A Hybrid Clustering & Routing Method For Energy Efficient Wireless Sensor Network

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Abstract: Enhancement of lifetime of wireless sensor networks is one of important challenges on which many researchers are working on. In this paper a hybrid Clustering and routing method is proposed where many sets of three centroids are randomly selected and based on the least total mean distance of the network, a set of centroids are selected to form the clusters as usual. Then based on the energy present in the nodes in the descending order, we select three Cluster heads called the Main Cluster head, Deputy Cluster head and the Co Cluster head. During communication if the energy of the Cluster head is exhausted or drained out the deputy cluster head takes over and performs the duties of the cluster head. In case the energy of the Deputy Cluster head is also drained then the Co Cluster head takes over. Because of this arrangement the life of the sensor network gets stretched resulting in longer lifetimes. Even when a large traffic passes through a particular Cluster head then instead of using that cluster head a new path may be used utilizing the second or third cluster head.

Keywords: Clustering and Routing Techniques,Clusterhead,DeputyClusterhead, Co Clusterhead.

1.   INTRODUCTION

A Wireless Sensor Network is a collection of sensor nodes deployed in a physical area and connected through wireless links. A sensor node has four units that are used for sensing, communication, processing and power supply. Wireless sensor networks measures many parameters related to atmosphere of surrounding areas such as temperature, humidity, pressure etc. and converts them into an electrical signal. Signals are then transmitted to the base station by using radio transmitter either directly or through nodes or through cluster heads.

Some of the characteristics of a sensor network are limited battery strength, ability of self organizing, dynamic network, limited battery power, nodes mobility, routing and large scale of deployment. These characteristics of wireless sensor networks has resulted in wireless sensor networks being used in various military, civil and commercial applications that include surveillance and climate prediction habitat monitoring, vehicle tracking etc. Other applications include analysis of medical data and acoustic data.

There are many challenges in wireless sensor networks. Improving lifetime of wireless sensor networks is one of these. It is known that Clustering and routing are two very important techniques that are being used for

improving the lifetime of wireless sensor networks. Clustering is actually dividing the whole sensing field into small regions which are called Clusters. Then the nodes in the cluster elect or select their cluster heads through whom the clusters communicate with each other and base station. There are various ways by which the Cluster heads may be selected. The base station may select the Cluster head or the Cluster heads may be selected based on various factors such as their energy strength or trust factor or by regular rotation.

Here it is proposed to form the clusters by selecting the centroids in a random manner. It is proposed to select a set of three centroids and form the clusters around these three centroids and repeating the same procedure by selecting another set of three centroids and forming the clusters around the new set of centroids. The best set of centroids is then selected based on the computation of total length traversed for reaching the base station. Then a set of three cluster heads in each Cluster are selected that will be responsible for the communication. The three cluster heads are used one after the other in a sequence as the energy of each is drained. The overall effect will be increase in the lifetime of the network.

2. RELATED WORKS

In [1], Nidhi Gupta,Harsh Gupta and Ramlal Yadav have implemented an improvised Leach protocol so as to increase the lifetime of the wireless sensor network. According to them all the nodes in a network are not same. Some may have less energy and some may have more energy. Therefore they propose a stable election protocol by which they propose to increase the lifetime of the network by supplying additional energy to those nodes that have less energy so that they can also become cluster heads. Using this method the lifetime of the network also increases naturally.

Ravi Kishore Kodali states in [2] that consumption of energy may be reduced by using routing techniques which are based on multi hop and inverted tree mechanism. [2] has used multilevel leach mechanism that is composed of 1L leach and 2L Leach. Accordingly communication should start from the root node which is the node nearest to the base station. The root node sends a beacon packet to each of the surrounding nodes and the node sends an acknowledgement to indicate that they are in communication with the root node. Actually this is the process of root node finding its children. Now the children of the root node again follow the same procedure to find its children. Thus an unhindered path of communication is established in the network with the nodes communicating with their parent nodes and parent nodes communicating with their parents and so on using TDMA.

SaimaJamil,Saqib Jamil,Sheeraz Ahmed,Mohammad Zuba,Farman Sikandar in [3] implement a cross layer technique which not only takes the advantages of cooperative communication at the physical layer but also reduces the adverse effects of channel fading. This results in the decrease of power consumption. This method also has another advantage as it also reduces the data transfer delay. According to [3] the nodes are supposed to be stationary and are randomly installed. The Base station accepts data from the cluster heads and transfers data to the destination. The nodes gives the information regarding its residual energy to the base station which helps the base station in selecting suitable nodes and routes for data communications which substantially reduces energy consumption of the network.

In [4] Padmalaya Nayak and D.Anurag say that for reducing energy consumption one of the important factors is selection of an appropriate cluster head. It is known that Cluster head is selected and then rotated in the leach technique. In [4] it is proposed to have a super cluster head which will be selected from among the cluster heads and the purpose of this super cluster head is to send information regarding the remaining battery power, mobility of nodes and centrality of clusters to the mobile base station using suitable fuzzy descriptors. The fuzzy inference engine (Mamdani's rule) is the criterion for selection of the super cluster head.

In [5], Arzoo MiglaniTarunPreet Bhatia, Shivani Goel proposes an algorithm which they call as TBE (trust based efficient) Leach. This technique is an improvement over the existing leach technique. They propose trust

as a factor for the purpose of secure routing. Here every node has three components attached to it. The first component is energy watcher to see the amount of energy remaining in the nodes and the network. The second component is the trust supervisor whose purpose is to maintain the trust level of neighboring nodes and Cluster heads and distance manager. The third component is the Distance Manager. The function of the distance manager is to calculate the distance and maintain the distance between the node and the neighboring node and also distance between the Cluster heads and the nodes.

In [6], Aswathi T.S,Riyadh M,,Deepa C.M., propose a cluster based data aggregation routing algorithm (CDRA). In this method they follow the whole process of deployment of nodes, followed by cluster formation building of hop tree ,routing followed by updation of hop tree.

Sujoy Sett, Parag Kumar Guha Thakurta in [7] explains the concept of ad hoc network. According to them the ad hoc network consists of non- stationary nodes where the nodes will cooperate and coordinate amongst themselves for the purpose of transmission of data. They say that energy cannot be provided from outside to nodes in remote places or in places of geographically remote locations and only way in which energy can be saved is by means of activity switching and clustering. For large networks soft computing is an effective tool to provide best solutions to clustering and routing problems. Hence they have proposed selection of cluster heads based on genetic algorithm. They have derived the objective functions using which they have made the selection of optimal cluster heads.

Pawan Singh Mehra, M.N.Doja, Bashir Alam in [8] says that clustering is one of the ways by which we can build an energy efficient system. Here they have proposed self-organizing clustering scheme which considers all the real time parameters for setting up of clusters. In their proposed method re clustering does not take place repeatedly as they say that repeated re clustering diminishes the energy in the network quickly. Instead in their method re clustering happens only when Cluster head threshold falls below a certain threshold level.

In [9] Francesco Liberati,Guido Oddi,Andrea Lanna,Antonia Pietrabissa have proposed a scheduling algorithm for wireless sensor networks.The main aim of the proposed algorithm is to see that energy is saved without affecting the important tasks that have been assigned to the network such as datafusion.The scheduling policy as proposed in[9] takes into consideration the health status of the nodes as well as the quality of information provided by the nodes.The advantage of this method is that dynamically variable scheduling can be done which will serve our purpose of minimising energy consumption in wireless sensor networks.

In [10] Ahlawat.A, Malik V propose an improvement for the leach technique in which they propose a selection of a second cluster head called vice cluster head in a cluster. Accordingly, it is proposed that there should a second cluster head whose function starts after the energy of the first cluster head is drained so that communication is not affected in the event of the cluster head dying earlier. If the cluster head dies during communication then the vice cluster head takes over and performs the functions of the main cluster head as the purpose of the second cluster head is that the communication should not be affected in the event of the main cluster head dying out earlier.

It is known that in Leach method the cluster heads are rotated among all the nodes and every node has a chance of becoming a cluster head. The criterion for cluster head selection is based on various different parameters such as residual energy of node, distance of node from base station, trust factor of the node etc. As we have seen many authors have proposed different methods of clustering, different parameters for selection of cluster heads, different techniques for routing with the purpose of improving the lifetime and efficiency of wireless sensor networks.

In [10] it is proposed to have two cluster heads and when the energy of first cluster head is drained or exhausted the second cluster head takes over. We propose an improvement over the existing techniques. The disadvantage of the leach technique is that during rotation of cluster heads if a weak cluster head takes over then the network may break down. To overcome this problem only the nodes with the highest energies are allowed to

become cluster heads. The proposed method has tried to improve the lifetime of the network by using three cluster heads which shall sustain the network for a longer amount of time.

3. PROPOSED CLUSTERING AND ROUTING TECHNIQUE

In this technique it is proposed to have many sets of centroids, each set consisting of three centroids and based on the minimum distance to be traversed by the nodes, the best set of centroids are selected. It is also proposed to have three Cluster heads during communication process so that if energy of the first cluster head is exhausted, the second cluster head takes over and when energy of second cluster head is drained the third cluster head takes over. The advantage of this method is substantial improvement in the lifetime of wireless sensor network.

The proposed technique is composed of the following steps. First of all a set of three centroids are selected randomly. Then nodes form clusters around their nearest centroids. Whichever node is nearest to a particular centroid will be a part of the cluster around that centroid. Now the sum of distance from all nodes to their centroids is computed. Now a new set of three centroids is selected. A new set of clusters are formed. Again the sum distance from all nodes in the cluster to the centroids is computed. The process is continued. The centroid whose sum distance is minimum is selected as the final set of centroids around which clusters are formed.

Once the Clustering is completed the next step is selection of Cluster heads. Three Cluster heads are selected. The node with the highest energy is selected as the main cluster head, the node with the next highest energy is selected and called as Deputy Cluster head and node with the third highest energy called Co Cluster head is also selected. If the energy of the first cluster head is wholly drained or exhausted during communication then the second cluster head called Deputy Cluster head takes over and performs all the functions that would have been performed by the first cluster head. In the event of the Deputy cluster head also exhausting its energy the Co Cluster head takes over and performs the duties of the Cluster head. This will help to improve our network life span.

Also if a particular node has a large traffic through it thus reducing its energy then also that cluster head may be bypassed and communication may be done through the Deputy Cluster head or Co Cluster head.

4. RESULTS

This scenario and methodology are simulated using NS2 simulator and the quantities of energy consumed, delay occurred and ratio of Packet delivery are recorded for 30 nodes.

The delay, energy consumption and Packet delivery ratio of the proposed method have been compared with the existing Leach techniques. The results have been shown in forms of graphs. Figure 1 is the delay comparison graph of the proposed technique with the existing technique. In Figure 2 comparison of packet delivery ratio in form of a graph is plotted. In Figure 3 the graph for energy consumption comparison has been plotted.

As seen in the graph in Figure1, the proposed technique shows decrease of 40% in the delay as compared to Leach technique and 20% as compared to V leach technique.

The second graph in Figure 2 shows that packet delivery ratio is almost 100% using the proposed technique. Thus the packet loss using the proposed technique is almost minimum.

From the third graph shown in Figure 3.it may observed that energy consumed by the proposed method is 25% less as compared to leach method and 20% as compared to the V leach technique.

Thus we can see that the proposed method is providing better results as compared to the existing techniques for the simulation conditions used for experimentation.
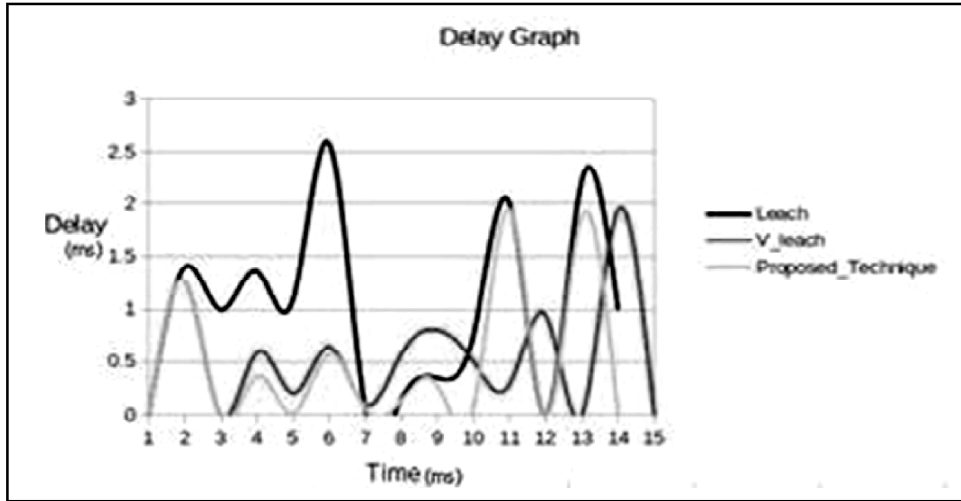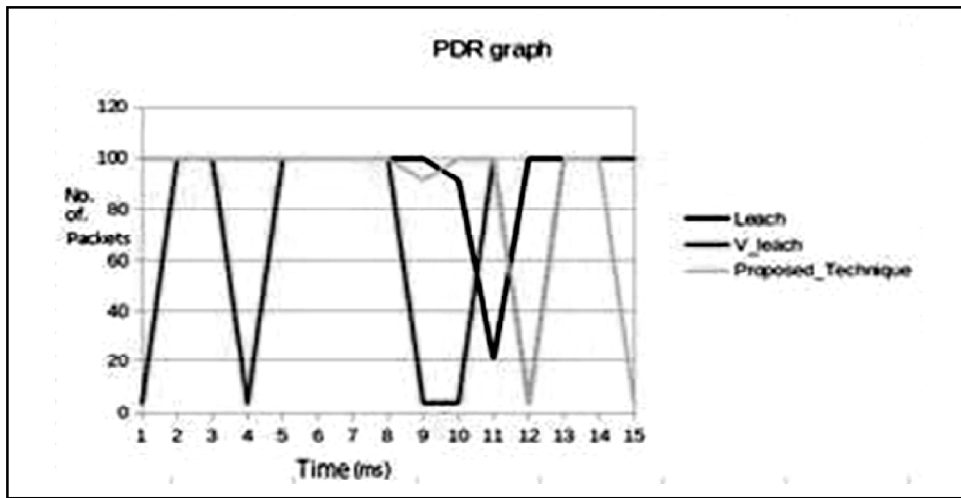
Figure 1: Delay comparison graph

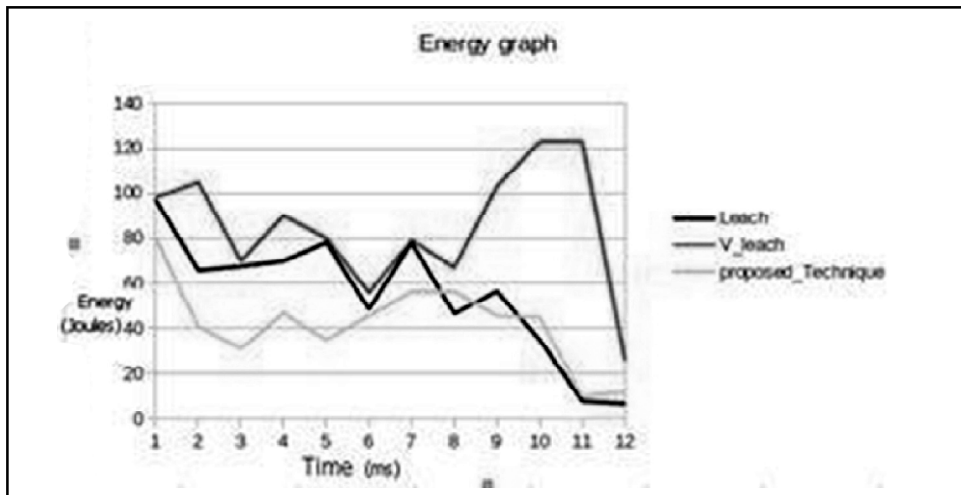**Figure 2: PDR comparison graph**

Figure 3: Energy consumption comparison graph

5.   CONCLUSIONS

It is found that the proposed Technique using three Cluster heads is not only more efficient in terms of energy consumption, packet delivery ratio and delay but also improves the overall lifetime of the network.

Since the proposed technique is using three Cluster heads, even after the first cluster head is drained, the second cluster head takes over and then after the second cluster head is drained the third cluster head takes over. Because of this the lifetime of the network increases and communication can take place till all the three cluster heads are drained out. The overall effect is the stretching of the lifetime of the networks till the energy in all the three Cluster heads are not drained out.

The proposed method allows lesser delays as compared to the leach and V leach techniques as can be seen in the first graph. As far as the Packet delivery ratio is concerned the proposed technique provides for almost 100%packet delivery ratio with only a small packet drop. The energy consumed is also almost 25% lesser as compared to the Leach and V leach techniques. Finally we can conclude that the proposed method is superior to the existing Leach and V leach techniques in all these aspects for the simulation conditions used for experimentation.

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