Minimizing Energy Consumption using Master Cluster Head Concept

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ABSTRACT
Wireless sensor network uses energy of various nodes employed in the network while doing transmission of data among nodes. For the network it is difficult to keep the level of energy of all nodes. Because while communicating, the nodes consumes energy from the battery source employed within the nodes. And during transmission or communication it is very difficult to replace the node's battery. Instead of replacing the battery we can reduce the energy consumption by using suitable protocol which can enhance the network lifetime. In this paper we have proposed the LEACH protocol with master cluster head concept. Before the communication takes place, protocol forms a cluster of nodes and the for one cluster a cluster head (CH) is selected. A CH is selected on the basis of maximum energy. The node within the cluster having maximum amount of energy and minimum distance from base station as compared to other nodes is selected as a CH. Then from the selected CHs, a master CH is chosen which has maximum energy level and minimum distance from base station. After selection of CHs and master CH within the network transmission takes place and nodes send their data to the CHs and then CHs send their data further to the master CH which aggregate the data and sends it to the base station. Proposed work reduces transmission between CHs and the base station and thus reduces the energy consumption and increases the lifespan of the network. Proposed work is also compared with the previous one in terms of FND, HNA. Simulation results shows that our work gives better result than the previous one & increases the life of network.

Keywords
Cluster head; Master CH; Network Lifetime; First Node Die (FND); Half of the nodes alive (HNA)

1. INTRODUCTION
In clustering, nodes are divided into clusters of finite sizes. Every cluster is handled by a cluster head (CH) node & all other nodes are known as the cluster nodes. All these cluster nodes cannot directly communicate with the base station or sink node. They firstly collect the data & then further pass it to the cluster head. Then aggregating of data is the function of cluster head then the CH passes this aggregated data to the base station[6]. This is how it helps in minimizing the consumption of energy & the lot of messages sent to the sink node. Also the nodes that are active during communication is reduced. Ultimately the clustering results in prolonged the lifespan of the network.

Sensor Node: In WSN a sensor node is the core element & is capable of sensing, routing, & processing etc. A sensor node basically consists of four basic components as shown in figure. A processing unit, a sensing unit, power supply unit and transceiver section.. The sensors actually give eyes and ears to the nodes. Sensor nodes have a variety of application such as in health, disaster relief scenarios, chemical processing and military.

a) Sensing Unit: Further the sensors themselves & ADC (analog to digital converter) combiningly makes the sensing unit. ADC is used to convert the sensed analog generated signal by the sensor to a digital form and then fed to the processing unit.

b) Processing unit: It is the heart of the sensor node. It processes the sensed signal & makes the output.

c) Transceiver Unit: This unit linked wirelessly to the RF channel and is connected to an omni-directional antenna which allows communicating in all the desired directions. The main function of this unit is to convert signal coming from previous processing unit into EM (electromagnetic) radio waves[6].

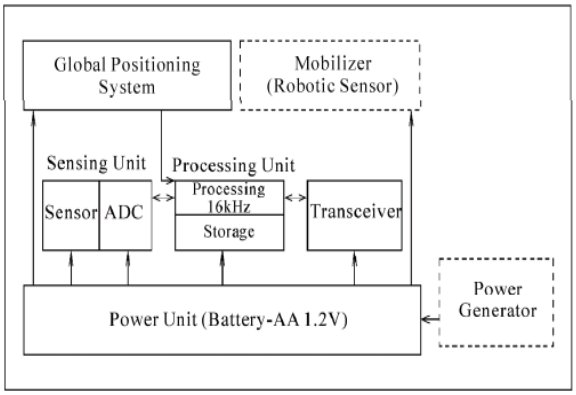

Fig.1 Sensor node architecture [6]

d) Power Supply Unit: The sensor nodes may be powered by using energy storage devices or by energy scavenging. The first method utilizes a group of small batteries made up of thin films of vanadium oxide and molybdenum oxiide. These are fabricated using tiny-machined gaps containing an electrolyte, in addition to chemical energy storage. The second method uses energy scavenging from the environment in order that the sensor node can operate uninterrupted. Widely used scavenging technique is the solar radiation.

In order to increase the network lifetime, it is necessary to design effective and energy aware protocols. Many researchers gave various kind of protocols for increasing the network lifetime.

1.1 LEACH Protocol
Low-energy adaptive clustering hierarchy (LEACH) is the foremost and very popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing energy consumption. LEACH divides the network into several

clusters of sensors. Clusters are constructed by using localized coordination and clusters are designed not only to reduce the amount of data that are transmitted to base station node, but also for making routing and data dissemination more scalable and robust. LEACH uses a random manner of rotation for higher-energy cluster head position rather than selecting in static manner, to give a chance to all sensors to function as cluster heads and decrease the battery depletion of an individual sensor and die quickly.
For LEACH, load of energy is greater and consumption of energy is much higher. So, in order to maintain the consumption of energy among nodes and to avoid earlier cluster head's death, periodical cluster head selection method is considered & each period in this process is defined as the round[9]. When clusters are made, each node takes the decision whether it can become a CH for the present round or not[7][8]. It is found by the suggested %age of the CHs for the network. Also for a node to be CH is considered.

This decision is taken by the node n by selecting a number between 0 and 1. If the number lies below a threshold value T (n), then that node becomes a CH for the present round. The threshold value is as:

$$T(n) = (p/[1-p(r \bmod 1/p)] \quad \text{if } n=>G$$

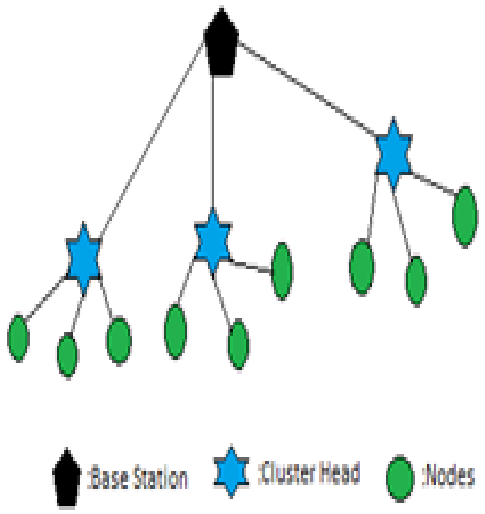

Fig. 2: LEACH Clustering Model

= 0 Otherwise

Here:

n = number of sensor nodes
r = present round

p = desired %age of cluster heads.

G= set of nodes not selected as cluster head.

By implementing this threshold, each node within 1/p rounds will be a CH at some point[9].

1.2 DSDV Protocol

In Proactive routing, each node has one or more tables that contain the latest information of the paths to any of the node in the network. The Proactive protocols are not suitable for larger networks, as they need to keep node entries for every node in the routing table of every node. This causes more overhead in the table of routing turns to increases energy consumption. Destination-Sequenced Distance-Vector routing (DSDV) is one of the routing table driven routing methods of sensor networks based on the Bellman-Ford algorithm. To reduce this regular update, Reactive Routing protocols were developed.

1.3 AODV Protocol

Ad-hoc On-demand routing protocol is a reactive routing protocol. Its a mixture or combination of both DSR and DSDV protocols. It borrows route discovery and route maintenance steps from DSR and borrows hop-by-hop routing from DSDV protocols. It is an On-demand routing protocol means routes only build when desired and minimize the routing table information. For finding path to the destination, AODV broadcast route request.

2. RELATED WORK

In paper [7] author compared his proposed Leach-Heterogeneous system with Leach-Homogeneous system. In his paper, he analyzes the basic clustering routing protocol (distributed) LEACH which is the Low Energy Adaptive Clustering Hierarchy protocol (homogeneous system) & then proposed a new routing protocol (heterogeneous system) using which the sensor nodes form the cluster and the cluster-head is elected based on the residual energy of the individual node calculation. Simulation results show that the nodes remain alive for a longer time (rounds) in proposed Leach-Heterogeneous system than Leach-Homogeneous system. Also first node dies (FND) and Half of the nodes alive (HNA) in the proposed Leach-heterogeneous system is compared with Leach-Homogeneous system in terms of network lifetime. In the Leach-Heterogeneous system the energy efficiency is increased near to 40% than Leach-Homogeneous system and lifetime of the networks also increased.

In paper [8] author proposed a distributed cluster head CH selection algorithm LEACH-DT that actually takes the distances from sensors to the base station that optimally balances the consumption of energy among the sensors. Instead of using a heuristic method, he propose a distributed LEACH-based CH selection algorithm in which based on the distances to the BS, nodes are automatically self-selected to become CHs with different probabilities, in such a way that the network can be balanced by balancing the energy consumption among the nodes. His simulation results shows that LEACH-DT outperforms the original LEACH by improving the network lifetime over 10%.

In paper [9] author proposed an energy efficient clustering algorithm for WSNs based on the LEACH algorithm. The proposed algorithm solves the extra transmissions problem that can occurs in LEACH algorithm. In order to solve the extra transmission problem, he make a change in the set-up phase of the LEACH algorithm. In this phase, once the cluster heads are selected, the other sensor nodes do not necessarily select the closest node. Among the cluster heads that, in comparison to themselves, have a shorter distance to the BS, these nodes select the closest cluster head and inform it that it will become a member of the cluster. If such a cluster head does not exist, it will not be the member of any clusters and will send its data directly to the BS. Using three metrics, First Node Dies (FND), Half of the Nodes Alive (HNA) and Last Node Dies (LND), he compare LEACH with his proposed algorithm in terms of the network lifetime. The simulation results show that the proposed algorithm can decrease the energy consumption of the network and dramatically increase the network lifetime for LND (Last Node Dies) metric in the case of the BS is located relatively close to the sensor nodes.

In paper [11] author gives a fuzzy logic based energy-aware dynamic clustering technique is proposed, which increases the network lifetime in terms of LND. Here, two inputs are given in the fuzzy inference system and a node is selected as a cluster head according to the fuzzy cost (output). Residual energy and node centrality are the two inputs of this FIS. Here, node centrality is the value to indicate that how central the node is among its neighbours. It is calculated by adding all distances from a node to its neighbours. Hence, the lower value of the node centrality indicates that the corresponding node requires lower energy as a CH. The main advantage of this protocol is that the optimum number of cluster is formed in every round, which is almost impossible in low-energy adaptive clustering hierarchy. Moreover, this protocol has less computational load and complexity.

In paper [12] author proposed a new technique for the selection of the sensors cluster-heads based on the amount of energy remaining after each round. Election of a cluster-head in each round is based on an energy value greater than ten percent of the residual value at each sensor. As the minimum percentage of energy for the selected leader is determined in advance and consequently limiting its performance and nonstop coordination task, the new hierarchical routing protocol is based on an energy limit value threshold preventing the creation of a group leader, to ensure reliable performance of the whole network.

In paper [13] author proposed a Cross Layer-Low Energy Adaptive Clustering Hierarchy model (CL-LEACH), an efficient routing protocol to increase the lifetime of the battery. CL-LEACH considers residual energy and for cluster head selection and provides an energy efficient transmission schemes for WSN.

3. PROPOSED METHODOLOGY

In this section the LEACH Protocol with Master Cluster Head mechanism has been implemented and discussed step by step. Master Cluster Head scheme is an extension implemented in existing LEACH Protocol. The entire work consists of two phases:

1. Setup phase
2. Cluster Head Selection

3.1 Setup Phase

Clustering is an important method for prolonging the lifetime of wireless sensor networks (WSNs). It involves grouping of sensor nodes having similar properties for clusters and choosing cluster heads (CHs) for all the clusters. CHs collect the data from respective cluster nodes and forward the collected data to base station. In this phase clusters are formed using information such as number of distance from base station, number of neighbour nodes and distance of neighbour nodes. The members of cluster will elect cluster head on the basis of respective energies of nodes. 10 nodes out of total 100 nodes will be elected as Cluster Head. The selected 10 Cluster Heads will be responsible for electing one Master Cluster Head among them. The common nodes will transfer data to cluster heads and cluster head will pass on data to Master cluster head. The Master cluster head will aggregate the data and send it to base station. The location of the base station is at the centre of the target area. There are no energy constraints for Base Station. The initial parameters are:

Table 1: Network Parameters

Network size	1200m × 1200m
Location of BS	Centre of target area
Number of nodes	100
Data packet size	500 byte
Packet size for path set-up	20 byte
Network topology	Random
Initial energy of each sensor	1.0J

3.2 Cluster Head Selection

The cluster heads are selected on the basis of nodes with maximum energy. The algorithm for cluster head selection runs periodically. A threshold value is defined below which a node is not allowed to become cluster head. The cluster heads in-turn selects the Master Cluster Head having maximum node Energy[1]. LEACH organizes its function of operation into rounds, where each round has a setup phase where clusters are formed.

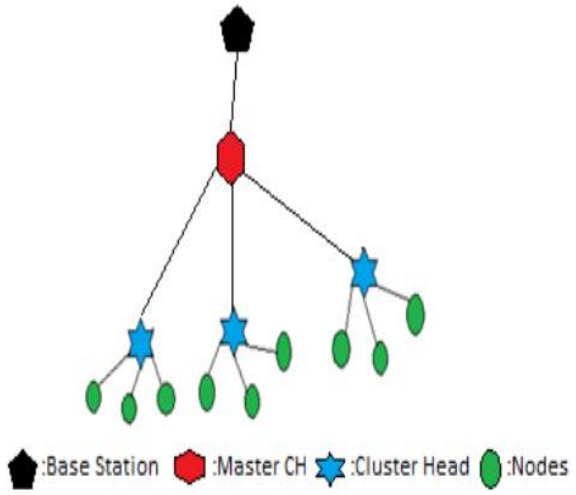

Fig. 3: Master Cluster Head

4. RESULTS

In the proposed research work, entire scenario has been simulated in Network simulator. The parameters considered for comparison are Network life time and Number of Nodes alive. Rounds are the number of times the algorithm runs periodically and selects cluster heads. Table below shows the comparison between proposed work & previous work. In the proposed research work when the number of round reaches 950 the nodes start dying. But in case of previous work First node dies after 890 rounds. From here it is clear that our proposed network remains in existence for a longer time than previous one.

Table 2: First Node Die and Half Nodes Alive

Parameters	**LEACH**	**Existing work**	**Proposed work**
FND	530	890	950
HNA	780	1230	1300

The figure below shows animation of FND.

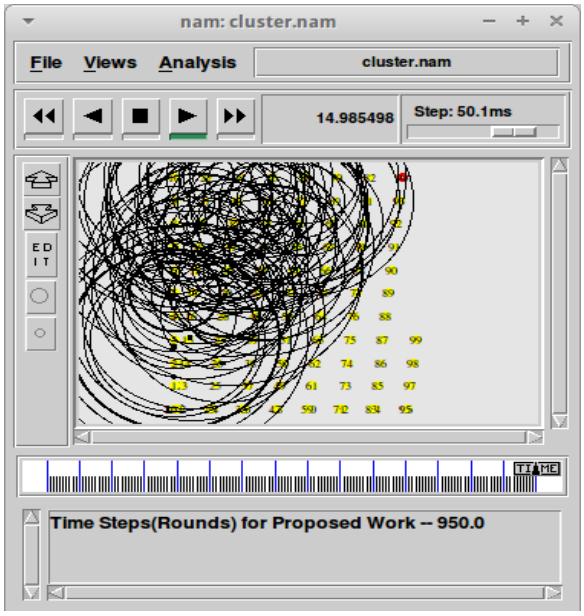

Fig.4: First Node Die

The figure below shows the simulation scenario when half of the nodes dies and half of the nodes alive. In case of previous work half of the nodes dies after 1230 rounds but in our case half of the network remain alive upto 1300 rounds as shown in the simulation (fig.5 below).

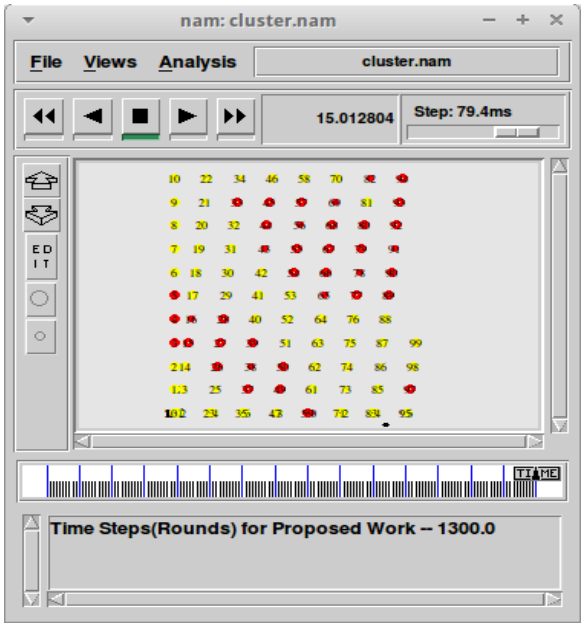

Fig.5: Half Nodes alive

A comparison has been shown in the form of graphs below.

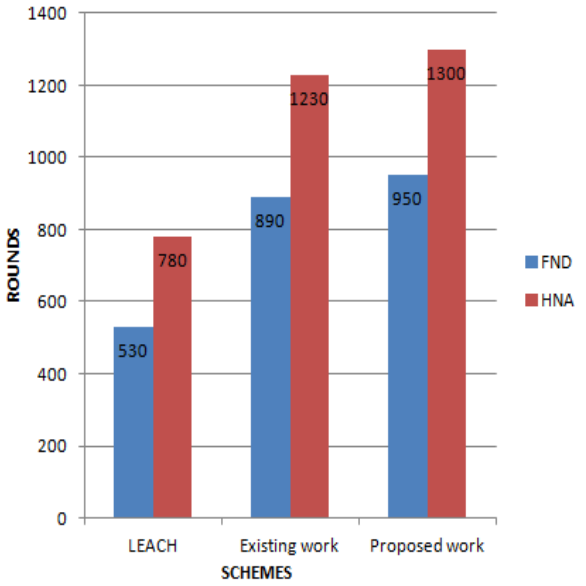

Fig. 6: Comparison of the schemes in terms of FND and HNA

5. CONCLUSION

It has been concluded that the proposed scheme introduced a new threshold value used in selecting the cluster heads in the network. We have also minimized the energy consumption of the sensor nodes with the new concept of Master Cluster Head selection. As a result, the proposed scheme has significantly reduced the energy consumption and increased the lifetime of the network compared to the existing schemes.

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