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ENHANCING UNDERWATER WIRELESS SENSOR NETWORKS FOR EFFICIENT MONITORING AND ROUTING

Pavithra.E [1], Arun Prasath.N [2], N. Kaleeswari [3] & R. Manivannan [4]

[1] Research Scholar, EASA College of Engineering and Technology, Coimbatore, Tamil Nadu, India

[2] Senior Assistant Professor, Department of ECE, EASA College of Engineering and Technology, Coimbatore, Tamil Nadu, India

[3] Professors, Department of ECE, EASA College of Engineering and Technology, Coimbatore, Tamil Nadu, India

[4] Assistant Professor, Department of EEE, EASA College of Engineering and Technology, Coimbatore, Tamil Nadu, India

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ABSTRACT

Underwater Wireless Sensor Networks (UWSNs) offer promising oceanic exploration capabilities but are limited by communication challenges and energy constraints. This study presents an Empirical Exploration System employing a Multi-population Synchronization Assessment Scheme and Dynamic Routing Technique to enhance energy efficiency and extend the lifetime of Underwater Acoustic Sensor Networks (UASNs). The proposed scheme dynamically activates or sleeps sensor subsets for target coverage. Simulation results in an NS-2-based underwater simulator showcase improved metrics in packet delivery, delay, energy consumption, and network longevity compared to existing protocols. This approach addresses dynamic challenges and adapts to changing sensor locations, showcasing its effectiveness in UWSN energy and communication management.

KEYWORDS: *Underwater Wireless Sensor Networks, Energy Efficiency, Dynamic Routing, Sensor Activation, Oceanic Exploration*

I. INTRODUCTION

Acoustic communication has been considered as the only feasible method for underwater communication in USWNs. High frequency radio waves are strongly absorbed in water and optical waves suffer from heavy scattering and are restricted to short-range-line-of-sight applications. Nevertheless, the underwater acoustic channel introduces large and variable delay as compared with radio frequency (RF) communication, due to the speed of sound in water that is approximately temporary path loss and the high noise resulting in a high bit error rate; severely limited bandwidth due to the strong attenuation in the acoustic channel and multipath fading; shadow zones; and the high communication energy cost, which is of the order of tens of watts.

In this context, geographic routing paradigm seems a promising methodology for the design of routing protocols for UWSNs. Geographic routing, also called of position-based routing, is simple and scalable. It does not require the establishment or maintenance of complete routes to the destinations. Moreover, there is no need to transmit routing messages to update routing path states. Instead, route decisions are made locally. At each hop, a locally optimal next-hop node which is the neighbor closest to the destination is selected to continue forwarding the packet. This process proceeds until the packet reaches its destination. Geographic routing can work together with opportunistic routing (OR) (geo-opportunistic routing) to improve data delivery and reduce the energy consumption relative to packet retransmissions.

Using opportunistic routing paradigm, each packet is broadcast to a forwarding set composed of neighbors. In this set, the nodes are ordered according to some metric, defining their priorities. Thus, a next-hop node in the forwarding set that correctly received the packet, will forward it only whether the highest priority nodes in the set failed in to do so. The next-hop forwarder node will cancel a scheduled transmission of a packet if it hears the transmission of that packet by a higher priority node. In OR paradigm, the packet will be retransmitted only if none of the neighbors in the set receives it.

II. LITERATURE SURVEY

A. Dbr: Depth-Based Routing for Underwater Sensor Networks

- Depth-Based Routing for Underwater Sensor Networks: Efficient, Dynamic, and Cost-Effective. This protocol utilizes local depth information, avoiding the need for complex localization processes. By forwarding data packets towards water-surface sinks, it achieves high delivery ratios with minimal communication cost. With the ability to handle dynamic networks and capitalize on multiple-sink architectures, it ensures energy efficiency and network longevity. Further enhancements, such as recovery algorithms, can be explored for improved performance in sparse networks. This distributed routing protocol optimizes energy consumption, extending the network's lifespan through informed routing decisions based on local data like depth, energy, and distance.

B. Distributed Routing Algorithms for Underwater Acoustic Sensor Networks

- Underwater Acoustic Sensor Networks Enhancing Efficient Geographical Routing for Collaborative Monitor; This study addresses data gathering in Underwater Acoustic Sensor Networks (UW-ASNs), offering novel distributed geographical routing algorithms. These algorithms balance the complex trade-off between channel efficiency and packet error rate by optimizing node decisions on next hops; transmit power, and forward error correction. Through simulation experiments, the proposed algorithms demonstrate their efficacy for delay-insensitive and delay-sensitive applications, achieving application-specific requirements while minimizing energy consumption. Tailored for static networks, these solutions hold potential benefits even in mobile scenarios due to their distributed nature.

C. Energy-Efficient Routing Schemes for Underwater Acoustic Networks

- Enhancing Underwater Acoustic Networks Novel Protocols, Unique Challenges, and Performance Insights. This study delves into the distinctive characteristics of underwater acoustic networks, addressing attenuation, propagation delays, energy consumption, and more. It unveils crucial insights driving protocol design and network deployment, leading to a new class of energy-efficient routing strategies that outperform traditional approaches. With a comprehensive ns2 implementation, the research examines routing performance in the context of MAC and PHY models, emphasizing issues like interference. This work offers valuable protocol guidelines, considering hop-distance, delay, and energy consumption for robust underwater network design.

D. Performance and Trade-Offs of Opportunistic Routing in Underwater Networks

- Underwater networks face challenges like high error rates, shadow zones, and limited bandwidth. Opportunistic routing leverages broadcast and overhearing, aiding packet reception and channel use. While it may introduce delays due to multiple forwarding nodes, it addresses underwater issues effectively. We analyze underwater channel efficiency in opportunistic routing, observing enhanced packet reception and channel utilization. Unlike traditional routing, opportunistic routing forwards packets even if not all neighbors receive them, reducing retransmissions and energy usage. Fewer retransmissions also curtail collisions in the wireless medium, crucial for underwater acoustic-based communication.

III. PROPOSED METHODOLOGY

A. Enhancing Underwater Wireless Sensor Networks for Efficient Monitoring and Routing

Underwater wireless sensor networks (UWSNs) hold immense promise in monitoring marine environments, offering insights into aquatic life, environmental conditions, and natural phenomena. However, UWSNs face challenges due to acoustic communication limitations and constrained sensor energy. This study proposes innovative solutions to address these issues. A dynamic system prototype is developed for efficient target identification and energy management in Underwater Acoustic Sensor Networks (UASNs). An Empirical Exploration System coupled with a Dynamic Routing Technique optimizes sensor activation for specific goals, adapting to changing conditions. Furthermore, a novel topology control algorithm adjusts node depths to minimize void nodes and enhance geographic routing. Simulation results demonstrate its efficacy in reducing void nodes, improving packet delivery, and lowering end-to-end delays.

Additionally, an opportunistic routing protocol is designed to combat acoustic communication challenges in static UWSNs. Enhanced beaconing algorithms disseminate neighbor locations while a geo-opportunistic routing strategy directs packets towards sonobuoys, mitigating channel congestion. A reactive maximum local routing approach further improves delivery rates by adjusting node depths to avoid lengthy hop paths, reducing collisions, packet errors, delays, and energy consumption. These advancements collectively bolster the efficiency, reliability, and longevity of underwater sensor networks, paving the way for enhanced marine exploration and monitoring capabilities.

1. Initialization

This module initializes network nodes in the topology, catering to network animator (nam window) through specified syntax. Node creation occurs in two modes: random and fixed. In random motion, nodes are generated within preset X and Y ranges, while fixed motion involves assigning specific X and Y positions to nodes. Sensor nodes possess self-awareness of positions, determined by global coordinates like GPS or energy-efficient methods. Nodes require neighbor position awareness, crucial for geographic routing. Routing uses anycast, geographic, and opportunistic protocols, employing greedy forwarding, while addressing void nodes involves a recovery mode based on depth adjustment. Underwater wireless networks employ SEA swarm architecture, comprising mobile underwater sensor nodes and surface sonobuoys that move cohesively with ocean currents. The model includes sensor (Nn) and sonobuoy (Ns) nodes with a communication range (RC).

2. Mpsa Algorithm Phase

The sensors are tied with a wire so that the height can be adjusted according to the target. The sensing range size of each sensor may differ due to its heterogeneous sensor type. Base station (BS) is placed, up above the sea level to collect the messages which is transmitted from the sea bed. At a particular time, each sensor could be in one of four modes: active, asleep, malfunctioned, and dead. Only active sensors will work to detect the targets and consume battery power. To save the battery power, sensors that are not active can be turned off. Sensor may be dead due to battery power depletion, or get lost due to external factors. By using different number of sensors and targets we can run the MPHSA algorithm to get various outputs. And the number of iterations can also be extended until we get better solution to detect the target.

MPSA Algorithm

1. At the τ-th key time survival sensors are updated
2. Initialize the parent harmony memory HM.
3. Divide HM into sub-HM (sub-HM1, sub-HM2, …, sub-HMδ)
4. Initialize the current iteration number as 1(ie., η=1,2,….,n)
5. if rand(0, 1) < HMCR then
6. Choose two harmonies xnew1 and xnew2 from sub-HMi
7. if rand(0, 1) < PAR(η) then
8. Make a uniform crossover operator on xnew1 and xnew2, and replace the resultant value in te place of xnew1 and xnew2.
9. End if
10. Let xnew be the one of xnew1 and xnew2 with a better fitness value
11. else
12. Randomly generate a feasible harmony as xnew
13. end if
14. If xnew is better than worst harmony in sub-HMi, xnew replaces it
15. end for
16. η = η + 1
17. end while
18. Decode the best harmony among all sub-HMi's
19. If number of covers is non zero, randomly choose one of the covers as the output, otherwise output is zero i.e., no solution.

Sensor nodes incorporate sequence numbers, unique IDs, and position data. Beacons carry node details and known sonobuoy info from set Si (t). Underwater nodes lack GPS, relying on localization services for location. This curbs excess broadcasts, boosting network throughput. Data tagging, node tracking, and coordination rely on location. Nodes transmit new beacon info, updating Si (t); outdated data flags (L) are reset. Efficient beaconing minimizes collisions and sync. After broadcasting, nodes establish new timeout. Enhanced underwater network efficiency is achieved through judicious beaconing strategies.

3. Sleep-Wake Management

This work introduces a method for establishing sleep schedules in Wireless Sensor Networks (WSNs) to optimize sensor energy usage. Sensors alternate between active and asleep states, with active sensors changing over time. The proposed approach sets sleep schedules at key intervals, starting from initialization. If initial coverage is incomplete, subsequent key times are triggered. Sensor information updates and sleep schedules ensure complete target coverage. Forwarding sets are computed, and packets are broadcasted with next-hop forwarder addresses. Nodes receiving packets set timers for priority-based broadcasting. Opportunistic routing prioritizes highest nodes, suppressing lower-priority transmissions upon successful data receipt. Performance evaluation includes comparison with geographic, opportunistic, and existing routing protocols for Underwater Sensor Networks.

IV. EXPERIMENTAL RESULTS

A. Delay ratio

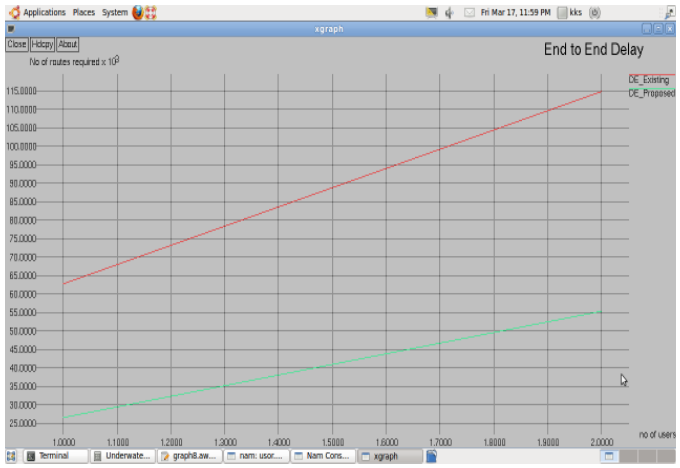

Figure 1: Above Figure Mention Delay ratio of our Proposed and Exiting Comparison.

In this work compare previous and present process of delay ratio, here red line mention existing delay ratio and green line is proposed delay ratio, in our proposed work reduces the delay compared to existing process system.

B. Energy Consumption Rate

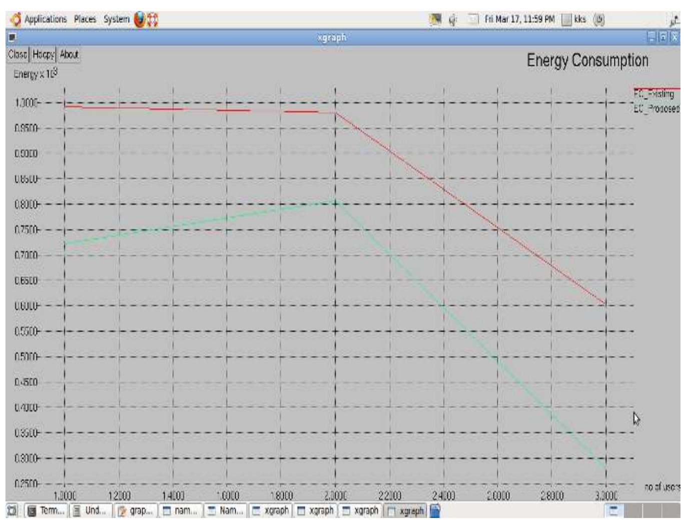

Figure 2: Above Figure Mention Energy Consumption Ratio of our Proposed and Existing Comparison.

In this work compare previous and present process of energy Consumption rate, here green line mention proposed energy ratio and red line is existing energy ratio. Our proposed work reduces consumption of energy compared to existing process.

C. Packet Delivery Ratio

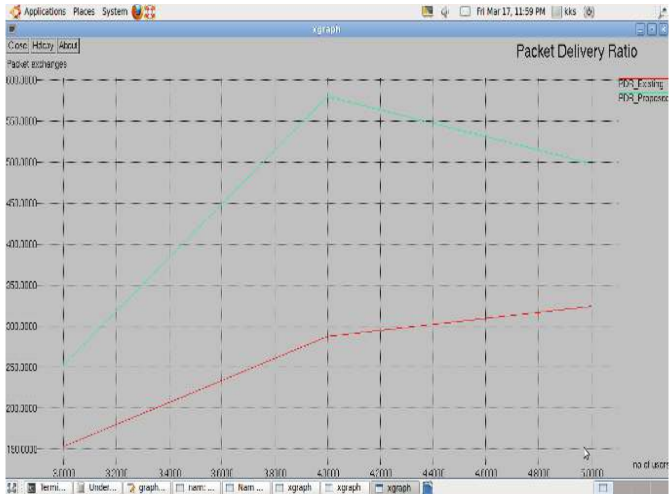

Figure 3: Above Figure Mention Packet Delivery of our proposed and Existing Comparison.

In this work compare previous and present process of Packet delivery, here green line mention proposed ratio and red line is existing packet ratio. In our proposed work improves Packet delivery rate compared to existing process.

D. Average Throughput Ratio

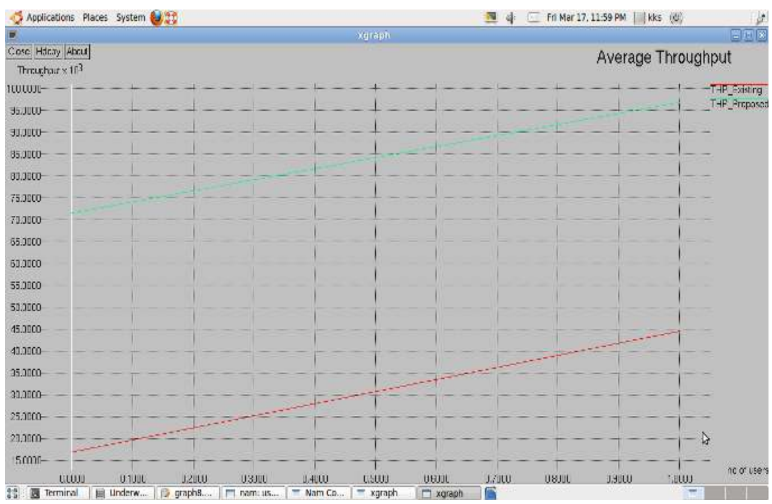

Figure 4: Above Figure Mention throughput Ratio of our Proposed and Existing Comparison.

In this work compare previous and present process of Throughput ratio, here green line mention proposed, red line is existing ratio, in our proposed work improved Throughput ratio compared to existing and previous process.

V. CONCLUSIONS

In the realm of Underwater Acoustic Sensor Networks (UASNs), where traditional recharging methods are unfeasible, this study's proposed Empirical Exploration System demonstrates significant strides in enhancing energy efficiency and network lifetime. The utilization of the Multi-population Synchronization Assessment Scheme, coupled with a Dynamic

Routing Technique, offers an adaptive approach to sensor activation and sleep scheduling, effectively addressing the challenges posed by changing sensor locations. Through comprehensive simulations, our approach outperforms existing protocols across critical performance metrics, affirming its effectiveness in enabling prolonged and efficient underwater exploration missions.

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