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An Approach towards Unequal Clustering in Wireless Sensor Networks

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Abstract:
Wireless Sensor Network is collection of dispersed sensors collecting data to provide observability in to the physical environment of interest. WSN's are used everywhere now a day's such as weather monitoring, fire detection, military surveillance, medical diagnosis, home automation, remote sensing etc. Mainly the sensors are dropped in a remote and as they are battery operated so it is required to efficiently use their energy. One the battery is exhausted it is impossible to recharge or replace the battery. Thus the paper provides the need of clustering so as to wisely use the energy and hence enhancing the lifetime of the network. The paper moves from the basis of clustering i.e. LEACH and then moving onto its advancements and then from homogeneous clustering towards unequal clustering. Unequal clusters are made on the basis of left energy of the nodes and the distance from the base station. Thus the nodes closer to the base station forms smaller clusters or we can say that as the distance goes on decreasing the size of the cluster is also reduced. Further in this paper certain optimization algorithms have been discussed such as GA, PSO etc to further optimize the clusters made by unequal clustering methods. With these methods the approach is made dynamic.

Keywords: WSN, Clustering, LEACH, HEED, Unequal Clustering, GA, PSO.

1. INTRODUCTION

Wireless Sensor Network is gaining importance in today's world due to the advancement in micro electronic and mechanical systems [1]. Wireless sensor networks have thus act as a gateway in between physical environment and the humans. Collecting data from the environment and processing it for the human use make wonders to happen. The application area involved in wireless sensor networks are weather monitoring, fire detection, flood control, surveillance in military, remote area sensing, home automation, medical monitoring, industrial automation and many more. The sensor network is nothing but collection of large number of small sensors distributed over the area of interest. These sensors sense the physical world to collect the data and then process it for human interpretations. So a sensor generally consists of battery, computational element, memory, controller, sensing element to do its functioning. All these sensors are connected to the base station where the information collected is aggregated [2] and conclusions are made. As the sensors are small in size and due to this advantage they are being deployed in the areas where human intervention is not easily possible. The sensors are battery operated and being deployed in harsh environments it is required to manage the battery efficiently. Replacement of batteries or renewable source of battery [3] is not possible because of their deployment in rough terrains, so researchers have developed many algorithms and protocols to use the batteries wisely so that they lasts for a longer period. One of the methods opted for efficient use of batteries is to arrange the sensors in the form of clusters. A cluster is a group of sensors where each group is having its own leader called as cluster head (CH) and the members called as member nodes. The member nodes sense the information and then send it to the cluster head [4]. The cluster head fuses the received data from the member nodes and transmits it to the base station. In this way every node now has to communicate to its cluster head and cluster head then send to the the base station either in a single hop or multi hop manner [5]. This saves the energy. Now the question arises that how to select the cluster head and how to decide the members associated with each cluster head. So various methods have been suggested by the researchers for this. This paper will provide a review for the various methods of equal and unequal clustering with their advantages and the method for the selection of cluster head. The paper will focus on how unequal clustering helps to reduce the consumption of energy. Further this unequal clustering can be optimized by using various bio inspired algorithms. Now we can go through various clustering algorithms. This protocol scatters the load among the whole network and it gives chance to every node to become a cluster head the protocol lacks in maintaining the energy of the network because of random selection of cluster heads. Even the node can be made a cluster head if the energy left with it is very low, thus cluster head can die earlier. Further it does not take into consideration the distance between base station and cluster as a factor. Thus the clusters nearer to the base station lose their energy faster than other clusters thus letting the network die. Various improvements are done on this basic LEACH protocol [7] thus optimizing the energy consumption of the network. Some of the improvements worked on the process of selection of cluster head and some taken distance between base station and cluster as the factor. Here the energy efficient cluster head selection is done by taking into account the residual energy of the nodes and distance of nodes to the base station. Another method is Hybrid Energy Efficient Distributed (HEED) clustering protocol. Here the probability of every sensor to be a cluster head is based on their remaining energy. The nodes which are uncovered in any of the cluster have twice the likelihood to become the cluster head. When a node is in the range of many clusters then it will select its cluster head depending on average minimum reach- ability power [8]. This protocol can use multi hop communication and sometimes flooding for data transmission between different cluster heads. HEED thus stabilize the network and improves the lifetime of the network

as compared to LEACH. In this protocol also some of the clusters that are close to the base station may die early as they have to transmit more traffic. As already said that the nodes which are not covered in any of the cluster they have twice the likelihood to become the cluster head [9] thus they are the cluster heads without any member nodes and they are forced to interact with the base station. This results for the creation of unwanted number of cluster heads thus unbalancing the consumption of energy in the network. Another method is weight based clustering algorithm which shows that the nodes that are being handled by the cluster head depend on mobility, battery power of nodes and transmission power. This will not degrade the networks performance. In this algorithm [10] the selection of cluster head can be delayed as long as possible so as to avoid the repeated computation for selecting the cluster head. Load balancing among cluster heads is the important feature of this algorithm. Here load balancing is achieved by defining a threshold on the nodes that a cluster head can handle. This will assure that cluster heads will not be overloaded at any time. A factor called load balancing factor is used to measure the degree of load balancing. Communication between the nodes and cluster heads and among the cluster heads is another major issue of this algorithm [11]. Here cluster heads work in dual power mode. For inter cluster communication the cluster heads operate in higher power mode and while for intra cluster communication the cluster head use low power mode. This algorithm thus adapts itself dynamically with changing topology of the network.

2. UNEQUAL CLUSTERING

Although these techniques of clustering helped in optimizing the lifetime of the network to a greater extent, but the clusters formed by these methods were generally homogeneous in nature [12]. In the research it has been found that the clusters which are nearer to the base station consume more energy as they transmit heavy load through them. They thus if of equal size to that of other clusters lots of their energy will be consumed in maintaining intra cluster and inter cluster communication. So it can be thought that the clusters near the base station will die soon thus leaving the network isolated even if the rest of the clusters are having energy left within them. Thus homogeneous networks bring the unequal load on the cluster heads. So the researchers thought for the need of unequal clustering. Unequal clustering can be categorized on the basis of probabilistic and deterministic approach. The probabilistic approach follow the random and hybrid selection of cluster heads and the deterministic approach follows the weight, fuzzy, compound and heuristic approach. One such method of [13] probabilistic approach is unequal clustering where the base station is located at the middle and the cluster heads are arranged uniformly in umbilical circles around the base station and the nodes are arranged in the voronoi [14] region. Data is aggregated by the cluster heads from the nodes and is transmitted to the base station under multiple hop communication. In this method instead of directly sending the information to the base station the cluster heads transmits the information to its closest neighbor. Another method is Energy Efficient Unequal Clustering (EEUC). This is a dispersive combative algorithm where the cluster heads are choosen on the basis of partial competition. It [15] follows the multi hop communication process to communicate among different clusters and hence to base station. The cluster forwards its traffic for the node that is having more residual energy left. One such method is Unequal Clustering Routing algorithm (UCRA) [16]. In this method the clusters are made on the basis of remaining energy of the smart dust and the distance of smart dust from the base station. Thus now distance among the nodes and the base station plays a important role in the formation of unequal clusters. Now the clusters that have affinity to the base station will be compact in size than those that are long away from the base station. Less cost is required by the small clusters to maintain intra cluster communication. This method has minimum energy utilization for inter cluster communication. Here aggregation of data is not done. In this method a threshold is defined in regard to distance between the cluster head and the base station. If the value defined for the threshold is less than the distance then the cluster head instantaneously transmits its information to the base station otherwise sends its data to other cluster head that is having more energy. Now the researchers again optimized this technique and a way is find out to further improve the UCRA method. The new defined method is Unequal Clustering and Connected Graph Routing Algorithm (UCCGRA) [17]. This method adopted the vote based method for the formation of unequal clusters and for communication purposes it utilized connected graph theory. For the formation of unequal clusters the distance of the nodes from the base station must be known and the clusters are formed according to the formula

$R_i = (1- C *\{ d_{max} – d(v_i, sink)\}/ d_{max} - d_{min})R_{max}$ [17] here R_{max} is the maximum competition radius which is predefined

V_i is the node and R_i is its distance to the sink.

C is constant and lies between 0 and 1. The competition radius varies from $(1 – C)R_{max}$ to R_{max}

Now comes the turn to select the cluster heads and this is based on vote based method. There is a competition among nodes to become the cluster heads. This vying is based on the factors such as residual energy, topology and the transmission power. The vote function will show the left energy and the topology and the distance function to represent the transmission power. Now the announcement function will be calculated for each node and the node having the maximum announcement value will be selected as the cluster head

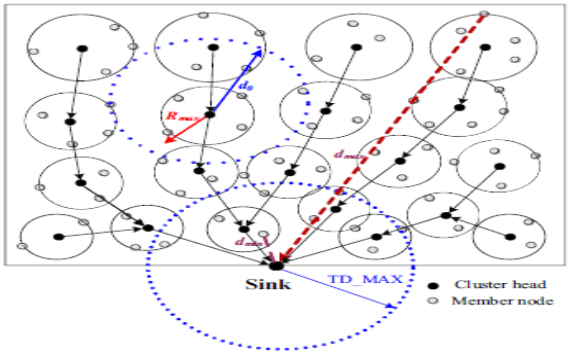

Figure.1. Unequal Clustering Routing Algorithm [17]

The results show that the UCCGRA method was much more efficient in conserving the energy than the above mentioned techniques. The new algorithm provided with the formation of unequal clusters depending on the distance of nodes and the sink thus avoiding the hot spot problem. Though the network become more energy efficient but this made the network static as when deployed in larger networks, some of the nodes may remain isolated [18] because of their non inclusion in any of the cluster. Now each of this isolated node will try to communicate with the base station directly thus consuming more energy. If we want to cover the isolated nodes into the clusters large number of clusters will be formed and it is known that presence of large number of clusters will also degrade the performance of the network [19]. Now a need is arise to make the network intelligent to create an imbalance in

the unequal clustering. So the researchers moved on to bio inspired algorithms so that network can create unequal clusters depending on energy and distance intelligently. One such approach adopted by the researcher is the formation of unequal clusters using Genetic Algorithm. Genetic algorithm [20] is used to maximize the lifetime of the network by means of rounds. The cluster heads are denoted as 1 and the member nodes as 0 thus the binary representation of the network. This may be seen as chromosome of humans. Genetic Algorithm evaluates the chromosomes by calculating the fitness function [21].

Crossover and mutation are applied on the best calculated fitness function. This will produce a new population better than the previous one or we can say that in a cluster, cluster heads keep on changing rather than the formation of new clusters. This will help in minimizing energy consumption. This follows a localized approach. One such method is Particle Swarm Optimization Algorithm. This is a bio inspired routing protocol for clustering. Here the clusters are formed in a dynamic manner so as to minimize the consumption of energy and hence prolonging the network lifetime. Here also large number of iterations is carried out and a group of variables is created whose values lie closer to the member that is near to the target [22]. The process of forming of clusters starts from creating a random population of N particles. For each particle a fitness function is created. A weight factor W is calculated for the iteration. The best position (p best) for each particle will be calculated. Global best value (g best) is the best fitness among all the particles. Velocity (V) will be calculated for each particle. This provides the both local and global approach for the creation of new clusters. Other methods that can be used are ant colony optimization, flower pollination algorithm [23]. All these methods are inspired by some or the other natural process. Understanding these methods and applying them to form clusters and hence enhancing the lifetime of the network can create wonders. All such algorithms can be applied on the different methods of formation of unequal clusters. The method can be more optimized by using these bio inspired algorithms and soft computing techniques [24], thus providing better energy efficiency of the batteries and hence the lifetime of the network.

3. CONCLUSION

In this research paper we have gone through the importance of making clusters and how these clusters can be made energy efficient so that the lifetime of the network can be enhanced. The paper provides us with the various schemes of clustering starting from homogeneous clusters towards unequal clustering. It has been described here that the homogeneous networks are more energy consuming and once the clusters closer to the base station get exhausted of their energy then some portion of the network may get isolated or the problem of hot spot may arise. Thus we have approached towards formation of unequal clusters. Again this approach sometimes may become static and for bigger networks some of the isolated nodes may remain uncovered thus consuming more energy. So researchers have shifted towards intelligent techniques inspired by nature. Genetic algorithm, Particle swarm optimization, ant colony optimization, flower pollination algorithm are discussed here. These algorithms help to create unequal clusters depending upon energy and the distance of nodes to the base station, thus creating intelligent clusters. Further we can try to optimize our clustering techniques using neural networks and fuzzy logic.

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