Mobicast Routing Protocol with Multiple Sink Zone Formation in Underwater Sensor Networks

Ms.HEMALATHA E[1]
PG Scholar, K.S.Rangasamy College of Technology, India
Email: hemamtech21@gmail.com

Mrs.Dhivya V.P[2]
Assistant Professor, Department of Information Technology,
K.S.Rangasamy College of Technology, India
Email: dhivyavp@gmail.com

Abstract — In this paper, we groping the multiple Sink Zone formation Mobicast routing protocol for 3-D Underwater Sensor Networks (USNs). The 3-D USNs consists a number of sensor nodes which are deployed in 3-D environment and Sensor nodes are float at dissimilar depths to monitor a specified phenomenon. The Autonomous Underwater Vehicles travels a path which is defined by user to collect a sensed data from a sensor node. The Mobicast Routing Protocol for Underwater Sensor Networks is used to afford a spatiotemporal solution for the Underwater Sensor Networks and also it provides efficient Data Collection and Power saving routing protocol for Underwater Sensor Networks. Involvement of the Multiple Autonomous Underwater Vehicles supports an application of multiple-sink Mobicast Routing Protocol for Underwater Sensor networks and also they gather a large number of sensor events or phenomena within a short time. The Parameters Analysis derived from this novel approach are Successful delivery rate, Power Consumption, Message Overhead.

Keywords - Underwater Sensor Networks, Mobicast routing, Autonomous Underwater Vehicles.

I. INTRODUCTION

Presently, the Underwater Sensor Networks is one of the growing technologies in the global environment. The Underwater sensor Networks support a variety of applications such as seismic monitoring, ocean equipment monitoring, leak detection, Oceanographic data collection, Pollution monitoring, offshore examination, disaster anticipation, assisted navigation and tactical supervision. Therefore, the purposes of underwater sensor networks for aquatic environments are abundant. In underwater communication there are low data rates compared to terrestrial communication, since underwater communication uses acoustic waves instead of electromagnetic waves.

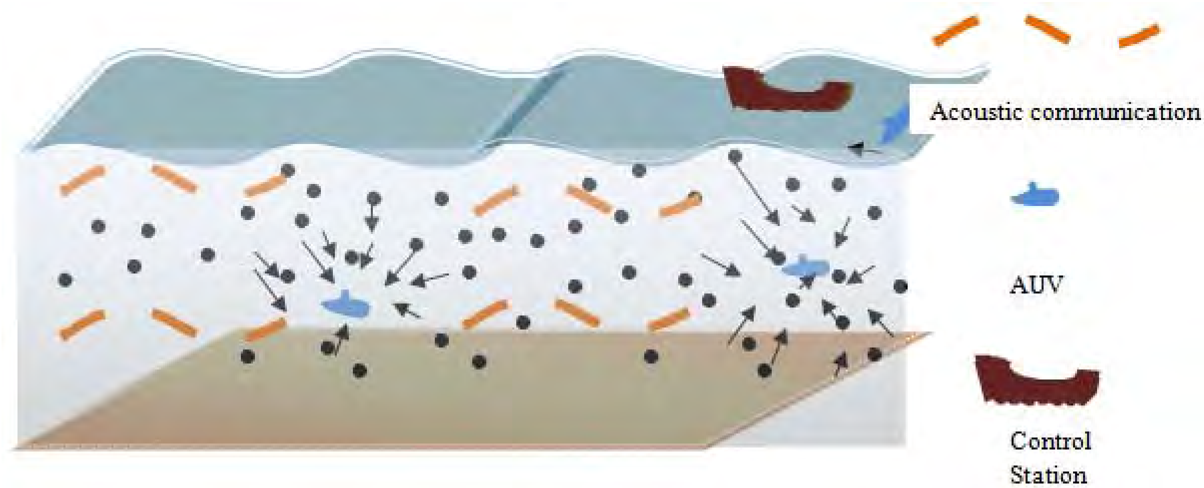

Figure 1.1 Underwater Sensor Networks

Figure 1.1 demonstrates the Underwater Sensor Network Model. The Sensor nodes deployed in an underwater environment intended for collectively monitoring the ocean environments. To communicate with the sensor nodes and to gather the sensed data at sink node, the underwater sensor network uses the acoustic communications because of harsh environments. Acoustic signal is the only communication medium that might work well in underwater environment. Compared to RF communications in terrestrial wireless sensor networks the sound has better dissemination characteristics in ocean environments, hence it is the most adopt proficiency for underwater communications. The USNs differ from the terrestrial wireless sensor networks in a variety of ways [3][4], such as Communication mode, Power, Expenditure, Deployment, Node Mobility, Memory, and Spatial Correlation.

The foremost threats in the creation of underwater acoustic networks are as follows [3]:

- Usually the battery powers in USNs are not rechargeable because the solar power cannot be utilized.
- The bandwidth available in marine environments is extremely low.
- Due to Ocean Current effect the network breakages are occurred.
- The Underwater Sensors are high cost because it needs extra protective sheaths and only limited suppliers.
- Long and variable propagation delays, fading and multi-path problems are occurred in USNs.
- Sensors in Underwater environments are prone to failures because of fouling, corrosion, etc.
- High Bit error rates.

Generally the AUV is equipped with communication devices used to communicate with sensor nodes which are equipped with acoustic transceivers. In USNs, the spatial and temporal communication paradigm is one major issue to collect data from sensor nodes. Hence, the spatiotemporal solution for Underwater Sensor Networks is used to maximizing the data collection while reducing the power consumption. Because of critical challenges of Underwater Sensor Networks, the data collection and power savings are most important concerns. The Mobicast or Mobile Geocast is used to deliver data with spatiotemporal paradigm, which is suitable for AUV to collect the sensed data from sensor nodes.

RELATED WORKS

The AUV or Mobile Sink is continuously collect the sensed data from the sensor nodes deployed in marine environments based on route path which is defined by the user and finally report the sensed information to the control station within short route path [5]. It is more crucial to prolong network lifetime for USNs when compared with terrestrial sensor networks [6].The network lifetime is improved by utilizing the Autonomous Underwater Vehicles. Especially, in 3-D USNs the network lifetime is one of the important factors to measure the performance of the Underwater Sensor Networks. The AUVs can travel at any depth in an ocean environment to collect a sensed data and it enhances the capacities of Underwater Sensor Networks. In last few years, the usage of AUVs in USNs enhanced in many ways.

One of the foremost challenges in Underwater Acoustic Sensor Networks is to provide the efficient Data Collection. The user defined a path to efficiently collect the data and minimizing the travel time. Hence, one of the main problems for efficient data collection in Underwater Sensor networks is to endow with an appropriate path. The scheduling protocols [7] are simulated to find out the best Routing Path Algorithm to improve the data collection while minimizing the AUV travel time. The Underwater Data Collection Using Robotic Sensor Networks [8] uses the Communication Constrained Data Collection Problem (CC-DCP) which is directly associated with the Travelling Salesman Problem and it provides an AUV path planning algorithms to improve a performance of multi-nodes communication.

To achieve the purpose of the reliable data collection, an AUV is usually used to effectively collect the sensed data from sensor nodes [9]. Because of Ocean current effect, network disconnection is occurred in USNs. In multiple UUV-Approaches [9], the multiple underwater unmanned vehicles used to enhance the network connectivity. In this Approach , the underwater vehicles deploy more sensors to repair the network disconnectivity and also it can serve as local sinks to sensors in the isolated partitions, and ferry the data from the isolated sensors to the nearest connected part of the network. The Multiple mobile data collectors [10] are introduced to maximize the network life time. Integer Linear Program (ILP) used to find the optimal placement of data collectors and with multi-hop routing paths to transfer information from sensors to data collectors

The Mobicast Routing Protocol [11], is the first mobicast routing protocol for underwater sensor networks and the main aim of this paper is to triumph over the hole problem, diminishing the energy consumption whereas exploiting the data collection. This protocol is well suited for AUVs to collect the sensed data with spatial and temporal solution. Here, the AUV continuously collect the sensed data from the series of 3-D spherical region based on the user-defined direction path. The main problems in this paper is efficient data collection because the sensor nodes usually is in sleep mode and waking up of sensor nodes in the next 3-D region while providing notification messages to reduce power consumption and network disconnection. In Mobicast Routing Protocol, the Autonomous Underwater Vehicles (AUVs) continuously collect the sensed data from the sensor nodes in underwater environments even if it is drifted by the ocean currents. The ocean currents drifted the sensor nodes and also it causes a network fragmentation or hole problem. The apple slice is used to secure the routing path stability by building the several segments and also solve the hole problem or network fragmentation.

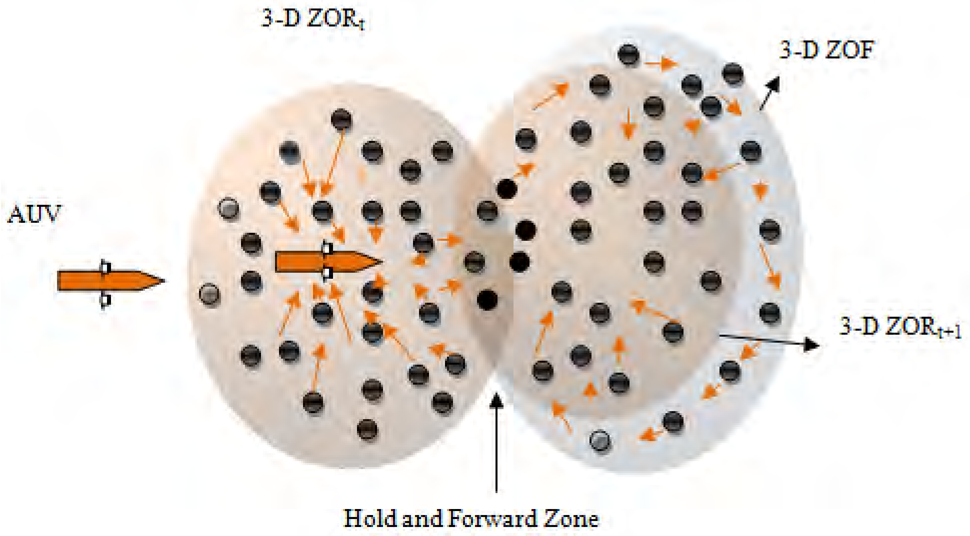

FIGURE 1.2 Mobicast Routing Protocol Model with single AUV

SYSTEM MODEL

By enumerating multiple AUV in Mobicast routing protocol, this paper supports the applications of multiple mobile sink mobicast routing protocol in an underwater sensor networks environments and also enabling communication of large number of sensor nodes within in a short interval. Here, the Underwater Sensors are randomly deployed in 3-D Underwater Sensor Networks environments. The Sensors in Ocean bottom cannot sufficiently sense some phenomena, hence the 3-D [4] are used to observe those phenomena by performing mutual sampling of the 3-D underwater environments.

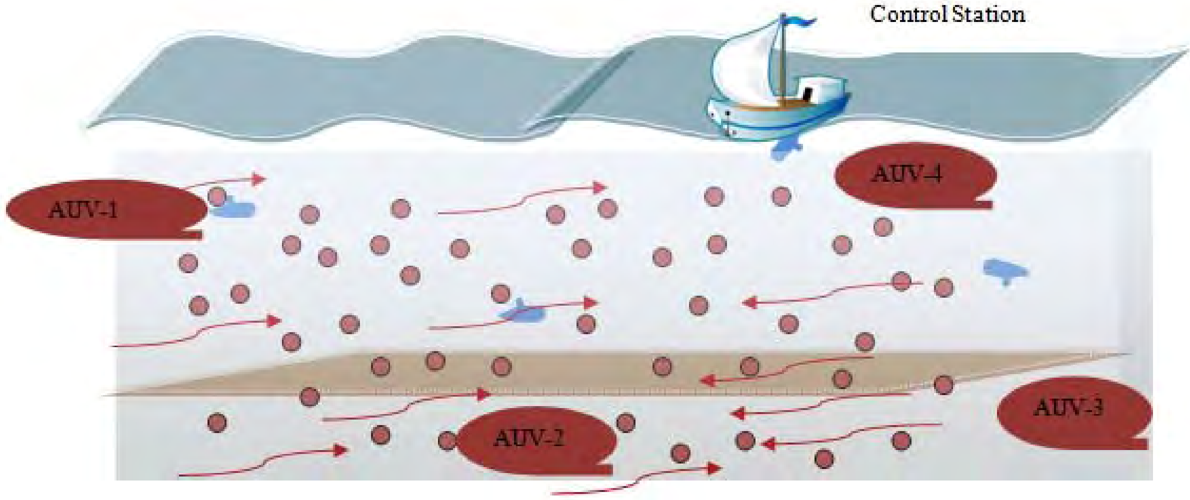

FIGURE 1.3 Multiple AUV for 3-D Underwater Sensor Networks

In order to detect a given phenomenon, the sensor nodes in 3-D USNs float at different depths. In this paper, we proposed a multiple AUV in mobicast routing protocol which is used to provide an application of multiple sink mobicast routing protocol for Underwater Sensor Networks environments. The AUV is normally equipped with sophisticated communication tools, more resources like memory storage, communication relays, etc. Here, the multiple AUVs are used to gather the sensed information from the sensor nodes available in 3-D underwater environments and the user defined routing path, phenomena need to collect data from sensor nodes for every AUV used in 3-D Mobicast routing protocol for Underwater Sensor networks

The AUVs continuously create the 3-D Zone of Relevance [11] and used to gather the sensed data from the sensor node located only in the 3-D Zone of Relevance. The AUV ferry the sensed information from the corresponding sensor nodes. The spatiotemporal character of a mobicast is to collect the sensed data from sensor nodes that will be present at time *t* in the 3-D ZOR, where both the location and shape of the 3-D ZOR are a function of time over some interval (t_{start}, t_{end}) Assumed that an AUVs travels a circle path around a given observed areas. The AUVs constructs a series of 3-D ZORs over different intervals (t_{start}, t_{end}), and only sensor nodes located in the 3-D ZOR at the time interval (t_{start}, t_{end}) must wake up to send sensed data to the corresponding AUV. It is observed that 3-D ZOR is evolved and continuously moves with the AUV over time. To save power and send sensed data to the AUVs, sensor nodes in 3-D ZORs must be woken up and kept in the active mode to wait for the arrival of AUVs. The AUVs cannot successfully receive the sensed data in time if sensor nodes in 3-D ZORs are still in the sleep mode.

This problem is more serious in USNs because that propagation delay of USNs is larger than that of WSNs. A excellent mobicast routing protocol in USNs must alert the sensor nodes in 3-D ZOR at time *t*, even if there is hole problem and the ocean current effect. The specific characteristics of USNs, such as low communication bandwidth, huge propagation delay, and ocean current are significantly different from wireless sensor networks (WSNs). To think about the specific features of USNs, a new mobicast routing protocol is developed in 3-D USNs [11]. The major design challenge is to develop a power-saving mobicast protocol in 3-D USNs to overcome the unpredictable 3-D hole problem. A “apple peel” scheme of the mobicast protocol is proposed to solve the unpredictable 3-D hole problem.

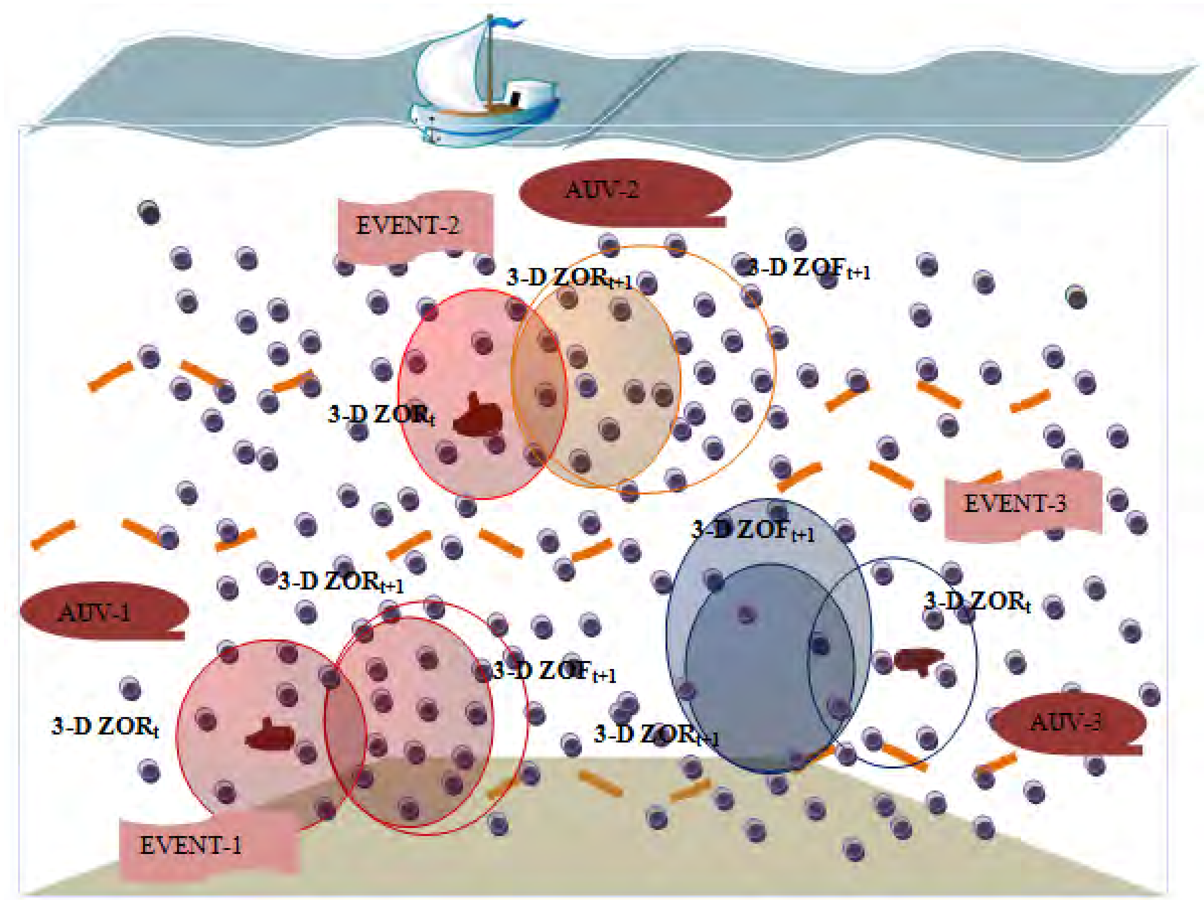

FIGURE 1.4 Multiple AUV for 3-D Underwater Sensor Networks with 3-D Sink Zone Formation

The 3-D ZOF$_{t+1}$ is a spherical forwarding region created by every AUV at time t and this region has the responsibility to transfer a mobicast messages for all sensor nodes in 3-D ZORt+1(3-D spherical region at time t+1).The 3-D ZOF$_{t+1}$ cover the region of 3-D ZOR$_{t+1}$ for to wake up all sensor nodes while AUVs approaching to ferry the sensed data and assured the routing path continuity for mobicast message delivery. Therefore, to determine the size of the 3-D ZOF$_{t+1}$ and there are two ways to determine the size of 3-D ZOF$_{t+1}$ [11].

1. Larger in size of 3-D ZOF$_{t+1}$ overcome the hole problem and it leads to higher successful delivery rate,

2. Smaller in size 3-D ZOF$_{t+1}$ cannot cover the hole problem and unsuccessful to wake up all the sensor nodes in 3-D ZOR$_{t+1.}$ 3-D ZOF$_{t+1}$ should be capable of sending the wake up message to all the sensor nodes in 3-D ZOR$_{t+1}$.

Hence, the 3-D ZOF$_{t+1}$ size is determined based on the drifted distance of sensor nodes by calculating the velocity of ocean currents and the network density. If the larger number of sensor nodes is drifted by ocean currents the size of 3-D ZOF_{t+1} is enlarged up to cover all the sensor nodes in 3-D ZOR_{t+1} . The second method is used to determine the number of sensor nodes needed to transfer the mobicast notification messages. Hence, the "**Apple slice**" is used to determine the number of sensor nodes by divide the 3-D ZOF_{t+1} into numerous parts. The individual segments of ZOF_{t+1} are extended based on the sensor nodes drifted by ocean currents.

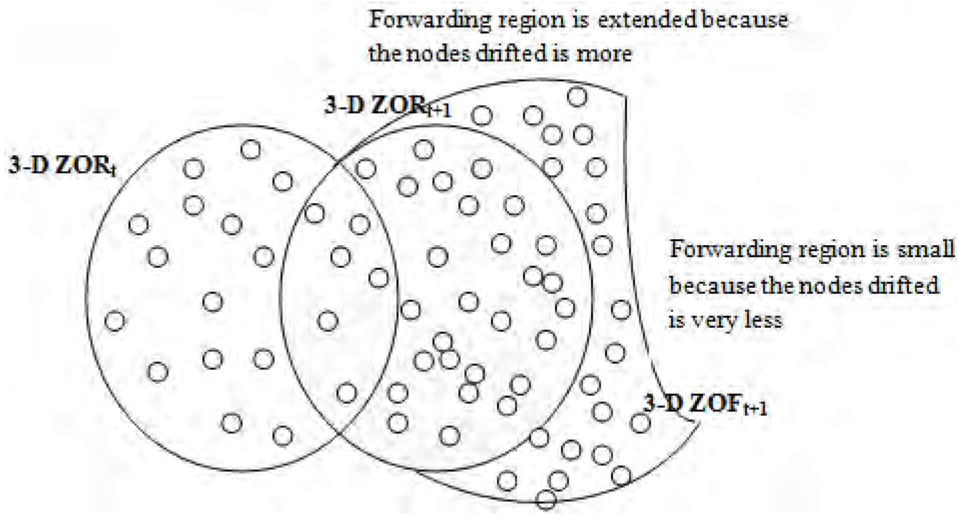

FIGURE 1.5 segment expansion based on drifted distance of sensors

MULTIPLE AUV-MOBICAST ROUTING PROTOCOL

In Multiple AUV-Mobicast Routing Protocol, the multiple AUV incessantly generate the spherical region for every time interval based on the phenomena and route path provided by the user. Every individual AUV transfers the mobicast messages to the corresponding 3-D $ZOR_{t.}$ Besides, the sensor nodes belong to that 3-D ZOR_t might send the sensed data to the consequent AUVs. The AUVs ferry the same or different phenomenon or events data which is defined by the user. At the time of collecting the data from 3-D ZOR_t ,the AUVs create the 3-D ZOF_t which is used to transfer the wake up messages to the sensor nodes located at 3-D ZORt+1.The unpredicted hole problem and ocean currents are solved by the Apple Slice technique. In Multiple AUV the main problem is that the sensor nodes have a chance to receive wake up message from different AUV for different phenomena. To avoid that overlapping of requests, AUV send the AUV id and event id with mobicast message. Then, before sending the observed data to AUV, the sensor nodes verify the AUV id and event id, if it is same as for corresponding AUV and transfer the data.

The Multiple AUV-Mobicast Routing Protocol consists of three phase:

1 .Creation and Notification Phase

2. Hole Problem Reduction Phase

3. Data Collection Phase

In Creation and Notification Phase, the AUVs create the corresponding 3-D ZOR_t and transfer the mobicast messages to all the sensor nodes in 3-D ZOR_t before some interval of time. While the AUVs approaching the sensor nodes in 3-D ZOR_t USNs for the sensed result the AUVs must wake up. And the second phase is Hole Problem Reduction Phase, here the 3-D ZOR_{t+1} and 3-D ZOF_{t+1} is created by the Multiple AUV to avoid the unpredictable hole problem. At time t, the AUVs collect the sensed data from sensor nodes in corresponding 3-D $ZOR_{t,}$ at the same time the AUVs create the 3-D ZOR_{t+1} and 3-D ZOR_{t+1} . The 3-D ZOF_{t+1} is used to wake up the sensors located in the 3-D ZOR_{t+1} USNs at time t. The Apple slice technique is applied in every 3-D ZOF_{t+1} to avoid the unpredictable hole problem. In Data Collection Phase, the every AUV collect the data based on the phenomena or events which are defined by users.

ALGORITHM:

Creation and Notification Phase:

Step 1: The AUVs and Sensors acquire the position based on range based or range-free localization techniques [12]. AUVs constantly create the 3-D ZOR^3 for to ferry the data from sensor nodes located in that 3-D $ZOR_{t.}$ And the 3-D ZOR_t is created based on the following formula [11].

$$Z_t(N_i) = (x_i - x_a)^2 + (y_i - y_a)^2 + (z_i - z_a)^2 - R^2 = 0$$

Step 2: Each AUV transfer the mobicast message Pm (R_{id}, E_{id}, N_i, Zt (N_i), m, r, VA) [11] to the sensor node which is needed to observe the given phenomenon. Where R_{id} is the id of AUV, E_{id} is the id of events or phenomena given by user.

Step 3: After sensor nodes woke up, it verify the following conditions.

if ((Z_t **(**N_i**) ≤0 & ((**$R_{id,}$ E_{id} (received by individual sensor nodes)) = ($R_{id,}$ E_{id} of individual AUV))

Step 4: When above conditions is satisfied the sensor nodes transfer the observed data to the AUVs at time t and at the same time the AUVs create the 3-D ZOR_{t+1} and 3-D $ZOF_{t+1.}$

Hole Problem Reduction Phase:

Step 1: While collecting the data from the sensor nodes in 3-D ZOR_t the AUVs transfer the mobicast message to the 3-D ZOR_{t+1} by hold and forward zone. And also the 3-D ZOF_{t+1} transfer the wake up messages to the sensor nodes located in 3-D ZOR_{t+1} to avoid the unpredictable hole problem [11].

Step 2: The apple slice technique is used to transfer the messages to all sensor nodes in spherical region at time t+1 even if it is drifted by the ocean currents [11].

Data Collection Phase:

Step 3: After sensor nodes at 3-D ZOR_{t+1} woke up by the above steps, it verifies the following conditions.

if ((Z_{t+1} **(**N_i**) ≤0 & ((**$R_{id,}$ E_{id} (received by individual sensor nodes in 3-D ZOR_{t+1})) = ($R_{id,}$ E_{id} of individual AUV))

Step 4: After satisfying the above conditions the sensor nodes at 3-D ZOR_{t+1} transfer the sensed data to the AUVs

PERFORMANCE METRICS

Successful deliver rate:

Number of nodes located in ZOR_{t+1} which can successfully receive the mobicast messages and wake up, divided by the total number of nodes in $ZOR_{t+1.}$

Power Consumption:

The power consumed by all sensor nodes in USNs.

Message Overhead:

Total number of packets that all sensor nodes transmitted, including the control and mobicast messages, divided by the minimum number of packets used in our mobicast protocol.

Average Delay time:

The total delivery delay time divided by the total number of nodes in $ZOR_{t+1.}$

Throughput:

The total number of data packets which the AUV receives from sensor nodes in ZOR_{t+1} per second.

SIMULATION

Our paper presents the Multiple-AUV Mobicast Routing Protocol in Underwater Sensor Networks. The Aqua-sim (ns2 simulator) [13] and Aqua3-D emulator used for to simulate our routing protocol. The Aqua-sim is one of the ns2 based simulator used for 3-D Underwater Sensor Networks and effectively simulates the Underwater Acoustic channels. Our simulation consists 1000 of sensor nodes, and these nodes are deployed in 3-D Underwater Sensor Networks. The Communication range of AUVs and all Sensor nodes are 10 and 5 units respectively. The AUVs collect the sensed data with interval of 10seconds.The Power consumption of sensor nodes in sleep mode, transmission and receive mode are 8mW, 2W, 0.75W.

CONCLUSION

In this paper, we present a Multiple Mobicast Routing Protocol for supporting the applications of Multiple AUV with spatiotemporal solution in 3-D Underwater Sensor Networks. The AUVs are continuously creating the 3-D ZOR_t for efficiently collect the data with lower power consumption and the simulations may demonstrate the performance analysis in terms of Throughput, Average Delay time, Message Overhead, Power Consumption, Successful delivery rate.

REFERENCES

[1] John Heidemann, Yuan Li, Affan Syed, Jack Wills, Wei YE, "Underwater Sensor Networking: Research Challenges and Potential Applications" USC/ISI Technical Report ISI-TR-2005- 603.

[2] Ian F. Akyildiz, Dario Pompili, Tommaso Melodia "State of the Art in Protocol Research for Underwater Acoustic Sensor Networks", WUWNet06, September 25, 2006, Los Angeles, California, USA, ACM 1 59593-484-7/06/0009 ...$5.00.

[3] Manjula.R.B, Sunilkumar S. Manvi "Issues in Underwater Acoustic Sensor Networks" International Journal of Computer and Electrical Engineering, Vol.3, No.1, February, 2011 1793-816.

[4] Ian F. Akyildiz, Dario Pompili, Tommaso Melodia "Challenges for Efficient Communication in Underwater Acoustic Sensor Networks" Broadband & Wireless Networking Laboratory.

[5] D. Walker, "Micro autonomous underwater vehicle concept for distributed data collection," in Proc. IEEE Oceans, Boston, MA, Sep. 2006, pp. 1–4.

[6] Andong Zhan and Guihai Chen, Wei Wang"Utilizing Automatic Underwater Vehicles to Prolong the Lifetime of Underwater Sensor Networks" IEEE, Computer Communications and Networks, 2009. ICCCN 2009. Proceedings of 18th Internatonal Conference.

[7] Geoffrey A. Hollinger , Parastoo Qarabaqi, Urbashi Mitra , Gaurav S. Sukhatme, Milica Stojanovic , Hanumant Singh, Member, IEEE, and Franz Hover, Member, IEEE "Communication Protocols for Underwater Data Collection using a Robotic Sensor Network" 2011 IEEE.

[8] Geoffrey A. Hollinger , Parastoo Qarabaqi, Urbashi Mitra , Gaurav S. Sukhatme, Milica Stojanovic, Hanumant Singh, Member, IEEE, and Franz Hover, Member, IEEE "Underwater Data Collection Using Robotic Sensor Networks" IEEE journal on selected areas in communications, vol. 30, no. 5, June 2012.

[9] Winston K.G. Seah, Hwee-Xian Tan, Zheng Liu, Marcelo H. Ang, Jr." Multiple-UUV Approach for Enhancing Connectivity in Underwater Ad-hoc Sensor Networks" OCEANS, 2005. Proceedings of MTS/IEEE.

[10] Waleed Alsalih, Selim Akl, and Hossam Hassanein" Placement of multiple mobile data collectors in underwater acoustic sensor network" IEEE Communications, ICC 2008 proceedings.

[11] Yuh-Shyan Chen and Yun-Wei Lin"Mobicast Routing Protocol for Underwater Sensor Networks" IEEE Sensors Journal, Vol. 13, No. 2, February 2013.

[12] A. Y. Teymorian, W. Cheng, L. Ma, X. Cheng, X. Lu, and Z. Lu, "3D underwater sensor network localization," IEEE Trans. Mobile Comput.,vol. 8, no. 12, pp. 1610–1621, Dec. 2009.

[13] P. Xie, Z. Zhou, Z. Peng, H. Yan, T. Hu, J.-H. Cui, Z. Shi, Y. Fei, and S. Zhou, "Aqua-sim: An NS-2 based simulator for underwater sensor networks," in Proc. MITS/IEEE OCEANS, Biloxi, MS, Oct. 2009, pp. 26–29.