International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

Void Avoidance and Power Consumption Through Underwater Wireless Sensor Network

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Abstract: An underwater sensor network (UWSN) has many distinguishing characteristics that set it apart from conventional networks. Low latency, energy limitation, dynamic architecture, high rate of error, longer p dynamic architecture propagation delay, and are all examples of this. Because of its capacity to increase the efficiency of UWSNs in conditions of PDR and energy savings, opportunistic connectivity has gained recently a lot of interest as a way to overcome the restrictions of an environment. Underwater detectors can use opportunistic information routing to jointly transmit a packet to its target which is a better strategy for lossy and sparse networks. In this study, researchers present Opportunistic Void Avoidance Routing (OVAR), a unique routing algorithm that addresses the void issue and high bit - error without depending on any location. OVAR can easily circumvent all types of vacant areas at the least price such as power and latency while selecting the cluster of candidate terminals with the actively managing throughput. Each forwarding network can establish a trade-off between energy usage and advancement of the packet by altering the no. of nodes in its sending set, depending on the quality of its neighbors. OVAR can also choose any forwarding configuration from the sender in any route without adding any input layers. In terms of PDR, energy usage, and average E-E delay, the findings of our exhaustive simulation analysis reveal that OVAR surpasses alternative protocols.

Keywords: Wireless Sensor Network, void, OVAR, UWSNs, nodes, acoustic

1. INTRODUCTION

More than two-thirds of the planet's surface is covered by water. This ecosystem is vital to human existence since it serves as a mode of transportation and has an impact on the earth's climate as well as worldwide production due to its abundance of natural materials. Because of these factors, researchers have recently focused more on UWSNs to evaluate and discover undeveloped submerged areas and enable a variety of applications like energy exploration, oceanic data analysis, pollution tracking, strategic monitoring gas or oil spill tracking, and so on [1]. Strong communication methods are essentially necessary to properly finish the communication operation between the submerged devices to make such deployments viable. Many transmission protocols were developed to address various challenges in TWSNs [2,3], making these networks a hot topic of research. Many UWSN problems remain unsolved and require further research. When contrasted to TWSNs, UWSNs have distinct traits and capabilities [4]. memory. Furthermore, it is difficult to charge or replace their batteries once they have been deployed. UWSNs, as previously stated, employ auditory transmissions, whereas TWSNs typically use radio waves. While radio waves do not transmit effectively in underwater communication and incur from distortion, sound waves provide wireless

transmission in underwater areas with a sufficient range, reduced reflectivity, and improved dependability [5]. Underwater factors like significant resistance and noise level, time-varying multi-path transmission, and low-speed audio propagation influence the audio waves. Due to these underwater characteristics, there is a significant rate of latency and error, as well as a momentary loss of connectivity, restricted bandwidth ability, and high energy transmission costs. Because UWSNs communicate using acoustic waves, the simple application of typical TWSN algorithms to UWSNs degrades system performance [8]. As a result, numerous underwater protocols to increase communication in underwater networks have been developed. These proposed UWSN procedures took into account a variety of underwater characteristics and addressed a variety of issues. In the severe underwater setting, changing or charging batteries of submerged networks was a very difficult and expensive process. An increasing lifetime of the network is a crucial goal in UWSNs.
Researchers suggest a new OVAR protocol to improve performance and dependability in the lossy and dense underwater setting in this work. In comparison to protocols that use high-cost localization to retrieve their geographic parameters in an underwater area. OVAR's approach to dense and lossy environments imposes less cost. However, unlike testing protocols that rely on global network architecture, OVAR relies solely on one-hop nearby node data.

2. RELATED WORK

[9] provides the depth-controlled routing protocol. DCR, on the other hand, modifies the node depth by regulating the topology to arrange the topology of the network and enhance data transmission. This was the first satellite routing system for UWSNs that allows node detectors to navigate vertically for topology management. The centralized topological control (CTC) protocol [10] was created to regulate and organize better the topology of the network by modifying the depth of specific nodes, considerably reducing the influence of the void region communication issue on network connectivity. Furthermore, a DTC is employed, with each module being localized. As a result, if it comes into contact with a void, it will solve the problem by computing the new dimension. CTC and DCR, on the other hand, use a lot of energy to alter the architecture. GEDAR is a geographically and opportunistically based methodology. GEDAR transmits packets to the forwarding group nodes via a greedy relaying technique. When packet data is lost in the detector, the depth parameter of the void detector gets used to determine how to recover it. The protocol executes routing to decide which neighbors are qualified to complete the packet exchange via routing data regarding the current emitter sensor, its neighbors, and sonobuoys. A subset of nearby sensors has been programmed to keep transmitting packets to the sonobuoys. Detectors are chosen as candidates based on the proportion of advance they have made toward the sonobuoys. Due to the extremely huge forwarding group, GEDAR has a high cost, requiring more resources to transmit identical packets.

[11] presented a multitrack technique termed GGFGD. Choosing the next little cube goal and choosing the node of the next step in the small cube goal are the 2 phases in this technique. Packets of data are eagerly delivered to the sonobuoy using the GGFGD algorithm, with the surrounding nodes having the most residual power, the least delayed communication, and the least route loss chosen as the next step. This method, however, has a high rate of duplicated communications. The underwater detector networks, AUVs, submerged gates, and up-level doors are part of a channel path and smart depth procedure. The group's routing algorithm uses digital entities to plan itself for finding multiple routes for a threshold entry depending on parameters like delay, channel utilization, and energy, utilization. The level portal then works with a fundamental media transporter to reverse the trajectory of the media to enhance internet compatibility and dependability in the partitions of the network. Segmentation in this approach

necessitates a large computing effort and a lot of energy. Protocol for void-aware pressure routing (VAPR)20.

3. PROTOCOL FOR OPPORTUNISTIC VOID-AVOIDANCE ROUTING

In this part, we go over the details of our OVAR method.

a. *Model of the System*

Researchers consider that each network uses an integrated depth detector to determine its present depth. Furthermore, decentralized beaconing [13] could be used to determine the data packet distance between nodes and the sink. Due to the water circulation, nodes travel in a stochastic horizontal orientation and their minor vertical motions are inconsequential. The UWSNs get their energy from batteries. In terms of power usage and broadcast range, nodes are similar. The Thorp method was used to design and control the power level of underwater audio propagation [12]. Furthermore, researchers analyze a lossy network in which route loss and bit inaccuracy are proportional to the signal amplitude and distance traveled. The frequency-domain f is multiplied by the route loss or distortion over distance d.

$$A(d,f) = A_0 d^k \alpha(f)^d \qquad (1)$$

where A0 is a unit-normalizing factor and k represents geometric distribution constant, which in practical settings was set to 2. Moreover, the Thorp equation defines the absorption factor (f). The SNR is the ratio of the transmitted amplitude that includes meaningful information to the signal power. The SNR ratio across distance d with bandwidth components f could be stated as follows [14] using the attenuation equation 2:

$$SNR(d,f) = \frac{PR(f)}{A(d,f)PN(f)} \qquad (2)$$

where PN(f) and PR(f) denote the forwarding node's underwater ambient noise and the power consumption, etc. SNR at the sensor must be greater than a threshold value to decode the input signals without error. heat energy PNth(f), v waves PNw(f), shipping PNs(f), and volatility PNt(f) are the four primary elements of ambient sound in the undersea environment, that can be written as :

$$PN(f) = PN_t(f) + PN_s(f) + PN_w(f) + PN_{th}(f) \qquad (3)$$

b. *Overview of the OVAR*

Represents permanent endpoints, in the single paradigm, or a no. of permanent endpoints, in the multiple sink design, is a distinct important characteristic in building void-aware network algorithms for sensors that have been overlooked in most steering method advances in this sector. By this capability, the sink(s) can commence the method of building a void-avoidance path for all devices in the system to their endpoints, which is analogous to the route implementation phases of several matrix routing algorithms in WSNs. Each network periodically transmits a signal that comprises the destination node data as well as some adjacent data for modifying the forwarding table to collect reachability data and locate neighbor networks. Some MAC protocols [14] have already incorporated and used the beaconing method for nearby node finding. Without adding significant overhead, this technique may be enhanced to handle the hop data necessary by OVAR.

c. *Algorithm for Routing*

Researchers choose a forwarding group in the OVAR kernel function depending on two criteria: packet progress and probability of packet delivery. In this part, we'll go through how receiving signals can be used to assess packet delivery probability. There are four phases to the OVAR proposed method. To guarantee that network layers are eliminated from forwarding groups, a vertex graph is generated at each node, and certain groups, e.g clique sub-graphs, are generated by a heuristic. Second, Estimated Packet Advancement is used to determine the optimum forwarding set to maximize the chances of a packet being delivered successfully. Third, the forwarding set's number of sending nodes was changed to strike a balance between dependability and power usage. Finally, before transmitting the packet, the waiting time is determined at each candidate network. To demonstrate the technique, examine the local OVAR case shown in Figure 1.

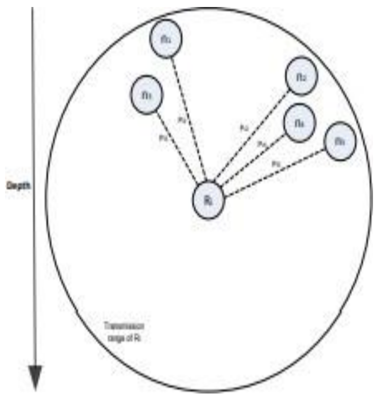

Figure 1: Forwarding packet in node Ri

d. *Advancement of the packet:*

Researchers propose a fitness component,, to determine the priority of relaying networks, which expresses the depth variance between the receiver's level, Dr and the giver's level, Ds,, in a standardised result as follows:

$$\alpha = \frac{D_s - D_r}{R} \quad (-1 \leq \alpha \leq 1) \qquad (4)$$

where R denotes the sensor node's transmission distance. A relay network with a lower concentration has a greater priority to transmit packets, per the fitness value, because it is present on the surface in which the sink was situated. Because of the presence of a vacant area in the transmission range, a negative performance phenomenon suggests that the receiver nezztwork is placed below the transmitter. This value is then normalized to fit inside the range [0,1] as follows:

$$\beta = \frac{1}{2}(\alpha + 1) \quad (0 \leq \beta \leq 1) \qquad (5)$$

Now researchers can discuss the four parts of our network topology: creating the vertex graph and then breaking it into groups, choosing the best forwarding set, modifying the no. of data transmission in the forwarding set, and lastly calculating the time delay, Algorithm 1 describes all of these processes in detail.

Algorithm 1 OVAR Routing Algorithm

```
procedure RECEIVEPACKET(R_i, P)
    if Packet has not already been received and
        R_i ∈ forwarding set of P then
        Calculate α and T_hold
        Set forwarding timer
    else
        Drop P
    end if
end procedure

procedure FORWARDPACKET(R_i, P)
    if forwarding timer expired then
        F(R_i) = ∅
        L(R_i) = {n_k | 1 ≤ k ≤ c}
        G(R_i) = AdjacencyGraph(L(R_i), Table(R_i))
        Ψ(G(R_i)) = CliqueSubGraphs(G(R_i))
        for all Φ_z ∈ Ψ(G(R_i)) do
            Calculate EPA(Φ_z)
        F(R_i) = Φ_z with maximum EPA value
        for j = 1 to r do
            Calculate EEPA(F, j)
        j_max = arg max_j EEPA(F, j)
        for all j > j_max do
            F(R_i) = F(R_i) − n_j
        P.ForwardingList ← F(R_i)
        Forward P
    else
        Drop P
    end if
end procedure
```

e. Construction and grouping of adjacency graphs:

With the use of info given by beaconing, each relaying node, Ri, constructs its adjacency graph G(Ri) at the first phase of OVAR implementation. The transmitting node pulls all clique sub-graphs (groups) from G to eliminate the probability of input layers in a Ri. The forwarding network should choose the optimal group with the optimal packet progress and energy consumption among others to send the packet after generating all viable hidden-node-free clusters.

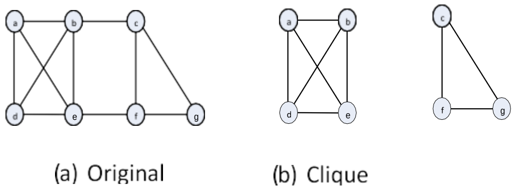

Figure. 2: Generating a clique graph from the original graph

It is an NP-hard task to convert any graph into a set of core sub-graphs (in which all vertices are directly related to each other) [15]. As a result, we use a heuristic for transforming G(Ri) to a sequence of sub-graphs with no input layers in each sub-graph that is more highly scalable. Removing some edges from an adjacency network can lead to groups with the identical node degree for all vertices in each group, which can then be transformed into many clique sub-graphs. Figure 2 illustrates how an adjacency graph may be turned into core subgraphs using an instance.

4. EXPERIMENTAL OUTCOMES

This part contains the details of our numerical simulation as well as the performance outcomes. Researchers developed computational methods for OVAR and two additional newly proposed Adhoc networks, HHVBF and VBF, using Aqua-Sim [16], an NS-2 based modeling program for underwater audio networks.

a. Setup for simulation

Developers use the transmission scheme presented in Section III-A to recreate a lossy underwater milieu in our experiments. Researchers use the CSMA MAC method without the ACK, RTS, and CTS mechanisms, as do the majority of research in this area. The broadcast power was set to 90 dB re Pa, and the coverage area was set to 98 meters for all terminals. The data creation rate was set [17]to One packet per sec, which essentially prevents two consecutive packets from interfering. The network bit rate was Ten kbps, and the underwater acoustic wave transmission speed was 1450 m/s..

b. Results and Analysis

Researchers compare OVAR's efficacy to that of HHVBF and VBF in terms of PDR, power tax, and E-E delay in this part.

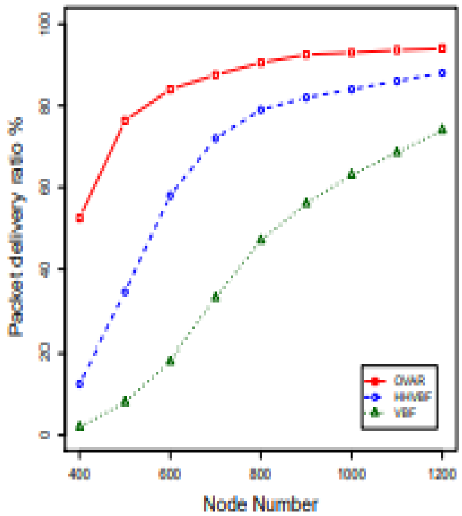

Figure 3: PDR vs node density

c. PDR:

The ratio of the no. of packets received successfully by the sensor nodes to the no. of packets produced by the provider. Figure 3 shows the findings for the PDR at various node densities. PDR is improved by boosting the no. of nodes since it minimizes the size and quantity of empty areas. In a dense channel, more sending units have the opportunity to be inserted in the transmission range, resulting in a high PDR for communication algorithms. In-network congestion, on the other hand, the network participants are disconnected, resulting in a smaller PDR. Because it automatically avoids all paths leading to a vacant area and improves forwarding possibility in each phase towards the target, OVAR has a greater PDR than other routing algorithms (particularly in sparse networks). When the vacant area emerges in the routing pipes of the VBF and HHVBF algorithms, therefore, packet loss increases. Furthermore, these methods do not use packet delivery possibility as a criterion for selecting forwarding networks.

d. Energy tax:

The power tax is measured in millijoules (mj) and is based on the amount of energy utilized p er router and each communication to transmit a packet to its target along with the energy used in transmitting, obtaining, and idle modes

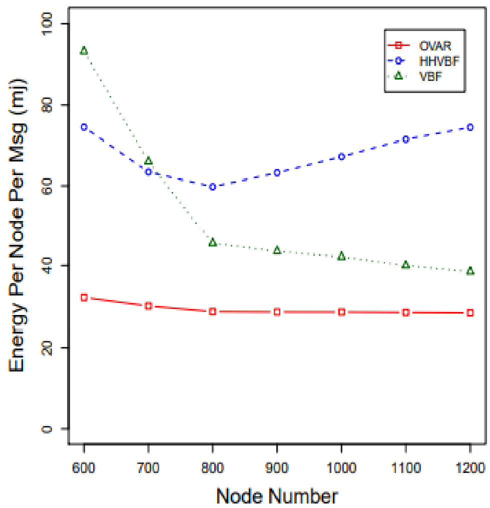

Figure. 4: Message energy usage vs. density of node

The power tax for each procedure is plotted against the no. of nodes in Figure 4. As can be observed, OVAR uses less energy to send each message to the sink than other methods. This is because OVAR groups forwarding contenders together in a cluster, preventing unnecessary packet transfers and conflicts. Therefore, in HHVBF and VBF, the pipe circumference has a significant impact on overall power usage and PDR.

e. ***Average E-E delay**:*

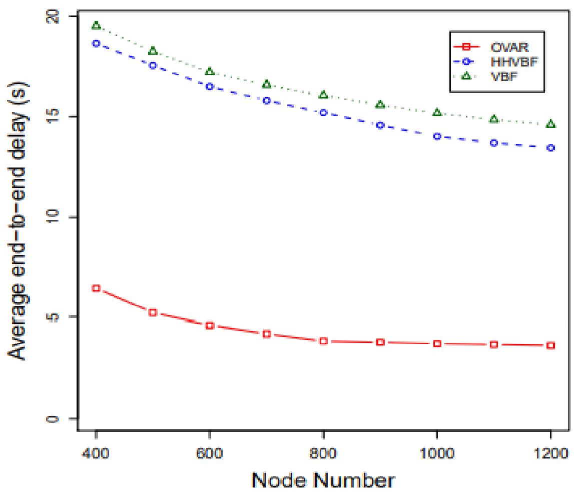

Figure 5: Average E-E delay vs node density

When estimating the E-E delay, researchers take into consideration packet dispersion, delivery, and holding times. Figure 5 shows the average E-E delay for each methodology. Because the relaying node can identify more eligible nodes in its vicinity, the average E-E delay for all methods lowers as the no. of nodes increases. Furthermore, in HHVBF and

VBF, nodes with superior movement towards the sink can be found on the pipe's exterior, and neglecting them can cause the latency to grow. Fig 6 shows the effect of Signal intervals on PDR.

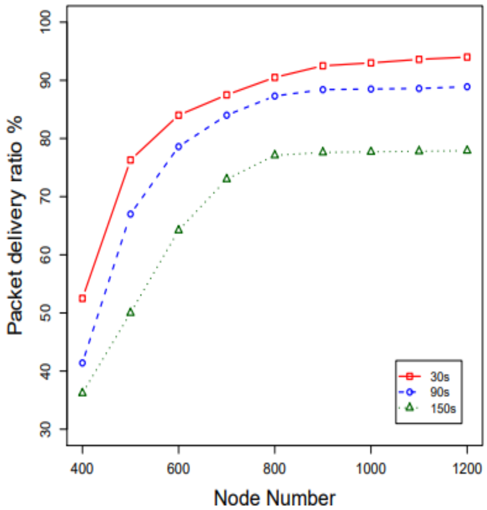

Figure 6: Effect of Signal intervals on PDR

5. CONCLUSION

In this research, researchers looked into opportunistic networking in UWSNs and how it can solve the disadvantage of inconsistent audio transmission by utilizing the assistance of intermediary nodes to route packets. Researchers suggested OVAR, an adaptive routing algorithm, to reduce the number of packet losses by effectively bypassing vacant zones and to improve system throughput in the presence of significant background sound and channel weakening. In this study, researchers present Opportunistic Void Avoidance Routing (OVAR), a unique routing algorithm that addresses the void issue and high bit - error without depending on any location system. OVAR can easily circumvent all types of vacant areas at the least price such as power and latency while selecting the cluster of candidate terminals with the actively managing throughput. Each forwarding network can establish a trade-off between energy usage and advancement of the packet by altering the no. of nodes in its sending set, depending on the quality of its neighbors. OVAR can also choose any forwarding configuration from the sender in any route without adding any input layers. In terms of PDR, energy usage, and average E-E delay, the findings of our exhaustive simulation analysis reveal that OVAR surpasses alternative protocols.

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