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# Enhanced LEACH Protocol for Wireless Sensor Networks

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***Abstract*—Low-Energy Adaptive Clustering Hierarchy (LEACH) is MAC based protocol which uses time division multiple access (TDMA) that for clustering and a simple routing mechanism in WSN's. Wireless Sensor Network (WSN) include numerous battery-powered nodes or devices. The initial energy of these nodes or devices is insufficient to transfer the data continuously, where data transmission costs a major part of it. The key requirement is to select the cluster head (CH) based upon the battery state and the separation range between the cluster head and the base station. The head of the cluster directs data between clusters and coordinates the activities of its component nodes. Clustering preserves the energy of the nodes and extends the network's lifespan. This paper deals with the selection of cluster heads in the network-based upon the battery state of the node and the separation range between the cluster head and the base station using the multipath algorithm and free space algorithm.**

***Index Terms*— Base station, Cluster Head, Enhanced-LEACH, LEACH, Wireless Sensor Networks.**

## I. INTRODUCTION

Wireless Sensor Networks (WSN's) are widely chosen as one of the essential technologies of the twenty-first century. In recent decades they have gotten attention from academics to industry worldwide. A WSN comprises hundreds to thousands of sensor nodes that can communicate with one another through radio. Nodes work together to complete a common task. Environmental observations, military spying, and industrial operational management are just a few examples [1]. The underlying premise of WSNs is that, while each sensor node's functionality is restricted, the network's overall power is sufficient for the desired purpose. The most significant element for WSN is its energy efficiency and long lifespan. Optimized programs, operating systems, and communication protocols can help get a longer lifespan [2,3].

Based on the routing of data from node to base station, routing protocol in a wireless communication network is divided into two types, i.e., flat routing protocol and hierarchical routing protocol [4,5]. The main disadvantages of a flat routing protocol are cost, as it requires a large number of routing tables which in turn require more storage space to store the routing tables. Hierarchical routing protocol has been introduced to overcome the drawback of the flat routing protocol by developing the enhanced algorithm [6]. Cluster-based hierarchical routing techniques partition a network into various clusters by building a hierarchy of sensor nodes. Each cluster consists of a cluster head (CH) and multiple sensor nodes. Each sensor node collects information and sends it to

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the appropriate CH [7,8]. Based on a specified routing algorithm, the data is gathered by CHs and forwarded to the BS, which is the next hop or main station [9].

In wireless sensor networks, clustering is crucial to extend network lifetime (WSNs). It entails grouping sensor nodes into clusters and choosing each group's cluster heads (CHs) [10]. CHs take data from nodes in the cluster and consolidate it before sending it to the base station. The sensor node's lifetime depends upon that node's battery state; considering all the nodes in the wireless network, a cluster is formed in the network. Transfer of data from one location to other location depends upon the separation range between the cluster head and the base station in the network [11,12].

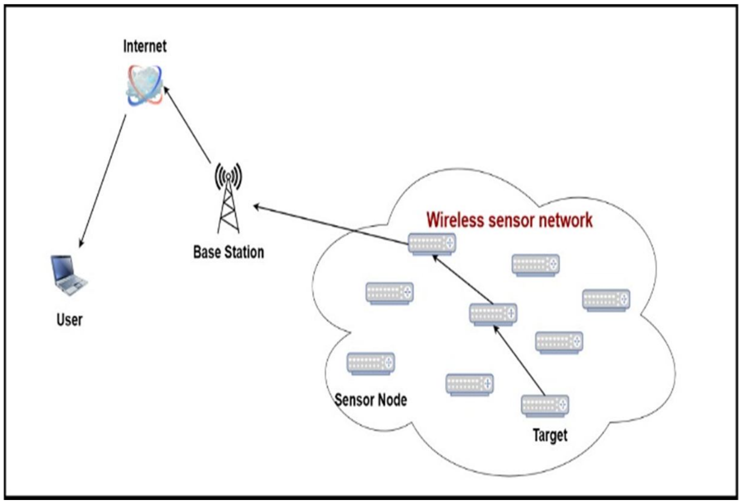


Fig 1: Structure of Wireless Sensor Network

Considering the specific number of nodes, the algorithm selects the cluster head based on the surplus energy and the distance between the base station and cluster heads [13]. At first, the dead nodes are checked and removed from the list then the cluster heads are elected in the given area of the WSN [14,15]. For every iteration, the battery state of the nodes is being analyzed. Finally, the new cluster heads are selected, which then transfers data to the nearest cluster, saving the energy of the remaining cluster nodes. The iteration is unbroken until a single cluster is left out in the network [16].

## II. METHODOLOGY

Techniques for cluster formation and cluster head selection improve network performance and extend network lifespan by reducing energy utilization [17,18]. LEACH (Low Energy Adaptive Clustering Hierarchy) comprises a new method for forming distributed clusters that allows many nodes to self-organize and algorithms for adjusting clusters with rotating cluster head positions are used to evenly divide energy consumption across all nodes [19,20].

The following algorithm 1 illustrates the cluster head selection mechanism in WSN's

**Algorithm 1: Algorithm for Cluster Head (CH) selection strategy**

Step 1: Start

Step 2: Node serial for identification

Step 3: Battery State

Step 4: operation mode, either head or node

Step 5: Every new round, the counter will be reset

Step 6: Possibilities of becoming cluster head

Step 7: Number of rounds involved in doing work

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Step 8: Distance between node and base station
Step 9: Distance threshold
If (BS distance> distance threshold)
        Use multipath algorithm
Else
        Use free space algorithm
End if
Step 10: Field set-up
Step 11: WSN Node count
Step 12: Breadth of the field
Step 13: Length of the field
Step 14: Coordinate sink
Step 15: List of all the node objects
Step 16: Obtain random coordinates for nodes
For x in the range of nodes
        While
                Obtain a list of x and y pairs at random
                If not
                        No overlapping
                        Break
Step 17: Populate all nodes into the list
Step 18: Node parameter set-up
Step 19: initial energy Eo
Step 20: Energy for data aggregation
Step 21: Energy for free-space transmission
Step 22: Energy for multipath transmission
Step 23: Energy for Tx
Step 24: Energy for Rx
Step 25: Probability to become head
Step 26: Maximum number of turns
Step 27: Fraction of nodes in advanced power
Step 28: Amount of surplus energy in each advanced node
For x in range surplus nodes
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While (1)
    If (remaining energy= normal energy)
        updates the list with surplus energy nodes
            break
Step 29: Cycle starts
Step 30: List of dead nodes
Step 31: The shortest distance between two cluster heads
For x in range
     Examine remaining energy
For n in node collection
    If (remaining energy <= 0)
        Updates the list of dead nodes
For n in dead node
    If (node collection. Count(n))
        Removes dead node
Step 32:  Premature death of WSN before reaching the last round
If there are no more active nodes
    There are no more active nodes in the network
    Break
Step 33: Nomination and Election of cluster heads

for n in node collection
    Reset cluster head history at new epoch
    Attempt to position itself as the head
    If (selected as head)
        Send message to base station
Step 34: Optimisation
    cluster heads to be preserved (whitelist)
    cluster heads to revert normal nodes (blacklist)
While cluster
    Communication with BS is simulated in a random queue
    If cluster
        For item in cluster
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                        If (min distance> T)
                                The cluster head is disqualified and becomes node
                While blacklist
                        Cluster removes
For c in cluster
        Send to BS
Step 35: Establishment
if there is at least one cluster
        For n in node_collection
                If node is not head
                        Identify which node/sink to receive the message sent from n
                        For c in the cluster
                                If (distance< min_distance)
                        Data transfer
                        If (there are no nodes)
                                Data gathering will be handled by the base station/sink
                        Else
                                Data will be sent to the closest cluster
Else
No transmission for this round
Step 36: Stop
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The proposed algorithm for selecting cluster head mainly involves three steps: 1. The distance threshold is computed based on the battery state, 2. The number of rounds engaged in conducting work, 3. And the distance between the node and the base station [21]. If the distance between the node and the base station is more than the distance threshold, the node will utilize the Multipath method; if the distance is less than the threshold, the node will use the free space algorithm. The formula used to compute the distance threshold is given by:

d_thres = (self.e_tx_fs / self.e_tx_mp) ** 0.5 # distance threshold (1)

Where:

self.e_tx_fs is Energy taken to send a msg to bs in free space

self.e_tx_mp is Energy taken to send a msg to bs in multi-path

The field is then built up based on the number of nodes in the wireless sensor network installed. We considered 100 nodes in this analysis. The field's width and height are represented by the X and Y dimensions, respectively, and are set to 100. The surplus energy node % is determined when the field is set up, and the surplus nodes are calculated using the formula.

surplus_nodes = nodes_number * surplus_energy_node_percentage (2)

The dead nodes are examined once the excess nodes have been determined. Then, the remaining energy of the dead node is examined, and if the remaining energy is less than or equal to 0, the dead node list is updated. The cluster head is nominated soon after the nodes are added, based on the rounds completed, node energy, and distance between the node and the base station.

The cluster heads are then saved, and the list of cluster heads is checked to ensure that normal nodes are restored. The minimal distance between the node and the base station disqualifies the cluster head [22]. The establishment follows the node optimization, which primarily analyses at least one cluster. If the node is not the head in node collection, the algorithm determines which node/sink will receive it and collects it. If the node and base station are separated by a significant distance and is less than the minimum distance, the node is chosen as the transmission and reception node, the closest cluster [23].

tx_rx_node is the transmission and reception of the node (3)

The tx_rx_node is then used to send the data to the base station. If there is no tx_rx_node at the end of the cycle, the no transmission for this round message is sent to the base station. The cycle continues until at least one cluster is present [24]. The cycle in this method repeats 8000 times, making the algorithm efficient.

TABLE I. COMPARISON OF LEACH PROTOCOL DESCENDANTS

| Category | Protocol | No of Cluster Heads | Advantages | Limitations |
|---|---|---|---|---|
| Residual Energy | LEACH | Indeterminate | Utilizes the TDMA schedule to extend the network's life cycle. | They are assuming that CH nodes are not distributed evenly. |
| | | | Balances Energy Usage | CH is selected randomly |
| | | | Reduces nodes' energy discharge. | Single hop is used |
| | LEACH-B | Determinate | Cluster heads are accountable | Overhead cost growth |
| | | | Residual energy is taken into consideration | |
| | | | The Network lifespan is improved | |
| | LEACH-I | Determinate | CH's are elected based on residual energy and location of nodes | CH aggregates received data to reduce data transport costs, but this is not viable for nodes that receive distinct data [3]. |
| Centralized | LEACH-C | Determinate | Ideal Clusters are considered The rounds in the small network are high | Information of node's location is needed |
| | | | The left-over energy is the basis of cluster head election | Overhead on the base station [4] |
| | | | The distribution of CH's is better | |
| Mobility | LEACH-M | Indeterminate | High mobility in CH's and non-CH's | Additional Overhead [5] |
| | | | Energy efficient | |
| Energy efficiency | LEACH-VH | Indeterminate | When the main CH reaches a threshold, the VH node replaces it. | Additional treatment for VH node |
| | LEACH-T | Determinate | The number of cluster members determines the number of time slots in TDMA. | Random selection of CH's |
| | | | Offers an optimal cluster count. | |
| | LEACH-TB | Determinate | CH's are fixed | The selection of CHs is based on a random timer [8]. |
| Distance | I-LEACH | Indeterminate | Optimal CH selection increases the lifespan of the network | Calculation is complex |
| | EADCR | Determinate | Improvement in the network longevity | The selection of CH is complex [10] |
| | BN LEACH | Indeterminate | Compared to others, execution is better | Increased complexity |

## III. Results and Discussion

We tested our proposed model with a simulation for a maximum of 100 nodes populated within the given dimension area. Fig 1. shows the first round of iteration. Although the total number of nodes that popped up was 100 nodes (indicated in black colour), during this iteration, there were 6 cluster heads (indicated in red colour) formed in the wireless sensor network.

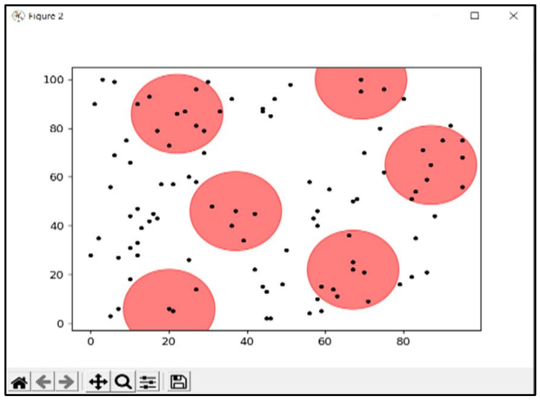


Fig 2. Number of Cluster Heads in the WSN

Figure 2. Indicates the graphical representation of nodes and the number of iterations in the considered WSN [25]. When the number of iterations is less than or equal to 1041, the number of nodes considered remains the same. When the iterations are greater than 1041, the number of nodes in the wireless sensor network decreases gradually.

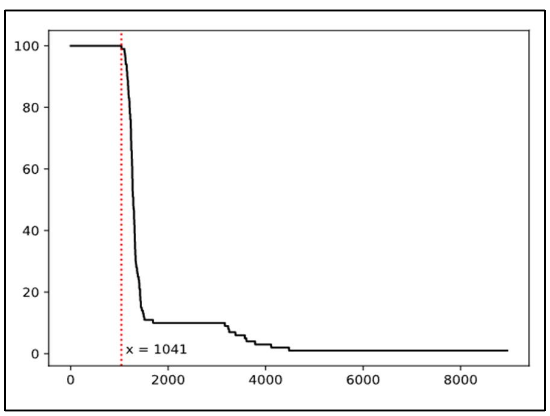


Fig 3. Maximum number of nodes generated below a threshold value

## IV. Conclusion

This paper describes the enhanced LEACH protocol for the Wireless Sensor Network for the cluster heads are chosen based on the state of the nodes' batteries and the distance between them and the base station. Furthermore, our simulation results were compared with previous results. It was observed that the simulations showed better improvement in the cluster head selection and extended the network lifetime effectively for each iteration in the given area of the Wireless Sensor Network.

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