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FOC-MOP – Fuzzy optimal clustering based Multi-Objective parameter route selection for energy efficiency

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Abstract

Recently, the research area interest towards the development of wireless sensor network (WSN) has increased. However, WSNs have one of significant issues as improving an energy-efficient routing protocol. A WSN has a crucial problem of energy consumption that effects the network lifetime as sensor nodes have a limitation of power. To overcome these limitations, it's required to improve energy-efficient communication protocols for WSNs. Different types of techniques have considered by various research communities for providing energy-efficient solutions for WSNs. The energy consumption reduces using the clustering as an efficient data collection method and the collected data forward to a cluster-head which belong to the nodes in clustered networks. The information transmits to BS (base station) either in an uncompressed or compressed manner after collecting all data by a cluster-head from all member nodes. Based on other cluster-heads, the data transmit in a multi-hop network. Due to the heavy inter-cluster relay, earlier death happens to the cluster-heads (CHs) that locates very closely to the sink. Therefore, a fuzzy optimal CH selection algorithm has proposed to select the optimal CHs to improve the lifetime. Based on different parameters like cluster load, communication cost, neighbour density, node degree, inter and intra cluster distance, and node energy, the proposed algorithm of CH selection chooses the CHs. To determine an optimal route for transmitting the data from CH to sink, the modified Emperor Penguin Optimization (EPO) uses after selecting the CH. The proposed technique implements and compares with other earlier methods in terms of packet delivery ratio, lifetime, energy consumption, end to end delay and throughput. The proposed approach shows best performance than the other methods based on the simulation results.

Keywords: Cluster load, Emperor Penguin Optimization, Fuzzy optimal, Cluster head selection, WSN.

I. Introduction

Wireless sensor network includes a range of sensor nodes which are distributed spatially and interconnected without using any wires. For transmission of sensed data to other nodes and to a designated sink point, i.e., Base Station (BS) via wireless channels, the environment sensing performs by sensor nodes and their communication components utilize in a WSN [1]. The transmitted data collects at BS to act as either an access point or a supervisory control processor

for a human interface or as a gateway for other networks. A wireless sensor network can perform the acquisition of concurrent data in existing conditions at different interest points located over wide areas based on the collaborative utilization of a massive number of sensor nodes. Figure 1 represent the architecture view of WSN.

Fig.1: Architecture of WSN

Because of the energy constraints of sensor nodes, their utilization limits severely in despite of the benefits of a WSN. During the data transmission, sensing of environment, and wireless communication, sensor nodes energy consumes in a network [2]. Various routing protocols focus on attaining the power consumption in WSNs. Most of the routing protocols are not well suited for wireless networks practically because they have developed for wired networks to obtain high Quality of Service (QoS) [3]. For data routing, different protocols have proposed for sensor networks.

Clustering has used as an energy efficient data gathering method for reducing the energy consumption. The collected data transmit by each node to a cluster-head which the nodes belong to in clustered networks [4]. The data transmit either in a compressed or uncompressed way to the BS once collecting the data from all member nodes. In a multi-hop network, the data transmit over other cluster heads. It tends to the earlier death of cluster heads closer to the sink owing to the heavy inter-cluster relay.

Fig.2: Clustering Network formation

In the past, different selection mechanisms have introduced as efficient CH selection can decrease consumption of energy. A simple process uses in most of the available approaches. The primary step includes the selection of CHs that contain higher remaining energy. The CHs among member nodes have rotated in the second step for energy efficiency. The nodes energy considers in these selection methods, not the nodes density and location. In multi-hop WSNs, the hotspots issue raises in case of not considering the deployed nodes location [5]. However, the problem refers to the CHs earlier death if they near to the sink or due to the inter-cluster traffic relay in crucial paths. Figure 2 shows the clustering formation as a network.

A multi-objective fuzzy clustering algorithm proposes to improve the lifetime of WSNs and overcome the limitations of previous methods. The CHs select using the proposed CH selection algorithm using different parameters like node degree, node energy, communication cost, inter and intra cluster distance, neighbour density, and cluster load [6]. After choosing the CHs, the modified Emperor Penguin Optimization (EPO) exploits for determining an optimal route to transmit the information from CH to sink to establish the collision-free routing path.

1.1 Background algorithm overview

1.1.1 Emperor Penguin Optimizer (EPO)

The emperor penguin, called *Aptenodytes forsteri* scientifically. In all of the penguin species, it is the heaviest and tallest one [7]. The female and male emperor penguins are similar in size and plumage. During winter season, emperor penguins breed and spend their lifetime in open ice. Emperor penguins are the species that only survive based on huddling during the Antarctic winter. Emperor penguins huddling behaviour decomposes into four phases such as:

- Produce and estimate the huddle boundary of emperor penguins.
- Determining the temperature profile around the huddle.
- Estimation of distance between emperor penguins.
- Relocating the effective mover.

The huddling behaviour has a significant feature that each penguin gets an equal opportunity for the huddle warmth. Mathematically, the huddling behaviour of emperor penguins models as follows. This model has an objective of determining an effective mover [8]. Here, the huddle assumes as situating on two-dimensional L-shape polygon plane. The huddle boundary produces by emperor penguins randomly in the first step. Around the huddle, the temperature profile and the distance between emperor-penguins have determined useful for more exploration and exploitation. The huddle boundary re-computes and the best optimal solution retrieves using the emperor penguins' updated positions with the effective mover. Figure 3 represent the flow chart of Emperor Penguin Optimizer method.

- **Huddle boundary generation of emperor penguins:** The positions of emperor penguins locating via a polygon shape border in a huddling. One or two neighbour penguins choose randomly by the emperor penguin for huddling. Based on the wind flow around a huddle, its boundary is calculated. Compared to the wind movement, a penguin mobility is gentler. To demonstrate the created random huddle boundary, complex variables have used.

- **Temperature profile estimation around the huddle:** The energy consumes while creating the huddle and increases the ambient temperature.
- **Distance estimation among emperor penguins:** Once the huddle boundary is generated, the distance between the best optimal solution and the emperor penguin has computed. The fitness value has concerned as the best and current optimal solution. The locations update for other search agents or emperor penguins based on the optimal solution.
- **Relocate the effective mover:** Updating the emperor penguins' positions based on the optimal solution or mover which is responsible for other search agents' varied locations in a current search space.

Fig.3: Flowchart of Emperor Penguin Optimizer

Contributions of this paper

This paper presents a fuzzy optimal CH selection algorithm that selects the optimal CHs based on fuzzy based multi objective parameters. To determine an optimal route for transmitting the data from CH to sink, the modified Emperor Penguin Optimization (EPO) is introduced. This helps to minimize the energy consumption and to enhancing lifespan of hierarchical WSN. Cluster creation is carried out by k-means clustering algorithm. This algorithm divides the data set into K clusters. In the presented approach, the CH for each cluster is selected based on multiple selection parameters such as cluster load, communication cost, neighbour density, node degree, inter and intra cluster distance, and node energy. After the CH selection, Emperor Penguin Optimizer (EPO) with an enhanced fitness function with link quality factor (LQF), relative distance factor (RDF), and residual energy factor (REF) parameters is utilized to identify an energy efficient route to transmit the data. The following are the main contributions in this paper:

- In this proposed method, the network is clustered and the CH for every cluster is selected based on multiple parameters such as cluster load, communication cost, neighbour density, node degree, inter and intra cluster distance, and node energy.
- This multi parameter CH selection algorithm increase the CH stability and avoids CH rotation and frequent CH re-election due to CH failure.
- The Emperor Penguin Optimization (EPO) algorithm with an enhanced fitness calculation method is introduced to evaluate the node fitness using different parameters like link quality factor (LQF), relative distance factor (RDF), and residual energy factor (REF).
- The optimal routing path determined by the proposed method reduces the routing load and improves the energy efficiency of the network with the help of EPO's efficient routing path selection strategy.

II. Literature Survey

In [9], the uniform setup phase of the CH selection has used in the centralized LEACH (LEACH-C) for providing an improved cluster. Unlike LEACH protocol, a steady-state phase has included in the LEACH-C. Both position and energy level data of sensor nodes transmit to the BS in set-up phase. The clusters are also creating by the BS. Compared to the formed clusters using the distributed algorithm, the centralized clusters are resulted better performance. The robustness and scalability don't provide for larger networks using centralized clusters. However, this algorithm has some limits. The network topology is required to keep unchanged over time, and sensor nodes are deployed uniformly. Another limit is that all the nodes are assumed to be homogeneous and have the same energy consumption model and each node is aware of its own position through RSSI localization. In particular, this algorithm is heuristic, which may lead to the failure of clustering.

In [10], the proposed technique resolves the sensor nodes issue that have homogeneous features that not suit for different practical applications. It's require to collect non-sensitive and

sensitive data that are differentiate each other. The sensor nodes with heterogeneous properties are appropriate for practical applications as all sensor nodes contain different characteristics. But this method failed to address the problem of unequal clustering and also leads to different sizes of clusters which leads to energy unbalancing among the member nodes.

In [11], authors propose two different protocols: one is developed based on a centralized approach (Fuzzy-C) and a special partitioning strategy, i.e., a centralized clustering algorithm which divides the network into a fixed number of clusters. The complete knowledge about network topology has included at the sink node as presumed. The sensor nodes separate into k clusters by the sink node and all CHs are bounded. Based on the neighboring data of a node only which would more essential for WSNs, the other technique with a distributed clustering algorithm. While simulating the results, a centralized algorithm uses as a benchmark for distributed algorithm performance evaluation. The better performance may provide using the centralized algorithm based on the network topology. Since this method works with fixed number of clusters, it may not work well in the dense networks and increase the cluster size where large number of nodes are involved.

In [12], the proposed scheme of RE_TOPSIS (Reliability-based Enhanced Technique for Ordering of Preference by Similarity-Ideal-Solution) has used to choose the CH efficiently and it is a distributed mechanism to introduce a Reliability Index in the F-TOPSIS. By using six different criteria for CH selection, the proposed technique of E-TOPSIS allows to take autonomous decisions by sensor nodes using obtained ranking indices. In the existing process of fuzzy based CH selection, deficiencies remove by the proposed technique. Within the transmission range spectrum, the status broadcasts to the nearby nodes with the elected CH. In a distributed algorithm, a self-directed decision can consider that has to be taken themselves as CHs by the nodes. From other CHs, multiple status updates receive by the remaining member nodes within the transmission range and link with the CH according to the maximum values of relative RSSI (Received Signal Strength Indicator) and the Euclidean distances. However, all nodes have operated with their own indices like their neighboring nodes. However, all nodes have operated with their own indices like their neighboring nodes.

K. Arthi and A. Singara Rajiva Lochana (2018) [13] has developed an energy-efficient Z-DSS (zone-based dual sub sink) protocol to improve the network lifetime near the trajectory in WSNs. For balancing the nodes energy consumption near to the trajectory, the mapping between nodes and SSs (sub sinks) has scheduled in the protocol. The collision during the data transmission between clusters reduces and improves the network throughput using the hybrid adaptive time synchronization technique. The proposed method shows best performance in the increased throughput and reduced energy consumption than the existing methods. However this hybrid adaptive time synchronization method minimizes collision during data transfer between clusters, but failed to address the routing overhead between the clusters.

Mohammed Farsi (2019) [14] proposes a novel protocol to limit the clustering and congestion in WSNs. Two different phases involve in the CCR (Congestion-Aware Clustering and Routing) protocol such as the setup phase and the transmission phase. Based on the features like fault tolerance, scalability, reliability, stability, load distribution, and low overhead, the characterization of CCR protocol has performed. Compared to the LEACH protocol, the

proposed method proves the best results in terms of network performance, prolonged lifetime, and increased transmitted data packets in each round. The main drawback in this method is the excessive consumption on energy during parameter estimation phase and there is no resource usage control mechanism like equipping nodes with GPS for knowing the distance between the nodes exist in this method.

S. Murugaanandam (2019) [15] has improved a new protocol known as RE-TOPSIS for reducing the sensor nodes' energy consumption. The performance factors of QoS such as packet delivery ratio, delay, and throughput have measured and chosen the best CH using the proposed technique. Based on the simulation studies, the proposed scheme provides the results in terms of improved network lifespan, reduced energy consumption, and decreased frequency by about 20 to 25% in CH selection per round than the LEACH and Fuzzy-TOPSIS methods. But this method failed to address the overhead occurs during data transmission especially in large networks and in dense clusters.

Sonam Lata (2020) [16] has proposed a new centralized fuzzy based clustering algorithm based on three parameters like centrality, concentration, and energy level. Fuzzy logic technique elects a vice cluster head. The proposed algorithm is outperformed in improved reliability and reduced energy consumption by analyzing the simulation results. The limitations found in this method is the absence of effective data aggregation in the clustered environment particularly in dense clusters. The routing overhead may get increased in dense clusters which affects the overall energy efficiency.

III. Proposed optimal CH selection & finding optimal routing using FOC-MOP method

Providing of an efficient and stable cluster heads is the major objective of the proposed method and an optimal routing scheme prolongs the network lifetime and decreases energy consumption. Two different phases involve in the proposed approach such as cluster head selection and cluster formation and route establishment. Based on the clustering mechanism, the clusters are formed. After that, fuzzy based multi-objective selection method is used for optimal CH selection. By using the parameters like inter & intra cluster distance, node energy, communication cost, neighbour density, node degree, and cluster load, the proposed algorithm of CH selection chooses the CHs. For optimal path selection, Emperor Penguin Optimizer method employs after selecting the CH. Thus, the energy consumption of sensor nodes reduce. Figure 4 shows the architecture view of proposed framework.

Fig.4: Architecture diagram of proposed system

Radio energy model

Energy model is described as an estimating energy depleted during the transmission, reception and data collection. The energy model used in our approach considers that 1 bit of data transmitted from the sender X to neighbour Y with the distance $Dis(x, y)$ with consumed energy $E(x, y)$ shown in the following equation. The energy consumption is categorized as follows. The first part denotes the energy consumed E_x on node X for initiating the outgoing data transmission. The second part denotes the energy spent E_s for transmitting the data from X to Y. The third part indicates the energy consumed E_c by the node Y to receive the data transmitted from node X to node Y. This whole process can be explained in the following equation 1

$$E(X, Y) = C_1 + C_2 + Distance(X, Y) \text{ Eq (1)}$$

Here, the C_1 & C_2 represent the constant value with the base of wireless devices type and application environment.

Cluster formation phase

The cluster formation is playing a key role in the energy consumption and it creates the cluster using k-means clustering algorithm. K-Means is considered to be the simplest unsupervised clustering algorithm used for clustering. This algorithm divides the data set into K clusters and value of K in this case is calculated using the below mentioned equation 2. The resulting clusters have more intra-cluster and less inter-cluster similarity. This algorithm consists of several iterations and steps:

$$k = \sqrt{\frac{n}{2\pi}} \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}} \frac{D}{x_{bx}^2}} \text{ Eq (2)}$$

where D refers to the network field dimension, n indicates the number of sensor nodes, and x_{bx} denotes the average distance of all sensor nodes to the BS.

After estimating the k value, compute the distance between the each sensor nodes to the cluster centers. The Euclidean distance formula is used to estimate the distance and each point assigned to the closest center of the cluster. Then determine the new center for the cluster using the

mean value of all sensor nodes in their respective clusters. The Euclidean formula is described as follows in equation 3:

$$DIS_{CC} = \sqrt{\sum_{i=1}^N (X_n - X_C)^2} \quad \text{Eq (3)}$$

Here, DIS_{CC} is the distance between nodes & center of the cluster, X_n represents the coordinate of the node n, X_C is the coordinate of the cluster centers.

CH selection phase

The proposed CH selection algorithm proposes a multi-parameter cluster head selection algorithm. The proposed CH selection algorithm selects the CHs based on Node energy, Inter & Intra cluster distance, Node degree, Neighbour density, Communication cost & Cluster load parameters. The description of the parameters are discussed below:

Node energy:

For CH selection, the sensor node with great residual energy uses as the CH node responsible for significant methods such as data aggregation and collection. To carry out different tasks, more energy is required. It describes using every SN balance energy using below equation 4:

$$NE = \sum_{i=1}^N \frac{1}{EN_{CH_i}} \quad \text{Eq (4)}$$

where, EN_{CH_i} represents CH remaining energy and n refers to the number of CHs.

Intra-cluster distance: The distance between CH and its members is the intra-cluster distance which can improve the link quality among CMs and CH and offer better cluster quality. By using below expression 5, the intra-cluster distance can determine:

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad \text{Eq (5)}$$

where, x and y represent the nodes 'n' coordinates on the search field D.

Node degree: The reachable cluster member (CM) nodes represent the CH degree which balances the load of CH. A CH node degree indicates using the following formulation 6:

$$NDE = \sum_{i=1}^N CM_i \quad \text{Eq (6)}$$

where, CM_i represents the ith member of CH.

Neighbour density: The detection of number of available neighbouring nodes is one of the major challenging problems for a SN. Node with highest possibility elects as CH and estimates the number of neighbors based on below equation 7:

$$\text{node density (ND)} = \frac{|n_i - n_0|}{n_0} \quad \text{Eq (7)}$$

where, n_i indicates the node's adjacent nodes and n_0 refers to the optimal number of neighbors, ND indicates node density.

Communication cost: To increase the high data delivery reliability, the communication cost must be considered. It helps to find out the feasible path for the communication that can sustain for the entire communication. Burst traffic may occur often in WSNs due to their periodic broadcasting nature. So, selecting the strong forwarders is important to control the data loss during transmission. The communication cost can be calculated in two ways.

- Intra-cluster communication cost
- Inter-cluster communication cost.

The inter-cluster communication cost defines as the sum of links' costs between the CHs and the total links' cost between all cluster members and their CHs is described in the intra-cluster communication cost. By using below equation 8, the communication cost can estimate.

$$C_{cost} = \frac{d_{avg}}{B_r} \quad \text{Eq (8)}$$

where, B_r indicates the node broadcasting radius, and d_{avg} refers to the average distance between a node and its neighbour node.

Cluster load: For load balancing between CHs, the cluster load parameter uses. The reduction of maximum load between various CHs is considered and can express as follows in equation 9:

$$CL = \frac{\max(|C_j|)}{\frac{1}{C} \sum_{j=1}^C (|C_j|)}; \quad \forall j = 1, 2, \dots, C \quad \text{Eq (9)}$$

By using the below formula 10, a weight determines using above parameters:

$$W_n = C_1 NE + C_2 D + C_3 NDE + C_4 ND + C_5 C_{cost} + C_6 CL \quad \text{Eq (10)}$$

where, C_1, C_2, C_3, C_4, C_5 , and C_6 are weight factors, and $C_1 + C_2 + C_3 + C_4 + C_5 + C_6 = 1$. The node that has smaller value of weight will choose as the cluster head.

Fuzzy model

Fuzzy Logic method uses for choosing the best candidate to process the CH in the proposed work. For decision making behavior of human being, fuzzy logic approach operates as an efficient one. In the proposed work, the fuzzy system basic structure shows below in figure 5:

Fig.5: Basic structure of fuzzy system

Fuzzifier: In Fuzzy based applications, the system inputs are crisp set which need to be transformed into fuzzy sets. Each fuzzy set is assigned a degree of membership. Thus, conversion of crisp set into suitable linguistic value is done with fuzzifier.

Fuzzy Rule Base: It consists of IF-THEN rules decided by the user. Rule base with if-then defines the dynamic behavior of the fuzzy system. The fuzzy rule base is also referred to as knowledge base.

Inference Engine: Fuzzy inference engine with inputs and IF-THEN rules tries to simulate the inference system of human being. Fuzzy Inference Engine plays a vital role in inferring and drawing conclusion from the conditions in rule base.

Defuzzification: Defuzzification process carry out the mapping of the fuzzy set acquired from the inference engine into a crisp output value which can be used for drawing some conclusion.

Fuzzification

We used five multi objective variables as input for FL. Node energy, Inter & Intra cluster distance, Node degree, Neighbour density, Communication cost & Cluster load are the multi objective selection parameters. The fuzzifier crisp input variable with their maximum and minimum values for calculating CH eligibility are shown below.

Input	Variables
Node energy	low medium high
Distance	low medium high
Neighbor density	sparse medium dense
Communication cost	low medium high
Cluster load	low medium high

Fuzzy rule base

Membership values obtained after fuzzification are fed to the rule base for IF-THEN conditions. Using the Fuzzy AND and OR operators on the inputs, a value is obtained. Aggregation method union all the output and a maximum value is chosen from the aggregated fuzzy set. To obtain the eligibility index by the Fuzzy Logic, the following fuzzy rules are used.

Rule	Energy	Distance	Density	Cost	Load	Eligibility
1	Low	Low	Dense	Low	High	Good
2	Medium	Low	Dense	Medium	High	Better
3	High	Low	Dense	High	High	Better
4	Low	Low	Sparse	Low	High	Good
5	Medium	Medium	Medium	Medium	Low	Better
6	High	Low	Medium	High	High	Good
7	Low	Low	Medium	Low	High	Good
8	Medium	Low	Medium	Medium	High	Better
9	High	Low	Sparse	High	High	Better

10	Low	Medium	Dense	Low	Medium	Good
11	Medium	Low	Sparse	Medium	High	Better
12	High	Medium	Dense	High	Low	Far better
13	Low	Medium	Sparse	Low	Low	Better
14	Medium	Medium	Dense	Medium	Low	Far better
15	High	Medium	Medium	High	Low	Far better
16	Low	Medium	Medium	Low	Low	Good
17	Medium	Medium	Sparse	Medium	Low	Far better
18	High	Medium	Sparse	High	Low	Far better
19	Low	High	Dense	Low	Medium	Good
20	Medium	High	Dense	Medium	Medium	Far better
21	High	High	Dense	High	Medium	Far better
22	Low	High	Medium	Low	Low	Good
23	Medium	High	Medium	Medium	Low	Better
24	High	High	Medium	High	Low	Far better
25	Low	High	Sparse	Low	Medium	Good
26	Medium	High	Sparse	Medium	Low	Far better
27	High	High	Sparse	High	High	Far better

All the nodes are compared on the basis of eligibility and the node with the maximum chance is then elected as the cluster-head. Each node in the cluster associates itself to the cluster-head and starts transmitting data.

Optimal path finding with EPO

From current CH to sink, the optimal path determines using the Emperor Penguin Optimizer (EPO) to improve the multi-hop routing efficiency and reduce the cost of long-distance transmission, and to decrease the energy utilization while data transmission on routing path. For transmitting data, an adjacent CH will elect as relay node when longer communication distance exists among the corresponding CH and Sink. Compared to the direct transmission between corresponding sensor node and sink, more energy saves. Different parameters like link quality factor (LQF), relative distance factor (RDF), and residual energy factor (REF) have considered to transmit the data with reduced energy and balance the load. They can estimate using below equations 11-13:

$$REF = \frac{\max(En(CH_i)) - (En(CH_j))}{\max(En(CH_j))} \quad \text{Eq (11)}$$

$$RDF = \frac{DIS(CH_i, CH_j)^2 + DIS(CH_j, SI)^2}{\max(DIS(CH_i, CH_j)^2 + DIS(CH_i, SI)^2)} \quad \text{Eq (12)}$$

$$LQF = \frac{RT_n - RT_{min}}{RT_{max} - RT_{min}} \quad \text{Eq (13)}$$

Whenever source node CH_i distant away from sink, it's vital to choose the relay sensor node CH_j . The relay node with lower cost of link chooses to transmit the information to sink. The fitness function computes using below equation 14:

$$fitness = \sum_{i=1}^n w_i * fp_i, \quad \text{where } \sum_{i=1}^N w_i = 1 \quad \text{Eq (14)}$$

Where, fp_i refers to the particle i fitness parameters.

The routing method with EPO characterizes into four different steps such as:

- CH neighbours random generation
- Energy determination among produced CH neighbours
- Compute the distance among CH neighbours
- Relocate the best mover

Random generation of CH neighbours: The CH determines two adjacent CHs from the transmission range randomly in the step. Based on the network field gradient (link speed or transmission), the adjacent neighbouring CHs have chosen.

Energy estimation among generated CH neighbours: Due to the CHs selection with high speed within the range, more energy can save on sensor nodes under the process of CH neighbour generation. The energy profile performs completely in the EPO's exploration and exploitation process. The remaining energy on CHs detects while estimating the energy profile.

Estimating distance among the CH neighbours: By computing the distance among CHs, the best optimal solution will estimate.

Relocating the mover: For transmitting the information to the retrieved best solution agent, the CH uses in the mover. The best adjacent CH position will update and perform using below equation 15:

$$UP_{CH}(x + 1) = best(x) \quad \text{Eq (15)}$$

The updated position indicates as $UP_{CH}(x+1)$. The above equation shows the updating of next position of CH for transmitting the data. The similar process continues until retrieving the path to reach the SINK.

Algorithm

```

For all node n
    Clustering
    Select CH for each cluster
        Calculate weight (n)
    If (weight = low)
        Select 'n' as cluster head
    End if
End for
Initialize the parameters
For all nodes n
    Fitness (n)
Estimate energy profile
    For all nodes n
        Estimate the best agent
        Update the best optimal CH selection
    End for

```

```

End for
Evaluate the fitness of the CHs
  For each CH
    Estimate REF, RDF, LQF
    If (REF & RDF & LQF = high)
      Select the CH for data forwarding
    Else
      Reject the CH for data forwarding
    End if
  End for
Update the best path
End

```

IV. Result and discussion

Simulation setup

The proposed method evaluation and comparison with the existing techniques have described using the following scenario. In a 1000x500m network area, the random deployment and sparse feature of sensor nodes is considered. The node position is static. The network size is varied from 50 to 400. The initial energy of the sensor nodes is 100joules. CBR traffic is enable for communication and the sensor nodes are able to send the data packet at the constant bit rate level. The data packet size is 1024bytes. The network was simulated for up to 100ms. Table 1 shows the simulation parameters. The cluster parameters represented in table 2.

Table1: Simulation parameters

PARAMETER	VALUE
Application traffic	CBR
Transmission rate	1024 bytes/ 0.5ms
Radio range	250m
Packet length	8192 bits
Routing Protocol	AODV
Simulation time	100ms
Number of nodes	50, 100, 200, 300, 400
Area	1000 x500 m ²
Transmission Protocol	UDP
Initial Energy	100j

Table2: Cluster parameters

PARAMETER	VALUE
Clustering algorithm	k-means
Cluster type	Unequal
Number of clusters	4 to 8

Node deployment	Random waypoint
-----------------	-----------------

The execution was carried out multiple times under different network sizes. The results were compared with some of the existing methods like Z-DSS, CCR, RETOPSIS & LEACH-FC. The parameters of energy consumption, packet delivery ratio, network throughput, routing overhead, and end-to-end delay have evaluated to verify the network performance. The evaluation results are described below:

Fig.6: End to End Delay

The above result figure 6 shows the experimental outcome of the execution of the both existing and the proposed methods under 50 to 400 varying network sizes. End to end delay is described as the difference of estimated time and the total time taken by a data packet to reach the destination. Congestion affects the end to end delay of the data packets. In the proposed method, the congestion is effectively handled by the fuzzy congestion control algorithm. Hence the delay in the proposed method is comparatively less than the previous methods. The simulation results are listed in the table 3 below:

Table3: Comparison Analysis of proposed with existing methods for Delay

NODES	FOC-MOP	LEACH-FC	RETOPSIS	CCR	Z-DSS
50	0.011	0.037	0.062	0.079	0.085
100	0.025	0.041	0.084	0.098	0.106
200	0.068	0.084	0.146	0.168	0.195
300	0.148	0.160	0.191	0.217	0.256
400	0.259	0.316	0.338	0.362	0.410

Fig.7: Energy Consumption

Energy is the vital parameter for the sensor network. Every node in the network is equipped with initial energy. In our simulation the initial energy was 100joules. The sensor nodes consumes energy to perform network activities. The energy consumption should be optimized for improved network lifetime. The selection of energy efficient routing path by the proposed EPO algorithm optimizes the energy consumption and network lifetime. The existing methods were not considered the energy efficient path hence the energy consumption comparatively higher than the proposed method. The average energy consumption rate of the proposed method was 6.5j where as it was as high as 8.5j in the previous methods. Figure 7 represent the graphical view of energy consumption. The simulation results are listed below table 4:

Table4: Comparison Analysis of proposed with existing methods for Energy consumption

NODES	FOC-MOP	LEACH-FC	RETOPSIS	CCR	Z-DSS
50	3.14	3.96	4.72	4.87	5.13
100	3.92	4.68	5.01	5.23	5.48
200	4.93	5.18	5.93	6.071	6.210
300	5.8	6.14	6.8	7.027	7.348
400	7.067	7.510	8.20	8.619	8.943

Fig.8: Overhead

The parameter overhead is related to the amount of overhead incurred to the network often due to the implemented method / algorithm. It is related to the amount of additional control packets, resources the algorithm / method requires to complete the given task. Also, the frequent disturbances in the routing path often increase the overhead. In the proposed method it was controlled by the EPO algorithm with the effective selection of energy efficient paths. Also, the effective clustering of the network improves data aggregation. Thus, the overhead was under controlled level in the proposed method where the existing methods failed in this. Figure 8 shows the graphical representation of Overhead. The recorded overhead values are listed below table 5:

Table5: Comparison Analysis of proposed with existing methods for Overhead

NODES	FOC-MOP	LEACH-FC	RETOPSIS	CCR	Z-DSS
50	1.29	1.38	1.43	1.55	1.69
100	1.26	1.44	1.58	1.96	2.17
200	1.40	2.01	2.42	2.93	3.05
300	2.30	3.06	3.77	3.91	4.18
400	3.01	4.19	4.59	4.90	5.11

Fig.9: Packet Delivery ratio

PDR can define as the ratio between total number of delivered packets and the total number of sent packets from source to destination node. The path failure, congestion are the prominent factors that affects the PDR rate. The effective data aggregation through cluster heads and the energy efficient path selection of the EPO algorithm ensures the smooth delivery of the data packets to their own destination. The existing methods provided the solution for congestion controlling and did not consider about the effective routing. So the PDR of the existing methods was as low as 0.85 whereas the PDR was as high as 0.97 in the proposed method. Figure 9 shows the packet delivery ratio. The experimental results are listed below table 6:

Table6: Comparison Analysis of proposed with existing methods for PDR

NODES	FOC-MOP	LEACH-FC	RETOPSIS	CCR	Z-DSS
50	0.9310	0.9156	0.8719	0.8690	0.8125
100	0.9795	0.9369	0.9026	0.8847	0.8348
200	0.9991	0.9430	0.9103	0.8973	0.8418
300	0.9726	0.9497	0.9256	0.9065	0.8578
400	0.9739	0.9548	0.9370	0.9186	0.8794

Fig.10: Throughput

Throughput refers to how much data can be transferred from one sensor to another in a given amount of time. Throughput defines the successful transmission rate of the network. The occurrence of congestion in the routing path is major factor affects the network throughput. The efficient path selection strategy of EPO and data aggregation used in the proposed algorithm keeps the throughput high in the proposed method. The highest throughput rate recorded in our execution was 171kbps in the proposed method whereas throughput in existing methods was as low as 124kbps. Figure 10 represent the throughput. The complete experimental results are listed below table 7:

Table7: Comparison Analysis of proposed with existing methods for Throughput

NODES	FOC-MOP	LEACH-FC	RETOPSIS	CCR	Z-DSS
50	131.81	124.14	119.43	113.34	101.22
100	144.13	133.42	127.93	119.34	108.28
200	151.42	143.17	133.98	122.88	113.46
300	165.75	152.46	142.88	129.88	118.76
400	171.01	160.42	154.68	149.59	124.36

Conclusion

This work has introduced a Fuzzy optimal clustering combined with modified Emperor Penguin Optimization algorithm-based route selection for energy efficiency in WSNs. The paper proposed the FOC-MOP algorithm based on the emperor penguin optimizer. The proposed work has utilized the multi-objective cluster head selection technique for efficient CH selection in the clustered environment. The proposed CH selection algorithm selects the CHs using the inter and intra cluster distance, node energy, node degree, neighbour density, communication cost & cluster load parameters. The modified EPO algorithm identifies an optimal route for data transmission from CH to sink. The modified EPO utilizes residual energy factor, relative distance factor & link quality factors to identify the best nodes for routing purpose. Based on the nodes and varied population size in WSNs, the proposed model has simulated. Compared to the earlier energy optimization protocols, the proposed FOC-MOP algorithm provides best results in achieving energy efficiency and increased network lifetime through the simulation outputs.

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