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Original Article

Optimized Routing on Wireless Body Sensor Network Using Adaptive Lion Optimization Algorithm for IoT

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Abstract - *WSN (Wireless Sensor Network) locates patient-related data through Wireless Body Sensor Network (WBSN). This monitored health information should be transported to the pond (base station) in a significant manner by accessing the routing technique. As the base station receives more sensitive data, its lifespan is shorter. In this paper, the main goal is to extend the lifespan of dispersed IoT sensor nodes while reducing the transmission time. The presented technique contains two parts, namely. Cluster formation and routing. In cluster formation, for cluster head selection, an adaptive lion optimization algorithm (ALOA) is presented. After the CH selection process, clusters are used by weight function. Finally, data transmission is done by using the LOADng protocol. Several measurements are used to examine the efficiency of the technique that is being provided. The outcomes demonstrate that the proposed procedure outperformed the alternative approaches.*

Keywords - *Internet of things (IoT), Lion optimization, LOADng, Routing, Data transmission.*

1. Introduction

The WSN is renowned for locating fuses (BS) and other focus points for local base stations. Each isolated focal point has a microcomputer, cell phone, battery and some sensors in the application space. WBSNs are a subset of the WSN that can be used to predict specific changes in sensor centers [12, 13]. Different types of biomedical sensors (e.g., body temperature, heart rate, ECG, EEG, etc.) can be detected over a period of time, thereby controlling installation costs and collecting and separating data related to patients' underlying symptoms. The WSN has multiple sensor nodes to achieve explicit tasks [12, 13]. Regularly, the terminal assets are obliged in light of the fact that battery power goes on for a brief timeframe. Like this, energy effectiveness is an essential issue in the WSN.

Similarly, the IoT is a developing worldview for presenting more insightful applications [32]. Specifically, IoT is incorporating WSN viable with Smart Cities, Healthcare, and Transport, and the sky is the limit from there.

Table 1. List of symbols

SYMBOLS	EXPLANATION	SYMBOLS	EXPLANATION
a	maximum weight	L, B	random value
b	minimum weight	B_F	Position of the female lion
m	Number of access points presented in the transmission area	D_d	Distance between the female lion
h	Total number of cluster head	$\{SB_1\}$	Existing position of the female lion
C^n	Normal access point	$\{SB_2\}$	Perpendicular to $\{SP_1\}$
C^H	Cluster head	H_{ij}	Nomad lion's present location
C^s	Sink node	$rand_j$	A random number between [0,1],
C_j^H	j^{th} Cluster head	$RAND_j$	Random vector
$C_c^{\varepsilon}(l)$	cumulative energy of complete CH	P_i	Probability value
B	position of the prey	$M_{O_i} and B_{M_O}$	delay of a present i^{th} lion in nomads
L	location of the hunter	N	Quantity of nomad's lion
γ	Random value	M_R	Resident males in a pride

While this merger offers many advantages, it also faces a few challenges, such as scaling, working effectiveness, energy efficiency and security. Energy productivity at WSN is enhanced using the portable sync hub through ideal clustering, steering, and information collection [9]. Among them, cluster development is reasonable for further developing energy productivity in many exploration projects [10, 15]. There are small, standardized clusters of sensor nodes in a cluster-based network. Clusters promote energy efficiency and quality of service (QoS) through information assortment.

Moreover, network power productivity upgrades by designing the network in an ideal setup. For instance, a hexagonal network [31] is considered to develop network energy proficiency further. Hexagon-based WSN further develops network execution as far as estimation, unwavering quality and energy effectiveness. Mainly, it enhances the information assortment measure by empowering bounce-by-jump information assortment. Moreover, ideal directing is done on WSN for the motivations behind energy productivity and QoS advancement.

The information gathered from the access point is forward the composed information to the CH. This work aims to gather all the information from non-CH nodes and forward it to a destination [23, 22]. For data transmission, routing protocols are utilized. For routing AODV protocols, location depends on routing, hierarchical routing, etc. Routing protocols are used to reduce time consumption and choose the shortest path. Energy utilization within the system's lifespan is a major challenge in a wireless sensor network. Many methods have been introduced to deal with all three problems recently. The paper describes an energy-efficient hierarchical clustering protocol for WSNs that can lead to better power optimization [16]. An efficient routing protocol has been developed at WSN to maintain a reasonable range of measurement, energy efficiency and reliability [34]. Ambiguous logic and the genetic algorithm was developed to decrease the power utilization of WSN. To lengthen the network's lifespan, a genetic algorithm-based procedure for selecting cluster heads was created [20]. In [19], in an effort to prolong network life, the authors have developed a WSN clustering-based data communication system. The WSN, with its vague logic-based power capability, was created in [18] and affected by energy and core properties. Ambiguous logic was used to develop the CH selection process [33], extending the system's life and speeding up performance.

Using an IoT sensor node, the primary purpose of this work is to collect data, which is then transmitted between the source and destination while energy, delay and balancing time. ALOA and LOADng protocols are utilized to achieve this objective. The rest of the paper was structured as follows, with section 2 explicitly outlining the literature review on the proposed topic. The proposed methodology is thoroughly detailed in section 3, while section 4 presents the experimental result. Lastly, section 5 presents the concluding portion.

2. Literature Survey

A lot of researchers have established information transfer to WSN. Among them, a few works are listed below; Sujanthi and Nithya Kalyani [2] aimed to develop secure aware dynamic cluster-depend routing in WSN-assisted IoT. To achieve this objective secure deep-learning algorithm was presented. This work was mainly focused on energy-efficient routing and security. The qualitative Prediction Phenomenon (QP2) was presented for CH selection during clustering. Data encryption was achieved using the One Time Present (OT-PRESENT) cryptographic algorithm. After encryption, the collected information is forwarded to the destination through the optimal path.

Jain and Jay Kumar [5] aimed to develop cluster-based routing in bi-layered WSN-IoT. Here, they mainly focused on energy hole problems. This problem increased the number of dead nodes. The cluster, in this case, was created using K-means. Following cluster creation, weight values were used to choose the cluster heads. After cluster formation, a coverage hole was detected. In this paper, they detect a problem in three places. Fuzzy logic was used to detect the problem. Finally, the optimum route was collected by utilizing Emperor Penguin Optimization Algorithm. The effectiveness of the algorithm was evaluated by using different methods.

Mahajan et al. [1] aimed to develop naturally inspired algorithm-based SN-Assisted IoT Smart Farming Applications. Here, they created the protocol known as the Nature-Inspired algorithm-based Cross-layer Clustering (NICC). An improved cluster for routing was discovered using the newly designed NICC. For optimal path selection, Bacterial Foraging Optimization (BFO) was presented. The performance was compared with various methods.

Jiwayan et al. [7] gave the optical wireless sensor network energy-efficient nozzle fittings. Optical communication and wireless sensor networks are combined in this approach. Here, they used a vector calibration approach to identify active centers in the network. The mathematical test first detected node conditions that rely on finding the result with energy recognition. A review of their proposed technique's hypothesized and simulated approach for simulation results is presented.

Moreover, Jiveyan et al. [6] have provided low-power PSO-based node fitting in optical WSNs. Here is the impact of the Hub area on power usage when transferring via the system. The calculation uses PSO to improve the location of the centers through very low power usage. This method changed rapidly. By improving the position of the center, the energy usage of the center is easily decreased, and the global implementation of the system is enhanced. From the system, energy was saved.

Kumar et al. [30] explained an energy-efficient routing in VANETs using an algorithm. Here, the modified AODV is used for routing. The AODV was enhanced by using a genetic algorithm. The optimal path selection process is used for increases the overall lifetime of transmission.

Rajkumar Singh Rathore *et al.* [3] developed energy-efficient routing. To achieve this concept, hybrid optimization called as whale and grey wolf algorithm was presented. For directing, this strategy delivered improved outcomes. Moreover, Ramadhani Sinde *et al.* [28] developed energy-efficient scheduling. The deep reinforcement learning (DRL) algorithm was introduced to achieve this concept. The proposed approach was used to minimize the lifetime of the network and latency minimization.

3. Proposed Data Transmission in WSN Using IoT Sensors

A major objective of the proposed methodology is to transmit data from a source to a destination. To attain this objective, adaptive lion optimization algorithm (ALOA) and LOADng protocol were used. Like WSNs and MANETs, the WBAN has some constraints on energy, processing, computation, diversity, storage, etc. WBAN uses remote access to record patient health information using biosensors. These biosensors are used to determine different parts of the patient's body, such as temperature, ECG, blood pressure, heart rate, movements, EEG, etc. The central coordinator also sends health data towards the PS through intermediate devices. After that, medical professionals obtained the required data from the PSS using the Internet for appropriate tests and studies. Accordingly, the physician may prescribe the proper medication to the patient or take immediate action whenever a problem related to sensors is detected. Figure 1 provides the schematic representation of the proposed technique.

As shown in the figure, wearable sensors collect data from the human body. For capturing the information, ***n*** number of sensors is located on the body. The BS receives the information gathered from the body. The best path for transmitting data is chosen to prevent delays. Initially, the access points are clustered for transmission using the ALOA algorithm. Then based on the path, data are transmitted to the BS. Then, data are stored on the medical server. Finally, the medical experts access the data from the medical server.

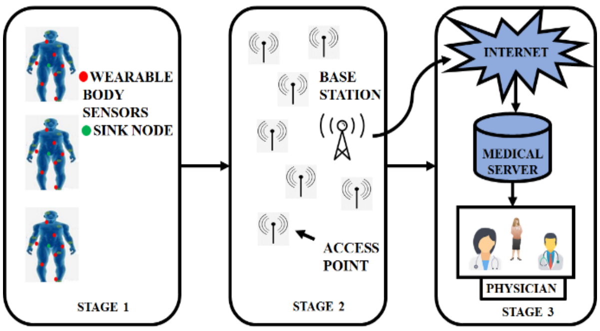

Fig. 1 The basic outline of the proposed approach

3.1. Data Collection

The size of the geographical area selected is 200X200m. 150 access points with the main energy of 1.5 joules are currently active in the network. An access point distribution is taken randomly. The position of BS is 50,100, and the velocity of the mobile node is 50(m/s), whereas the number of maximum packets is 2500. Let us consider the patient P_i; each patient consists of n number of wearable sensors. The sensors collect the data from the body. From the body, body temperature, pulse, ECG, EEG, and so on are collected. Once it has been received, the data is transmitted to the sink node. The sink node transfers the data to the BS using the optimal path.

3.2. Optimal Cluster Head Selection using ALOA

Clusters are created using the CH option. Through the access point, the sink node sends the BS data. A large number of access points are available, and multi-path transmissions are available. It may produce delays and traffic. To avoid the problem, initially, the clusters are formed. To speed up the data transmission process, initially, the CHs are selected among the n-number of the access point. In this paper, the ALOA method is used for CH selection. A combination of the LOA and OBL strategies is called ALOA. The characteristics and behaviour of lions are the basic motivation of the lion optimization method. CH process is explained given below;

3.2.1. Step 1: Solution Encoding

Solution encoding helps to find the optimal CH. At first, the CHs are randomly chosen. Spontaneously created solutions are called lions. Some of the lions presented in the initial solutions are selected as nomadic lions, while the remaining lions are roughly divided into P subgroups known as Prides. The solution length is $[1, D]$, where D is the number of CH selected in the geographical area. The initial sample solution is given in equation (1). In equation 1, each lion is represented as CH.

$$S_i = \begin{bmatrix} 1140527389 \\ 825476890 \\ \ldots\ldots \\ 723436475 \end{bmatrix} \tag{1}$$

3.2.2. Step 2: Opposite Solution Generation

To improve the solution's ability to search, the opposing solutions are used. Using the following equations, the opposite answer is generated (2). This step is used to reduce the searching time.

$$\overline{S} = a + b - S \tag{2}$$

Where a stands for the highest weight value and b for the lowest weight value. Equation provides $S_i(k)$ opposing solution (3)

$$\bar{S}_i(k) = \{\bar{S}_1(k), \bar{S}_2(k), \ldots, \bar{S}_n(k)\} \tag{3}$$

3.2.3. Step 3: Fitness Evaluation

Following the creation process, the solution's effectiveness is evaluated according to the fitness function. The fitness in this work is built using energy (E), delay (D2) and distance (D). A minimizing function is the fitness value. The equation contains the fitness function (3).

$$Fitness = Min[\beta_1 * D + \beta_2 * E + \beta_3 * D^2] \quad (4)$$

In equation (4), the distance (D) is calculated as follows;

Distance is the separation between such a CH and an access point. Distance is how far such a CH is from an access point. There is always a minimum speed in a good network. Equation (5) is used to compute the distance.

$$D = \frac{\sum_{k=1}^{m}\sum_{\substack{j=1 \\ j\in t}}^{h}\left\|C_t^n - C_j^H\right\| + \left\|C_j^H - C^S\right\|}{\sum_{t=1}^{m}\sum_{j=1}^{m}\left\|C_k^n - C_j^H\right\|} \quad (5)$$

Where;

$m \rightarrow$ Number of access points presented in transmission area

$h \rightarrow$ Total number of cluster head

$C^n \rightarrow$ Normal access point

$C^H \rightarrow$ Cluster head

$C^s \rightarrow$ Sink node

$C_j^H \rightarrow j^{th}$ Cluster head

The Energy (E) is Measured as Follows

There are opportunities to select the maximum energy access point as CH. So, the energy of each should be maximum. During the transmission, minimum energy is only consumed. The energy calculation is given in equation (6). Due to cumulative energy, the maximization problem is converted into a minimization problem,

$$E = \frac{\sum_{j=1}^{h} C_c^{\epsilon}(j)}{h \times \max_{j=1}^{h}\left[\varepsilon\left(C_j^n\right)\right] \times \mathop{Max}_{l=1}^{h}\left[\varepsilon\left(C_j^H\right)\right]} \quad (6)$$

$$C_c^{\varepsilon}(l) = \sum_{t=1}^{m}\left[1 - \varepsilon\left(C_j^n\right) * \varepsilon\left(C_j^H\right)\right]; (1 \leq j \leq h) \quad t \in j \quad (7)$$

$$h \times \max_{j=1}^{h}\left[\varepsilon\left(C_j^n\right)\right] \times \mathop{Max}_{l=1}^{h}\left[\varepsilon\left(C_j^H\right)\right]$$

The parameter $C_c^{\varepsilon}(l)$ can be denoted as the cumulative energy of complete CH and the parameter $h \times \max_{j=1}^{h}\left[\varepsilon\left(C_j^n\right)\right] \times \mathop{Max}_{l=1}^{h}\left[\varepsilon\left(C_j^H\right)\right]$ can be denoted as the product of the complete number of CHs, the maximum parameter of the energy of CH, and the remaining access point presented in the transmission.

Delay is Calculated as Follows

A good transmission system should have a minimum delay. The ideal CH selection procedure reduces network delay to the absolute minimum. The postponement is a direct recommendation to the membership of the cluster. The delay value varies from 0 to 1. The delay is calculated using equation (8).

$$D^2 = \frac{\mathop{Max}_{i=1}^{h}\left(C_{m,i}^H\right)}{m} \quad (8)$$

3.2.4. Step 4: Update the Solution

The updation is carried out using the following functions;

Hunting Process

Initially, the lions are randomly separated into subgroups. Among the cluster, the maximum fitness value is placed as the middle group, and the other groups are placed as right and left wings. If PREY (P) escape from the hunter, the PREY updates its position. The updation function is given in equation (9).

$$B' = B + rand(0,1) \times \%I \times (B - L) \quad (9)$$

Where; B represents the position of the prey, the hunter's location is represented as L, and hunter fitness improvement is represented as %I.

The left and right wings of the new hunter are calculated using equation (10).

$$L' = \begin{cases} Rand(L,B), L < B \\ Rand(L,B), L > B \end{cases} \quad (10)$$

Where; (L, B) indicates the random value

The female lion updates their position using equation (11).

$$B_F' = B_F + 2d \times Rand(0,1)\{SB_1\} + U(-1,1) \times tan(\theta) \times D_d \times \{SB_2\} \quad (11)$$

$$\{SB_1\} \cdot \{SB_2\} = 0, ||\{SB_2\}|| = 1 \quad (12)$$

Where;

$B_F \rightarrow$ Position of the female lion

$D_d \rightarrow$ Distance between the female lion

$\{SB_1\} \rightarrow$ Existing position of the female lion

$\{SB_2\} \rightarrow$ Perpendicular to $\{SP_1\}$

Roaming Operation

Roaming is also a search operation in which lions search around the region to improve the solution. The lion pushes toward the region's chosen region by n units, where n is an arbitral number with uniform distribution.

$$n \sim U_d(0,2 \times D^D) \quad (13)$$

D^D is the distance connecting the male lion location and the selected territory area.

After that, the nomad lion searches the new place randomly. The nomad updates their position using equation (14).

$$H_{ij} = \begin{cases} H_{ij} if Rand_j > P_i \\ RAND_j otherwise \end{cases} \tag{14}$$

Where;

H_{ij} → Nomad lion present location
$rand_j$ → Random number between [0,1],
$RAND_j$ →Random vector
P_i → Probability value

The probability value of each nomad is evaluated as follows;

$$P_i = 0.1 + min\left(0.5, \frac{(M_{O_i} - B_{M_O})}{B_{M_O}}\right) i = 1,2,\ldots N \tag{15}$$

Where,

N→ Quantity of nomad's lion
M_{O_i} and B_{M_O} → delay of the present ith lion in nomads

Mating Operation

Mating is essential in ensuring lions' subsistence. It is a straight grouping of caregivers to give birth to two new babies. New cubs were formed after the male lion and cub were selected for mating.

$$Offspring_j 1 = \gamma \times F_j + \sum \frac{1-\gamma}{\sum_{i=1}^{N_R} SV_i} \times M_j \times SV_i \tag{16}$$

$$Offspring_j 2 = (1-\gamma) \times F_j + \sum \frac{\gamma}{\sum_{i=1}^{M_R} SV_i} \times M_j \times SV_i \tag{17}$$

M_R → Resident males in a pride,
γ → Random value

3.2.5. Step 5: Termination Criteria

The iteration is terminated once it reaches the maximum iteration. Among the iteration, the best fitness is designated. Depending on the best fitness, optimal CH is designated. The selected CH is utilized for additional handling.

3.3. Cluster Formation

The clusters are then designed based on the shortest distance after the CH selection process. Each minimum distance node is formed to get a cluster.

3.4. Routing using LOADng

Following Cluster construction, LOADng is used to accomplish the routing. In addition to route discovery and route maintenance, the LOADng protocol keeps up with AODV's activities. As part of the route discovery process, the source floods REQs throughout the organization. This message will be sent until you arrive at the objective. In Route maintenance, on the off chance that a route between the source and objective comes up short, route maintenance will be executed. The disappointment of the route is perceived when the data packet is not sent to the following jump towards the destination.

4. Results and Discussion

This paper analyses the effectiveness of the proposed routing method on the WBSN. Using NS2 software, the presented approach is implemented. The effectiveness of the presented technique is implemented using various parameters like delay time, delivery ratio, overhead, throughput and energy consumption.

4.1. Experimental Results

Through the use of the modelling tool network simulator 2.0, the suggested methodology is put into practise. Here, a distinct method is connected to the performance. In this paper, the best cluster head is chosen using ALOA, and routing is carried out using the LOADng protocol to extend network life while reducing energy usage. In this paper, 150 nodes are used for the experimental investigation. Table 3 lists the simulation variable that was used in this analysis.

Table 2. Simulation parameter used in this paper

Parameters	Range
The size of the geographical area	200 × 200 m
Number of access points present in the network	150
Primary energy	1.5 J
Initial idle power	0.035
Initial receive power	0.395
Initial transmit power	0.660
access point distribution	Random
Position of BS	(50,100)
The velocity of the mobile node	50(m/s)
Propagation	Two ray rounds
Channel	Wireless channel

Table 3. Simulation Setting

Parameters	Range
Simulation tool	NS2
Processor	Intel Core i7
Memory	8GB
Operating system	Windows 10

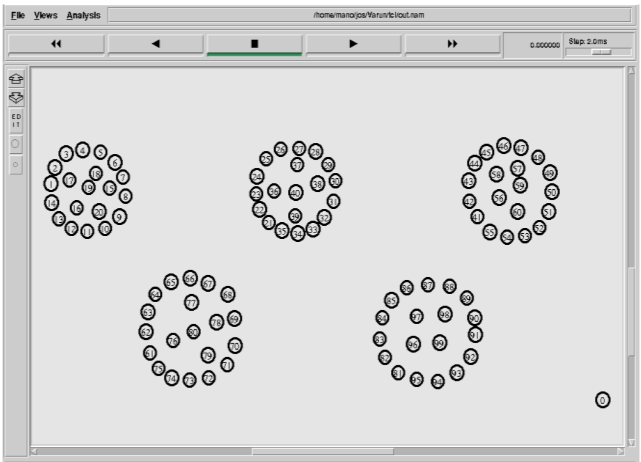

Fig. 2 Access point creation

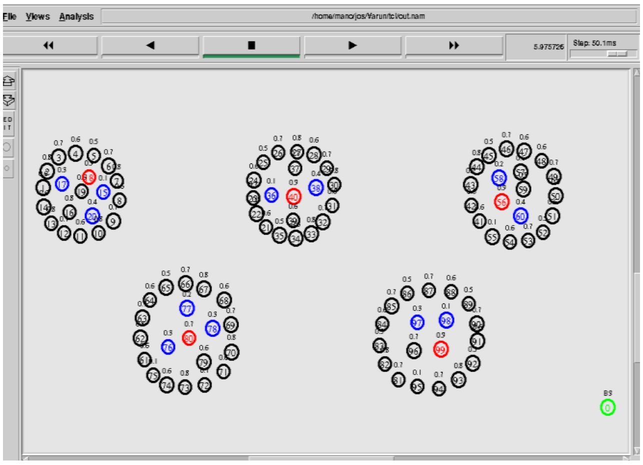

Fig. 3 Cluster head selection

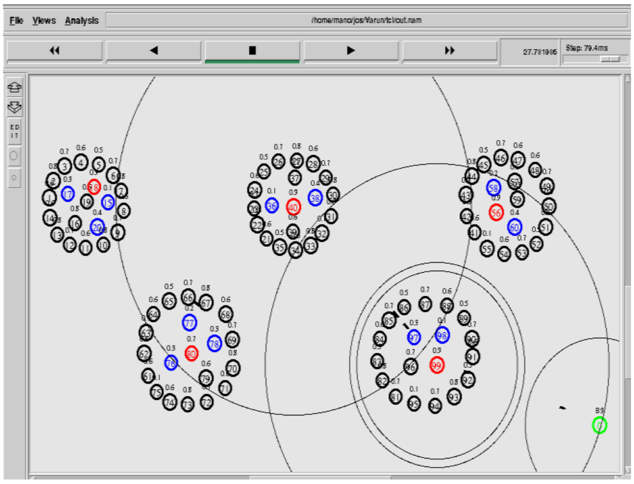

Fig. 4 Data transmission

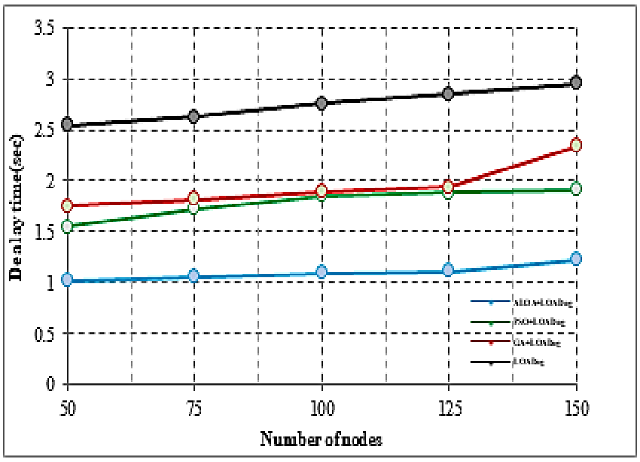

Fig. 5 Performance analysis based on delay time

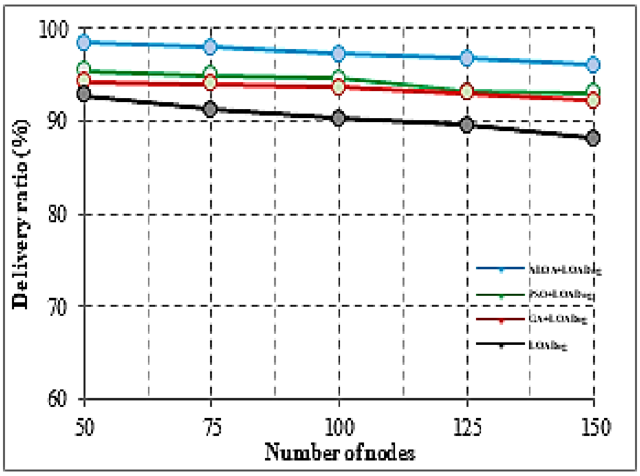

Fig. 6 Performance analysis based on the delivery ratio

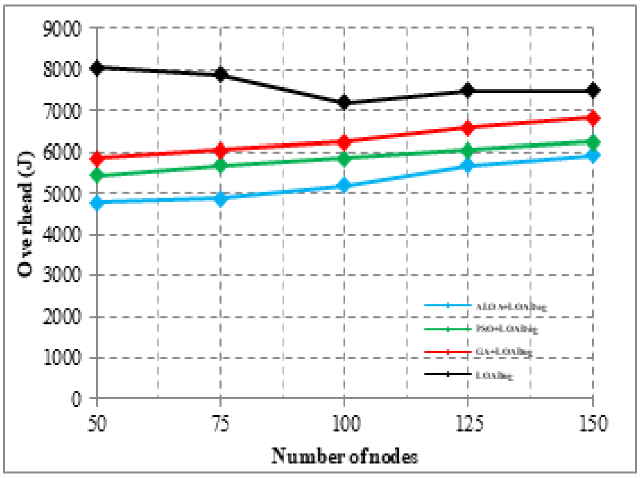

Fig. 7 Performance analysis based on overhead

Figure 5 shows the comparative analysis based on the delay time. The good system has a minimum delay time. When analysing Figure 5, the suggested ALOA+LOADng approach has taken the minimum time to transmit the data packet. Due to an efficient path selection mechanism, the proposed method has a shorter end-to-end delay than competing methods. Here, the number of nodes increases, delay time also increases.

Figure 6 specifies the data transmission ratio for the different methods using the node's varying amount. Here, they utilized 150 nodes for performance analysis. When analysing Figure 6, the suggested approach speedily delivers the packet compared to the existing method. If the node is 50, the suggested approach attained a better delivery ratio of 98.5%, 95.5% for using PSO+LOADng, 94.3% for using GA+LOADng and 92.82% for using LOADng-based data transmission.

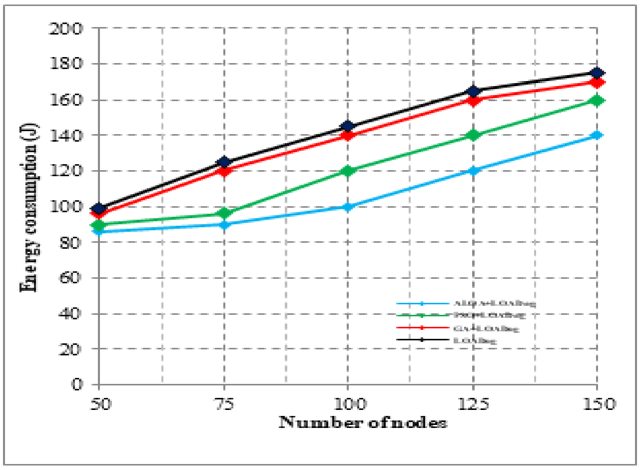

Fig. 8 Performance analysis based on overhead

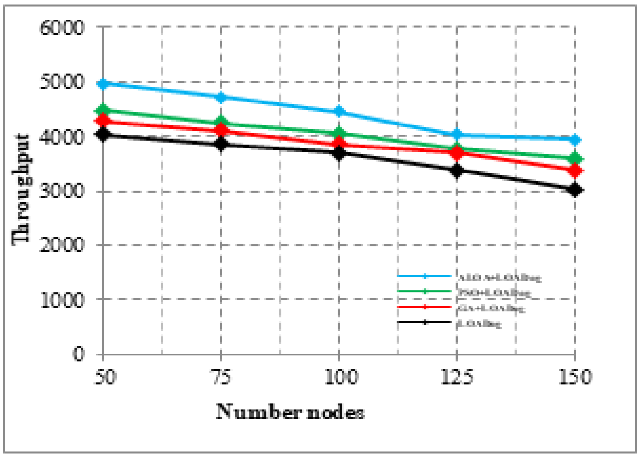

Fig. 9 Performance analysis based on Throught

The graph clearly shows that the suggested approach attained the maximum data delivery ratio. It is because the proposed method is selecting the CH using ALOA. The other technique is determining the optimal CH using a single optimization algorithm. Network lifetime is one of the leading problems in a WSN. The network failed during the data transmission period, and the corresponding data of corresponding data also loosed. To reduce data loss, the lifetime of the system should be improved.

The effectiveness of the proposed approach is tested based on packet overhead in Figure 7. To demonstrate the efficiency of the recommended approach, the recommended approach is compared to three methods, namely PSO+LOADng, GA+LOADng and LOADng. When analyzing Figure 7, the recommended practice attained fewer control packets overhead associated with further approaches. This is since the suggestion utilized ALOA+LOADng for path selection and the CH selection process. Figure 8 details the energy usage by varying numbers of nodes. Energy consumption should be minimum in a good network system. When analyzing Figure 8, if the node is 50, the proposed method takes a minimum energy of 86J, which is 90J for using PSO+LOADng, 96J for using GA+LOADng, and 99J for using LOADng-based data transmission. As per the figure, we can understand suggested approach obtained the maximum outcome compared to the existing algorithms. In this illustration, the system uses less energy while extending the network's life. Figure 9 shows an examination of the effectiveness of the proposed method in terms of overall throughput. Throughput is measured using the total number of packets received from CH to BS until a certain percentage of the total network power is scattered. Here, also presented technique reached the maximum output. According to the results section, the proposed method performed better than the other methods.

5. Conclusion

Efficient data transmission in the WBAS network has been clearly explained. Wearable and implantable sensor networks have been employed in numerous sectors, including the military, security, healthcare, agriculture, and transportation, thanks to technological advancement. In this paper, two contributions—clustering and routing—have been established to extend network life and reduce energy usage. For clustering, optimal CHs are selected using ALOA and routing LOADng protocol has been used. This proposed system effectively transmits the data from one place to another. The results section clearly demonstrates that the proposed approach outperformed alternative methods in terms of throughput, power consumption, overhead, delivery ratio, and delay time.

References

[1] Hemant B. Mahajan, and Anil Badarla, "Cross-Layer Protocol for WSN-Assisted IoT Smart Farming Applications Using Nature Inspired Algorithm," *Wireless Personal Communications*, vol. 121, pp. 3125–3149, 2021. *Crossref*, https://doi.org/10.1007/s11277-021-08866-6

[2] S. Sujanthi, and S. Nithya Kalyani, "Secdl: Qos-Aware Secure Deep Learning Approach for Dynamic Cluster-Based Routing in WSN Assisted Iot," *Wireless Personal Communications*, vol. 114, no. 3, pp. 2135-2169, 2020. *Crossref*, https://doi.org/10.1007/s11277-020-07469-x

[3] Rajkumar Singh Rathore et al., "Hybrid WGWO: Whale Grey Wolf Optimization-Based Novel Energy-Efficient Clustering for EH-WSNS," *EURASIP Journal on Wireless Communications and Networking*, pp. 1-28, 2020.

[4] Srinivasa Rao Patri, and L. Nithyanandan, "Network throughput Optimization for Relay Based NB-CR-IoT Wireless Body Area Network," *International Journal of Engineering Trends and Technology*, vol. 70, no. 9, pp. 148-154, 2022. *Crossref*, https://doi.org/10.14445/22315381/IJETT-V70I9P215

[5] Jay Kumar Jain, "A Coherent Approach for Dynamic Cluster-Based Routing and Coverage Hole Detection and Recovery in Bi-Layered WSN-IoT," *Wireless Personal Communications*, vol. 114, no. 1, pp. 519-543, 2020. *Crossref*, https://doi.org/10.1007/s11277-020-07377-0

[6] Navdeep Kaur, Deepika Sharma, and Prabhdeep Singh, “Classification of Hierarchical Routing Protocols in Wireless Sensor Network: A Survey," *International Journal of P2P Network Trends and Technology,* vol. 3, no. 1, pp. 28-33, 2013.

[7] Ziwei Yan et al., “Energy-Efficient Node Positioning in Optical Wireless Sensor Networks,” *Journal of Optik*, vol. 178, pp. 461-466, 2019. *Crossref,* https://doi.org/10.1016/j.ijleo.2018.09.186

[8] Md. Shariful Islam, Md. Ashek Raihan Mahmud, and Md. Jashim Uddin, "Analysis of the Feasibility and Constraints of Implementing Next-Technology Mobile Networks in Bangladesh with its Outcomes on Human Body," *International Journal of Engineering Trends and Technology*, vol. 70, no. 10, pp. 339-349, 2022. *Crossref,* https://doi.org/10.14445/22315381/IJETT-V70I10P233

[9] Pavani Movva, and Polipalli Trinatha Rao, “Novel Two-Fold Data Aggregation and Mac Scheduling to Support Energy Efficient Routing in Wireless Sensor Network,” *IEEE Access*, vol. 7, pp. 1260-1274, 2019. *Crossref,* https://doi.org/10.1109/ACCESS.2018.2888484

[10] Ahmad Ali et al., “Enhancement of RWSN Lifetime Via Firework Clustering Algorithm Validated by ANN,” vol. 9, no. 3, p. 60, 2018. *Crossref,* https://doi.org/10.3390/info9030060

[11] Astanginiselvaraj, and Dr. C. Senthilkumar, "A Lion Optimization Based Energy Efficient Clustering in WSN," *SSRG International Journal of Electronics and Communication Engineering,* vol. 8, no. 4, pp. 18-21, 2021. *Crossref,* https://doi.org/10.14445/23488549/IJECE-V8I4P104

[12] MortezaSalehi_Panahi, and Mortaza Abbaszadeh, “Proposing a Method to Solve Energy Hole Problem in Wireless Sensor Networks,” *Alexandria Engineering Journal*, vol. 57, no. 3, pp. 1585-1590, 2018. *Crossref,* https://doi.org/10.1016/j.aej.2017.05.012

[13] S. Nithya Kalyani, and S. Sujanthi, “Dynamic Clustering Approach in Wireless Sensor Networks,” *International Journal of Management, Technology and Engineering,* vol. 8, no. 9, pp. 781-785, 2018. *Crossref,* https://doi.org/16.10089.IJMTE.2018.V8I11.17.2099

[14] M.Supriya, and Dr.T.Adilakshmi, "Secure Routing using ISMO for Wireless Sensor Networks," *SSRG International Journal of Computer Science and Engineering,* vol. 8, no. 12, pp. 14-20, 2021. *Crossref,* https://doi.org/10.14445/23488387/IJCSE-V8I12P103

[15] Jian Shen et al., “An Efficient Centroid-Based Routing Protocol for Energy Management in WSN-Assisted IoT,” *IEEE Access*, vol. 5, pp. 18469-18479, 2017. *Crossref,* https://doi.org/10.1109/ACCESS.2017.2749606

[16] Shiv Singh, and Bhumika Gupta, “OSEECH: Optimize Scalable Energy Efficient Clustering Hierarchy Protocol in Wireless Sensor Networks,” *International Conference on Advances in Computing, Communications and Informatics (ICACCI),* pp. 1441-1446, 2016. *Crossref,* https://doi.org/10.1109/ICACCI.2016.7732250

[17] M.S.Krishnaveni, and Dr.K.Kavitha, "Secure Routing in Wireless Sensor Network using HTARF," *SSRG International Journal of Computer Science and Engineering,* vol. 3, no. 5, pp. 27-30, 2016. *Crossref,* https://doi.org/10.14445/23488387/IJCSE-V3I5P104

[18] Ashutosh Kumar Singh, and Neetesh Purohit, “An Optimised Fuzzy Clustering for Wireless Sensor Networks,” *International Journal of Electronics,* vol. 101, no. 8, pp. 1027-1041, 2014. *Crossref,* https://doi.org/10.1080/00207217.2013.805387

[19] Mohammad Rakibul Islam, and Jinsang Kim, “Step-by-Step Approach for Energy-Efficient Wireless Sensor Network,” *IETE Technical Review,* vol. 29, pp. 336-345, 2012. *Crossref,* https://doi.org/10.4103/0256-4602.101314

[20] Tahir Emre Kalayci, and Aybars Uğur, “Genetic Algorithm–Based Sensor Deployment with Area Priority,” *Cybernetics and Systems,* vol. 42, no. 8, pp. 605-620, 2011. *Crossref,* https://doi.org/10.1080/01969722.2011.634676

[21] Surendra Verma, and Dr. K C Mahajan, "A Survey on Energy Efficient Routing Protocols for Wireless Sensor Networks & Comparative Analysis with USEP," *SSRG International Journal of Electronics and Communication Engineering*, vol. 3, no. 10, pp. 14-18, 2016. *Crossref,* https://doi.org/10.14445/23488549/IJECE-V3I10P104

[22] Kemal Akkaya, and Mohamed Younis, “A Survey on Routing Protocols for Wireless Sensor Networks,” *Ad Hoc Networks,* vol. 3, no. 3, pp. 325-349, 2005. *Crossref,* https://doi.org/10.1016/j.adhoc.2003.09.010

[23] J. N. Al-Karaki, and A. E. Kamal, “Routing Techniques in Wireless Sensor Networks: A Survey,” *IEEE Wireless Communications*, vol. 11, no. 6, pp. 6-28, 2004. *Crossref,* https://doi.org/10.1109/MWC.2004.1368893

[24] Prabhdeep Singh, Navdeep Kaur, and Ravneet Kaur, “A Review: Comparative Analysis of Routing Protocols in Wireless Sensor Network,” *International Journal of P2P Network Trends and Technology,* vol. 3, no. 1, pp. 12-17, 2013.

[25] Ashwini.R, and Mrs. Pooja Mohnani, "Application of Wireless Sensor Network in Home Automation," *International Journal of Computer & Organization Trends,* vol. 4, no. 3, pp. 64-71, 2014. *Crossref,* https://doi.org/10.14445/22492593/IJCOT-V9P301

[26] Nagashetty B Kolar, and Dr. Raju Ramakrishna Gondkar, "Adaptive Energy Efficient MAC Protocol for Increasing Life of Sensor Nodes in Wireless Body Area Network," *International Journal of Engineering Trends and Technology,* vol. 68, no. 1, pp. 95-97, 2020. *Crossref,* https://doi.org/10.14445/22315381/IJETT-V68I1P215

[27] Pavani Lakshmi Alluri, Daisy Rani Alli, and D.V. Rama Koti Reddy, "Modelling Thermoelectric Generators to Harvest the Low-Temperature Changes in Electronic Devices," *International Journal of Engineering Trends and Technology*, vol. 70, no. 9, pp. 105-110, 2022. *Crossref,* https://doi.org/10.14445/22315381/IJETT-V70I9P210

[28] Ramadhani Sinde et al., "Refining Network Lifetime of Wireless Sensor Network Using Energy-Efficient Clustering and DRL-Based Sleep Scheduling," *Sensors,* vol. 20, no. 5, p. 1540, 2020. *Crossref,* https://doi.org/10.3390/s20051540

[29] Ziwei Yan et al., "Low-Energy PSO-Based Node Positioning in Optical Wireless Sensor Networks," *Journal of Optik*, vol. 181, pp. 378-382, 2019. *Crossref*, https://doi.org/10.1016/j.ijleo.2018.12.055

[30] Ankit Kumar et al., "An Enhanced Energy Efficient Routing Protocol for VANET Using Special Cross Over in Genetic Algorithm," *Journal of Statistics and Management Systems*, vol. 22, no. 7, pp. 1349-1364, 2019. *Crossref*, https://doi.org/10.1080/09720510.2019.1618519

[31] Rahul Priyadarshi et al., "A Hexagonal Network Division Approach for Reducing Energy Hole Issue in WSN," *International Journal of Pure and Applied Mathematics*, vol. 118, no. 20, pp. 1003-1008, 2018.

[32] Ademola P. Abidoye, and Ibidun C. Obagbuwa, "Models for Integrating Wireless Sensor Networks Into the Internet of Things," *IET Wireless Sensor Systems*, vol. 7, no. 3, pp. 65-72, 2017. *Crossref*, https://doi.org/10.1049/iet-wss.2016.0049

[33] Davood Izadi, Jemal Abawajy, and Sara Ghanavati, "An Alternative Clustering Scheme in WSN," *IEEE Sensors Journal*, vol. 15, no. 7, pp. 4148-4155, 2015. *Crossref*, https://doi.org/10.1109/JSEN.2015.2411598

[34] Inbo Sim, and Jaiyong Lee, "Routing Protocol with Scalability, Energy Efficiency and Reliability in WSN," *Intelligent Automation & Soft Computing*, vol. 16, no. 4, pp. 567-577, 2010. *Crossref*, https://doi.org/10.1080/10798587.2010.10643101