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# A Novel Improved Fuzzy Logic with Zonal Stable Election Protocol Algorithm for Heterogeneous WSN to Extend the Network Lifetime

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**Abstract:** To detect and keep track of the state of the physical environment, wireless sensor networks are networks made up of thousands of randomly distributed sensor nodes. The limited performance of batteries, which in most cases cannot be changed or recharged, is what makes wireless sensor networks viable. To lower the energy expenditures of sensor nodes and hence increase the lifetime of wireless sensor networks, researchers frequently create energy-efficient routing protocols. Numerous studies have shown that threshold-based (CH) group-head selection algorithms used in hierarchical routing systems can significantly increase network longevity. Mass height distribution and load distribution are significant issues. In this research, we present a new heterogeneous routing system called Enhanced Fuzzy and Zone Stable Election System (ZSEP), which allows for mixed direct and indirect communication between sensor nodes and base stations. Data sent to the base station is sent using a pooling technique.

Unknown in terms of size, this region is split into three sections based on the nodes' energies. In this paper, we propose an extended band stability selection protocol for heterogeneous WSNs, which is a heterogeneous sensitive routing protocol for sensor nodes communicating with base stations, as well as a hybrid scheme where a subset of nodes communicate directly with BSs, with the remainder depending on BS. This research suggests a mix of the ZSEP algorithm with fuzzy logic technology to address the aforementioned issues and increase network lifetime.

Because asymmetric clustering is a tactic researchers have suggested to address current problems, it is listed here. The suggested strategy creates unequal groups in the population. Fuzzy, which is based on ZSEP, contrasts with established routing protocols like ZSEP and LEACH. Using simulations from MATLAB 2021a, we contrasted the new protocol with the original program. According to simulation results, the proposed protocol can minimize the number of endpoints while increasing the number of live nodes, as well as the number of dead nodes, packets transmitted to the BS, and transmission rate.

**Keywords:** WSN,Fuzzy logic, Clustering, Efficiency,Energy lifetime

## INTRODUCTION

One of the economic corridors is the wireless sensor network (WSN).[1] The development of numerous fields worldwide depends on the use of wireless sensor networks, yet there are still issues with power supply [2]. Battery power used by sensor points is constrained. As a result, the network life is prolonged. This subject is still being researched. Base stations and sensor nodes make up the wireless sensor network.[3] The sensor nodes can gather data and send it to the base station. The base station may be placed in the center of the network domain or on either side, depending on the kind. SEP [4] is a clustering algorithm protocol that is proposed in two power levels (heterogeneous levels), where it is designed to select different probabilities to select the block head of the nodes while taking into account the power level, and the deployment architecture of the node sensor is described [5]. Because of its

  

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classification, SEP is inefficient in terms of energy usage. Based on their initial energy level, sensor nodes are classified into three areas. Faisal et al. [6] September saw an increase in energy efficiency. Block presidential elections are inefficient in Z-SEP because at least two presidents are elected during the rounds and run concurrently, resulting in high energy usage[7]. To prevent this, we developed a two-tier heterogeneous protocol with sensor zones of different node classes, one for advanced nodes and the other for basic nodes.[8]

## RELATED WORK

Many scholars are focusing on energy conservation in network protocols. SEP [9] is a two-level heterogeneous protocol in which sensor nodes are classified as ordinary or advanced, with advanced nodes having more capacity than conventional nodes[11]. The sensor nodes were divided into three separate areas by Z-SEP [12], with the first and second regions having the same node type, and the Z-SEP wireless protocol is not energy efficient because the cluster leader is elected simultaneously[13].

Az-SEP is a more advanced Z-SEP proposed in [14] that uses synchronous group chairman election as well. In AZ-SEP, the data is forwarded by the AZ-SEP block header to the neighboring block header, who then transfers it to the next block header, and so on. Until the data is received by the base station. Harshita Chaurasiya et al [15] constructed SEP by constructing an evolutionary SEP algorithm protocol and then utilizing a genetic algorithm to pick a group leader[16]. M.M. structures stable and randomly dispersed nodes. SEP can conserve energy in an inhomogeneous field. Islam et al. know all dimensions of the complicated coordination and sensor node dimensions. [17].

The primary function of WSN sensor nodes is to gather, process, aggregate, and broadcast data to the base station in order to detect the environment around them. Utilizing a live broadcast is the simplest method for a node to connect to a base station or aggregator[18]. The records must be transferred, nevertheless, through numerous postings. Rapid resource depletion and node mortality as a result of excessive power usage are the outcomes [19]. One method to cut down on power usage is to send data from one node to another before sending it all the way to the BS.

A more targeted form of selecting grouping is the Low Power Adaptive Clustering Hierarchy (LEACH) [20]. However, it is only intended for homogeneous WSNs and does not account for the requirement that all sensor nodes have varying beginning energies. The Stable Election Protocol (SEP) algorithm published in [21] is used to adapt the protocol to heterogeneous WSNs. It has two distinct levels. This means that the sensor nodes have two distinct forms of starting energy.

A Stable Zone Election Protocol (Z-SEP) technique was proposed to improve protocol performance in heterogeneous WSNs by splitting the wireless network area into three distinct parts [8]. Zone 0 is chosen at random by the normal nodes, and the first and second zones are chosen at random by the advanced nodes.

In terms of operation, advanced sensor nodes first send sensor data to the group head (CH), after which the received data is transmitted to the base station via the CH, and sensor data containing sensor information is transmitted directly to the base station (BS) via ordinary nodes. The referred Enhanced SEP (E-SEP) approach has also been given [9], which assumes three different forms of starting energy for sensor nodes. The Distributed Energy Efficient Aggregation (DEEC) methodology [10] exhibits multi-level heterogeneity as well.

## MOTIVATION AND ISSUES IN THE EXISTING SYSTEM

A wireless sensor routing method called Z-SEP makes use of nodes with various power outputs. In this protocol, sensor nodes are linked to the BS via a hybrid method that entails both CH communication and direct interaction with the BS. In Z-SEP, nodes are classified as either normal or progressed. Ordinary nodes lack advanced node power. The domain area, however, is restricted and separated into three regions: (1) Region 0 (2) Region 1 (3) Region 2. The usual nodes are placed in area 0 and surrounding the BS.

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District 1 contains half of the advanced nodes, whereas District 2 contains the other half. Ordinary nodes provide data directly to the BS, but CHs are built in advanced nodes, and data from the CH's member nodes is collected, aggregated, and sent to the BS.

- According to Z-SEP, CH is made up of advanced nodes that gather data from member nodes, combine it, and transfer it to BS. These nodes also use more energy and degrade more quickly, which causes the sensor network to be unstable. The lifespan of the sensor network is thereby decreased.
- Z-SEP is a heterogeneous routing protocol that preselects CHs at random. As a result, low-power, high-level nodes like CH are picked at random, which could cause the sensor network to become unstable.
- Regular nodes and CHs with pre-subscriptions are directly connected to the BS in Z-SEP. Distance and energy consumption are closely correlated, therefore a channel uses more energy to transfer data to the base station and degrades more quickly the farther it is from the base station.Sensor networks consequently lose their dependability.

**Major Contributions**

In this paper, we assume that the base station is not aware of the spatial dimension and has no energy limits. Nodes with lower energy consumption ought to be located nearer to the base station, whilst nodes with higher energy consumption ought to be situated farther away. An IF-ZSEP approach is suggested on this premise. In IF-ZSEP, the forward node's CH keeps delivering data to the neighboring CH until the data is successfully received by the BS after a number of hops. This increases the lifespan of the sensor network while reducing CH power use. We additionally choose advanced CH nodes based on the following three factors: First, threshold. (3) The separation from the base station; and (2) the remaining power nodes.

**System models**

A heterogeneous network model and a power consumption model were used to design the suggested routing protocol. Each model is briefly described in the sections that follow. The suggested protocol takes into account heterogeneous WSNs with general and sophisticated sensor nodes.

We presume that enhanced nodes perform significantly better than existing nodes. There are n(1 - m) normal nodes and n(1 - m) extended nodes as a result. The starting capacity of basic and advanced nodes is represented by Enrm and Eadv, respectively. As a result, the initial energies of basic nodes are Enrm = E0 and advanced nodes are Eadv = E0(1+). As a result, the approximate total performance of all nodes (generic, advanced, and overall) is as follows::

$$E_{normalenergy} = nE_0(1-m)$$

$$E_{advancedenergy} = nmE_0(1+\alpha)$$

$$E_{totalenergy} = nE_0(1+\alpha m)$$

Energy dissipation model:

We suppose that advanced nodes perform multiple times better than regular nodes. There are n advanced nodes and n(1 - m) normal nodes as a result. The starting power of basic and advanced nodes is referred to as Enrm and Eadv, respectively. Enrm = E0 for general nodes and Eadv = E0(1+) for advanced nodes as a result of this. As a result, the performance of all nodes, including advanced nodes and general nodes, may be roughly described as:

**Clustered based routing**

Sensor networks are typically organized into clusters or groups. Multiple nodes are connected to the chosen CH, who is chosen by a vote of the cluster nodes. The network is made up of groups, each of which has one CH and numerous member nodes. The member nodes explore the environment and communicate their findings to the CH, which must

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analyze them before sending them to the BS. The aggregation method extends the life of the network and balances the performance of each node. A common clustering strategy is depicted in the diagram, which contains groups, cluster chiefs, cluster members, and distant BS. Several collecting strategies based on different CH selection parameters have been devised to attain this purpose.

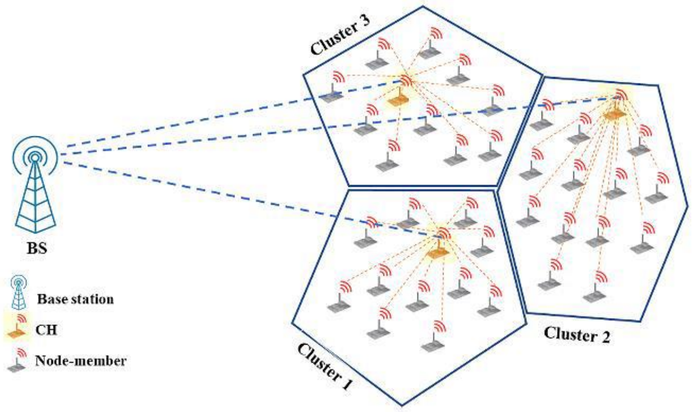


Figure1: Clustering technique in WSN

**Stable Election Protocol (SEP)**

The SEP (Stable Election Protocol) technique [12] makes use of the additional power factor () between advanced nodes and general nodes as well as the heterogeneous characteristic parameter m to maximize the stable region of the stratification process. To improve stable area, SEP balances electricity usage. The energy fairness limit predicts that advanced nodes will become cluster leaders more frequently than standard nodes.

**Enhanced Stable Election Protocol (E-SEP)**

SEP is a type of E-SEP (Enhanced Stable Election Protocol). In contrast to SEP, this protocol is usable by sensor nodes at many network levels, including general, intermediate, and advanced nodes.

E-SEP locates CHs based on the probability of each type of node, much like SEP. The likelihood that general, middle, and upper nodes will develop into CHs is influenced by the following variables.

$$P_{normal} = \frac{P_{opt}}{(1 + \alpha \times m + \lambda \times \mu)}$$

$$P_{intermediate} = \frac{P_{opt}\,(1 + \alpha)}{(1 + \mu)(1 + \alpha \times m + \lambda \times \mu)}$$

$$P_{advanced} = \frac{P_{opt}\,(1 + \alpha)}{(1 + \lambda)(1 + \alpha \times m + \lambda \times \mu)}$$

**Zonal Stable Election Protocol (Z-SEP)**

In the network, Z-SEP (Zone Stable Election Protocol) displays two levels of node heterogeneity. Z-SEP differs from other protocols in that basic nodes near the BS use direct forwarding technology while more sophisticated nodes want block headers. The network is split into Area 0, Area 1, and Area 2 when this strategy is used, as indicated in the picture. man in his bachelors. The information gathered at the zone 1 and zone 2 nodes is transmitted to the base station using aggregation technology.

  

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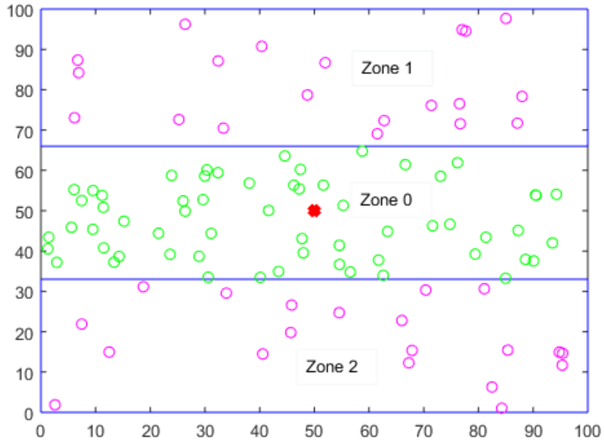


Figure2:The distribution of nodes in the network for the Z-SEP protocol

## THE PROPOSED MODEL

### Improved Fuzzy based Zonal Stable Election Protocol (IF-ZSEP)

In this section, we shall introduce the Enhanced Fuzzy Protocol with Zonal Stable Election Protocol (IF-ZSEP). First, we will outline the proposed protocol's node deployment approach, and then we will introduce the link connection, which is a combination of direct and CH connections. Finally, we shall depict the various steps of IF-ZSEP implementation.

### Node deployment strategy

In our protocol, we consider a fixed BS located in the network's center, and each node is aware of its location. Furthermore, the sensor nodes are distributed at random and remain in place once installed. Additionally, as depicted in the picture, the network region is split into two sections (areas 1 and 2). 1. Advanced nodes are found in area 2, while generic nodes, which are less potent than advanced nodes, are found in region 1. The power consumption increases with the distance between the node and the base station. region 1 therefore has general nodes near the BS, and region 2 has advanced nodes further from the BS. As a result, typical nodes use a direct link to relay data to the base station. Advanced nodes, on the other hand, choose CHs and create clusters using an aggregation technique. After importing the data, Charter aggregates it and sends the resulting data to BS.Clustering Zone 2 can increase the effectiveness of data transfer and prolong the life of advanced nodes.

### Fuzzy Model

Fuzzy logic is utilized to effectively aggregate and assess multiple characteristics in order to improve the metrics employed by various routing algorithms in wireless sensor networks. The suggested solution improves the fuzzy inference system (FIS) based ZSEP-E and lengthens network lifetime by converting defined inputs into outputs using fuzzy logic.

A fuzzy logic-based system's goal is to determine and choose the best fool depending on the input. For the proposed model, we employed the inference approach. Using heuristics and fuzzy logic design methodologies, we can characterize our system in a straightforward mathematical manner.

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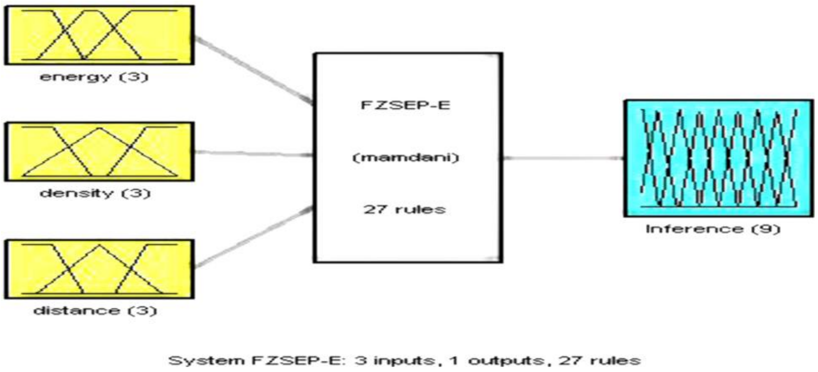


Figure3: Improved Fuzzy based ZSEP system architecture

The three entry points To change the system input to fuzzy groups, three parameters are used: node power level, node-BS distance, and node strength. Me, middle, and high performers are reflected in the membership qualities. Intensity has three functions: diffuse, medium, and dense, and distance has three functions: near, medium, and distant. The input variables are Power, Density, and Distance, which stand for the node's remaining power, number of surrounding nodes, and distance from the node to the site, respectively.

It can change the Member Work Score to Low, Medium, or High based on the initial performance level of the Normal, Medium, and Advanced nodes. The process of applying fuzzy logic to represent a particular output is known as fuzzy inference. Making decisions and spotting patterns depend on mapping.All elements defined in membership functions, logical operations, and If-Then rules are included in the fuzzy inference process. The proposed system's fuzzy IF-THEN reasoning mechanism's rules are displayed in the table. Calculations involving trigonometric and trapezoidal functions of variables are made easier by fuzzy rules.

Table1: Fuzzy inference system IF–THEN rules

| Energy level ($e$) | Density (ds) | Distance (dt) | Inference |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0.5 | 0.5 |
| 0 | 0 | 0 | 1 |
| 0 | 0.5 | 1 | 0.5 |
| 0 | 0.5 | 0.5 | 1 |
| 0 | 0.5 | 0 | 1.5 |
| 0 | 1 | 1 | 1 |
| 0 | 1 | 0.5 | 1.5 |
| 0 | 1 | 0 | 2 |
| 0.5 | 0 | 1 | 1 |
| 0.5 | 0 | 0.5 | 1.5 |
| 0.5 | 0 | 0 | 2 |
| 0.5 | 0.5 | 1 | 1.5 |
| 0.5 | 0.5 | 0.5 | 2 |
| 0.5 | 0.5 | 0 | 2.5 |
| 0.5 | 1 | 1 | 2 |
| 0.5 | 1 | 0.5 | 2.5 |
| 0.5 | 1 | 0 | 3 |
| 1 | 0 | 1 | 2 |
| 1 | 0 | 0.5 | 2.5 |
| 1 | 0 | 0 | 3 |
| 1 | 0.5 | 1 | 2.5 |
| 1 | 0.5 | 0.5 | 3 |
| 1 | 0.5 | 0 | 3.5 |
| 1 | 1 | 1 | 3 |
| 1 | 1 | 0.5 | 3.5 |
| 1 | 1 | 0 | 4 |

Fuzzy inference techniques involve membership functions, logical operations, and If-Then rules among other important elements. The proposed system's fuzzy HA-THEN inference mechanism's rules are displayed in the table. We employ the trigonometric and trapezoidal functions of the fuzzy basis variables to streamline calculations.

$$Inference = 2e + ds + 1 - dt$$

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We use the suggested technique to group a network of N sensor nodes. Asymmetric grouping is used in this situation. The competition radius is less for sensor nodes that are nearby the receiver than it is for nodes that are farther away. Rounds are used to separate protocol activities. A revolution is the period of time between the next two block formats. Setup and balancing are the two steps of each round.
Each node broadcasts a brief HELLO message providing the node ID and power during network setup. This message is broadcast on a regular basis to signal the existence of a node. During the preparation stage, a block is made and a block header is chosen.An organization leader for the virtual organization will be chosen at this point in the proposed process. The suggested method chooses CH in a non-probabilistic way. Three parameters—distance from the base station, remaining power, and density (number of neighbors)—are used in conjunction with fuzzy logic to accomplish this. These variables are used by the fuzzy inference engine to compute outcomes using fuzzy if-then rules. The conflict radius and grade are the output parameters. The competition radius shows a node's coverage, whereas rank represents the likelihood of a node being chosen as a CH. Temporary CH status is granted to the node that received the highest rating during the competition.
The membership functional domains are specifically created to include all nodes, even with repeated empirical tests for various network sizes.The fuzzy groups for the output variables rank and competition radius are shown in Figures 4-5, while the fuzzy groups for the input variables density, power, and distance to the base station are shown in Figures 1-3, respectively.

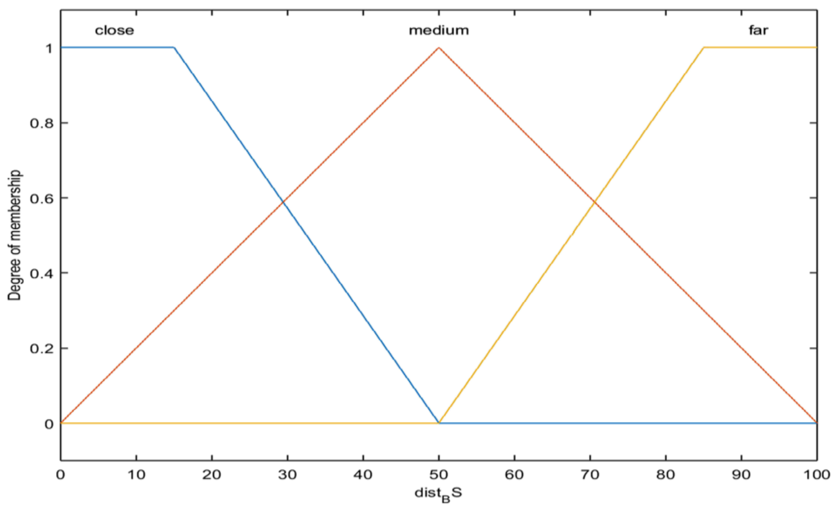

Figure4: Fuzzy set for input variable ‘density’

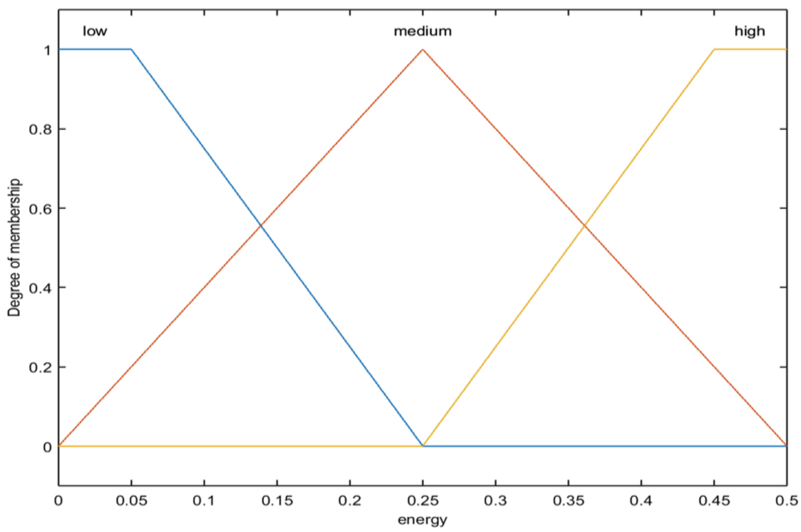

Figure 6: Fuzzy set for input variable ‘energy’

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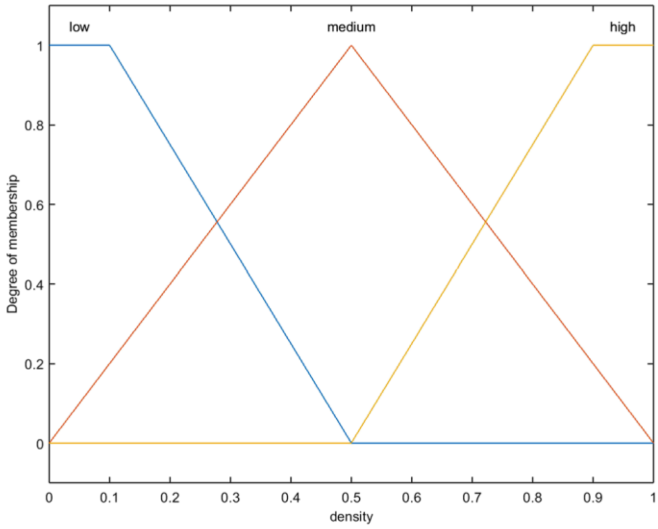


Figure 7: Fuzzy set for input variable ‘dist_BS’

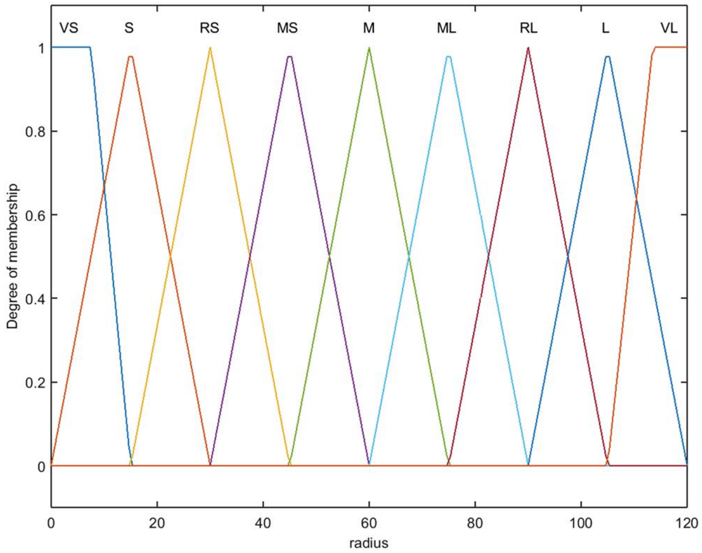


Figure 8: Fuzzy set for output variable'rank’

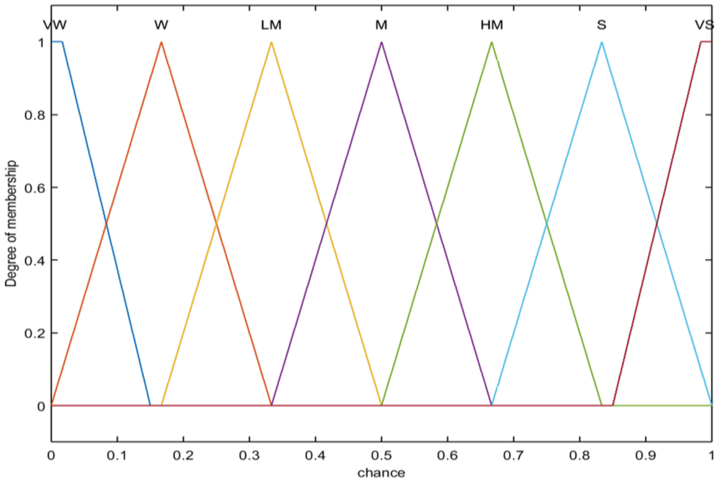


Figure 9:Fuzzy set for output variable ‘radius’

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By default, the fuzzy inference engine (FIS) combines linguistic values with explicit input values. Chaining functions are used by the engine. The grammar of Mamdani was created. Distorted input values are handled in this way. The 27 hypothetical rules that permit mixed language input and output values are listed in Table 3 as a whole.

Similarly, the outcome is an ambiguous language value. The output of linguistic variables is cleaned to clear values using the CoA (Centric by Area) approach. Any node that is not yet a cluster head will join the closest cluster head after a cluster head has been chosen.

**Network Architecture**

Because the nodes for some protocols are distributed randomly throughout the domain, they cannot efficiently use power. For the best node energy consumption, the sensor zone is divided into 3 zones (zone 0, zone 1, and zone 2). Assume that the field's nodes cannot be moved and that the size of the field is unknown. Some nodes are also more powerful than others.

Assume that all nodes, often referred to as forward nodes, contain (m). Normal is (1 - m) n nodes. Given that IF-ZSEP is a two-level heterogeneous routing system, nodes can be categorized as either ordinary or advanced. Advanced nodes have more energy than normal nodes. Area 0 contains regular nodes that are close to the base station, whereas regions 1 and 2 have advanced nodes that are farther from the base station.Advanced nodes are positioned farther away from the base station and regular nodes are put closer to the base station because the corners demand more energy to transfer data and are farther from the base station. Advanced nodes form clusters where one node serves as a base station, while ordinary nodes connect directly with the base station.

**CH Selection**

We present a fresh CH selection criterion for the suggested method. Three variables determine CH in advanced nodes.

Threshold value

Node's residual energy

Distance from BS

Each node initially selects a value at random between 0 and 1. The node will be chosen as the CH for the current period if the supplied number is below a predetermined cutoff. The strength of the nodes that remain after the first round is calculated. A node will be labeled CH in that round if it still has more power. The CH is determined by the BS distance if the nodes' remaining energy is equal. It is more likely CH the closer it is near BS. The sensor network has a longer steady time because this method results in fewer CH deaths. The multi-hop protocol is used by the CH to connect to the BS.The CH at the field's corner transmits data to an adjacent CH, and so on until it transmits data to the BS by way of an adjacent CH. When opposed to a direct connection, this method uses comparatively less electricity. boosting the sensor points' remaining energy as a result, extending the network's life. The choice of complicated CH nodes is another crucial consideration.

## IMPLEMENTATION OF IF-ZSEP

Each round in IF-ZSEP is repeated on a regular basis and comprises of a preparatory phase and a steady state. CHs send "block header advertisement" via the CSMA MAC protocol, and all CHs utilize the same amount of power to send this advertisement. During the configuration phase, non-CH node receivers stay turned on to receive announcement messages from the CHs. The nodes without CH then examine the signal intensity received from the announcement message and select the CH with the highest signal strength as the nearest CH.

Each non-CH node must tell the CH that it will become a member node of that cluster after selecting the nearest CH. Each member node communicates this information to the CH using the CSMA MAC protocol. After receiving messages from member nodes, CH builds a TDMA schedule and assigns time slots to member nodes. Finally, during

 

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the steady state phase, member nodes send data to CH within their given time period, avoiding data collisions. After all nodes have finished transmitting data, the CHs aggregate data, deduplicate data, and compress data to a suitable extent in order to maximize bandwidth utilization.

The IF-ZSEP routing protocol is a block-based heterogeneous routing mechanism that is an upgraded version of the Z-SEP routing system. IF-ZSEP's purpose is to reduce power consumption while enhancing network life. The IF-ZSEP protocol demonstrates well-controlled power consumption and protocol time in terms of dead nodes, average power consumption, and packet transmission rate to the BS during communication in order to accomplish this. The IF-ZSEP methodology is detailed in a flowchart, as seen in Figure 3.

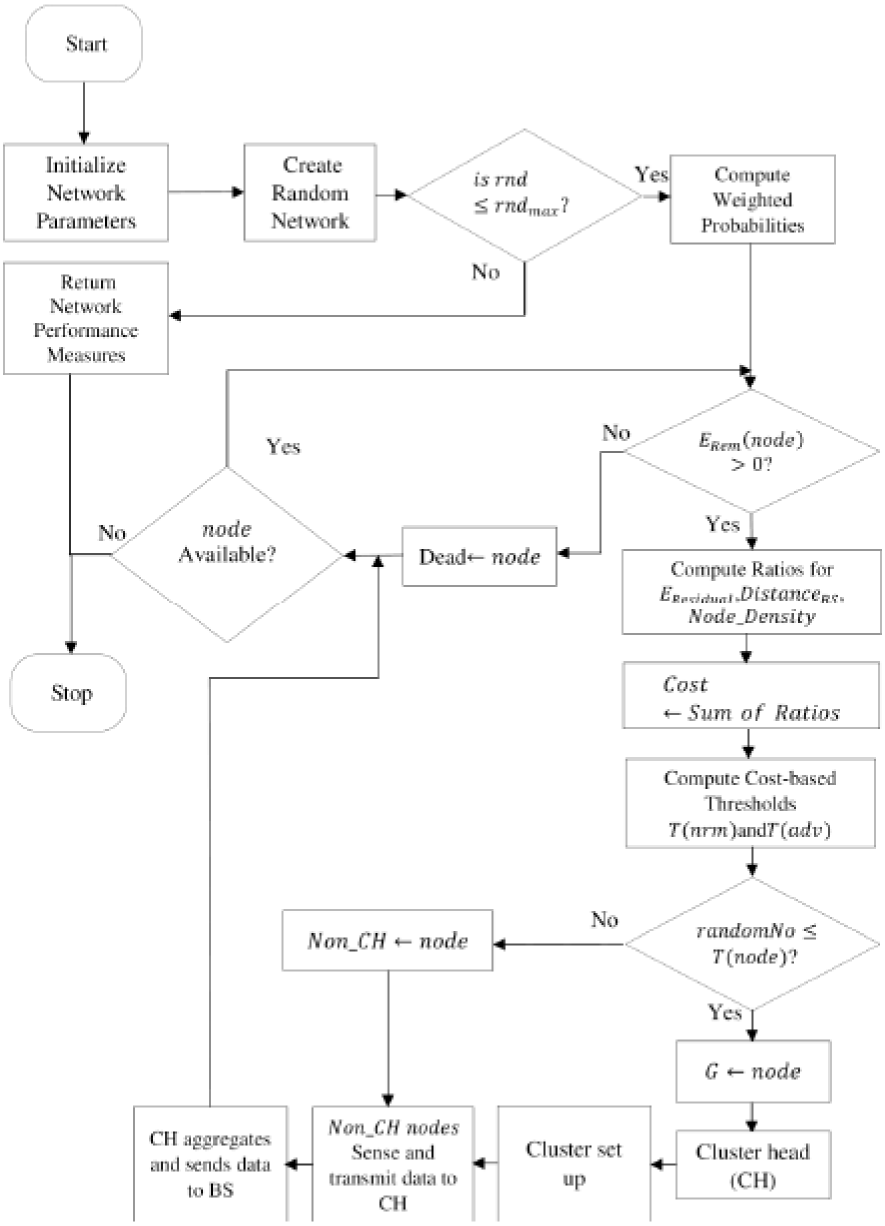


Figure10: Flow chart of the proposed IF-ZSEP protocol

## SIMULATION RESULT

In MATLAB 2021(a), we model a sizable wireless sensor network with a square area of 100 m by 100 m, and we divide the field into three rectangular sections in accordance with the Fuzzy Enhanced with ZSEP (IF-ZSEP) protocol.

  

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The total number of sensors (n) randomly distributed across all regions is 500. In regions 1 and 3, advanced nodes having the capability of multiple typical nodes are uniformly distributed. Intermediate nodes with higher performance than standard nodes are dispersed in the zone alongside standard nodes. 2.

The overall population (n) of sensors deployed at random across all regions is 500, with 20% being developed nodes, i.e. m = 0.2. Enhanced Fuzzy with ZSEP performance was compared to ZSEP with LEACH. To make a fair comparison with ZSEP and LEACH, we keep the same heterogeneous node configurations as m = 0.2, b = 0.3, a = 3, and a = 1.5 in ZSEP and TRASH, as well as the same energy levels across all areas.

The stable phase spans the time from the creation of the network until the demise of the first sensor node.the total number of rounds from the beginning of network operation till the final node died.HND: Half Node Death number of rounds until half of the sensor nodes in the network are destroyed.The total number of nodes that are not completely depleted after each round is called the active nodes per round.Letters to BS how many packets were transmitted to BS.

The graphic illustrates the many node properties that influence which node will be chosen as CH. The energy and density of the nodes chosen by CH increase together with the rise in node energy and density, as seen in the image. Sixth, the likelihood that any node will be chosen as CH decreases as distance from BS increases. Furthermore, the likelihood of a node being chosen as CH is minimal even in the presence of high density, close proximity of BSs, and low energy level, as illustrated in the picture. 6b, c.

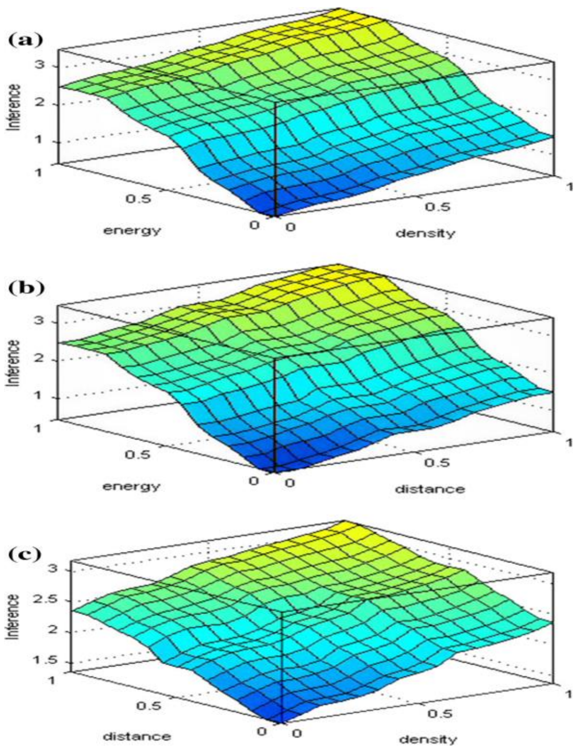


Figure 11: Surface view inference as a function of energy and density. b Surface view inference in relation to energy and distance. c Surface view inference in relation to distance and density

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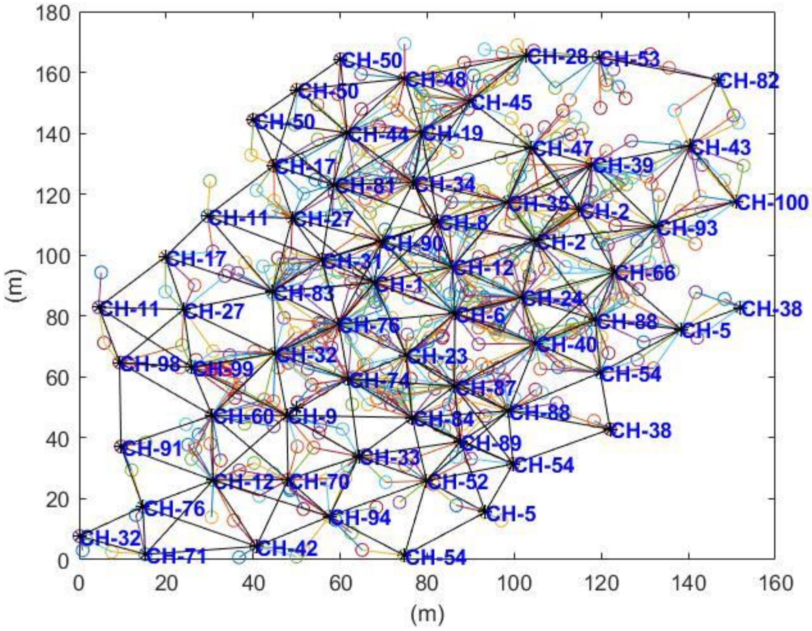


Figure 12: CH selection of the proposed IF-ZSEP

When employing cluster heads with different input characteristics than FSEP-E and ZSEP-E, the suggested ZSEP-improved removal (IF-ZSEP) has a longer stable period than FSEP-E and ZSEP-E.

ZSEP-improved Fuzzy experienced its first node death in round 2237, whilst Z-SEP and SEP experienced theirs in rounds 1148 and 1672, respectively. In comparison to Z-SEP and SEP, the purge-enhanced settling time with ZSEP increased by roughly 23% and 42%, respectively. The proposed IZ-SEP protocol outperforms Z-SEP and SEP in terms of network stability.

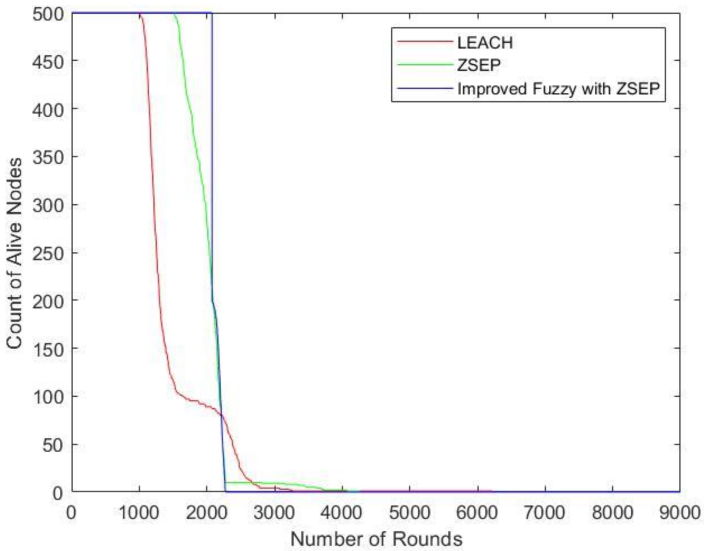


Figure13: The number of alive nodes per round

The curve in the figure demonstrates that the LEACH protocol performs the worst at the start of the network when compared to the other three protocols. The first node dies and the network becomes unstable at round 1008 of the LEACH protocol, while it happens in round 1520 of the SEP protocol. When the rounds approach 1520, the suggested

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enhanced Fuzzy protocol with ZSEP outperforms Z. procedure-Sept. by 15%. The original, but with a longer lifetime, is the first node that died in 2123, whereas the first node, Z-SEP, died in 1520. After the 4000th round, the proposed ZSEP performed better than Z-SEP in terms of stability period and repeatability.

The number of dead nodes in the Fuzzy algorithm optimized for ZSEP is lower while the network continues to operate than in the other three protocols. All nodes in the original protocols die after 8000 rounds, whereas the ZSEP-optimized Fuzzy protocol offers outstanding results after 9000 rounds, considerably boosting the overall network lifetime, as shown in Figure 4.

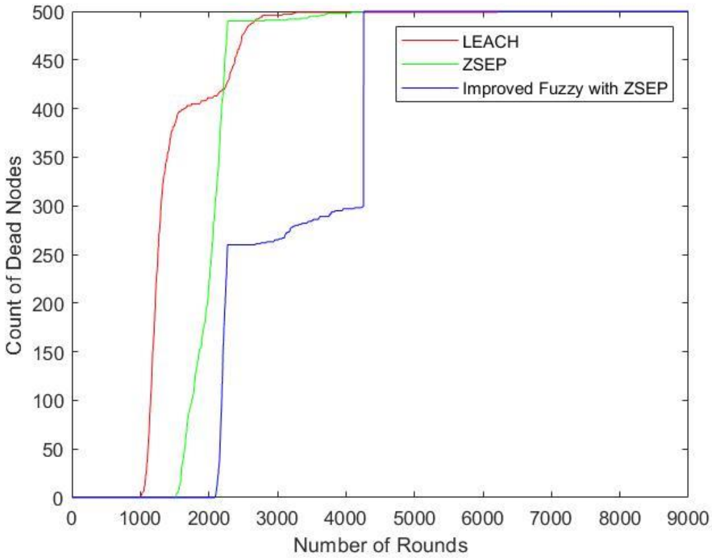


Figure14: The number of dead nodes per round

The Fuzzy algorithm has less dead nodes than the other three protocols when it comes to maximizing ZSEP network performance. The fuzzy protocol optimized for ZSEP gives outstanding results beyond 9000 rounds, greatly prolonging the network's lifetime compared to the original approach, which eliminates all nodes after 8000 rounds (see Figure 4).

The graph demonstrating an improved fuzzy algorithm utilizing ZSEP clearly demonstrates that the performance is significantly greater than previous protocols since it delivers more packets to the BS. The other three identical protocols, as shown in the picture, are unable to improve on the proposed new method.

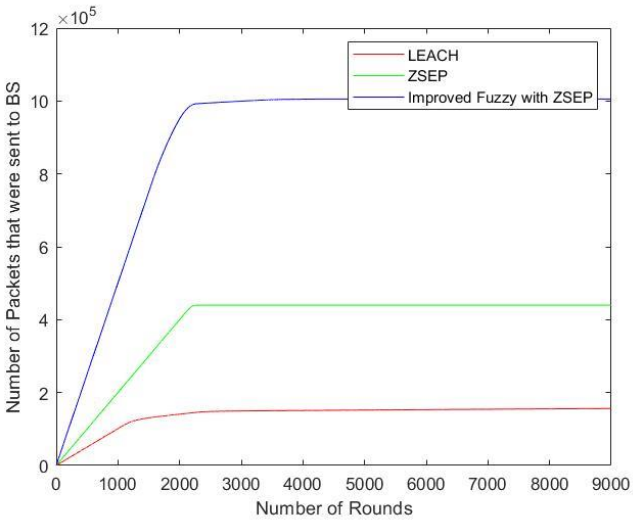


Figure15: The number of packets sent to BS per round

  

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The photos demonstrate the superior processing performance of the suggested fuzzing strategy, which chooses dense clusters with high-energy nodes as cluster heads. This indicates that ZSEP provides better data to the base station than ZSEP does. The graph unequivocally demonstrates that, in terms of packets transmitted to the base station, ZSEP is less effective than Fuzzy with ZSEP. The current ZSEP can send a maximum of 121013 packets to the BS, but the proposed ZSEP-improved Fuzzy can send a maximum of $7.6\times10^{13}$ packets to the BS.

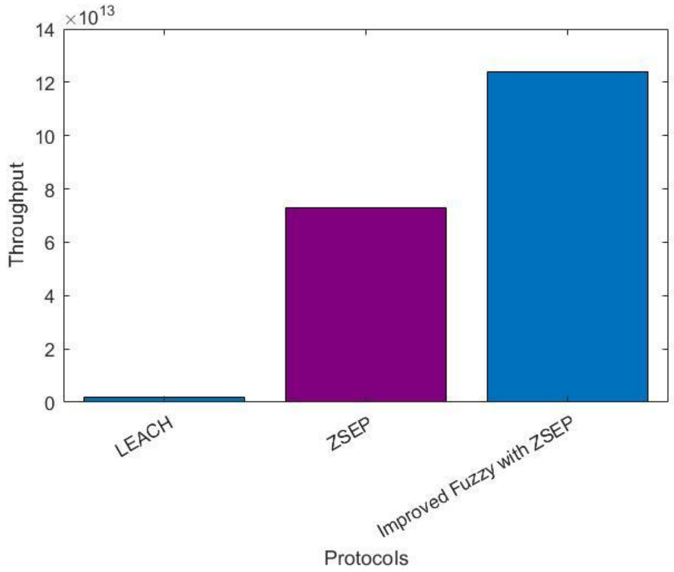


Figure16: Throughput of the proposed protocol

The suggested Improved Fuzzy with ZSEP has a minimum end-to-end delay of 0.025ns, whereas the traditional LEACH has a delay of 0.2ns.

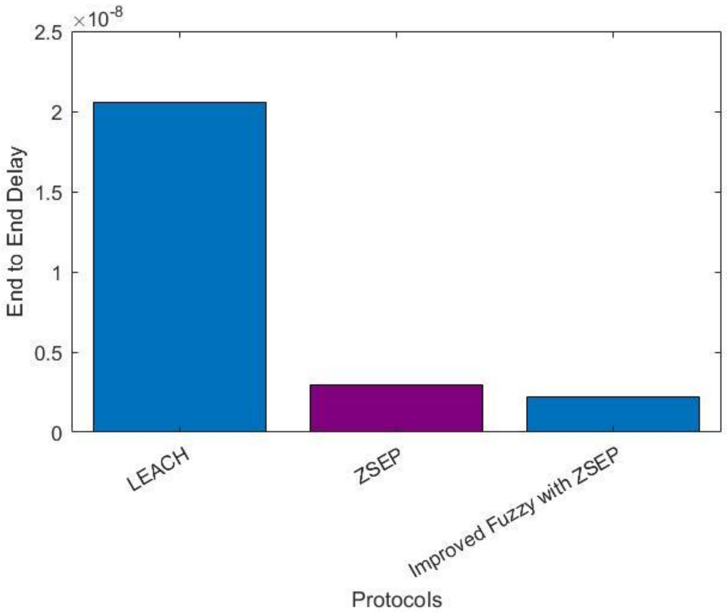


Figure17: End to end delay of the proposed protocol

The simulation findings demonstrate that the ZSEP-optimized fuzzy extends the network lifetime by around 8% relative to the ZSEP-optimized fuzzy by delaying the death of the initial node FND. We used MINITAB to conduct a statistical analysis of 10 distinct matching t-test trials in order to compare the mean differences in the FND measurements between the two approaches under the same simulation settings.

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## DISCUSSION

As we can see, SEP uses a lot of clusters, which explains why a lot of packets are transmitted to the cluster head in SEP. More group heads translate into fewer member nodes (no CH nodes), which results in more packets being sent to BS and less packets being sent to CH, especially when there are many groups present in the network. Fewer clusters and cluster heads result in more non-cluster master nodes, which increases the amount of packets delivered to methanol and decreases the amount that reach the base station. On the other hand, the fact that 65% of the nodes in region 0 pass the fetched data straight to the BS can account for the increase in base station transmission speed brought about by fuzzy optimization utilizing ZSEP. In actuality, the remaining 35% of nodes are split equally between two clusters (regions 1 and 2), each with 25% of the total.As a result, there are less CHs in both locations, which means that member nodes are sending the group on that CH fewer packets. This explains why ZSEP performance has slowed down. Additionally, the packets are not instantly transmitted to CH or BS if the network loses all of the sensor nodes.

## CONCLUSION

The key difficulty for WSN routing protocol development is to create energy-efficient protocols while also enhancing network longevity. In this paper, a hierarchical routing system for a WSN with two degrees of power heterogeneity is suggested, with the network domain separated into two zones based on node power. Ordinary nodes interact directly with a BS in ZSEP's proposed Enhanced Fuzzy Protocol (IF-ZSEP), whereas advanced nodes communicate with a BS via pooling techniques. IF-ZSEP is a hierarchical cluster-based heterogeneous steering system with several interests, including a new CH selection technique and a CH connection with BS. Since IZSEP is a two-level heterogeneous routing protocol, IF-ZSEP mixed mode is used for communication. In other words, while advanced nodes use pooling technology to send data to BSs, standard nodes link directly to BSs. Data can be transferred from CH to BS with minimum energy usage since the link between CH and BS is multi-hop rather than direct, increasing the protocol's active nodes.

Also, the choice of CH is determined by the node's remaining power and its distance from the BS. This raises the stakes.As the stability period lengthens, so does the rate of packet delivery to the base station, resulting in a significant number of events being identified and transmitted to the base station for further action. The algorithm provided in this article extends the network's life by taking into consideration essential criteria for the selection of temporary and ultimate group leaders. In order to achieve outstanding outcomes, it is paired with fuzzy logic. The aim function for balancing grid energy consumption takes the distance to the collector into consideration. Using asymmetric pooling, hot areas are also addressed. Additionally, the stability duration and packet delivery are enhanced by this tactic. According to measurements of network longevity, average remaining power, and packet delivery, the suggested ZSEP outperforms other established protocols like ZSEP and LEACH. We intend to add Quality of Service (QoS) metrics and efficient node deployment technologies into our routing protocol in the future.

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