AN OPTIMIZED ENERGY-EFFICIENT HELLO ROUTING PROTOCOL FOR UNDERWATER WIRELESS SENSOR NETWORK

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ABSTRACT

Underwater wireless sensor network (UWSN) is a great technological advancement for numerous implementations, such as pollution monitoring tsunami offshore gas and oil reservoirs. Coherent routing with optimal energy use is necessary to send received data from the sensor to the sink hub. The distinct characteristics of the underwater circumstances make designing routing protocols problematic. Therefore, a novel Dove-based Hello Routing Protocol (DbHRP) was proposed to increase the data broadcasting rate within low energy. The nodes are initially initialized, and their positions are estimated. Subsequently, the dove function finds the SP(SP) from source to target, and the status of the target node is analyzed for data packet transmission. The data transfer function is planned based on the destination node's initial request priority if the target node needs to receive more data from a different source hub. Finally, the UWSN communication parameters were measured and compared with prevailing models.

KEYWORDS

Underwater Wireless Sensor Network (UWSN), Shortest path, Source node, Target node, Routing Protocol.

1. INTRODUCTION

The fact that three-quarters of the ground atmosphere is occupied by water suggests that a few of the world's oceans must be investigated further [1].Certain aspects of underwater environments and their dynamics require further study [2]. This could contribute to several implementations that remain obscured and partially submerged and are connected to a massive assortment of armed services and quasi-applications such as crop production [3], coastlines and safeguards, telephony, and weather controls and vigilance, lookup operations, and so on [4]. These apps might also link to many other applications [5]. Consequently, UWSN systems are a pressing concern, particularly in the rapidly expanding field of oceanic studies [6]. The study's outcomes have been described by comparing several underwater sensors [7]. The route is complicated to follow in the aquatic setting compared to specific other systems found throughout nature andis tied to altitude variables [8]. The environment may be variable as subsea components, i.e., Sometimes muddy and often salty [9]. Therefore, to address all of the UWSN characteristics, a technique compatible with each nature is required [10]. Relative to other established networks, such as aerial and trunked radio, pulses get a slower submarine transmission speed, the cluster heads are more prominent, and non-recyclable energy supplies are scarce [11]. Consequently, anything relies on electricity usage, the proportion of actual use, and the component of protracted connection [12].As previously said, an exterior mobile independent device is utilized chiefly for effectively routing transmitted information from one area to another [13]. They are inexpensive compared to other types of communication [14]. After gathering every node's report, it travels to a specific area to transmit it, and then, after completing this procedure at each point, it returns to

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the originating position [15]. This step is repeated for each node. Once the information is collected, a bit stream is generated based on the specific quantity of current specificationsand other criteria [16]. Transferring large databases in any interaction is challenging without the quickest path between them [17].

Consequently, those systems may be less efficient despite transferring huge and comprising such as video and sampling data [18]. However, because they are robust compared to other forms of connection, they are chosen for relatively brief conversations. The concept of networking detectors below the surface water was inspired by developing technologies revolving around automated vehicles and multilevel routing (MR) security possibilities [19]. Despite the potential for communication problems, the science of acoustics is flexible enough to assist in making the concept a reality. Interconnected transmission methods have seen advancement in recent years, making them particularly useful for independent channels.

Section 2 provides the previous studies review. Section 3discussesthe methodology. Section 4 details the results. Section 5concludes the work with future work.

2. REVIEW OF PREVIOUS STUDIES

Frequency band, visual, and electrostatic transmission are some methods that fall under this category. To take advantage of the enormous available bandwidth required, they are used for specific distances based on the application necessity [20]. Due to the severe attenuation characteristics of such wide bandwidth transmissions, antenna systems were required. Recently, clustering UWSN [21], energy-efficient UWSN [22], etc., were implemented to reduce the constraints and requirements of data transfer. However, those approaches do not offer a high throughput rate and require less energy usage. Considering all these issues, the present investigation aimed to develop the optimal routing strategy for the UWSN application, which was tested with chief metrics, and outstanding results were obtained.

2.1. A Few Recent Associated Works of UWSN are Detailed as Follows

The routing scheme called clustering (RSC) is implemented for the UWSN as the optimized routing protocol to control the energy utilization of UWSN. Additionally, the communication overhead and throughput parameters were investigated by Sun et al. [21]. Finally, the results verified the implemented strategy's robustness by performing the comparative analysis. However, this study did not address the path selection process, which resulted in high implementation time.

Kumar et al. [22] have established the energy-efficient paradigm (EEP) for the UWSN dynamic topology. The chief reason for adopting this objective is. Usually, the sensor nodes need more energy to capture and transfer data to the other end. Hence, the high energy usage might degrade the sensor network's robustness by reducing the node's lifetime, resulting in packet loss. To control these issues, the energy-efficient model is included in this study, which has kept the designed model in the optimal status. However, a high packet drop occurred.

The multi-hop routing protocol (MHR) is implemented for the UWSN by Yang et al. [23]. Here, the multi-hop system offered the multi-SP of ever-connected hubs in the sensor environment. This function has tended to earn less transmission delay time. Also, the multipath has reduced network data traffic by forwarding the overloaded data to another path. Here, the energy was optimized by controlling the packet-sharing time. However, it is not aware of malicious events.

Noorbakhsh and Soltanaghaei [24] have executed the grid-based routing system (GRS) for the UWSN framework. Here, the frequency resources were shared for the nodes in the grid framework. So, the energy resources were initiated before the data-sharing process. When the data broadcasting function began, the energy resource allocation was terminated. In this way, the energy constraints of the UWSN were optimized. However, if any nodes were moved from the grid environment, they lost their data transmission (DT) ability.

Ismail et al. [25] have conducted a routing protocol analysis (RPA) of target node localization and mobility. Different functions were tested through this routing protocol analysis,including finding the SP, localization, and energy management. Finally, the performance of the routing protocols was specified under their unique characteristics. Later, those classified protocols were utilized for the specific function process in the UWSN. However, using the different protocols for a single UWSN tended to cause more resource usage.

Ali et al. [26] introduced a novel, time-based, reliable link (TBRL) for the dynamic topology routing protocol. Primarily, the topology of each node is calculated, and the reliable link is accessed by selecting the best forwarders for the Communication. Next, the data packets have been sent through the selected reliable path. It acts as an efficient protocol for underwater Communication and supports smart city monitoring facilities. However, this method can be enhanced by selecting the more optimal path.

Though many existing techniques were developed for better transmission, energy efficiency, and reliability, the proposed DbHRP improves the performance of the existing approaches. This method differs from other clustering methods, which aim to reduce energy consumption at the node level but experience high packet drop rates, compromising data reliability. The model also presents an intelligent packet-scheduling system based on target requests, making data transfer more dependable and adaptive. In contrast to multi-hop routing protocols that minimize transmission latency and optimize network traffic, the DbHRP model presents an optimized scheduling system for improving network resilience and making data transmission reliable. It also adjusts routing paths dynamically according to network topology, maintaining ongoing data flow and reducing error. It also performs a sophisticated shortest-path scheme adaptive to network dynamics, minimizing energy overhead and enhancing overall performance. This method achieves an adaptive and optimized routing scheme, achieving energy efficiency, transmission robustness, and network reliability. The comparison of existing limitations and proposed methods advantages is provided in Table1.

Table1. Comparison of Existing with proposed

Author	Existing Method	Limitations	Proposed
Sun et al. [21]	RSC	Inefficient path selection	Develops a SP selection process that reduces the delay and energy usage
Kumar et al. [22]	EEP	high packet drop has occurred	It improves data transmission reliability by introducing an optimized scheduling method based on target requests.
Yang et al. [23].	MHR	Increases the transmission latency	Improves network resilience by transmitting data based on network conditions
Noorbakhsh and Soltanaghaei [24]	GRS	Inefficient data transmission occurs	Dynamically adjusts routing paths based on real-time network topology to ensure continuous data flow.
Ismail et al. [25]	RPA	It increases the resource usage	The hybrid routing system consumes less energy and reduces overhead
Ali et al. [26]	TBRL	Limits in suitable path selection and increased delay	Develops shortest-path Selection to improve transmission efficiency

2.2. Problem Statement

Recently, UWSNs have focused on discovering underwater resources and instantaneous data acquisition. In contrast to regular WSNs, UWSNs experience distinct challenges like high delay, low bandwidth, node mobility, and power restrictions. Several routing methods have been developed for energy minimization, such as clustering-based schemes, multi-hop, and grid-based models. Yet, traditional models cannot accommodate dynamic data broadcasting scenarios, resulting in high packet loss rates, poor path selection, and network performance degradation. Moreover, energy-efficient frameworks cannot balance network lifetime and data transmission reliability in dynamic topological variations. A new DbHRP that combines an intelligent shortest-path selection scheme with an optimized scheduling strategy to improve energy efficiency, reduce latency, and improve overall network performance in UWSNs is introduced to overcome these limitations.

3. METHODOLOGY

The current study's primary steps are outlined below,

- Initially, the needed sensor hubs were created in the UWSN environment.
- Consequently, a novel DbHRP was executed to find the SP of every hub and to transfer the packets optimally.
- Once the SP was enabled, then the status of the target hubs was estimated. If the target node has different source hubs, the data has been scheduled based on the target request.
- Henceforth, the data is transferred effectively between the sensor users, with optimized energy usage.
- Finally, metrics like network lifetime, latency, energy consumption, throughput, and data transfer speed were measured and compared with other models.

3.1. Proposed Methodology

A novel Dove-based Hello Routing Protocol (DbHRP) was established for the UWSN to improve the data broadcasting rate between the users. Primarily, the required sensor nodes were created with the sensing capacity, and then the dove function was activated to measure the SP between the sources and sink nodes. If the sink node has to receive more data from a different source node, then the data transmission is scheduled as per the target's first request priority, which helps control energy usage. The Dove Optimization Algorithm (DOA) enhances the HELLO Routing Protocol performance by dynamically optimizing critical routing parameters. HELLO-based wireless network protocols employ periodic message exchanges to build and maintain routes, but ineffective parameter adaptation may lead to unnecessary energy wastage and network congestion. DOA is inspired by doves' foraging and migration behavior and optimizes transmission power, node selection, and route stability parameters. DOA employs adaptive exploration and exploitation mechanisms to optimize HELLO intervals, offering energy-efficient neighbor discovery and preventing redundant transmissions. The optimization also alleviates link failures by periodically reconfiguring the optimal routes according to network conditions, making DOA appropriate for mobile and resource-constrained networks.

3.1.1. Node Initialization

A novel DbHRP is proposed for energy-efficient routing (ER). The proposed DbHRP combines dove optimization [27] and hello protocol. Initially, the required nodes are initialized in the network environment. The node initialization is expressed in Eqn. (1).

$$N = N_z\{z = 1,2,3, \dots \dots k\} \tag{1}$$

$N$is the UN, and $k$defines the quantity of nodes. Here, the data sent by sensor nodes is collected by many surface sinks at the water body's surface. Most sensor nodes are located under the water's body, while others are positioned above the surface. According to the quality of the link, the data packets were transferred. A reliable connection sends the data gathered from one node to another. The success of the routing is verified after the arrival of data to any of the sink nodes. The sinks can communicate with each other with more bandwidth and less latency due to an acoustic communication capability. Here, the DbHRP is a position-aware routing protocol. Due to the water's movement, the sensor hubs' position varies. So, the position of the employed nodes is updated by the dynamic topology discovery algorithm described in [26].For underwater Communication, the acoustic medium is mainly used. The acoustic channel was generated by [28] for the recommended model, considering factors such as water temperature, pressure, and salinity.

3.1.2. Shortest Path Finding using DbHRP

After confirming the position of each node, a short path is estimated. The suggested DbHRP moves the data from the node to the sink. The shortest route is selected depending on two parameters, namely link quality and distance. Dove selects the nearest spots with more crumps in dove swarm optimization. Thus, in the presented technique, the SP is selected so that the information packets can reach the sink node. The fitness features of the Dove identify the node with the nearest distance and the great link quality. It is expressed in Eqn. (2).

$$N_{z_s^d} = \arg max[f(N_z).(s,d)] \tag{2}$$

Here $N_{z_s^d}$Is the next forwarding node selection function, $s$represents the link quality d denotes the node's distance, and f is the fitness function. Link quality indicates the strength and stability of the communication link between two nodes. Distance is the logical distance from the present node to the destination. However, the link quality is concerned with the pressure parameter at the network. Hence, the target node is selected to forward the packet. The process is repeated until the SP is selected for the sink hub. Based on this optimization, the source Node chooses the optimal forwarder node with a shorter distance and lower pressure. This reduces the useless transmissions to the other nodes, which causes low energy consumption.

3.1.3. Analyzing Target Node Status

The destination node's availability to transfer the data is assessed once the path has been selected. The Eqns. (3) and (4) are used to analyze node availability.

$$t_z = \lambda t_z^{-1} + e^{\left[f(N_z) - f(N_{z_s^d})\right]} \tag{3}$$

$$t_z = \begin{cases} if\ f\left(N_{z_s^d}\right) = 0 & available \\ if\ f\left(N_{z_s^d}\right) \neq 0 & not\ available \end{cases} \tag{4}$$

Here $t_z$is the target node availability, λ represents the tracking function, and $t_z^{-1}$is the previous (source) node. $if\ f\left(N_{z_s^d}\right) = 0$ it means the node is available for packet transmission and $if\ f\left(N_{z_s^d}\right) \neq 0$means the node is unavailable for packet transmission. The Dove's satiety degree updating function attains the target node availability. To locate more food, doves go in the direction of the Dove with the greatest level of satisfaction. In each iteration, the satiety degree of the Dove is updated. Through this Dove behavior, the status of the selected nodes is updated. The status of the nodes is analyzed through Eqn. (3) and identified using the condition given in Eqn. (4). If the node is available, the packets are sent to the destination.

3.1.4. Scheduling Data Request

Each source node contains the same type and an equal number of sensors. Each data packet is sent to the destination node with a priority number that is dynamically assigned by the source. The sink node validates the arrived packets' source address and priority digit and orders the packet. Priorities were assigned, and the scheduling algorithm then scheduled the packets for transmission according to the priority number. The first request priority sent the data to the target node, and the proposed routing protocol carried out the data transmission.

Algorithm 1. DbHRP

```
Start
{
    Initialization ()
    {
        $\text{int } N, N_z$
        $N_z \rightarrow z = 1,2,3,......k$
        //initialization of node
    }
    The position of the node has been assessed.
    developed DbHRP
    // The protocol has been developed to incorporate the necessary features.
    {
        Pathfinding ()
        {
            $\text{int } N_{z_s^d}, f$
            //pathfinding variables are initialized
            $N_{z_s^d} \rightarrow \arg\max[f(N_z)]$
            //target node is estimated based on the fitness function
            // SP is selected by repeating the function
        }
        Target node status ()
```

```
        {
                $\text{int } t_z, \lambda$
                //The variables for node analysis have been initialized.
                if $f(N_{z_s^d}) = 0$
                {
                        available node
                }
                else{
                        Node is not available.
                }
        }
        Data request scheduling ()
        {
                The information was supplied in alignment with the original priority request.
        }
} Stop
```

Algorithm 1 details the developed model's procedures and methodologies, including pseudo-code-formatted mathematical function parameters. The code was executed, and the outcomes were validated. The workflow of the designed protocol is also given in Fig.1.

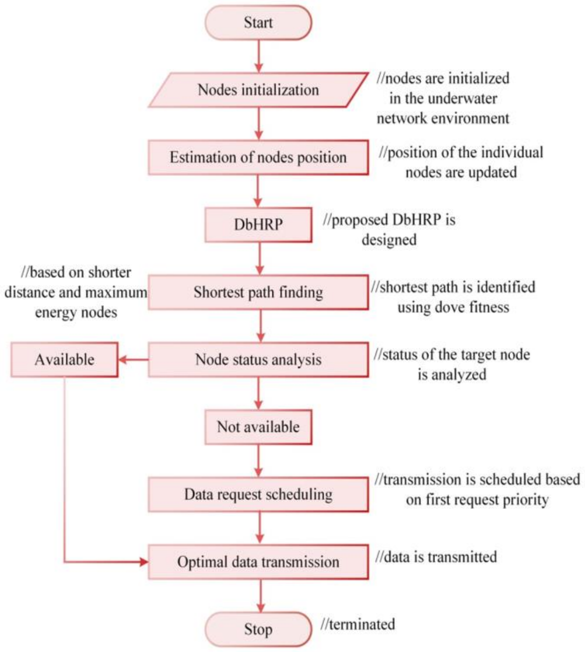


Fig.1. Flowchart of DbHRP

4. RESULTS AND DISCUSSION

The developed DBHRP is designed and executed in the MATLAB platform. Primarily, the required nodes are initialized in the network environment. A new DbHRP for energy-efficient routing is proposed, and its performance metrics are assessed. The simulation parameters required for execution are tabulated in Table 2.

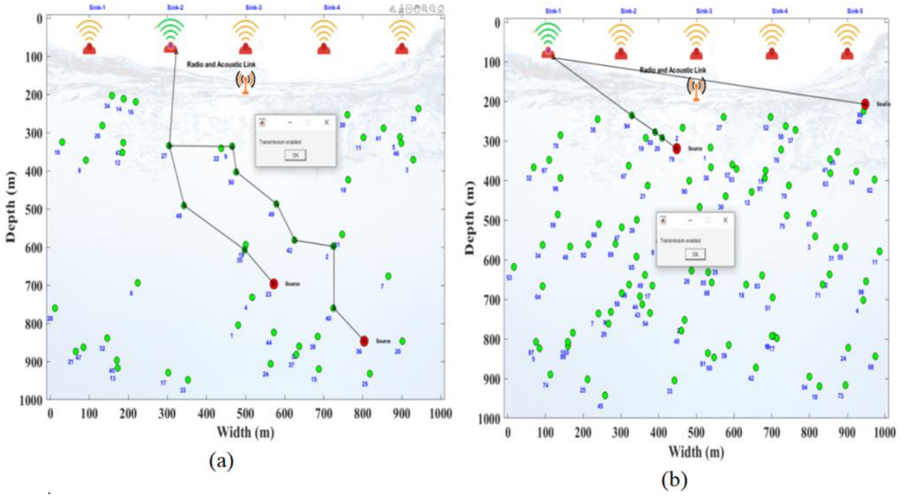
Table 2. Simulation parameters

Parameter	**Description**
Platform	MATLAB
Nodes	50,100,150,200,250,300,350,400,450,500
Wireless channel	Acoustic and radio
Network area	$1000 \times 1000\ m^2$
Frequency	15KHz
Mobility of nodes	Random
Sink hub	5
Antenna	Omni antenna
Packet size	1000 bytes
Range of Transmission	70m
Network topology	2D
Receiving power	0.1 W
Transmitting power	0.5W
Idle power	0.008 W
Communication medium	Wireless
Initial energy	1000 J

The simulation parameters in Table 2 were selected to closely mimic actual UWSN conditions while balancing computational efficiency and accuracy. The network size (1000×1000 m^2) and number of nodes (50–500) were chosen to examine scalability and network performance at different densities. Realistic signal propagation is provided by the transmission range (70m) and frequency (15KHz), which are under-accepted requirements for underwater Communication. The undersea nodes' energy constraints determine the power consumption, and the initial energy (1000 J) offers an adequate operational lifespan. The antenna and 2D topology were used to facilitate modeling to capture the important routing dynamics in underwater networks (UN).

4.1. Case Study

The proposed DbHRP is tested with varying numbers of nodes to examine its functioning range. Here, for the study of DbHRP, an efficient RP system is tested with 50 and 100 sensor nodes and 5 sink hubs. The simulation result for the shortest route finding data transmission is shown in Fig.2. Here, the red color node indicates the two source nodes, source 1 and source 2. (b). The black shaded line indicates the SPs specified by the source nodes using the iteration of the fitness function to send the data to the sink. Further, the DT process was enabled through the selected path.



(a)

(b)

Fig.2.Path finding and transmission of data packets: (a) 50 nodes, (b) 100 nodes

4.2. Performance Analysis

The developed model's performance is validated and compared with current methods such as whale green UN (WGUN) [29], cluster MR (CMR) [30], ER reliable multipath (ERRM) [31], optimized Depth RP (ODRP) [32], TBRL [26], Depth Cluster Routing (DCR), Adaptive DR (ADR) and Collision DR (CDR) [33].

4.2.1. Throughput

It defines the total quantity of packets collected successfully by the sink hub presented at the water's surface. Also, it validatesthe total amount of information a system can process at a specific time. The throughput rate can measure the efficiency of the system. It is calculated by the Eqn. (5).

$$T = \frac{arrived\ packets}{simulation\ time} \tag{5}$$

The replica throughput rate for WGUN attained is188 Kbps, ERRM scored 299 Kbps, and the TBRL protocol gained 269 Kbps. At the same time, the proposed technique achieved a throughput rate of 161 Kbps, 191 Kbps, 214 Kbps, 296 Kbps, and 338 Kbps for 100-500 nodes, respectively. This comparison shows that the proposed scheme's throughput is higher than other methods.

4.2.2. Energy Consumption

The network's total energy used to gather data, transmit, and receive is called energy consumption (EC). The average energy taken to select the target nodes at one round is considered energy consumption. It mainly depends on the range between destination and source and the size of the packet. It is measured in Joules (J). The resulting values are recorded in Table 3.

Table 3. Comparison of EC

Energy consumption (J)				
Nodes	WGUN	TBRL	ODRP	Proposed
100	229	164	659	144.6
200	398	362	1110	338.4
300	1880	568	1431	495.6
400	3449	748	1784	598.3
500	5018	927	2224	691.4

4.2.3. Network Lifetime

It is described as the network's active phase until node death. The factors such as the frequency of utilized nodes, distribution, and connection impact the network's lifetime (NLT).The NLT comparison is provided in Table.4 The low energy consumption increased the network lifespan.

Table 4. Comparison of NLT

	Network lifetime (s)			
Number of nodes	DCR	ADR	CDR	Proposed
100	721	720	714	925.39
200	735	730	750	1187.40
300	814	809	804	1392.37
400	869	863	859	1408.37
500	889	884	898	1492.25

4.2.4. Packet Delivery Ratio

It is determined by adding up every data packet that leaves the source node and makes it to the sink hub. It is determined by the ratio of total packets reached at the sink hub to the complete packets sent from the source node. The calculation of average PDR is expressed in Eqn. (6). The comparison is shown in Table 5.

$$PDR = \frac{arrived\ packets}{total\ packets\ sent} \tag{6}$$

Table 5. Comparison of PDR

Packet delivery ratio (%)			
Number of nodes	TBRL	ODRP	Proposed
100	50	73.82	75.36
200	70	75.8	78.4
300	81	84.82	86.4
400	85	91.9	92.4
500	89	96	97.5

4.2.5. Delay

There is a delay in the data packet's transit from the source node to the sink hub. It is the typical delay of all information packets flowing at the target from various sources. This parameter validates the time efficiency of the routing protocol. The delay is calculated using the expression described in Eqn. (7). The DbHPRdelivered the data quickly, which shows efficiency. The comparison of delay rate is noted in Table 6.

$$D = \frac{time\ taken\ to\ deliver\ Information\ packets}{total\ packets} \tag{7}$$

Table 6. Delay rate comparison

Delay(ms)			
Number of nodes	TBRL	CMR	Proposed
100	369.4	610	322
200	319.6	512	241
300	240.1	436	184
400	198.6	338	158
500	159.4	253	134

4.2.6. Transmission Loss and Path Creation

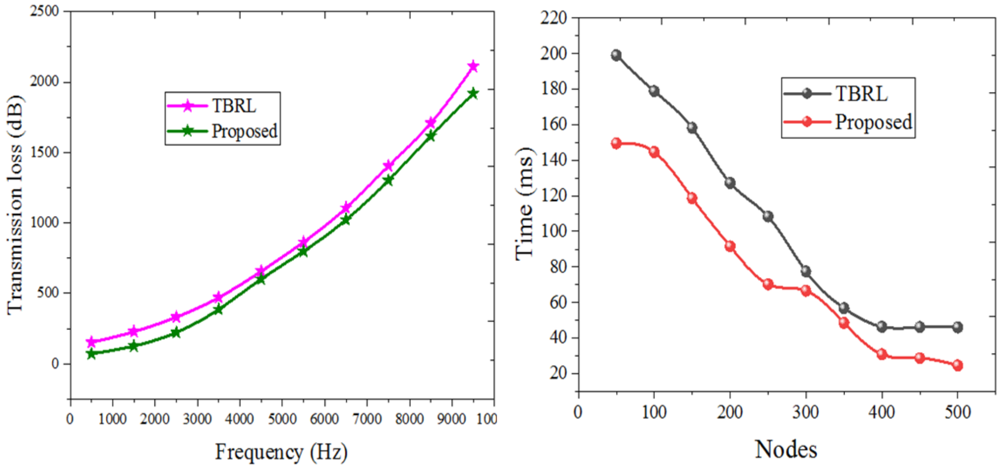
The system's performance improved when the transmission loss (TL)was lower. TheTL is computed by Eqn. (8).

$$L_T = 20logt + \phi^* t^* 10^{-3} \tag{8}$$

Here, the distance between the receiver and sender is indicated as$t$ measured in meters,ϕ is indicates the absorption coefficient computed in dB/km.The amount of time needed for the system to find a route from its starting point to its final destination to forward the data packet to the sink nodes is termed path creation (PC) time. The time consumed for achieving a short path and the transmission loss by the presented optimized protocol is given in Fig.3 with the different number of initialized nodes.

The proposed DbHPR attains the TL(dB) of 71.445, 127.009, 223.259, 387.31, 601.59, 798.782, 1021.908, 1302.295, 1616.716, and 1918.469 for the different frequencies such as 500 Hz to 9500 Hz in 1000 Hz intervals respectively. Also, it attained the path in 149.5ms, 144.62ms, 118.63ms, 91.57ms, 70.23ms, 66.65ms, 48.59ms, 30.83ms, 28.69ms, and 24.6005ms for 50 to 500 nodesin 50 nodes intervals respectively. Overall metrics validation showed that the best results were obtained using the specified framework. Therefore, the structure that has been provided is sufficient for effective routing in the UN. Furthermore, it consumes a low energy rate with minimum delay. Additionally, the optimal routing path is created quickly and within a short distance, making it easy to transmit data.

Additionally, to justify the outcomes of the proposed DbHPR, the resultant values are compared with the perspective UWSN routing research such as Low Clash Probability Routing (LCPR) [34], Enhanced Metaheuristic based Multi-hop Protocol (EMMP) [35], Anchor Nodes Served Protocol (ANSP) [36], Cooperative Delay and Security Aware Routing (CDSAR) [37] and Q-learning based Energy Aware Protocol (QEAP) [38]. The comparison of the resultsis shown in Table7.



(a) (b)

Fig.3. (a) Transmission Loss comparison (b) Path creation time

Table 7. Overall comparison statistics

Methods	Throughput (Kbps)	PDR (%)	Energy usage (J)	Network Lifespan (sec)	Delay (ms)
LCPR	178.8	78.56	1805.7	759.76	526
EMMP	192	83.75	1584.2	955.64	467
ANSP	203	87.62	1286.6	1034.45	423.8
CDSAR	248.5	90.45	903.5	1112.7	387.6
QEAP	283.9	92.67	835.46	1287.6	286
Proposed	338	97.5	691.4	1492.25	134

The proposed DbHPR validated a very efficient outcome compared to the prevailing UWSN routing methods. Therefore, the presented approach is very efficient for Communication in the UWSN. Using the DbHPR, UWSN can be more reliable, efficient, and versatile. To verify the Selection of dove optimization over other optimization algorithms, The hello routing is hybrid with other optimizations such as Whale Optimization Algorithm-Based Hello Routing (WOA-HR), Ant Colony Optimization-Based Hello Routing (ACO-HR), Particle Swarm Optimization-Based Hello Routing (PSO-HR), Cuckoo Optimization Algorithm-Based Hello Routing (COA-HR), and Zebra Optimization Algorithm-Based HelloRouting (ZOA-HR) and its performance is evaluated is displayed in Table8.

Table 8. Comparison with existing models

METHODS	Throughput (Kbps)	Network lifetime (%)	PDR (%)	Delay (ms)
WOA-HR	124	65.321	72.4	310
ACO-HR	210	70.892	78.6	275
PSO-HR	181	76.134	82.9	240
COA-HR	214	81.502	87.3	200
ZOA-HR	163	88.021	76.1	170
Proposed DbHRP	338	94.814	97.5	134

The Dove-based Hello Routing Protocol (DbHRP) demonstrated superior performance compared to existing optimization techniques in several key metrics, including throughput, network longevity, Packet Delivery Ratio (PDR), and latency. It surpassed WOA-HR, ACO-HR, PSO-HR, COA-HR, and ZOA-HR, achieving a throughput of 338 Kbps and extending the network's lifespan by 94.814%. Additionally, DbHRP recorded a PDR of 97.5% and a reduced delay of 134 ms, outperforming its counterparts. These findings underscore DbHRP's exceptional capabilities in enhancing network efficiency. Dove optimization is well suited for UWSNs due to its energy efficiency, low latency, and adaptive routing capabilities. The DbHRP protocol identifies the shortest and most reliable routes, reducing transmission delays and optimizing energy consumption. It prioritizes target nodes to facilitate efficient data transmission, ensuring robustness in challenging underwater environments. Compared to conventional models, it significantly increases stability, reduces congestion, and increases overall network performance.

4.3. Discussion

DbHRP is a potential candidate for UWSN real-world deployments. DbHRP provides energy-efficient and adaptive, which is well suited for underwater environment monitoring. DbHRP's energy-efficient route selection prevents extended network lifetime. It also offers a low-latency and dependable data transmission mechanism for real-time detection of tectonic activities to avert disasters. DbHRP's adaptive routing method guarantees continuous data transmission even in the event of dynamic topological changes created by ocean currents. DbHRP's adaptability makes it a feasible option for real-world UWSN applications, providing reliable, energy-efficient, and adaptive underwater Communication.

5. CONCLUSION

The balance between the energy usage and network lifetime of the UWSN nodes is currently broad research for several human benefits applications. So, this article presented a novel DbHPR to accomplish energy-efficient routing in the UWSN. The sensor nodes are set up in the MATLABsoftware, and the node's position at each deep water level is estimated. Next, the Dove's fitness function of the protocol is activated to create a shorter path by selecting the optimal forwarding nodes. Furthermore, the node's status is estimated based on Dove's satiety degree testing,and the transmission is done according to the priority request from the target node if the node is unavailable. Hence, the performance is validated and compared. The designed approach attained a higher rate of 338 Kbps throughput and a lower delay rate of 134ms. Also, the PDR rate is increased to 97.5% with a maximum network lifetime; the PDR rate is improved by 5% to the existing protocols; also, the throughput of the system is significantly increased by 39 Kbps; additionally, the energy consumption rate is 691.4 Jwhich is reduced approximately by 15% than the perspective protocols. The Selection of optimal nodes in DbHPR efficiently reduced the energy usage and improved the throughput and PDR. Thus, the designed model successfully performed efficient routing in the UWSN.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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