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Performance Evaluation of Underwater Routing Protocols DHRP, LASR and DFR for Underwater Wireless Sensor Network using MATLAB

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Abstract. Communication issues in Underwater Wireless Sensor Networks (UWSNs) are the main problem. In this research paper and we proposed "Dolphin Heterogeneous Routing Protocol" (DHRP) and it determine the most efficient path to destination, it balance the energy and it increase the lifetime of nodes. Due to the lack of growth in underwater wireless communications, Communication cables are still used for underwater communication. The use of wires to ensure the communication of sensor nodes at the ocean's depths is extremely costly. In underwater wireless sensor networks, determining the optimum route to convey sensed data to the destination in the shortest amount of time has become a major difficulty (UWSN). Because of the challenging communication medium, UWSN routing protocols are incompatible with those used in traditional sensor networks. Existing routing protocols have the problem of requiring more energy to send data packets, as well as experiencing higher delays due to the selection of ineffective routes. This research introduces the Dolphin Heterogeneous Routing Protocol (DHRP) to tackle the routing issues faced by UWSN. The swarming behavior of dolphins in search of food is the inspiration for DHRP. In order to find the best route in UWSN, DHRP goes through six essential processes are initialization, searching, calling, reception, predation and termination.

Keywords: UWSNs, Routing Protocol, DHRP, LASR, DFR protocols

I. INTRODUCTION

Wireless sensor networks come in various forms and sizes, including a specialized type called underwater wireless sensor networks (UWSN). These networks enable wireless communication among sensor nodes and autonomous underwater vehicles (AUVs) located beneath the water surface, facilitating collaborative activities through audio links within a specified underwater area. The concept of wireless underwater sensor networks originated in the United States at the end of World War II, initially designed for submarine communication using analog modulation in the 8-11 kHz frequency range. Vehicle-to-vehicle communication within UWSNs serves multiple purposes, including improving security and obtaining valuable information about the maritime environment. The applications of UWSNs are diverse, encompassing areas such as underwater data collection. , locating oil fields and underwater assets, conducting ocean sampling and environmental monitoring, and providing vital information during times of disasters to prevent or mitigate their impact [11]. UWSNs also play a crucial role in pollution detection in rivers and seas, weather tracking, and the compilation of ocean statistics.

However, UWSNs face a myriad of communication challenges due to the unique characteristics of the underwater environment. Bandwidth is inherently limited in underwater settings, resulting in elevated bit error rates. Furthermore, battery power is severely constrained, and energy efficiency is a pressing concern due to the high energy consumption, mobility of nodes, and the likelihood of sensor node failures. Additionally, the extended propagation times and heightened error rates pose formidable obstacles for routing protocols in UWSNs.

To overcome these formidable challenges, numerous geographic routing algorithms have been proposed for UWSNs, with the aim of addressing issues related to node mobility, propagation time, and error rates. These algorithms strive to improve the reliability and efficiency of communication in UWSNs, while also conserving energy and extending the lifespan of sensor nodes. By employing innovative routing mechanisms, UWSNs can enhance their performance and enable seamless communication in the challenging underwater environment.

The UWSNs represent a specialized subset of wireless sensor networks with unique communication requirements and challenges in underwater environments. Despite the constraints posed by limited bandwidth, high bit error rates, and restricted battery power, UWSNs find applications in diverse domains such as underwater data gathering, asset location, environmental monitoring, and disaster management. Through the utilization of advanced routing algorithms and innovative communication techniques, UWSNs have the potential to revolutionize underwater communication and enable a wide array of underwater applications.

PROBLEM STATEMENTS

The electromagnetic wave, commonly referred to as the carrier for radio communication, functions within a designated frequency range but faces limitations in communication range due to absorption at higher frequencies and channel attenuation. In fresh water, the scope of radio communication is restricted to less than a meter. However, by employing lower frequencies, typically between 30-300 Hz, radio frequency waves can travel over greater distances through conductive salty water. This, however, necessitates large antennas and high transmission power, which may become cost-prohibitive [10]. For underwater communication, radio communication modems are not suitable due to the high absorption and attenuation rates, making them ineffective for reliable long-range communication. As an alternative, acoustic communication is an ideal choice for underwater environments. Acoustic communication utilizes sound waves as the carrier for transmitting information, and it can cover long distances in water due to its low frequency and low absorption characteristics [10]. Acoustic communication has been widely used in various underwater applications, such as environmental monitoring, disaster detection and prevention using sensor nodes, pollution detection in rivers and seas, weather tracking, and ocean statistics compilation [11]. Despite its advantages, underwater acoustic communication also faces several challenges. Bandwidth is often constrained in underwater environments, which limits the data rate and transmission capacity. High bit error rates are common due to the scattering, absorption, and multipath effects of sound waves in water, resulting in potential data loss or corruption. Restricted battery power is also a concern for underwater sensor nodes, as energy consumption must be carefully managed to prolong the operational lifetime. Energy efficiency and dependability are critical considerations in underwater communication systems, where frequent node mobility and the likelihood of sensor node failures due to harsh environmental conditions are significant concerns [11]. To address these challenges, various geographicalVarious routing algorithms have been suggested for Underwater Sensor Networks (UWSNs) with the goal of optimizing routing paths, reducing energy consumption, and addressing challenges posed by high bit error rates and node mobility. Despite these efforts, UWSNs are regarded as partially connected networks, and protocols tailored for land-based sensor networks may not be directly suitable. This is due to the distinct characteristics of the underwater environment, including elevated propagation delays and error rates. [3]. Therefore, tailored solutions that account for the specific challenges of underwater acoustic communication are required to ensure reliable and efficient communication in UWSNs.

II. LITERATURE REVIEW

For underwater sensor networks (UWSNs), An asynchronous, scalable localization technique [6] has been presented to predict node movement. In order to ascertain the present mobile sensor nodes' location —which is essential for routing decisions in UWSNs—the method makes use of a tidal mobility model. Additionally, in order to enhance communication efficiency within UWSNs, a back-off technique for adjusting contention windows, as proposed by Dario and colleagues, is implemented. A multimedia pass protocol has been suggested to facilitate novel applications such as photo and video collection, tactical and coastal monitoring and classification, as well as underwater disaster avoidance [17]. Researchers have devised a method to enable effective data transfer in Unified Wireless Sensor Networks (UWSNs), considering constraints such as limited battery power, bandwidth, and propagation delay in sensor nodes. In response to the challenge of securely coordinating subsea vessels, a secure communication suite with features like vehicle validation and privacy has been developed. The 2011 proposal by Dini and colleagues guarantees the confidentiality and integrity of all talks in UWSNs using this suite. For UWSNs, a number of localization methods have been developed, such as Liute et al.'s "Anchor-Free Localization" technique from 2012. This approach builds an algorithmic structure for locating nodes in UWSNs by incorporating both mobile and fixed nodes and using data from nearby nodes. In 2018, Walter and colleagues presented "Arc Moment," a two-dimensional technique that leverages the Euclidean distance formula to enhance node mobility. In addition, a three-dimensional method known as "KRUSH-D" has been suggested to solve node mobility problems and improve network connectivity. o enhance communication stability in UWSNs, this approach employs the well-established Kruskal method and utilizes Euclidean 3-

dimensional distance computation for channel selection [18]. As for routing methods, Mangla et al. (2016) suggested the "Sensor Nodes with a Cluster of Energy-Efficient" protocol, which accounts for each sensor node's throughput, energy optimization, and reliability. Additionally, Mangla et al. (2018) suggested UWSN routing strategies based on variables like delay, energy efficiency, and packet delivery rate. In addition to being able to be combined to create various network scenarios, all of these protocols and algorithms can be used as standards to evaluate the efficacy of routing protocols and help determine which protocol is best for UWSNs.

Routing protocols that are geographical, proactive, and reactive: For information to be transmitted in ad hoc networks between source and destination nodes like Vehicle Ad-hoc Networks, or VANETs, routing protocols are essential. Reactive, proactive, and geographical routing protocols are among the various varieties of routing protocols. In proactive routing protocols, sometimes known as protocols that are driven by tables, every node in the network keeps a routing table in order to store and share information with other nodes. Proactive routing protocols, such as DSDV (Destination Sequence Displace Vector Routing), Fisheye State Routing, or FSR, and OLSR (Optimized Link State Routing), are utilized in VANETs. DSDV, specifically, enables nodes to exchange data packets with other nodes within the network and is based on the Bellman-Ford algorithm. Information like the hop count, sequence number, and IP address are contained in every packet. To guarantee precise routing decisions, The network's nodes update their topology data. instantly, at predetermined intervals, or on a regular basis. To put it briefly, VANETs use Table-driven or proactive routing protocols, such as FSR, OLSR, and DSDV to create and maintain routing tables for effective data exchange between network nodes. These proactive protocols, which are based on predefined routes, maintain up-to-date routing data and guarantee dependable ad hoc network communication.

OLSR (Optimized link State Routing): The routing protocol known as OLSR (Optimized Link State Routing) is used in ad hoc networks. that uses "hello" messages to gather data about nearby nodes [20][2]. Each network node sends "hello" signals to its neighbors when a problem is detected, and it also keeps track of all the nodes in its table—a process known as the classical link state algorithm. To mitigate the time-consuming process, OLSR uses a multipoint relay plan to reduce the sensor node's flooding expense. Protocols for reactive routing, also referred to as on-demand routing protocols, on the other hand, are intended to establish and select routes only as needed. These protocols, which include Ad-hoc On-Demand Distance Vector (AODV), Temporally Ordered Routing Algorithm (TORA), and Dynamic Source Routing (DSR), help to reduce network traffic by identifying routes and only searching for destinations when necessary. Proactive-based routing protocols might not be appropriate regarding underwater sensor networks (UWSN), where nodes travel quickly and with high mobility as a result of the high bandwidth usage and quantity of table data. Because of this, UWSN frequently uses reactive routing protocols like TORA to dynamically create routes based on network requirements. On-demand protocols are reactive routing protocols, such as AODV, DSR, and TORA. that are used, whereas OLSR, or "Hello" messages are used by the optimized link state routing protocol to learn about nearby nodes.

AODV: The Ad-hoc On-Demand Distance Vector (AODV) represents a responsive routing mechanism designed to adapt to environmental changes, primarily employed when a node intends to transmit data to another node [20]. Recognized as a reactive routing protocol, AODV constructs routes dynamically on-demand, only when the need arises. This protocol builds upon the Dynamic Source Routing (DSR) method, initiating route discovery in AODV by broadcasting a Route Request packet (RREQ).. Forward pathways are established using Route Reply packets (RREP). Active nodes along the path dynamically create and maintain the route table entries in AODV. In order to prevent routing loops, a routing table entry's usage is examined after it expires. In order to prevent route breakdowns and guarantee effective routing, AODV additionally uses a destination sequence number. The ability of AODV to support multi-hop routing—in which nodes can travel via multiple routes to reach the destination—is one of its main advantages. As a result, nodes can effectively accomplish their objectives without having to actively manage the whole route to their destination. All things considered, AODV [35-37] is an automated and effective routing protocol for ad hoc networks, able to optimize the routing process and create routes dynamically on demand. [2]DSR: This straightforward, effective routing protocol was created especially for wireless ad hoc networks with numerous hops [2]. It eliminates the requirement for previously built network infrastructure by enabling the network to self-organize and configure. By using source routing, packets are sent.

VBF: Using the "pipe" concept, the location-based routing protocol VBF takes a novel approach to forwarding data packets traveling from one place to another [3]. In VBF, every packet includes all available information about the forwarder, source, and destination uses the vector data contained in a packet to determine its current location when it is received. The packet is routed to its destination if it has reached the specified pipe. Otherwise, the packet is discarded if it falls outside the pipe, saving the network from needless overhead. Utilizing location data to inform routing decisions, VBF is especially helpful in situations requiring precise location-based routing [3].

Hop-by-hop vector-based forwarding, or HH-VBF: HH-VBF, a location-dependent routing protocol, extends the principles of VBF by employing a hop-by-hop approach to relay data packets from one location to another [4]. Similar to VBF, HH-VBF directs packets through multiple per-hop forwarding pathways, which are determined by the forwarder node utilizing a pipe-based technique.. In HH-VBF, the forwarding choice at every hop is determined by the forwarder node's location in addition to the packet's current location. Because of this, routing decisions can be made more precisely and locally. by accounting for the node locations and current network topology. HH-VBF aims to provide accurate and efficient packet forwarding in low-node networks. where location-based per hop forwarding may be used to achieve better performance. By utilizing a pipe-based method to combine the concepts of per hop forwarding and location-dependent routing, Routing performance and efficiency are increased as HH-VBF improves VBF's functionality and offers a forwarding method customized to the unique features of the network [4].

Depth - Based Routing (DBR)*:* DBR stands out as an effective routing protocol tailored for dense and dynamic underwater networks [2]. Notably, DBR excels in scalability and efficiency, eliminating the need for localization data in the routing decision-making process. Instead, DBR relies solely on depth measurements obtained from depth sensors to gauge the underwater environment. Consequently, routing paths for data packets are established using the depth information collected from these sensors. arrive at the sink, which is usually at the water's surface. This method eliminates the need for extra localization data and enables scalable and effective routing in underwater networks. In undersea environments that are dynamic and dense,, where localization might not be practical or feasible, Depth-Based Routing (DBR) is a helpful technique. It achieves this by enabling effective and dynamic routing in underwater networks through the use of depth sensor data [2]. Because of its unique methodology, DBR is an effective routing method for scenarios involving underwater communication.

TC-VBF(Topology-Control-Vector-Based Forwarding*):* Not only does it guarantee dependable data transfer to wireless sensor networks, but it also optimizes the use of energy resources. It is divided into two sections: internet coverage and internet connectivity. The network's coverage is the first [4]. How the sensor node confirms the target land determines this. It makes an effort to use less energy while offering dependable sensing regions. System affinity is a clever sensor relationship topology that makes use of UWSN architecture to control and run power.

HH-DAB: It will be resilient, scalable, and energy-efficient, with a multi-sink architecture. It does not require full dimension allocation information, nor does it require any new types of nodes or specialized technology, meaning there are no extra costs. Complicated routing tables do not need to be tracked.Nodes' mobility in the presence of water currents can be easily controlled[4].

Multisink opportunistic routing protocol: By cutting down on pointless packet transmissions, it conserves energy. Due to its stronger processing capabilities, longer transmission range, and larger memory, the mesh node is the most expensive sensor node in this protocol [5].

DFR (Directional Flooding Based Routing Protocol): When packets are flooded in one direction without a path being established to the destination, high reliability is also provided[2].

DSR: From a source to a sink, it determines a path using location awareness and link quality as metrics. The routing protocol in use at the source determines this.

Dolphin Protocol: It guarantees the authenticity of the links and the network topology. The network's lifespan is extended and energy balance is achieved. It depends on the inherent qualities of dolphins.

TABLE1 Underwater routing protocol: advantages and disadvantages

Related work	Merits	Demerits
Multi-sink opportunistic routing protocol[5]	It achieves a high delivery rate at a low energy cost[5]and It saves energy by reducing redundant packet transmissions.	Because it produces a substantially faster delivery rate, it consumes more energy than a single sink route, Mesh node is very expensive in this protocols node as a result of its increased memory, increased transmission range, and superior processing ability[5].
VBF(Vector-Based Forwarding Protocol)[4]	In dense networks, it lowers network traffic. It saves power. Furthermore, it manages dynamic topologies with dependability and effectiveness [3].	In sparse networks, it is ineffective. The routing pipe radius threshold is very delicate. and it has a substantial impact on routing performance [3].

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HH-VBF	It has the capability to discover extra channels for delivering data in networks with sparse nodes, displays resilience in the face of node failures, and is minimally impacted by the radius of the routing pipe.	By making the nodes on the path later, the void and the Algorithms can automatically select alternate routes forward. It has
[23].		By delaying the nodes along the path, the system can automatically choose alternative routes to overcome obstacles. However, the use of hop-by-hop routing vectors results in significantly higher communication overhead compared to VBF.[3].
TheHH-DAB(Hop-Hop DynamicAddressing Based RoutingProtocol)[4]	The system will incorporate a multi-sink architecture and emphasize resilience, scalability, and energy efficiency.It does not require any new types of nodes or specialized technology. The mobility of nodes in the presence of water current can be simply managed[4].	Too many broadcast messages areusedtoforwarddatapacketsandassignnodesIDs[1].
OLSR(OptimizedLink State Routing) andAODV(Ad-hocOnDistance Vector RoutingProtocol)[20]	Interrestrialnetworks,itis employed[2].	UWSNs don't work well with them. Because hello messages are exchanged on a regular basis, UWSNs have a lot of signaling overhead. Finding the path takes some time in consistent performance due to the slow speed of the acoustic signal and the high likelihood of packet loss underwater. .Control messages required to find a path in UWSNs have a high overhead because to the limited bandwidth.WeproposedaDFRtoaddresstheseconcerns[2].
DFR[2]	Low communication overhead DFR (DirectionalFloodingBasedRoutingProtocol):High reliabilityisalsoofferedwhenpacketsarefloodedinonedirectionwithoutapath beingestablishedtothedestination[2].	Deliveringapackettoasinkrequiresmoretime.
LASR[2]	Itfindsarouteemployingusinglocationawareness and link quality as a source to sinkmetric	Itisdependentontheroutingprotocolusedatthesource.
Dolphin protocol[7]	Itisensuresthenetworktopologyandlinkauthenticity.Energyisbalanced,andthenetwork'slifetimeisincreased.	It is dependent on naturalcharacteristicsofdolphins.

SIMULATION

A number of factors, including malicious nodes, pause duration, network size, and link failure, etc., are used to assess the protocol's performance. The network size, or more precisely, the number of nodes, is the parameter selected for simulation experiments in this research project. 250 nodes are haphazardly placed in a 3D monitoring area for the simulation. The communication radius is 500 meters, and the layer width is 400 meters. The relationship between acoustic pressure and transmission distance determines that pressure. Table 5 lists all of the parameter configurations that were used to assess and contrast DHRP with DRF and LASR, two earlier routing protocols[38-40].

TABLE 5: Simulation Parameters

Parameters	Values
Data transmission rate	20 kbps
Underwater speed of sound	2000 m//s
Transmission radius of SN	≈350 m
Packet Size	74 bytes
Layer width	≤150 m
MAC Protocol	CW-MAC 802.11DCF
Packet size	20 bytes
Sink Number	≥4
Power of Transmit	60 W
Acoustic data transmission	113 dB (μPa)
Acoustic pressure of layer	110 dB (μPa)
Boundary of Network	1.5 km x 1.5 km x 1.5 km
Number of SN	101000
Runtime	1500 s
Initial energy of SN	450 J
Bandwidth	100 Hz
Idle state	168 mW

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PERFORMANCE METRICS

The total energy that a wireless sensor network underwater uses for all of its packets is referred to as the packet delivery ratio, or PDR (UWSN).

$$PDR = \frac{Overall\ packets\ received\ by\ all\ destination\ node}{Overall\ packets\ sent\ by\ all\ source\ nodes}$$

End-to-End Delay (ETED): In a network, like an underwater wireless sensor network (UWSN), this is the total amount of time that each packet must travel from the start of its transmission until it reaches the sink node. $ETED = timeofpacketsent - timeofpacketreceive$

The total amount of time that each packet in a network, like an underwater wireless sensor network (UWSN), must travel from the start of its transmission until it reaches the sink node is known as the end-to-end delay (ETED).

· The percentage of data packets that a network's sink node has successfully received relative to the total number of data packets transmitted by all sensor nodes is known as the average energy consumption, or AEC [41][42].

$$AEC = \frac{\left(\sum_{j=1}^{g} \quad EC\right)}{g}$$

In this case, "g" stands for the hop count, which indicates the number of network hops, or intermediary nodes, a packet has passed through and "EC" stands for energy consumption, which indicates the quantity of energy used [43][44].

The energy consumption of various nodes and the relationship between DHRP and them, are shown in Figure 5. Increasing the number of nodes by default results in higher energy usage. On the other hand, DHRP uses less energy than DRF and LASR. This is explained by the fact that more energy is used when probe packets are broadcast in order to find relay nodes before sending data packets. DHRP, on the other hand, takes advantage of the swarming behavior of dolphins to select the best node quickly without overloading the network, resulting in minimal energy consumption.

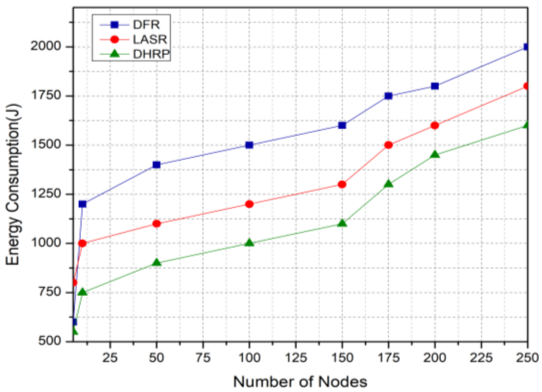

FIGURE 5 Total Energy Consumption in the network

The end-to-end delay relationship between various nodes and DHRP is shown in Figure 6. When compared to DHRP, delays are greater for Dynamic Feedback-based Routing (DFR) and Load Adaptive and Stable Routing (LASR). This is because DHRP greatly reduces end-to-end latency by using its calling phase to send data packets directly to dependable nodes. The avoidance of loop paths through DHRP is another factor contributing to the decreased delay in DHRP. Conversely, the repeated transmission of probe packets causes increased delay for DFR and LASR [45][46].

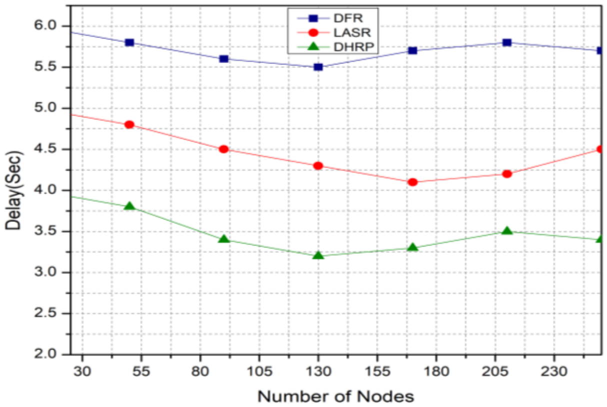

FIGURE 6 Delay in network for packet delivery

The correlation between DHRP and simulation time, along with the sensor node death rate, are depicted in Figure 7. It is observed that, for all protocols, a higher rate of sensor node death corresponds with an increase in simulation time. Because DFR and LASR transmit data packets directly without relying on relay nodes, they use a lot of energy. Furthermore, packet collision exacerbates LASR and DFR's energy consumption. These elements lead to a high energy consumption and a higher node death rate in these protocols. On the other hand, DHRP minimizes energy by taking into account the nodes' residual energy and avoiding looping paths.

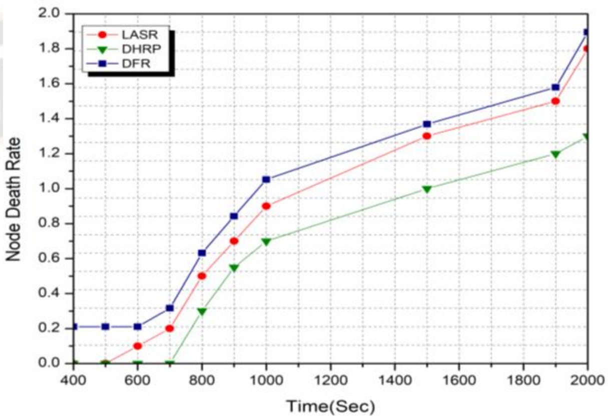

FIGURE 7 Node Death Rate in the network

The relationship between the number of nodes and the packet delivery ratio and DHRP (Dolphin Heterogeneous Resilient

Protocol) is shown in Figure 8.

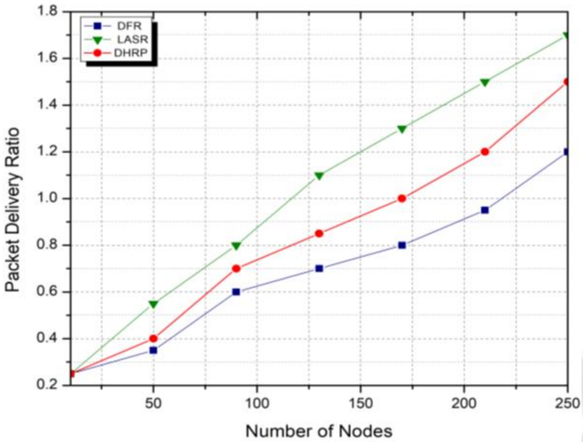

FIGURE 8 Packet Delivery Ratio

Initially, the packet delivery ratio rises in tandem with the node count. Nevertheless, the packet delivery ratio begins to decrease at a given node count. All protocols show an improved packet delivery ratio up to 90 nodes. Nevertheless, once they reach 90 nodes, both LASR (Localized Adaptive Sleep Routing) and DFR (Dynamic Fuzzy-based Routing) exhibit diminishing returns in packet delivery. Optimizing each node's energy levels at peak energy is largely dependent on the predation phase of DHRP. Through the use of neighbor identification and the avoidance of error and loop routes, DHRP improves the packet delivery ratio to the intended destination.

III. CONCLUSION

In this work, routing protocols and methods for enhancing challenges with connection or communication in environment of submerged wireless sensor network. It includes a breakdown of transfer, propagation delay, Doppler spread or distribution, sound, multipath and transmission loss. 3-D-based communication architecture will be thoroughly reviewed for the benefit of UWSNs. Employer choice in communication is the main topic of this study. Wireless sensor networks submerged in water are best suited for acoustic communication. As opposed to radio frequency, we have demonstrated that acoustic signals cause a larger propagation delay. In this paper we compare underwater routing protocol and explain best routing protocol in environment of underwater Future work will be to develop underwater sensor network communication protocols that are efficient. We also want to improve reliability of the network. In this study, the DHRP routing protocol, which is bio-inspired, is suggested for UWSN. Initialization, Searching, Calling, Reception and Predation, and Ending are the six key phases of DHRP.Thesixdistinctphasesareusedtodeterminetheoptimum pathtoalocationandarebasedonthenaturalcharacteristicsofdol phins. In order to help discover the optimum route in a dynamic environment, DHRP ensures that the links are legitimate and that the network topology is correct. When transmitting data, each node is given preference, which helps avoid loop paths and provide a more effective way. Future aspects of this research project could behoned using various bio-inspired optimization strategies and assessed using various parameters.

REFERENCES

1.Agarwal.Kanika, Rakesh.Nitin, “Node mobility issues in UWSN,” International ConferenceonSmart System,Inovationand Computing(ICSSIC), pp.1-8,2016

2.D. Hwang and D. Kim, “DFR: directional flooding-based routing protocol for underwatersensor networks,” in Proceedings of the IEEE OCEANS, pp. 1–7, IEEE, Quebec, Canada,September2008.

3.N. Nicolaou, A. See, P. Xie, J.-H. Cui, andD.Maggiorini, “Improving the robustness oflocation-based routing for underwater sensor networks,” in OCEANS 2007-Europe, p. 1,IEEE,2007.

4.M.AyazandA. Abdullah, “Hop-by-hopdynamic addressing based(H2-DAB)routingprotocolforunderwaterwirelesssensornetworks,” inProceedingsoftheInternationalConferenceonInformationand MultimediaTechnology(ICIMT’09),pp.436–441,December2009.

5.T.Li,“Multi-sinkopportunisticroutingprotocolforunderwatermeshnetwork,” inProceedingsof theInternationalConference onCommunications, Circuits and Systems(ICCCAS’08), pp. 405–409, May2008

6.Dong, M., Li, H., Yin, R., Qin, Y., & Hu, Y. (2021). Scalable asynchronous localizationalgorithm with mobility prediction for underwater wireless sensor networks. Chaos, Solitons&Fractals, 143, 110588,2020.

7. Walter.Nishit, Rakesh.Nitin, “SEE THROUGH Approach for the solution to Node Mobilityin UWSN,,” International Confrence on Smart System, Inovation and Computing(ICSSIC),pp.19-29, 2018.

8.Wu, Tq., Yao, M. & Yang, Jh. (2016). Dolphin swarm algorithm. Frontiers Inf TechnolElectronicEng17, 717–729.

9.Bansal.Rubal,Maheshwari.Saurabh,andAwwal.Payal,”Challenges andIssuesinImplementation of UWSN,”SpringerNatureSingaporePteLtd, pp.507-514, January2018.

10.R.Alak, and S.Nityanand, “Selection of Communication Carrier for UWSN,” InternationalSymposiumon Advanced Computingand Communication (ISACC), pp.1-7,2015.

11.Felemban.Emad, S.K.Faisal, Q.M.Umair, A.S.Adil, and Q.B.Saad,”UWSN Applications,”International Journal ofDistributed Sensor Networks, pp. 1-14,2015.

12.H.Min,Y.Cho,J.Heo,“EnhancingtheReliability ofHeadNodesinUWSN”,MDPISensor, pp.1194-1210,2012.

13.K. Anwar, A.Ihsan, G. Abdullah, K.Nawsher, A.Mohammed, R.U. Atiq, and M.Hasan,“RoutingProtocols

forUWSN,"MDPISensor, pp. 1-30.2018.
14.Lloret.Jaime, "Underwater Sensor Nodes and Network," MDPI Sensor, pp. 11782-11796,2013
15.Mangla.Jyoti, Rakesh.Nitin, "Cluster-Based Energy-Efficient Communication in UWSN,"International Confrence on Smart System, Inovation and Computing (ICSSIC), pp. 1-8,2018.
16.Pompili Dario, Akyildiz A., (2010) A Multimedia Cross Layer Protocol for UnderwaterAcousticSensor Network.IEEE Trans.onwirelesscommunication, 9(9),pp.2924-2933.
17.Pompili Dario,. Akyldiz Ian F., (2009) Overview of Networking Protocols for UnderwaterWireless Communications. IEEE Transaction on wireless communication, 9(2), pp. 16345-16363.
18.Walter.Nishit, Rakesh.Nitin, "KRUSH-D approach for the solution to node mobility issue inUWSN," Networking Communication and Data Knowledge Engineering (NCDKE), pp.89-98,2018.
19.Agarwal.Kanika, Rakesh.Nitin, "Node mobility issues in UWSN," International ConferenceonSmart System,Inovationand Computing(ICSSIC), pp.1-8,2016.
20.Bansal.Rubal,Maheshwari.Saurabh,andAwwal.Payal,"ChallengesandIssuesinImplementation of UWSN,"SpringerNatureSingaporePteLtd,pp.507-514, January2018.
21.Felemban.Emad, S.K.Faisal, Q.M.Umair, A.S.Adil, and Q.B.Saad,"UWSN Applications,"International Journal ofDistributed Sensor Networks, pp. 1-14,2015.
22.H.Min,Y.Cho,J.Heo,"EnhancingtheReliability ofHeadNodesinUWSN",MDPISensor, pp.1194-1210,2012.
23.K. Anwar, A.Ihsan, G. Abdullah, K.Nawsher, A.Mohammed, R.U. Atiq, and M.Hasan,"RoutingProtocols forUWSN,"MDPISensor, pp. 1-30.2018.
24.Lloret.Jaime, "Underwater Sensor Nodes and Network," MDPI Sensor, pp. 11782-11796,2013
25.Mangla.Jyoti, Rakesh.Nitin, "Cluster-Based Energy-Efficient Communication in UWSN,"International Confrence on Smart System, Inovation and Computing (ICSSIC), pp. 1-8,2018.
26.Pompili Dario, Akyildiz A., (2010) A Multimedia Cross Layer Protocol for UnderwaterAcousticSensor Network.IEEE Trans.onwirelesscommunication, 9(9),pp.2924-2933.
27.Pompili Dario,. Akyldiz Ian F., (2009) Overview of Networking Protocols for UnderwaterWireless Communications. IEEE Transaction on wireless communication, 9(2), pp. 16345-16363.
28.R.Alak, and S.Nityanand, "Selection of Communication Carrier for UWSN," InternationalSymposiumon Advanced Computingand Communication (ISACC), pp.1-7,2015.
29.Walter.Nishit, Rakesh.Nitin, "KRUSH-D approach for the solution to node mobility issue inUWSN," Networking Communication and Data Knowledge Engineering (NCDKE), pp.89-98,2018.
30. Narayan, Vipul, et al. "A Comprehensive Review of Various Approach for Medical Image Segmentation and Disease Prediction.
31. Mall, Pawan Kumar, et al. "A comprehensive review of deep neural networks for medical image processing: Recent developments and future opportunities." Healthcare Analytics (2023): 100216.
32. Narayan, Vipul, et al. "Severity of Lumpy Disease detection based on Deep Learning Technique." 2023 International Conference on Disruptive Technologies (ICDT). IEEE, 2023.
33. Saxena, Aditya, et al. "Comparative Analysis Of AI Regression And Classification Models For Predicting House Damages İn Nepal: Proposed Architectures And Techniques." Journal of Pharmaceutical Negative Results (2022): 6203-6215.
34. Kumar, Vaibhav, et al. "A Machine Learning Approach For Predicting Onset And Progression""Towards Early Detection Of Chronic Diseases "." Journal of Pharmaceutical Negative Results (2022): 6195-6202.
35. Chaturvedi, Pooja, A. K. Daniel, and Vipul Narayan. "A Novel Heuristic for Maximizing Lifetime of Target Coverage in Wireless Sensor Networks." Advanced Wireless Communication and Sensor Networks. Chapman and Hall/CRC 227-242.
36. Walter.Nishit, Rakesh.Nitin, "SEE THROUGH Approach for the solution to Node Mobilityin UWSN,," International Confrence on Smart System, Inovation and Computing(ICSSIC),pp.19-29, 2018.
37. Tian-qiWU,MinYAO,Jian-huaYANG,"DolphinSwarmAlgorithm,"FrontiersofInformationTechnology&ElectronicEngineering(FITEE),pp.717-728.
38. .SureshWati,NitinRakesh,ParmanandAstya,"DataCommunicationIssuesinUnderwaterSensorNetwork,"InternationalConferenceonComputing,Communication,andIntelligentSystem(ICCCIS).pp.150-155(2019).https://ieeexplore.ieee.org/xpl/conhome/8966553/proceeding.
39. .Suresh Wati, Nitin Rakesh, Parmanand Astya, "Attacks in Underwater Sensor Networks"International Journal of Interdisciplinary Innovative Research &Development (IJIIRD). Pp.113-115(2020).
40.. Suresh Wati, Nitin Rakesh, Parmanand Astya, "Heterogeneous resilient approach related to communication issues in the underwater sensor networks" 060007-1-15(2023).
41. Kumar, Vimal, and Rakesh Kumar. "A cooperative black hole node detection and mitigation approach for MANETs." In Innovative Security Solutions for Information Technology and Communications: 8th International Conference, SECITC 2015, Bucharest, Romania, June 11-12, 2015. Revised Selected Papers 8, pp. 171-183. Springer International Publishing, 2015.
42. Kumar, V., Shankar, M., Tripathi, A.M., Yadav, V., Rai, A.K., Khan, U. and Rahul, M., 2022. Prevention of Blackhole Attack in MANET using Certificateless Signature Scheme. Journal of Scientific & Industrial Research, 81(10), pp.1061-1072.
43.. Kumar, V. and Kumar, R., 2015. An adaptive approach for detection of blackhole attack in mobile ad hoc network. Procedia Computer Science, 48, pp.472-479.
44. Kumar, V. and Kumar, R., 2015, April. Detection of phishing attack using visual cryptography in ad hoc network. In 2015 International Conference on Communications and Signal Processing (ICCSP) (pp. 1021-1025). IEEE.
45. Kumar, V. and Kumar, R., 2015. An optimal authentication protocol using certificateless ID-based signature in

MANET. In Security in Computing and Communications: Third International Symposium, SSCC 2015, Kochi, India, August 10-13, 2015. Proceedings 3 (pp. 110-121). Springer International Publishing.

46. Kumar, V. and Kumar, R., 2017. Prevention of blackhole attack using certificateless signature (CLS) scheme in MANET. In Security Solutions for Hyperconnectivity and the Internet of Things (pp. 130-150). IGI Global.