

Energy efficient hybrid routing protocol for Wireless Sensor Networks Using AI Technique

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Abstract

Wireless sensor networks (WSNs) are frequently used in various critical sectors such as monitoring of nuclear power plants, habitat monitoring, precision agriculture, internet of things (IoT), industrial management, etc. Various challenges such as the limited resources in sensor nodes can bound their usefulness. In the critical application of WSN, energy conservation is a major problem in the routing process to extend network life. Clustering is one of the promising techniques for efficient utilization of energy in the network. Our proposed method is using a hybrid routing protocol for efficient utilization of energy in the network. In our hybrid clustering mechanism, Fuzzy Logics is used for the selection of cluster heads based on distance, noise, and residual energy as parameters of sensor nodes. The simulation results show that our proposed method has a 43.57% better stability period than the SEP protocol. The simulation results also show that the hybrid routing protocol has 15 % better network lifetime than SEP Protocol.

Keywords: Routing, Region-based, Fuzzy logic, Residual energy.

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1. Introduction

A group of tiny nodes known as sensors will perceive the environment and relay data to the base station in conventional WSN. The base station is capable of processing and aggregating all data and converting it into usable information. An individual, operator, or computer system may process the data from the base station and take appropriate action based on it. For example, a healthcare monitor may inspect the status of a patient by looking at the data gathered by sensors that are placed on the body of the human. We must increase the reliability and availability of information from the outside world; we must provide facilities to enable us to access this information from external networks. We can access information directly from base stations or sensors through the internet and various cloud repositories and fog servers [1]. As result, the information provided by sensors or base stations can be obtained and used by doctors or other applications located in various remote or geographical locations. Users

can monitor their application by sensor node and its resources remotely without physically accessing it. Many applications use this facility to detect greenhouse gases in the atmosphere, earthquake forecasting, and emergency relief by accessing data from various sensors via satellite. This is possible when all the sensors or base stations are connected through Internet [1].

Internet interconnected sensor networks (IISN) [12] have many ways for adversaries to hack the network. Because of its broadcast existence and versatility, it often draws a large number of risks to the network. As a result, IISN should be capable of providing protection, dignity, anonymity, and stability against a wide range of threats and assaults. Companies that provide surveillance services have a strong opportunity as communication between the Internet, sensors, and smart devices grow. The operational complexities of completely effective integration are important. A large amount of data must be handled to successfully handle query handling. However, the benefits of bringing the Internet into WSN are compelling enough to overcome these obstacles. The WSN was not initially completely incorporated with the

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internet. It can function as a capillary network that provides services through a standard interface, as well as an IP-based network that is directly connected to the host of the internet [12]. A routing protocol is required among communication nodes in WSN to determine a secure and shortest path between a start node and the last node for communication to be effective. Routing protocols can provide contact paths between other communicating nodes and the sink node. These routing ways are designed to maximize the lifespan of WSN. Several rules and protocols are configured to spread the load across all sensor nodes, lowering power consumption and energy-efficient routing in WSN [3 -5]. The routing protocols are classified into two parts first is flat routing protocols and the second is hierarchical routing protocols. Each sensor node in a flat routing protocol is at the same level and has a specific global address, while in hierarchical approaches such as LEACH [13][19], C-LEACH [13][19], and TBC[21], some kind of hierarchy is used. Routing is a major issue for which deterministic algorithms cannot be used. As a result, optimization algorithms can able to recover issues of routing protocol and choose the best path from a large number of possible paths [6].

When connecting the sensor nodes to the Internet, many problems occur during routing that must be resolved.

- IPv4 and IPv6 addresses are not used by sensors when connecting to the Internet. The IP addresses do not have direct access to the sensors. Sensors communicate with one another using location-based and data-centric protocols. These problems can occur in gateway and overlay solutions, but not in proxy-based solutions.
- There is a need to make the TCP/IP protocol and the sensor-based protocol compatible. Since both worlds are distinct and need network and application layer interoperability.
- Since sensor networks have limited resources, it is not feasible for data to be accessible at all times or for data streams to be obtained from sensors or historical values. To conserve capacity, wireless channels have a low bandwidth and data rate.
- Sensor networks are dangerous. Both nodes must be distributed near the source of the events, where they can effectively interpret the world and use radio and wireless networks for data transmission and reception. As a result, any malicious node will easily target it, hurting the network.

The main contribution of proposed protocol is based on the concept of soft computing aka fuzzy logic for balancing energy and choice of cluster head among super nodes.

The remain content of the paper is structured as follows: Section 2 gives a brief summary of background of WSN routing. Section 3 provides a detailed summary of existing approach; Section 3 gives the brief description of the proposed approach. In Section 5 summarizes the simulation and result analysis. Finally, the concluding remarks and suggestions for further research is given in Section 6.

2. Background

2.1. WSN Architecture

In general, nodes are distributed at random, and the architecture is devoid of infrastructure. To achieve protection and efficiency in WSNs, sensors must communicate with one another. There are two types of sensor network architectures: flat and hierarchical [1]. In Flat architecture, the sensor nodes are at the same level. All sensor nodes are distributed randomly and pass data with the help of each other. In hierarchical architecture, there are mainly two types of nodes. The first is called normal nodes and the second is called cluster head nodes. Hierarchical architecture has been made with the help of a cluster which is a group of nodes. The cluster has initially two levels of node cluster head (CH) and normal nodes. Both nodes in this architecture have the same function and duty to the network. Because of the vast number of nodes, it is not possible to delegate unique responsibilities to any one of them.

2.2. Routing Challenges

There are various routing challenges and issues in WSN which are listed as follows[2] [7].

- (i) In a WSN, resource utilization and power consumption are a significant obstacle. If the network does not choose the optimal route, then the network consumes high energy and resources.
- (ii) Another problem in a WSN is load balancing, which can arise due to an unequal distribution of sensor nodes. For uniform power consumption, sensing and transmitting loads should be spread uniformly among nodes in each cluster.
- (iii) Another issue arises as a result of the deployment of sensor nodes in a hostile environment. For energy-efficient networking and network service, a routing route must be discovered in a random deployment of nodes.
- (iv) Data collection is a crucial step in WSN since identical data from different nodes can be aggregated in certain ways, eliminating duplicate data. This method of data collection should be promoted because it results in fewer transmissions.
- (v) Latency is defined as the time it takes for data packets to travel from point A to point B. This is also an issue in WSN, many hop data combinations will reduce data transmission latency in certain situations.
- (vi) Scalability is another problem in WSN due to the enormous number of sensor nodes in WSN. As a result, the routing algorithm must be capable of dealing with scalable networks. Routing is an energy-intensive process, which poses a significant obstacle in WSNs.

Routing is the process of determining the best route among nodes that finishes at the base station. If the route from the source to the base station is not optimal, other nodes will not

follow it when more energy is absorbed. As a result, when constructing a routing protocol for a WSN, extra consideration should be taken. Any of the problems listed above are NP-hard, which means they cannot be solved using a deterministic solution. We need some type of optimization algorithm or high-level method to deal with this type of problem. The optimization strategy employs some objective method to determine the easiest and most optimum way [6] [7].

3. Related work

WSNs are one of the most recent developing phenomena. Sensors are incorporated in the majority of the products that humans use. As a result, it is extremely difficult for developers and researchers to create a sensor network that is both resilient and fault-tolerant. The most important element to consider when constructing a sensor network is energy efficiency routing. Various ways of data collection and transmission have been proposed. The most basic kind of data transmission is direct transmission, in which every node sends collected data to the sink node without regard for other nodes.

This strategy causes network instability since nodes that are far away from the sink node die quickly since it consumes more energy as the distance from the sink node increases. The following approach is multi-hop transmission, in which sensor nodes located distant from the sink node communicates data via intermediary nodes (relay nodes). As a result, nodes near the base station die since the majority of their energy is wasted when sending data to other nodes. Clustering is the third strategy. Clustering assists us in maintaining energy balance in the sensor network.

Clustering divides the whole region into clusters, and every cluster has a cluster head who is collected all data in charge of data transmission to the base station, while other nodes operate as cluster members. Cluster members perceive their surroundings and relay the information they gather to the cluster leader.

LEACH is the first protocol proposed for hierarchical clustering which is created specifically for sensor networks. In this protocol, each node has the same capacity and has an equal chance of being chosen as the cluster leader. The protocol operates in two stages. The first phase is cluster creation, and the second step is cluster head selection using a randomized technique. LEACH has the problem of not being suitable for heterogeneous networks.

SEP [18] is another protocol that was proposed for hierarchical sensor networks. The protocol takes into account two kinds of sensor nodes (normal and advanced nodes). Each node has an equal opportunity to be chosen as cluster heads [8].

Advanced nodes have a better chance of being chosen as the cluster head since they have more energy than conventional nodes and so die after a longer period. SEP is not supporting to efficient node deployment, and the cluster head is chosen by evaluating the residual energy of each node. TEEN[14] Protocol was proposed for time-critical

applications since it has hard and soft thresholds for minimal data transfer only when necessary, resulting in energy savings from less transmission [8]. TEEN has the same disadvantage as SEP. ESEP was an extension of SEP [18] for correctly distributing energy on the network and assuring the network's maximum lifespan. E-SEP consider three level of hierarchies i.e, normal, advanced, and super nodes.

The residual energy of nodes is used to determine cluster selection in SEP. As a result, the network's energy balance suffers. SEP-FL was offered as a way to prevent unstable regions in the SEP protocol. For cluster head selection, this protocol employs two parameters. The two parameters are residual energy and distance between base station and node. This technique also leads to poor placement of sensor nodes throughout the whole sensing region. All of the protocols mentioned above are deployed at random. Hybrid Routing is one approach for poor deployment. This protocol is hybrid in nature and it splits the entire field into fixed regions and using hybrid routing techniques to improve energy usage and operational stability. This protocol enables both efficient use and comprehensive coverage area. This procedure is based on two levels of heterogeneity [8] [9].

Various researchers and academics have focused on network energy consumption, security, and routing methods. Zengin et al. [16] proposed a survey on WSN routing protocols. In this proposed survey the author discusses several routing protocols for dealing with scalability, power, flexibility, computation complexity, and survival issues. This study summarizes the routing technique and concludes that the ant-based technique is recognized as an excellent technique that has been concerned more than any other method.

Guo et al. [17] investigated intelligence routing protocols in WSN intending to increase network lifespan. They explored smart algorithms like Reinforcement Learning (RL), Genetic Algorithm (GA), Fuzzy Logic (FL), and Neural Networks (NNs) to evaluate their network lifespan performances. Mukhtar et al. presented a protocol, region-based mobile routing protocol, which also focuses on node mobility in the WSN. Mobile routing nodes are added in the proposed protocol, which will travel around the network and be responsible for communication between CHs and BS but will not participate in the network's sensing functions. The protocol divides the network into two zones, one closer to the sink with no mobility and one farther away with mobile routing nodes. The goal of this research is to improve network stability by enhancing network lifetime and energy conservation.

Fuzzy logic is a mathematical concept that was developed to express approximate human reasoning [15]. To put it another way, fuzzy logic is utilized to simulate human decision-making behavior. In contrast to standard computing systems that examine just two values (0 and 1) to represent whether a value belongs or not, fuzzy logic considers intermediate belonging values in the range [0,1]. The basic idea is to convert crisp variables into verbal inputs first. This is referred to as fuzzification. In contrast, the system's output is a linguistic variable that will be turned into a crisp (digital) variable, a process known as defuzzification. Whenever fuzzy

logic is implemented into the routing process, whether to determine the optimal route, the best CH, or for resource allocation... and so on. It consistently exhibits considerable improvement in terms of the number of active nodes and, as a result, the network lifespan [15].

Some other way to improve routing in wireless sensor network is the use of optimization algorithms such as hybrid swarm intelligence algorithm [9], genetic algorithm [10], and some other hybrid algorithm [9]. The AI-based fuzzy approach, anonymity, AI and Fuzzy technology, some related work is summarized from these papers [22 - 25].

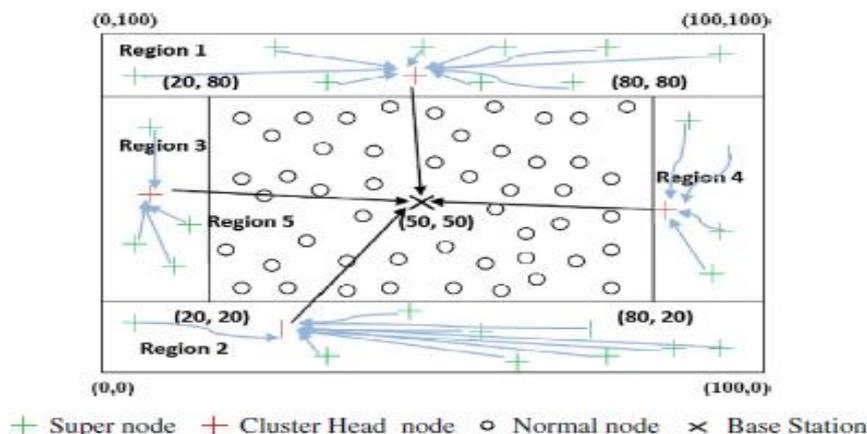


Figure 1. Deployment of Nodes in Sensing Area

Most sensor network protocols utilize just the residual energy parameters for CH selection.

4. Proposed approach

The proposed system consists of a heterogeneous sensor network that has two kinds of nodes (normal and super nodes). These sensor nodes are uniformly distributed in (N X N) unit2 network area for carrying out sensing and data transmission process. The proposed system assumes that the sink node is situated at the center of the deployment region.

For efficient coverage of the sensing field, it is divided into fixed five regions (R1, R2, R3, R4, and R5). It is assuming that the sink node and other nodes are static in nature.

The proposed system consists of the following sections: -

4.1. Region-Based static clustering and hybrid Routing in Sensor Networks

The network can be efficient when the network has an efficient routing protocol. Routing Protocol is said to be efficient when it consumes minimum energy for routing of information and provides maximum coverage area. This results in an increased lifetime of the whole network. Maximum coverage of the area is valuable in collecting information from all sensor nodes. If the network has not had maximum coverage, then there is the occurrence of some holes in the network. To address this issue, region-

based static clustering is utilized, in which the entire area is separated into fixed regions based on sensor node energy levels in X-Y coordinates, as shown in Fig. 1. Normal nodes are deployed in R-5 as these are close to the Base station and these nodes can directly transmit their sensed data to the base station. Super nodes are special types of nodes that have higher energy than normal nodes and are deployed in the region which are far away from the Base station. Super nodes are deployed in R-2, R-3, R-4, and R-1. The nodes in these region use hybrid clustering technique for data transmission. Super nodes are selected as cluster heads as normal nodes have less energy and they die out soon as compared to super nodes due to more distance between the base station and sensor nodes consume more energy. In each region R-1, R-2, R-3, R-4 we select only one cluster head per round. At each round, four cluster heads are selected. This approach results in inefficient energy utilization and increases the lifetime of the network.

4.2. Proposed Architecture of Node Deployment

In our proposed architecture the whole sensing area is separated into five regions. The sink node is located at the center of the sensing field.

Table 1. proposed architecture details

Region Number	Dimension	Type of Nodes (randomly deployed)
Region 1	$0 < X \leq 100$ and $80 < Y \leq 100$	Super nodes
Region 2	$0 < X \leq 100$ and $0 < Y \leq 20$	Super nodes
Region 3	$0 < X \leq 20$ and $20 < Y \leq 80$	Super nodes
Region 4	$80 < X \leq 100$ and $20 < Y \leq 80$	Super nodes
Region 5	$20 < X \leq 80$ and $20 < Y \leq 80$	Normal nodes

The normal nodes are deployed in an area close to the Base station while super nodes are located in a region that is far or a significant distance from the base station. It is depicted in Table 1. In our proposed system, if the normal nodes are selected as cluster heads then they result soon in dead nodes as it will consume more energy in the data aggregation process than the data transmission process. The proposed system has also done clustering in super nodes deployment for better network lifetime of the network.

4.3. Selection of Cluster head using Fuzzy logic based on Distance, Residual Energy, and Noise Factor: -

The proposed protocol is based on the concept of soft computing aka fuzzy logic for balancing energy and choice of cluster head among super nodes. While designing most routing protocols, residual energy is the only parameter that has been focused on, but in our proposed system three-parameter has been considered. Residual energy, noise factor, and distance are the parameters that have been considered while a selection of cluster heads at each node. Three input parameters are well-defined in the fuzzy system as given below:

$$X = \{(D, \mu(D))\}, D \in \text{Dist}$$

$$Y = \{(RE, \mu(RE))\}, RE \in \text{Res. En.}$$

$$Z = \{(N, \mu(N))\}, N \in \text{No}$$

where Dist represents as distance, Res. En represents residual energy, No represents noise.

D, RE, and N are the elements of Dis, Res. En. and No respectively. $\mu(D)$, $\mu(RE)$, and $\mu(N)$ are the membership function for distance, residual energy, and noise input variable. The membership function for a distance of the node from a base station is given below and it is graphically represented in Table 2.

Table 2. Membership function

Input	Membership
-------	------------

Distance from Base Station	close	Considerable	Far
Residual Energy	Low	Adequate	High
Noise Factor	less	Significant	High

Superiority order for input function while selecting of cluster head is:

Distance from Base Station > Residual Energy > Noise
 Precedence order for ranking of output membership is:
 $R1 > R2 > R3 > R4 > R5 > R6 > R7 > R8 > R9 > R10 > R11 > R12 > R13 > R14 > R15 > R16 > R17 > R18 > R19 > R20 > R21 > R22 > R23 > R24 > R25 > R26 > R27$. It is also depicted in Table 3.

Table 3. Output membership function

Output	Membership Function
Cluster Head selection probability	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R24, R25, R26, R27

Table 4. The proposed rule sets

Noise	Distance	Residual Energy	Output membership
Less	Close	Low	R11
Less	Close	Adequate	R3
Less	Close	High	R1
Less	Considerable	Low	R15
Less	Considerable	Adequate	R6
Less	Considerable	High	R5
Less	Far	Low	R19
Less	Far	Adequate	R18
Less	Far	High	R12
Significant	Close	Low	R13
Significant	Close	Adequate	R7
Significant	Close	High	R2
Significant	Considerable	Low	R14
Significant	Considerable	Adequate	R8
Significant	Considerable	High	R4
Significant	Far	Low	R20
Significant	Far	Adequate	R17
Significant	Far	High	R16
High	Close	Low	R23
High	Close	Adequate	R10
High	Close	High	R9
High	Considerable	Low	R24
High	Considerable	Adequate	R22
High	Considerable	High	R21
High	Far	Low	R27

High	Far	Adequate	R26
High	Far	High	R25

The proposed model for data transmission:

The proposed rule set is represented in Table 4.

Data Transmission (node, base station)

1. If ((node==normal nodes) &&Residual Energy (node) >Th)
2. node sensed the environment and directly transmit the data to the base station.
3. else(node==super node)
4. Formation of the cluster among super nodes.
5. Selection of cluster head among super nodes using Fuzzy Logic Rule.
6. Sensing of the environment by cluster member.
7. Transmission of sensed data by cluster member to respective cluster head
8. Data Aggregation at Cluster Head.
9. Data Transmission from Cluster Head to base Station.

The proposed system uses following equation for calculating the membership function

$$\mu(N) = \begin{cases} 1 & \text{if } N < .4 \\ (.8-N)/4 & \text{if } .4 \leq N \leq .8 \\ 0 & \text{if } N > .8 \end{cases}$$

$$\mu(D) = \begin{cases} 1 & \text{if } D \leq 40 \\ (80-D)/40 & \text{if } 40 < D \leq 80 \\ 0 & \text{if } D > 80 \end{cases}$$

$$\mu(R.E) = \begin{cases} 0 & \text{if } R.E \leq 0.15 \\ (R.E-0.15)/0.35 & \text{if } 0.15 < R.E < 0.5 \\ 1 & \text{if } R.E \geq 0.5 \end{cases}$$

Now suppose the set of super nodes distance from base station are as:

$$\text{Distance (D)} = \{25, 45, 60, 85, 95\}$$

The leftover energy of each node called Residual Energy at Each node are as:

$$R.E = \{0.1, 0.2, 0.35, 0.5, 0.8\} \text{ and}$$

Noise factor at each node as:

$$N = \{0.1, 0.3, 0.5, 0.7, 0.9\}$$

For Distance from base Station set {25, 45, 60, 85, 95}, the degree of membership is as {1, 0.8, 0.5, 0, 0}. So, the

membership function for distance is determined using a fuzzy decision mechanism are as follows:

$$\{25| \text{close}, 45| \text{considerable}, 60| \text{considerable}, 81 | \text{far}, 95| \text{far}\}.$$

For Noise set {0.1, 0.3, 0.5, 0.7, 0.9}, the degree of membership is as {1, 1, .75, .25, 0}. So, the membership function for noise is determined using a fuzzy decision mechanism are as follows:

$$\{0.1| \text{less}, 0.3| \text{significant}, 0.5| \text{significant}, 0.7| \text{significant}, 0.9| \text{high}\}.$$

For Residual Energy set {0.1, 0.2, 0.35, 0.5, 0.8}, the degree of membership are as {0, 0.2, 0.5, 1, 1}. So, the membership function for residual energy is determined using a fuzzy decision mechanism are as follows:

$$\{0.1| \text{low}, 0.3| \text{adequate}, 0.5| \text{adequate}, 0.7| \text{high}, 0.9| \text{high}\}$$

The suggested system employs a fuzzy operation for cluster head selection, employing an AND operation between Distance, Noise, and Residual Energy.

$$\mu(D) \wedge \mu(N) \wedge \mu(R.E) = \min(\mu(D), \mu(N), \mu(R.E))$$

Table 5. Fuzzy relation

Distance/ Noise	25	45	60	85	95
0.1	1^1	0.8^1	0.5^1	0^1	0^1
0.3	1^1	0.8^1	0.5^1	0^1	0^1
0.5	1^0.75	0.8^0.75	0.5^0.75	0^0.75	0^0.75
0.7	1^0.25	0.8^0.25	0.5^0.25	0^0.25	0^0.25
0.9	1^0	0.8^0	0.5^0	0^0	0^0

Table 5. considering Distance and Noise the operative value for considering the system with R.E is having value =1.

Table 6. Fuzzy relation after ^ operation

Distance/Noise	25	45	60	85	95
0.1	1	0.8	0.5	0	0
0.3	1	0.8	0.5	0	0
0.5	.75	0.75	0.5	0	0
0.7	.25	0.25	.25	0	0
0.9	0	0	0	0	0

So, the operative value for distance/Noise is presents in Table 7.

Table 7. Fuzzy relative value

Distance/Noise	25	45	60	85	95

0.1	1	0.8	0.5	0	0
0.3	1	0.8	0.5	0	0

For a particular design as the initial value, we consider Distance and Noise as a set of 1.

Table 8. Output table

Distance/Noise	25
0.1	1
0.3	1

For the Final selection of cluster head, we take AND operation between R.E AND (Distance /Noise) which depicted in Table 9 and Table 10.

Table 9. Fuzzy relation R.E AND (Distance /Noise).

R.E/(Distance/Noise)	0.1	0.2	0.35	0.5	0.8
25/0.1	0 [^] 1	0.2 [^] 1	.5 [^] 1	1 [^] 1	1 [^] 1
25/0.3	0 [^] 1	0.2 [^] 1	.5 [^] 1	1 [^] 1	1 [^] 1

Table 10. Output table

R.E/(Distance/Noise)	0.5	0.8
25/0.1	1	1
25/0.3	1	1

The output of the system is considered when supported by higher membership is as follows in Table 11.

Table 11. Output table with the degree of membership

S.No	Distance	Degree	Noise	Degree	Energy	Degree
1	25	Close	0.1	Less	0.5	High
2	25	Close	0.3	Less	0.8	High
3	25	Close	0.1	Less	0.8	High
4	25	Close	0.3	Less	0.5	High

So Four Rule Set has been fired having different membership values.

The selection of clusters is done based on having the strongest output membership. In our Rule system, the strongest output membership when Noise=0.1, Distance=25, and Residual Energy =0.8.

5. Simulation and Result

The simulation is conducted out in the MATLAB framework on a heterogeneous sensor network with an area of 100X100 m². The network has 200 nodes in total, with

nodes deployed in regions based on their energy level. Region 5 has only one super node, although the remainder of the region has several super nodes. We consider super node deployment to be 60% of total node deployment, with the remaining nodes deployed as standard nodes. The simulation parameters are listed in the Table 12. The node deployment is represented in Figure 2.

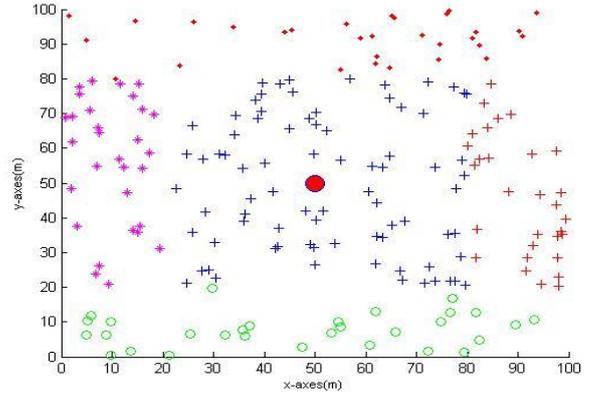


Figure 2. Proposed protocol of node deployment

Table 12. Parameter table for simulation

Parameters	Value
Initial Energy	0.5 J
Energy Factor (α)	1
Energy Consumed in transmission E_{elec}	50 nJ/bit
Energy Consumed by the amplifier to transmit at shorter distance E_{fs}	10pJ/bit/m ²
Energy Consumed by the amplifier to transmit at larger distance E_{amp}	0.0013pJ/bit/m ⁴
Energy Consumed in Data Aggregation	5nJ/bit /report
Packet Size	500 byte

Table 13. Node details

Node Types	Total number of nodes
Super node in Region 1	30
Super node in Region 2	30
Super node in Region 3	30
Super node in Region 4	30
Normal node in Region 5	80

The section contains the comparison of our proposed protocol under distance, residual energy, and load parameter with SEP Protocol in the same heterogeneous condition.

The proposed protocol is compared with SEP [19] protocol and is summarized in the following table

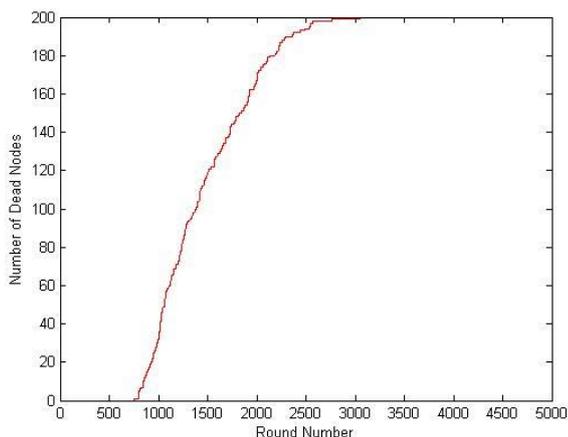


Figure 3. Number of Dead Nodes Vs Number of Round in SEP [19] Protocol

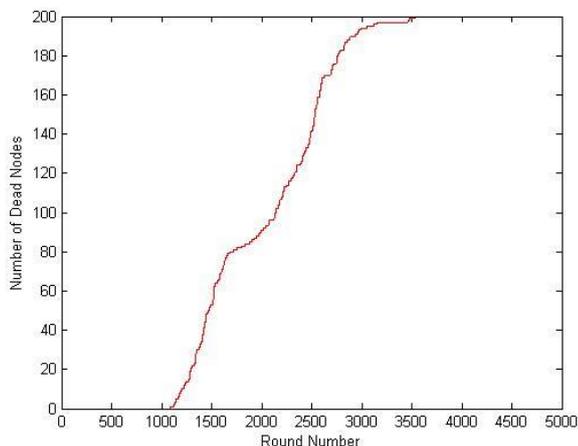


Figure 4. Number of Dead Nodes Vs Number of Round in Proposed Protocol

Table 14. Performance metrics

Performance Metrics	SEP	Proposed method
Stability Period (Number of rounds after first node dead)	755	1084
Network lifetime (Number of rounds after all nodes are dead)	3053	3532
Normal node lifetime	1717	1759
Super node Lifetime	3053	3532
Throughput (Total number of the packet transmitted to Base Station)	61506	79394

5.1 Result analysis

The energy-constrained sensor nodes consume more energy during transmission of data packets rather than node process or generating data packets. This work analyses deployment of various types of nodes in different locations is based on node energy because of the weighted probability for both normal and super nodes in the field. In the desired approach data is sent through different level hierarchy architecture by optimum and efficient CH selection process in the zone that maximizes the number of rounds and improves network life.

- Sensors are efficiently communicating with each other by our proposed protocol.
- It utilises less resources as memory, energy and processing capacity.
- As our proposed method is efficient then it effectively implements security protocol.

6. Conclusion

In this paper, we proposed a region-based hybrid routing approach that reduces energy consumption in each cycle while increasing network lifetime and throughput. When the proposed method is compared to SEP[19], network lifespan is increased because super nodes die slower than regular nodes. The deployment of various types of nodes in different locations is based on node energy because of the weighted probability for both normal and super nodes in the field. The simulation results show that the proposed protocol has a 43.57% better stability period than the SEP protocol. The simulation also shows that the region-based hybrid routing protocol has a 15 % better network lifetime than SEP[19].

Future study considerations include dividing the network field into more than two sections and incorporating more routing nodes to reduce transmission distance, which will save energy. Experiments may also be carried out in the same model by modifying the movement path or directions of the routing nodes. This research may be expanded by adding more routing nodes to the system.

References

- [1] C. M. Cordeiro and D. P. Agrawal, “Ad-hoc and sensor networks theory and application.” World Scientific publication, 2006.
- [2] N. A. Pantazis, S. A. Nikolidakis and D. D. Vergados, “Energy-efficient routing protocols in wireless sensor networks: A survey.” IEEE communications surveys & tutorials, vol. 15, no. 2, pp. 551-591, 2012.
- [3] C. Nakas, D. Kandris and G. Visvardis, “Energy efficient routing in wireless sensor networks: a comprehensive survey.” Algorithms, vol. 13, no. 3, pp. 72, 2020 .
- [4] P. Nayak, G. K. Swetha, S. Gupta and K. Madhavi, “Routing in wireless sensor networks using machine learning

- techniques: Challenges and opportunities,” *Measurement*, pp. 108974, 2021.
- [5] W. S. Kiran, S. Smys and V. Bindhu, “Enhancement of network lifetime using fuzzy clustering and multidirectional routing for wireless sensor networks,” *Soft Computing*. Vol. 24, no. 15, pp.11805-18, 2020.
- [6] A. Barzin, A. Sadegheih, H. K. Zare and M. Honarvar, “A hybrid swarm intelligence algorithm for clustering-based routing in wireless sensor networks,” *Journal of Circuits, Systems and Computers*, vol. 29, no. 10, pp. 2050-63, 2020.
- [7] H. Mostafaei, “Energy-efficient algorithm for reliable routing of wireless sensor networks,” *IEEE Transactions on Industrial Electronics*. Vol. 13, no. 66, pp. 5567-75, 2018.
- [8] F. A. Aderohunmu and J. D. Deng, “An enhanced stable election protocol (SEP) for clustered heterogeneous WSN,” Department of Information Science, University of Otago, New Zealand, 2009.
- [9] M. Sajwan, D. Gosain and A. K. Sharma, “Hybrid energy-efficient multi-path routing for wireless sensor networks,” *Computers & Electrical Engineering*. Vol. 1, no. 67, pp. 96-113, 2018.
- [10] T. Wang, G. Zhang, X. Yang and A. Vajdi, “Genetic algorithm for energy-efficient clustering and routing in wireless sensor networks,” *Journal of Systems and Software*, vol. 1, no. 146, pp. 196-214, 2018.
- [11] I. Ghosh, “Study on hierarchical cluster-based energy-efficient routing in wireless sensor networks,” *International Research Journal of Engineering and Technology (IRJET)*, vol. 5, pp. 688-691, 2018
- [12] J. H. Park, S. Gritzalis, C. H. Su, R. Roman and J. Lopez, “Integrating wireless sensor networks and the internet: a security analysis,” *Internet Research*, vol. 3, 2009.
- [13] S. K. Singh, P. Kumar and J. P. Singh, “A survey on successors of LEACH protocol,” *IEEE Access*, vol. 14, no. 5, pp. 4298-4328, 2017.
- [14] A. Manjeshwar and D. P. Agarwal, “TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks,” *INIPDPS*, vol. 1, no. 2001, pp. 189, 2001.
- [15] M. Baghour, S. Chakkor and A. Hajraoui, “Fuzzy logic approach to improving stable election protocol for clustered heterogeneous wireless sensor networks,” *J. Theor. Appl. Inf. Technol*, vol. 53, no. 13, 2013.
- [16] A. Zengin and S. Tuncel, “A survey on swarm intelligence based routing protocols in wireless sensor networks,” *International Journal of Physical Sciences*, vol. 5, no. 14, pp. 2118-2126, 2010.
- [17] W. Guo and W. Zhang W, “A survey on intelligent routing protocols in wireless sensor networks,” *Journal of Network and Computer Applications*, vol. 38, pp. 185-201, 2014.
- [18] G. Smaragdakis, I. Matta and A. Bestavros, “SEP: a stable election protocol for clustered heterogeneous wireless sensor networks,” *InProceedings of 2nd International Workshop on Sensor and Actor Network Protocols and Applications*.
- [19] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, “Energy-Efficient Communication Protocols for Wireless Microsensor Networks,” *In Proceedings of the 33rd Hawaiian International Conference on Systems Science (HICSS)*, 2000.
- [20] W. B. Heinzelman, A. P. Chandrakasan, and H. Balakrishnan, “An application-specific protocol architecture for wireless microsensor networks,” *IEEE Trans. Wireless Commun.*, vol. 1, no. 4, pp. 660670, 2002.
- [21] K. Kyung, L. Chang, M. Sung and Y. Hee. “Tree-Based Clustering(TBC) for Energy Efficient Wireless Sensor Networks,” *In proceeding of IEEE 24th international conference on advanced information networking and applications workshops*, pp. 680-685, 2010.
- [22] Z. Ji, H. Li, X. Liu, Y. Luo, F. Chen, H. Wang and Liang Chang, “On efficient and robust anonymization for privacy protection on massive streaming categorical information,” *IEEE Transactions on Dependable and Secure Computing* vol. 14, no. 5, pp. 507-520, 2015.
- [23] S. Xiaoxun, H. Wang, J. Li and J. Pei, “Publishing anonymous survey rating data,” *Data Mining and Knowledge Discovery*, vol. 23, no. 3, 379-406, pp. 2011.
- [24] Z. Hui, J. He, G. Huang, Y. Zhang and H. Wang, “Dynamic optimisation based fuzzy association rule mining method” *International Journal of Machine Learning and Cybernetics*, vol. 10, no. 8, pp. 2187-2198, 2019.
- [25] J. Haixin, R. Zhou, L. Zhang, H. Wang and Y. Zhang, “Sentence level topic models for associated topics extraction,” *World Wide Web*, vol. 22, no. 6, pp. 2545-2560, 2019.