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RESEARCH ARTICLE OPEN ACCESS

SPOTTED HYENA BIO-INSPIRED OPTIMIZATION CLUSTERING AND FORD DISTRIBUTING SHORTEST ROUTING FOR EFFICIENT COMMUNICATION IN WIRELESS SENSOR NETWORK

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ABSTRACT

Wireless Sensor Networks (WSN) contain sensor nodes that transmit with each other using only wireless channels. They are deployed in unreachable regions to gather information about the circumstances. Nonetheless, sensor nodes have limited energy, which poses a significant challenge to expanding Network Lifetime (NL). Therefore, the most crucial issue is to reduce nodes' energy consumption and increase the NL. To cope with these problems, this research uses the Ford Distributing Shortest Routing Protocol (FDSRP) with Spotted Hyena Bio-inspired Optimization (SHBiO) technique for efficient data transmission in WSN. Initially, the proposed forms Cluster Members (CMs) using the Reliable Congestion Free Node Selection (RCFNS) method. Based on the CMs, the optimal Cluster Head (CH) picks using the SHBiO method. Subsequently, the proposed FDSRP protocol finds the shortest path between CH and the Base Station (BS). This proposed protocol works based on a proactive process to transmit packets. The proposed simulation experiment is conducted in a Network Simulator version 2 (NS2) environment. Analysis shows the proposed method produces significantly better throughput, packet transmission, and drop rate while consuming less energy than other methods.

I. INTRODUCTION

WSN comprises numerous small nodes with sensing, computing, and data transmission capabilities [1]. It is prevalent in various applications, such as green agriculture, medical care, military, and environmental monitoring, because they are convenient to deploy, easy to self-organize, and capable of real-time tracking [2]. It consists of several fully connected and wirelessly connected sensor nodes. Each sensor node collects incoming possibilities, grabs data, and transmits it back to the Base Station (BS) [3]. However, since most sensor nodes are battery-powered, replacing or recharging the battery is challenging.

Nonetheless, the energy of WSN nodes is still restricted, and it should be designing energy-efficient routing protocols to decrease energy consumption [4], [5]. By grouping the WSN nodes, the nodes' Energy Consumption (EC) can be virtually reduced, and the network's life cycle can be prolonged [6]. Behind the WSN nodes, usually, a cluster forms, with a CH node elected in each cluster [7]. Thus, cluster quality and CH selection significantly impact network performance and lifetime [8]. In clustering, nodes are grouped to construct clusters, as presented in Figure 1. The cluster consists of members called CMs, and each cluster selects a CH to collect and transmit the packets (data) to the BS.

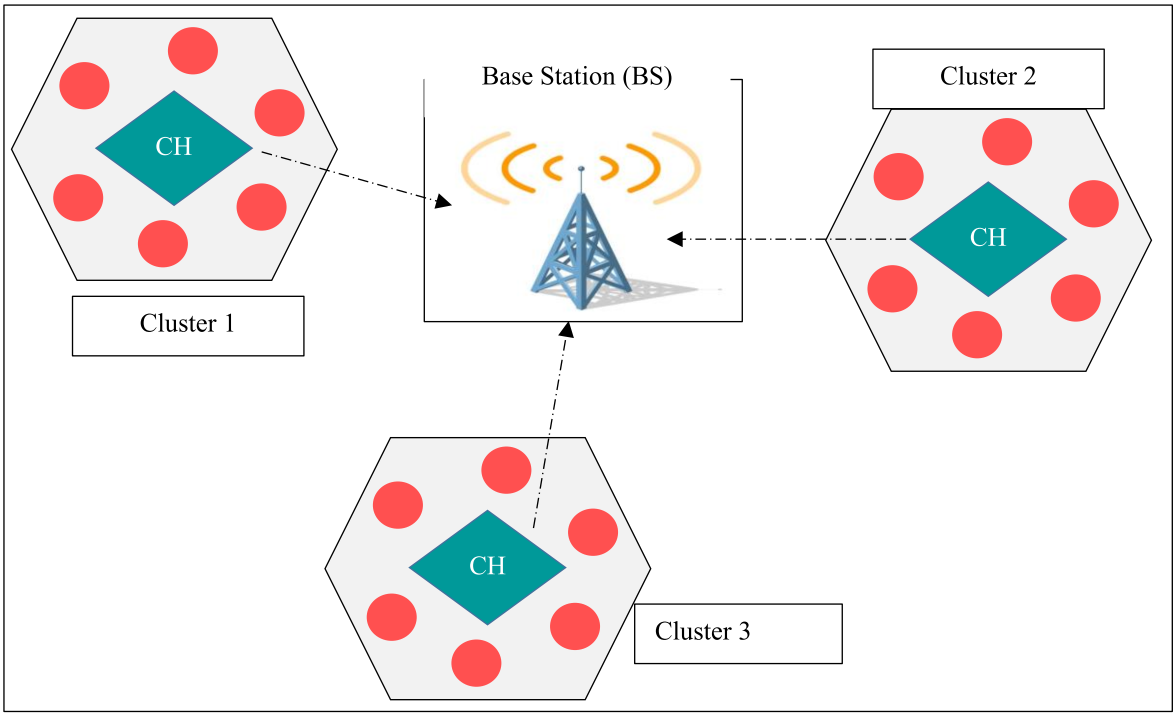

Figure 1: Structure of Cluster formation.
Source: Authors, (2026).

Therefore, different approaches were required for CH decision-making. However, if the CH is selected incorrectly, the packet transmission between the cluster members and the sink nodes will consume more energy than other sensor nodes. An outline of research issues related to WSN energy optimization follows:

- Network durability and data transfer efficiency are challenged as energy resources are limited within WSN nodes.
- Traditional methods had a high delay during data communication in the network.
- It isn't easy to design an effective leadership election technique.

This research introduces FDSRP with the SHBO methods for WSN based on the research issues. The foremost goal of this research is to use the shortest path to enhance Energy Efficiency (EE) and data communication performance in WSNs. This study's significant contribution is outlined as follows:

- We devise an RCFNS method to form a cluster of members for data communication.
- The SHBiO method quickly finds solutions in WSNs and determines the better CH from CMs.
- To design, a proposed FDSRP protocol is employed to find the shortest path between CH and BS.
- Efficacy CH preference and the creation of appropriate data communication aid increase the network's average lifetime.
- Additionally, the BS will acquire more packets because nodes utilize less energy to transmit packets.

Table 1: Nomenclature.

Notations	Description
$\mathcal{L}_N$	List of nodes
n	node
$\mathbb{M}_{Tr}$	Traffic mass
$\mathcal{P}_{size}$	Packet size
$\mathcal{T}_{\mathfrak{B}q}$	Total buffer queue
$\mathcal{M}_q$	Maximum buffer queue
$\mathcal{C}_{level}$	Congestion level
$\mathbb{T}_{Energy}$	Transmit energy
$\mathbb{R}_{Energy}$	Received energy
$\mathbb{J}$	Constant
Avg_{Energy}	Average energy
$\vec{g},\vec{k}$	Coefficient vector
$\vec{\mathfrak{D}}_{\mathcal{H}}$	Hyena distance
$MinN_{count}$	Minimum node count
PR_I	Previous route information
N_{count}	Hop count

Source: Authors, (2026).

Table 1 describes the nomenclature used in this paper.

I.1 ORGANIZATION OF THIS PAPER

Section 2: Review of existing works
It examines the recent methods of packet communication in the WSN environment.

Section 3: Proposed design
Detailed proposed design methodologies, architecture diagram, and flowcharts are illustrated.

Section 4: Experiment result analysis
Simulation results setup and comparison performance analysis are described.

Section 5: Conclusion of the work
It presents the summary of the proposed work findings and the results obtained from the proposed work.

II. BACKGROUND STUDYaveley

The author [9], concentrated on EE communication in 5G WSNs with an IoT environment. This study involved the Deep Belief Network (DBN) technique for a routing protocol and the Mantaray Foraging Optimization (MRFO) algorithm to elect the CH for data communication. Thus, the methods offered increased the PDR and NL while reducing energy consumption. By 10] the study deals with the efficient WSN using the MOFAC-GA-PSO method. In turn [11] focused on the QoS improvement routing in WSN. This study used the Elite Niche Clonal Evolutionary Computing (ESQRA-ENCEC) method to minimize the latency and energy consumption in the network. However, multi-hop communication is a challenging task for data transmission.

By [12] have designed an Emperor Penguin Colony (RPC) method for EE data gathering in WSN. The suggested method analyses the intrusions and ignores the malicious nodes in the network. Yet, nodes are generally powered by batteries, which have restricted power and are challenging to replace, [13], [14] have concentrated on link quality in WSNs with IoT. The study employed the Link Quality-based Energy-Efficient Routing (LQEER) protocol to calculate the connection rate during communication. This method decreased the packet loss in the network. According to [15] novel focused on enhancing the NL in the IoT network using an Improved Energy-Efficient Clustering Protocol (IEECP).

This method contained the CH selection using the fuzzy method to reduce the node's energy consumption. However, the offered protocol suffered the CH selection because it didn't analyses adequate energy for data communication. By [16] developed Meta-inspired Hawks Fragment Optimization (MIHFO) with Energy Efficient Engroove Leach Clustering Protocol (EELCP) to resolve the previous issue. Then, they introduced a protocol to create a group for communication. Then, the Heuristic Wing Antfly Optimization (HWAFO) approach is used for path selection for data communication. However, it fails to attain efficient PDR throughput performance.

Table 2: Summary of extant approaches for WSN.

Author's name	Published year	Method used	Features	Issues
[17]	2021	BSO–MTLBO	Minimize the energy draining.	It is a complicated task.
[18]	2022	CVX-DV-hop	Resolve optimization issues.	High cost.
[19]	2024	Angle-Based Asymmetric Sorting Method	Minimize the computation overhead	Didn't provide QoS performance.
[20]	2024	MinMax-DV-hop	Address optimization problems.	Failed to achieve high PDR.
[21]	2024	RANP-PSO	To improve the localization accuracy.	Higher energy consumption.
[22]	2021	MACO-QCR	Less delay and high energy efficient.	High traffic.
[23]	2024	HDASCII-AE	Improved energy efficient.	Data transmission is an arduous task.

Source: Authors, (2026).

Table 2 illustrates the summary of extant approaches for WSN. By [24] Study has presented a shuffled ARSH-FATI method for lifetime maximization in the network. Another study [25] used a Salp Swarm Algorithm (SSA) technique for NL maximization in the network. This method enhanced the energy efficiency performance. Likewise [26] the novel employed cooperative WPT-based multihop communication for NL maximization.

III. PROPOSED DESIGN

This section illustrates the details of the proposed SHBiO-FDSRP approaches and explains how the optimal CH selection process can extend the network lifetime. The proposed workflow is presented in Figure 2. The proposed system involves vital stages: i) Node deployment, ii) Forms a cluster of members, iii) CH selection and iv) Shortest path identification.

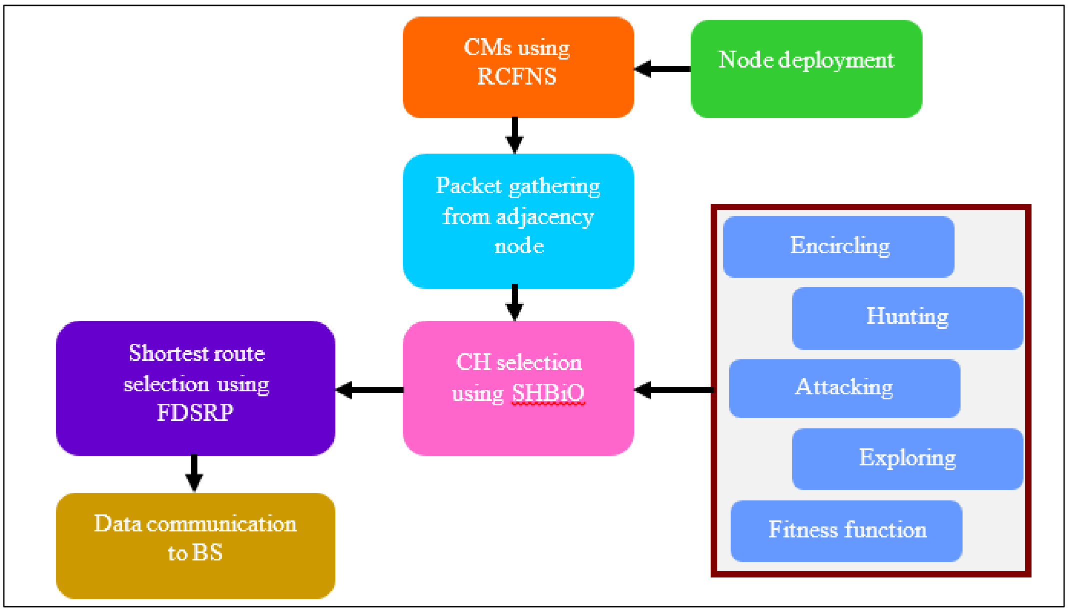

Figure 2: Proposed overview of the packet communication.
Source: Authors, (2026).

Firstly, nodes are generated randomly in the network, and then energy-efficient nodes form a group. Following that, the proposed SHBiO method is utilized for efficient CH selection for data transmission to BS. Finally, the shortest path is identified using the FDSRP protocol.

III.1 NODE DEPLOYMENT

The node deployment phase is crucial to the success of data transmission. At this stage, approximately 100 nodes are used in the network. The nodes are distributed at various positions from top to base over a 1000*1000m area. Every node has a distinct identity, energy, etc., which is maintained in the route table. Figure 3 describes the node deployment in WSN. Let assume, list of nodes$\mathcal{L}_N = \{n_1, n_2, n_3 \dots n_N\}$, where, n lies the nodes in the network and N denotes total number of nodes.

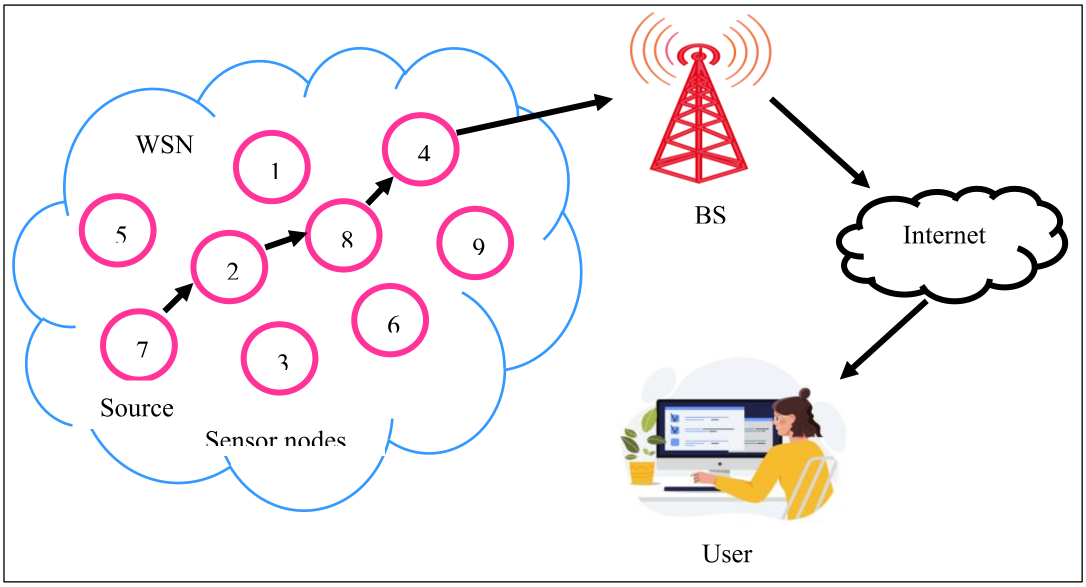

Figure 3: Architecture for distribution of node in WSN.
Source: Authors, (2026).

III.2 RELIABLE CONGESTION FREE NODE SELECTION (RCFNS)

In this phase, the Reliable Congestion Free Node Selection (RCFNS) approach is employed to form cluster members in the network. This method identifies the traffic less with reliable nodes for data gathering. When traffic volume increases, some data may not be sent or sent at the lowest transfer rate, resulting in data congestion without complete transfer. Overloading the node buffer queue can cause data deletion. To make the routing process more accessible, routes with less traffic must be chosen. All neighboring nodes adjust their queue lengths continually and send this information to the source. Traffic mass $(\mathbb{M}_{Tr})$ is estimated as the buffer queue size for all neighboring nodes, as described in equation 1.

$$\mathbb{M}_{Tr} = \frac{\sum \mathcal{P}_{size}}{\mathcal{T}_{\mathfrak{B}q}} \quad (1)$$

Here, $\mathcal{P}_{size}$ lies the packet size, and $\mathcal{T}_{\mathfrak{B}q}$ denotes the total buffer queue.

$$Tr_{\mathcal{L}} = \frac{\mathbb{M}_{Tr}}{\mathcal{M}_{\mathfrak{B}q}} \quad (2)$$

From equation 2 describes the maximum buffer based traffic congestion level$Tr_{\mathcal{L}}$. Here, $\mathcal{M}_q$ denotes the maximum buffer queue.

$$\mathcal{C}_{level} = 1 - Tr_{\mathcal{L}} \quad (3)$$

Equation 3 estimates the congestion level of each node in the network. The value of congestion level must be between 0 and 1. Greater than 1 indicates heavy traffic, which may result in high packet loss. Do not select this node as a forwarding node.

$$CM_{dis} = \sqrt{(a_1 - a_2)^2 + (b_1 - b_2)^2} \quad (4)$$

Equation 4 evaluate the two node distance based Euclidean process [27]. Accordingly, the energy needed to send or acquire a data over distance CM_{dis} can be expressed as:

$$\mathbb{T}_{Energy} = \mathbb{J} * CM_{dis} \quad (5)$$

The transmit energy $(\mathbb{T}_{Energy})$ node consumes energy to send data over a certain distance, and the energy is boosted based on the distance from the receiver. Below equation is used to estimate the received energy $\mathbb{R}_{Energy}$can be expressed as:

$$\mathbb{R}_{Energy} = \mathbb{J} * CM_{dis} \quad (6)$$

One node consumes receiver energy $(\mathbb{R}_{Energy})$to obtain data from other nodes. Like the transmitter, receiver energy relies on the distance among the transmitter and receiver.

$$Avg_{Energy} = \frac{\sum_{i=1}^{N-1} C_{reE}^{i}}{N} \quad (7)$$

From equation 7 calculate the average energy the node in the network. Here, C_{reE}^{i} lies the current residual energy of node. In WSNs, the proposed RCFNS method of picking the optimal nodes accomplishes proper cluster formation and expands the NL.

III.3 SPOTTED HYENA BIO-INSPIRED OPTIMIZATION (SHBIO)

The SHBiO method is used for Cluster Head (CH) selection based on hyena bio inspired process. The algorithm's central conception is to emulate spotted hyenas' social behavior. This method involves only four steps: encircling, hunting, attacking, and exploring. Figure 4 describes hyenas' searching for prey and hunting process.

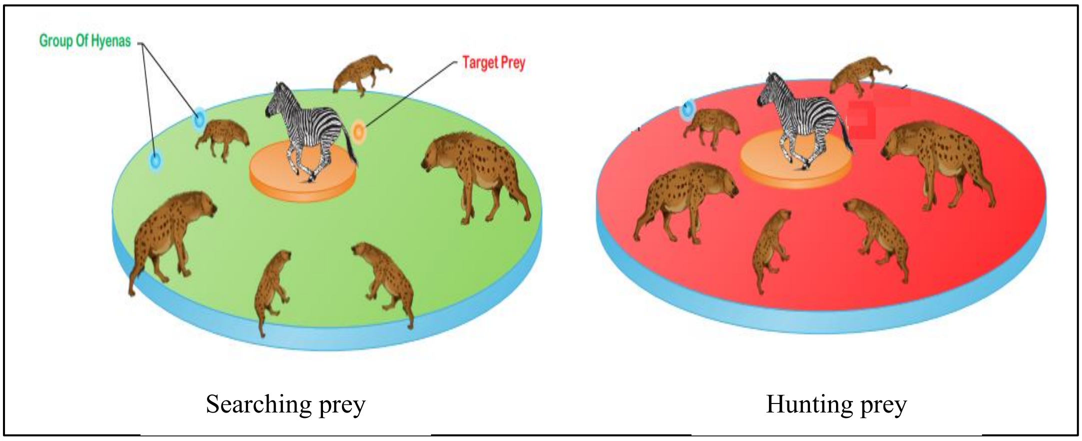

Figure 4: Graphical representation of SHBiO method.
Source: Authors, (2026).

In this method, a group of trusted friends directs hunting behavior to the optimal search agent and accumulates the optimal solution. The following expressions indicate spotted hyenas' encircling behavior.

$$\vec{\mathfrak{D}}_{\mathcal{H}} = \left|\vec{\mathcal{g}}.\overrightarrow{\mathbb{P}_{py}}(\mathrm{t}) - \vec{\mathbb{P}}_{\mathcal{H}}\right| \quad (8)$$

$$\vec{\mathbb{P}}(\mathrm{t}+1) = \vec{\mathbb{P}}_{py}(\mathrm{t}) - \vec{\mathcal{k}}.\vec{\mathfrak{D}}_{\mathcal{H}} \quad (9)$$

The above equation is find the prey and hyena distance$(\vec{\mathfrak{D}}_{\mathcal{H}})$. Let assume, $\mathfrak{t}$ lies the current repetitions, and $\vec{\mathcal{g}}$,$\vec{\mathcal{k}}$ are the coefficient vectors. $\vec{\mathbb{P}}_{py}$ and $\vec{\mathbb{P}}_{\mathcal{H}}$ are the location vector of prey and hyena, correspondingly. || denotes the absolute values and . denotes the multiplication.

$\vec{\mathcal{g}}$,$\vec{\mathcal{k}}$, $\vec{\mathcal{H}}$ calculations as,

$$\vec{\mathcal{g}} = 2 \cdot \overrightarrow{R_{v1}} \tag{10}$$

$$\vec{\mathcal{k}} = 2\vec{\mathcal{H}} \cdot \overrightarrow{R_{v2}} - \vec{\mathcal{H}} \tag{11}$$

$$\vec{\mathcal{H}} = 5 - \left(\text{repetitions} \times \frac{5}{Maximum_{\text{repetitions}}}\right) \tag{12}$$

Herein,$\overrightarrow{R_{v1}}$, $\overrightarrow{R_{v2}}$ are the random vectors limit [0,1], repetitions =0, 1, 2, 3 ....$Maximum_{\text{repetitions}}$. The search agent updates their hyenas and prey locations. To mimic the hunting manners of spotted hyenas and identify promising space areas, the following equation is expressed:

$$\vec{\mathfrak{D}}_{\mathcal{H}} = \left|\vec{\mathcal{g}} \cdot \overrightarrow{\mathbb{P}\mathbb{B}}_{\mathcal{H}} - \vec{\mathbb{P}}_{\mathcal{H}}\right| \tag{13}$$

$$\vec{\mathbb{P}}_{\mathcal{H}} = \overrightarrow{\mathbb{P}\mathbb{B}}_{\mathcal{H}} - \vec{\mathcal{k}} \cdot \vec{\mathfrak{D}}_{\mathcal{H}} \tag{14}$$

$$\vec{\mathcal{G}}_{\mathcal{H}} = \vec{\mathbb{P}}_{\mathcal{H}} + \vec{\mathbb{P}}_{\mathcal{H}+1} + \cdots + \vec{\mathbb{P}}_{\mathcal{H}+i} \tag{15}$$

Where, $\overrightarrow{\mathbb{P}\mathbb{B}}_{\mathcal{H}}$ lies the position of best hyenas and $\vec{\mathbb{P}}_{\mathcal{H}}$position of other hyenas. $\vec{\mathcal{G}}_{\mathcal{H}}$ Denotes cluster of hyenas. Based on the above process, the hyena strikes the prey, as denoted by the equation below.

$$\vec{\mathbb{P}}(\mathrm{t}+1) = \frac{\vec{\mathcal{G}}_{\mathcal{H}}}{i} \tag{16}$$

Algorithm steps:

Input: Hyenas$\mathcal{H}$, Avg_{Energy}
Output: Picking of Cluster Head (CH)
Start procedure
    Initialize the hyena's population $\mathcal{H}$
    Read nodes Avg_{Energy}
    Import parameters$\mathcal{g}$, $\mathcal{k}$
    $\overrightarrow{\mathbb{P}\mathbb{B}}_{\mathcal{H}}$ is the position of best hyena
    $\vec{\mathcal{G}}_{\mathcal{H}}$ is the cluster of hyena
    If $(\mathrm{t} < i)$
        For each search
            Update the present location of hyena
        End for
        Update the parameters
        Estimate the fitness of each hyena
        Update the $\vec{\mathcal{G}}_{\mathcal{H}}$
        $\mathrm{t} = \mathrm{t} + 1$
    End if
    Return CH
End procedure

The above algorithm steps is used to select the CH based on hyena behavior. Therefore, this method elect CH based on fitness function and behavior of hyenas.

III.4 FORD DISTRIBUTING SHORTEST ROUTING PROTOCOL (FDSRP)

In this phase, after cluster formation, we use the FDSRP protocol to identify the path for data communication without loss with minimum latency. Nodes within the minimum hop count are appropriate for routing, considering the balance between nodes. This method identifies the neighbor node and selects the path for proficient communication in WSNs. Every node sends data to determine the different nodes within its communication range. The node keeps a separation line among successive nodes below a profundity threshold, allowing it to select the best forward node most suitable for data communication. When a node transmits the packet, it reveals a Route Request (RREQ) message to its adjacency node. Since the adjacency node may be the destination, it sends a Route Reply (RREP) message with other important information (source and destination addresses, hop count, RREQ ID sequence number, etc.). It records the value of R there in the route table.

$$\mathfrak{P}^{loss} = N_{v,u} Log_{10}(\mathrm{CH}) + p_c \tag{17}$$

From equation 17 describes the two node communication path loss$\mathfrak{P}^{loss}$. Here, v, u are the adjacency nodes and p_c denotes the positive constant values.

$$\mathcal{S}_{NR} = \frac{Sl_{power}}{Ns_{power}} \tag{18}$$

$$\mathcal{S}_{NR(db)} = 10log_{10}\mathcal{S}_{NR} \tag{19}$$

From equations 18 and 19 identify the signal to noise ratio($\mathcal{S}_{NR}$). Let us assume, Sl_{power} and Ns_{power} lies the power of signal and noise, correspondingly.

$$T_{RE} = \sum_{\mathcal{L}_{Ni}=1}^{N} \frac{\mathcal{E}_{drop}}{|R_{BS}|} \tag{20}$$

The above equation is used to identify the total residual energy-based energy drop $\mathcal{E}_{drop}$ and range of base stations in the network.

$$N_{count} = \left[\frac{\mathcal{L}_N(n_s, n_d)}{T_{RE}}\right] \tag{21}$$

The above equation finds the hop count (N_{count}) during the path discovery for data communication in the WSN.

Algorithm steps:
Input: Hop count(N_{count}), CH, $\mathcal{L}_N$ and routing information R_I
Output: Choose a route with minimum congestion $\mathbb{R}_{short}$
Start procedure
    Initialize the hop count(N_{count}), CH and$\mathcal{L}_N$
    For each $CH \in C_G$ do
        $For\ each\ nodes\ n_i = 1{:}\ \mathcal{L}_N$
            Node n send the RREQ
            $If(R_I < PR_I \& N_{count} < MinN_{count})$
                Node RREP
                Calculate distance CH to BS
                Select shortest route($\mathbb{R}_{short}$)with minimum congestion level.
            Else
                Ignore the node or path
            End if
        End for
    End for
End procedure

The above algorithm steps efficiently identify the routing for data communication in WSN. Here, PR_Ilies the route information, $MinN_{count}$ denotes the minimum node count, and C_G denotes cluster group. This method attains the proficient route selection minimum congestion level in the path.

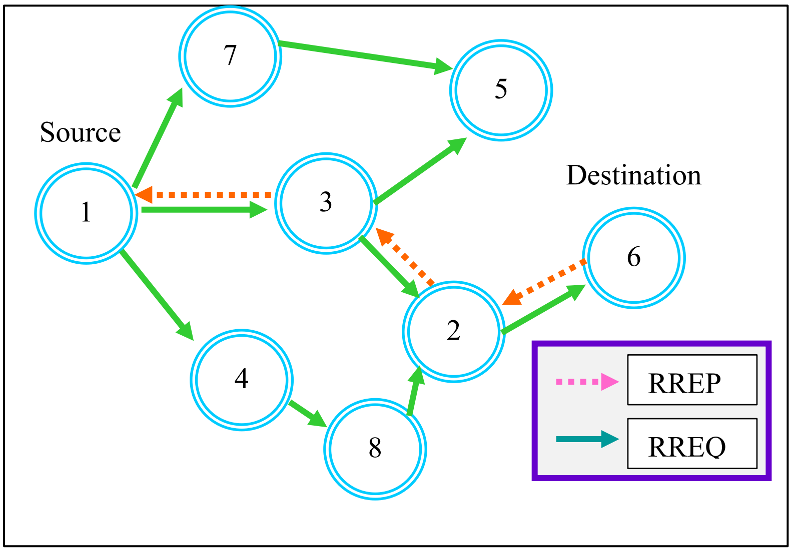

Figure 5: FDSRP protocol's shortest path identification.
Source: Authors, (2026).

Figure 5 illustrates the FDSRP protocol's shortest path identification process. Another process is data communication between the sender and receiver, as presented in the algorithm steps below.

Algorithm steps:
Input: Shortest route($\mathbb{R}_{short}$)
Output: Data transmission
Start procedure
For every $n_i = 1{:}\mathcal{L}_N$ do
If acknowledgement received ==true
Check node id, response with minimum congestion path
Estimate the total residual energy
$If\ (send\ packet == true)$ Then
Data transmission to the next node.
Else
Ignore route
End if
Else if acknowledgement received ==false
Packet drop or loss
End else if
End if
End for
End procedure

This stage constructs the following packet exchange and routing process efficiently and effectively data transmission. Figure 6 illustrates the data transmission process.

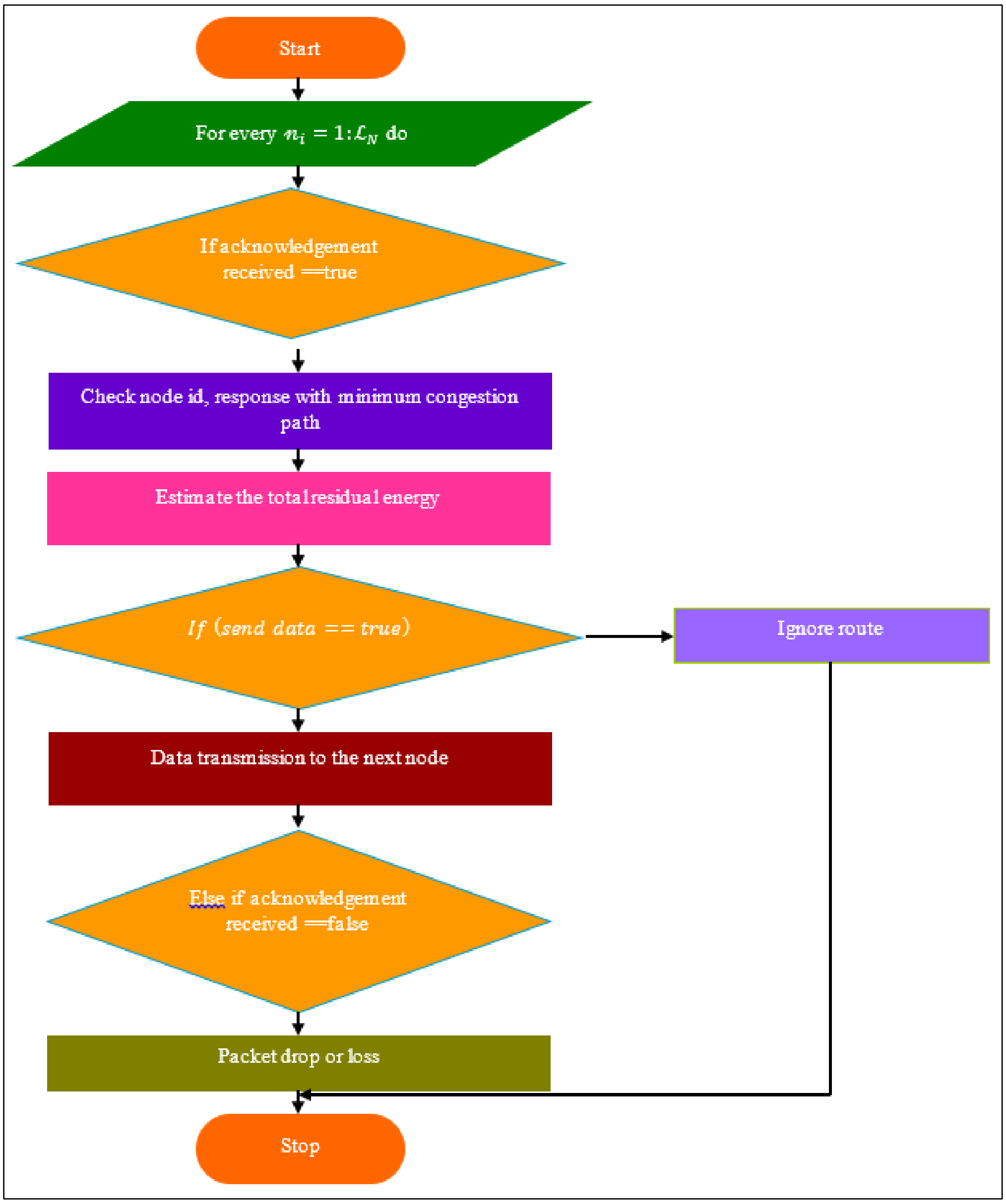

Figure 6: Flow diagram for data transmission.
Source: Authors, (2026).

IV. RESULT AND DISCUSSIONS

We strategically positioned 100 sensor nodes and monitored the environment using a Network Simulator (NS-2) to initiate the simulation process. Table 3 presents the simulation network configuration of this system. The experiment results are the proposed FDSRP-SHBiO compared with the Cooperative Sink Isolation-Multi-Hop Topology Driven Clustering Approach (CIS-MTDCA), LQEER [14], and IEECP [15] protocols.

Table 3: Network configurations and their values.

Parameters	Values
Network field	(1000, 1000) m^2
Network type	WSN
Initial energy	50J (or) 0.5J
Traffic type	Constant Bit Rate (CBR)
Number of nodes	20, 40, 60, 80 and 100
Deployment	Randomly
Packet size	512 bytes

Source: Authors, (2026).

IV.1 PERFORMANCE ANALYSIS

The proposed protocol efficiency analyzes vital performance parameters like PDR, throughput, NL, latency, and energy Consumption (EC).

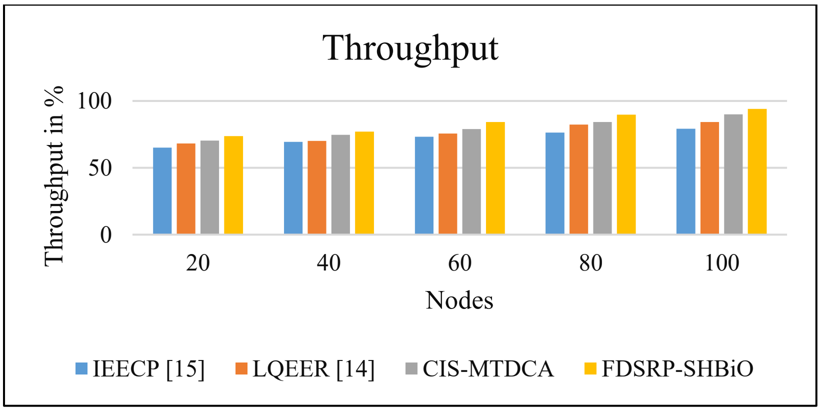

Figure 7: Performance analysis for throughput and its comparison.
Source: Authors, (2026).

Figure 7 shows the throughput results of different protocols, namely CIS-MTDCA, LQEER [14], IEECP [15], and the proposed FDSRP-SHBiO protocol. The throughput parameter is presented in percentage. The findings of the proposed attained average throughput is 94.09%. The existing methods' average throughput is 79.24%, 84.36%, and 90.11% for IEECP [15], LQEER [14], and CIS-MTDCA correspondingly.

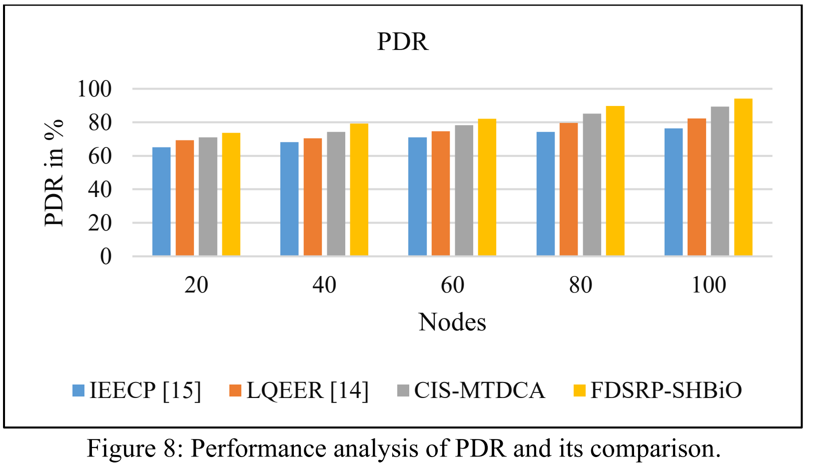

Figure 8: Performance analysis of PDR and its comparison.
Source: Authors, (2026).

Figure 8 presents the PDR results of diverse protocols, namely CIS-MTDCA, LQEER [14], IEECP [15], and the proposed FDSRP-SHBiO protocol. The PDR parameter performance is shown in percentage. The proposed protocol achieved 94.2%, while the CIS-MTDCA protocol attained 89.42%. The existing IEECP [15] and LQEER [14] protocols are 76.3%, and 82.36%, respectively.

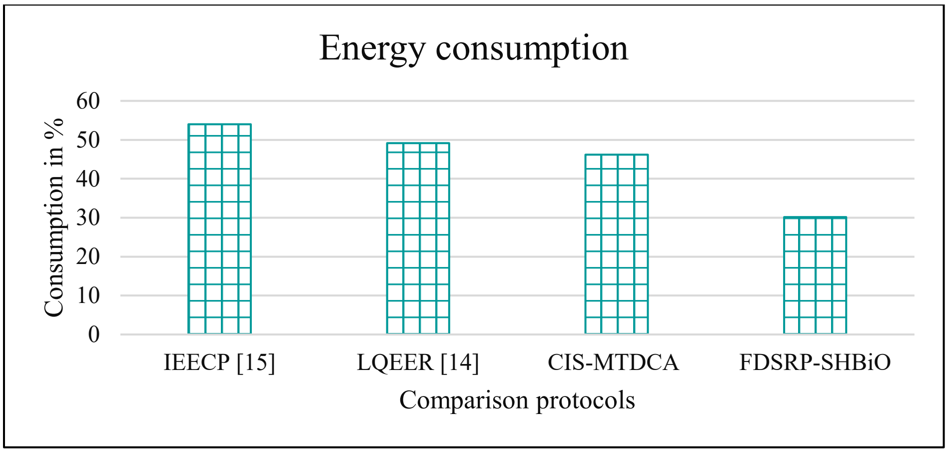

Figure 9: Performance analysis of energy consumption and its comparison.
Source: Authors, (2026).

Figure 9 illustrates the energy consumption results of diverse protocols, namely CIS-MTDCA, LQEER [14], IEECP [15], and the proposed FDSRP-SHBiO protocol. The energy consumption parameter performance is shown in percentage. The proposed protocol achieved 30.15%, while the CIS-MTDCA protocol attained 46.2%. The existing IEECP [15] and LQEER [14] protocols are 54.02%, and 49.17%, respectively.

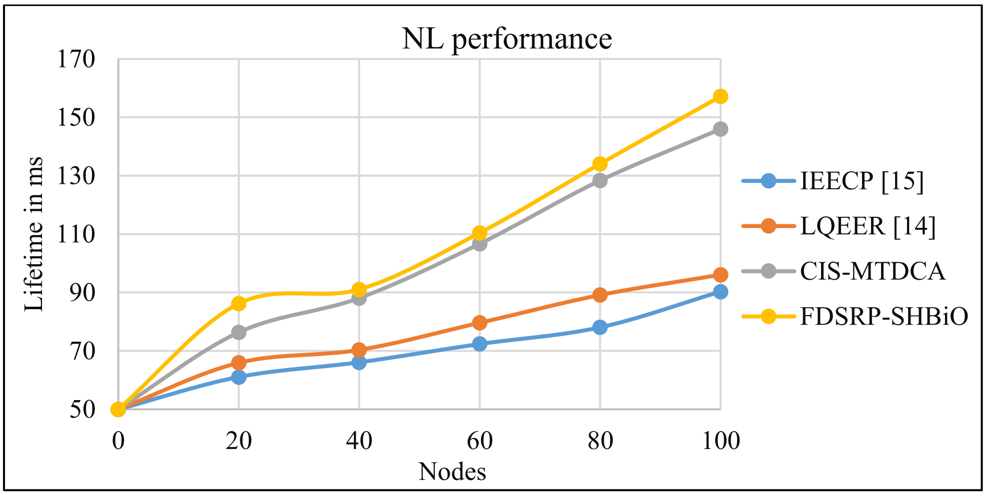

Figure 10: Performance analysis of network lifetime and its comparison.
Source: Authors, (2026).

Figure 10 illustrates the energy consumption results of diverse protocols, namely CIS-MTDCA, LQEER [14], IEECP [15], and the proposed FDSRP-SHBiO protocol. The proposed SHBiO method proficiently elected the CH has attained high network lifetime than other existing protocols. The proposed protocols attained results are 86.19ms, 91.07ms, 110.42ms, 134.08ms and 157.16ms for 20, 40, 60, 80 and 100 nodes.

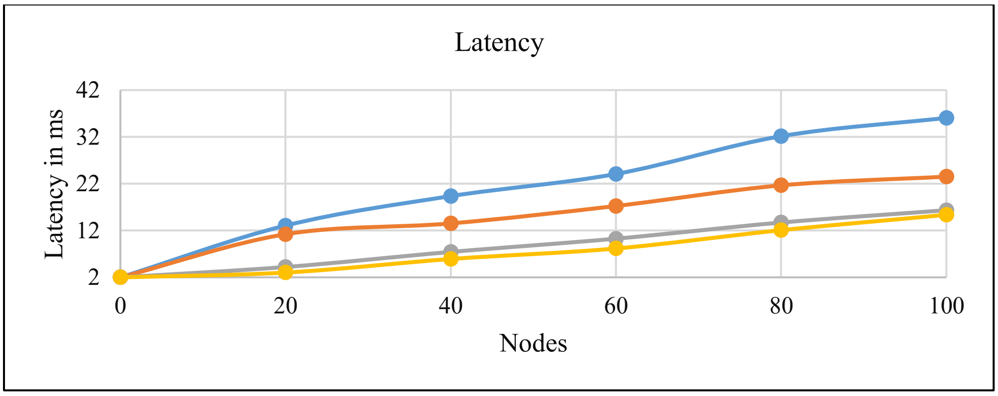

Figure 11: Performance analysis of latency and its comparison.
Source: Authors, (2026).

Figure 11 describes the time complexity of the proposed protocol compared to previous protocol outcomes. The proposed method attains latency at 3.02ms, 5.92ms, 8.16ms, 12.08ms, and 15.35ms for 20, 40, 60, 80, and 100 nodes. Yet, the existing protocols achieve a higher latency performance than other methods.

Table 4: Proposed and various previous protocols comparison performance.

Protocols	Total nodes	Throughput in %	PDR in %	NL in ms	Latency in ms
Proposed	20	73.62	73.62	86.19	3.02
	40	77.05	79.21	91.07	5.92
	60	84.31	82.05	110.42	8.16
	80	89.73	89.76	134.08	12.08
	100	94.09	94.2	157.16	15.35
CIS-MTDCA	20	70.35	71.03	76.35	4.21
	40	74.62	74.32	88.09	7.43
	60	79.04	78.36	106.69	10.26
	80	84.27	85.11	128.36	13.71
	100	90.11	89.42	145.97	16.34
LQEER	20	68.2	69.24	65.92	11.21
	40	70.19	70.41	70.34	13.52
	60	75.51	74.62	79.62	17.24
	80	82.43	79.61	89.15	21.65
	100	84.36	82.36	96.08	23.51
IEECP	20	65.16	65.03	61.08	13.06
	40	69.37	68.13	66.1	19.35
	60	73.19	71.08	72.36	24.08
	80	76.29	74.35	78.07	32.15
	100	79.24	76.3	90.31	36.06

Source: Authors, (2026).

Table 4 shows the overall performance of the proposed and previous protocols in terms of comparison outcomes for efficient communication in the network.

V. CONCLUSION

This novel introduced the proposed FDSRP-SHBiO protocol to improve network lifetime in WSN. The proposed RCFNS method is employed for groups of CMs without traffic and reliable nodes based on buffer length, received energy, and transmitted energy. In addition, based on efficient CMs, we selected energy-efficient CH using the SHBiO method for data communication between CH and BS. Finally, the FDSRP protocol finds the shortest path for communication in the network. An NS2 simulator is employed to test the proposed protocol using various parameters. The simulation results of the proposed compare CIS-MTDCA), LQEER, and IEECP protocols. These protocols were tested on multiple cases using nodes and CH. The level of PDR is 94.2%, throughput is 94.09%, and NL is 157.16ms for 100 nodes. The outcomes describe the proposed protocol obtains superior performance regarding PDR, throughput, and NL.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: S. Shameema Begum and V. Vijayalakshmi.
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