



# **Energy and Time Efficient Routing Protocol for Shortest Path in Underwater Networks**

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**ABSTRACT:** The Ocean remains the least explored area on this planet. Pollution monitoring, offshore exploration, oceanographic data collections and technical surveillance are the applications of UWASNs. Underwater acoustic sensor networking is the enabling technology for more applications. In this paper, several fundamentals key aspects of underwater acoustic communication are investigated. Different architecture for 2D and 3D underwater sensor networks are discussed. The main challenges posed by underwater environment are detailed for the development of different communications. Here we proposed the shortest path routing scheme based on time and distance as well as energy and distance between the sensor nodes for effective communications. The results for both the experiment are different and are based on AODV routing protocol. Also, to implement this proposed environment, we use 2D architecture due to the complex deployment in 3D space. Study and analyzing the routing scheme on the basis of different parameters such as routing overhead, throughput, error rate, collision detection and packet delivery ratio is the main aim of this paper.

**KEYWORDS:** Underwater sensor networks (UWSNs); acoustic communication; acoustic networks; shortest path; routing protocols

## **I. INTRODUCTION**

Underwater acoustic sensor network consist of a number of sensor nodes [1] [2], stationary or mobile, connected wirelessly via acoustic communication deployed to monitor various events over a given area. Oceanographic data collection, pollution monitoring [4], offshore inspection and tactical vigilance are the ocean bottom applications. Multiple unmanned or autonomous unmanned vehicles (AUVs, UUVs) equipped with underwater sensors, will also find application in exploration of natural resources and gathering of scientific data missions.

To make these applications viable, there is a need to enable underwater communication among various devices in underwater acoustic sensor nodes. These sensor nodes and vehicles must have self configuration capabilities i.e., they must exchange their information, location and configuration and to relay monitored data to an onshore station. Sensor network nodes have very low cost and can be permanently deployed on the sea floor. Such a system enables frequent observations and helps to empower resource recovery.

There are some challenges why we use underwater devices. First, radio is not suitable for underwater because of extremely limited propagation while acoustic waves is a promising form of underwater communications. Second, the shift from RF to acoustic changes the physics of communication from speed of light ( $3 \times 10^8$  m/s to the speed of sound (around  $1.5 \times 10^3$  m/s), difference of five orders of degree. While propagation delay is trivial for short range RF, it is a central fact of underwater wireless. This has deep indication on localization and time synchronization [4] [8]. Finally, energy conservation of underwater sensor network will be different than terrestrial network because the sensors will be larger in some important applications which requires large amount of data.

## **II. RELATED WORK**

In [2] authors investigated the key aspects of underwater acoustic communication and discussed different architectures. Open research issues are reviewed and cross layer approach of all communication functionalities is suggested in [3]. In [4] authors explained the designing of 2D and 3D networks and acknowledge the coverage and connectivity issues of three dimensional networks in [8]. Several aspects in the design of acoustic networks that maximizes throughput and reliability while minimizing power consumption is detailed by authors in [5]. In [7] we



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studied the basic architecture and protocols reviewed. Designing an UWSN that maximizes throughput with many limitations such as low bandwidth, large propagation delay, highly varying multipath are detailed by the authors in [9]. In [11] dynamic addressing based Hop-by-Hop routing protocol is proposed to provide scalable and time efficient routing. In [13] authors figured issued like data forwarding, deployment in UWSNs under different conditions and comparison of different algorithms proposed recently. Detailed overview on current solution for medium access control, transport and network layer protocols are given and architecture for two dimensional and three dimensional networks are proposed in [16]. In [17] different routing protocols are compared name DSDV, DSR and AODV. AODV offers quick adaption to dynamic link conditions, low processing and memory overhead, low network implementation, and establish unicast line to destinations within the ad hoc networks. In [18] characteristics and functionalities based overview of eight different protocols are conferred and comparison and discussion of their merits and drawbacks are provided.

### III. APPLICATIONS

- A. *Tectonic monitoring*: Underwater sensor network are able to provide warnings for tsunami to the seaside areas.
- B. *Device monitoring*: Sensor network are very helpful to check failures or any other problems in early phase [12]. They enable control of different equipments (sensors, remotes) immediately after the positioning.
- C. *Aquatic underwater*: UWSN figures the route for cables and modems undersea for investigation and help in seeking treasured minerals underwater. They also help in detecting reservoirs and oil field.
- D. *Pollution monitoring*: Different kinds of pollution monitoring like biological, chemical pollution can be accomplished. It covers monitoring parameters, pH levels, temperature, conductivity etc.

### IV. RESEARCH CHALLENGES IN UNDERWATER COMMUNICATION

- A. *High maintenance*: The conservation and maintenance of underwater sensors are high. The demands are growing because underwater sensors are very pricey [11].
- B. *Reliability*: Oceans and seas are not immobile as compared to the terrestrial network systems. This is one of the enormous challenges in underwater network environment.
- C. *Finite battery power*: Battery power in underwater sensor network [14] is very bounded as the interval charging is not possible timely which leads to the disrupted communication amid sensors.
- D. *Fouling and corrosion*: Sensors are prone to decay due to fouling and corrosion [15].
- E. *Narrow bandwidth*: UWSN has limited bandwidth which leads to low data rate and large propagation delay which affects every efficiency latency and throughput
- F. *Mobility*: sensor nodes mobility is passive due to the water current. Autonomous underwater vehicle are proactive.
- G. *Time synchronization*: Due to low data rate and high power consumption time synchronizing of different sensor nodes or networks is not possible.

### V. PROPOSED WORK

UWASN are very difficult to implement due to different factors of the environment. Due to uncertainty in underwater environment, the target is to establish static underwater network for time and energy based shortest path scheme. In this proposed network we use existing 2D architecture for future computations.

In this paper, we try to implement time-based [6] [10] and energy-based shortest path for communication between the sensors. For this, design the shortest path routing protocol that locates the shortest path from one random sensor node to another sensor nodes based on time and energy scheme. After finding the shortest path, we can easily analyze the different factors.

In our deployment scheme, we use Ad-hoc on demand distance vector routing (AODV) scheme to implement shortest path. Based on our proposed scheme, we study different parameters in underwater sensor network. AODV offers quick adaption to self starting, dynamic link condition and multi-hop routing among participating node wishing to establish and maintain our proposed network. It allows mobile nodes to obtain routes quickly for new destinations that are not in active communication [18].

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This routing scheme [7] [13] randomly selects source and destination over the surveillance environment. To select the shortest path, this dynamic scheme counts minimum distance with time and energy. Numbers of nodes are selected randomly each time in the deployment area.

To find out minimum path during transmission of the packets, we consider number of tests in under water sensor network.

## VI. NETWORK ARCHITECTURE

UW-ASNs communication architecture:

In this section we illustrate the communication architecture of UWASNs [3]. The underwater sensor network topology is an open research point in itself that needs further research. Here we discuss the following architecture [5] [9].

### A. 2-Dimensional sensor network

In this, a cluster of sensor nodes are anchored to the base of the ocean with deep ocean anchors. In Fig.1, Underwater wireless sensor nodes are hooked to one or other underwater sinks (UW-sinks), which are the network devices in charge of carrying data from the ocean bottom network of the surface station. To achieve this objective, UW-sinks are equipped with two acoustic transceivers i.e., vertical and horizontal transceiver. The horizontal transceiver is used by UW-sink to communicate with the sensor nodes in order to send command and configuration data to the other sensor nodes. Also, it collects the observed data from the neighbor nodes. The vertical links is used by the UW-sink to convey the data to the surface station. Vertical transceiver must be long range transceiver for deep water application. The surface station onshore is equipped with the acoustic transceiver so that it allows and receives the multiple parallel communications simultaneously with the deployed UW-sinks. Sensors can be connected to the sinks via direct link or through multi-hop path.

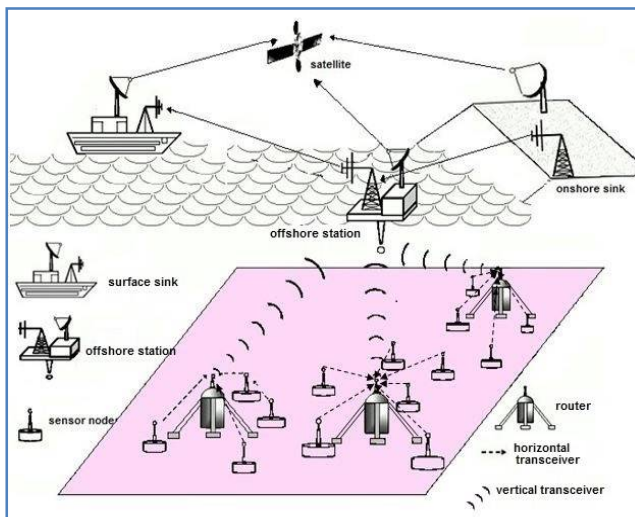


Fig.1. 2D architecture

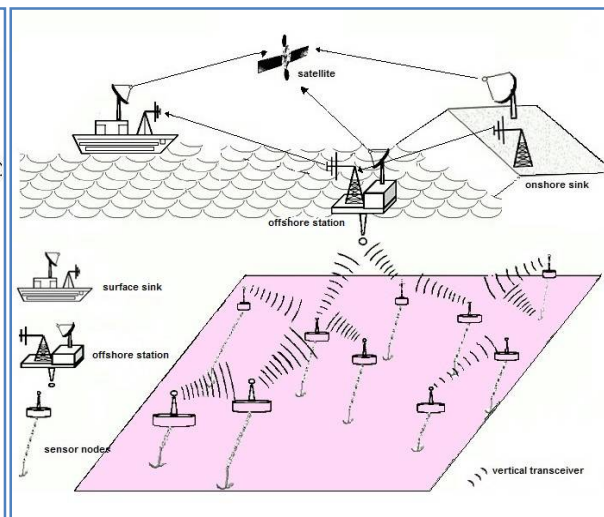


Fig.2. 3D architecture

### B. 3-Dimensional sensor network

3D underwater network are used to detect and observe aspects that can inadequately decisive by the means of ocean root sensor nodes. 3D architecture primarily focuses on cooperative sampling of 3D ocean environment. In this, sensor nodes skim at different height in order to observe 3D phenomenon. In Figure 2, each sensor is moored to the ocean bottom and decked with non-submersible buoy that can be bloated by a pump [17]. The surface beacon forces the sensors nearing the ocean surface. The distinct depth of the sensors can be coordinated by adjusting the limit of the strand that joins the sensors to the bower. But still many problems appear with such a planning, which needs to be clarify in order to perform 3D sampling [12]. 3D sensors should regulate their base in order to attain full column



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analysis according to the sensing range. Network devices should adjust their base in such a way that at least one line always exists from every sensor to the offshore station.

## VII. TIME AND ENERGY BASED ANALYSIS TO FIND SHORTEST PATH

Different parameters [1] are analyzed on the basis of time to find out shortest path using dynamic routing scheme. The parameters are explained below-

- A. Throughput: In general, throughput is the rate at which something can be processed. But here, throughput is the rate of successful message delivery over a given communication channel. Throughput can be calculated as

$$T = (P - ((dc + nc) * pd * dn)) / P$$

Where T is the throughput which measures how many unit of information a network can process in a given amount of time as shown in fig.3, 4. P is the number of packets which has to be delivered, dc is the number of dead collision, nc is the number of normal collision, pd is the packet drop and dn is the number of dead nodes in our proposed network.

- B. Routing overhead: Routing overhead is flooding packets throughout the communication network as shown in fig.5, 6. Here, Routing overhead can be calculated as

$$O = ((dc + nc) * pd * dn)$$

Where O is a routing overhead and on the basis of this formula, various observations have been made.

- C. Collision detection: Collision detection can be calculated as:

$$CD = dc + nc$$

We find the number of collisions per second in this paper. Collision occurs when two nodes attempts to transmit information at the same time. Here, we plot the number of collision for number of iterations as shown in figure 7, 8.

- D. Packet delivery ratio: Packet delivery ratio is defined as the ratio of data packets received by the destination to those generated by the source. Here, experiment shows for packet delivery per 500 packet transfer in underwater sensor network as shown in figure 9, 10. We have calculated packet delivery ratio as follows

$$PDR = (P - (pd * 2)) / P$$

- E. Error rate: In figure 11, 12, experiment result is shown for error rate in dB between the total number of nodes and error encountered in the network. Error rate is the number of bit per errors per unit time. Error rate (E) is calculated as follows :

$$E = (\text{mean}(E) + (dn * pd + \text{error occurrence})) / n$$

## VIII. SIMULATION RESULTS

Here the simulation of underwater acoustic sensor network is done in MATLAB. To accomplish all these challenges, experiment is done by plotting 50 numbers of nodes, 15 numbers of iterations, and 500m X 500m of MATLAB environment to find out the performance by the shortest path. The proposed analysis of different parameters on the basis of time and energy are simulated on this above platform.

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## A. Throughput:

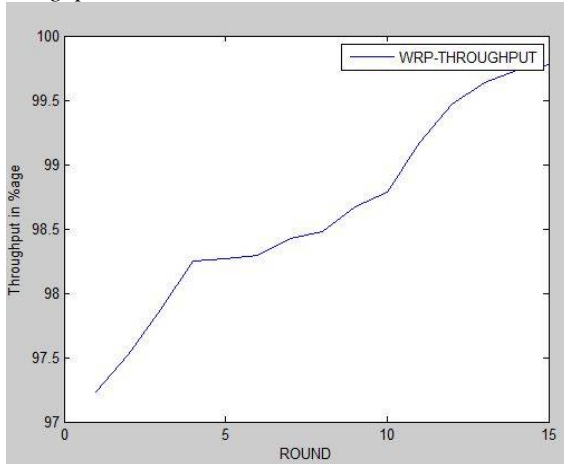


Fig. 3. Time based

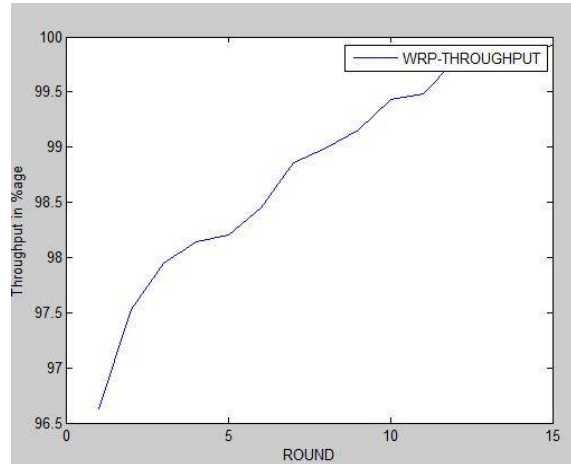


Fig. 4. Energy based

## B. Routing overhead:

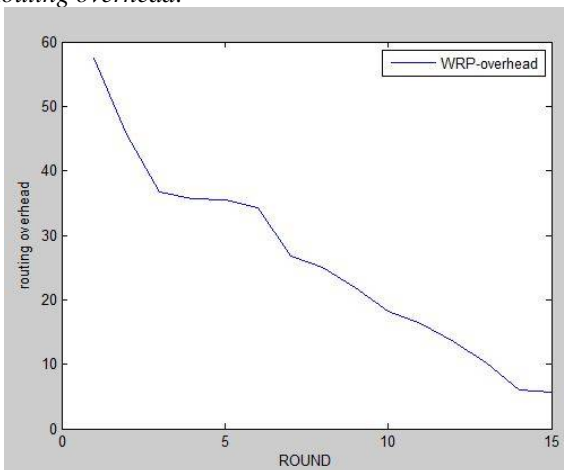


Fig. 5. Time based

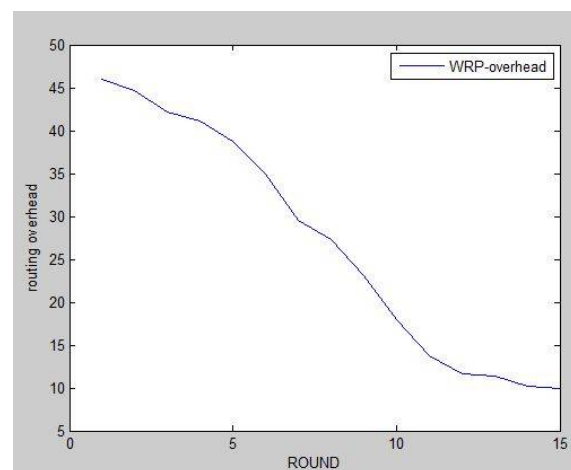


Fig. 6. Energy based

## C. Collisions:

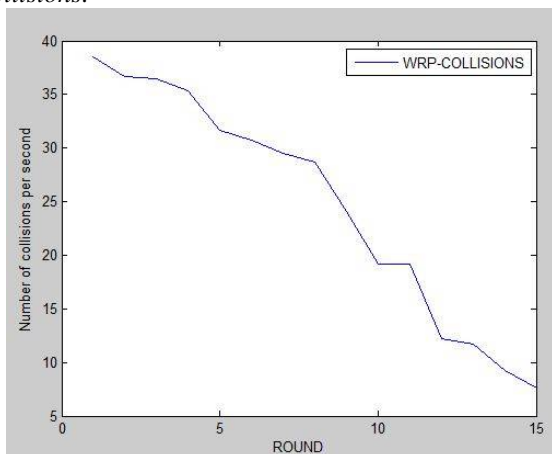


Fig. 7. Time based

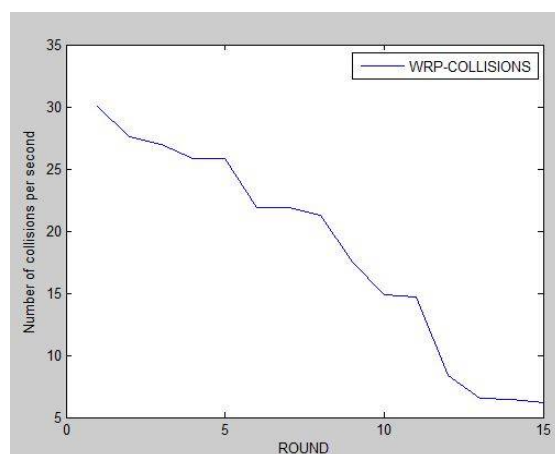


Fig. 8. Energy based



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## D. Packet delivery ratio:

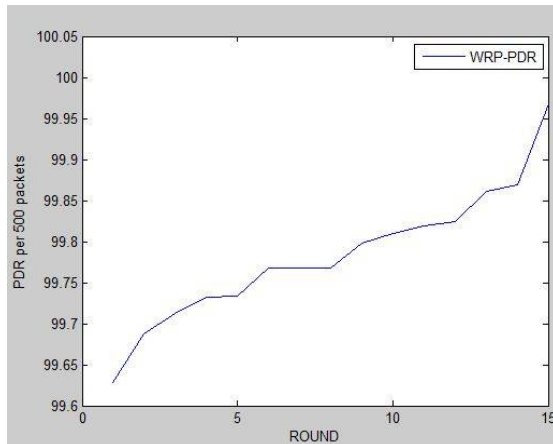


Fig. 9. Time based

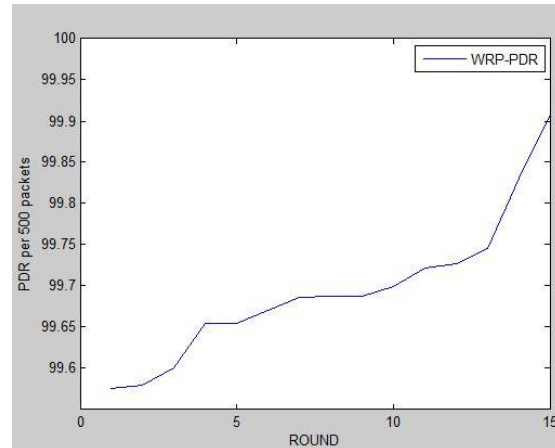


Fig. 10. Energy based

## E. Error rate:

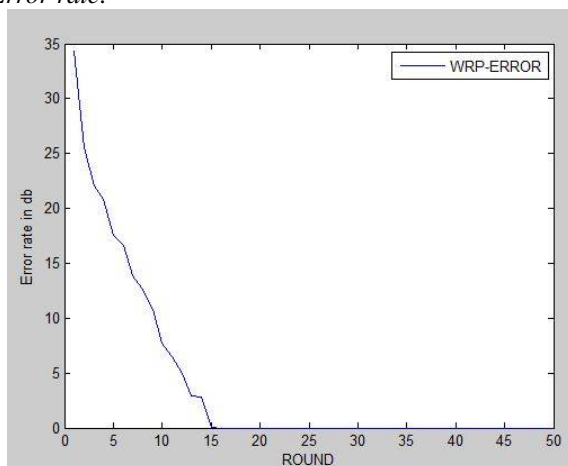


Fig. 11. Time based

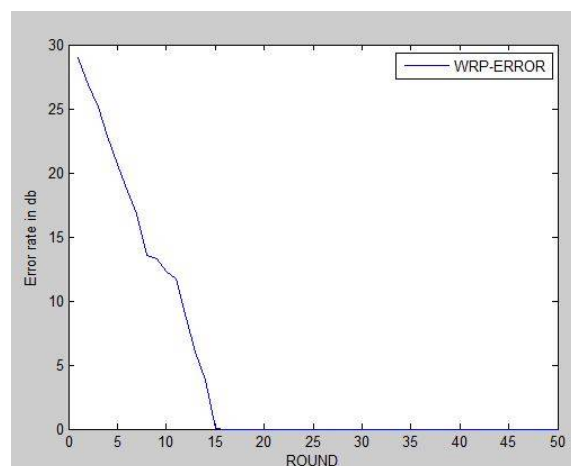


Fig. 12. Energy based

## IX. CONCLUSION

In this paper, we have given the basic visionary architecture of underwater acoustic sensor network. We have discussed the main challenges composed by the underwater channel, characteristics of the underwater channel. Also focus on the research issues. The main objective of this paper is to provide efficient communication. We have provided a mathematical analysis for shortest path based on time and energy using dynamic routing scheme in UWASNs. Further we have simulated the proposed model using MATLAB to test the performance effectiveness in terms of different parameters.

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