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Heterogeneous Clustering using Modified Stable Election Protocol (M-SEP) in WSN

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Abstract - **Small networked and inexpensive communicating sensors are rapidly being employed in industrial applications and environmental monitoring, thanks to significant advances in technological development in recent years, particularly in microelectronics and wireless communication technology. However, the utilization of wireless sensor networks in such applications is constrained by sensor limitations such as processing capacity, memory size, and energy consumption. Or the networks own constraints, such as the network's limited capacity, network dynamics caused by topological variation, and the proper communication protocols suited to this type of network. In this paper, we put the Modified-Stable Election Protocol (M-SEP) and the Low-Energy Adaptive Clustering Hierarchy (LEACH) to the test in a variety of scenarios where high level heterogeneity is presented.**

Keyword - **LEACH, M-SEP, WSN, etc.**

I. Introduction

WSNs are made up of a large number of sensor nodes that are deployed in the environment and are powered by batteries. Because replacing the batteries of each node in the sensor network is impractical, it is necessary to make efficient use of the limited energy available, which necessitates the development of an energy efficient algorithm. Because the nodes in the WSN are spatially distributed, sending sensed data to the base station or sink node requires multi-hop communication when the base station or sink is out of range. As a result, a greater number of intermediate nodes are required to send this sensed data to the desired destination, which consumes more network energy because all intermediate nodes forward data from their neighbours and they need energy to do so, motivating us to limit the number of hops and intermediate nodes 2involved in data transmission by adopting a clustering technique in which nodes are grouped together.
Each node in the cluster sends data solely to the cluster head in charge, who then aggregates all of the data from the member nodes and sends it to the sink or base station. We chose hierarchical cluster based routing for this study because of its energy efficiency, data aggregation, load balancing, and better network lifetime. The procedure of selecting cluster chiefs determines whether these protocols are centralised or distributed. The location of each node in the cluster, as well as their residual energy, are used to determine which of them should be chosen as the cluster head. One such protocol is LEACH [1]. The LEACH protocol is a chain-based protocol in which each node exclusively communicates with its preceding and succeeding nodes. Next-door neighbour and minimises the number of communicating nodes, which helps to save energy.
We compare the Modified-Stable Election Protocol (M-SEP) [2] and Low-Energy Adaptive Clustering Hierarchy (LEACH) based cluster head election in order to find a strategy that increases the network's lifetime while lowering its energy consumption.

II. Literature Review

Because energy dissipation during communication is proportional to the square of the distance from the transmitting sensor node to the sink, the energy of C H nodes rapidly depletes, reducing the network's lifetime. One option is to rotate the role of a CH across all sensor nodes, as proposed in the low-energy adaptive clustering hierarchy (LEACH) [3], power-efficient gathering in sensor information systems (PEGASIS) [4] and hybrid energy efficient distributed clustering (HEED) [5,6,7] papers. However, in a heterogeneous environment, these protocols function poorly because low-energy nodes die more quickly than high-energy nodes.
[8] invented the stable election protocol (SEP) in which each sensor node in a heterogeneous two-level hierarchical network votes for the best candidate.
Based on its starting energy relative to that of other nodes, the network elects itself as a cluster head.
[9] presented the enhanced stable election procedure (SEP-E) in [10], which adds three levels of heterogeneity to SEP. Similarly, to address the issue of heterogeneity, numerous authors have proposed new clustered routing techniques [11,12, and 13].

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III. PROPOSED METHOD

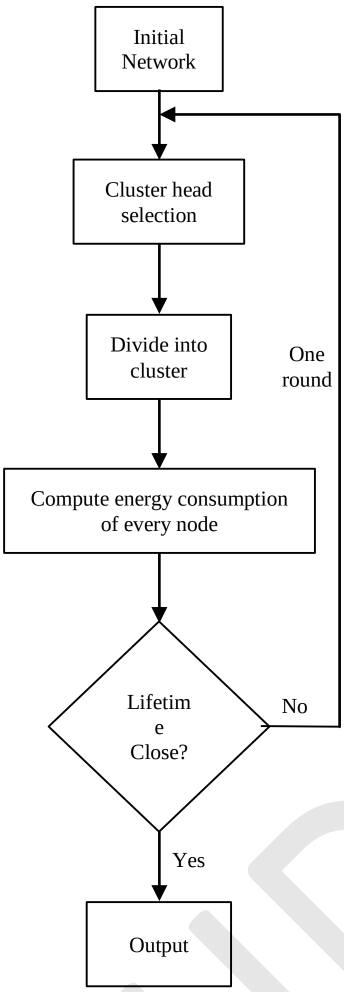

Figure 1: Flow chart for LEACH protocol

During the setup phase, a randomly generated cluster head is chosen from a range of 0 to 1 in each sensor node, and if the chosen number is less than some threshold T(n), the node is chosen as the cluster's head. T(n) formulas are as follows [41]:

$$T(n) - \int_0^n \frac{p}{1-p\left[r \bmod \left(\frac{1}{p}\right)\right]} \text{ with } n \in G \qquad (1)$$

Where p is the ratio of cluster headers to total nodes in the network, r is the current round's number, and G is the set of cluster nodes except the cluster head from the previous rounds 1/p. The cluster's header node then broadcasts to the entire network that it is becoming a cluster head, and each node determines whether or not to join that cluster based on the intensity of the received data and responds to the relevant cluster header.

Protocol for a Stable Election (SEP)

The Stable Election Protocol (SEP) [42] takes into account sensor node heterogeneity, which means that each node has a different energy level than the others. The initial energies of participating nodes are used in the cluster-head selection process in SEP. The time interval before the first node dies will be extended thanks to this clusterhead selection process. This period is known as the stability period, and it is critical in many situations when every sensor node's response is needed. The SEP network region is made up of a number of normal nodes (n) with E 0 energy and a percentage of advance nodes (m) with energy () times that of regular nodes. SEP maintains a balance between normal and abnormal energy usage.

Let E_0 be the initial energy of normal node then energy of advance node will be:

$$E_0 * (1 + \alpha) \qquad (2)$$

The total energy of the new heterogeneous network will be:

$$n * (1 - m) * E_0 + n * m * E_0 * (1 + \alpha) = n * E_0 * (1 + \alpha * m) \qquad (3)$$

Hence total energy of WSN will be $1 + \alpha * m$ times more than as compared to homogenous environment. This will increase the number of epochs in proportion to energy which is first improvement over conventional protocols like LEACH. To extend the stability period new epoch must be $1/popt * (1 + \alpha * m)$, since the networks has $\alpha * m$ times greater energy and $\alpha * m$ more normal nodes.

Hence the Stable Region can be increased by $1 + \alpha * m$ through SEP if:

1. Each normal node will be elected as clusterhead only once $\frac{1}{popt} * (1 + \alpha * m)$ rounds per epoch;
2. Each advanced node will be elected as a cluster head exactly $(1 + \alpha)$ times every $\frac{1}{popt} * (1 + \alpha * m)$ rounds per epoch; and
3. The average number of clusterhead will be $n * popt$ per round per epoch.

Election Protocol for Modified-Stable (M-SEP)

Modified-SEP [43] is a step forward from the stable election protocol in that varying levels of heterogeneity are taken into account to improve overall system performance.

M-SEP improves system performance by combining the concepts of normal and advanced nodes, such as SEP and sleep-wake scheduling. With varied beginning energies, nodes with a larger coverage area can be deployed for the same cost. The network model used in M-SEP has

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several levels of heterogeneity, with some nodes having the same initial energy as in the conventional LEACH protocol, some advance nodes having a higher energy index than normal nodes, and some super advance nodes with even higher energy levels than advance nodes.

It is noticed when a network is simulated with these levels of heterogeneity, it is observed that performance is much better in term of network lifetime, throughput etc. In M-SEP as level of heterogeneity changes normal nodes, advance nodes and also the super advance nodes could be part of clusterhead selection process. Figure 2 shows the flow diagram for proposed M-SEP approach.

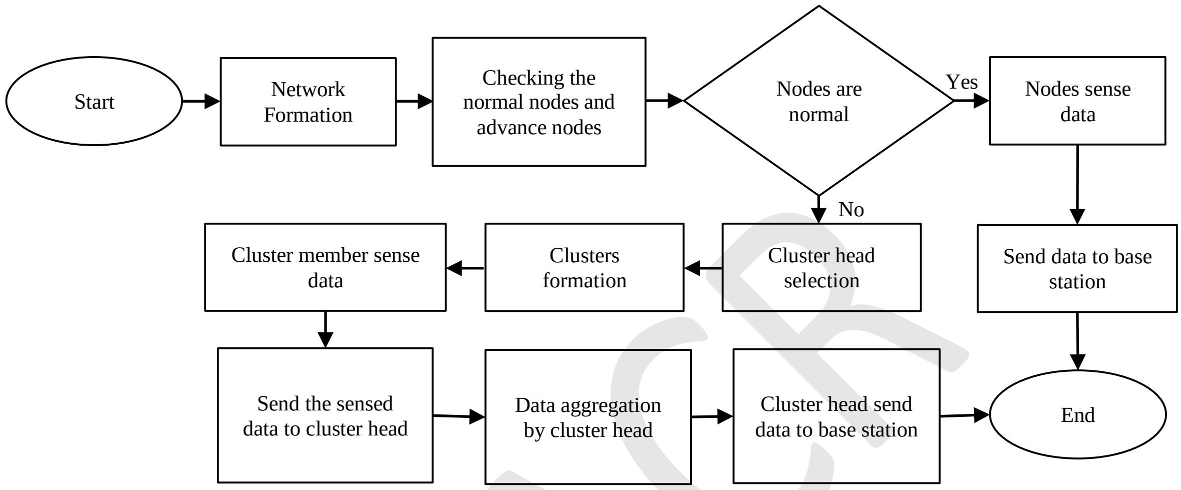

Figure 2: Flow diagram of proposed M-SEP algorithm

1) Levels of Heterogeneity

Consider a network model with n number of normal nodes and m is fraction of normal nodes to be advance nodes. Let the probability function for normal and advance nodes are p_{nrm}, p_{adv} and α is the energy difference between normal and advance nodes.

Then the probability of election of normal and advance nodes as clusterhead will be given as:

$$p_{nrm} = p/(1 + \alpha * m) \tag{4}$$

And for advance nodes:

$$p_{adv} = p * (1 + \alpha)/(1 + \alpha * m) \tag{5}$$

Considering three levels of heterogeneity and allowing super advance nodes with β time more energy than advance nodes to be a part of network.

IV. Simulation and Results

A. Simulation Parameters

Table 1: Simulation parameters

Field area	100×100 meter squares
Number of nodes in the field	100
Optimal election probability	0.1
Initial energy of nodes	0.5 j
Energy consumption of transmit and receive amplifiers	500 nano joules per round
Maximum Iterations	12000

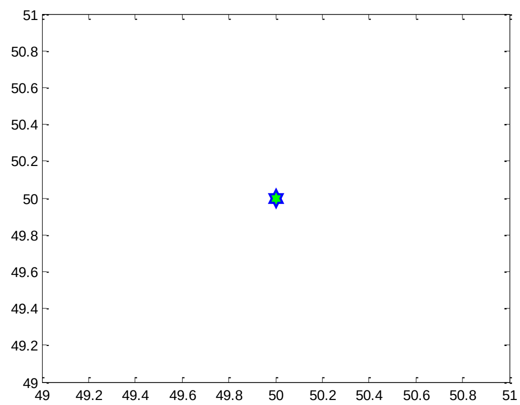

Figure 3: Network field

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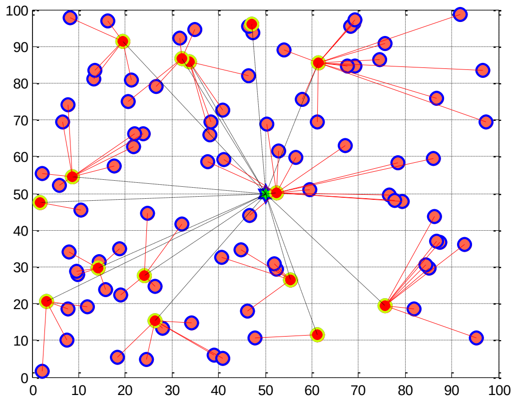

Figure 4: Sensor node deployment

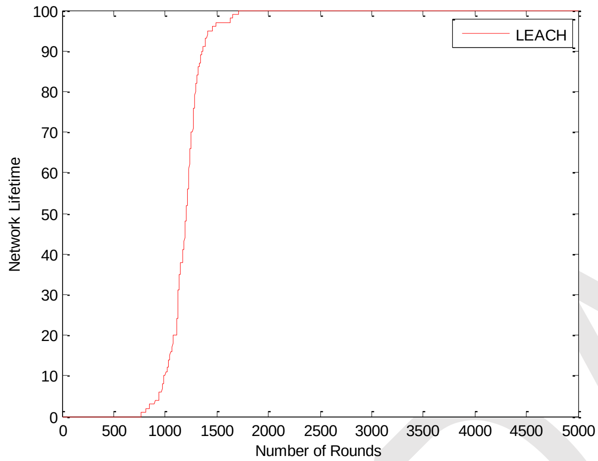

Figure 5: Graph between network lifetime and no. of rounds for LEACH approach

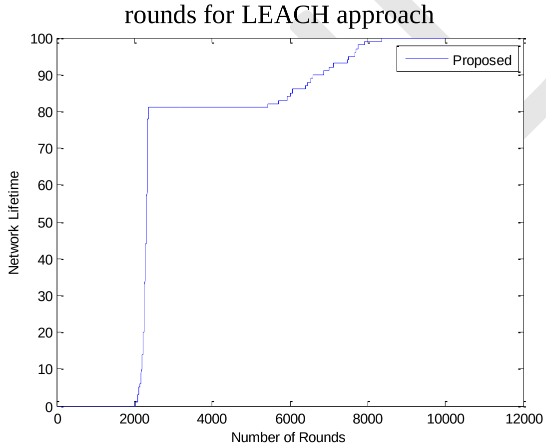

Figure 6: Graph between network lifetime and no. of rounds for M-SEP approach

Figure 6 shows a graph between network lifetime and no. of rounds for M-SEP approach. Considering field dimensions in x and y directions to be 100 meters. The total numbers of nodes are assumed to be 100 with 10% probability to become a cluster head. Initial energy of the energy model is 0.5. The performance is evaluated for 12000 iterations.

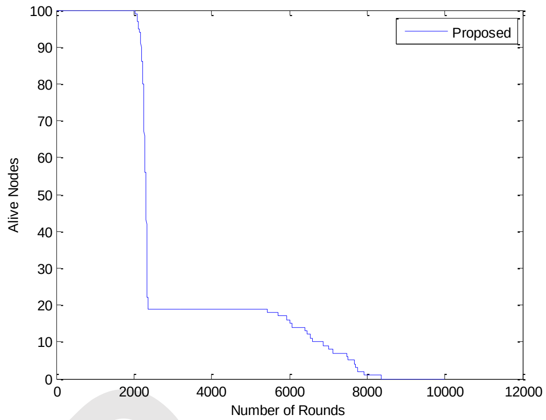

Figure 7: Graph between alive nodes and no. of rounds for M-SEP approach

Figure 6 shows a graph between alive nodes and no. of rounds for M-SEP approach. Considering field dimensions in x and y directions to be 100 meters. The total numbers of nodes are assumed to be 100 with 10% probability to become a cluster head. Initial energy of the energy model is 0.5. The performance is evaluated for 12000 iterations.

Table 2: Performance evaluation of proposed approach

	First Node Dead	Packets To BS
LEACH	1017	13660
Proposed (M-SEP)	1968	35848

V. Conclusion

Wireless sensor networks have a wide range of applications that have sparked study in this sector. Several studies are being carried out with the goal of making these networks more energy efficient. Several points were taken into consideration at the conclusion of this study. For a better understanding of our work, evaluation is required. For a better understanding of our work, which is the evaluation of routing protocols for wireless sensor networks, we have divided it into two scenarios, each of which consists of a simple WSN protocol. For the time being, we have focused on the M-SEP protocol and conducted a comparative study by implementing various topologies.

Using the Modified Stable Election Protocol (M-SEP) and the LEACH algorithm, this research presents an energy management framework for Wireless Sensor Networks. On the basis of network lifespan f, it was discovered that the M-SEP outperforms the LEACH.

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