

A CIRCUMSTANTIAL ANALYSIS ON EVIDENCE AND GEOLOGICAL INFORMATION BASED ROUTING PROTOCOL IN UNDERWATER SENSOR NETWORKS

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DOI: 10.47750/pnr.2023.14.501.139

Abstract

In recent days, underwater wireless sensor networks (UWSNs) are now a prominent topic for research. These systems may perform a variety of submarine tasks, like tidal, acoustic, hydrological, and seabed navigation. UWSNs, however, are subject to a number of restrictions and objections, such as significant sea intrusion and noise, lengthy propagation latency, a limited radio spectrum, graphical model architecture, and energy storage restrictions for sensor nodes. The creation of network topologies is one approach to solving these issues. Information may be efficiently sent across the system from the expert node to the target node using a communication scheme. The submarine routing protocols for UWSNs are examined in this paper. Existing underground route accords may be categorized into three types and they are energy based, data based and geographic based protocols. In this paper we have discussed the evidence-established and geological information-established covenants. In addition, we discuss underwater routing methods' research obstacles and potential possibilities, which can aid future exploration.

INTRODUCTION

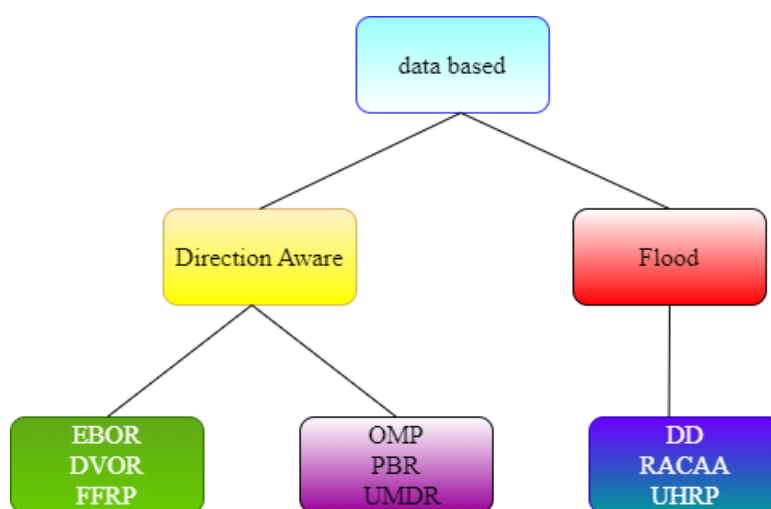
A mechanism called the voip service is used to choose an effective route for information to go from source to destination. When choosing the route, which depends on the communication standard, modulation schemes, and quality measures, the procedure runs into a number of problems. In a wireless sensor node (WSN), the information collected by the IoT devices is normally sent to the base station that connects the sensor network to other systems (perhaps the internet), where it is evaluated and appropriate action is taken. Solitary interaction happens in extremely tiny sensor networks when the base station and nodes (sensor nodes) are in close proximity to one another. However, in most WSN applications, the communication range is so broad that hundreds of base stations are needed. The majority of the sensor nodes are so far away from the cluster heads (gateway) that they cannot interact with the core network directly in this case, necessitating multi-hop transmission. Direct engagement is another name for reaction, whereas form of interaction is another name for non-linear and non-information exchange. The overall navigation mechanism of the system is designed to send data. Typically, station position serves as the foundation for node identification and routing in packet switching techniques. Instead of focusing on the collection data in a single cluster, we want a wireless sensor network to detect the required data throughout the deployment process. The routers within the perceived range will be alerted to the occurrence and begin to gather data, which they will then communicate to the sink node for

additional processing. The queryable relay nodes primarily take the signal from the sensor node to the intermediate nodes into account and choose the most effective approach based on the data information in the communication path.

In order to create an adaptive infrastructure, the UWSN places several detectors submerged. The location of cluster heads is frequently used in potential implementation to get important files material. The study of routing protocols based on geographic information is crucial. Routing protocols maintain the path and transmit information in accordance with location information, enabling directed file transfers and lowering communication latency. The geographic information-based routing protocols primarily take into account the infrastructure and choose the optimal course using geographical data.

RELATED WORK

Fig 1. Various data based routing protocols in UWSN



It is also hard to create a suitable routing standard for UASNs because of the high error rate, long propagation delay, and unreliable communication between nodes.

Protocols Addressing Direction Aware

Based on the specific approach that is outlined in the protocols that are concerned with direction awareness, the detectors choose the most appropriate next hop to use for proper transmission of information. The most important aspect of these direction-aware routing protocols is data transmission efficiency.

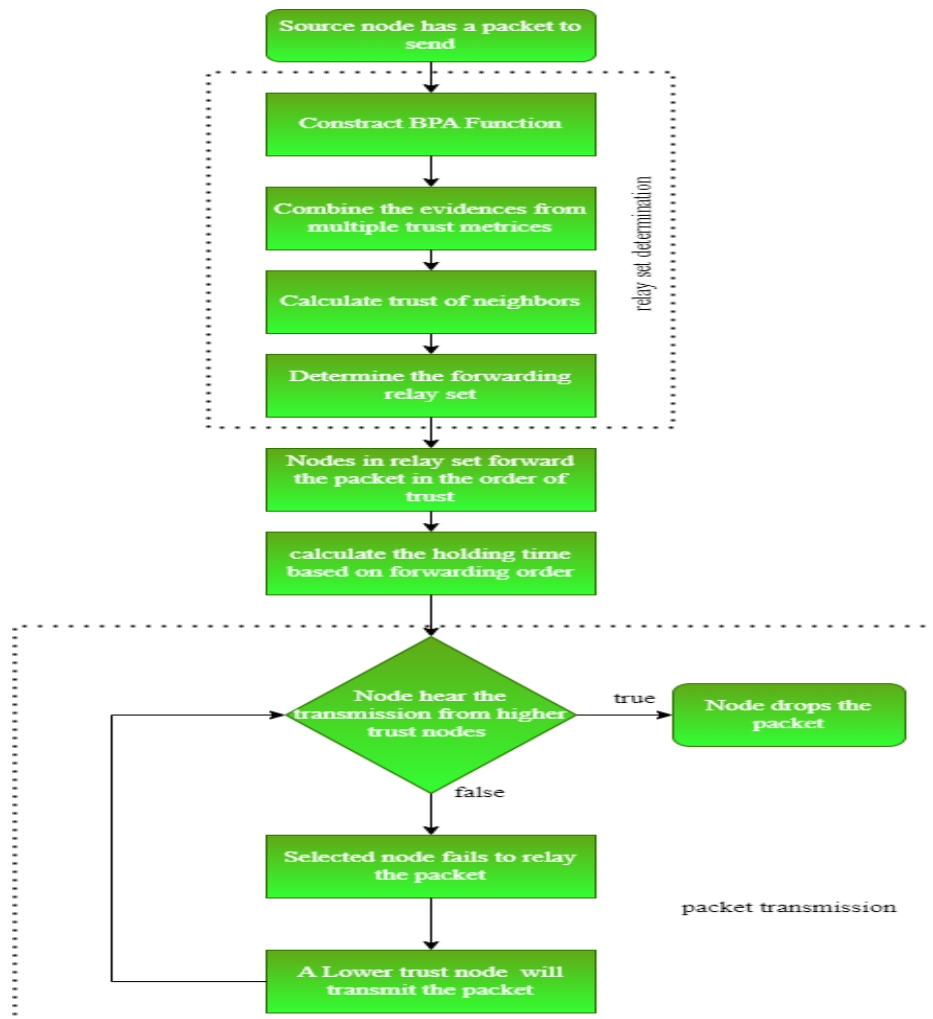
EBOR:

When routing the messages to the external drain, Zhigang Jin devised the Dempster-Shafer evidence theory (DST) based opportunistic routing (EBOR) system[16]. The base station considers both the probability of packet delivery and residual energy while determining the best subsequent hop in EBOR. To save power, confidence computing is used to optimize the number of neighbors taking part in transmitting. The data packet can then efficiently arrange the transfer of packets toward the surface sink thanks to the nodes' mutual trust. The EBOR protocol is able to increase the number of packets delivered and extend the overall network's life span by evenly dispersing remaining energy.

The EBOR encryption uses the advantage of route discovery to transport packets from the source node to the surface sink with the assistance of several neighbors. The data packet must be aware of the locations and energy levels of its neighbors in order to determine the subsequent hop. So, during the initial phase, the sensor nodes detect the submerged sound pathway to gather data and update it. For the EBOR protocol's forwarding relay set,

the source node's suitable neighbors are chosen using the DST approach. Relay nodes then forward the packet according to the DST-determined order of trust. The priority of the packet that the node forwards increases with more trust. The relay set nodes will each get a hub. Given the way ambient noise propagates, destination apex must reserve time between packets to avoid crashes. The duration for the most reliable node is 0. If the intermediate apex does not receive the transmission from the higher-trust node during its holding time, it will either drop the message and forward it. The message will be sent step by step until it hits the water drain.

Fig .2: Flow diagram of ENOR routing protocol



PACKET DELIVERY PROBABILITY ESTIMATION

In this section, the author calculates the PDP $p(m,d)$ of m bits for the source node and its neighbor. The Thorp dispersion theory is used by the EBOR standard to construct an underwater communication channel. Pathway loss is defined as the degradation on a given, unimpeded transmission path across a distance d for a single frequency f brought on by massive decaying.

$$A(d, f) = d^k a(f)^d \text{----- (1.1)}$$

K - spreading factor

$a(f)$ - absorption coefficient

The dispersion parameter k is used to describe the propagation path. For spherical spreading, the most common values are $k=2$, as power dispersion between detectors is omni-directional. The Thorp's formula for describing the absorption coefficient $a(f)$ for f at kHz is given by

$$10 \log(f) = \frac{0.11 \times f^2}{1+f^2} + \frac{44 \times f^2}{4100+f^2} + 2.75 \times 10^{-4} f^2 + 0.003 \text{ -----(1.2)}$$

The average signal-to-noise ratio (SNR) over distance d and frequency f is given by ,

$$\gamma(d, f) = \frac{E_b/A(d, f)}{N_0} = \frac{E_b}{N_0 d^k a(f)^d} \text{ ----- (1.3)}$$

E_b = average transmission energy per bit

N_0 = noise power density in an acoustic channel

This paper makes use of the binary phase shift keying (BPSK) modulation, which is prevalent in modern acoustic modems. Since each symbol in BPSK contains a portion, the likelihood of bit error across distance d is calculated as follows:

$$p_e(d) = \frac{1}{2} \left(1 - \sqrt{\frac{\gamma(d, f)}{1+\gamma(d, f)}} \right) \text{ ----- (1.4)}$$

$$p(d, m) = (1 - p_e(d))^m \text{ ----- (1.5)}$$

DST BASED FORWARDING RELAY SET SELECTION

This method is employed for choosing the suitable vertex in order to onward the relay set using the EBOR protocol. The Bayes rule of conditional probability has been expanded into DST. It makes it possible to determine a degree of belief based on various metrics and the evidence that is available. Instead of relying solely on a particular parameter, such as height, several parameters are selected from this paper to help the origin knot while choosing the best following flit. In EBOR, the metrics chosen are the possibility of packet delivery, residual energy, also efficient transmission distance. The criterion for routing decisions within numerous suggested routing agreements is to select the shortest path. However, the shortest path's nodes will consume more energy when compared with other nodes as a result of this criterion, reducing the network's lifespan. In order to achieve uniform consumption and extend the network's lifespan, the unused power of junctions should be included in consideration. In order to reduce retransmissions and improve delivery rates, PDP should be considered due to the dynamic nature of the undersea surroundings. When confronted with many parameters, the origin knot has difficulty determining

the neighbor nodes' priority. To evaluate the trustworthiness of neighbor nodes, we group all the affirmations from these three parameters using the DST as a suitable method.

$$m(\varphi) = 0;$$

$$\sum_{n_{ij} \in \Delta_i} m(n_{ij}) = 1$$

$$m_1(n_{ij}) = \frac{energy_{ij}}{\sum_{j=1}^k energy_{ij}} \text{-----}(1.6)$$

The standard approach to estimating the PDP is explained. However, the dynamic and unreliable communication between nodes is caused by factors like the ocean current or the activities of marine animals. The PDP is calculated using exponential smoothing, which considers the previous communication between the junctions to improve the accuracy based on prediction. The formula looks like this:

$$p(d, m, t) = \epsilon p(d, m) + (1 - \epsilon) p_{record}(V) \text{-----}(1.7)$$

$$m_2(n_{ij}) = \frac{P_{ij}}{\sum_{j=1}^k P_{ij}} \text{-----}(1.8)$$

In the actual scenario, there are very few sink nodes placed on the water surface. Therefore, the space-based standard whereas the depth-based voracious standard makes it easy for packets to be prematurely advanced to the sea surface when there is no sink node, causing packet detour when transmitted to the surface sink. The author suggests the ETD metric to ensure that the packet is sent directly to the sink node.

$$ETD_{ij} = |n_{ij}| \cdot \cos \alpha \text{-----}(1.9)$$

$$m_3(n_{ij}) = \frac{ETD_{ij}}{\sum_{j=1}^k ETD_{ij}} \text{-----}(1.10)$$

The trust value of node n_{ij} can be calculated by combining evidence or BPA functions from various metrics using Dempster's rule of combination. The following is the definition of the combination rule, an associative operation:

$$trust(n_{ij}) = (m_1 + m_2 + m_3)(n_{ij}) = \frac{m_1(n_y)m_2(n_y)m_3(n_y)}{1 - K} \text{-----}(1.11)$$

K - normalization factor

$$K = \sum_{n_{i1}, n_{i2}, \dots, n_{ik}} m_1(n_{ij})m_2(n_{ij})m_3(n_{ik}) \text{-----}(1.12)$$

After determining the trust, the source node chooses the neighbors for the forwarding relay set F. First, F is assigned to the node with the highest trust. As the chance of successful forwarding increases, the neighbors that can communicate with all of the nodes in F are chosen in order of

trust. $p_{success}$ transcend the predetermined value $p_{threshold}$. the following defines the probability of success :

$$p_{success} = \prod_j (1 - p_{f_{ij}}) \text{-----}(1.13)$$

$p_{f_{ij}}$ - the total number of knots in that particular set f_i

FILLING TIME OF THE SENDER

The packets are forwarded out by the origin knot to its next knot in the forwarding relay set F_i nodes outside of F_i will not receive it. When a F_i node receives a packet from a source node, they are aware of their holding time. During their holding time, nodes will drop the packet if they can hear the transmission from the higher-trust node; they will forward the packet when the holding time is up. Following receipt of the packet from the source node, the chosen node will set up its own forwarding relay set, moving the packet hop by hop until it reaches the surface sink. The filling time of the j th node f_{ij} in F_i of undersea network timer is challenging to synchronize, it is computed as follows once it gets the packet from the data packet:

$$T_{f_{ij}} = \frac{d(n_i f_{i1})}{V_{sound}} + \sum_{p=1}^{j-1} \frac{d(f_{ip}, f_{i,p+1})}{V_{sound}} - \frac{d(n_i f_{ij})}{V_{sound}} + j \times T_{proc} \text{ ---- (1.14)}$$

T_{proc} - container computing time

V_{sound} - undersea ultrasonic wave amplitude

ENERGY CONSUMPTION ANALYSIS

Under the EBOR protocol, The energy output necessary to transport the transmissions includes the power needed by the transmitter, neighbors and other participants of the forwarding transmission group to transmit, receive, and transmit the messages.. It considers the E_t has the energy utilization E_r for sending and getting a bundle, separately. If there are j nodes in the forwarding relay , then the total energy required to transmit a packet one hop to the neighbors is follows :

In UASNs, collisions and retransmission waste a lot of energy. As a result, These problems are lessened by the EBOR protocol, which establishes unique permission wait times to avoid collision that permits several nodes to participate in the relay of packets to boost the rate of distribution. Because of this, the EBOR protocol can transport more packets while consuming less power.

Energy Tax

The power levy's definition is the average amount of power used for each successfully forwarded container. If m transmissions were effectively delivered to the basin, and the energy output used to send m packets is E_{total} , then the energy tax is calculated as follows:

$$E_{tax} = \frac{E_{total}}{m} \text{ -----(1.15)}$$

Jain's Fairness Index:

In deep water, the deployed apexes are scattered and far apart. As a result, a few apexes will move the power output due to uneven energy consumption, resulting in coverage gaps. Both the lifetime of the network and the rate at which the surrounding nodes consume energy will be sped up by these holes. As a result, the UASNs' performance is largely reflected in their energy distribution. The following is the definition of the Jain's fairness

index, this is employed to determine how uniformly power is consumed:

$$J(energy_1, energy_2, \dots, \dots, energy_N) = \frac{(\sum_{i=1}^N energy_i)^2}{N \cdot (\sum_{i=1}^N energy_i)} \dots \dots \dots (1.16)$$

the EBOR protocol, which is based on DST and allows routing protocol to choose the best next hop in the face of various parameters. The data packet optimizes the data rate, power use, and end-to-end delay by taking into account the three metrics PDP, ETD, and residual energy when choosing the next trip for each transfer. Additionally, endpoints in the channel set are given different holding times based on their trust, which reduces conflicts and routing.

PBR (Prioritize Based Routing)

Shreema Shetty suggests using a prioritized forwarding (PBR) strategy for an underwater sensor architecture to keep track of crucial water parameters for fish farming. The underwater sensor nodes, which are positioned at shallow locations and shift in accordance with the sea currents, are what produce the constrained drifting modeling approach. Because mobility of nodes has a substantial impact on network performance,[18] the PBR protocol takes the constrained floating mobility model into consideration. The suggested protocol's sensor nodes measured the water's properties, and packets of sensory input were given a higher priority by being labeled as emergency or routine. The high-priority packets were sent using the least amount of delay possible. When choosing a routing method, factors such as node packet loss, buffer space, and one hop delay are taken into consideration and effective neighbor locations to accomplish effective data packet forwarding to the sink node while consuming as little power as possible.

Prioritize based routing (PBR)[18] is an efficient type of strategy in terms of power consumption, end-to-end delay, buffer space, and node packet loss. Depending on the water characteristics, data packets are also prioritized. The standard has been designed and developed with the underwater acoustic sensor network for fish farming in mind. PBR routes data packets hop by hop using a sink paired with a polished structure. In order to find the next hop node to sink the datagram, it uses control packets of a minimal size to minimize sampling rate and disturbance. The load distribution among the nodes is measured using the regular basis. In addition to which is considered in this routing algorithm. Temperature, dissolved oxygen, pH, salinity, and other water-related measurements. Data grams are prioritized using salinity. Crisis data grams are generated whenever a measured water parameter value exceeds or falls below the standards for farming water quality. When the measured water parameter falls within the ideal water required quality for fish farming, periodic packages are created. How crisis and ordinary packages are evaluated depends on the order in which the water characteristics are considered. Water temperature is regarded as a major concern when identifying if a datagram has crisis or normal features.

Description

Critical data receive high priority under this protocol, and packets are routed down a less congested path to the sink. There are three phases to the procedure: Phases involve acquiring appropriate training, sensing the underwater environment, choosing a routing protocol, and transmitting.

Process of Connectivity Knowledge

Every device gains knowledge of the sink-hop count value during this period. The sink initiates the channel's activation phase after the nodes have been put in the target area. The sink sends a tonne of HELLO packets over the system. The HELLO package is made up of the Source Identifier and Hop count value. The Source Identity has the address of the receiver end. The HELLO packet from the sink will have its Hop count value set to 0, and each location sets its Hop parameter to a very large value that is higher than the channel's longest

path. Node X will determine if a finally got HELLO packet's hop count is greater than the hop count value of before increasing to ++ and resuming the loop, a newly received HELLO packet must have a hop count larger than another freshly received HELLO packet. Node x either drops the HELLO packet or re-transmits it with the updated Hop count number. Once the channel's setup step is complete, each site will keep track of the value of its hop count from the sink.

Stage of Submarine Ambient Monitoring

Understanding the physical environment of the fish farming zone is crucial. Temperature, dissolved oxygen, pH, salinity, and turbidity are just a few of the significant water characteristics that the device detects. After the Connectivity Cognitive learning period is over, the nodes begin measuring the required environmental quality. Data forwarding and measuring the underwater environment are taken into account in the proposed protocol. Through emergency and regular packets, the protocol distinguishes between critical and regular events. Header, Priority, The 256-bit datagram is made up of different fields for measured underwater sensor values like temperature, dissolved oxygen, pH, salinity, and turbidity. The Headers cell represents the source and destination addresses required for data packet routing. When a router detects that the measuring water data point is within the optimal range required for aquaculture cultivation, conventional transmissions are generated by setting the priority field to zero. If the sensed value is inside or beyond the specified water range of parameters, it adjusts the priority field to 1 to create an emergency packet. The data grams are placed in the sending data structure of the IoT device before being forwarded to the drain.

Phases of Channel Cluster Formation and Transmission

The measurement-generated data grams should be delivered to the bottom sink. Whenever node x has data packets to send, it broadcasts a TCS protocol to find an appropriate neighbor forward the created datagram. The origin identity, payload identification, and number of hops make up the TCP package. Both are given 16 bits of space. The existing PING packet has a binary identification called Packet ID; the hop count value of node x is HC; and the HC rate of the TCP package is matched to the HC level of the TCP package by the receiver sites. If node y's hop count is lower than the provided hop count value Node y responds to the PONG message in the incoming PING message. The first and second fields of the PONG message, respectively, display the source and destination unique IDs of the PONG message. The specific identity for the current PONG packet can be found in the Packet ID columns. The HC field is used to input the Hop count value. The Start Time PONG field contains information on the residual energy of node y, as well as its buffer space, packet loss, and the time the PONG message was delivered from node y. When receiving a PING packet, nodes also examine their own packet loss rate and determine whether their hop count value exceeds the hop count number set in the PING message obtained. If either Sequence number or loss rate exceeds the prescribed limit, it will either drop the PING packet or return the PONG response. Node x sends a PING message and waits for its nearby hubs to transmit a PONG response at the appropriate moment. When computing the metric, the round trip time and PONG packet transmission delay are taken into consideration. The degradation of packets at the device determines it.

$$\text{Node packet loss} = (P_r - P_t) / P_r \text{ ----- (2.1)}$$

P_r – Received Packets

P_t – Transmitted Packet

Based on the priority of the data packet for the PONG signal it got from its neighbors, Router x chooses the best routing protocol. The proposed PBR relay node selection and data packet forwarding method are described in Section A. No matter how much information needs to be sent or how many packets there are, the method

accounts for consistent time for each packet. The approach is linear for a stream of data packets and has an $O(n)$ time complexity, where n is the number of available. It also includes a constant bound time of $O(1)$; the implementation from each function, among other things, can change these values.

Choosing a routing protocol and a sending strategy

1. BEGIN
2. if (packet ID is mount in Qh)
 Drop a identical data packet
3. else if (packet ID is mount in Qf)
 Drop a identical data packet
4. else store data packet in forwarding queue buffer Qf
5. end if
6. if (buffer size ≥ 1)
7. Initiate PING packet and wait time δ
8. Calculate min and max merit factor for PONG messages
9. Check emergency packet "E" in key value field of buffer
10. End if
11. If E
12. Then
13. Send packet to next node with minimum merit factor and store packet ID in queue
14. Else if R
15. Then
16. Send packet to next node with maximum merit factor and store packet ID in queue
17. End if
18. END

In order to simplify the calculation of next hop eligible forwarders for both emergency and regular packets, this routing protocol uses a weighted function. Router x produces an urgent datagram whenever the measured water parameters are either above or below the range of ideal water quality needed for aquaculture. The next hop forwarder node is selected using the Quality ratio algorithm. The Lowest Quality ratio is used to decide the emergency packet's next hop, whereas the Highest Quality value is used to decide the ordinary packet's next hop. The quality factor is calculated on the applicant neighbor data type metrics with one hop lag, residual energy, buffer space, and node packet loss based on data packet. The emergency packets are transported to the sink along a route with a low latency thanks to the values that are supplied to the operation.

The Merit factor used to select the best data packet forwarding node is ,

$$\text{Merit factor} = \{\text{Min } 1 \leq k \leq n\{x\}\} \text{----- (2.2)}$$

For forwarding an emergency packet, apex x selects next apex y with the lowest quality ratio. When selecting the adjacent apex to send an urgent datagram, all three metrics are taken into account. The minimum congested path toward the next hop neighbor is defined by the Minimum Merit factor. The second parameter specifies the neighbor node's remaining energy with the intention of achieving a level playing field with the help of power consumed. The buffer space that is available in the neighbor node of the next hop is specified by the third parameter. This parameter facilitates the allocation of traffic load among the nodes. If there is a tie for the following routing location amongst adjacent nodes, the node with the least latency is chosen. Router x produces periodic data grams when the measured environment quality is within the acceptable water category needed for fish farming. Then Network x chooses the best standard package router, based on the nearest neighbor node with the highest merit factor. This maximal efficiency makes use of the leftover energy, remaining buffer space, and node packet loss of the potential neighbor node. Regular packets are sent to the sink since the method's parameters were configured to send them. By providing more, this enables the network lifetime to be prolonged. The apex with the maximal basin power is chosen if there is a tie among the adjacent apexes for the position of next sender.

Each node has a packet history queue Q_h a forwarding priority queue Q_f . Q_h stores a unique id for each data packet that is sent, and Q_f stores emergency and regular packets that need to be forwarded in order of priority. Node y checks its packet history queue Q_h to see if a data packet has already been sent when it receives one. Node x either discards the packet or stores it in the sending prioritized queue if the information id is present in Q_h . By storing the packet identifier of the previously forwarded packet, the packet history queue reduces data repetition. The protocol record loop minimizes information by saving the package identification of the previously forwarded transmission repetition. Before storing the datagram in its forwarding priority queue, node x checks to see if the packet identifier is already present in the packet history queue. It will either discard the package if it is present or store it in Node x will select the next forwarder node with the lowest Merit factor if it has an emergency packet in The priority of the stored data packet determines the key value. Node x searches its forwarding priority queue Q_f for an urgent package. Node x will select the next forwarder node with the lowest Merit factor if it has an emergency packet in Q_f . If there are no crisis packets in the sending forwarding table, the next forwarder node y with the highest value is chosen to send precise data. When a packet of information is received, server y would respond to node x with an acknowledged response.

Flood-Based Forwarding Procedure

Until the data reaches the destination node or the maximum number of modifications is achieved, the data in the flooding algorithm is broadcasted to the adjacent apexes by the location obtaining it. The majority of flood routing protocols are simple, efficient, and do not need routing path or computing navigation operations. Because of their simple implementation and great uptime, flooding algorithms are desirable. Resource waste and internal message exposure are two problems.

RACAA:

Anwar Khan offers two networking approaches for UAWSNs: response time networking and cooperative routing with adaptive amplification (RACAA)[19]. RAR considers accessibility throughout each route when advancing packets to the surface of the ocean. This avoids apexes when connectivity isn't established and forwarder nodes aren't accessible for network communication. For each step to organize, the likelihood that data packets will be successfully transmitted is estimated. This stops the station's negative effects. However, due to the seachannel's random nature, its features could change after processing and before data transmission. RAR's coordinated networking and switch system were combined to create the RACAA protocol. A relay node in RACAA boosts its transmission power when a data error happens more than typical; It receives more than 50% from the sender before continuing to the destination. This increases the reliability even more when such packets

are forwarded. Unlike the traditional approach, these protocols don't require any prior knowledge of the nodes' positions in order to build the routes. The nodes' movements are controlled by ocean currents and tides, which makes computing difficult.

RAR: Reliability-Aware Routing

Data Routing

If the device is within the network area of the base station, the access point transmits data straight to the sink node when it is prepared for transmission. Otherwise, the node chooses across. The sensor nodes choose neighboring relay nodes for multi-hopping. The depth is the smallest at relay nodes. A routing protocol must be selected by any location that needs to send data to another node. Conditional means are used to determine all of the paths from each single node to the surface of the sea when data transmission in multi-hopping is required. Any path lacking a routing protocol from the sensor node to the water's surface is disregarded. This is because there is no connection from such a passage to the water's surface. Choosing this route will result in data packets as a result of communication being lost. Hello signal exchanges already provide knowledge of a path's connectivity and relay node availability. The chance of mistake for every link is estimated using the average signal-to-noise ratio (SNR), which is done when a sensor node chooses all linked paths that lead from itself to the edge of the water. The average SNR $\bar{\gamma}(d, f)$ between two apexes that transmitted using an submarine channel of frequency f and are separated by a distance d ,

$$\bar{\gamma}(d, f) = \frac{E_b}{N(f) \times B} \frac{1}{A(d, f)} \text{-----} (3.1)$$

Where ,

E_b - average amount of energy needed to send just one bit

$A(d, f)$ - Attenuation

N - Noise power density B - Acoustic bandwidth

Path decaying naturally exhibits an exponential probability distribution, and the accompanying average SNR also exhibits an exponential probability density function, calculated for a specific SNR value.

$$f_{\gamma}(\tau) = \frac{1}{\gamma} e^{-\frac{\tau}{\gamma}} \text{-----} (3.2)$$

whose error probability p_e , is the integral of the product of the error probability at a specific SNR value $p_e(\tau)$, times the consecutive density function of the SNR

$$p_e = \int_0^{\infty} p_e(\tau) f_{\gamma}(\tau) d\tau \text{-----} (3.3)$$

The error probability for this scheme's BPSK modulation is ,

$$p_e = \frac{1}{2} \left(1 - \sqrt{\frac{\gamma}{1+\gamma}} \right) \text{-----} (3.4)$$

In relation to this, the likelihood of effectively transmitting a single packet between nodes separated by a distance d increases ,

$$p_s = (1 - p_e)^k \text{-----}(3.5)$$

Where,

k - size of the specific packet

A detector apex selects the link for data routing that is connected to itself and offers the best chance of effectively transmitting data grams forward towards the edge of the water.

RACAA: Cooperative Routing with Adaptive Amplification for Availability Awareness

The RAR technique forwards data across a single link. Such a link might not always be dependable, and its state might change after calculation and before data transfer due to the roughness and unpredictability of the sea channel. In order to assess whether data is transferred across a reliable link, the RACAA scheme which combines RAR with cooperative routing and the adaptive power of relay nodes is used. The explanation of the RAR method is similar to that of the RACAA system, with the addition that the RAR scheme uses coordinated forwarding and adaptive amplification of the received signal by the relay apexes. A network device utilizes additional system throughput to transfer data when the probability of an error exceeds a predefined threshold data to its intended audience when amplifying adaptively.

Scalable Coordinated Scheduling Amplification

In collaborative networking, a civilization S broadcasts data grams, which are then picked up by a circuit router R and transmitted to a destination node D by at least one relay node R situated in the path between S and D . The appropriate information is then extracted by combining the two copies of the data that were transmitted from R to D .

D receives a information symbol x broadcast by S as ,

$$a_{SD} = b_{SD}x + n_{SD} \text{-----}(3.6)$$

a_{SD} - signal received at D

b_{SD} - channel gain from S to D

n_{SD} - additive white Gaussian noise (AWGN) along the $S - D$ link

When R receives the broadcasted data symbol x from the source, it is displayed as

$$a_{SR} = b_{SR}x + n_{SR} \text{-----}(3.7)$$

Where,

a_{SR} - signal received at R

b_{SR} - channel gain from S to R

n_{SR} - additive white Gaussian noise (AWGN) along the $S - R$ link

Predictive boosting suggests that the received signal is amplified at R prior to sending it to D when ever the error value is higher than a specified limit of 50%. This cutoff point is provided by,

$$a_{SD} = A^2 b_{RD} a_{SR} + n_{RD} \text{ ----- (3.8)}$$

Where ,

a_{SD} - signal that D receives from R

b_{RD} - channel gain along the $R - D$ link

n_{RD} - AWGN along the R to D link

The mathematical definition of the factor by which R amplifies the a_{SR} signal is represented by the symbol A^2 ,

$$A^2 = \frac{\rho}{p_s b_{SR}^2 + \sigma^2} \text{ ----- (3.9)}$$

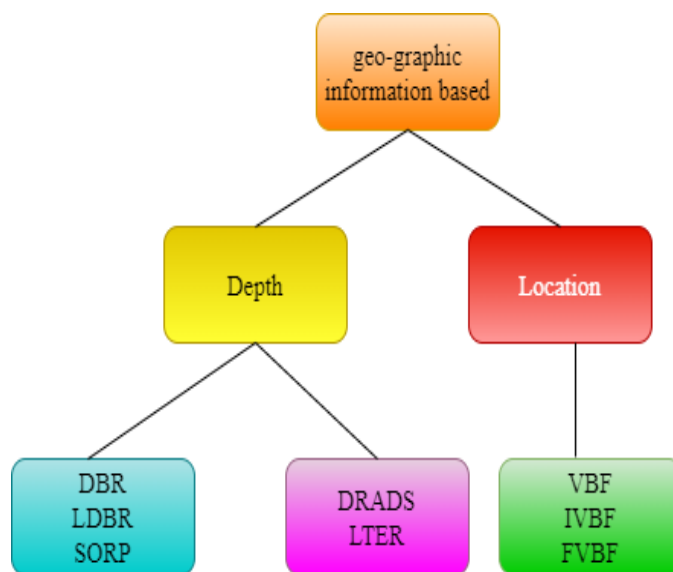
Where ,

ρ - It equals transmission power P_R of the relay R .

This method takes $\rho = P_R$ and adjusts P_R in accordance with the above-calculated bit error likelihood. Unfavorable channel conditions are indicated if the packets at R have a bit error probability greater than 50%. Consequently, Unless it increases its transmit power to highest, the signal transmits packets to D using standard energy. An increase in the relay's power reduces spoofing by raising the SNR and, subsequently, the likelihood of lost packets. In order to implement friendly connectivity, at least three nodes are needed. Nodes for the source, relay, and destination are these. The relay and destination then receive the messages that the source prepares and transmits. The RAR scheme did not include the optimal path. Instead, data packets were dispatched from a source and received by a relay before being forwarded on to their intended location. Prior to choosing the routing protocol, the origin selected a nearby node in the shallowest layer. However, The origin chooses a neighbor at the lowest depth as an intermediate destination using RACAA's friendly route. The network device in RACAA is the node that has the lowest depth after the destination node and is a mutual neighbor of the generated pair. The broadcasted data packets from the source are received by both the reflector and target values in RACAA. The access point then awaits the recipient data type decision as to whether or not to forward the identical data to the destination. The destination evaluates the possibility of data transmission errors. If this probability falls below the limit, the target does not require the relay unit. Since it does not get a request from the source, the relay node is aware of this. the predefined interval to the base station, resulting in the relay node's timer expiring. The timer for receiving a request from the destination node begins as soon as the relay node gets the data grams from the base station. Based on the crucial details about the nodes it exchanges hello packets with, the origin nodes send the channel and target values.

The schematic below illustrates the movement of packets to the surface using the RAR and RACAA techniques. It illustrates that when nodes are added, hello messages are sent to communicate vital information. A data type ID, level, number of neighbors, and exclusion from the surface sink are all significant pieces of data. A data packet must confirm the existence of its neighbors before delivering data. When the time restriction for verifying neighbors expires, the information is lost if it is unable to locate a neighbor. On the other hand, if neighbors are discovered, the base station looks to see if it has a path that connects it to the water's surface. Using the essential details regarding the amount of neighbors of each node, from the proximity of the source node all the way down to the sea surface, is used to determine the sensor nodes gained through hello packet exchange. When the base station finds a linked connection, it forwards messages. This method begins, and the packets are dropped, until they float to the top of the water or the period expires.

Fig .3 : Various geo-graphic information based routing protocol in UWSN



Geo-graphic information based Intensity Connectivity

The connectivity is the main factor taken into account by geographic information-based routing protocols when selecting the best path.

Standard for Intensity Connectivity

The device just needs to be set up for the intensity network architectures to obtain information about the depth of the nodes; they are not required to know where each node is. As a result, less energy is spent and information is transmitted more quickly thanks to the depth-based clustering algorithms, which make it easier for the source node to select the best path and next-hop node based on the knowledge about the node's depth.

LDBR

Safia gul suggested a low intensity scheduling algorithm (LDBR)[22]. The latent power technique is used in LDB to decrease power usage.

DBR Protocol

The intensity protocol makes use of the multi-sink UWSN topology. Throughout the deployment procedure, many nodes are placed near the water's surface. Multiple location estimations are not carried out for transmission in DBR because a node just needs to share its depth details with other sensor nodes. The surface sensor nodes comprise a large number of sink nodes identified as information sinks and situated to gather data from underwater nodes at the water's surface. After these sinks combine the data packets received from the sensor nodes, they make decisions using the analyzed data produced by the sinks. Once more, these sinks integrate the data based on the transmitting device's depth details.

Sensor apexes located at various depths underwater can communicate with one another. After processing the collected data, the sinks may decide whether it should be sent to apex at a minimal height or apex at a higher depth. For the purpose of communication, each node initially perceives its own current depth (D_c). The sensed value is updated in the packet header field Depth as a result of this depth being measured in relation to the surface of the water. The packet is then distributed by the sensor. Every network node periodically updates their current positions. When a multicast package is received, the amount of height specified in the packet header is evaluated; the intended receiver can only transfer the packet data if it is greater than its own present dimension. If the aforementioned value is lower than the receiving data type current depth, the broadcast packet is deleted. The distribution packet header for the DBR protocol contains the sender ID, the current depth of the transmitting node, and the packet sequence number. The Sender ID column provides information about the originating node. The source node's position can be found in the packet's depth field, which is also assigned a sequence number by the packet sender node. depicts the underwater current of the sender node in reference to the water's surface. This depth data is updated as the packet is transmitted to the surface sink node. Each relay node in the distance between the source and sink pathways updates the depth information. By doing this, packets can be sent to the sink instead of being endlessly forwarded throughout the network, which creates a bottleneck. The UWSN architecture has been successfully used by the DBR protocol. Making information available to sink nodes, which are normally found near the water's surface, is the main goal. All of the nodes are currently positioned with respect to the sink plane deployment, which is the water's surface. Data packets are eagerly received. The detectors moved to the surface of the water. The depth field of a forwarded packet contains the depth details of the base station that provided the most recent transmission.

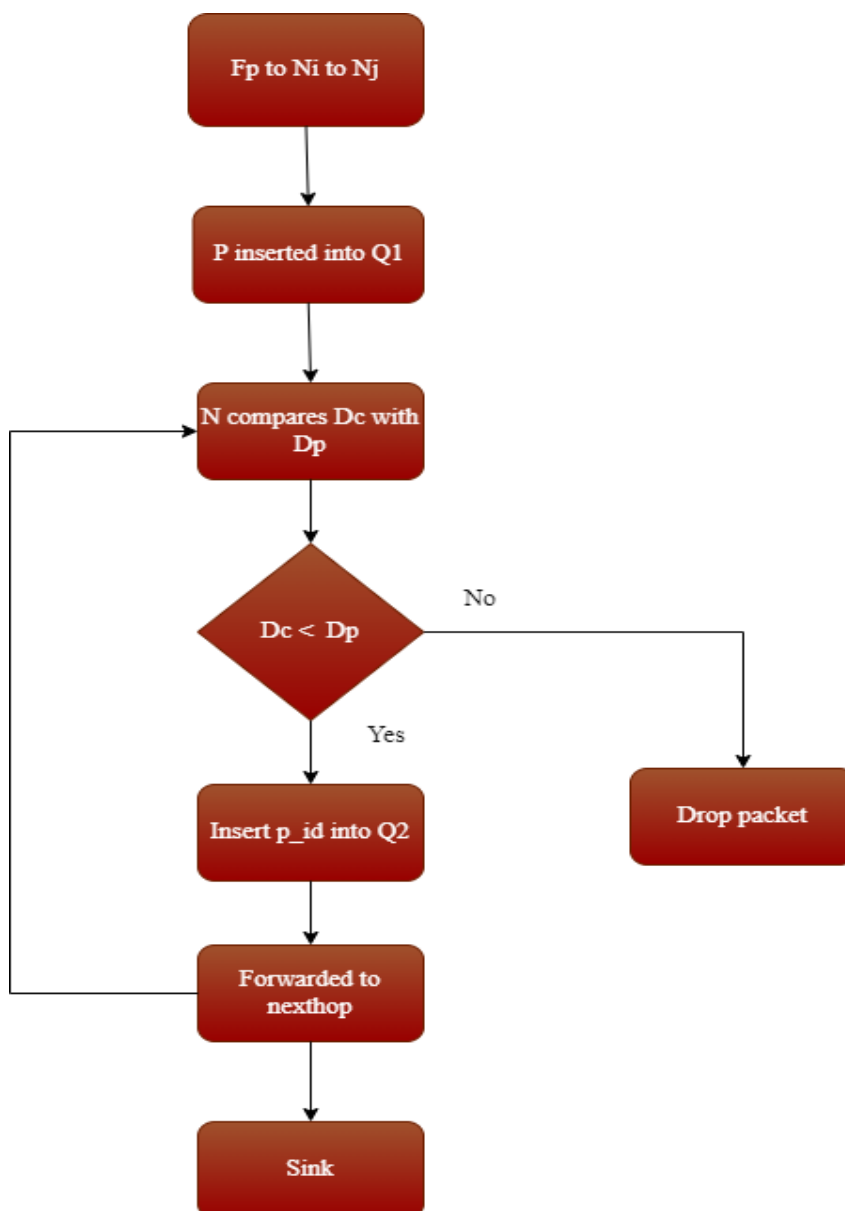
Steps :

Step 1 : Verify the payload of the incoming signals.

Step 2 : A density sector comparison

Step 3 : A transmission information storage and session id's.

Fig .4 : Flow diagram of DBR routing protocol



The processes in the DBR standard for broadcasting packets from sensor nodes to sinks on the water's surface. When the depth of the current node that has obtained the packet is greater than the depth that is specified in the packet header, the scenario in which the sensor node that has received the broadcast packet actually lies beneath the source node that is attempting to forward the packet to the sink nodes that are situated at the water's surface is illustrated. The very same datagram will keep being transmitted over the system for a long time without really arriving at itsintended location, which is the sink at the water level, if the node does not compare those values and instead broadcasts the packet again. The DBR technique therefore resolved the issue of the data packet being lost in the network without actually reaching the sink node. The packet header is updated as each time following adds its current depth, improving the possibility that the message will be transmitted in the right way and not away from the water's surface.

There is a good possibility that several neighboring sensor nodes will be able to pass the packet to the sink nodes because their depth may be lower than that of the transmitter. Additionally, many packets could travel the same path to the destination, creating unwanted data transmission. In this case, the DBR protocol makes use of priority queues to cut down on the quantity of duplicate messages that are transmitted to the sink node. This

eliminates the issue of a single node sending the message numerous times. Additionally, this might avoid overall energy increases brought on by increasing transmissions from sensor nodes and traffic conflicts brought on by repeated broadcasts.

LDBR Protocol

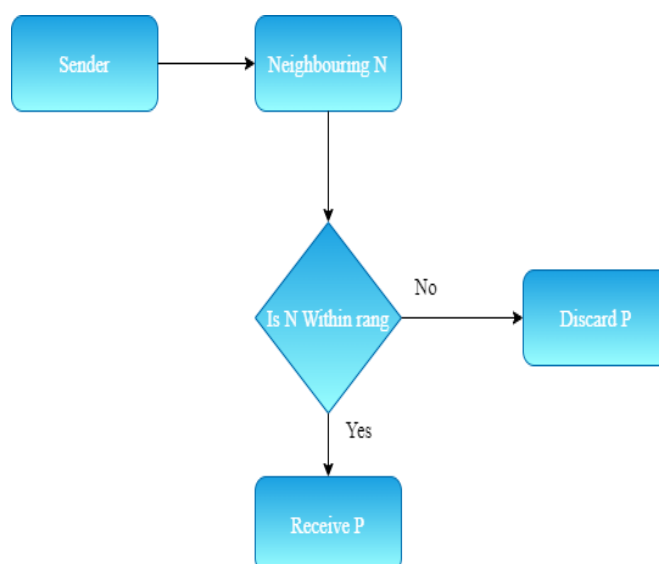
The depth information is the basis for communication in DBR. The data will be sent and received to the water surface by apexes that have been placed in the sea's depths. The DBR routing protocol has a lot of problems. The author didn't get around all of those problems, but she did focus on how much energy was used. Communication in the DBR protocol consumes a lot of energy. The author worked around this issue to make the previous algorithm better. This is an improvement over the old one called the LDBR protocol.

[22] In LDBR, two parameters, To determine whether or not to forward a packet, the sender and relay sensor nodes' depths are considered. The DBR protocol, however, also implements this. Our suggested approach differs in that it considers energy usage and the shortest travel distance to expedite communication and make it reliable. The original DBR protocol is therefore supplemented with a compact and robust depth based routing (LDBR) protocol. To increase the network's duration and guarantee that underwater sensor nodes and sinks at the water's surface can operate, the independent energy value of a single transmitting node, the energy values of relaying nodes, and the actual position of the relaying node are all taken into account.

At the sea bed in LDBR, sink nodes are also present. All of the packet's nearby nodes (N_i-N_j) should receive it, and it should be positioned in the Q1 priority queue. A comparison is made between the data type current depth and the previously embedded packet depth. The package will be held in Q1 for a specific amount of time. The message will be delivered to the next hop or similarity measure if the node's energy is high and its current depth is less than its previous depth ($D_c < D_p$). If that neighbor is closer to the water's surface, the message will be routed to the surface sink. If the data type power level is low, it will simply discard the packet.

Forwarding selections

Fig .5 : Forwarding selection in LDBR routing protocol

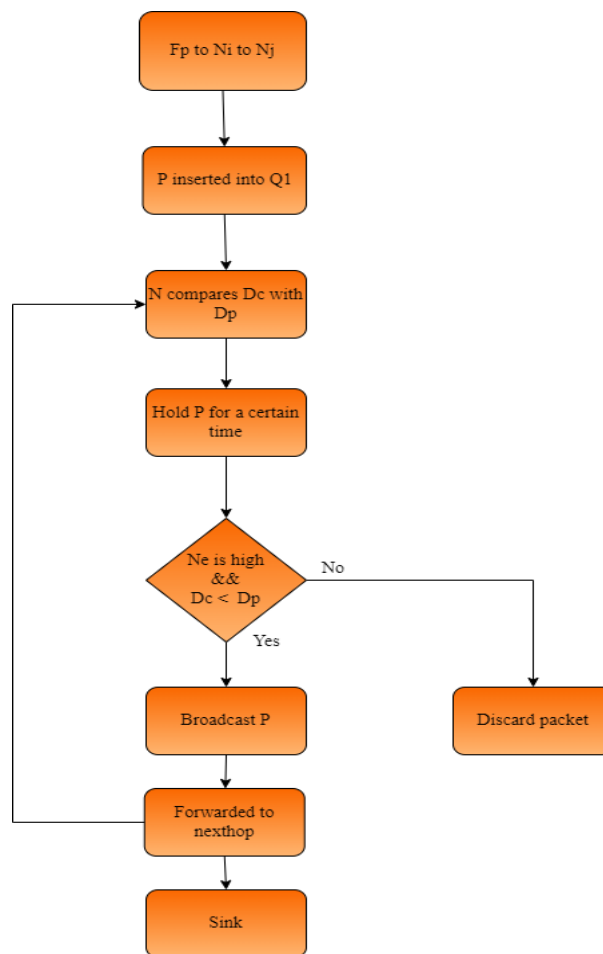


According to the preceding flow diagram, the message transmitted by S (the transmitter) will be acknowledged by all nearby nodes; however, if there is a node deployed outside the transfer amount that does not respond to the message, the message should be deleted. Apex S, for instance, is the sender; its entire one-hop adjacent

apexes are n_1 , n_2 , and n_3 . Outside of the transmission ring, N_3 is used. When a sensor knot S broadcasts a message, any of the neighboring apexes can acknowledge it. Because apex n_3 is below S , the packet is removed.

The author came up with the name "LDBR" for the new standard. It makes the network's energy use more efficient. The energy meter was used here by the author; The energy levels are used to represent each node's remaining energy in the network. When it sends and receives a packet, the sensor node consumes energy. As a result, the total energy consumed during communication is taken into consideration. Additionally, as a packet history buffer, we make use of the priority queues Q_1 and Q_2 ; in the DBR protocol, where they were utilized.

Fig .6 : flow diagram of LDBR routing protocol



In the above flow diagram, a packet is sent to all of its neighbors rather than being put in the Q_1 (priority queue). The Q_1 receives the inbound packets. Whether the data type new intensity (D_c) is greater than its prior range (D_p), it will either broadcast the packet towards the sink or check to determine if it has a high rate energy (N_e). The package will be discarded if $D_c > D_p$.

DRADS:

This type of routing standard was explained by Usman Shakeel for underwater wireless sensor networks (UWSNs). The underwater opportunistic routing (UWOR) standard, it introduces a Novel $EEL|_{success}(F_i)$ metric, the anticipated discontinuation between transmit apex i and destination, serves as the source of

inspiration for the author. The author identifies two shortcomings in UWOR. First, in the UWOR standard, the sensor apex sends data packets to the forwarder node with a higher reliability link ($EEL^{\alpha\%}$), ignoring the forwarder node's depth, which leads to more hop counts. The second flaw that causes an increase in is the grouping time of the forwarder node cluster. As a result, the author change the $EEL|_{success}(F_i)$ metric and add depth aware routing to DRADS[24]. Because it is based on the opportunistic routing (OR) scheme, it performs reliable routing.

The author find two flaws in UWOR ,

- ❖ The probabilistic discontinuation ($EEL|_{success}(F_i)$) rises when the delay of the sender point cluster is included in $|_{success}(F_i)$, resulting in a decrease in network goodput. The amount of data grams collected on time at the destination determines network goodput.

- ❖ Due to the utilization of OR, UWOR chooses a forwarder node ($EEL^{\alpha\%}$) with a high degree of dependable link. If the chosen routing site is near the source node, UWOR transmits a datagram there. This concurrently increases the number of hops and the amount of energy needed.

The author wants to increase the performance of delay-sensitive UWSN applications across the system. Our inspiration comes from the designers of the UWOR protocol, who create a cluster-based forwarding set selection approach. Each neighbor node of the source node calculates the synchronization latency seen between nodes within a cluster. The coordination delay of each access point lengthens the latency, which reduces UWOR's throughput. However, in DRADS, we employ the depth awareness and reliability link parameter to remove the synchronization lag in between router nodes, thereby reducing the number data hops and increasing system throughput. There are three sections in this section: data forwarding, the phase of setting up routes, and network architecture. The first subsection discusses this network's architecture. The route Setup phase depicts the setting up of the system. The final subsection discusses the data transmission process.

Network Architecture

Acoustic and radio modems are housed in a stationary sink on the surface of the submarine in DRADS. The radio modem communicates with the near sea data center, whereas the acoustic modem communicates with underwater sensor nodes. Over a 50 km network area, 1600 randomly placed nodes are present. These detectors gather the essential information from the surroundings with the aid of forwarder nodes, then forward it in a multi-hop manner to the sink. The receptors' broadcast range has been set at 3.6 km, and the depth threshold is 1 km. According to this, the forwarder node with a depth of less than 1 km and a more trustworthy link will be taken into account.

Route Setup Phase

Before sending a control message to everyone in their transmission range, sensor nodes use their depth sensors to assess their depth when they are deployed in a certain network area. The transmitter node's ID, the depth, and the number of neighbors are the three basic forms in the control messages. Detectors having a lower depth than the source node will become its neighbors within the origin data type radio range. A list is maintained that contains the details of each sensor node's neighbors. The neighbors on this list will be sorted using relay importance. The transmission range of the source node includes five network devices. Two neighbors are below the depth barrier, while three nodes are above it.. Nodes 3 and 5 will not be given the priority to become forwarders because DRADS takes into account forwarder nodes that are located above the depth threshold. Therefore, the list only takes into account nodes 2, 4, and 1.

The author gave ($EEE^{\alpha\%}$) values of 1, 2, and 3 rather than representing $EEE^{\alpha\%}$ as a probability ranging from 0 to 1. This was done for the sake of simplicity. Instead the first apex has a more flexible connection than the fourth, apex 1 has more importance than apex 4. As a result, apex 1 will be taken as the sending node.

While establishing routing setup, UWOR determine $EEL|_{success}(F_i)$ from,

$$EEL|_{success}(F_i) = \frac{L^{i \rightarrow F_i} + L_{coord}^{F_i} + L^{F_i \rightarrow sink}}{P_d^{i \rightarrow F_i}} \text{----- (4.1)}$$

$$L^{i \rightarrow F_i} = T_{MAC} + T_{tx} + d_{l, f_i^1} + T_{ack} \text{----- (4.2)}$$

Where,

T_{MAC} - MAC contention time

T_{tx} - Transmission time of data packet

The non critical routers won't please send datagram until the high priority node doesn't properly accept it. If the high priority node is unable to correctly receive the message, the non - critical location will send the information in its place. The likelihood that a node will successfully receive and transmit a datagram is determined by Eq. (4.3).

$$p[fwd = f_i^j] = p_{i, f_i^j} \prod_{k=1}^{j-1} (1 - p_{i, f_i^k}) \text{----- (4.3)}$$

The j th node ensures that the transmitter will not respond an ACK packet to the $(1 - j)^{th}$ forwarder. j th will hold the data packet until then to avoid packet duplication. $L_{coord}^{F_i}$ mathematical representation of coordination delay as shown in Equation 4.4.

$$L_{coord}^{F_i} = \sum_{j=1}^{|F_i|} (p[fwd = f_i^j] * \sum_{k=1}^{j-1} d_{f_i^k, f_i^{k+1}} + T_{ack}) \text{----- (4.4)}$$

The total latency from the original point to the destination is referred to as $L^{F_i \rightarrow sink}$. To estimate discontinuation the linked data grams ($EEEL_j^{\alpha\%}$) is essential. Parameter is set to 0.95 as its value. Eq. (4.5) can be used to figure out $L^{F_i \rightarrow sink}$, which is the forwarder node's maximum $EEL|_{success}(F_i)$

$$L^{F_i \rightarrow sink} = \sum_{j=1}^{|F_i|} (p[fwd = f_i^j]) \text{----- (4.5)}$$

The likelihood that a datagram will be properly responded by at least one forwarder node is

Called $P_d^{i \rightarrow F_i}$. To improve the DRADS's performance, the author excludes coordination among forwarder nodes. $L_{coord}^{F_i}$ are therefore removed. parameter from Equation 4.1 and alter this equation in the manner depicted in Eq. 4.6.

$$L^{F_i \rightarrow sink} = \sum_{j=1}^{|F_i|} (p[fwd = f_i^j] * EEEL_j^{\alpha\%}) \text{----- (4.6)}$$

The forwarder node that has a lower depth and a higher $EEEL^-(F_i)$ metric is regarded as such. As a result, our

goal is to assign relay priority to each forwarder node. The author determines the data sending importance, which is used to higher $P_d^{i \rightarrow F_i}$ order to achieve high goodput. Eq.(4.7) displays the statistical representation of the relay importance parameter of UWOR.

$$EEL^-(F_i) = \sum_{j=1}^{|F_i|} (EEL_j^{\infty\%} + d_{i,f_i^1} + \sum_{k=1}^{j-1} d_{f_i^k, f_i^{k+1}}) * p[fwd = f_i^j] \text{----- (4.7)}$$

The author eliminated the forwarder node's coordination delay, resulting in the mathematical expression of the new importance parameter is shown in Equation 4.8

$$EEL^-(F_i) = \sum_{j=1}^{|F_i|} (EEL_j^{\infty\%} + d_{i,f_i^1}) * p[fwd = f_i^j] \text{----- (4.8)}$$

Stage of Data Transmission

During the stage of data transmission, sensor nodes will forward the important entities to its forwarder node when they detect it in the surrounding area. During the route setup phase, each sensor node will create a list from which the forwarder node will be chosen. It will be considered useful data if the packet arrives at the sink within the specified time frame. However, if the transmitted packet's end-to-end latency exceeds the deadline, it will be considered useless and discarded.

Location-Based routing Standard

To implement destination routing algorithms in submerged cellular networks, sensor nodes must be aware of their location data. The optimal path confirmation mechanism based on the geographic location information is to establish a route using the node location information, such as angle and distance. After learning the exact location of the destination node, the source node can quickly choose the optimal neighbor node as the next-hop node to send data. The nodes can save network energy and improve data transmission efficiency by successfully preventing data packet flooding.

FVBF

Renfei Bu introduced a fuzzy logic vector-based forwarding routing protocol[26], the usefulness of which is assessed by considering the energy and position data of sensor nodes. The fuzzy logic

approach also considers variables like the projecting, the networks' charge levels, and the acceptable distance to forwarder nodes. With the energy-efficient routing algorithm based on fuzzy logic, operability and fuzzy routing judgements are possible.

An FVBF-based forwarding is presented by the author. This technique offers three variables as fuzzy input variables to a fuzzy inference system to assess the desirability of an adjustment process: VD, projection, and residual energy ratio (RER).

Constraint factors

Valid distance

The logic underlying the notion of VD in the process of data transmission is the extent of a data type's proximity to the sink node that should be taken into account while choosing a communication protocol. A node's VD after receiving a data packet is defined as

$$VD = d \times \cos \theta \text{ ---- (5.1)}$$

where the coordinates of the destination S_0 at the sea surface are (X_0, Y_0, Z_0) , the coordinates of the source node S_1 are (X_1, Y_1, Z_1) , and the coordinates of the forwarder node F are (X_f, Y_f, Z_f) . When $C_i(X_i, Y_i, Z_i)$ receives a data gram from F, the distance between C_i and F is expressed by the symbol d. The angle formed by FC_i and FS_0 is θ . As a result of Equation 6, we can calculate the VD of this packet.

The thorp theory explained to the user that there are fewer hops to the sink node and even less end-to-end latency if the VD is high indeed. Additionally, a separate relaying technique uses less power within the 1-hop communication range.

Proof : Assuming that node S_2 is located on the portion of the line (S_1, S_3) , apex S_1 can transfer message directly to S_3 (first-hop) or via another route S_2 (multi-hop). These two sending techniques use varying amounts of power. Assume that the receiver can identify the path accurately when they are received and the power is P_v .

In general, the energy consumed in the 1-hop range is ,

$$E = P_{out}T_{tx} + E_{elec} \text{ ----- (5.2)}$$

Where P_{out} signifies the transmitted signal power, T_{tx} the packet length time, and E_{elec} the energy spent by the sender to the destination. Let

$$= A(d, f)N(f)P_0T_{tx} + E_{elec}$$

$$N(f)P_0T_{tx}d_{1,3}^k 10^{\frac{\alpha(f)d_{1,3}}{10}} + E_{elec} \text{ ----- (5.3)}$$

$$\begin{aligned} E_{multiple} &= A(d_{1,2}^k, f)N(f)P_0T_{tx} + A(d_{2,3}^k, f)N(f)P_0T_{tx} + 2E_{elec} \\ &= N(f)P_0T_{tx}d_{1,2}^k 10^{\frac{\alpha(f)d_{1,2}}{10}} + N(f)P_0T_{tx}d_{2,3}^k 10^{\frac{\alpha(f)d_{2,3}}{10}} + 2E_{elec} \text{ ----- (5.4)} \end{aligned}$$

The amount of energy necessary to send data from node S_1 to node S_3 Both single-hop and multi-hop forwarding strategies are used. In the event where the multi-hop short-distance forwarding system uses less power than the unified system, then follows that $(E_{single} > E_{multihop})$. The author can drive using Equations 5.3 and 5.4.

$$d_{1,3}^k 10^{\frac{\alpha(f)d_{1,3}}{10}} - d_{1,2}^k 10^{\frac{\alpha(f)d_{1,2}}{10}} - d_{2,3}^k 10^{\frac{\alpha(f)d_{2,3}}{10}} > \frac{E_{elec}}{N(f)P_0T_{tx}} \text{ ----- (5.5)}$$

Projection

The Thorp communication framework suggests that the propagation loss of data transmission increases with distance from the news outlet direction. The power density used for the information transmission is decreased when all of the relay nodes are connected from the source node to the sink node. As a result, the projection (P), which measures how close a node is to the quickest route, should be one of the energy optimization criteria.

C_i distance from the routing vector $S_1 S_0$ is ,

$$P = \frac{|S_1 C_i \times S_1 C_0|}{|S_1 C_0|} \text{ -----(5.6)}$$

Where,

“x” - vector cross product

The author defines a metric of P as ,

$$P = \frac{P}{w} \text{ ----- (5.7)}$$

Where ,

w - pipeline threshold

In this situation, the author chose R. It is important to remember that when C_i is on the line that connects the source and the sink, P decreases to a minimum of $P = 0$. The concept of P seeks to minimize the distance between the origin and sink's navigation matrix and the information transmission route.

Residual energy ratio

The residual part of detectors must be taken into account when choosing every next hop node since an underwater sensor node's battery power is undesirable or impractical to exchange and replenish. It uses an active forwarding decision strategy in some way. The following is how the author calculates the RER in this study:

$$RER = \frac{CE - E_{tr}}{TE} \text{ -----(5.8)}$$

Where,

CE - energy of current node

TE - total energy of initial node

RER - predicted residual energy after data transmission

E_{tr} - during transmission consumption of energy

$$E_{TR} = P_{out} T_{tx} + E_{txelec} \text{ ----- (5.9)}$$

E_{txelec} - energy consumed by the transmitter electronics

Mechanism of logic interpretation

In the above section, the approximate optimum computation of desirableness employs a fuzzy logic framework.

Three covariates make up the fuzzy inference system, and the functions of each section are described below.

Anonymity

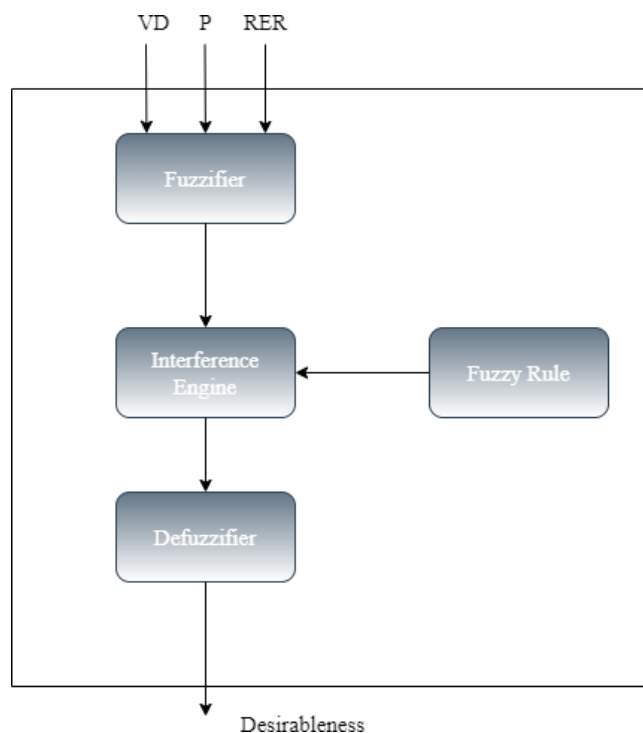
Based on their linguistic properties, input variables are transformed into different membership functions via anonymity. For each node V, a linguistic variable of a constraint factor and a fuzzy set called "unique standard" are defined. The goal of a fuzzy variable is to translate the value of a node's constraint factor into the fuzzy set's desirable membership degree $V(\text{input})$. Below is a list of the fuzzy input variables and associated language factors that were utilized to calculate desirableness.

VD - (hinder, close, medium, far)

Projection - (small, medium, big)

RER - (low, medium, high)

Fig .7 : Construction of Fuzzifier



In general, fuzzy logic inference systems frequently make use of triangular and trapezoidal membership functions. In this work, the input variables of position information, VD and P, are given as pyramid attribute values for mediating factors and quintic functions for border variables. The triangular and trapezoidal membership functions used in this fuzzy inference approach .

$$\mu_1(x) = \{0 \ x \leq a\}$$

$$\left\{ \frac{x-a}{b-a} \ a \leq x \leq b \right\} \text{ -----(5.10)}$$

The RER membership function, ie, $\mu_v(RER)$, should take into account the fact that a node with a high RER gets allocated a high membership value. All hubs have substantial remaining energy at the start of the system, and RER is almost at its maximum. As a result, starting with 1, these regions' subset values gradually stabilize. Their power rating decreases gradually until another barrier, let's say Z, because it reaches that level. (where $\Gamma \in [0, 1]$ is a parameter). Following that, the equivalent membership declines at a faster pace.

$$\mu_v(RER) = \{1 \quad z \leq RER \leq 1\}$$

$$\{0 \quad \tau \leq RER \leq Z\} \text{----- (5.11)}$$

With the use of the classifier, it is possible to forcibly prevent nodes with a high desirability value from using up all of their power above a given level. The variable of can be modified to alter the critical limit of τ .

Unclear framework

The control board is where all the input parameters that feed control rules to the learning algorithm are stored. Fuzzy rules are a set of linguistic control rules that include expressions like "if-then," "otherwise," "also," "and," and "or." The 9 linguistic variables used for the output variable "desirability" are very tiny (VS), small (S), rather small (RS), medium small (MS), medium (M), medium large (ML), rather large (RL), large (L), and very big (VL). Both extremely small and extremely large quantities can be expressed using the trapezoidal function. The other linguistic variables also make use of the triangle membership function. The associated language variables in the fuzzy inference engine produce decisions that resemble those made by humans based on fuzzy control rules and produce fuzzy control variables.

Defuzzifier

The fuzzy solution space is de-fuzzified by the de-fuzzifier. In other words, it extracts one sharp output with the help of the fuzzy space. Furthermore, the middle of region approach is employed as a de-fuzzifier method. The FVBF method has a piecewise function in matching relationships that employs fuzzy logic decision making. Piecewise functions with an extra qualifier can characterize the function's nature. For instance, a function that is linear in each of its sub domains but may be different in each. In this vein, the concept of desirability may be optimally computed in a fuzzy logic system, which demonstrates a node's suitability in forwarding data packets.

CONCLUSION

The several widely used routing methods in underwater wireless networks are the main subject of this research project. In UWSN, routing might be difficult and for various settings and situations, many protocols are created. Also included is a comparison of the several suggested strategies. Most people utilize and can apply the developed routing protocols. For a fundamental knowledge, it is helpful to have a full overview of routing approaches with examples. In order to create a routing protocol for underwater wireless sensor networks, future research directions might be based on the research gaps that have been identified, so in this paper we have discussed the data based and geographic based routing protocols for the future use.

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