An Enhanced Routing Approach on the Void Regions in Underwater Sensor Networks

V.Venkatesa Kumar[1], M.Monisha[2], M.Newlin Rajkumar[3]
Department of Computer Science and Engineering
1 & 3 - Assistant Professor's, 2 – P.G. Scholar
Anna University Regional Campus Coimbatore, Coimbatore – 641 046, INDIA.
mail2venkatesa@gmail.com,moni.munivel@outlook.com, newlin_rajkumar@yahoo.co.in

Abstract: ***Underwater Wireless Sensor Networks (UWSNs) is one of the promising technology to explore and monitor the lakes, rivers, seas, and oceans. The data gathering is limited due to acoustic communication in underwater. To improve the communication bandwidth, the unique characteristics and dynamic network topology of the underwater wireless sensor networks are designed. In this work, GEDAR protocol is used. It is any cast, multihop, efficient protocol for data packet delivery from sensor nodes to multiple sonobuoys at the sea surface in the underwater environment. When the nodes are present in the void communication void communication region, it switches to the recovery mode which based on depth adjustment technique. GEDAR is also used to discover and monitor the routing paths along the void regions. Simulation results show that the significant improvement of the network performance for GEDAR when compared with other baseline solutions for network traffic loads.***

Keywords: ***Underwater sensor networks, Geographic routing, Opportunistic Routing, Void nodes.***

I. INTRODUCTION

One - third of the Earth is covered by water. The deep ocean is mostly unexplored habitat on our Earth [1]. Wireless communication through the oceans is one of the enabling technologies for the future development of sensor networks and ocean observation system [4]. Underwater Wireless Network (UWSN) consists of a large number of small inexpensive sensors which are deployed underwater with sonobuoys on the surface [3]. The sensor nodes drift along with the water dynamics results in an error-prone [8]. The only feasible method for UWSN is an acoustic communication [12]. It is important to use the energy efficiently in underwater. In order to maximize the lifespan of networks, the traffic should be sent that can avoid nodes with low energy [13].

Geographic routing is the most preferable to route the packets in UWSN. It uses the position information to route towards the destination[11].It is an attractive option for networks and suffers from void node problem[3].It is more difficult to cope with mobile voids and 3D in networks[7]. It does not require the maintenance or establishment of complete routes towards the destination. A locally optimal next-hop is the neighbor closest to the sonobuoy is selected to forward the packets [12].It occurs when the destination is rechargeable. The node present in this region is called as the void node. If any node stuck in this region, the packet has to discard or use some recovery technique [11].In opportunistic routing, the packets are broadcast towards a forwarding set off several neighbors [11]. If the neighbors are not received, the packet will be retransmitted [3]. If the node with the highest priority failed to receive, then the next highest priority performs the data forwarding [3]. It is a technique to deliver the communication in networks when a particular node cannot forward the packet [14]. It can work together with geographic routing to improve the data delivery. The Geographic and opportunistic Routing with Depth Adjustment-based topology control for communication Recovery (GEDAR) over void regions uses the greedy opportunistic mechanism to route the data packets to sonobuoy.

The rest of the paper is organized as follows, Section 2 summarizes an overview of the existing approaches and their void region strategies. In Section 3, the brief explanation about GEDAR is provided. In Section 4, the design of the GEDAR and its implementation. The performance evaluation is described in Section 5. Finally, Section 6 describes the conclusion and future works.

II.RELATED WORK

Geographic based protocols are leverage the location information of the sensor nodes to forward the data packets from source to destination [1].Vector- Based Forwarding (VBF) protocol uses the distance between nodes and routing vectors to determine whether the data packets forward or not [6]. In VBF, each packet carries the positions of the source, the destination and the forwarder [6]. The packets are routed along a virtual routing pipe formed by the vector from source to destination location. As soon as it receives a packet, it determines the distance towards the forwarding vector [3].It is localized and an energy efficient routing algorithm [13]. VBF is robust against vulnerable sensor nodes and error-prone [8]. It attempts to bypassing the void region boundary by shifting the forwarding vector and back-pressure method [10]. Each node measures the suitability of the nodes to calculate its desirableness factor. If the factor is less than a defined threshold, then the node will schedule the packet transmission with respect to priority [12].DCR is a geographic routing protocol which uses the greedy forwarding strategy to send the data packets towards sonobuoys [9]. It performs topology control to determine the set of nodes and next-hop to calculate new depth [3]. It keeps on continue until reaching the destination node [9]. Depth - Based Routing (DBR) uses the node depth information to route the data packets from one node to another. It forwards the data packets greedily towards the water surface and reaches multiple data sinks to deploy in the undersea [1]. The current sender broadcasts the packet and the qualified candidate node has chosen if it closer to the receiver [9]. Multisinks are used to improve the routing success ratio upon the node distribution [1]. When a node receives the packets, it compares with the depth of the previous sender with own depth [3].

Hop-by-Hop dynamic addressing based(H2-DAB) implements the dynamic addressing among sensor nodes without localization information[1].When a node determines that it has sufficient data for surface communication, it uses the acoustic modems to tell nodes along the path to the surface to create a radio link[16].In RPR, the payload and the packet header are encrypted. Each node has a key and its certificate. Network Wide Secret key (NSK) is used to encrypt the information among the nodes. Gateway Public Key (GPK) encrypts the payload during the forwarding process. Then, node decrypts the head and check whether the packet is signed by the legitimate node. The packet with proper signature is only accepted [12].

Vector Based Void Avoidance (VBVA) is used to address the mobile void problem and three - dimensional in UWSN [7]. This is performed until the data packets reach a node towards the destinations [12]. In Hydrocast, the depth information of nodes to route packet upward to receive by any sink deployed in the water surfaces [10].When a node determines the local maximum of that particular data node, it performs a search for all the nodes in the underwater to identify whose depth is lower than its own depth by the controlled flooding [12] for maintaining the paths of node[11]. To determine a cluster of the neighbor nodes without any hidden terminal problems for redundant packets [14], so recovery mode handles communication void region [9].

Void Aware Pressure Routing (VAPR) is a geographic and opportunistic routing to provide routing direction for data packets with minimal overhead. It exploits beacon packet to the void areas [16]. It reachability information by periodic beacons was disseminated in the network [10]. Multi-modal communication is easy to implement and estimate the radio range to ensure connectivity. It creates weight to select an optimal set of nodes with minimum distances [5]. It computes data latency and trade-off network energy cost to be sent and decide how to transmit the data [10]. It results in the high end-to-end delay to transmit the gathered data in the sea surface [12].

The GEDAR uses the greedy opportunistic mechanism to route data packets. To overcome the problem of a void region, the depth adjustment apparatus is used to move void nodes to new depths. Multisink is used to balance energy consumption and improve data delivery ratio. If the node can't forward the packet, then switches to the void node recovery mode and allows broadcast communication from routing tables. If the node cannot identify new depth, then the recovery mode function is called once again [1].

III. GEDAR

The GEDAR is a novel approach for short time monitoring underwater sensor networks. It uses the greedy opportunistic forwarding technique to determine depth adjustment and set of forwarder nodes in a void region as a recovery mode. It uses the greedy opportunistic forwarding strategy to forward the packets to some sonobuoy for next-hop selection. Each packet is broadcast to the forwarding set of several neighbors. If the link is not performing well, a packet may lead to the loss. The packet will retransmit only if none of the receivers receives it. Opportunistic routing reduces the number of possible retransmissions and helps in decreasing the number of possible collisions in the network [11]. Each sonobuoy at the sea is equipped with GPS and uses periodic beaconing to identify location information of the neighbors. GEDAR overcomes the problem of the void region by depth adjustment technology [12].

IV.DESIGN OF GEDAR

A. Periodic Beaconing

It plays a major role in GEDAR. Each node gets the location information of neighbors and reaches the sonobuoys. It broadcasts the periodic beacons and handles received beacons. In this beacon information consists of a sequence number, its unique ID and the location. The sequence number does not need to be synchronized with all sonobuoys. It uses only the ID to identify them and the depth information is omitted in beacon message while deploying in the sea surface. With this information, the neighbor nodes reach the sonobuoys. Location information is used to collect the data and track them underwater. To minimize the chance of synchronization and collision, add the random jitter between 0 and 1[12].

B. Neighbors candidate set selection

It determines which neighbor nodes are qualified to the next hop forwarder. In each hop, the packet has to send towards the sonobuoys. The distance between the source and the destination with the elimination of neighbors in the underwater [12].

C. Next-hop forwarder set selection

In a next-hop forwarder, it has to select only one neighbor. If the link had broken, the packet may be lost. The set is composed of the suitable nodes from the candidate set so that the selected nodes must hear about the transmission to avoid the hidden terminal problem. The Normalized Advance (NADV) is used to measure the goodness of each next hop candidate node. It corresponds for the optimal trade-off between the link and proximity cost to determine the candidate node based on priority. The signal attenuation is high due to the channel fading in underwater [12].

D. Recovery Mode

It is used when the node fails to forward the data packets. The depth adjustment is used to move the void nodes from void communication region. If the node present in the void region, it does not have any neighbor to reach the sonobuoys. The void node can change their status and send the void node announcement even stops the beacon. This is used to avoid the cascading effects of void nodes during the depth adjustment technology. If the node discovers it in the void communication region then it starts the communication void node recovery technique [12].

V.PERFORMANCE EVALUATION

We evaluate the difference between other routing protocols with GEDAR protocol. GEDAR employ the mechanism to deal with void communication regions, i.e.., when a packet gets stuck in a void mode, it discards. Identification of communication void region is done by periodic beaconing and performs the routing. The objective is to analyse the performance of GEDAR protocol in terms of the packet delivery ratio, end-to-end delay, energy consumption and throughput [11].The experimental setup and simulation results are explained below.

A. *Experimental Setup*

Aqua-Sim is a flexible and high fidelity UWSN simulator developed on Network Simulator (NS-2) to simulate the impairment of the acoustic channel [12]. Series of simulation can be done by varying the number of nodes [11]. Deploying the nodes in random with the range of 20 to 100 in a 3D region of size and 4 sonobuoys at the sea surface. In GEDAR the node will rebroadcast the packet and packet will be dropped after 4 retransmissions. The results run with an average of 95% confidence interval [11].

B. *Experimental Results*

The packet delivery ratio (PDR) is presented in Fig. 1.

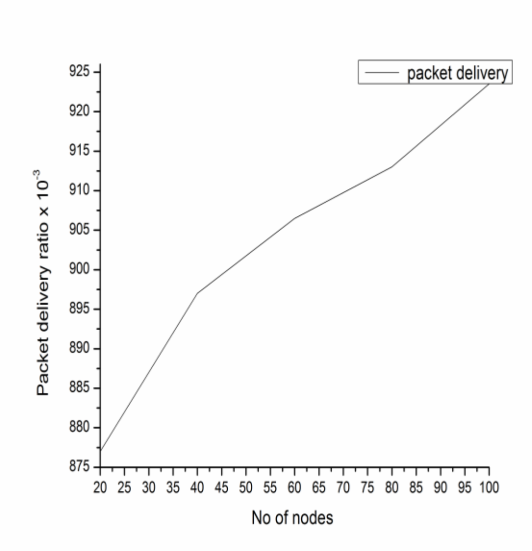

Fig .1 Time Vs Packet Delivery Ratio

This increase the network density leads to increase in PDR. To deal with communication void regions, the depth adjustment topology control is used. To discover and maintain the explicit paths in void regions, the channel is not overloaded with extra transmissions of data and control packets.

Fig. 2 shows the average end-to-end delay. The delay is due to the queuing of the data packets in the recovery mode. The delay decreases with increase in the number of the nodes. The first data packet is delay due to the depth adjustment technology.

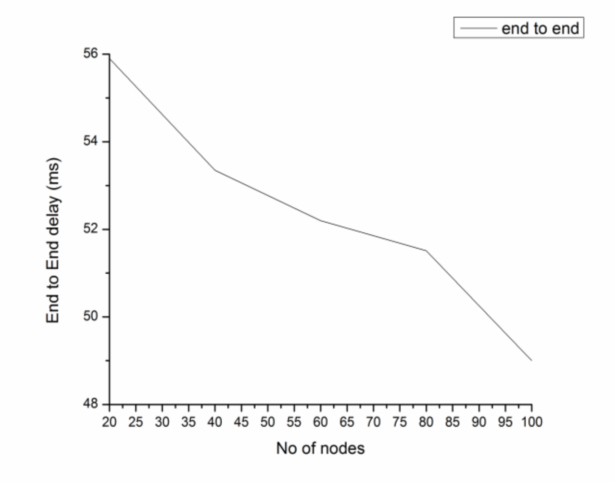

Fig. 2 Time Vs End-to-End delay

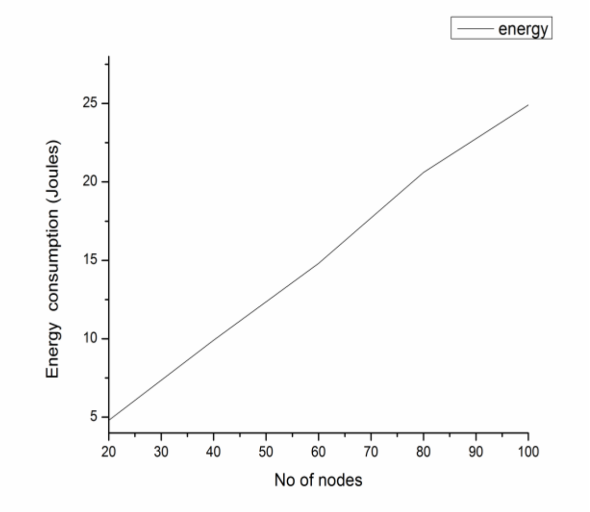

Fig. 3 Time Vs Energy Consumption

As in Fig. 3, the average displacement per node is high with respect to lower density. The energy decreases while delivering the data with increases in the number of nodes.

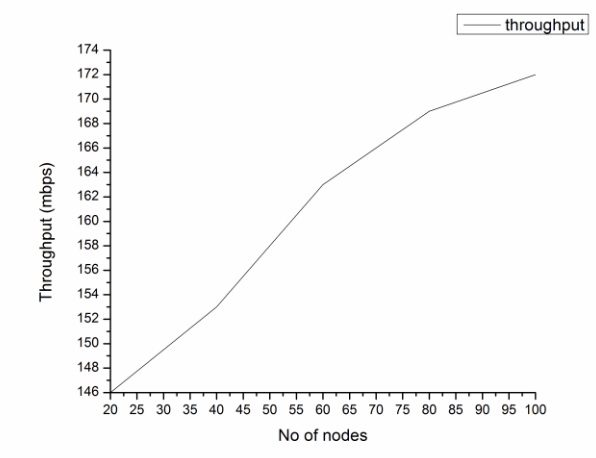

Fig. 4 Time Vs Throughput

In fig. 4, the throughput ratio increases with decreases in the number of nodes. It is calculated with respect to the number of nodes in source and destination in the underwater sensor network. As the network density increases, it reduces the depth adjustment which gives better results. Thus, the simulation shows the result of all parameters which had chosen.

IV. Conclusion and Future Work

In this paper, the GEDAR routing protocol to improve the data routing in underwater sensor networks. GEDAR is a simple and scalable protocol to use the location information of the sensor nodes to broadcast the communication medium. The packets forward towards the surface with opportunistically and greedily approach to the sonobuoys. Furthermore, GEDAR provides a novel depth adjustment based topology control mechanism used to move void nodes to new depths to overcome the communication void regions. Our simulation results showed that geographic routing protocols based on the position location of the nodes are more efficient than pressure routing protocols. Moreover, opportunistic routing proved crucial for the performance of the network besides the number of transmissions required to deliver the packet. The use of node depth adjustment to cope with communication void regions improved significantly the network performance. GEDAR efficiently reduces the percentage of nodes in communication void regions. Consequently, GEDAR protocols improves the network performance while comparing this with the existing underwater routing protocols for different scenarios of the traffic load and network density.

In future, plan to enhance the work by using the layering phase to identify the shortest path to communicate the data packets between nodes. Since the nodes are dynamic in nature we are choosing it an on-demand and identify the threshold frequency.

References

[1] Guangjie Han, Na Bao, Li Liu, Daqiang Zhang and Lei Shu, "Routing protocols in underwater acoustic sensor networks: a quantitative comparison" *International Journal of Distributed Sensor Networks* 11, no. 10 (2015): 858593.

[2] Hai Yan, Zhijie Jerry Shi, and Jun-Hong Cui, "DBR: depth-based routing for underwater sensor networks" In *International conference on research in networking*, pp. 72-86. Springer Berlin Heidelberg, 2008.

[3] Hina Nasir, Nadeem Javaid, Shaharyar Mahmood, Umar Qasim, Zahoor Ali Khan, and Furqan Ahmed, "Distributed Topology Control protocols for Underwater Sensor Networks" in *Network-Based Information Systems (NBiS), 2016 19th International Conference on*, pp. 429-436. IEEE, 2016.

[4] John Heidemann, Milica Stojanovic, and Michele Zorzi, "Underwater sensor networks: applications, advances and challenges" *Phil. Trans. R. Soc. A* 370, no. 1958 (2012): 158-175.

[5] Michael O'Rourke, Elizabeth Basha, and Carrick Detweiler, "Multi-modal communications in underwater sensor networks using depth adjustment" In *Proceedings of the Seventh ACM International Conference on Underwater Networks and Systems*, p. 31. ACM, 2012.

[6] Peng Xie, Jun-Hong Cui, and Li Lao, "VBF: vector-based forwarding protocol for underwater sensor networks" In *International Conference on Research in Networking*, pp. 1216-1221. Springer Berlin Heidelberg, 2006.

[7] Peng Xie, Zhong Zhou, Zheng Peng, Jun-Hong Cui, and Zhijie Shi, "Void avoidance in three-dimensional mobile underwater sensor networks" In *International Conference on Wireless Algorithms, Systems, and Applications*, pp. 305-314. Springer Berlin Heidelberg, 2009.

[8] Riliang Xing, and ZhangBing Zhou, "Sub-region Query Processing in Underwater Wireless Sensor Networks" In *Identification, Information, and Knowledge in the Internet of Things (IIKI), 2015 International Conference on*, pp. 105-109. IEEE, 2015.

[9] Rodolfo WL Coutinho, Luiz FM Vieira, and Antonio AF Loureiro, "DCR: Depth-Controlled routing protocol for underwater sensor networks" In *Computers and Communications (ISCC), 2013 IEEE Symposium on*, pp. 000453-000458. IEEE, 2013.

[10] Rodolfo WL Coutinho, Azzedine Boukerche, Luiz FM Vieira, and Antonio AF Loureiro, "Local maximum routing recovery in underwater sensor networks: Performance and trade-offs" In *Modelling, Analysis & Simulation of Computer and Telecommunication Systems (MASCOTS), 2014 IEEE 22nd International Symposium on*, pp. 112-119. IEEE, 2014.

[11] Rodolfo WL Coutinho, Azzedine Boukerche, Luiz FM Vieira, and Antonio AF Loureiro, "GEDAR: geographic and opportunistic routing protocol with depth adjustment for mobile underwater sensor networks" In *Communications (ICC), 2014 IEEE International Conference on*, pp. 251-256. IEEE, 2014.

[12] Rodolfo WL Coutinho, Azzedine Boukerche, Luiz FM Vieira, and Antonio AF Loureiro, "Geographic and opportunistic routing for underwater sensor networks" *IEEE Transactions on Computers* 65, no. 2 (2016): 548-561.

[13] Sarath Gopi, Govindan Kannan, Uday B. Desai, and S. N. Merchant, "Energy optimized path unaware layered routing protocol for underwater sensor networks" In *Global Telecommunications Conference, 2008. IEEE GLOBECOM 2008. IEEE*, pp. 1-6. IEEE, 2008.

[14] Syed Zarar, Nadeem Javaid, Arshad Sher, Ahmad Raza Hameed, Zahoor Ali Khan, and Umar Qasim, "Geographic and Opportunistic Clustering for Underwater WSNs" In *Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2016 10th International Conference on*, pp. 57-62. IEEE, 2016.

[15] Uichin Lee, Paul Wang, and Youngtae Noh, "Pressure routing for underwater sensor networks" In *Proceedings of the IEEE, INFOCOM*. 2010.

[16] Youngtae Noh, Paul Wang, Uichin Lee, and Mario Gerla, "Vapr: Void aware pressure routing protocol" *WUWNet Work-In-Progress Poster* (2010).

BIOGRAPHY

Dr.V. Venkatesakumar is presently working as Assistant Professor in the Department of Computer Science and Engineering, Anna University Regional Campus, Coimbatore. He received his Bachelor of Engineering Degree from Bharathiyar University, Master of Engineering Degree and Ph.D from Anna University Chennai. He has more than ten years of Teaching Experience. He has published many papers in reputed International Journals and has Chaired many Conferences. He is a Life Member of International Association of Computer

Science and Information Technology, International Association of Engineers and in many International Associations. His research interest includes Cloud Computing, Internet of Things, Big Data Analytics.

M.Monisha is pursuing her Master of Engineering in Computer Science and Engineering with specialization in networks from Anna University Regional Campus, Coimbatore. She received B.tech in Information Technology in the year 2015 from J.N.N Institute of Engineering, Chennai. She is a Member of International Association of Engineers, ResearchID, and International Associations. Her research interests are Wireless Sensor Networks, Underwater Sensor Networks and Web Technologies.

Dr.M Newlin Rajkumar is presently working as Assistant Professor in the Department of Computer Science and Engineering, Anna University Regional Campus, Coimbatore. He received his Bachelor of Engineering Degree from Bharathiyar University, Master of Science (M.S by Research) from National Chiao Tuns University, Taiwan and Master of Business Administration (IBM) from Anna University, Coimbatore. Presently he is pursuing his Ph.D in Anna University Chennai. He has more than ten years of Teaching Experience. He has published several papers in reputed International Journals. He is a Professional Member of ACM, Member of IEEE India Council, Life Member of International Association of Computer Science and Information Technology, International Association of Engineers and in many International Associations. His research interest includes cloud Computing, Internet of Things, Big Data Analytics, Network Security, Security Protocols and Network Management.