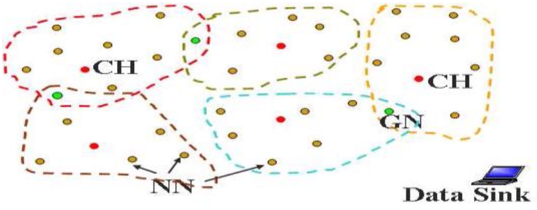

Fig.2. Diagram of a typical cluster network showing CH, GN and NN

The way a node in a cluster will send data to the data sink is first it will send it to its clusterhead. This clusterhead will find a route through the GN to the other clusterheads which will then send the data to the data sink which is shown in figure 2. This process of jumping between transit nodes to route data is called multi-hop routing.

3.ENERGY EFFICIENT HIERARCHICAL CLUSTERING ALGORITHM

Cluster sizes is a very important issue in energy saving. Small clusters will save power consumption in intra-cluster communication but it will also increase the complexity of the network. On the other hand, fewer clusters means less nodes in the network and thus simple communication, but the intra-cluster communication consumes more power.

The method proposed by *S. Bandyopadhyay and E. J. Coyle* takes account of the above-mentioned problem by limiting the number of hops a node takes in communicating with its CH. This method uses the *k*-tree cluster framework and optimizes the value k value to minimize power consumption with in a cluster.

The k-tree clustering algorithm is a technique that ensures that every node within a cluster can communicate with its cluster head by using a maximum of k hops. Since the nodes have a limited transmission range to reduce power consumption, a node cannot always transmit to its cluster head directly. A node thus needs to use other nodes in its transmission range to relay its data. A nodes data will not be relayed more than k times within a cluster.

A CH is selected as a *volunteer* with probability p, to transmit to all nodes in its communication range notifying them about its CH status. The message then gets forwarded to all nodes k hops away. The optimal k value is a predetermined number that is set according to the size of the network. All nodes that receive these advertisement messages are considered a cluster member of the CH from which it received this message.

If the message is received by another volunteer CH it is ignored. If a node falls short of being within the k-hop range of any volunteer CH, it automatically becomes a CH. These are known as *forced CHs*. A node can also become a forced CH if it does not receive a CHs advertisement in a specific time t (time needed to send data k hops away).

Consider there are h levels in the clustering hierarchy with level 1 being the lowest level and level h being the highest. The sensors communicate the gathered data to level-1 clusterheads (CHs). The level-1 CHs aggregate this data and communicate the aggregated data to level-2 CHs and so on. Finally, the level-h CHs communicate the aggregated data to the processing centre.

The algorithm works in a bottom-up fashion. Each sensor decides to become a level-1 CH with certain probability p1 and advertises itself as a clusterhead to the sensors within its radio range. This advertisement is forwarded to all the sensors within k1 hops of the advertising. Each sensor that receives an advertisement joins the cluster of the closest level-1 CH; the remaining sensors become forced level-1 CHs. Level-1 CHs then elect themselves as level-2 CHs with a certain probability p2 and broadcast their decision of becoming a level-2 CH. This decision is forwarded to all the sensors within k2 hops. The level-1 CHs that receive from level-2 CHs joins the cluster of the closest level-2 CH. All other advertisements from level-2 CHs joins the cluster of the closest level-2 CH. All other level-1 CHs become forced level-2 CHs. Clusterheads at level 3, 4, h are chosen in similar fashion, with probabilities p3, p4, ph respectively. Clusterheads at level 3, 4, h are chosen in similar fashion, with probabilities p3, p4, ph respectively.

4. RESULT AND DISCUSION

Sensor Nodes n=1000 are randomly distributed in the area 250x200m. We grouped the sensor and formed the cluster heads which covered the maximum area and each cluster heads are communicate to each other. The algorithm is implemented by using the MATLAB tools which is shown in figure 3. The algorithm searches the minimum hops i.e shortest path which is shown by green line in figure 4 and cluster heads are also shown in figure 4. We use the iteration method to find the dead nodes which are not covered by any cluster. White nodes shown in figure 5 are dead nodes. If the no. of white nodes are less means all the nodes are covered by the cluster. We try to cover all the nodes in the cluster

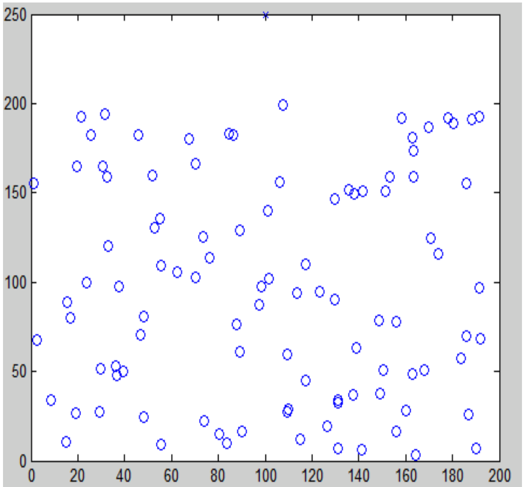

Fig 3.Distributed Sensor Nodes

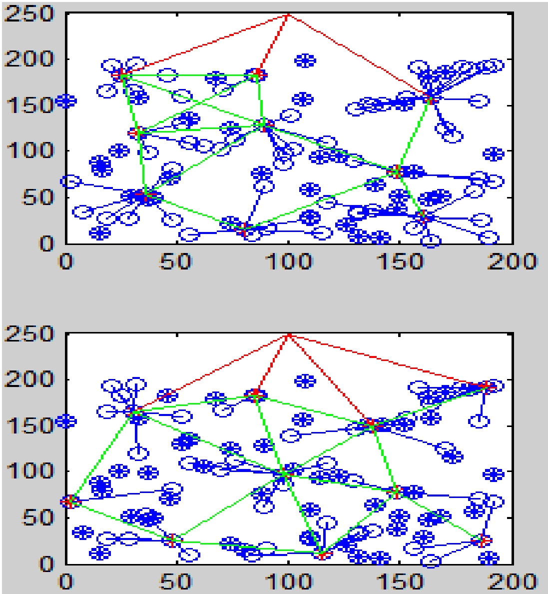

Fig 4.Formation of Cluster Heads

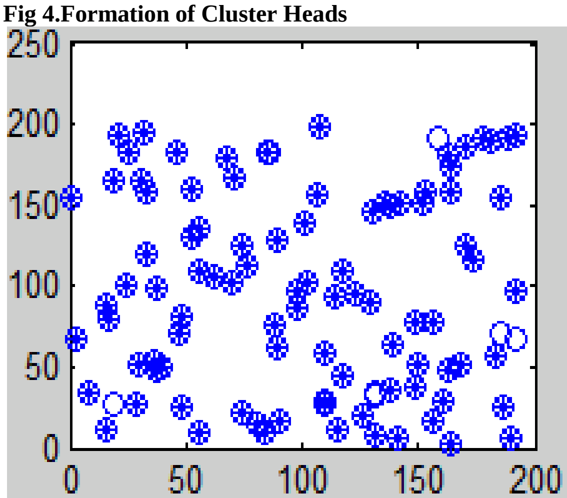

Fig 5. Clusters Formed (White cells represent Dead nodes)

CONCLUSION

We have simulated a distributed algorithm using MATLAB tools. The main objective of which is to organize sensors into a hierarchy of clusters. It achieves a good performance in terms of lifetime by minimizing energy consumption for communication and balancing energy loads among all the nodes. If no. of hops are less, the energy consumption is less which is shown in figure 3 & 4. we also try to minimize the no. of dead nodes which is shown in figure 5.

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