OARMIC - Obstacle Avoidance based Autonomous Robotics Movements with Interference Less Multi-Channel Underwater Sensor Network

J. Premalatha, P.M. Joe Prathap

Abstract--- Underwater (UW) sensor networks have been drawing additional attention investigation interests newly due to their diverse specialized submissions. Autonomous robots (ARs) function as unidentified UW surroundings must be able to keep away from flooded obstacle, for instance rock face, snow obstacle, and oceanic changes. The use of AR for data gathering presents significant recompense including elasticity in sensor deployment, substantial energy savings, and minimized collisions, hidden node issues, interference, and conflicts. We propose the use of AR to move along deep-sea segments and accumulate data onto the sensors. Moreover the methodology for obstacle prevention by ARs that are built with advanced cameras (AC). The data accumulated from the support of two ACs placed in vertical and horizontal directions are functioned in actual time to give obstacle discovery coordination as per the locations. Obstacle detection and avoidance in a different direction, computed based on fuzzy logic optimization using border detection, segments of route and curves. By using horizontal and vertical obstacle detection create a route to reach the destination without obstacle interruption. AR has the knowledge to justify the sea floor and angular changes equal to 20 meters ahead of its movement. We also present dissimilar AR mobility's and inspect the result of diverse network size parameters on network outputs such as delay throughput and packet delivery ratio. Each AR then transports the received data to the outside base station (BS). In order, the outside BS transmits the received data from AR to the network tower control server. Also, we focus on the condition based channel allocation for UW in order to avoid the transmission issues. We design an active and stretchy channel reuse plan for the condition channel allocation, and prepare the interference situation as a flexible nosiness free chart as per the sensors current location sharing and a predetermined threshold of interference. Because of heavy interference the optimal output may not be possible for more data transmission due to its high computational cost. By using this proposed achievement we overcome all the issues.

Keywords--- Autonomous Robots; Obstacles; Interference; Collision; Condition Channel Allocation; Noise Free;

I. INTRODUCTION

Most of the investigations into underwater sensor network (UWSN) are focused on how to minimize energy utilization to extend the sensor lifetime. Opportunistic path selection based on the channel allocation without interference with AR data collection has been projected as a feasible approach to enhance the routine of UW multihop communication. Though, the exponential enlargement of the channel bandwidth responsive sensor traffics poses a big confront with the presentation of the path selection in terms of interference less channels bandwidth assurance. To resolve this issue, a narrative method is designed to opportunistically broadcast the information and provide bandwidth guarantee for the bandwidth-sensitive traffic. There are few investigations solving the issue of UW sensor communication that makes sure the delay limitations of channel bandwidth are the main issue for AR data collections that need delay-sensitive path selection. In previous from some analysis, the outputs achieved various results but each suggestion has some limitations. Some analysis has high computational and overhead complexity. Some revisions have not originated the optimal path selection. In this proposed, we examine the solution to develop the energy efficiency of UW sensors along with proper channel allocation that minimizes the delay to transmit data onto the sensors to AR and the final destination base station. The following devices are participating in the communications.

Sensors execute the environmental sensing process. Data sensing and collection based on the placements and environment, Sensor might sense smoke, fire, gas leakage, temperature, speed, pressure, and all changes from environments. Each sensor contains a limited queue space, which keeps the observed data until the node is able to contact the AR as it reaches within sensors range. The AR is liable for accumulate data from the sensors and transporting it to the CC. It is a high proficient device along with the processing energy, huge buffer and storage space and a longer transmission range. The AR placements based on the environmental situation as like the volume of data, channel capacity, travelling time period considered as the quality of service metrics. Apart from this consider the AR speed, sea depth, and the needed service duration that the AR is able to stay under sea before reaching it to the upper surface to renew its resources.

After collecting the data from AR then the base station uploads the data to the CC as per the protocols. Behind the transmissions of the upper surface network can connected via satellite, cellular, wimax or any other network structure.

Before a data scheduling, the sensors shares their individual particulars of each sensor region through a control message, which contains the locations and velocities of the broadcasting and environmental conditions as well as the volume of data to be delivered.

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Then, the dynamic scheduling plans starts as per local situations. Based on the predicted normal and critical positions of the live sensors, a vibrant interference less graph is build for each time window, where each summit in the graph stands for a communication channel and two edges are connected by a border if their joint interference is beneath a convinced level.

II. RELATED WORKS

We should also note that some application types heavily depend upon the sensing location since the obtained measurements are meaningful only if it refers to an accurate location. Localization in terrestrial wireless networks has been studied widely and detailed surveys are presented on this topic[7]. They can furnish tsunami warnings to coastal span and discover the results of submarine earthquakes. Sensors can be utilized to recognize hazards on the seabed, find hazardous rocks or shoals in shallow waters, mooring locations, submerged wrecks, and to present bathymetry profiling[4].

Continued research over the years has resulted in improved performance and robustness as compared to the initial communication systems[1].

In acoustic and ultrasonic communications, researchers usually work on varying the type of modulation and communication protocol, in order to minimize the effects of reflections, and on achieving as high a communication data rate as possible[3].

As long as the current velocity vector is outside of the VO, the robot will not collide with an obstacle at any time in the future. Based on this feature, we can conduct real-time motion planning by combining the technology of graphics and the method of optimal control[6].

The interference in underwater acoustic (UWA) communications includes both unintentional interference, such as interference from sonar operations and marine mammals, and malicious jamming[2].

This work presents a novel, multiple-features based, two-step method for impersonation detection in an additive white Gaussian noise (AWGN)-limited, line-of-sight UWA channel[8]. The immiscible cost of cables there is importance for a high-speed communication between the remote end and the surface.

Wireless communication, or sometimes simply wireless, is the transfer or information or power between two or more points that are not connected by an electrical conductor[5].

OARMIC Implementation

Our proposed technique helps to minimize the force of energy sufferers by the short distance transmissions and ARs that take a trip across the network region to collect the data Consequently, the AR used to send the collected packets immediately to the surface and deliver such US packets to the CC.

It acts as a gateway device, which delivers collected UW real time data from the sensors to the CC.

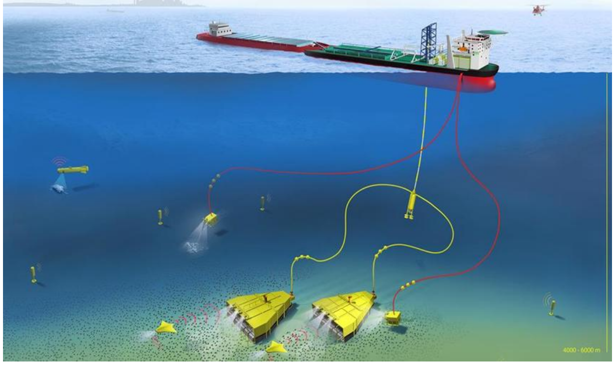

Figure 1: AR movement in UW

Therefore, no multihop sensor communication is desirable and sensors need only to send the data inside a short range distance. As per the Figure.1, we consider a 3Dimensional sensors placed at unusual sea level. A central controller (CC) on the sea outside control room device collects the observed packets from the sensors through AR equipments. Also CC act as a scheduling device that creates the sensors resource planning decision and AR movement to the network. Though the data are observed and transmitted from the set of sensors by the multiple UW acoustic channels, this situations handled by the MAC layer to eliminate cruel interference among multiple channels. Also sensors need to suppress the noise from channel detection. With the aim to recover the network outcomes, we utilize an active and bendable reuse channels that allows multiple sensors to send at the same time with less interference and good receiving bits per second. A network graph, indicated by G = (L, E), is created based on the present active sensors in the network. In the graph each link L_i in set L represents a present connected links. The distance from link L_i to link L_j , $i \neq j$, is distinct as the distance from the sending sensor L_i and the receiving AR in the link represented by L_j. The interference link distance I_D of a link is clear as the smallest acceptance distance A_D from other AR links relating to an exact interference less threshold.

By the use of effective localization process in UW sensor networks, it is possible for the sensors to obtain their own locations and compute the reference distance by the control packet exchange among the network to find AR. These distance estimations and location information transferred to the CC to update the network details. Compute the edge link weight L_{wi} ,L_{wj} with $i \neq j$ is defined as

$$WL_{wi}\,L_{w} = \begin{cases} 1, & \text{If } L_i\, \varepsilon S(L_j) \text{ else } L_j\, \varepsilon S(L_i) \\ 0, & \text{if not} \end{cases}$$

Where S (L_i) describes the nearby sensor set. For the channel link denoted by L_i with travelling distance TDi between the sensor and the AR, the equivalent I_D TDj is computed as

$$TDj = 20log_{10}|C(Bw, Dist)| = 20log_{10}|C(Bw, Dist)| - \sigma + \beta(DPt, DPr)$$

where σ is the interference less threshold and C(Bw, $Dist_c$) and C(Dpt, Dpr) can be calculated according to.

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$$C(BW, Dist) = \frac{1}{\sqrt{PS(BW, Dist)}}$$

β(DPt , DPr_i) is a sea under water depth regulation factor to specify the situation of water I_D, where DPt and DPr indicates the depths of the sending sensor and the AR, in order. Note that bigger σ denotes less interference and longer I_D. Then compute the duration of the safety interval S_T is as $S_T = \frac{\mathrm{Dist\_}}{c}$ where the average I_D called as Dist_ related to the standard d_0. The path loss signal PS of the UW acoustic channel propagation signal in orientation to $Dist_r$ is reliant on mutually to the Dist and the channel bandwidth BW, i.e.,

$$\mathrm{C(Bw, Dist) = Dist^{pl} fd(BW\ \ )^{Dst-Rd}}$$

Where Rd_r is the reference distance and pl is the path loss promoter explaining the outline of propagation acoustic channel. The channel bandwidth capacity is captured by fd(Bw), After the link weight estimation the relevant interference less graph constructed and leaving out all its high weight links. The scheduling plans are monitored by the CC node from beginning of network initiation. Using the sharable knowledge's of sensors this find the utmost concurrent transmission cluster with the purpose of optimizes the transmission throughput.

Sensors adjust the transmissions as per the scheduling plans to the AR, and the concerned sensors start transmissions as a result. While AR moving around the network it needs to find the obstacle border and also must to avoid that area by calculating the seabed incline detection and altitude. During ARs movement the obstacles in the path are notified and the skin tones for each obstacle border area are mined: Plot the obstacles Locations as

$$\begin{pmatrix} X_O \\ Y_O \\ .Z_O \end{pmatrix} = Z(\vartheta, \Theta) \begin{pmatrix} X_{AR} \\ Y_{AR} \\ .Z_{AR} \end{pmatrix} + \begin{pmatrix} X \\ Y \\ .A \end{pmatrix}$$

where x , y and z are narrow obstacle points, x_{AR} and y_{AR} and Z_{AR} are robotics points, ϑ is terrain angle, Θ is yaw viewpoint, A is the obstacle altitude, and $Z(\vartheta, \Theta)$ is a change matrix defined by

$$Z = \begin{pmatrix} Cos(\vartheta)X....Cos() - Cos()X....Sin(\vartheta)......0 \\ Cos()X...SinCos(\vartheta) - Cos(\vartheta)X...Sin()...0 \\ .0.......................................0..................1 \end{pmatrix}$$

Fuzzy relationships play a vital role in fuzzy inference model (FIM), because they can express relations between input variables. A FIM binary expression BE is defined as a FIM division of X × Y. Therefore, if {i} and {j} are group of devices, then BE(i, j) is obscure to be the membership degree of function (MDF) µBE (i, j), which is connected with each set (i, j) in BE.

$$BEIJ = \frac{1}{S}\Sigma \mathrm{BEij} \rightarrow \mathrm{Iij}$$

In the definitions, BE_{ij} and I_{jj} implies the degree of MDF of µBE(i, j). Here, FIM operator i → j = min(1-(i+j),1) was applied.

The task description for an AR is to move from the starting point to the aimed point. The AR can find the obstacles as shown in the Figure.2 in its way by means of FIM. Though collect more information about the obstacle, and minimize the probability of false observations. Using FIM conclude the obstacle size and distance. Find the degree of obstacle it should visible within the AR range. In the background of AR direction finding, four levels (very secure, secure, unsafe, and very unsafe) were clear to explain

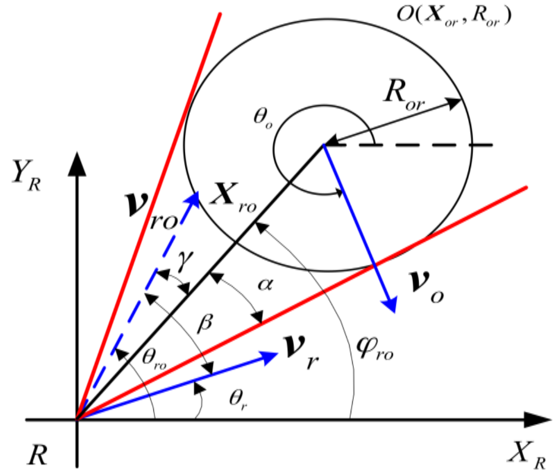

Figure 2: Obstacle Detection

$X \;\; = 1\text{-}\frac{1}{1+k}$ movement. The MDF of the secure and distance metrics are formulated, respectively, in $Y \;\; = \frac{1}{1+k}$ where X and Y are FIM variables resolute by the rule set. When an obstacle present in AR view by computing the secure and distance metrics fid the closeness of the obstacle.

$$\mathrm{Minmax(BE < BEST)}$$

$$\mathrm{WL_{wi}\,L_w} = \begin{cases} 1, & \mathrm{If\,BE < (BEST)_{ij}} \\ 0, & \mathrm{if\,not} \end{cases}$$

Change the FIM defuzzification output into a csharp results.

During usual process, the ARs will move into the network area at a specified speeds and facilities. Though, sometimes the sensors placed in a particular position on the critical situations and complicated environments, which needs a higher range of observations and validations to know the acceptable changes. If high changeable values detected by the sensors such messages are marked as "urgent situation" (US) messages and they are noticed as such in the message header. The ARs may also be advised to omit few sensors on the way to adjust for faster movement of US data delivery to the BS.

III. RESULTS AND DISCUSSIONS

Network designed with three dimension underwater network with 75 to 175 sensors deployed under sea with needed autonomous robotics. Each node built with OARMIC protocol thus the nodes having the knowledge of finding path towards robotics to the destination.

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The results shows the performance outputs of this network design

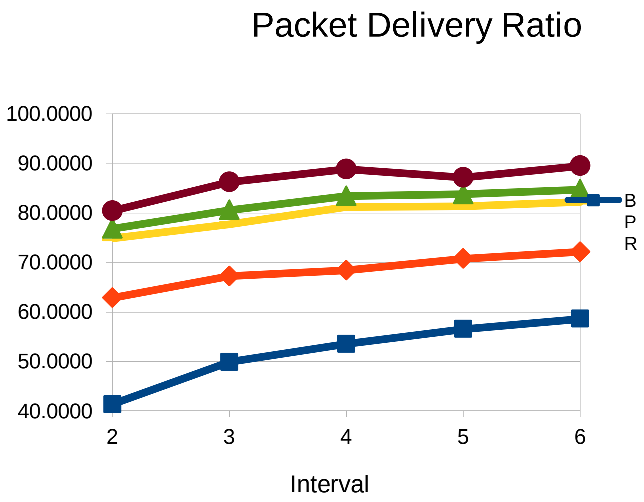

Figure 3: Interval Vs Packet Delivery Ratio

Packet Delivery Ratio (PDR) - This is the result of sum number of received data packets at the destination divided by total number of sent packets from source node. As shown in the Figure.3

$$PDR = \frac{\text{Received Packets Count}}{\text{Sent Packets Count}}$$

OARMIC shows the improved results than the existing protocols. Because of the AR movements inside the sea area easily all the sensors can find the route to pass the sensed packets through AR to destination. Obstacle detection also the reason for the fast moving AR towards sensors and base station. Even in critical environment nodes can pass the packets easily to AR instead of creating multiple hop path. So that the graph shows the high PDR as per the formula given above. By changing the packet generation time as packet interval to check the PDR results using various underwater protocols to proof their best performance.

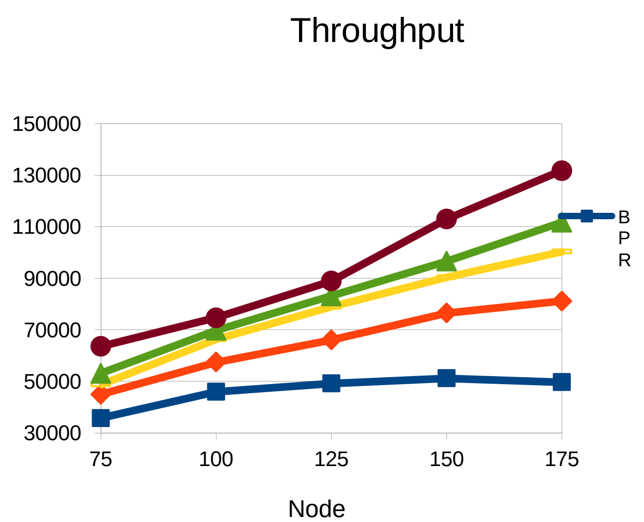

Figure 4: Node Vs Throughput

Bits per second received at the destination end considered as a throughput result. Here in the output graph Figure.4 protocol OARMIC shows the high throughput outcome than the remaining compared underwater sensor protocols. As explain in the PDR due to the AR movement in underwater along with the obstacle detection using fuzzy optimization to avoid false observations thus minimizes the imagination obstacle detection and provides the perfect movement of AR among sensors and towards the entire network. This technique raises the more receiving bits at the destination points. By varying number of nodes from 75 to 175 nodes on network to presents the throughput results.

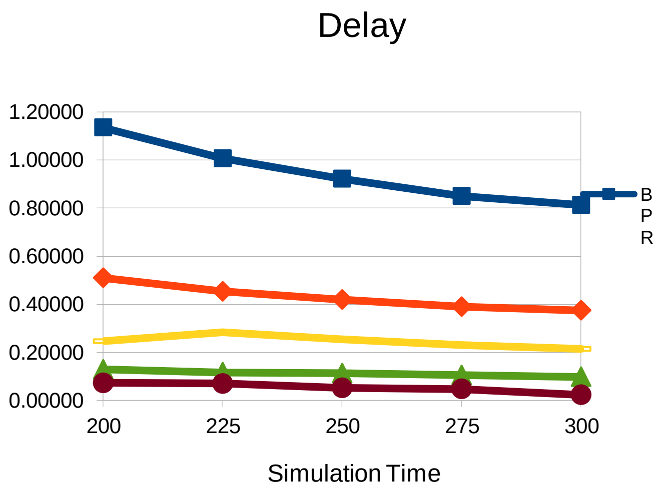

Figure 5: Simulation Time Vs Packet Delivery Ratio

Delay explains the packet travelling time from observed sensor location to destination. This includes the channel waiting time, path finding time, and packet waiting at queue time. Summation of all these time durations gives the total delay at destination. Figure.5 shows the delay graph of underwater sensor protocols. Among those protocols OARMIC presents the best result with less delay output than the available protocols. This less delay shows the best routing established from the senders to end receiver. Simulation time variation based delay presented on the output.

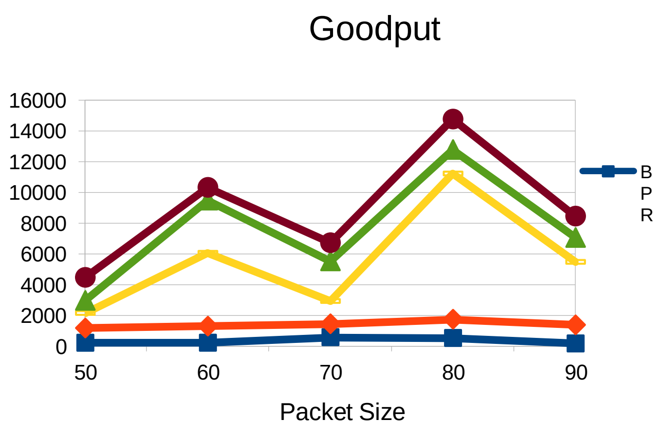

Figure 6: Simulation Time Vs Packet Delivery Ratio

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Goodput presents the perfect reception of data packets at end. It considers only the data packets received at the end device. The Good put is a ratio among received amount of data packets, and the total delivery duration. This period includes, Inter packet time spaces during packet generation, transmission time, Propagation speed, queuing delay, node keeping time and retransmission time and so on. Figure.6 shows the Good put result of proposed OARMIC and the relevant protocols. Among those proposed one shows the best Good put due to the discussed reasons.

IV. CONCLUSION

OARMIC protocol discussed about the simplified underwater data transmission procedures using autonomous robotics by detecting obstacles under sea to eliminate the routing delay using fuzzy logic rules. This optimized technique avoids the obstacle detection faults and shows the accuracy detection even the obstacle in uneven shape. Also the sensors can mark the packet state as normal or emergency. So that the robot can move to that specified emergency area as per the protocol method and collects the packets to deliver quickly to the destination end. This improves the packet delivery ratio in results and minimized the delay.

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