# Heterogeneous WSN Advanced Energy Optimization Protocol based on Node Energy

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*Abstract*— **Wireless Sensor Networks (WSNs) are the fastest-growing technology, with applications ranging from environment monitoring to traffic flow prediction to eavesdropping to research and academic disciplines. Due to the random deployment of sensor nodes in a wireless environment, security metrics have emerged as the most promising challenge that communication wireless networks face today.**

**To optimize the life cycle of heterogeneous wireless sensor networks (WSNs), the stable election protocol (SEP) is an upgraded algorithm of the Low Energy Adaptive Clustering Hierarchy (LEACH). The uneven energy consumption of cluster heads and nodes, on the other hand, would reduce the lifetime. On the one hand, include node energy in cluster head election to reduce cluster head energy consumption; on the other hand, lower node energy consumption in the cluster through indirect transmission by intermediate nodes. SEP is a heterogeneous-aware protocol that extends the time interval before the first node dies (what we call the stability period), which is critical for many applications where sensor network feedback must be dependable. SEP is based on the weighted election probabilities of each node to become cluster head depending on its remaining energy. When comparing the LEACH protocol and the SEP protocol with the enhanced Efficient-SEP protocol using the suggested algorithm by MATLAB, the results reveal that the enhanced E-SEP protocol works well in balancing the energy consumption to improve the lifetime.**

***Index Terms*—** Heterogeneous wireless sensor networks Efficient Stable Election Protocol, greeting routing, election probability

## I. Introduction

As an emerging application area for ad hoc networks, wireless sensor networks (WSNs) have gotten a lot of interest. WSNs are made up of a group of sensor nodes that are low-power, low-cost, and multifunctional, as well as having wireless processing and communication capabilities. These sensors communicate over a short distance using a wireless medium and work together to accomplish a similar goal, such as environmental monitoring, target tracking, and industrial process management [1]. The idea is to use a group of small, inexpensive fixed sensors to sense physical properties about the surroundings and then communicate them to a sink node [2]. Despite the diversity of WSN applications, the primary function of WSNs is to sense data, process it, and transmit it back to a specific node (base station or sink). The routing protocol specifies data that allows nodes to choose routes between them. The goal of routing in WSNs is to send data from a sensor node to a predetermined destination sensor node. To achieve this goal, an appropriate routing protocol must be developed to establish paths between sensor nodes and the destination. The restrictions of network resources such as energy, storage, and bandwidth, as well as communication connection failures, multidimensional optimization difficulties, and a variety of network constraints and requirements, make building routing protocols for WSNs particularly difficult. The system architectural mode and routing design are inextricably linked.

WSNs are designed to function autonomously and untetheredly in potentially harsh, unpredictable, and dynamic settings. The basic objective of a WSN is to sense and gather data from a target domain, process it, and forward it directly to the target node. However, this task is impossible to do since the required transmission energy increases proportionally to the square of the distance. As a result, multi-hop communication is used to route data. To complete this duty effectively, an energy-efficient routing protocol must be developed to establish paths between sensor nodes and the data sink. Because there may be multiple different paths to a target node, the routing decision has a big impact on load balancing, end-to-end reliability, and latency. The path must be chosen in such a way that the network's lifetime is maximized. WSN presents significant issues in network structure, topology discovery, communication scheduling, routing control, and signal processing due to resource limits.

 

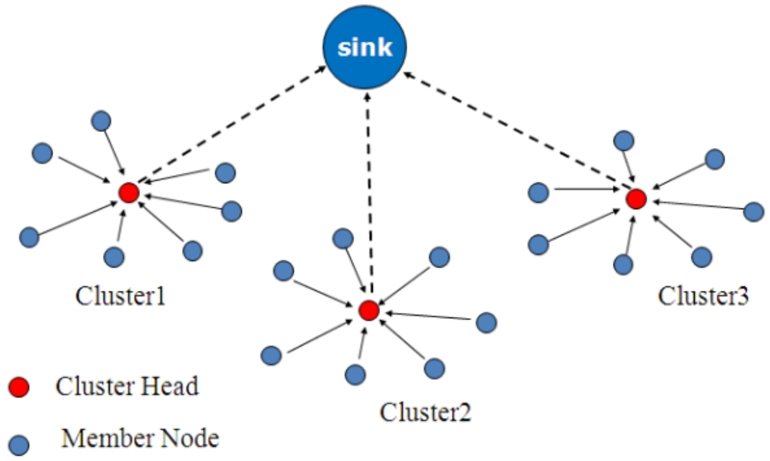


**Figure1.** Heterogeneous Models for WSN

Wireless sensor networks (WSNs) are a highly distributed network of small, lightweight wireless nodes deployed in huge numbers to monitor the environment or system. Building such sensors is now possible thanks to advancements in micro-electromechanical systems [3]. The expanding computational capacity of WSN technology necessitates that these sensor nodes be more prepared to handle more sophisticated functions. During the deployment of a base station in a sensor network, energy conservation, sensor node coverage, and reliability challenges are addressed. Base stations are typically believed to be static, although in some circumstances, they are assumed to be mobile in order to collect data from sensor nodes.
As a classic technique in clustered routing protocols, the LEACH [4] protocol is a Low-Energy Adaptive Clustering Hierarchy protocol. The cluster head node is chosen in a random loop to balance the energy consumption of nodes within the network, and it is clustered based on the signal intensity received by the node. The Stable Election Protocol (SEP), a heterogeneous aware protocol based on weighted election probabilities of each node to become cluster head based on their individual energy, was proposed in [5. This method ensures that cluster heads are chosen at random and dispersed based on the fraction of energy consumed by each node, ensuring that the nodes' energy is used uniformly.
The SEP [5] algorithm is a type of LEACH-based heterogeneous network clustering routing technique. The SEP algorithm takes an energy heterogeneous approach, increasing the likelihood of high-level nodes becoming cluster heads based on the beginning energy of distinct sets of different cluster election probabilities, so that high-level nodes and ordinary nodes die at the same time. However, the SEP algorithm still has an uneven cluster head distribution, a large number of nodes in the cluster, and no consideration for the node's leftover energy. Clustering is a promising strategy for extending the life of WSNs. Propose a new, more powerful approach based on the original protocol right now. Improved-SEP and other related techniques for improvement.

## II. LITERATURE REVIEW

A literature study analyses old data and generates a mix of new and old data. As a result, this part contains a brief explanation of numerous research papers as well as the presence of research paper summary and synthesis.
Many coordinating displays have been presented to achieve the imperativeness capability in remote sensor frameworks, according to L. Subramanian and R. H. Katz (2000)[6], and LEACH is the typical one. The goal of this project is to provide a flexible low-power guiding display that takes into account a couple of ideas from centre points in order to select perfect bundle heads. In order to extend the framework lifetime, genetic estimation is linked to improving controllable parameters of the suggested display. The application points of interest can depict the wellbeing limit. The efficacy of the proposed guided show is demonstrated by simulation data. According to three previous LEACH-based shows, the typical increase in the framework lifetime is 82 percent. The proposed coordinating show can successfully change the criticality of centre point utilisation while also extending the lifetime of the framework.
For energy efficiency, Tiwari et al., (2015) [7] used the distributed clustering technique (Modified DEEC). Cluster heads are chosen depending on the network's residual and average energy. To make a node a CH, a random integer is picked, and if it is less than the probability threshold, the node becomes a CH for the round. The nodes with the highest leftover energy have the best chance of becoming a CH. Because each node spends energy checking its candidacy for CH, the number of rivals for CH must be minimized to simplify the selection process. This is accomplished by only selecting nodes with an energy level greater than a predetermined threshold. As a result, intra-cluster communication suffers. The data is collected by the cluster head from member nodes that are within its range.

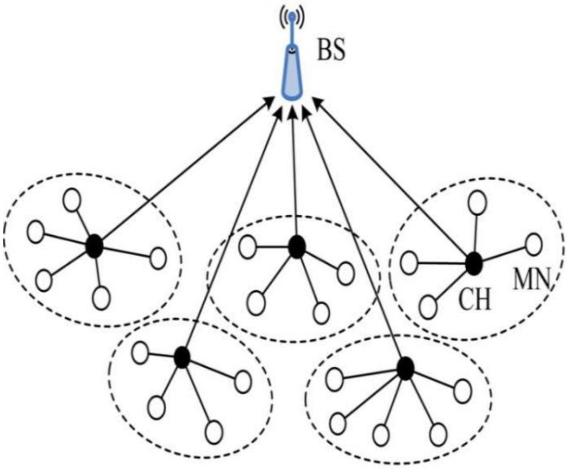


**Figure2.** Clustering in LEACH Protocol

Smaragdakis et al. [8] are known for a LEACH variant called the Stable Election Protocol (SEP). It is primarily intended for dual-level heterogeneous networks with doublet types of sensors (particularly Advance and normal nodes). Advance sensors, on average, retain more energy and must be turned CHs more frequently than conventional nodes. The CHs chosen here refer to the starting energy of the sensor. The biggest drawback is that the CH's choice is not dynamic. As a result, advanced nodes that are far away from the sink waste their energy more quickly and eventually cease to exist. For a multilayer heterogeneous network, SEP is ineffective.

SEP has been enhanced, according to Malluh et al. [9.] Advanced nodes are also chosen as CHs more frequently than regular sensors. The number of nodes connected to each CH is also taken into account. As a result, the sensor nodes can be distributed evenly throughout the CHs. EM-SEP also chooses the higher energy sensor as a CH if there are more than one sensor available to be a CH at a given round. These two elements lengthen the sensor network's stable time. The main disadvantage of this method is that it ignores the cost of inter-cluster communication.

A stability-based clustering procedure, which is an extension of SEP, has been described by Rehman et al. [10]. In WSN, heterogeneous sensors are spread at random. In the previous round, a node with a lower Energy Consumption Rate (ECR) is preferred as CH. The existence of a difference between a node's initial and residual energy is implied by ECR. The fundamental flaw is that advanced nodes are always punished when they are chosen as a CH.

Stable Election Protocol (SEP) is a heterogeneous-aware protocol proposed by Georgious et al. [11] to extend the stability period and average throughput. SEP is based on the residual energy-weighted election probabilities of nodes to become CH. Nodes are classified into two groups based on their energy levels: advanced nodes and regular nodes. The energy of advanced nodes is higher than that of typical nodes. Advanced nodes have a higher chance of becoming cluster heads than standard nodes.

The Stable Election Procedure (SEP), a heterogeneous aware protocol based on weighted election probabilities for each node to become cluster head depending on their individual energy, was presented in [11]. This method ensures that cluster heads are chosen at random and dispersed based on the fraction of energy consumed by each node, ensuring that the nodes' energy is used uniformly. The SEP analyzed two types of nodes (two tier in-clustering) and two level hierarchies. The LEACH [12] protocol, which maintains the Integrity of the Specifications like a standard clustering technique, performs badly in the heterogeneous WSN.

## III. Analysis of SEP Algorithm

The SEP [13] algorithm is proposed by G. Maragdakis as a classical heterogeneous network clustering routing algorithm. This agreement is developed on the basis of the LEACH protocol, adding the initial energy isomorphism of this element, using the second energy heterogeneous network. According to the heterogeneous characteristics of the network is divided into ordinary nodes and high-level nodes, and set a different cluster election probability, so that the cluster election probability of high-level nodes is bigger more than the ordinary node. So that the high-level nodes and ordinary nodes close to the same time to death, and extend the stability of the network cycle.

SEP routing protocol is a typical two level initial energy heterogeneous WSN cluster protocol which contains 2 different energy nodes including common nodes and advanced nodes. The core idea of the SEP protocol is that computing the cluster head election probabilities of nodes according to the different initial energy and takes a random round mode to change the cluster head nodes. So, all sensor nodes can share the network load and can reduce network power loss to prolong the lifetime network.

### *A. Cluster Establishment Stage*

It is assumed that the initial number of nodes is n, and the nodes are divided into common nodes and advanced nodes. Among nodes, the optimized cluster head ratio is $P_{otp}$. The initial energy of the common node is $E_0$. The energy of the advanced node is $1+\alpha$ times of common node that is $(1+\alpha)\ E_0$.

The total node proportion of the advanced node is m, so the total energy of the whole heterogeneous WSN is as follows [9]:

$$n(1-m)\, E_0 + nm\,(1+\alpha)\, E_0 = n(1+m\alpha)\, E_0 (1)$$

The energy demand of cluster head is bigger compared with others because cluster heads are responsible for coordinating activities between clusters and transmitting data to base stations. Therefore, the responsible cluster head is constantly rotated which makes the energy even consumed in the SEP protocol. Each node determines whether or not it can be a cluster head in the present wheel according to the respective computing probability. Each sensor node randomly selects a value between the [0 1], and compares it with the threshold $T(i)$. If the value is less than $T(i)$, the node can be elected as a cluster head; otherwise, it isn't be a cluster head.
The SEP algorithm is still a random selection cluster head mechanism using LEACH algorithm. The clustering process is to select whether to join the cluster according to the received cluster head node signal strength through the non-cluster head node. In this way, the cluster head is not evenly distributed, and its clustering method makes the number of nodes in the cluster random.
In the SEP algorithm, the election probability is only related to the initial energy of the node, but not with the residual energy; After the network is running for some time, the residual energy of the high-level node may not have the residual energy of the ordinary node, and the probability of becoming the cluster head is still higher than that of the ordinary node. This speeds up the death of some advanced nodes and reduces the overall survival time of the network. SEP algorithm is used in single-hop transmission mode, such a transmission so far away from the cluster head nodes need to spend a lot of energy to carry out long-distance information transmission, making the nodes in the network premature death, reducing the network life cycle.

### *B. Transmission Stage*

After the cluster is built, the members of the cluster communicate with the cluster head nodes in the allocated time slot to complete the transmission of the data collected in the corresponding area. The cluster head determines the allocation time slot by sending Time Division Multiple Address (TDMA) scheduling table, and the cluster nodes are in the dormancy state of the non-transmission slot which is one way of SEP protocol to save energy. After receiving the data, the cluster head converges and compresses with its own data and sends it to the sink node.

## IV. IMPROVED EFFICIENT-SEP PROTOCOL

Regarding the inadequacies of SEP referenced above,we present the nodes residual energy to partake in the edge computation to alter probability of turning out to be cluster headsof nodes within time. The interlude nodesin clusterare additionally presented, so cluster nodescan transmit the apparent data.

### *A. Energy Consumption Model*

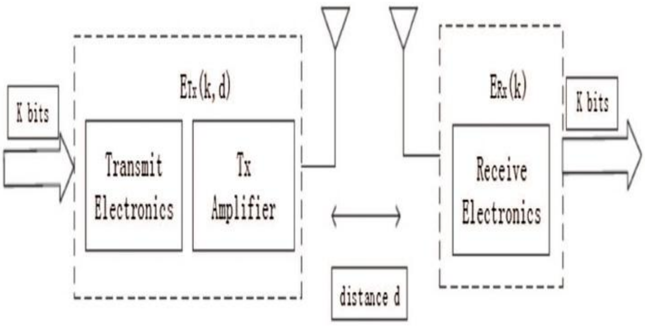


**Figure3:** Energy Consumption Model

In record, energy utilization of accepting or sending k bit data whendistance d is presented.
Supplicant time

$$E_T(k,d) = \begin{cases} E_{elec}\, k + E_{fs}\, kd^2 & d < d_0 \\ E_{elec}\, k + E_{mp}\, kd^4 & d > d_0 \end{cases} \quad (2)$$

Accepting time

$$E_R(k) = E_{R-elec}(k) = E_{elec}\, k \quad (3)$$

$E_{elec}$is energy dissipated of the transmission a unit of data; $E_{fs}$and $E_{mp}$is energy dissipated for gain magnifying; $d_0$ is threshold distance.

### *B. Cluster Head Election Method*

By just presuming the initialenergy can't settle unbalanced energy utilization wonder by SEP.So nodes residual energy join the estimation of cluster headelection perspective to build WSN life cycle. On a basic level, the node with very less residualenergy hassmaller chance to be clusterhead, in order to adjust the energy utilization among nodes and life cycle enhancement.
The node residual energy is $E_r$;and total residual energy is $Es$; andenergy referencefactor is $E_c$.

$$E_c = e^{-(E_r - \frac{E_S}{n})} \qquad (4)$$

Mentioning to original SEP cluster head election procedure, node residual energy is integrated as energy reference factor $E_c$. As in SEP, the initial energy for normal nodes is $Eo$, and for advanced nodes, $Eadv = 1+\alpha Eo$.
Assume for intermediate nodes, $E_{int} = 1+\mu Eo$.
We have: $\mu = \alpha/2$
Our probability setting $popt$ remains the same. However, the total initial energy of the system is increased by the introduction of both advanced and intermediate nodes:

$$n\cdot E_o(1-m-b) + n\cdot m\cdot E_o 1+\alpha + n\cdot b\cdot(1+\mu) = n\cdot E_o(1+m\cdot\alpha+b\cdot\mu) \qquad (5)$$

Where $n$ is the number of nodes, $m$ is the proportion of advanced nodes to the total number of nodes $n$ with energy more than the rest of the nodes and $b$ is the proportion of intermediate nodes. The overall energy of the network is increased by a fraction of $(1+m\cdot\alpha+b\cdot\mu)$ and the new epoch of the system must be equal to $Popt\cdot(1+m\cdot\alpha+b\cdot\mu)$.
$E_c$ is the energy reference factor taken from, equation no.4, if we choose $P_{nrm}$, $P_{int}$ and $P_{adv}$ for probabilities of becoming normal, intermediate and advanced nodes respectively. Hence we have:

$$P_{nrm} = P_{opt}/(1+m\cdot\alpha+b\cdot\mu)*E_c (6)$$
$$P_{int} = (P_{opt})\times(1+\mu)/(1+m\cdot\alpha+b\cdot\mu)*E_c (7)$$
$$P_{adv} = (P_{opt})\times(1+\alpha)/(1+m\cdot\alpha+b\cdot\mu)*E_c (8)$$

To guarantee that the sensor nodes must become cluster heads as we have assumed above, we must define a new threshold for the election processes, referring back to Eq. (5). The threshold $(n_{nrm})$,$(n_{int})$, $T(n_{adv})$ for normal, intermediate and advanced respectively becomes:

$$T(n_{nrm}) = \begin{cases} \frac{P_{nrm}}{1-P_{nrm}[r \text{ x } mod(1/P_{nrm})]} & if\ n_{nrm} \in G' \\ 0 & otherwise \end{cases} \qquad (9)$$

From above we have n × $1-m-b$ normal node, which ensures that our assumption (1) is exact.
Where $G'$ is the set of normal nodes that has not become cluster head in the past $1/P_{nrm}$ round $r$, the same analogy follows for the intermediate and advanced nodes,

$$T(n_{int}) = \begin{cases} \frac{P_{int}}{1-P_{int}[r \text{ x } mod(1/P_{int})]} & if\ n_{int} \in G'' \\ 0 & otherwise \end{cases} \qquad (10)$$

We have $n\times b$ intermediate nodes; with $G''$ as the set of intermediate nodes that has not become cluster head in the past $1/P_{int}$ round $r$.

$$T(n_{adv}) = \begin{cases} \frac{P_{adv}}{1-P_{adv}[r \text{ x } mod(1/P_{adv})]} & if\ n_{adv} \in G''' \\ 0 & otherwise \end{cases} \qquad (11)$$

We have $n\times m$ advanced nodes; with $G'''$ as the set of advanced nodes that has not become cluster head in the past $1/P_{adv}$ round $r$.
From Eq. (9), (10), and (11), the average total number of cluster heads per round will be:

$$n\cdot(1-m-b)\times P_{nrm} + n\cdot b\times P_{int} + n\cdot m\times P_{adv} = n\times P_{op} (12)$$

This gives us the same number of cluster heads compared with the original LEACH setting. However, because of the heterogeneity energy setting, energy dissipation is better controlled.

### C. *Intermediate Node Mechanism*

SEP protocol does not optimize the data transfer between the members of the cluster, and the member nodes in the cluster transfer the information to the cluster heads directly. So, it will spend higher energy transfer information and shorten the lifetime of the network greatly for the edge nodes that are far away from the cluster head. Therefore, in this case, joining the intermediate nodes will obviously improve the adverse effects of the edge nodes and balance the energy consumption of each node.

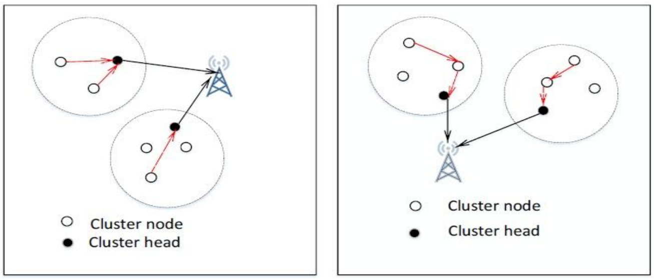


**Figure 4:** Direct compares indirect transmission

The principle of the intermediate node mechanism is that the nodes in the cluster use the intermediate nodes to transmit the information indirectly so as to reduce their energy consumption and prolong their life. After cluster structure is formed, the cluster node i computes the energy consumed $E_1$ that transmits information indirectly through other nodes in this cluster. We select the node with the smallest $E_1$ as the Intermediate node of node i. Compare $E_1$ with $E_i$ which the energy consumption of direct transmission. If $E_1 < E_i$, the node i transmits indirectly through the intermediate nodes; otherwise, the node transmits directly.Figure 4 is the comparison between direct transmission and indirect transmission in a cluster. Part (a) shows the direct transmission in a cluster and part (b) shows the indirect transmission in a cluster.

### *D. The Greedy Routing*

Greedy forwarding algorithm is a routing algorithm based on geographic information which is usually called the greedy routing algorithm. Each group has already contained its destination node location or target area position, and each node has already known the location of its own and its direct neighbor nodes. In the algorithm, nodes are always forwarding packets to adjacent nodes of the nearest target node.
We suppose node x receives packet P from node Z at a certain time.

$$w \in N: P_w = D \qquad (13)$$

$$w \in N, y \in N: Distance(y, D) \min[Dis\,\text{tance}(w, D), Dis\,\text{tance}(x, D)](14)$$

If the above two formulas do not meet (13), x will directly forward the packet to the node w of the destination D; if it satisfies (13) and it does not meet (14), it will go directly following perimeter forwarding mode.
Perimeter forwarding mode: here, the necessary conditions for using the perimeter forwarding model are the following two:

$$w \in N: P_w = D \qquad (15)$$

$$w \in N : Dis\,\text{tance}(w, D) > Dis\,\text{tance}(x, D) \quad (16)$$

If the above is satisfied in (15) and (16), the algorithm will forward the packet to the counterclockwise node Y (where, $y \in N$) according to the right hand rule until the packet reaches the node Z. If the condition satisfies $Distance(z,D) > Distance(x,D)$ which means the distance between Z and destination location D is less than the distance between the node x that enters the perimetermode and the destination location D, the algorithm will change mode to greedy mode on node Z.
In this work, greedy forwarding algorithm is used to help the cluster head look for an energy-efficient routing to reduce the energy consumption.

## V. RESULT AND ANALYSIS

This project mimics a clustered wireless sensor network on a 100m x 100m field. Normal and advanced nodes are spread randomly (uniformly) across the field. This means that each sensor's horizontal and vertical coordinates are chosen at random between 0 and the dimension's maximum value.
The performance parameters which are generally used to evaluate the WSN clustering protocols are as follows:

- Alive Nodes vs Number of Round.
- Alive Nodes vs Number of Round.
- Residual Energy of Nodes.

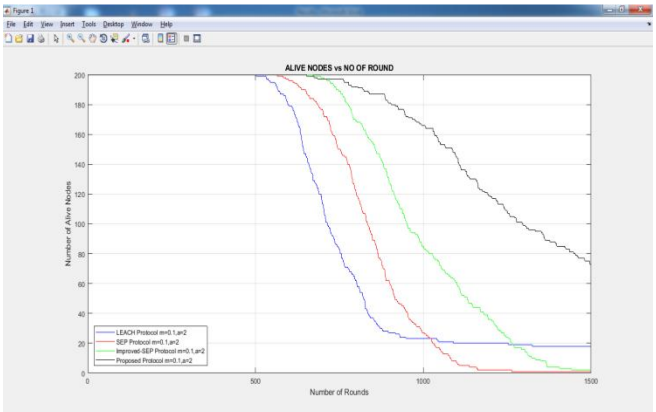


**Figure 5:** Alive node vs Rounds

Figure 5 shows a comparison plot of Alive nodes vs Rounds at m=0.1 and a=2, and it is clear that the lifetime of nodes is longer in the Proposed Algorithm than in LEACH, SEP, and Improved SEP, as it takes into account residual energy and divides nodes into normal, intermediate, and advanced nodes categories.

 

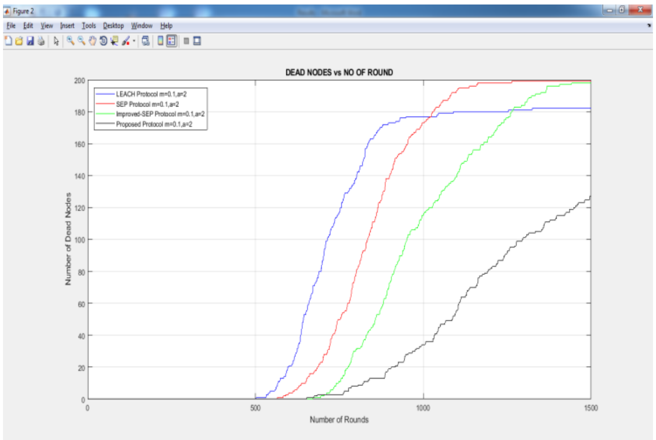


**Figure 6:** Dead node vs rounds

Figure 6 shows that in the Proposed Algorithm, only a small percentage of nodes are dead at rounds =1500, compared to LEACH, SEP, and Improved SEP. The fewer the dead nodes, the more resilient the algorithm. In comparison to existing algorithms, the suggested approach has a very high percentage of lifetime increase.

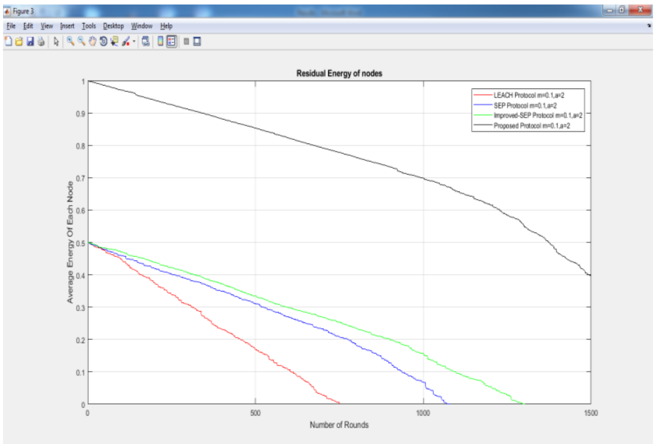


**Figure 7:** Residual energy vs nodes

In this section, residual energy is compared between the LEACH, SEP, and enhanced SEP protocols. Figure 7 depicts the outcome of the residual energy comparison. The basic goal of a WSN is for nodes to consume less energy. In comparison to LEACH, SEP, and Improved SEP, the proposed algorithm is built in such a way that it consumes less energy. The method is more balanced when the nodes are divided into three categories: normal, intermediate, and advanced, and then the residual energy factor is applied to each round.

The X-axis in the graph above represents the number of rounds in the network, while the Y-axis represents the average energy of each node.

## VI. CONCLUSION

SEP is dynamic in the sense that no prior distribution of the various levels of energy in the sensor nodes is assumed. Furthermore, our Efficient SEP analysis is not simply asymptotic, i.e. it applies equally well to small and large networks. Finally, SEP is scalable since it does not require precise knowledge of each node's position in the field.

With the new cluster head election method based on node residual energy, the indirect transmission mechanism based on intermediate nodes, and greedy routing, the SEP protocol can efficiently balance node energy consumption and improve the life cycle.

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