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# Network Life Enhancement in Wireless Sensor Network

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**ABSTRACT**
In Wireless Sensor Network the main focus is on developing a mechanism to extend the network lifetime by energy balancing. To achieve this, LEACH (Low Energy Adaptive Clustering Hierarchical) protocol and LEACH-CC (Leach-Centralized with Chain) protocol is used. But LEACH and LEACH-CC have some limitations that are overcome by Group based routing protocol which is presented in this paper. In this study the nodes are grouped into one group that lies in the same range which senses the similar data from the field in which nodes are deployed in. Each group has only one active node for sensing the data and others are at sleep mode which increases the lifetime of network by saving the energy used in transmitting the duplicate data. Two base station locations are used to overcome the hotspot problem and to reduce the distance problem. The results shows that Group based routing protocol perform better than LEACH and LEACH-CC and extend the lifetime of network.

**Keywords:** Base station, LEACH, LEACH-CC, Threshold energy, Sensor Node, Wireless sensor network

## I. Introduction

A Wireless Sensor Network is a collection of micro sensor nodes organized into a cooperative network. Typically, a large number of nodes are randomly deployed within a geographic area. The basic functionality of the sensor nodes are data sensing, data processing and communication with other nodes or base station. To perform these operations the sensor nodes need to have a power supply (usually a battery), which has a limited lifetime. These nodes may be deployed in an unpractical environment where it would be impossible or inconvenient to recharge the battery. These nodes are used in multiple areas such as military area for battlefield mapping and target surveillance, area monitoring, health care etc. Energy is a major concern in WSN. As sensor nodes are constrained with battery powered, the energy usage has to be carefully managed in order to prolong the lifetime of the system.

## II. Low Energy Adaptive Clustering Hierarchical Protocol (LEACH)

W. R Heinzeolman proposed LEACH protocol [1], which is based on cluster structure and hierarchical technology. LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the energy load evenly among the sensors in the network. The operation of LEACH is broken into rounds and each round has two phases: set-up phase and steady phase. In set-up phase, the clusters are formed; in steady phase, data is transfer. When clusters are created, each node decides whether or not to become a cluster head (CH) for the current round. This decision is made by the node "n" choosing a random number between 0 and 1. If the number is less than a threshold, the node becomes a CH for the current round. The threshold value is calculated based on an equation1:

$$T(n)= P / (1-P*(r*mod1/P)) \quad \text{if } n \in G \quad \ldots (1)$$

Where $P$ = the desired percentage of CHs (e.g. $P$=0.05), r= the current round, and G is the set of nodes that have not been selected as a CH in the last (1/$P$) rounds [1].

Using this threshold, each node will be a CH at some point within 1/$P$ rounds. During first round, each node has a probability $P$ of becoming a CH. The nodes that are CHs in first round cannot be CHs for the next 1/$P$ rounds. Thus, the probability that the remaining nodes are CHs would increase, since there are fewer nodes that are eligible to become CHs. After 1/$P$ rounds, all nodes are once again eligible to become CHs. LEACH assumes that all nodes are in range of wireless transmission of the base station which is not the case in many sensor deployments. Around 5% of the total nodes play as CHs in every round [2].

The shortcomings in LEACH are:

1. The CH node is randomly selected. After several rounds, the node with more remaining energy and the node with less remaining energy have same probability to select as CH [2]. If the node which has less energy is selected as CH, it will drain out energy and die quickly in short time, so

that network lifetime will be short and affect the performance.

2. The CH directly sends the data to base station, if the CH which is far away from base station, it spend a lot of energy to send the data. Thus, the energy is drained very fast and that node is quickly died. These affect the network life and performance.

## III. Leach-Centralized With Chain Protocol (LEACH-CC)

LEACH-CC performs better than LEACH. It is based on LEACH protocol with the chain routing scheme. At the beginning of each round, LEACH-CC requires that each node transmit information about its location and energy level to the base station. So, during the set-up phase this information is obtained. The base station computes the [3] average energy node and those nodes having energy level below the average energy cannot be CHs for the current round. Once the optimal CHs and associated clusters are found, the base station transmits this information to all the nodes in the network.

During the steady-state, nodes send their data to the CH into frame form during their allocated transmission slot. The CH aggregates the data. The base station may be far away, so LEACH-CC forming chains between CHs and select only one CH as leader to transmit to the base station instead of multiple CHs. The data is transferred from one node to its CH and then it is forwarded to next CH and then finally to the leader CH. From leader CH the data is finally sent to the base station. This approach will distribute the energy load evenly among the sensor nodes in the network.

The base station has global knowledge of the location and energy of all the nodes in the network, so it can produce better clusters that require less energy for data transmission. It also uses the chain routing scheme which is established between clusters to reduce the amount of nodes which are participate for communication to the base station.

The limitations of LEACH-CC are explained below:

1. In this protocol, at the beginning of each round, each node sends information about its current location and energy level to base station. So a part of energy is used to do this.
2. This protocol uses multi- hop routing by forming chains between cluster-heads and selecting only one cluster-head to transmit to the base station which is closest node. The closest CH will die in a short time because this CH transmits all data in all time. Thus, the nearest node to base station tends to die early and death rate increases creates hot-spot problem and reduces the network lifetime.

## IV. Purposed Protocol

To overcome the limitations a Group based routing protocol has been proposed, which uses grouping phase and the model to select the appropriate node as CH. This protocol grouped the nodes into one group that lies in same range so one cluster has many groups. After grouping, it selects the CH and active group nodes. Only one node from each group will be always active for transmission to its CH. The node will remain as CH until energy level is not less than threshold energy. Also, node from each group will remain active until energy level is not less than threshold energy. Due to this, it saves energy of other nodes belongs to same group and save energy of CH also by prevents the transmission of duplicate data. Grouping and clustering is done at only lower level and will use LEACH protocol for data transmission at abstract level.

### 4.1 Description of the Adopted Energy Model

The energy model adopted for purposed protocol is described as follows:

- Radio dissipates $E_{elec}$= 50 nJ/bit to run the transmitter or receiver circuitry.
- $\square_{amp}$= 0.0013 pJ/bit/$m^4$ for transmit amplifier.

The energy dissipates for the radio transmission $E_{Tx}(k,d)$ of a message of k-bit over a distance d, the radio expands:

$$E_{Tx}(k,d)= E_{elec}* k + \varepsilon_{amp} * k * d^2 \quad \ldots\ldots\ldots\ldots(2)$$

The value generated by equation 2 called Threshold energy. Threshold energy is the minimum energy require for transmission of sensed data. Moreover, two base stations location are used which reduces $E_{Tx}(k,d)$ as compared to multi-hop routing and single-hop routing.

### 4.2 Description of the Proposed Routing Model

**I. Network Deployment**

It is assumed that the sensor nodes of network are deployed randomly with uniform distribution of energy, each node has same initial energy, computation power etc; resulting the Wireless Sensor Network is formed in a homogeneous formation. The network is randomly deployed in a fixed square region.

- Each sensor node has a unique identity.
- All sensor nodes are fixed after deployment.
- Physical location of nodes is unknown.
- BS is unique, fixed and deployed two BS locations.

Fig. 1 shows a 100 node with id sensor network in a fixed region 100m*100m. Both BS locations are located far away from the network.

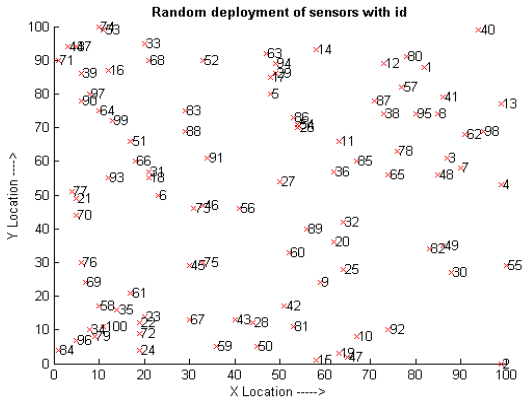


**Figure 1: Randomly deployed network**

## II. Clustering and Grouping Phase

The whole network is divided into cluster. Each cluster has unique number of sensor node and one sensor node belong to only one cluster. After that, the nodes that lie in the same range are grouped into one group. The grouping parameter $g_d$ used in this study has been used in [4] which measures the distance and the nodes to be a part of group must lie within this parameter value. Fig. 2(a) shows the grouping of sensor node. Fig. 2(b) shows links between members of each group in each cluster.

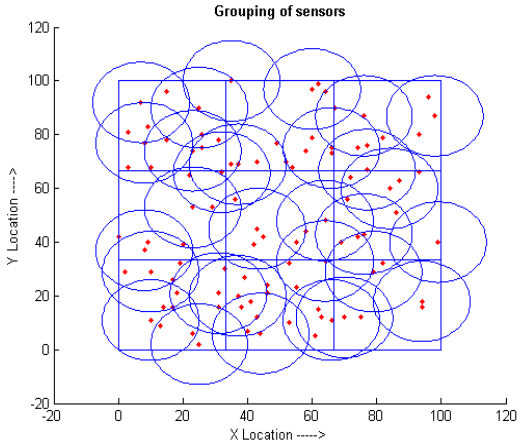


**Figure 2: (a) Grouping of Sensor**

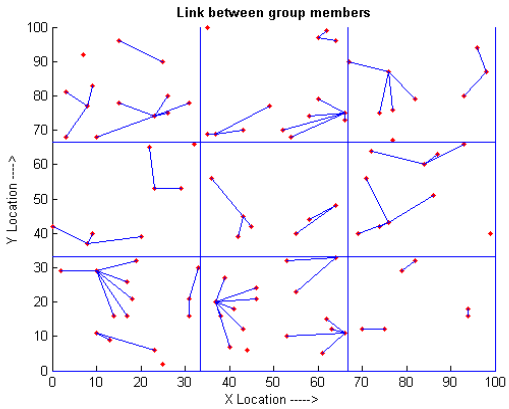


**Figure 2: (b) Link between Group Members**

## III. Selection of CH and Active Group Node

Before selection of CH and active group node, the protocol finds the distance from each node to both base station location and consider only minimum distance. Fig. 3 shows the selected CH, active group node of each group and other node of each group which are at sleep mode.

**Steps to find CH:**

1. Initially, it will randomly select the node N1 from each cluster.
2. Calculate threshold energy1 using equation2.

$$threshold\_energy1 = E_{elec} * k + \varepsilon_{amp} * k * d\_BS^2$$

3. Compare the energy of N1 with threshold_energy1

If energy_value(N1) < threshold_energy1
Select new node for cluster_head(CH)
Else
Set N1 as Cluster_head=CH

It considers the $d\_BS^2$ minimum distance from selected node N1 to base station. The CH broadcast the message to rest of the nodes with its own ID in its own cluster. On receiving the message, the receiving node adds it to its list and the nodes data transmit to its CH using CH'ID.

**Steps to find active group node:**

1. Initially, it randomly selects only one node GN from each group in each cluster.
2. Calculate threshold_energy2 using equation2.

$$threshold\_energy2 = E_{elec} * k + \varepsilon_{amp} * k * d\_CH^2$$

3. Compare energy of GN with threshold_energy2.

If energy_value(GN) < threshold_energy2
Select new group_node(GN)
Else
Current_round= GN

It considers the $d\_CH^2$ distance from group node GN to CH.

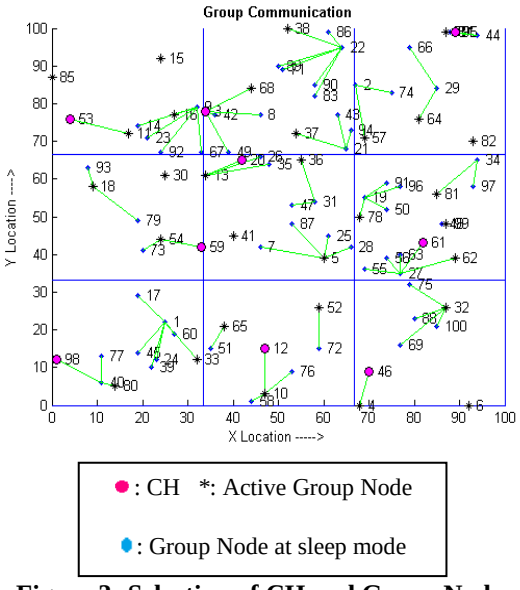





**Figure 3: Selection of CH and Group Nodes**

## V. Performance Evaluation

The protocol is simulated using several random 100 node network. Fig.1 shows a random 100 node network. The various parameter used for simulation are listed in Table 1.Our goal is the comparison of the performance of LEACH, LEACH-CC and Group based routing protocol. The comparison is on the basis of network lifetime.

**Table1. Simulation parameters**

| No. | Parameter | Values |
|---|---|---|
| 1. | Number of Sensor Nodes | 100 |
| 2 | Network Area | 100*100 |
| 3. | Initial Energy of Each Node | 2J |
| 4. | Transmitter circuitry dissipation ($E_{elec}$) | 50nJ/bit |
| 5. | Transmit amplifier $\varepsilon_{amp}$ | 0.0013 pJ/bit/$m^4$ |
| 6. | Base-station location for LEACH and LEACH-CC | (50,175) |
| 7. | Base station location for Purposed Protocol | (50,175)and (50,-75) |

Fig.4 show that total number of alive node over simulated time where many number of node are dead in LEACH and LEACH-CC while 93% nodes are alive in Group based routing protocol.

Thus, Group based routing protocol extends the network lifetime.

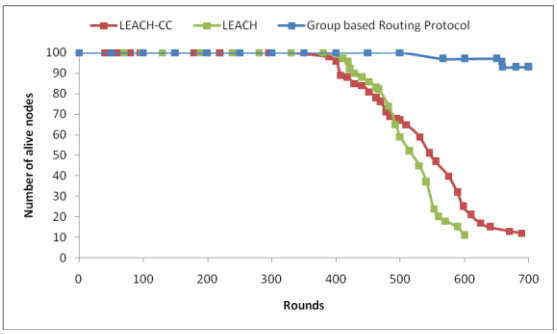


**Figure 4: Network Lifetime**

## VI. Conclusion

In this paper, Group based routing protocol has been proposed and it is founded that this protocol performs better than LEACH and LEACH-CC. The purposed protocol distributes the energy load among the nodes to increase the network lifetime. With groups, it saves energy due to prevent the transmission of duplicate data. By using two base station locations, it divides the whole network into two networks on distance basis so the CH transmits data at minimum distance to base station which reduce the dissipation energy for transmission. Thus, it enhance the network lifetime. Because two base station locations used, the cost also increased but it does not affect on the network because it save a lot of energy which is comparable to cost factor. This protocol will give the better performance as network size increase.

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