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Comparison Of UWSN & WSN With Energy Harvesting Algorithms

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Abstract— UWSN faces many challenges in terms of energy consumption and routing. In recent years, energy harvesting has emerged as a promising solution to address the energy consumption issues in the UWSN. It faces many challenges in terms of energy consumption and routing. In recent years, energy harvesting has emerged as a promising solution to address the energy consumption issues in the UWSN. Routing protocols play a crucial role in ensuring efficient communication in the UWSN. In this context, the implementation of a routing protocol that takes into account the energy harvesting capabilities of UWSN nodes is essential to maximizing network lifetime. In general, localized or non-localized deployment techniques can be used to place the sensor nodes in the UWSN and WSN. So far, balancing energy usage has been a difficult problem in both networks. When it comes to UWSN and WSN, inefficient energy use has an impact on network metrics like stability period, node mobility, transmission rate, end-to-end latency,and packet delivery ratio. Most previous routing protocols are based on cooperation and clustering but do not implement an energy harvesting technique at Sensor nodes. Therefore, this research suggests an Analytical Approach towards Reliability with Cooperation for the UWSN's Energy Harvesting (ARCUNEH) Protocol. A modification of the already-proposed ARCUN protocol is called ARCUNEH. The suggested method selects relay nodes from one of their surrounding nodes based on the sensor node's collected vitality level. In UWSN, we directly implement ARCUNEH, while at WSN, we implement the modified EH based on environmental conditions. The ARCUNEH approach combines Piezoelectric Energy Harvesting and the amplifying forwarding (AF) technique at sensor nodes in order to increase the stability and lifetime of sensor nodes at UWSN and WSN. Finally, in this proposed method's simulation, It is compared to both network metrics, including the lifetime of the network, packet delivery ratio, energy consumption, and throughput. According to our simulation study, ARCUNEH performs better than LEACH. According to our simulation study, ARCUNEH performs better than LEACH, ARCUN, and RACE. Hence, both WSN and UWSN network sensor nodes can use the ARCUNEH Energy Harvesting Protocol to collect energy.

Keywords— Energy harvesting Algorithms,Energy Efficiency,WSN,UWSN,ARCUNEH

I. INTRODUCTION

Underwater Sensor Networks (UWSN) are a rapidly developing area of research that has drawn the attention of many researchers in recent years. These networks are comprised of a large number of tiny sensor nodes that are deployed in water for a wide range of applications such as oceanographic data collection, disaster prevention, and military surveillance. However, the deployment of sensor nodes in UWSN poses significant challenges due to the harsh underwater environment, including high attenuation, low bandwidth, and limited energy resources. To address these challenges, researchers have proposed various energy harvesting techniques to extend the lifetime of UWSN. Routing protocols play a crucial role in UWSN as they are responsible for efficient data communication between the sensor nodes. In UWSN, the routing protocol should be designed to take into account the unique characteristics of the underwater environment and the energy harvesting techniques used.

A. Underwater Wireless Sensor Network (UWSN)

The UWSN is a network used to carry out monitoring operations across a certain area. It has intelligent sensors and modified cars that can cooperate with one another through wireless connections. The sensor nodes data are retrieved through the surface sink. The sink node is equipped with a transceiver that can manage acoustic signals obtained from submerged nodes. Additionally, the transceiver has the ability to send and receive long-distance radio frequency signals for use in contact with the onshore station. The gathered information is utilized locally or linked to another network for a specific purpose. Traditional underwater wireless sensor networks developed by and real-time underwater wireless sensor network architecture in the form of the Internet of Underwater Things are both incorporated into the network architecture. Nodes in underwater wireless sensor networks can be placed both above and below the water. Each node must connect with the base station, other nodes in the same network, and other nodes to share information. The sensor network's communication technologies use electromagnetic, optical, or acoustic wave mediums to transmit data. Due to its attenuation properties in water, acoustic communication is the most well-known and often utilized approach among these several types of media. The process by which energy is absorbed by and transformed into heat in water is the source of the poor transmission factor. Acoustic signals, on the other hand, operate at low frequencies, allowing for long-distance transmission and reception.

B. Communication Network

Underwater wireless sensor networks (UWSN) are collections of interconnected underwater sensor nodes that exchange data wirelessly with one another. Due to the specific underwater environment's characteristics, including high attenuation, multipath fading, and constrained bandwidth, designing UWSN is difficult. Specialized communication protocols that are dependable, energy-efficient, and able to function under challenging underwater environments are needed for UWSN. The following are a few of the most popular communication protocols used in UWSN:

Acoustic Communication: This technique sends data via the water using sound waves. The most popular protocol in UWSN is acoustic communication because of its vast range and low power requirements. However, noise and interference also have an impact on it, which can impair communication.

Optical communication: This protocol transmits data over water using light waves. Compared to acoustic communication, optical communication offers a higher bandwidth and lower latency, but it can only be used for close-proximity communication and requires clear water.

Electromagnetic Communication: This protocol transmits data over the water using radio waves or magnetic fields. Due to the substantial attenuation of electromagnetic waves in water, electromagnetic transmission has a small bandwidth and short range.

For UWSN to perform optimally and provide dependable and effective data transmission, specialized routing algorithms and power management strategies are also necessary. UWSN frequently employ energy-efficient routing algorithms and cluster-based routing protocols to reduce energy consumption and increase network lifetime.To guarantee dependable and effective data transmission in the challenging underwater environment, UWSN design and implementation must carefully take into account communication protocols, routing algorithms, and power management approaches.

C. Wireless Senson Network (WSN)

Wireless Sensor Network (WSN) is a type of network that consists of a collection of small, low-power, autonomous sensor nodes that are wirelessly interconnected to cooperatively monitor and gather data from the surrounding environment.These sensor nodes are equipped with various types of sensors such as temperature, humidity, light, pressure, motion, etc., and are typically deployed in large numbers over an area of interest to enable distributed sensing and data collection. WSN are used in a wide range of applications, including environmental monitoring, smart agriculture, healthcare, industrial automation, surveillance, and many others. The data collected by the sensors in a WSN can be used for real-time monitoring, analysis, and decision-making, making them valuable tools for various industries and domains. WSN often operate in challenging environments with limited energy, processing, and communication capabilities, which poses unique design considerations and challenges.Various protocols and algorithms have been developed to address these challenges and optimize the performance of WSN. WSN have the potential to enable innovative applications and solutions by providing real-time data from remote and inaccessible areas. However, they also come with their own set of limitations and trade-offs, such as limited bandwidth, limited processing power, and potential security risks. Therefore, careful design and optimization are crucial for the successful deployment and operation of WSN in different application scenarios.

D. Motivation

The purpose of the survey of underwater wireless sensor networks is justified in this section. One of the emerging technologies that is getting a lot of attention and is taking centre stage in the minds of both researchers and practitioners is the underwater wireless sensor network. With the great technological advancements in UWSN, sensors have improved in terms of intelligence, flexibility, and size. They now consume less power, have more processing capability, and can work in a variety of underwater applications.

II. EXISTING SYSTEM

A. Existing System in WSN

Wireless Sensor Networks (WSN) consist of small, low-power sensor nodes with limited processing capabilities, communication range, and battery life. These nodes are deployed in a particular area to monitor physical phenomena such as temperature, humidity, pressure, and movement. One of the major challenges in WSN is to maximize the network lifetime while maintaining satisfactory performance. LEACH (Low Energy Adaptive Clustering Hierarchy) protocol is a popular clustering-based protocol for WSN that tries to overcome these challenges. LEACH protocol divides the network into clusters and rotates the role of the cluster head among the nodes to balance the energy consumption across the network. The cluster head is responsible for collecting and processing data from the nodes in its cluster and transmitting it to the base station. However, Each protocol has benefits and drawbacks. The LEACH protocol has some drawbacks that limit its energy efficiency and network performance.

Firstly, LEACH protocol uses randomized clustering, which may lead to uneven distribution of nodes and unequal energy consumption among the nodes. Some nodes may deplete their energy faster than others, resulting in premature network failure.

Secondly, LEACH protocol does not consider the residual energy of the nodes while selecting the cluster head. This may result in the selection of nodes with low energy levels as cluster heads, leading to a higher probability of cluster head failure and network degradation.

Thirdly, LEACH protocol does not provide any mechanism for data aggregation, which results in redundant transmission of data, leading to high energy consumption and bandwidth wastage.

Lastly, LEACH protocol uses fixed-size time slots for communication, which may not be optimal for dynamic network conditions. As a result, the protocol may not be able to adapt to changes in the network topology, leading to inefficient communication and energy consumption.

To overcome these limitations, These extensions incorporate mechanisms such as residual energy-based cluster head selection, data aggregation, and Energy Harvesting to improve the energy efficiency and network performance of the protocol.

B. Existing System in UWSN

Existing routing protocols for UWSN that take energy harvesting techniques into account are EARP, ARCUN, and RACE.

1.EARP is a reactive routing protocol that aims to minimize energy consumption by avoiding nodes with low energy levels. It uses an energy-efficient algorithm to calculate the shortest path between the source and destination nodes. However, EARP does not take into account the residual energy levels of the nodes while selecting the route, which can result in the selection of nodes with low energy levels, leading to reduced network lifetime.

2.ARCUN is a clustering protocol designed for UWSN, where sensor nodes are grouped into clusters. It uses an adaptive and reactive clustering mechanism that adjusts the cluster head selection based on various network parameters, such as node density, energy consumption, and communication range. However, the ARCUN protocol suffers from the selection of low-energy nodes as cluster heads, leading to reduced network lifetime.

3.RACE protocol divides the network into regions, with each region having a cluster head responsible for communication with the base station on the surface. The CHs are selected based on their residual energy levels, and the protocol periodically reorganizes the cluster membership to optimize energy consumption and improve network performance. However, the frequent reorganization of cluster membership can lead to increased overhead and energy consumption.

In conclusion, while existing routing protocols like ARCUN and RACE are efficient clustering-based routing protocols for UWSN that aim to optimize energy consumption and network performance, they have some limitations, such as the selection of low-energy nodes as cluster heads and high overhead due to frequent reorganization. Further research is required to design more energy-efficient routing protocols for UWSN that take into account the residual energy levels of the nodes, energy harvesting mechanisms, relay node selection, and selecting routes.

C. Drawbacks of UWSN Protocols

1. A routing strategy in UWSN for energy harvesting can be complicated and difficult due to the special features of the underwater environment. A full grasp of underwater communication, energy harvesting methods, and network architecture is necessary for the design and execution of such a protocol.
2. A routing protocol's performance may be impacted by the constrained bandwidth of underwater communication links. The available bandwidth may need to be taken into account by the protocol, and the routing decisions may need to be adjusted correspondingly.

III. PROPOSED SYSTEM

The proposed system should seek to maximize network lifetime while minimizing energy consumption and delay when implementing a routing protocol in UWSN for energy harvesting. To increase the lifespan of UWSN, they use energy-harvesting techniques. The batteries of the sensor nodes can be recharged using a variety of energy collection strategies, including solar energy, thermal energy, and kinetic energy. To optimize the energy usage of the sensor nodes, a routing protocol with energy considerations should be used. To lower the energy consumption of the entire network, the routing protocol should take the energy level of the nodes into account and route data through the nodes with the greatest energy level.

The techniques for data aggregation reduce the amount of data transmitted across the network. Reduce the quantity of data transported to lower the energy consumption and delay by using data aggregation techniques like spatial and temporal aggregation. Adapting to changes in the environment and network topology requires dynamic reconfiguration. For effective data transfer and to consume the least amount of energy, the routing protocol should be able to recognize changes in the network architecture and modify the routing paths accordingly. For certain applications, they offer QoS assurances. Depending on the needs of each application, the routing protocol should be able to offer a variety of QoS levels. In order to maximize network lifetime, reduce energy consumption and latency, and provide effective data transmission, the implementation of a routing protocol in UWSN for energy harvesting should include energy harvesting techniques, an energy-aware routing protocol, data aggregation techniques, dynamic reconfiguration, and QoS guarantees. The proposes ARCUNEH Protocol means Analytical Approach towards Reliability with Cooperation for UWSN Energy Harvesting. The ARCUNEH protocol is a proposed approach for enhancing the reliability of underwater wireless sensor networks (UWSN) through energy harvesting and cooperation-based communication.

IV. METHODOLOGY

A. ARCUNEH Protocol

ARCUNEH is an extension of the already-proposed ARCUN. A technique called ARCUNEH makes use of node cooperation in UWSN to increase reliability. The protocol proposes the use of two relay nodes with energy harvesting capabilities to transmit data from the source sensor node to the receiver sensor simultaneously. The relay nodes use the Amplify and Forward (AF) mechanism for regeneration, and data is obtained concurrently from two sources and analyzed at the destination nodes. The most accurate signal is selected from the two sources using the Fixed Ratio Combining (FRC) technique.

One of the main features of the ARCUNEH protocol is the use of piezoelectric energy harvesting in the relay sensor nodes. This approach can produce a reasonable amount of voltage by utilizing the stress of the water present on the piezoelectric material, which will generate electrical power, thereby extending the electric battery procedure for UWSN nodes.

The ARCUNEH protocol also considers the Euclidean distance between nodes to conserve energy and extend the overall network lifespan. It aims to increase network lifespan by reducing energy consumption and improving the efficiency of data transmission. Overall, the ARCUNEH protocol proposes an analytical approach towards enhancing the reliability of UWSN through energy harvesting and cooperation-based communication. It seeks to improve the network lifespan, conserve energy, and enhance the efficiency of data transmission while using piezoelectric energy harvesting in the relay sensor nodes.

B. Types of ARCUNEH

ARCUNEH is a hybrid routing protocol for wireless sensor networks. It is based on the combination of Cooperative Communication Protocol and Energy Harvesting Protocol to improve the reliability of Underwater Wireless Sensor Networks.

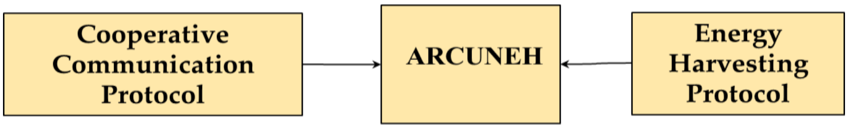


Fig. 1 The Combination of ARCUNEH Protocol

Fig. 1 shows the combinations of protocols that are used to form the ARCUNEH protocol
Cooperative Communication Protocol is a technique used to improve the reliability of data transmission in wireless networks, including Underwater Wireless Sensor Networks (UWSN). In UWSN, communication is often affected by fading, signal attenuation, and interference caused by the underwater environment. The Cooperative Communication Protocol addresses these challenges by allowing the nodes in the network to cooperate with each other to transmit data to the sink node. In a cooperative communication protocol, when a node detects that it cannot successfully transmit data to the sink node, it seeks help from other nodes in its vicinity to relay the data. The neighbouring nodes receive the data and then relay it to the sink node, thus increasing the probability of successful data transmission. This technique is known as cooperative diversity.
Cooperative diversity offers several advantages in UWSN. First, it enhances the reliability of data transmission by reducing the probability of data loss. Second, it enables energy-efficient data transmission as the nodes can adjust their transmission power based on the distance to the sink node. Finally, it reduces the overall delay in data transmission as the data can be transmitted through multiple paths simultaneously. The Cooperative Communication Protocol is often used in conjunction with other communication protocols such as the Medium Access Control (MAC) protocol and the Routing Protocol to ensure efficient and reliable data transmission in UWSN.

The Energy Harvesting Protocol is a component of the ARCUNEH protocol that enables the nodes in an Underwater Wireless Sensor Network (UWSN) to harvest energy from their surrounding environment to power their operations. UWSNs are typically deployed in remote and harsh environments, making it challenging to replace or recharge their batteries. Energy harvesting techniques offer a solution to this problem by allowing the nodes to collect energy from the underwater environment to extend their lifetime.
The Energy Harvesting Protocol in ARCUNEH utilizes different sources of energy, such as underwater currents or waves, to power the nodes in the network. The protocol uses energy harvesters, such as piezoelectric or electromagnetic transducers, to convert the mechanical energy from the underwater environment into electrical energy that can be used to power the nodes. The harvested energy is then stored in the nodes' energy storage units, such as batteries or supercapacitors, for later use. These Protocol is designed to be energy-efficient, ensuring that the harvested energy is used optimally. The protocol utilizes energy management techniques, such as duty cycling and power control, to regulate the energy consumption of the nodes. The nodes can adjust their energy consumption based on their available energy level to ensure that they operate within their energy budget.
The Energy Harvesting Protocol in ARCUNEH offers several advantages. It enables the nodes in the UWSN to operate for longer periods, reducing the need for frequent battery replacements or recharging. It also reduces the environmental impact of UWSN deployments by eliminating the need for frequent battery replacements. Finally,it enhances the reliability of the UWSN by ensuring that the nodes have a stable power source to operate from.

V. ARCUNEH PROTOCOL ARCHITECTURE

A. Architecture Diagram of UWSN

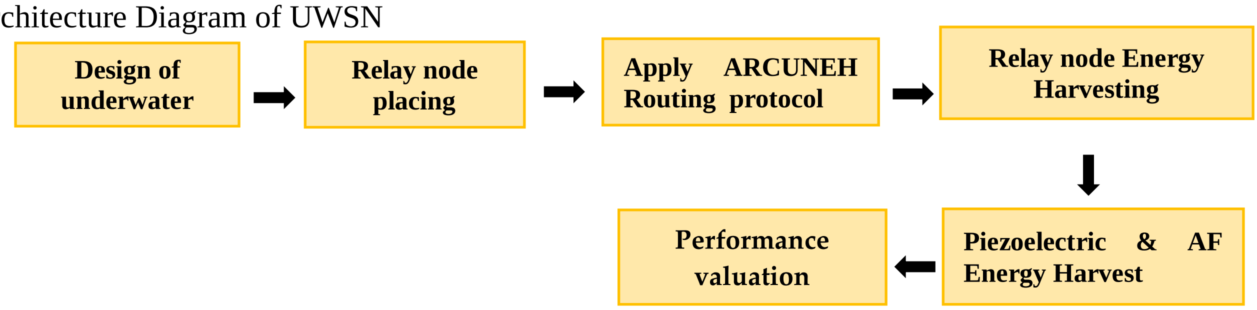


Fig. 2 Underwater Network (UWSN) block diagram

Fig. 2 shows the architecture diagram for implementing the ARCUNEH protocol in an underwater wireless sensor network, here is a brief description of each block in the architecture diagram for the ARCUNEH protocol:

1) Design of an Underwater Wireless Sensor: This block represents the design of underwater wireless sensors that are used to monitor and collect data from the underwater environment. The sensors are designed to be energy-efficient, low-power devices that are capable of communicating with each other and with the relay nodes.

2) Relay Node Placing: The relay nodes are strategically placed to ensure that the data collected by the sensors is transmitted to the sink node in an efficient manner. The placement of the relay nodes is critical to the overall performance of the ARCUNEH protocol.

3) Apply the ARCUNEH Routing Protocol: This block represents the implementation of the ARCUNEH routing protocol, which is designed to improve the reliability and energy efficiency of data transmission in underwater wireless sensor networks. The ARCUNEH protocol uses cooperative communication among the sensors and relay nodes to minimize energy consumption and increase the packet delivery ratio.

4) Relay Node Energy Harvesting: The relay nodes in the ARCUNEH protocol are equipped with energy harvesting mechanisms that allow them to collect energy from their environment. This energy is used to power the relay nodes, which helps increase the reliability and lifetime of the network.

5) Piezoelectric and AF Energy Harvest: The ARCUNEH protocol uses both piezoelectric and AF (acoustic flow) energy harvesting techniques to collect energy from the underwater environment. Piezoelectric energy harvesting is used to collect energy from the movement of underwater objects, while AF energy harvesting is used to collect energy from the flow of underwater currents.

6) Performance Valuation: The performance of the ARCUNEH protocol is evaluated based on two key metrics: packet delivery ratio (PDR) and energy consumption. PDR measures the percentage of packets that are successfully delivered to the sink node, while energy consumption measures the amount of energy used by the sensors and relay nodes in the network. The performance evaluation helps to determine the effectiveness of the ARCUNEH protocol in improving the reliability and energy efficiency of underwater wireless sensor networks.

B. Architecture Diagram of WSN

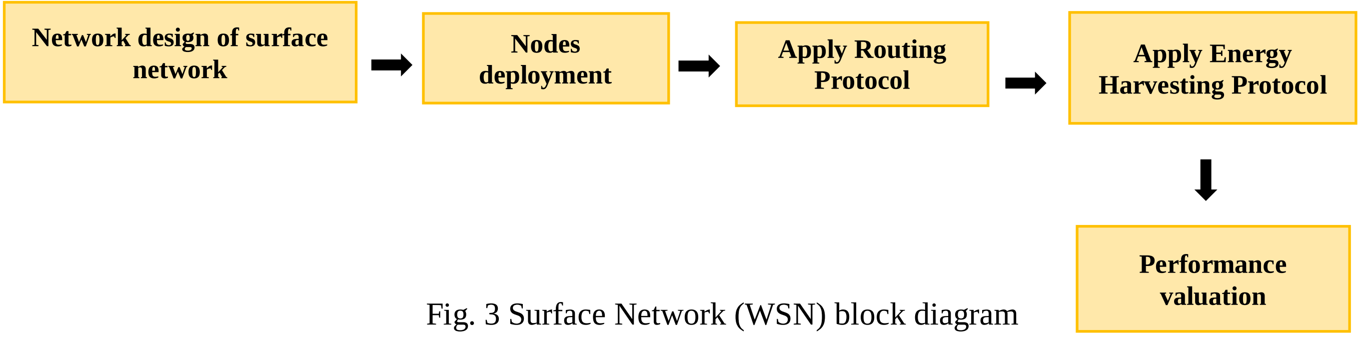


Fig. 3 Surface Network (WSN) block diagram

Fig. 3 shows the architecture diagram for implementing the ARCUNEH protocol in a wireless sensor network., here is a brief description of each block in the architecture diagram for the Energy Harvesting Protocol in WSN:

1) Design of the surface network: This block refers to the design of the network infrastructure for the WSN, including the selection of appropriate hardware components and the configuration of the network topology.

2) Node deployment: This block involves the physical deployment of the sensor nodes in the environment. The placement of the nodes is crucial as it affects the quality of data collection and transmission.

3) Apply the Routing Protocol: In this block, the routing protocol is applied to the network to enable communication between the sensor nodes and the base station. The routing protocol is responsible for determining the optimal path for transmitting data packets.

4) Energy Harvesting: This block refers to the process of harvesting energy from the environment to power the sensor nodes. The energy harvesting techniques can include using solar energy, wind energy, or any other available energy sources in the environment.

5) Performance evaluation: In this block, the performance of the WSN is evaluated in terms of packet delivery ratio and energy consumption. The packet delivery ratio measures the percentage of packets that are successfully delivered to the base station, while energy consumption refers to the amount of energy used by the sensor nodes to transmit data. The evaluation results can help optimize the network's performance by identifying any bottlenecks or areas for improvement.

C. Mathematical Computation

Underwater sensor networks (UWSN) can use energy harvesting techniques to extend the network lifetime and reduce the reliance on battery replacement. Energy harvesting systems can be designed to scavenge energy from various sources, such as wave motion, thermal gradients, and ambient light. The amount of energy that can be harvested depends on the characteristics of the energy source and the efficiency of the energy harvesting system. The mathematical formula for calculating the harvested energy can be expressed as follows:

$$E = \eta * A * \Delta T * Cp * \rho * V \longrightarrow \quad (1)$$

Where,
E: The harvested energy in joules (J)
The Efficiency of the energy harvesting system (unitless)
A: The surface area available for energy harvesting (m^2)
ΔT: The temperature difference between the energy source and the energy harvester (°C)
Cp: The specific heat capacity of the energy source (J/kg °C)
ρ: The density of the energy source (kg/m^3)
V: The volume of the energy source (m^3)

The Amplify and Forward relay protocol formula assumes that the energy harvesting system converts the harvested energy into electrical energy, which can be stored in a battery or used to power the sensor node directly. The efficiency of the energy harvesting system depends on the type of energy source and the design of the energy harvesting system. It's worth noting that the design of energy harvesting systems for UWSN can be complex, and there are many factors to consider beyond this simple formula, such as the location of the energy source and the environmental conditions of the underwater environment.

Amplify and Forward (AF) is a common relay technique used in wireless communication systems to improve signal quality and extend communication range. In an AF energy harvesting system, the relay node harvests energy from the received signal and uses it to amplify and forward the signal to the destination node. The amount of harvested energy and the quality of the received signal determine the performance of the AF energy harvesting system. The mathematical formula for the harvested energy in an AF energy harvesting system can be expressed as follows:

$$E = \eta * \gamma * P\_rx * T\_h \longrightarrow \quad (2)$$

Where,
E: The harvested energy in joules (J)
η: The efficiency of the energy harvesting system (unitless)
γ: The channel gain between the source node and the relay node (unitless)
P_rx: The received signal power at the relay node (Watts)
T_h: The harvesting time at the relay node (seconds)

The channel gain (γ) and the received signal power (P_rx) are affected by the distance between the source node and the relay node, the path loss, and the fading effects in the wireless channel. The efficiency of the energy harvesting system (η) depends on the type of energy harvester used and the design of the energy harvesting circuit. The harvesting time (T_h) is the time interval during which the relay node can harvest energy from the received signal.

In an AF energy harvesting system, the relay node uses the harvested energy to amplify and forward the received signal to the destination node. The signal amplification is typically modelled as a linear amplifier with a gain factor (G). The mathematical formula for the amplified signal power (P_tx) can be expressed as:

$$P\_tx = G * \eta * \gamma * P\_rx \longrightarrow \qquad (3)$$

Where,
P_tx: The amplified signal power at the relay node (Watts)
G: The gain factor of the linear amplifier (unitless)
The amplified signal power (P_tx) is used to calculate the signal-to-noise ratio (SNR) at the destination node and to determine the overall system performance.
It is important to consider the energy harvesting signal's attenuation level, which may be calculated using the equation (4)

$$A=20*\log10(V)+a(f)*(V) \longrightarrow \qquad (4)$$

Where, V represents the coverage area of transmission source node S. It is crucial to remember that the attenuated signal level and a(f), which measures attenuation over frequency, increase with a node's transmission range.
we obtain power collected for the relay's node.

$$\longrightarrow Eharvest = 0.7 * m * \frac{10^{\frac{(R+SVR)}{20}}}{4 * PR} \qquad (5)$$

Where,
SVR is the Sensitivity of received voltage that can be calculated for efficiency of energy using (SVR=20log10(M))
M is Voltage sensitivity
PR is an energy collecting hydrophone that adds value(PR=10*R/20)

D. ARCUNEH Protocol Implementing Steps:

1. Initialize the sensor nodes.
2. Sensor nodes are randomly placed on the sensor nodes.
3. Initialize the network parameters and variables, including the number of nodes, the transmission power, and the channel gains.
4. For each node in the network, determine its position and calculate its transmit power based on its distance to the destination.
5. Send a message from the source node to the destination node.
6. Upon receiving the message, each node calculates the received signal strength and amplifies the signal.
7. Each node forwards the amplified signal to the next node on the path towards the destination.
8. The destination node receives the final amplified signal and decodes the message.
9. If the destination node successfully decodes the message, it sends an acknowledgement to the source node.
10. If the acknowledgement is not received, the source node retransmits the message.
11. Repeat steps 3 to 8 until the message is successfully delivered to the destination.

12.Update the network parameters and variables based on the feedback received from the nodes to improve the routing efficiency and reliability.

E. UWSN Algorithm:

INPUT: ENERGY HARVESTING, NUMBER OF NODE, RANGE, SPACE DIM, ATTENUATION COEFFICIENT

OUTPUT: ENERGY CONSUMPTION, PACKET DELIVERY RATIO, ENERGY HARVESTING

```
1. DEFINE NETWORK 3D TOPLOLOGY N
2. NODES ARE RANDOM DEPLOYMENT
3. HOP COUNT DESIGN
4. HOP NEIGHBOUR NODE
5. ENERGY HARVESTING
6. SIMULATION TIME
7. For N nodes randomly placed
8. Check energy level of nodes
{
9. If  Energy level<0
Harvest the energy
Else
10. Total data packet send to destination
          If harvest energy not enough
         {
                  Terminate node
         }
                  Initialize the initial loop
}
11.  Harvest the energy
12.  Amplify and forward
13. Calculated channel less channel gain
         Harvest the energy
Update the energy
End
End
Repeat step 8
End
```

F. WSN Algorithm:

INPUT: NODE PLACEMENT, NUMBER OF NODE, RANGE, SPACE DIM, ATTENUATION COEFFICIENT

OUTPUT: ENERGY CONSUMPTION, PACKET DELIVERY RATIO, ENERGY HARVESTING

```
1. DEFINE NETWORK   TOPLOLOGY N
2. NODES ARE RANDOM DEPLOYMENT
3. DISTANCE NODES
4. ENERGY HARVESTING
6. SIMULATION TIME
7. For N nodes randomly placed
8. Check energy level of nodes
{
9. Energy level>energy consumed
10. Energy level update for each loop
         {
         If energy
         Consumed = received power
```

```
Share the data packet
}
Packet failed
Repeat step initial
}
End
End
```

G. Comparison of WSN and UWSN Parameters:

Wireless Sensor Networks (WSN) and Underwater Wireless Sensor Networks (UWSN) are two types of sensor networks that have different characteristics due to the different environments in which they operate.

Values and parameters are key aspects in both types of networks as they play a critical role in determining the performance of the network.

The following table compares the values and parameters in WSN and UWSN:

TABLE I
COMPARISON TABLE FOR WSN AND UWSN PARAMETERS

Values/Parameters	Wireless Sensor Networks	Underwater Wireless Sensor Networks
Communication range	Few hundred meters	Few meters
Transmission rate	Few Kbps	Few bps
Energy consumption	Lower	Higher
Node mobility	Less frequent	Rarely
Routing protocols	Designed for terrestrial environments	Designed specifically for underwater environments
Propagation characteristics	Follows line-of-sight or multi-path propagation	Follows multi-path, multi-hop, and acoustic propagation
Channel conditions	Less affected by water properties	Strongly affected by water properties such as salinity, temperature, and pressure
Packet delivery	High in terrestrial environments	Low due to high attenuation and interference in underwater environments
Energy harvesting	Easier due to the availability of solar and wind energy	Challenging due to the limited availability of light and difficulties in deploying energy harvesting techniques
Energy consumption	Can be reduced by optimizing protocols and algorithms	Must be carefully managed due to limited battery capacity and high energy consumption of underwater communication

Deployment	Easy to deploy and maintain	Challenging to deploy and maintain
Sensor node placement	Can be placed above ground level	Must be placed in the water

H. Advantage of ARCUNEH

1. High Packet delivery ratio
2. High through put
3. Reduced delay
4. Low Energy Consumption
5. Efficient Energy Harvesting
6. By lowering energy usage and optimizing data transmission, a routing algorithm created for energy harvesting in UWSN can increase network effectiveness. By avoiding nodes with low energy levels and reducing data transmission delays, the protocol can choose the data transmission channel that uses the least amount of energy.
7. The network lifetime extension is the main benefit of implementing a routing protocol for energy harvesting in UWSN. The sensor nodes can be powered by ambient energy sources such as vibrations, temperature variations, and sunshine using energy harvesting techniques. Routing methods that take energy harvesting into account can reduce energy usage and increase network lifespan.
8. In UWSN, energy harvesting techniques can save money because they do not require frequent battery replacement or recharging. This can drastically lower the network's maintenance expenses.

V RESULTS AND DISCUSSION

In this section, the results attained for the proposed ARCUNEH Protocol are evaluated. The simulation of the proposed
approach is analyzed in the MATLAB software and is validated by comparing with few state of art models in terms of dead nodes, energy consumption, packet delivery ratio,energy harvesting and throughput.

A. Node Placement for UWSN & WSN

We designed underwater wireless sensor network randomly placed Underwater wireless sensor network, nodes are placed randomly, nodes are placed (500 500 500) in underwater sensor network.

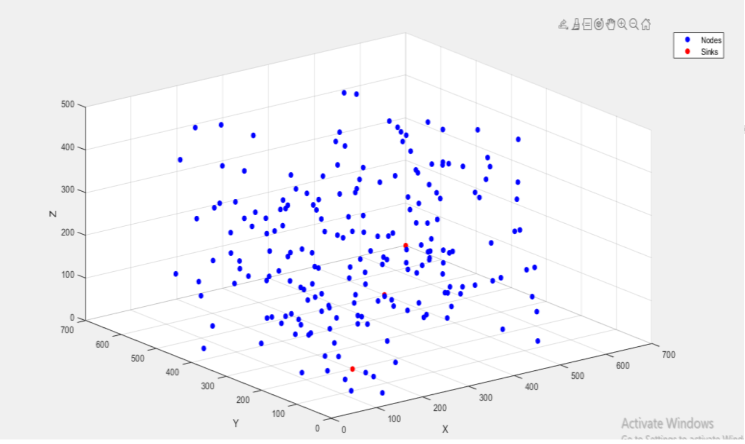


Fig. 4 Node Placement for UWSN

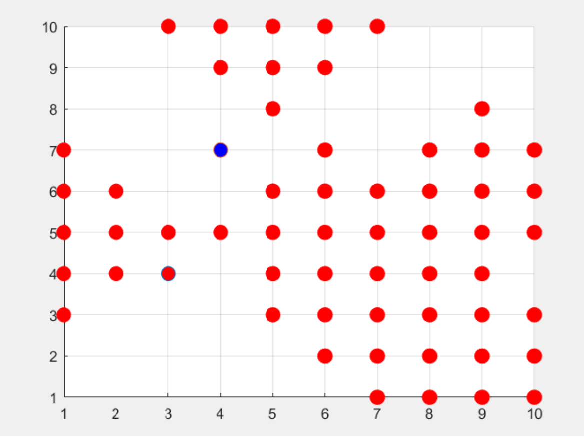


Fig. 5 Node Placement for WSN

Fig. 4 shows the node placement randomly in an underwater environment for 3D, where red nodes are sink nodes and blue nodes are source nodes. and Fig. 5 shows the node placement randomly in a 2D surface environment, where red nodes are source nodes and blue nodes are sink nodes.

B. Packet Delivery Ratio & Energy Consumption for UWSN

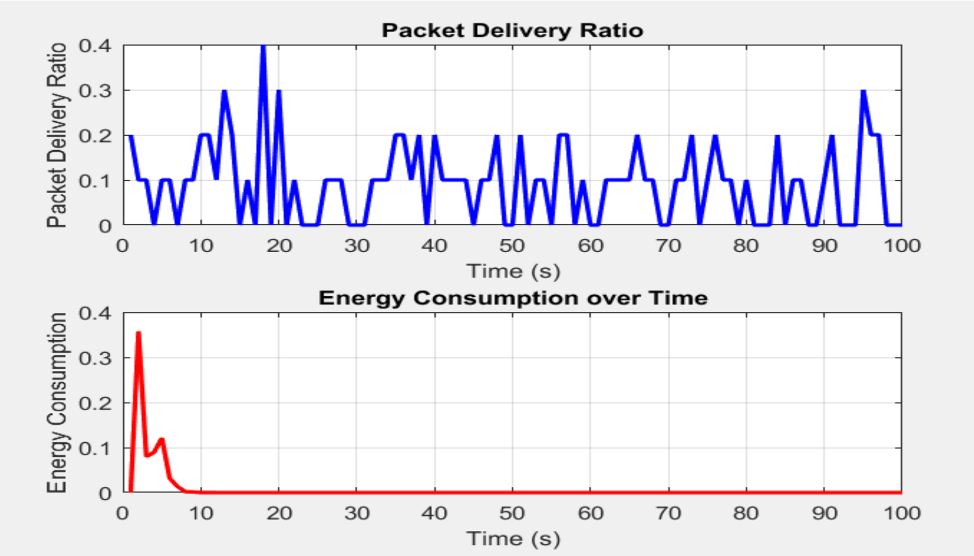


Fig. 6 Packet Delivery Ratio & Energy Consumption for UWSN

Average Packet Delivery Ratio: 3.8264
Average Energy Consumption: 0.3865931
Attenuation = 30 dB
S = 174.8309 dBm
Final Number of Dead Nodes: 4
Final number of live nodes: 6

In Fig 6 shows the PDR and Eg Consumption plotting in UWSN using ARCUNEH protocol,The given values represent the results obtained after plotting a graph in MATLAB, which shows the packet delivery ratio and energy consumption of UWSN nodes. The average packet delivery ratio is 3.8264, which indicates that the UWSN nodes were successful in sending packets during the 100s time period. However, the PDR cannot exceed 0.325 over the maximum 100s time period due to the limitations of energy consumption. The average energy consumption of the UWSN nodes is 0.3865931J, which implies that the nodes were able to balance their energy usage during the operation.The attenuation value of 30 dB and S value of 174.8309 dBm indicates the strength of the signal transmitted and received by the nodes, respectively. The final number of dead nodes was 4, which shows the impact of energy consumption on the stability of the network. The final number of live nodes was 6, which demonstrates the efficiency of the energy harvesting technique used in the UWSN nodes.

In summary, the results obtained from the graph plotted in MATLAB indicate that the UWSN nodes were successful in sending packets with an average packet delivery ratio of 3.8264 over a 100s time period, while maintaining an average energy consumption of 0.3865931J. The study highlights the importance of balancing energy usage in UWSN, and the effectiveness of energy harvesting techniques in improving the stability and lifetime of the network.

C. AF Energy Harvesting Underwater wireless sensor network

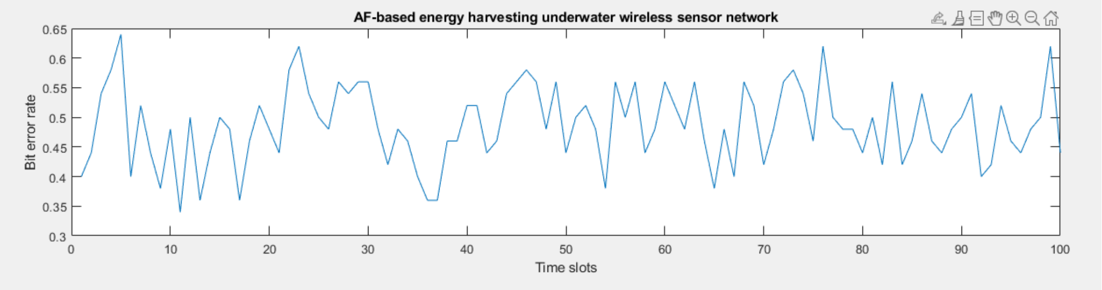


Fig. 7 AF Energy harvesting Underwater wireless sensor network

Output Values in AF Energy Harvesting:

Attenuation = 30 dB
S = 174.8309 dBm
Final Number of Dead Nodes : 3
Final Number of Live Nodes : 7
Average Packet Delivery Ratio : 9.9
Average Energy Consumption : -0.0018111

In Fig 7 shows the AF Energy Harvesting Plotting in UWSN, Based on the given output values, we can see that the AF Energy Harvesting Technique has resulted in a final number of 7 live nodes and 3 dead nodes in the UWSN network, with a maximum bit error rate of 0.65. The average packet delivery ratio (PDR) is 9.9, which indicates that a high percentage of packets sent were successfully delivered.

The average energy consumption is negative (-0.0018111), which suggests that the nodes were able to harvest more energy than they consumed, resulting in increased network lifetime.

The graph plotted over 100 time slots for bit error rate shows that the PDR ratio remained consistently high, indicating that the nodes were able to successfully send packets over the entire 100s time period.

In conclusion, the AF Energy Harvesting Technique has shown promising results in terms of improving PDR and energy consumption in UWSN nodes. The technique has enabled the nodes to harvest sufficient energy to sustain their operation, resulting in increased network lifetime and efficient packet delivery.

D. Packet Delivery Ratio & Energy Consumption for WSN

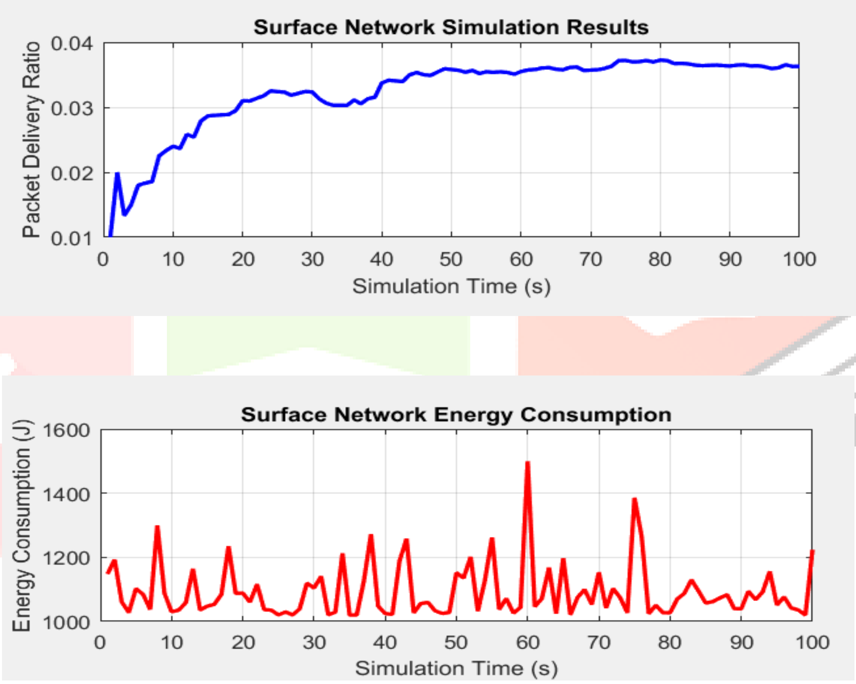


Fig. 8 Packet Delivery Ratio & Energy Consumption for WSN

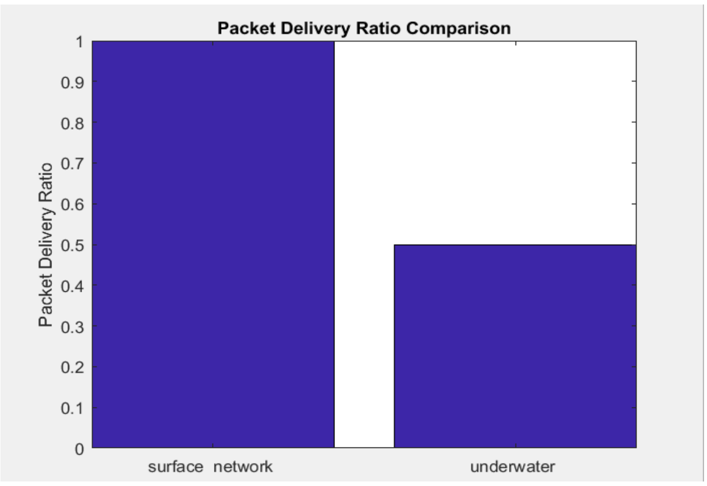
In Fig 8 shows the PDR and Eg Consumption plotting in WSN using Energy Harvesting(EH) protocol.The graph in Fig 8 shows the performance of the WSN using the Energy Harvesting protocol in terms of Packet Delivery Ratio (PDR) and Energy Consumption (Eg) over a 100s time period. The PDR represents the percentage of successfully transmitted packets in the network, while Eg consumption refers to the amount of energy consumed by the nodes in the network.

The graph shows that the PDR in WSN cannot exceed 0.0385 over a max 100s time period. This is due to the limited bandwidth and the high attenuation in the wireless communication channels. However, the WSN nodes can still successfully send packets with high energy consumption, as the graph shows that the Eg consumption can reach a maximum of 1500J.

To maximize the performance of the WSN, a good energy harvesting mechanism can be installed to harvest energy from the environment. This can help to reduce the energy consumption of the nodes and extend the network lifetime. The average PDR and Average Eg Consumption in WSN nodes can be calculated based on the data from the graph.

In summary, the Energy Harvesting protocol can improve the performance of the WSN by reducing the energy consumption of the nodes and extending the network lifetime. The PDR and Energy consumption can be used as key metrics to evaluate the performance of the WSN.

E. Comparison of Packet Delivery Ratio & Energy Consumption for UWSN and WSN



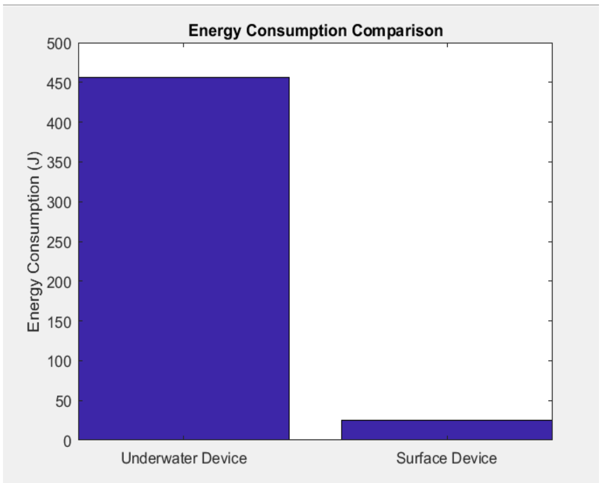


Fig.9 Comparison of Packet Delivery Ratio for WSN & UWSN
Fig.10 Comparison of Energy Consumption for UWSN & WSN

The fig. 9 compares the packet delivery ratio (PDR) for both WSN and UWSN networks using the ARCUNEH energy harvesting protocol. It can be observed that the PDR value increases in both networks when compared to ARCUN, RACE, and LEACH protocols. This increase in PDR is due to the implementation of energy harvesting techniques and the amplifying forwarding (AF) technique in the ARCUNEH protocol.
However, the PDR value is slightly lower in UWSN compared to WSN due to the unique characteristics of the underwater environment such as high attenuation, limited bandwidth, and high latency. These characteristics make it challenging to transmit data in UWSN, and hence the PDR value is slightly lower than in WSN. Moreover, the surface medium has less noise, lower attenuation, and other benefits, resulting in a higher PDR value for WSN compared to UWSN.
In conclusion, the implementation of the ARCUNEH energy harvesting protocol can significantly improve the PDR value in both WSN and UWSN networks. However, the environmental properties of the network also play a crucial role in determining the PDR value.

The Fig. 10 shows the comparison of energy consumption between WSN and UWSN based on different environmental properties after applying the Energy Harvesting ARCUNEH protocol. The graph indicates that the Energy Consumption decreases in both WSN and UWSN networks after applying the Energy Harvesting protocol compared to ARCUN, RACE, and LEACH protocols.
In the case of WSN, the Energy Consumption is minimum because of the air medium, low obstacles, fixed range, low density, and other benefits. On the other hand, in UWSN, the Energy Consumption is very high, which results in less network lifetime than WSN due to various factors such as high attenuation, limited range, and high density. To overcome this issue, we apply the Energy Harvesting ARCUNEH protocol to gain Energy from the environment to increase the life time of networks and reduce the energy consumption of nodes.
The graph shows that the energy consumption is reduced significantly in both WSN and UWSN networks after applying the Energy Harvesting ARCUNEH protocol. This is because the nodes in the network can harvest energy from the environment, which reduces the reliance on battery power. The reduced energy consumption prolongs the network lifetime, which is critical in many applications where replacing or recharging batteries is challenging or impossible.
In conclusion, the Energy Harvesting ARCUNEH protocol is an efficient method to reduce energy consumption and prolong the network lifetime of both WSN and UWSN networks. The protocol allows the nodes to harvest energy from the environment, which reduces the reliance on battery power, ultimately resulting in lower energy consumption and longer network lifetime.

TABLE II AVERAGE ENERGY CONSUMPTION OF UWSN & WSN

Number of nodes	Energy Consumption of UWSN (J)	Energy Consumption of WSN (J)
100 nodes	1.6086875	-0.022335
50 nodes	3.44303765	-0.01235
600 nodes	2.36117786	0.0080365

TABLE III PACKET DELIVERY RATIO OF UWSN & WSN

Number of nodes	Packet delivery ratio of UWSN	Packet delivery ratio of WSN
100 nodes	7.7	3.8735
50 nodes	11.2	3.6581
600 nodes	9.4	2.8371

Table II and III compare the Average Packet Delivery Ratio and Energy Consumption for UWSN and WSN based on different numbers of nodes present in the network. The tables show that as the number of nodes increases in the network, the energy consumption also increases in both types of networks. However, comparatively, the energy consumption is lower in WSN than UWSN. This is because the underwater environment presents more obstacles and challenges, such as high attenuation, noise, and mobility, which require more energy consumption to overcome.

On the other hand, the packet delivery ratio is better in UWSN than WSN due to the application of Energy Harvesting protocol. This is because the Energy Harvesting protocol allows the network to harvest energy from the environment, which increases the lifetime of the network and reduces the energy consumption of nodes. With more energy available, the nodes can transmit more packets, resulting in a higher packet delivery ratio.

In summary, the Energy Harvesting protocol has shown to be an effective solution for improving the performance of both WSN and UWSN networks. It reduces energy consumption, increases network lifetime, and improves the packet delivery ratio, especially in the challenging and harsh environment of UWSN.

VI CONCLUSION

Ineffectual energy use and viable energy collection are the difficulties with UWSN. These concerns have a considerable impact on general information about the organization exhibition.we introduced the ARCUNEH energy collecting strategy in this investigation. For cooperative-based correspondence, the suggested strategy used two hand-off hubs. Amplify and forward is a signal boosting and forwarding method used at relay nodes. At the destination node, a fix combining ratio approach is used to evaluate and choose correct signals. For energy collection, piezoelectric method was used.

1. We implemented an energy harvesting routing protocol to harvest energy, conserve energy, and reproduce energy.
2. We compute the results for two different networks to evaluate various parameters.
3. ARCUNEH Protocol can help researchers and engineers to develop more efficient and reliable underwater wireless sensor networks
4. It can also provide insights into how to optimize the performance of both UWSN and WSN in different environments and applications

FUTURE SCOPE

1. Optimization of energy harvesting techniques
2. Integration of AI and machine learning
3. Development of hybrid energy harvesting techniques
4. Deployment of energy-efficient routing protocols
5. Development of energy storage systems

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