Energy efficient cluster-based routing protocol for Wireless Sensor Network using Nature Inspired Mechanism

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Energy efficient cluster-based routing protocol for Wireless Sensor Network using Nature Inspired Algorithm

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Abstract:

WSN consist of tiny sensors which are distributed over the entire network having capabilities of sensing the data, processing it and convey it from one node to another node. The purpose of the study is to minimize the power utilization per round and elevate the network lifespan. In the present case, the nature inspired mechanisms are used to minimize the power utilization of the network. In the proposed study Butterfly Optimization Mechanism is used to choose the optimum quantity of CH from the dense nodes. The parameter is to be considered for the choosing of the CH is the remaining power of the node, interspace from the other nodes in the network, interspace from the BS, node centrality and node degree. The PSO is used to form the CH by choosing certain parameters such as interspace from the CH and the BS. The path is choosing by means of the Ant Colony Optimization (ACO) Mechanism. The route is optimized by the interspace, node degree and the choose remaining power. The inclusive performance of the projected protocol is measured in terms of stability period, quantity of active nodes, data acknowledged by the BS and the overall power utilization of the network. The results of the put redirect methodology are correlated with the extant mechanisms such as LEACH, DEEC, DDEEC, EDEEC [50-53] and also correlated with the swarm mechanisms such as CRHS, BERA, FUCHAR, ALOC, CPSO, FLION. This review will help investigators to discover the applications in this arena.

Keyword: Wireless Sensor Networks, Energy Efficiency, Throughput, Delay, Nature Inspired Algorithm

1. INTRODUCATION

With concern of Wireless Sensor networks lifespan, nature-inspired mechanisms are evolving as an appropriate technique. For increasing the lifespan of the network or in order to decrease sensing the unnecessary data by the battery-driven sensors, optimal network scope plays an important role. To sense and store the actual data from the nature, the large quantity of geographically distributed sensors communicated along the wireless means, it is formally known as Wireless Sensor networks (WSNs) [1]. Sensors are operating like repeater as they will accept the data, convert the analogue to digital form and redirect the data to the other nodes, CH and the sink. The BS will collect the data, analyze it and take decision as per the application. There are various parameters on which WSN architecture is depend such as fault tolerance (sensor node will redirect the packet and acknowledged the packet if some of the sensors get drained), scalability (how network will work if sensors will be added or removed), stability, power efficiency. These sensors are battery powered. So, after some time, the power of the sensors will get depleted and it affects the entire lifespan of the network. The purpose of the study is to maximize the network lifespan by increasing the quantity of nodes per round, data send to the BS and the optimal quantity of CH choosing. In the extant case, optimal network scope, clustering mechanism and the path choosing are mostly used in the WSNs to elevate the lifespan of the network.

WSN consist of tiny sensors which are distributed over the entire network having capabilities of sensing the data, processing it and convey it from one node to another node. These sensors sense the nature, evaluate, send and accept it. Military, weather forecasting, industrial area, medical services, agriculture or many other applications use the WSN for the data transmission. Sensors are limited battery powered and very compact in size. Once, sensors are placed in the harsh and no-man nature, these sensors will be used in the adequate way because it cannot be replaced and charged. Nodes drain their power in two ways such as sensing the natural data and conveying the data to the BS [2-10]. Most of the work has been done to maximize the entire lifespan of the network by saving the power of the sensors. Liank et al. [11] has put redirect the mechanism named as Huang mechanism, aims is to balance the power utilization in the entire network by using optimal choosing of clusters in the entire network. But the restriction of this mechanism is, it is very complex and if in case the data size of the packet is large then it may block the channel. In contract, Cardei et al. [12] have put redirect TianD mechanism, in which sensors nodes are arranged in disjoint set form to cover the maximal range. As compare to the Hunag mechanism, TianD mechanism is less complex in nature. However, the mechanism will not able to find the duplicate nodes and data in the nature.

2. LITERATURE SURVEY

The challenges faced by the wireless sensor network are power constraint, correct detection of data, and non-duplicate data, the sensors need to be placed in such a way that they in appropriate interspace from each other but considering the uncovered area which leads to the scope hole or blind area problem. For the above stated problem, Wang et al. [13] has put redirect a mechanism named as Scope Configuration Protocol. The protocol is well suited for the nature where the quantity of sensors is less or significant. After the literature survey, the two problems have been observed, i.e., power depletion of the sensors and the sensor node scope problem and there exit aback-and-forth between these two problems. In the literature, may authors have put redirect the solution for the individual problem but not provide collectively. After the survey, keeping the extant problems, we have collectively considered the problem and put redirect the multi-purpose optimization mechanism. There are various mechanisms are published in the literature for the WSN by using nature-inspired mechanisms [14-18]. There are multiples mechanisms put redirect by the authors to cover the optimal scope in WSN [19-21]. In [19], Metaheuristics for the deployment problem of WSN: A review, discuss ethe various types of issues while deploying the sensors in the nature by using nature-inspired mechanisms. In [20], Optimal sensor network layout using multi-purpose metaheuristics, author equated the three protocols and highlights the problem associated with mechanisms in terms of optimal scope. In [21], Transmutative intelligence in wireless sensor network: routing, clustering, lateralization and scope., have discussed the genetic, transmutative and theoretical, mathematical and practical applications of the cluster formation, optimal scope of the network and the lateralization problem in WSNs. Other challenges faced by the WSN is insufficient power of the sensors which leads to the network failure [14-17]. So, the main dissimilarity between the WSN and the other network is, WSN is oversensitive and vulnerable to the power. So, the optimal utilization of power mechanism is the esteem necessity for the wireless sensor network [20]. Nature-inspired mechanism is best suited for cluster formation and choosing the best path will elevate the life of sensors along which the we can elevate the entire lifespan, stability period and scalability of the network [21-23]. A cluster having CH who communicate with the other CHs in the network. Most of the power is consumed when the data is transfer in between the CHs and the BS. To turn down the power utilization in the clustered wireless sensor network, routing mechanism is used in between the CHs and the BS [24-27]. However, none of the mechanisms deliver serious effects of the problem in the wireless sensor network to cover the optimal solution. The purpose of the paper is to turn down the power utilization of the network during the data transmission by literature survey of recent clustering and routing mechanisms. We have also briefed the nature-inspired mechanisms and their applications used in the wireless sensor networks in terms of capacity, robustness, self-adaptability. We have also discussed the strengths and weaknesses of the work done by the different researchers in section 3. The optimization mechanism is segregated into three types such as model based, simulator based, mechanism based. Mechanism based is further bifurcate two parts such as deterministic and stochastic mechanism. Stochastic mechanism is further bifurcate two parts heuristic and meta-heuristic. The meta-heuristic mechanism which is further bifurcate four parts i.e., human inspired, geography inspired, physics inspired and bio-inspired. Bio-inspired mechanism is further bifurcate three parts transmutative, swarm based and plant based [62-64]. Furthermore, there are more than thirty swarm based optimization is put redirect by the researchers. The swarm-based mechanism is used in wireless sensor network to resolve many extant problems such as to upgrade the power efficiency of the network, to elevate the network lifespan, to maximize the packet delivery ratio in the network. The conventional routing protocols are inefficient to upgrade the power constrain of the wireless sensor network. So, to upgrade the power constrain of the network, researchers used the efficient clustering and routing protocols by the use of swarm-based approach. As per the research, the Ant Colony Optimization [28] is used to upgrade the power efficiency of the network and one of the efficient mechanisms for routing. A review chronology of the research is shown in the fig 1. The review is done on the basis of paper publication in the area of power efficiency, security based, delay, error free protocol and the cluster-based. The most of the paper were based on the cluster formation and based on the power efficiency upgradient of the network [65-70].

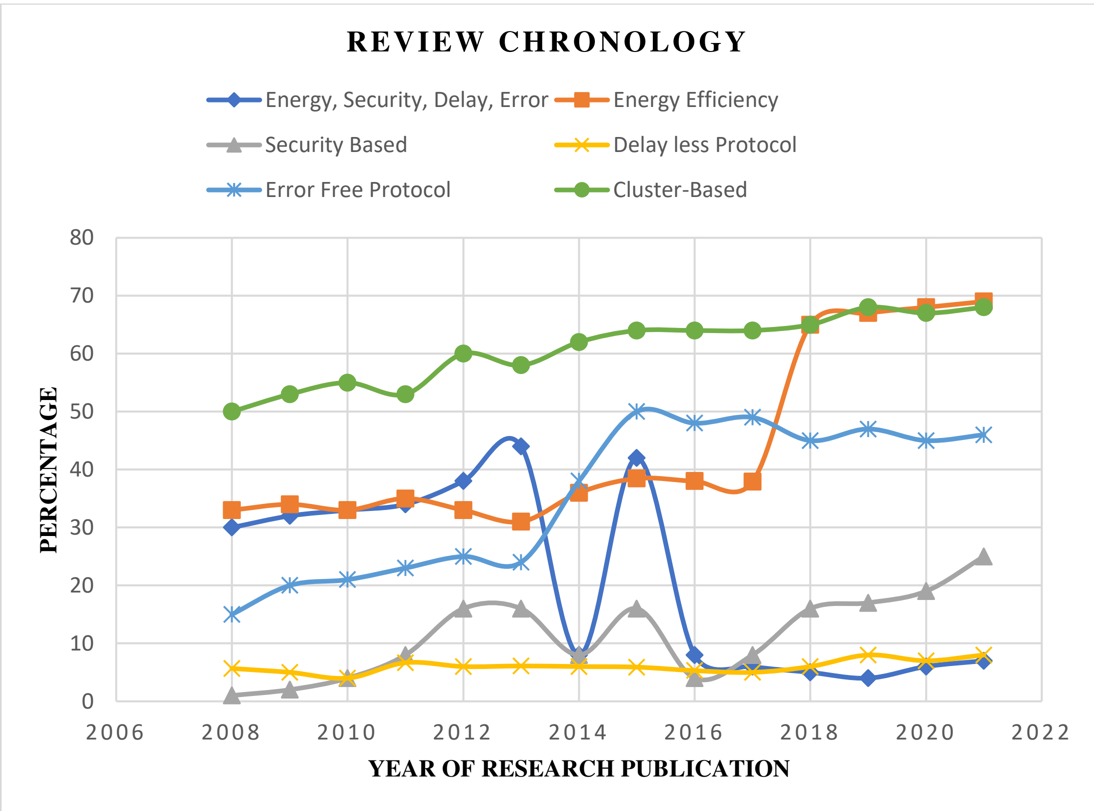


Fig 1: Review Chronology

2.1 Classical approaches

In 2002, LEACH was habituated by W. Heinzelman, the sensors choose their CH and form a cluster. CH collect all the data form the nodes and send the data to the BS. The elected CH will lose their power very fast. In 2017, Wang et al. put redirect a mechanism named as LEACH-impt [48]. Is LEACH-impt the communication follows the inter-cluster routing. The route is choosing on the basis of quantity of hops per path, path remaining power, power utilization per round. The overall performance of LEACH-impt in terms of power efficiency is upgraded but due to arbitrarily choosing of CH and changes in topology, the data loss is high.

Haseeb et al. put redirect a mechanism named as WECRR (Weighted Power-Efficient Clustering with Robust Routing protocol. In WECRR [47], the CH is choosing on the basis of deterministic strategy. Secondly, the routing decision is taken based on multi-facet factors such as traffic density, remaining power and packet error ratio. Furthermore, the route maintenance and load distribution among the nodes are upgraded by the protocol. But the restriction of the put redirect mechanism is that, the interspace between the node and the BS is not considered by the protocol. Again, Haseeb et al. has put redirect a mechanism named as AECR (Aware Cluster Based Routing) [45]. The CH choosing is based on the node density and the position of the node. The advantages of the mechanism are it turn downs the cluster overhead and communication cost and it mainly focus on the power of the node. The disadvantage of the mechanism is that it doesn't focus on interspace between the nodes [28].

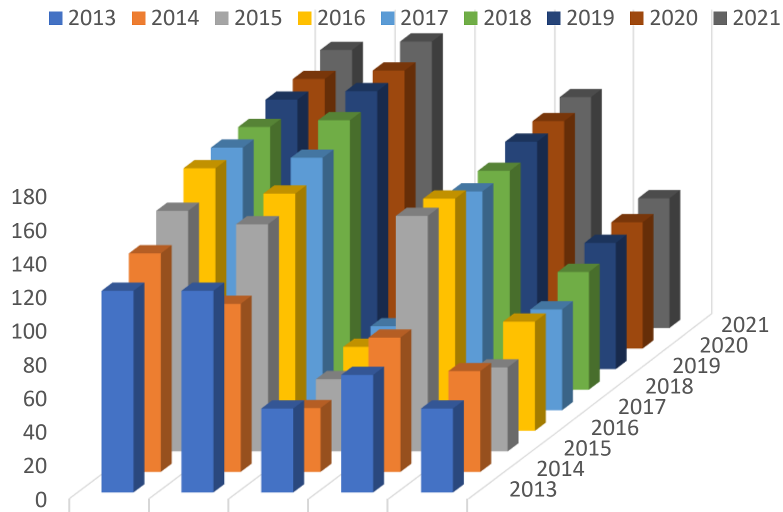
Hang and Zhang put redirect a mechanism named as WPO-EECRP [47]. In this protocol, the CH is choosing on the basis of remaining power, interspace from the node, interspace from node to BS and the cluster density. The mechanism works well when there is adjacent quantity of nodes are present in between the CH and BS and it will elevate the power utilization of the network.

2.2 Optimizations in WSNs using Swarm Intelligence

An optimization is achieved by designing a model, by using a simulation and by designing a mechanism. A detailed taxonomy of the swarm-based optimization used in WSNs is shown in Fig 2. The swarm-based mechanism is bifurcate two parts such as local search (deterministic) and global search (stochastic). Local search provides the theoretical assumption about the formulated problems, provide the analytical properties [71-72]. Guarantee of reaching the global minimum and at least a local minimum, whereas global search provides the guarantee in terms of probability. However global search is much faster than the local search. Additionally, the global search method is further classified into two parts: heuristic mechanism is problem-dependent mechanism and meta-heuristic mechanisms is problem-independent. Both the mechanism is used to speed up the process of finding the global optimum solution where the finding the solution is difficult. Because the heuristic mechanisms are based on the adaptive and greedy approach, therefore they are more prone to get stuck at local optima which result to fail to obtain global optima [29]. However, meta-heuristic is non-adaptive and non-greedy approach and able to find the global solution. The meta-heuristic mechanism is also known as nature-inspired mechanism. The nature inspired mechanism is further bifurcate four parts: bio-inspired, physics inspired, geography inspired and human inspired [30-37]. The bio-inspired mechanism is bifurcate three parts: transmutative, swarm based and plant based. Because the nature inspired mechanisms, most of the mechanisms are inspired by the biological system. Therefore, most of the parts of the nature inspired mechanisms are based on the bio-inspired mechanism. The transmutative mechanism is based on the Darwin's principle of choosing whereas the swam is based on the collective intelligence [38].

Fig 2: Taxonomy of the Swarm-Based Optimization

As per the research the most popular mechanism used for the CH choosing is butterfly optimization mechanism, for the cluster formation particle swarm optimization mechanism is popular and for the efficient route choosing the ant colony optimization mechanism is used by the researchers to upgrade the power efficiency of the wireless sensor network [73]. The ant colony optimization mechanism works with other popular mechanisms to upgrade the power efficiency of the network such as fuzzy logic [39]. Xie et al [41]. put redirect a mechanism based on the ACO for wireless sensor network named as Type-2 Mamdnai Fuzzy Logic System. The route in between the CHs is chooses on the basis of Ant Colony Optimization and the CH choosing is based on the remaining power, interspace to the BS and quantity of nearest nodes. The CHs choose all the statistics from the nodes and send it to the BS. Arjunan and Sujatha put redirect a mechanism-based o the fuzzy logic to develop the inadequate clusters and the routes were chooses using Ant Colony Optimization technique. The CHs are chooses on the basis of remaining power, node degree, interspace from the BS, node centrality and interspace from the nearest nodes [40]. The mechanism is well suited to maintain the lifespan of the network [74]. Trend of the literature Fig 3. shows that ACO, PSO and BOA is used by the many researchers to optimize the extant problem in wireless sensor network such as optimal route choosing, optimal quantity of CH choosing per round, optimal quantity of nodes is chooses per round and elevate the packet transmission in between the CH and the BS [42][51].



	PSO	ACO	FA	BOA	ABC
2013	120	120	50	70	50
2014	130	100	38	80	60
2015	143	135	43	140	50
2016	156	141	50	138	65
2017	156	150	50	130	60
2018	156	160	50	130	70
2019	160	165	50	135	75
2020	160	165	50	135	75
2021	165	170	52	137	77

Fig 3: Trends of the mechanism

3. WSN AND OPTIMIZATIONS

The main issues related to the wireless senor network is categories into three main sections such as power efficiency, Quality of service and the security. The optimization mechanisms are used in wireless sensor network to solve the extant problem i.e., optimal scope of the sensors, data aggregation, power efficient clustering and routing and the sensor lateralization. There is a correlation in between all the stated problems such as if we go for the service quality then we have to trade off with the lifespan of the network. Same follow with the security, for achieving the security, again we have to trade off with the lifespan of the network. If we address the problem individually, many loopholes exit and will never solved. So, to discover balanced wireless sensor network, we have to build the optimized mechanism which can handle all the problems simultaneously. The solution of the problem is to create a multi-purpose function and optimize the mechanism by using appropriate optimizer mechanism. For choosing the appropriate mechanisms, various factors have been considered such as problem type, time constraint, availability of resources, accuracy desired. To achieve the better performance of the network, the researchers have used many approaches in nature inspired mechanisms such as, classical approaches [28-32] and swarm intelligence-based approaches [33-43]. There are various types of mechanisms present in the literature focused on the different types of problem faced by the wireless sensor networks named as Optimal Scope, Data Aggregation, Power Efficient Clustering, Power Efficient Routing mechanisms, Sensor lateralization [75-76]. Table 1 shows the detailed survey of the extant mechanism in terms of the various parameters such as Power Efficiency, Latency, along put, Scalability, Connectivity, Load Balancing, Packet Loss Ratio, Reliability, Complexity.

Table 1: Survey of the extant mechanism with various parameters

S.No	Mechanism	Abb.	Authors	Year	Best For	Power Efficiency	Latency	Throughput	Scalability	Connectivity	Load Balancing	Packet loss rate	Reliability	Complexity
1	Ant Colony Optimization	ACO	Dorigo	1992	Path choosing, routing	H	S	H	H	M	M	M	M	M

2	Particle Swarm Mechanism	PSO	Kennedy and Eberhart	1995	Cluster, path choosing, gives optimum results in less parameters	L	S	M	H	N/A	S	H	M	S
3	Artificial Fist Swarm Mechanism	AFSA	Li et al.	2002	Cluster formation	L	M	S	H	M	M	H	M	M
4	Bacterial Foraging Optimization Mechanism	BFOA	Passion	2002	CH choosing, routing	M	M	S	M	M	S	S	M	M
5	Glowworm Swarm Optimization	GWO	Krishnanad and Ghose	2005	Path choosing, routing	H	S	S	M	M	M	M	S	M
6	Cat Swarm Optimization	CSA	Chu et al.	2006	Find best location for the near sink node, choose CH, Perform well with K-mean Clustering	L	M	M	M	S	M	M	S	M
7	Artificial Bee Colony	ABC	Karaboga and Basturk	2007	Cluster formation, CH choosing	M	S	M	M	M	S	M	L	M
8	Cuckoo Search	CS	Yang and Deb	2009	Cluster formation, CH choosing	M	S	M	M	M	S	S	M	S
9	Bat Mechanism	BA	Yang	2010	Node lateralization	M	S	M	M	M	M	M	M	M
10	Firefly Mechanism	FA	Yang	2010	Clustering, Node lateralization	M	S	M	M	M	S	M	S	M
11	Krill Herd Mechanism	KH	Gandomi and Alavi	2012	Finding the interspace	L	S	S	M	S	M	M	M	M
12	Dolphin Enholocation	DE	Kaveh and Farhoudi	2013	CH choosing, Security needs to be considered	M	S	M	M	M	M	M	M	H
13	Chicken Swarm Optimization	CSO	Meng et al.	2014	CH choosing	M	M	S	H	M	S	M	M	M
14	Grey Wolf Optimizer	GWO	Mirjalili et al.	2014	Network scope optimization, CH CHOOSING	H	M	M	H	M	M	M	M	H
15	Ant Lion Optimizer	ALO	Mirjalili	2015	Scope, connection, the network-longevity and minimized power utilization.	H	M	M	M	M	M	M	M	H
16	Dragonfly Mechanism	DA	Mirjalili	2015	lateralizationproblem	L	S	M	M	M	M	M	M	M
17	Whale Optimization Mechanism	WOA	Mirjalili and Lewis	2016	CH Choosing	M	S	M	M	M	M	M	M	M
18	Crow Search Mechanism	CSA	Lalireza Askarzadeh	2016	CH choosing, Work with few parameters	H	S	M	M	M	M	M	S	S
19	Grasshopper Optimization Mechanism	GOA	Saremi et al.	2017	Network lifespan, end-to-end delay, best with ABC	M	S	M	M	M	M	M	M	M
20	Butterfly-inspired Mechanism	BOA	Qi et al.	2017	Node lateralisation, cluster formation	S	M	M	M	S	S	S	M	M

21	Salp Swarm Mechanism	SSA	Mirjalili et al.	2017	Node lateralisation	S	M	M	M	S	S	S	S	M
22	Equilibrium Optimizer	EO	Faramarzi et al.	2019	Routing, Load Balancing, Clustering	M	M	H	M	M	M	M	M	H
23	Bald Eagle Search	BES	Alsattar et al.	2019	Latest Technology, Literature not available									
24	Harris Hawks Optimization	HHO	Heidari et al.	2019										
25	Nuclear Reaction Optimization	NRO	Wei et al.	2019										
26	Border Collie Optimization	BCO	Dutta et al.	2020										

3.1 Optimal Scope in WSN

Optimal Scope of sensors in the wireless sensor network is very essential part of the network to elevate the network lifespan. Scope of the area in such a way that it targets the entire area with minimum quantity of senor nodes. The key parameter of choosing the area is to choose the shape of the test area. In the extant literature, there are various shape available such as irregular, solid structure, hexagonal shape or the circular shape. In the figure, we show the four two-dimensional geometrical-based sensing shapes [54-57]. In the present case, the outline of the test area is uneven and multifaceted due to territory properties and solid shape. However, the hexagonal or a circular shape is use for the computational and conceptual ease. In general, hexagonal shape is applied or used by the researchers/industry experts because of its flexible and overlapping feature. Though, the circular shape is more pronoun because of its low complexity. The restriction is remunerated by growing the radius of the circle. Due to elevate in the radius of the circle, another problem comes into picture that is duplicate data sensed by the sensor. As more duplicate data is sensed by the sensor, there will more power utilization [58-60]. We can turn down the problem by enhancing the single purpose optimization problem into multi-purpose problems by choosing the other parameters.

3.2 Power efficient clustering and routing in wireless sensor network

As wireless sensor network is composed of the sensors which are inbuilt with the battery for shorter duration. These batteries are not be recharged, so the need of the power efficient networks is of the utmost importance in the extant case [61]. The sensors dissipate their power by sensing the data from the nature and send it to the BS by using multi-hop communication. For reducing the power utilization of the nodes, first clusters are formed, secondly CHs are chooses based on the remaining power, and thirdly, the path is chooses for the data transmission using optimum routing techniques. In the given domain, the problem faced by the networks are:

- The choosing of the CH having high power and choosing of routing path from each round.
- Maximization of network lifespan and packet delivery ratio to the BS.
- Interspace from the sensor node to the CH and CH to the BS should be minimized.

4 PROBLEM STATEMENT

The problem faced by the WSN are: To find the appropriate purpose function to preserve or creating the power efficient network. For remaining power, weighted power-efficient clustering with robust routing for wireless sensor network [44], and Aware cluster-based routing [45] is put redirect. The overall power of the network is preserved by considering the power as well as interspace. In clustering and routing in wireless sensor using harmony search mechanism [46], the lifespan is affected by the quantity of member nodes in of the CH. In energy efficient clustering routing protocol [47] based on parameters optimization in WSN, the information communication from Cluster Head to the Base Station also affects the network lifespan. The Ant colony optimization generate the packet loss due to the proactive and reactive mechanisms. The solution of the above mentioned to create a mechanism focused on the power of the node and the interspace of the node to the CH and from CH to the BS. The best path choosing will be implemented by multi-purpose function. And the packet drop ratio is minimized by the considering the power of each node. For creating the purpose function, one need to consider the remaining power, interspace from the node to the CH and from CH to the BS. Therefore, it will work in the small as well as large network.

4.1 Preliminaries

This section describes the network and power model as well as describe the PSO (Particle Swarm Optimization) is used to formulate the clusters, BOA (Butterfly Optimization) technique for finding the CH, ACO (Ant Colony Optimization) technique for finding the route from the source to the sink.

4.1.1 Network model

- Sensors are arbitrarily deployed in the network, later they are constant in nature.

- BS receives the data such as remaining power of the node, interspace from the sensors from all the sensors in the nature.
- To configure the network model of wireless sensor network, all the knob are comparable to each other in terms of original energy and the dispensation period.
- The interspace amongst the sensor knob to the Cluster Head and from Cluster Head to the BS is intended grounded on the Euclidean interspace.
- Clusters are formed using Cluster formation mechanism, then CHs are chooses using choosing mechanism. Then the routing mechanism is used to find the route from source to the sink.

4.1.2 Energy Model

Given in the research, a elementary radio model (1^{st} order) is measured to compute the power of the nodes. For conveying the l bits from the source to the sink over the interspace d is calculated by using the equation 1 and 2 respectively:

$$E_{TX}(l,d) = \begin{cases} LE_{elec} + LEfsd^2 & if\ d < do \\ LE_{elec} + LEmpd^4 & if\ d \geq do \end{cases} \tag{1}$$

Where LE_{elec} is the power used to run the converter (ETX) or (ERX) and the threshold value is d_0. For the experimental survey, free space and multi-path models is expressed as E_{fs} and E_{mp} . These values are depended on the converter amplifier model. Where d0 is expressed as

$$d_0 = \sqrt{\frac{E_{fs}}{E_{mp}}} \tag{2}$$

5 PUT REDIRECT METHOD

The put redirect model has three mechanisms: First is used to form clusters, second is used to choose the CH by considering the remaining power and the interspace from the sensors and other one is used to find the path or route over the entire network. The PSO is used to form the cluster, BOA is used to find the optimum quantity of CHs in each round and ACO is used to find the route from the source to the sink or from CH to the BS. The entire process is described in the figure 4.

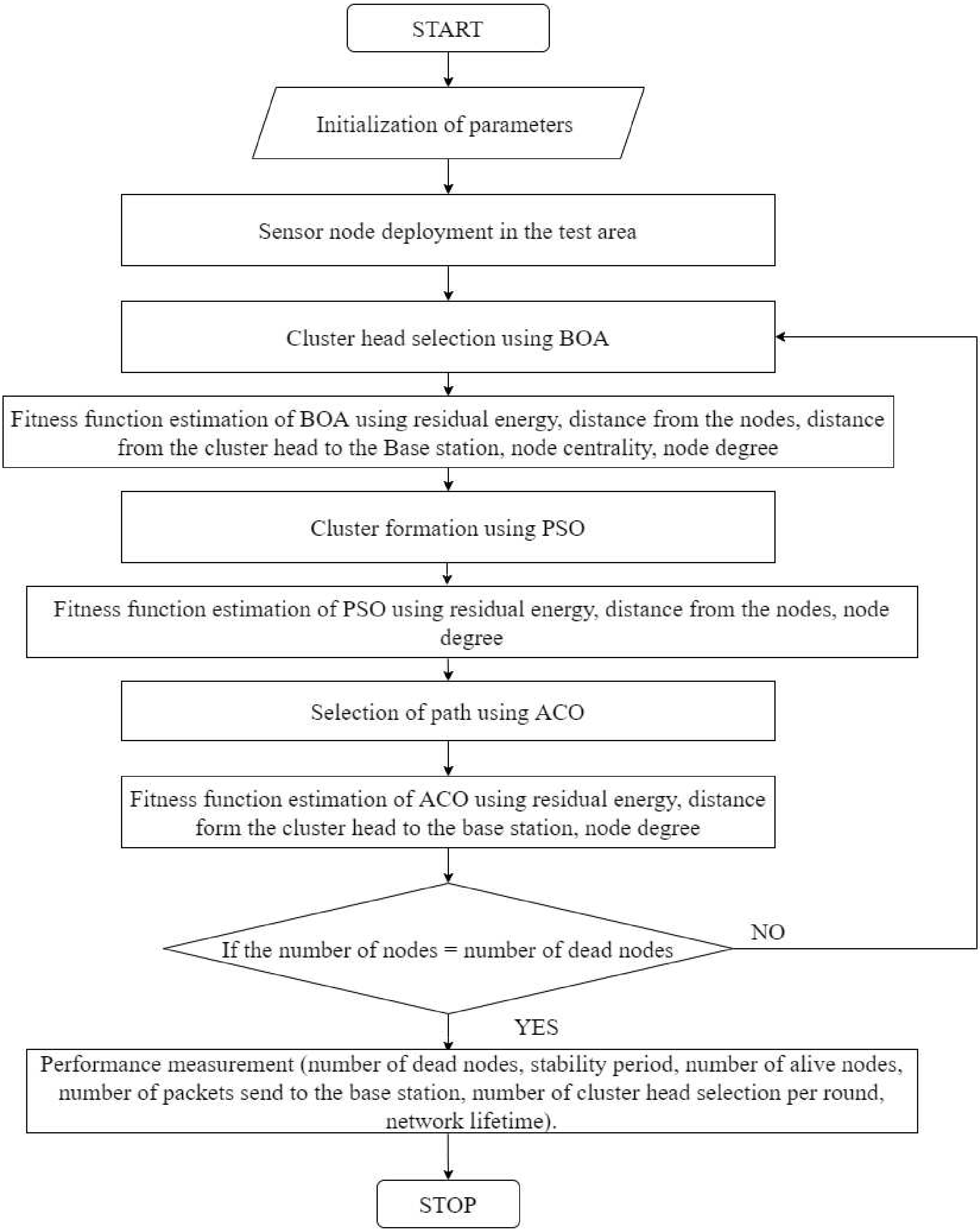


Fig 4: Flow Chart

6.1 CH choosing using BOA

BOA (Butterfly Optimization Mechanism) is introduced in 2019 by Sankalap Arora [50]. The mechanism shows the butterfly food search and its mating behavior. In general, butterflies are fascinated to every last one along the cologne of other apprehensions. The crusade of butterfly is moreover in haphazard way or in the way of the other butterflies who produces the stronger cologne. The purpose function is used to compute the inducement strength. The butterfly optimization mechanism chooses the ideal quantity of CH using the certain parameter: node notch, node uniqueness, interspace to its nearest, interspace between the Base Station to the Cluster Head and the remaining power of the sensors. The author use algorithm proposed by Prachi M. et al. [30]. The steps of the algorithm are as follows:

Node degree: It is defined as the quantity of sensors connect to the Cluster Head. The Cluster Head with the less quantity of knob are chooses as CH with the higher quantity of connected sensors deplete their power fast. The degree of the node is calculated as sum of power of all the sensors belongs to the CH. The weight value for the purpose function is 0.1.

$$ND = \sum_{i=1}^{m} I_i \tag{3}$$

Node centrality: It is defined as how much a node is halfway situated from the nearest nodes. The weight value for the purpose function is 0.1 and it is calculated by using the eq:

$$C_n = \sum_{i=m}^{m} \frac{\sqrt{\frac{\sum_{j\in n} dist^2(i,j)}{n(i)}}}{Network\ dimension} \tag{4}$$

where n(i) quantity of nearest node to the CH i.

Remaining Power of the node: The node with the higher remaining power will become the CH because the CH need to perform the various task such as aggregate the data, remove the duplicate data, data transmission to the BS. The weight value for the purpose function is 0.3. Thus, the node with higher remaining power will chose as the CH and the remaining power is calculated as:

$$R_e = \sum_{i=1}^{m} \frac{1}{E_{CHi}} \tag{5}$$

where the remaining power of the i[th] CH is E_{CHi}.

Interspace between the sensors: It is defined as the interspace from the sensors to the CH and from nearest sensors with in the cluster. Lesser the interspace, less power will be consumed in the transmission. The weight value for the purpose function is 0.2. Thus, the interspace is calculated by using the formula:

$$Dij = \sum_{i=1}^{m} \left(\sum_{j=1}^{Ii} dis(s_j, CH_i) / I_i \right) \tag{6}$$

where $dis(s_j, CH_i)$ is interspace from sensor node to the CH and $I_i$shows the i[th] sensor node within the cluster.

Interspace from the CH and BS: It shows the interspace from the from the CH to the BS. If the CH is far away from the BS, then it consumes more power for the data transmission. So, the nodes near to the BS is used to convey the data to the BS. The weight value for the purpose function is 0.25. The purpose function used to calculate the interspace from the BS to the CH is calculated as:

$$D_{CH-BS} = \sum_{i=i}^{m} dis(CH_j, BS) \tag{7}$$

So, the single purpose function to find the CH from the set of nodes is calculated as

$$F = \alpha_1 ND + \alpha_2 C_n + \alpha_3 R_e + \alpha_4 D_{ij} + \alpha_5 D_{CH-BS} \tag{8}$$

Mechanism

CH choosing using BOA

1. Fitness function derivation using $F = \alpha_1 ND + \alpha_2 C_n + \alpha_3 R_e + \alpha_4 D_{ij} + \alpha_5 D_{CH-BS}$
2. Generate a preliminary populace of butterflies.
3. Prepare impetus strength (I) at node I which is intended by f(xi)
4. Prepare shift possibility, sensor modality and power exponent.
5. For j=max quantity of reiterations
6. For every butterfly in populace
7. Calculate cologne $f = cI^a$
8. End for
9. Identify the optimum butterfly populace
10. For every butterfly in populace
11. Generate a arbitrary quantity r from [0,1]
12. If arbitrary quantity < population
13. $x_i^{t+1} = x_i^t + (r^2 \times g^* - x_i^t) \times f_i$ where f_i is butterfly fragrance, $g^*$is current iteration.
14. $else$
15. Move arbitrarily $x_i^{t+1} = x_i^t + (r^2 \times x_j^t - x_k^t) \times f_i$
16. End if
17. End for

18. Update the value of energy proponent
19. End for
20. Optimal quantity of CH chooses from the population.

6.2 Cluster formation using PSO

PSO is one of the oldest mechanisms is the nature inspired mechanism used by the researchers to find the optimum results in the WSN. The mechanism is put redirect by the Kennedy and Eberhart in 1995. The mechanism is inspired by the social behavior of the bird flocking of fish schooling. It is an effective method to solve the clustering problem in WSN. On the basis of centralized clustering, the clusters are formed by the BS. For this, BS sends the data collection message to all the sensors in the nature. After receiving the data, nodes send the data to the BS such as node id, location (interspace from the BS in and position), power loss and power loss ratio (velocity), and current power to send BS. Then BS initiates the clustering process steps as follows.

Function: PSO-Cluster formation

Initialize the optimization problem and mechanism, parameters.

1. for i=1 to the particle size do
2. Initialize Xi within the search range of (Xmin,Xmax) arbitrarily;
3. Initialize Vi within the velocity range of (Vmin,Vmax) arbitrarily;
4. pi=xi
5. end for
6. Evaluate each particle **// fitness value= $a\frac{\sum_{i=0}^{n} d(current\ node, member\ node\ i)}{n} + b\frac{\sum_{i=0}^{n} E(member\ i)}{E(existing\ node)} + (1-a-b)\frac{1}{number\ of\ nodes\ exist\ in\ the\ current\ node}$ where a & b is normalized values and n shows the quantity of nodes in the cluster
7. Identify the best position Ps;

//Loop:

8. While (Stop criterion is not satisfied & t < maximum iteration times) do
9. for i=1 to the particle size do
10. $V_i^{t+1} = \boldsymbol{\omega} V_i^t + c_1 r_1 (P_i^t - X_i^t) + c_2 r_2 (P_g^t - X_i^t)$
11. $X_i^{t+1} = X_i^t + V_i^{t+1}$
12. $P_i^{t+1} = P_i^t$
13. Evaluate fitness value
14. If fitness (P_i^{t+1}) < fitness (X_i^{t+1});
15. Update (P_i^{t+1});
16. End if
17. If fitness (P_g^{t+1}) < fitness (P_i^{t+1}) then
18. Update (P_g^{t+1});
19. End if
20. End for
21. End While

6.3 Routing Mechanism using ACO

Ant Colony Optimization is a metaheuristic mechanism inspired by the performance of the ants. Commonly, ACO applied on the discrete problems. ACO is used to find the shortest path from source node to the destination node by the use of graph in which the ant colony (nodes associated with the CH) is represented as a node and the L represent the link in between the nodes with different weights. In the initial phase, the weight of the link is calculated as the actual interspace in between the nodes by using arbitrarily quantity which is calculated by the mathematical formula. The disadvantage of ACO mechanism, i.e., undefined conjunction is overcome by improving the ACO in terms of remaining power, interspace from the destination and the knob degree. The route-finding procedure by using ACO is as follows:

1. In the formed CH, the ants are situated in every cluster. CH will create the way from the Cluster Head to the destination (BS). These routes data are known as redirect data.

2. Based on the probability matrix, the redirect containers are arbitrarily converted to the following CH. The redirect program packet is conveyed to the next CH until the packet is acknowledged by the BS.
3. The redirect packet will maintain the local data base about the visited CH, remaining power of the nodes and the CH (Remaining power of the nodes are calculated as the quantity of data conveyed along the network), interspace from the CH to the BS and the node degree.
4. The redirect data base is used to create the backward data base or backward packet. We need to create the backward packet because to extend the path until the packet reaches to the BS. The backward packet path is same as the path followed by the redirect packet.
5. The pheromone level of the link is updated by the remaining power, interspace to the BS and the node degree.
6. The next node for the transmission is chooses on the basis of **equation no. 9** which shows the chance of selecting the knob j as the subsequent knob i by means of ant k.

$$P_{ij}^{k}(t) = \begin{cases} \frac{[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{l \in \mathrm{N}_k}[\tau_{ij}(t)]^{\alpha}[\eta_{ij}]^{\beta}} & if\ j \in \mathrm{N}_k \\ 0 & otherwise \end{cases} \quad (9)$$

Where, the heuristic value and pheromone intensity are represented as η_{ij} and τ_{ij} respectively. To control the relative importance of the both the values, parameter α and β is used. Submission of nodes who has not visited yet is represented asN_k. Base on the data stored in the routing table by the CH, the heuristic and pheromone intensity are updated. Both the values are updated by the following formulas:

$$\eta_{ij} = \frac{1}{d_{CH}} \quad (10)$$

And $$\tau_{ij} = (1-\rho)\tau_{ij}^{old} + \sum_{k=1}^{m} \Delta\, \tau_{ij}^{k} \quad (11)$$

Where, d_{CH} shows the interspace from the CH, m shows the quantity of ants initialized and the pheromone deterioration quantity is shown as$\rho \epsilon [0,1]$. Where $\Delta\tau_{ij}^{k}$ is calculated as:

$$\Delta\tau_{ij}^{k} = \int \frac{Q}{c_k} \quad if\ the\ k^{th}\ ant\ traversed\ link\ (i,j), otherwise\ 0 \quad (12)$$

Where the value of Q is constant and the route cost is found by the ant is calculated asc_k.

$$c_k = \boldsymbol{\varphi}_1 E_r + \boldsymbol{\varphi}_2 d_{CH,BS} + \boldsymbol{\varphi}_3 N_D \quad (13)$$

Where the weighted values of$\boldsymbol{\varphi}_1$,$\boldsymbol{\varphi}_2$, $\boldsymbol{\varphi}_3$ are 0.5,0.3 and 0.2. For the successful communication, remaining power of the nodes should be considered as the priority because the node failure me leads to the communication failure. After that, to obtained the shortest interspace in between the CH and the BS is considered as the second priority because it consumes the minimum power or we can say that the power utilization is low in order to find the shortest interspace as compare to maintain the remaining power of the sensors. Lastly, we consider the node degree as a third priority, in which we choose the next CH as a hop having lesser quantity of member nodes. To find the route in between the source node to the destination node following steps need to be followed:

Routing Steps using ACO

1) Initialize pheromone exponential weight and heuristic exponential weight.
2) Generate the initial population of the ants.
3) for j=higher level of the iterations.
4) for each ant in the population.
5) Repeat the steps until kth ant complete its journey to the final destination.
6) Choose the successive ant using equation 9.
7) Update the pheromone using equation 11.
8) End for
9) Update the best solution.
10) End for
11) Output is the optimal route from source to the BS.

6.4 Cluster maintenance

In the literature survey present, the cluster preservation phase is one of the most significant stages to stable the load amongst the clusters. The cluster closer to the BS drain their power so fast because of the traffic of inter cluster. So, the preservation of the cluster is important factor to turn down the problem of knob disaster. Node failure mains to the network failure and maintenance of the cluster leads to the maximization of the lifespan of the cluster or the entire network. In the put redirect mechanism, if the power of the CHs drains to the below the threshold value, the butter fly optimization mechanism is used to initialized the cluster, partial swarm optimization mechanism is used to elect the CH and then ant colony optimization mechanism is used to find the optimised path in amongst the knob to the Cluster Head and Cluster Head to the BS to maximize the network lifespan. Furthermore, it leads to the maximize the quantity of data conveyed to the BS.

7. Performance Measurement

The performance of the put redirect mechanism is measured by considering various factors such as:

Number of active nodes: The quantity of active nodes elevates the lifespan of the network. It describes as the quantity of active nodes in the network.

Dead nodes: The stability period of the network is calculated till the first node die. The network life time will decree when the quantity of dead nodes will elevate per round.

Data send to the BS

Along put: quantity of bits conveyed to the BS and it will measure in quantity of bits conveyed per second.

Stability period: It is measured along at what round the first node die, quantity of rounds when half of the nodes die in the network

Power utilization in each round: The total power utilization is calculated by the power loss of each node in the network.

Packet Drop Ratio: Quantity of data lost during the transmission from node to the CH and from CH to the BS.

Congestion in the network: It is calculated as quantity of acknowledged data by the BS to the quantity of produced data by the nodes in the network.

8. Simulation Setup

The put redirect power efficient protocol is implemented and tested on the MATLAB. The reason for using MATLAB is that it is very appropriate for the data survey and gives mathematical operations. There are 300 devices arbitrarily positioned in the test reason of 200 m x 200 m. The first order radio model for the power efficiency is considered for analysing the put redirect model with the extant model. The simulation parameters used for the examination purpose is shown in table 2. The purpose of the put redirect mechanism is to turn down the power utilization in wireless sensor networks. SO, to achieve the object, author used the BOA for the CH choosing, PSO is used for the cluster formation process and ACO is used for the routing process.

Table 2: Simulation Parameter

Parameters	Value
Network Field	(200,200)
Quantity of nodes	500
Packet Size	4000 Bits
Eelec	50nJ/bit
Efs	10nJ/bit/m2
Eamp	0.0013pJ/bit/m4
EDA	5nJ/bit/signal
Do (Threshold Interspace)	70 m
Eo (Original power of the normal nodes)	0.5J

Parameter that are considered for the butterfly optimization algorithm are: population size considered as 200, switch probability has taken as 0.8, power exponent considered as 0.1 and sensor mobility is considered as 0.01. Now for the cluster formation, the parameters considered as Quantity of Particles, Number of of iterations, Inertia Weight, Local Weight (c1), Local Weight (c2), Fitness are as 200, 100, 0.8, 1.49, 1.49, Predication accuracy. For the optimal route consideration, the parameters chosen as Quantity of ants, Pheromone exponential weight, Experiential exponential weight, Disappearance rate are as 200, 1,1,0.1.

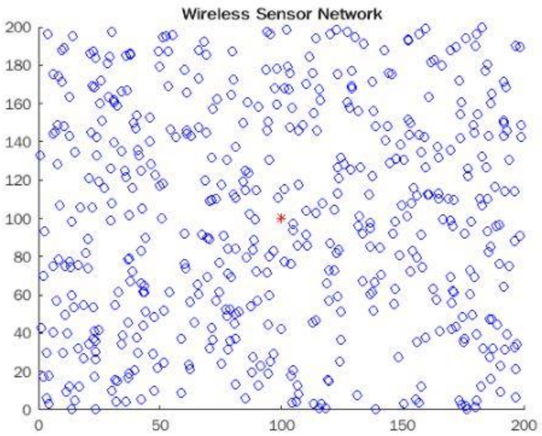


Fig 5: Illustration of Case 1.

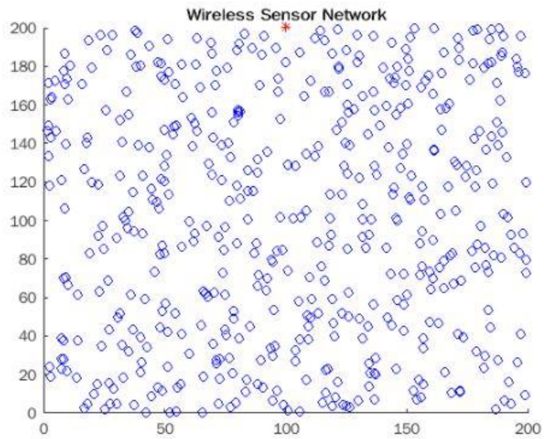


Fig 6: Illustration of Case 2.

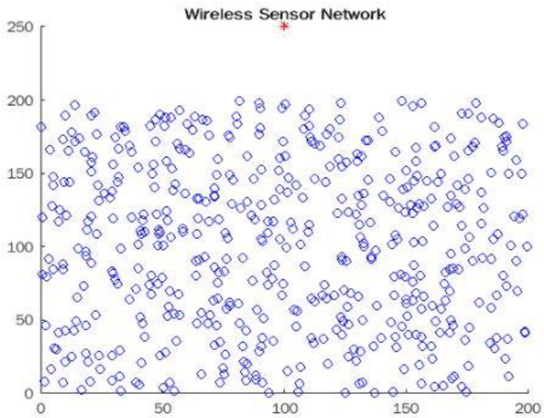


Fig 7: Illustration of Case 3.

The put redirect mechanism is validated in 3 cases.

Case 1: In the 1st case, the Base Station is placed at the centre of the test area (100,100) which is used to analyses the shorter interspace communication.

Case 2: In the 2nd case, the Base Station is placed at the last area which is in the range of the sensing reason (100,200). It is used to analyse the means range communication.

Case 3: In the 3rd case, the Base Station is placed at the outer area (100,250), which is situated far away from the examination zone. This case is used to analyse the extended rang communication.

8.1 Performance evaluation in terms of active nodes: The quantity of active nodes in put redirect mechanism is correlated with the LEACH, DEEC, EDEEC, DDEEC for 500 nodes in different cases such as in the 1st case, the BS is placed at the centre of the test area (250,250) which is used to analyses the shorter interspace communication, in the 2nd case, the BS is placed at the last area which is in the range of the sensing reason (100,250). It is used to analyse the means range communication, in the 3rd case, the BS is placed at the outer area (100,550), which is situated far-off from the test area. This case is castoff to analyse the long rang communication. The put redirect mechanism prolongs the network lifespan as compare to the other protocols.

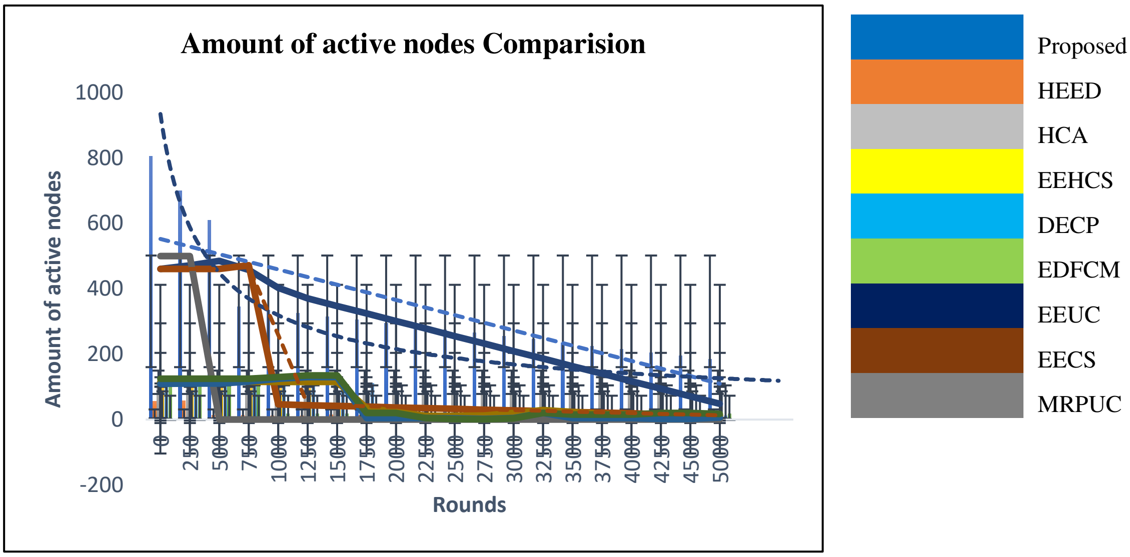


Fig 8: Number of Active Nodes

8.2 Performance evaluation in terms of stability period: The stability period is measured till the round when 1st node dies after the certain quantity of iterations. Fig 9 shows the quantity of dead nodes in the case 1, fig 10 shows the quantity of dead nodes for the case 2 and the fig 11 shows the quantity of death node for the case 3.

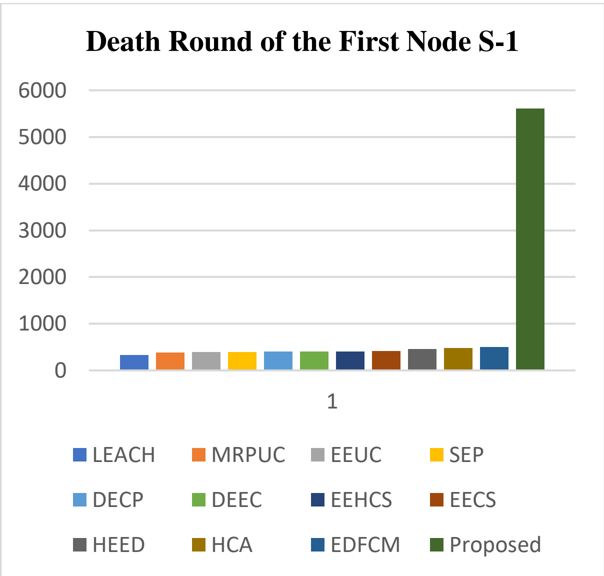


Fig 9: For the case 1

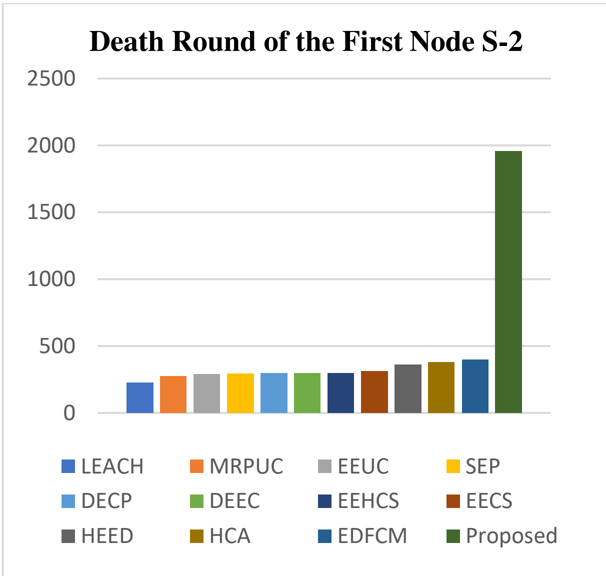


Fig 10: For the case 2

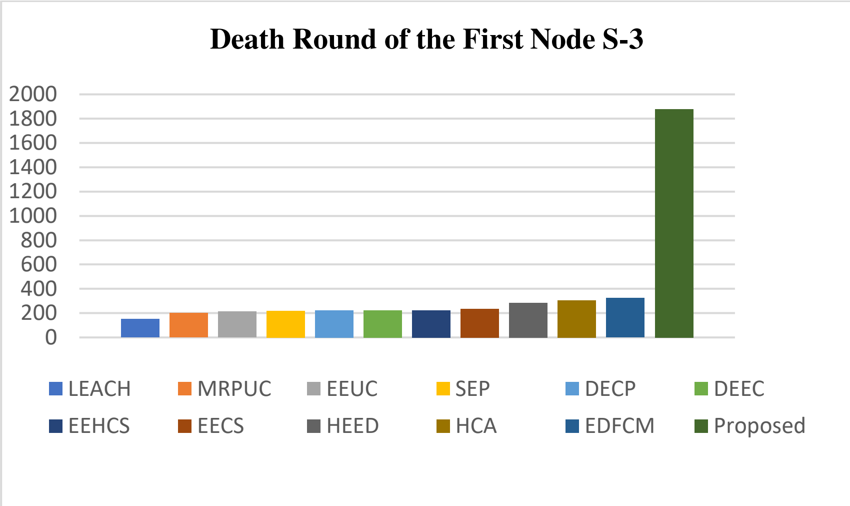


Fig 11: For the case 3

8.3 Performance evaluation of average power utilization: The performance evaluation of average power utilization of the put redirect mechanism is correlated with the extant mechanisms like LEACH, DEEC, MEEDEEC, SEP, EDEEC, DDEEC is shown in the figure 12. The power utilization is calculated when the BS is situated in centre of the region (100,250) and second comparison is based when the BS is situated far away from the BS (100,250) respectively. As per the result obtained from the mechanism, it is clearly shown that the put redirect mechanism gives higher power efficiency as compare to the LEACH and other mentioned protocols. The put redirect mechanism gives the higher power efficiency because it considers the optimal quantity of CH choosing per round, it includes the interspace while choosing the CH and optimal route when sending the data from one node to the other node. The reason behind the higher power utilization is that LEACH choose the CH arbitrarily and use single hop transmission whereas DEEC does not consider the interspace during CH choosing. The overall comparison in terms of remaining power of the put redirect mechanism with the extant mechanism is shown in the table 6.

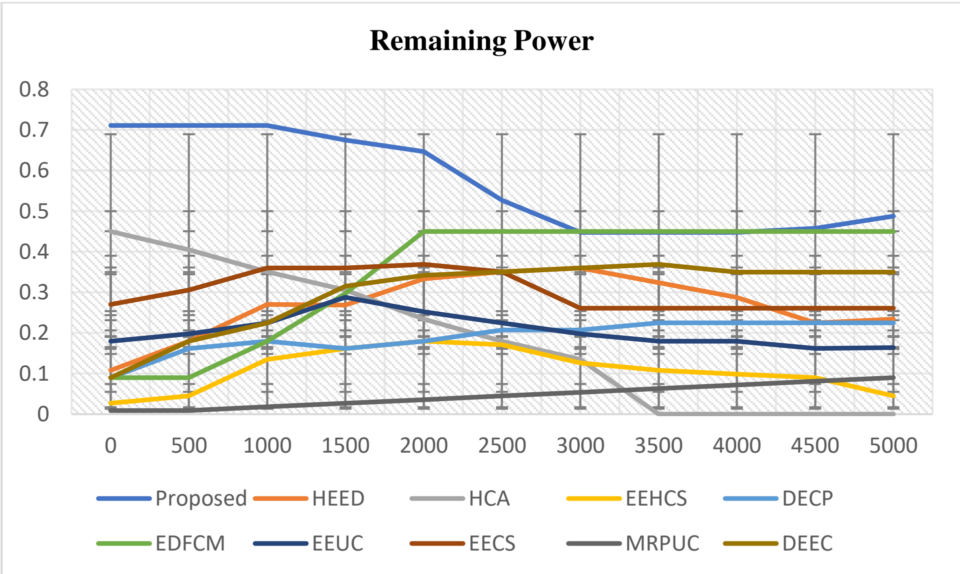


Fig 12: Remaining power

Table 6: Comparison of the remaining power of the extant mechanism with the put redirect mechanism

Rounds	Put redirect	HEED	HCA	EEHCS	DECP	EDFCM	EEUC	EECS	MRPUC	DEEC
0	0.711	0.108	0.45	0.027	0.09	0.09	0.18	0.27	0.009	0.09
500	0.711	0.18	0.405	0.045	0.162	0.09	0.198	0.306	0.009	0.18

1000	0.711	0.27	0.351	0.135	0.18	0.18	0.225	0.36	0.018	0.225
1500	0.675	0.2691	0.306	0.162	0.162	0.297	0.288	0.36	0.027	0.315
2000	0.64675	0.333	0.234	0.18	0.18	0.45	0.252	0.369	0.036	0.342
2500	0.52735	0.351	0.18	0.171	0.207	0.45	0.225	0.351	0.045	0.35091
3000	0.44775	0.36	0.135	0.126	0.207	0.45	0.198	0.261	0.054	0.36
3500	0.44775	0.324	0	0.108	0.225	0.45	0.18	0.261	0.063	0.369
4000	0.44775	0.288	0	0.099	0.225	0.45	0.18	0.261	0.072	0.349992
4500	0.4577	0.225	0	0.09	0.225	0.45	0.162	0.261	0.081	0.349992
5000	0.48755	0.234	0	0.045	0.225	0.45	0.1638	0.261	0.09	0.349992

8.4 Performance evaluation based on the packet transmission to the BS: The put redirect mechanism gives the higher packet acknowledged by the BS is that, the fitness functions of BOA, PSO and ACO reserve the power utilization of the nodes due to which leads to elevate the quantity of active nodes in the network along which the data packet will be conveyed to the BS. The fitness function chosen for the CH choosing and route choosing, it helps to minimize the overhead in the routing process due to which a smaller quantity of nodes dies in each round during the data transmission and it leads to the higher quantity of data acknowledged by the BS. In the extant mechanism, the inappropriate quantity of CH choosing and routing overhead, the lesser quantity of data is conveyed to the BS. Fig 13 shows the quantity of data acknowledged by the BS if there are 250 nodes are present in the case and Fig 14 shows the quantity of data acknowledged by the BS if there are 150 nodes are present in the case.

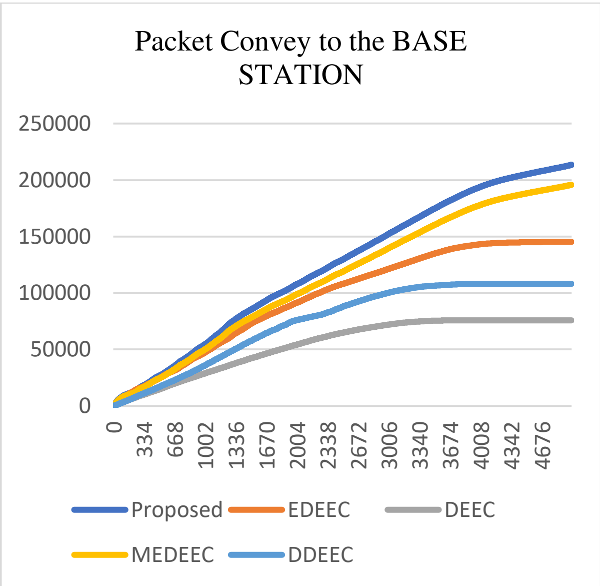


Fig 13: For the 250 Nodes

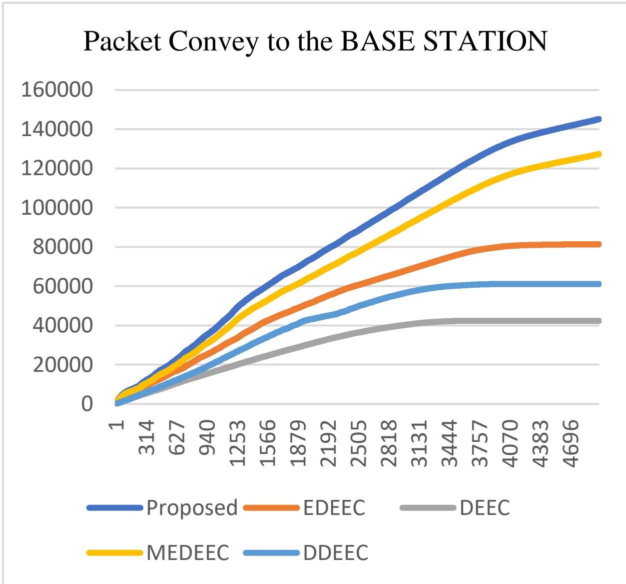


Fig 14: For the 150 Nodes

8.5 Performance evaluation of throughput: The inappropriate choosing of CH in the extant mechanism is the main reason for the higher power utilization in the data transmission. The put redirect mechanism chooses the CH and the route in the efficient way due to which higher data are conveyed to the BS and achieve the efficiency. The comparison of put redirect mechanism is correlated with the extant mechanism.

8.6 Performance evaluation of the network lifespan: Network lifespan is totally dependent on the remaining power of the nodes and the lifespan of the network got exhausted when entire node will lose their power. The network lifespan of the entire network is correlated when the first node die, half of the nodes die and last node die in the network. It is well said by the researchers that the demise of the 1st node in the network doesn't disturb the network execution but the system performance is affected when half of the node die in certain rounds or in the data transmission. Furthermore, the entire network gets drained when all the nodes die. So, to upgrade the network lifespan, the optimal quantity of CH choosing per round and chosen of optimal path from node to BS is mandatory requirement in the present case.

8.7 Comparative survey of the put redirect procedure with further cluster-based routing mechanisms

The comparative survey of the put redirect mechanism is correlated with some extant mechanism is shown in the figure 15. Table 7 shows the Comparative survey of Delay, Packet Drop Ratio, Throughput to the BS with the extant routing protocol.

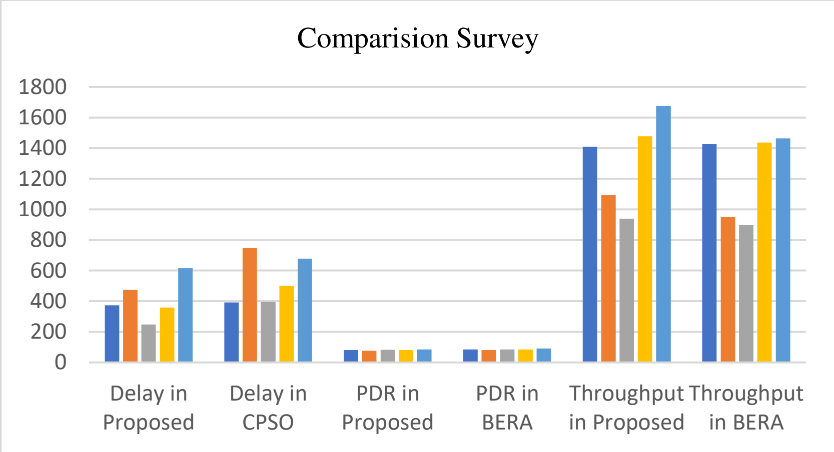


Fig 15: Comparison survey with CPSO, BERA

Table 7: Comparative survey of Delay, Packet Drop Ratio, Throughput to the BS with the extant routing protocol

	Delay		PDR		Throughput	
Nodes	Put redirect	CPSO	Put redirect	BERA	Put redirect	BERA
50	373.82	391	81.8197	84.0419	1409.99	1427.34
100	473.45	746.97	76.6302	80.0872	1094.45	951.33
150	248	395.48	82.5347	84.9127	940.1	899.76
225	359	501.48	80.4411	83.9704	1477.54	1436.96
315	616.1	677.81	85.1583	90.3678	1677.48	1463.59

	Delay		PDR		Throughput	
Nodes	Put redirect	FUCHAR	Put redirect	FUCHAR	Put redirect	FUCHAR
50	467.57	465.57	79.2301	83.1894	1415.3	1409.87
100	517.78	515.78	79.8012	81.1282	989.09	952.42
150	444.22	442.22	83.2691	84.238	989.44	937.5
225	696.14	694.14	85.7013	88.1779	1563.04	1502.28
315	539.6	537.6	90.044	91.5886	1475.36	1383.06

9. Conclusion

In the extant case of Wireless Sensor Network, the power utilization of the network is very high due to which the network lifespan gets turn down. So, to upgrade the network lifespan author focus on the following parameters such as optimal quantity of CH choosing par round, quantity of cluster formation and the optimal route choosing. The author uses the BOA, PSO and ACO to turn down the power utilization per round and elevate the network lifespan. The BOA mechanism is used to choose the CH, the fitness function was used with consideration of five parameters such as remaining power of the node, interspace from the nodes and the BS, node centrality and the node degree to turn down the CH choosing per round. The PSO is used to form the cluster by using certain parameters such as interspace to the CH and the BS. The ACO is used to find the best route from source to the destination by considering following parameters such as interspace to the neighbour node, remaining power of the nodes and the node degree. The performance of the put redirect mechanism was measured in three different cases in which the BS was situated at different positions. The put redirect mechanisms were correlated with the extant mechanism and result shows that the put redirect mechanism gives the higher result in terms of stability period.

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Declarations

Conflict of Interests The authors declare that there is no conflict of interests regarding the publication of this paper.

Consent for publication "Not applicable"

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