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Design and Implementation Optimization Algorithm for Underwater Acoustic Sensor Network

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Abstract - **Underwater Wireless Sensor Networks (UWSNs) contain several components such as vehicles and sensors that are deployed in a specific acoustic area to perform collaborative monitoring and data collection tasks. Tese networks are used interactively between different nodes and ground-based stations. Presently, UWSNs face issues and challenges regarding limited bandwidth, high propagation delay, 3D topology, media access control, routing, resource utilization, and power constraints. In the last few decades, research community provided different methodologies to overcome these issues and challenges; however, some of them are still open for research due to variable characteristics of underwater environment. In this paper, a survey of UWSN regarding underwater communication channel, environmental factors, localization, media access control, routing protocols, and effect of packet size on communication is conducted. We compared presently available methodologies and discussed their pros and cons to highlight new directions of research for further improvement in underwater sensor networks**.

Keywords- **UWSN Model, 3D topology, Quality-of-Service (QoS).**

I. INTRODUCTION

Two third of the earth surface is composed of water. So, it is widely believed that wider access to the aquatic environment enhances human knowledge and understanding of the world's oceans. Hence, the current development of communication systems produces scientific, economic and social benefits. New applications enable deeper ocean observation, environmental monitoring, surveying or search and rescue missions.

1. Underwater Wireless Sensor Network

In UWSN, the sensor nodes are with acoustic modem. They are densely distributed in the 3D aqueous space. The multiple gateway nodes with both acoustic and radio frequency modems are deployed at the water surface.

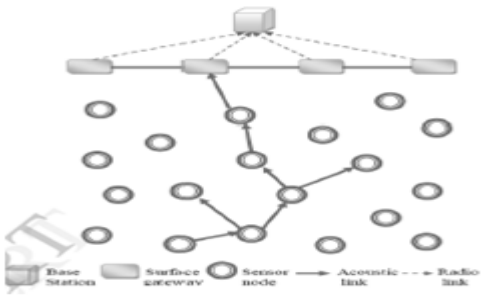

Fig.1. UWSN Model.

Each underwater sensor node detects or monitors the change in the environment. As shown in Figure. 1 when a data is received, the sensor nodes transmit data to the gateway nodes through the acoustic link. The surface gateway nodes receive the data and transmit it to the radio links. Compared to acoustic link the radio link are much reliable, faster and more energy efficient. The station where the information required is collected is called sink or base station. Multi-sink is deployed in larger applications. The multi-sink network is helpful in traffic balance and multiple path finding. Multi-sink help to find more path to the virtual sink (surface gateway) and can reduce packet collision and packet loss.

2. Energy Efficiency

The energy can be used efficiently by optimizing the packet size, transmit the packet in multipath channel; transmit the data via shortest distance nodes. By optimizing the packet size or length, increase the energy efficiency which improves effective and efficient transmission.

The acoustic channel is used to transmit data, since communication is done in Deep Ocean. The energy in the sensor node must be taken into consideration because the recharging cannot be done by solar. The optimization of packet length and effective data transmission is proven in acoustic channel.

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Multipath routing is used to transmit data in multipath channel. The source node has some packets to send via intermediate nodes to the destination node. The source node sends the route request to destination node. In response to the request destination node sends route reply to the source node. The packets are forwarded in multipath channel and efficiency of data transmission.

The data loss can be prevented when there are dense nodes in the network. The source node checks for the available neighboring nodes in the network. The node which is nearer gets the highest priority and data are forwarded. The intermediate node serves as the forwarding candidates. The data are transmitted without transmission with the accurate interval of time. Some definitions,

1. The sensor node in wireless sensor network is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.
2. Bandwidth is the carrying capacity of a channel or the data transfer speed of the channel in the network.
3. Throughput refers to how much data can be transferred from one location to another in a given amount of time.
4. Clustering is the grouping of similar objects or sensors. In other words, nodes belonging in a group execute different functions from groups.

II. OBJECTIVE

1. The objective of this research work is to maximize the utilization of the available underwater acoustic bandwidth and to achieve high throughput as well as to reduce the node turnaround wait time by using a Multi level evolutionary genetic algorithm (GA).
2. The main purpose of this research is to provide average minimum turnaround node transmission wait time and to increase the utilization of underwater acoustic bandwidth.
3. The simulation results prove that every node in the UWASN transmits in an average minimal turnaround time by minimizing the time slots and maximizing the throughput in the network by scheduling the possible nodes with parallel transmission.

III. RELATED WORK

Simranjeet et al., [1] implemented their idea in MAC layer, network layer and network topology. Cross layer approach is proposed to increase network efficiency in underwater networks. The network topology adapts itself for the environment changes while using vector based forwarding Energy consumption. The parameters such as average delay, success rate used to calculate the number of packets received at the sink.

Dario Pompili et al., [2] explored on "Distributed routing algorithm for underwater acoustic sensor network". The delay insensitive and delay-sensitive algorithms are proposed. The node jointly selects the best next hop, optimal transmitting power, Forward Error Correction (FEC) rate for each packet to minimize the energy consumption. The optimized packet size is set on-line for data forwarding. The packet train is simulated with packet size and time as the parameters.

Mohammed et al., [3] compared the MAC Layer protocols with Aloha, R-MAC, FAMA, UWAN_MAC and Broadcast MAC. The protocol efficiency is calculated. The performance result shows that energy consumption is high in FDMA and throughput is higher in UW-MAC, Broadcast MAC and FDMA protocols. When delay is tested as a parameter FDMA show irregular delay than UW-MAC and Broadcast MAC. The packet drop is higher in Broadcast than UW-MAC and FDMA. Final result proposes that UW-MAC is the optimum protocol in terms of throughput and energy efficiency.

Upendra Rawat et al [4] Underwater Acoustic sensor networks (UW-ASNs) are one of today's most prominent instantiations of the ubiquitous computing paradigm. In order to achieve high levels of integration, UW-ASNs need to be conceived considering requirements beyond the mere system's functionality. While Quality-of-Service (QoS) is traditionally associated with bit/data rate, network throughput, message delay and bit/packet error rate, we believe that this concept is too strict, in the sense that these properties alone do not reflect the overall quality-of service provided to the user/application. Other non-functional properties such as Scalability, Timeliness, Energy-Sustainability, Reliability, Mobility, Security must also be considered in the system design. This paper identifies the most important non-functional properties that affect the overall quality of the service provided to the users, outlining their relevance, state-of-the-art and future research directions.

IV. PROPOSED ALGORITHM

Optimization algorithm aims at minimizing the number of hops, because adding hops notably increases the total delay. The algorithm is to find the farthest node it can reach (G) and forward the message. The same method as mentioned in Optimization algorithm is used to determine whether the next node is closer to the destination. the optimal distance algorithm performs the best in comparative study and the undertaken in also prove this. But this does mean that optimal distance is the best choice for the following reasons:

1. This necessitates knowledge for the position of entirely nodes. But localization is problematic. Individual recently, there are researchers who convey conceivable schemes .
2. The our Optimization algorithm is easy to carry out and it is robust to contentions.

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3. The delay of optimal distance algorithm can be enormous, which is not acceptable by particular real-time applications. Consequently the best routing algorithm is still an open topic to discuss.

1.Genetic algorithm- The basic motivation of the genetic algorithm is survival of the fittest. Genetic algorithm (GA) is a particular class of evolutionary algorithms that uses techniques inspired by biological evolution such as inheritance, mutation, selection, and crossover. GA is a heuristic search algorithm based on the natural selection mechanism used in computing to find the actual or nearby result of optimization [24]. The genetic algorithm is applied as a computer simulation in which a population of abstract representations (called chromosomes or the genotype or the genomes) of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem which evolve towards better solutions [24].

The idea of evolution starts from the possible set of solutions that is the population of randomly generated individuals. Two parents are selected according to their fitness out of the population. It iterates that through all generations and in every generation, the best child is selected for the propagation of next generation by evaluating the fitness function. The algorithm generally stops either on reaching the maximum generation or by satisfying the fitness level of some specified stopping criteria. GA is robust in the search process for NP-complete problems [25]. In general, GA takes the different permutations of traditional TDMA matrices, where each node transmits in a separate time slot. This traditional TDMA matrix forms the initial population for this problem. By selecting two parents, from the

2. Proposed WSN Simulation Methodology- The situation in which we put together our simulation model was MATLAB. The name MATLAB stands for matrix laboratory. MATLAB, developed by Math Works Inc., is a software package for high performance numerical calculation and revelation.

The arrangement of examination capability, suppleness, reliability, and powerful graphics make MATLAB the foremost software package for technical researchers. MATLAB give an interactive situation with hundreds of dependable and precise built-in mathematical function [30]. These function present resolution to a broad range of mathematical problems counting matrix algebra, The nearly all significant feature of MATLAB is its programming competence, which is extremely easy to study and to use, and which allow user-developed functions . It as well allows access to FORTRAN algorithms and C codes by means of exterior interfaces. There are quite a few optional toolboxes written for exacting application such as signal processing. We have replicated LEACH, M-LEACH, F-LEACH and N-LEACH using MATLAB, a divide event based object oriented simulator. Table 1 lists the simulation parameters used. To assess the algorithms, we have used the subsequent performance metrics: simulation were perform using MATLAB for a clustered Wireless Sensor Networks, where nodes were arbitrarily deploy and it was assumed that each SN is proficient of sensing and transmitting data packet to its CH. A TDMA based MAC scheme was measured where SNs transmit one packet in their allocated time slots so that no collision occurs. The energy model adopt in [37] has been adopted to evaluate the energy obsessive by the nodes. The steady radio parameter i.e. α

The judgment is made in terms of the subsequent metrics:

1. **Energy expenditure:** This metric illustrate the energy consumed throughout the network operation.
2. **Network lifetime:** this metric illustrate the number of sensor nodes that die throughout the network process. Received data messages this metric illustrate the number of data messages productively deliver to the base station.

V. RESULTS AND DISCUSSION

1. Simulation Results

For the reason that the CH consumes further energy, our protocol allocates this role to sensor nodes with elevated remaining energy. following each round, these CH will be replace with further sensor nodes with added outstanding energy. LEACH does not get into account the outstanding energy of sensor nodes throughout the selection of CH. The alternative is made randomly and every one sensor nodes in the network engage in recreation that role every so often. furthermore, the CH communicate straight with the base station using the highest communication power, which need a high energy. Our protocol uses short distance transmission to diminish energy consumption.

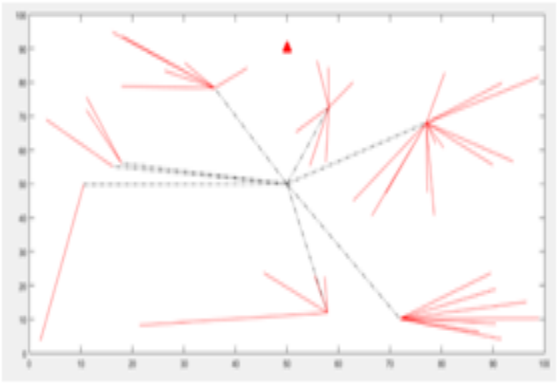

Fig.2. node UWASN usingGA-TDMA.

To examine the network lifetime, we have selected the subsequent three definitions: the time pending the first sensor node dies, the time awaiting half of the sensor nodes die, and the time awaiting the previous sensor

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node dies. Since extra than one sensor node is necessary to achieve the clustering, the last meaning represent the lifetime of the network when 80% of the sensor nodes die. In the case where the CH are not in the center of the clusters, a number of sensor nodes will consume additional energy than others. LEACH does not guarantee a good allocation of CH since the selection is done randomly without bearing in mind the network parameters. ten-node UWASN, the GA-TDMA takes only five time slots to schedule for node transmissions, whereas in HSR-TDMA, it takes ten time slots to schedule for node transmissions as shown.

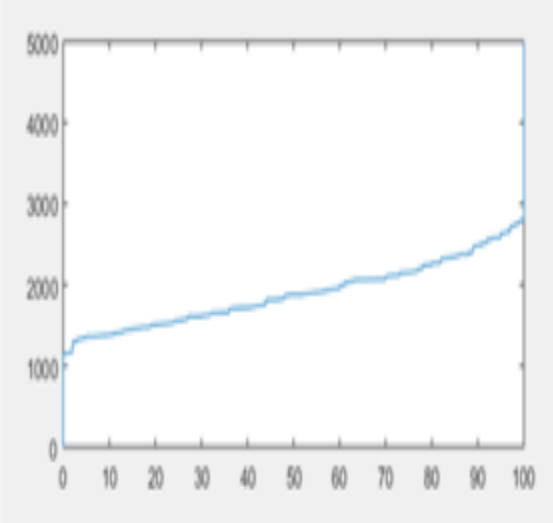

Fig.3. This shows that GA-TDMA has optimal node scheduling with a minimum of one transmission for every node in the network.

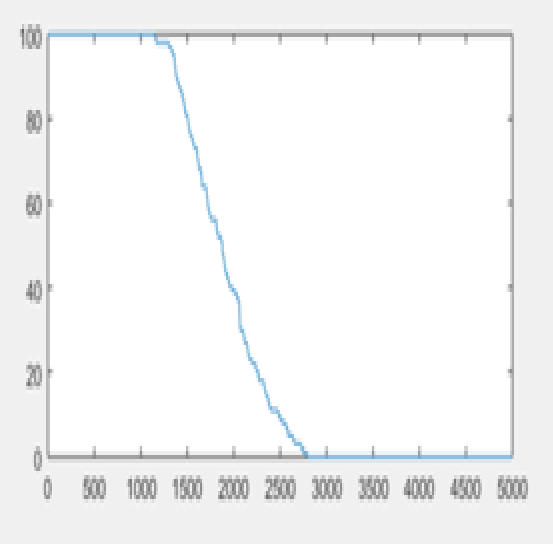

Fig.4.Resuts TDMA have transmitted.

Observed that nodes 9 and 10 in HSR-TDMA have transmitted only once in the second and fifth time slot that shows that it has to wait for ten time slots for its next transmission. This long turnaround wait time leads to the low successful packet transmission rate for those nodes, whereas in GA-TDMA, every node in the UWASN has an average minimal turnaround wait time of five time slots.

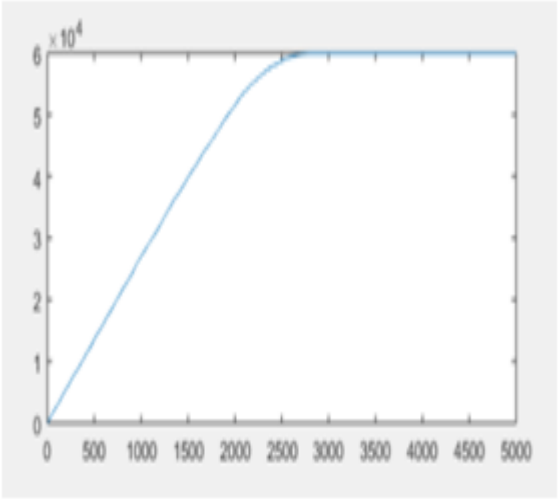

Fig.5. shows that as the number of nodes in UWASN increases.

shows that as the number of nodes in UWASN increases, HSR-TDMA frame length also increases, whereas in GA-TDMA, optimum frame length is maintained for various sizes of network. In each generation of the genetic algorithm, the fitness is evaluated

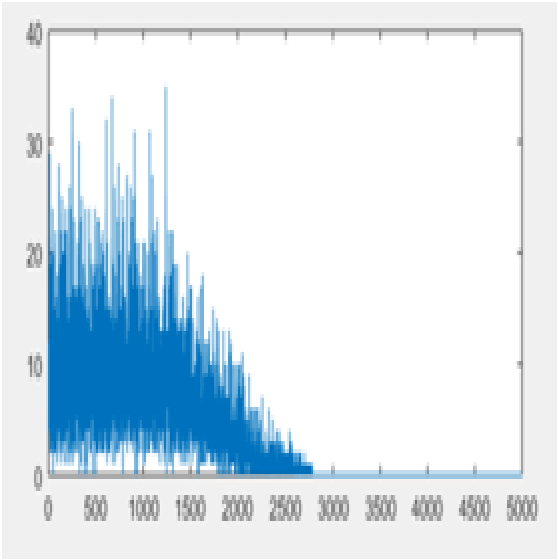

Fig.6. GA is run for 50 times and the average value of simulation result.

GA is run for 50 times and the average value of simulation result is shown in Figure 6: It was observed that a maximum node degree [ND] in the network has impacted the optimal TDMA frame length with the help of tight lower bound after the average GA run

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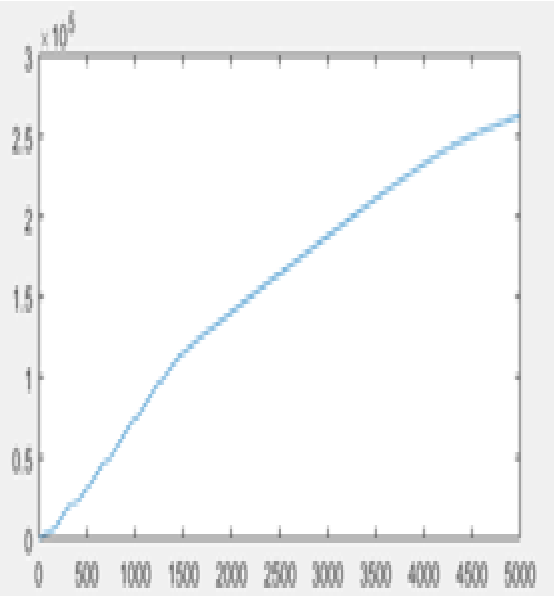

Fig.7. GA-TDMA transmitted twice.

it is also observed that the nodes 1 and 10 in GA-TDMA transmitted twice within five time slots which shows the utilization of available acoustic sensor bandwidth has been done in underwater by scheduling the possible nodes for parallel transmission. In comparison of GA with HSR and traditional approach, it was analyzed that for ten-node network, a throughput

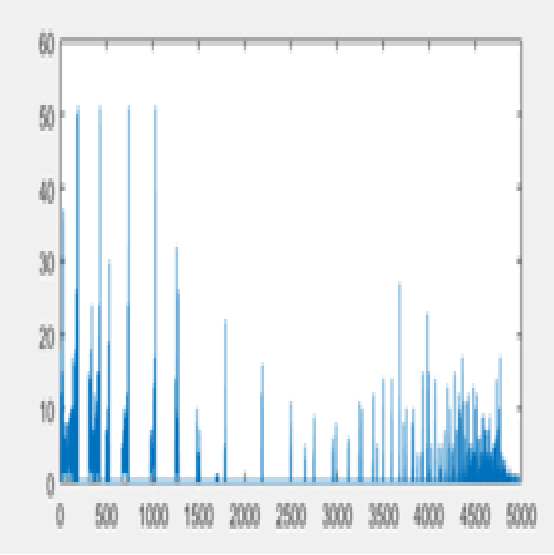

Fig.8. This proves that GA-TDMA has rapidly increased its throughput for UWASN as the cycle of transmission increases,

This proves that GA-TDMA has rapidly increased its throughput for UWASN as the cycle of transmission increases, and it overcomes HSR and traditional approach

Show the underwater channel utilization and average time delay of various network sizes in underwater based proposed algorithm. It is observed that the average time delay is getting increased as the size of the network gets increased. The underwater acoustic channel utilization is based on the connectivity of the network that is shown in Fig. 8. Figure 10 shows the computation time taken by the GA for various network sizes. It is also been observed as the number of nodes increases, the computation time taken by GA also increases. Therefore, the simulation result for various simulation scenarios proves that GA-TDMA outperforms in turnaround wait time.

Experiment Parameters

- Every Leach operation round consists of
- Set-up phase (clusters are organized).
- Cluster Head Selection.
- Cluster Formation.
- Steady state Phase (data transmission). One Round assumes 10 communication frames.
- We are assuming 3 bytes of date at each node to be send to the BS.
- pretentious the energy in the CH selection at the BS.
- pretentious the node registrations in the cluster have energy at every node
- After the cluster formation according to the equation the energy expenditure is intended.
- Assuming 10 nodes at each head and having ten dissimilar distances and ten different energies.

Parameters	**Values**
Network Field	100X100 m^2
Number of Nodes	100
E_o (normal energy of initial nodes)	0.5 j
Message size	4000 bit
E_{elec} (the radio dissipates energy to run the transmitter or receiver)	50 nJ/bit
E_{fs} (free space loss energy)	10nJ/bit/m^2
E_{amp} (multipath loss energy)	0.0013pJ/bit/m^4
EDA (compression energy)	5nJ/bit/signal
d_o (Threshold distance)	70 m
P_{opt}(probability of cluster heads)	0.1

The energy being degenerate to run the transmitter: Eelec=50 nJ/bit energy dissipation of the transmission amplifier:

Eamp = 100 pJ/bit/m2.

Transmission costs:

Etx (k, d)=Eelec k + eamp k d2

Receiving costs:

Erx (k) = Eelec K

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Where k is the length of the message in bits d is distance between nodes.

For LEACH Implementation's Parameters

Table 1 N- LEACH simulation parameter and its values

VI. CONCLUSION

The purpose of the research is to increase network throughput at access points by implementing the network coding algorithm. This paper presents review network coding in real underwater environment and demonstrates a significant improvement of network performance with network coding versus the standard queuing approach. In this paper to enhance the performance of LOARP, AODV and DSR routing protocols. This analysis is based on the packet delivery ratio, end to end delay and throughput. Increasing the number of nodes, mobility and control overhead. In this paper, low overhead routing protocol, is proposed and its performance is compared with two most popular protocols (AODV and DSR) in the reactive category. In order to improve the performance of existing, other protocols should be explored. Current result suggest the protocol to handle large propagation delay. Using genetic algorithm, the TDMA frame for underwater acoustic sensor network has been optimized in this study. In each generation of GA, different TDMA frame lengths have been achieved with at least one chance for each node to transmit in underwater. GA-TDMA minimizes the time slots to avoid the maximal turnaround waiting time of successive node transmission even for sizes of large networks. GATDMA also schedules the possible nodes for parallel transmission in the optimal TDMA frame to improve the utilization of available acoustic bandwidth in underwater. The result shows that higher throughput in the UWASN is achieved that outperforms the spatial reuse HSR-TDMA scheduling method. Finally, the efficiency and effectiveness of GA for node scheduling are validated with this outcome. Further research is required to improve upon the GA to reduce the computation time by finding variations of crossover and mutation.

VII.FUTURE WORK

In the fresh years a large number of MAC protocols for the WSNs have been available by the researchers. nearly all of the work on the MAC focus mostly on the energy efficiency in the sensor network [8]. though, still a lot of work has to complete in the other areas at the MAC layer such as:

1. **Network Security: -** Sensor network security at MAC layer to defend alongside eavesdrops and malicious performance has to be deliberate advance. Few researchers had previously proposed secure MAC protocol based on collective key but still higher schemes requirements to be developed.
2. **Nodes Mobility: -** The nodes in the WSNs were initially unspecified to be static. lately there has been growing interest in medical care and disaster response application where the mobile sensors can be close to the patient, doctor or first responder. The mobility at the MAC layer has been measured in MMAC [10][20], still there is a lot of scope for prospect investigate in this area.

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