Energy Efficiency in Wireless Sensor Networks using Cluster Allocation and Routing Algorithm

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ABSTRACT

In Wireless Sensor network (WSN) the energy consumed by the sensor network determines the wireless sensor network lifetime. By minimizing the power consumption of each node, the overall energy of the sensor network can be efficiently improved which in turn also improves the network lifetime. This can be achieved by using Multi hop communication. Though the energy consumed is reduced, the delay will be a trade-off in this communication. In this paper, we are analyzing the performance of Heterogeneous and Homogeneous sensors with optimal deployment of sensors. These Heterogeneous sensors are the high performance sensors which have higher energy compared to Homogeneous sensors. Thus by using this, the energy utilization can be efficiently improved compared to LEACH algorithm.

Keywords: Multi-hop, delay, Heterogeneous sensors, Homogeneous sensors, LEACH.

1. INTRODUCTION

A Wireless Sensor Networks (WSN's) is a collection of tiny wireless sensor nodes which are deployed such that each sensor node senses the information and transmits the sensed data from source to destination. It's very important that the data loss should be avoided and routing topology should not be affected by node failure or other environmental parameters.

The different challenges in the hierarchy of detecting the relevant quantities, monitoring and collecting the data, assessing and evaluating the information, formulating meaningful user displays, and performing decision-making and alarm functions are enormous. Thus the information needed by smart environments is provided by Distributed Wireless Sensor Networks, which are responsible for sensing as well as for the first stages of the processing hierarchy [1].

The sensor node has three different sub modules, where all are connected to a small battery. Here only the transmission sub module consumes more energy compared to other sub modules. By concentrating more on the transmission sub module, the overall network lifetime of the WSN. The basic architecture of sensor node is shown below in Fig.1

Generally there are two different types of sensors; they are Homogeneous and Heterogeneous sensors. The Homogeneous sensors the sensors in which all the sensor nodes in a network are of same type with equal amount of energy level and less expensive, where the Heterogeneous sensors are the high performance sensors with high energy level than the homogeneous sensors. And there are two different types of data transmissions, Direct transmission and the Multi hop transmission. In direct transmission, each node transmits the sensed data directly to the base station consuming more energy and leads to node failure which is a drawback.

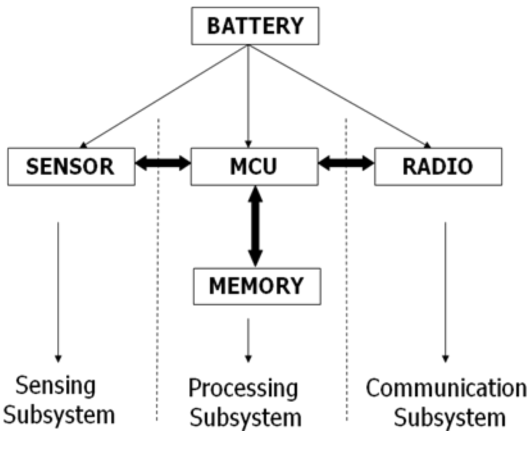

Fig.1 Basic Architecture of Wireless Sensor Node.

In case of Multi hop transmission the sensed data is transmitted from one sensor to its neighbor sensor node. Here the energy consumed for data transmission is much lesser than the direct transmission [2], [3], [4].

2. RELATED METHODS

By using these related methods, it is possible to reduce the wastage of energy by the sensor nodes. These methods are carried out in the node level and in clustering of nodes level. Also the packet loss and collisions are avoided with faster data transmission from source to destination. The different methods are mentioned below.

2.1 DETERMINING FORWARDING NODE

This method is used to forward the data to its neighbor node by considering the angle and the distance of the node location. Once the node transmits the data to its neighbor node, there is a chance of data transmitted to same source node. Thus backtrack situation is avoided i.e., same data is transmitted between two nodes forming infinite loop. By considering the angle, neighbor cluster head with the smallest angle is chosen as the candidate first, and the purpose is to use the shortest route to reduce energy consumption in forwarding data. If no cluster heads within 90 degree are available, the requesting cluster head must transmit data directly to the base station when the distance is reachable at the cost of consuming more energy; otherwise, it will seek for cluster heads outside 90-degree area [9].

2.2 DATA COMPRESSION

This method is mainly used to reduce the size of the data to be transmitted by compressing data and reduces the energy consumption of sensor nodes. This also filters the similar data packets sensed by the sensor node. By compressing the data, the transmission speed of the data packets is also increased proportionally [9].

2.3 SLEEP MODE

In WSN, the sensor nodes being active over long period or in ideal state consume more energy which reduces the overall network life time. Thus we go for periodic listening where only the nodes which are sensing will in the active mode and the others will be in sleep mode. In the sleep mode, only the transmission sub module will be turned OFF and the other two modules will be in ON state [9].

3. LEACH ALGORITHMS

3.1 LEACH

The LEACH (Low Energy Adaptive Clustering Hierarchy) is a type of hierarchical routing protocols in which whole network is divided into multiple clusters. A node in each cluster plays a leading role. LEACH arranges the nodes in the network into small clusters and chooses one of them as the cluster-head. First, Node senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. Transmitting data by the sensor node over long distance drains more energy thus in LEACH random election of the Cluster Heads(CH's) is done based on the probability of having maximum energy in each round comparing with other nodes in the cluster. Operations can be divided into two phases:-

1. Setup phase
2. Steady phase

In the setup phase, the clusters are formed and a cluster-head (CH) is chosen for each cluster. While in the steady phase, data is sensed and sent to the central base station. The steady phase is longer than the setup phase. This is done in order to minimize the overhead cost.

3.1.1. Setup Phase

In the setup phase, a predetermined fraction of nodes (p) is chosen such that they act themselves as cluster-heads. This is based on a threshold value, T(n). This threshold value depends upon the desired percentage to become a cluster-head- p, for the current round r, and the set of nodes that have not become the cluster-head in the last 1/p rounds. It is denoted by G. The threshold value is calculated by:

$$T(n) = \frac{p}{1-p\times(r\times mod\frac{1}{p})}\ \forall n \in G$$

Each node wants to be the cluster-head, chooses a random value, between 0 and 1. If this random number is less than T(n), then that node becomes the cluster-head for the current round. Each elected CH broadcasts a message to the rest of the nodes in the network inviting them to join their clusters. Based upon the strength of the received message signal, the non-cluster head nodes will decide to join the clusters. Thus non-cluster head nodes, informs their respective cluster-heads that they will be under their cluster by sending an acknowledgement message.

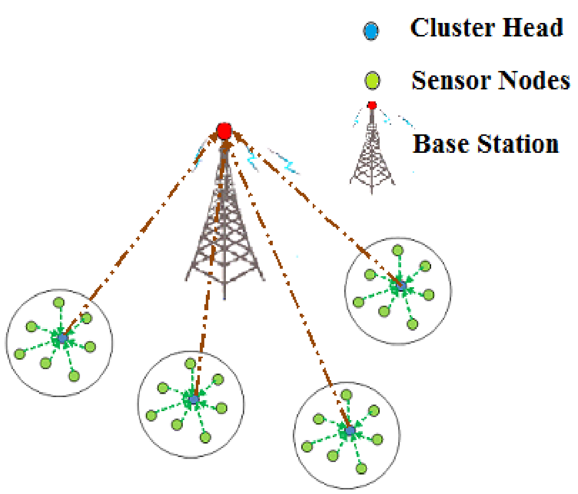

Fig.2 LEACH Algorithm.

3.1.2. Steady Phase

In the steady phase, the sensor nodes i.e. the non-cluster head nodes starts to sense information and sends it to their respective cluster-head according to the TDMA schedule. After receiving the data from all the member nodes, the cluster-head node aggregates it and then transmits it to the base-station. After a certain time period, which is determined a priori, the network again goes back into the setup phase and new cluster-heads are chosen for next round. Each cluster communicates to other clusters using different CDMA codes in order to reduce interference from nodes belonging to other clusters [5].

3.2 M-LEACH

Generally in LEACH, whole network is divided into multiple clusters such that all the CH's transmits the data directly to the base station consuming much energy due to long distance transmission resulting in reduced network lifetime. To avoid this we go for M-LEACH (Multi Hop-LEACH). Here the clustering process and CH election process will be same as the ordinary LEACH expect the data transmission from CH to base station [6].

In M-LEACH (Multi Hop-LEACH), once the data is collected from other nodes by the CH, instead of transmitting the data directly to the base station each CH will be transmitting the collected data to its nearest neighbor CH [7]. Thus the distance between the nodes gets reduced which also reduces the energy consumed for data transmission. But the only drawback is the delay occurring in the transmission [8].By increasing the number multi hops, the overall network lifetime of the sensor network will be efficiently improved at the same time delay during the transmission should also considered without affecting the network performance [8], [9]. Fig.3 shows the diagram of the Multi Hop LEACH.

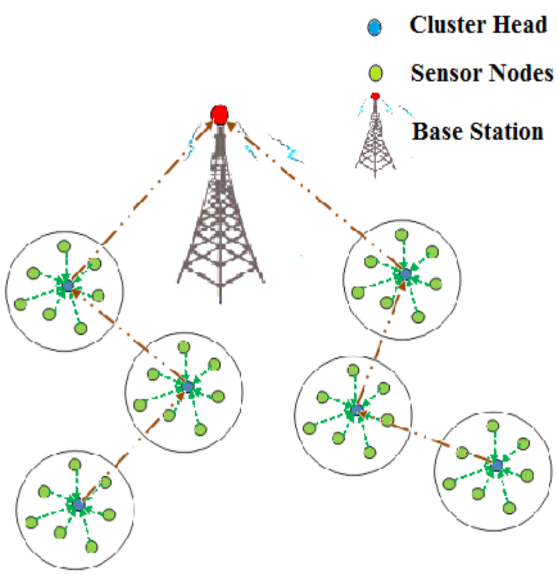

Fig.3 Multi Hop- LEACH.

4. SIMULATION RESULTS

In this study, the Network Simulator (NS)-2 is used as a tool for simulation process. The NS-2 is a discrete event driven simulator developed at UC Berkeley [10]. Fedora Linux environment is used with NS-2. NS-2 is suitable for designing new protocols, comparing different protocols and traffic evaluations, etc., it is an object oriented simulation written in C++, with an OTcl interpreter as a front-end [11], [12].Here, the deployment of the nodes in NS-2 is shown for the LEACH and the multi hop LEACH.

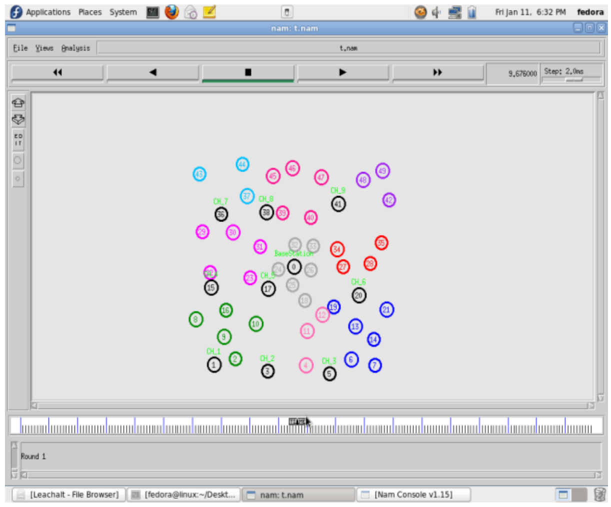

Fig.4 Deployment of nodes with CHs elected.

Once the nodes are deployed they are divided into various clusters electing their CH randomly based on the maximum energy for each round. The various simulation parameters which are considered are shown Table.1.

Deployment area	300*300m
Initial node Energy	100mJ
Channel Type	Channel/wireless channel
Antennae Type	Antenna/Omni antenna
Energy model	Battery
Radio Propagation model	Propagation/Two Ray Ground
Tx/Rx Power	1.0/0.8 mJ
Link Layer Type	LL
Max. Packets in ifq	50 bytes
Packet Size	1000 bytes
MAC type	MAC/802_11
Network interface Type	Phy/WirelessPhy
Interval	0.015sec

Table.1 Simulation Parameters.

Here simulation is done by considering the Energy and time parameters. The residual energy is reduced by increasing the time taken for the data communication.

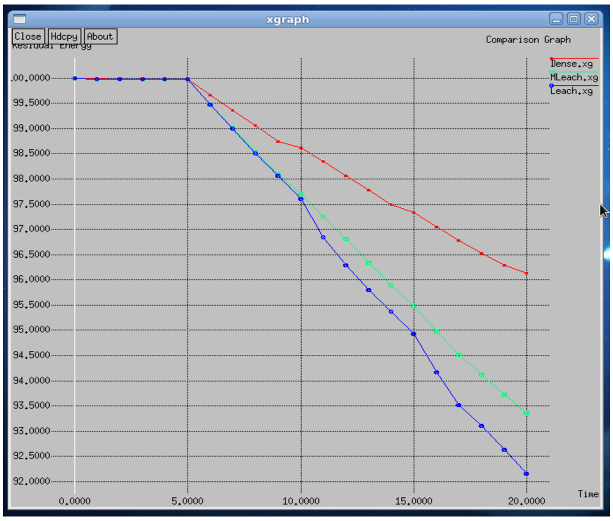

Fig.5 Comparison Graph between LEACH, M-LEACH and Denser deployment near base station.

The analysis is done by comparing the energy and time for different methods. Fig.5 shows the comparison graphs between LEACH, M-LEACH and Denser deployment with respect to residual energy and time. By deploying nodes denser near the base station, energy efficiency is much more improved compared to the LEACH and M-LEACH [9].

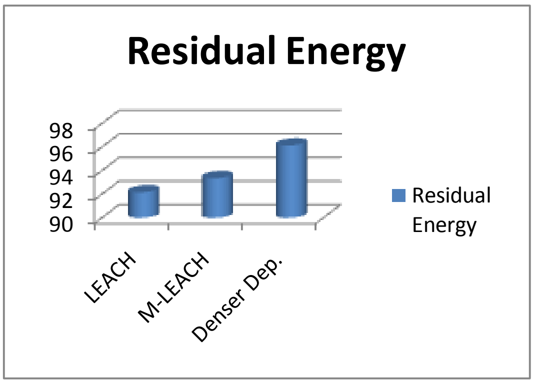

Fig.6 Energy Chart for various methods.

5. CONCLUSIONS & FUTURE WORK

In this paper, it is proposed that the Energy efficiency is done in wireless sensor networks using cluster allocation and routing algorithm with different LEACH algorithms. Thus results predict that the residual energy of wireless sensor network is much improved by using Multi hop in LEACH algorithm compared to direct transmission. Hence by deploying denser nodes near the base station, improves the energy efficiency much more than the general Multi hop LEACH. The performance is based on the overall Energy consumption and the network lifetime. Generally in WSN, sensors which are used will be of same type i.e., same energy level. In future, by deploying the Heterogeneous sensors for the CHs, the energy efficiency can be much more improved when compared to other different LEACH algorithms. The performance can be analyzed in the basis of Residual Energy and Life time of the Network and the Delay in the data transmission.

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