Geographic and Opportunistic Routing (GEDAR) Protocol for Communication of Underwater Sensor Networks

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Abstract- Underwater wireless sensor networks (UWSNs) have been showed as a promising technology to monitor and explore the oceans in lieu of traditional undersea wire line instruments. Nevertheless, the data gathering of UWSNs is still severely limited because of the acoustic channel communication characteristics. One way to improve the data collection in UWSNs is through the design of routing protocols considering the unique characteristics of the underwater acoustic communication and the highly dynamic network topology. In this paper, we propose the GEDAR routing protocol for UWSNs. GEDAR is an any cast, geographic and opportunistic routing protocol that routes data packets from sensor nodes to multiple son buoys (sinks) at the sea's surface. When the node is in a communication void region, GEDAR switches to the recovery mode procedure which is based on topology control through the depth adjustment of the void nodes, instead of the traditional approaches using control messages to discover and maintain routing paths along void regions. Simulation results show that GEDAR significantly improves the network performance when compared with the baseline solutions, even in hard and difficult mobile scenarios of very sparse and very dense networks and for high network traffic loads.

Keywords – UWSN, VAPR, GEDAR, UAN, DBR, OR, VAPR, Opportunistic protocol, topology control.

I. . INTRODUCTION

OCEAN represents more than 2/3 of the Earth's surface. These environments are extremely important for human life because their roles on the primary global production, carbon dioxide (CO2) absorption and Earth's climate regulation, for instance. In this context, underwater wireless sensor networks (UWSNs) have gained the attention of the scientific and industrial communities due their potential to monitor and explore aquatic environments. UWSNs have a wide range of possible applications such as to monitoring of marine life, pollutant content, geological processes on the ocean floor, oilfields, climate, and tsunamis and seaquakes; to collect oceanographic data, ocean and offshore sampling, navigation assistance, and mine recognition, in addition to being utilized for tactic surveillance applications. 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. 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. 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.

In the proposed method, propose the Geographic and opportunistic routing with Depth Adjustment-based topology control for communication Recovery over void regions (GEDAR) routing protocol. GEDAR utilizes the location information of the neighbor nodes and some known sonobuoys to select a next-hop forwarder set of neighbors to continue forwarding the packet towards the destination. To avoid unnecessary transmissions, low priority nodes suppress their transmissions whenever they detect that the same packet was sent by a high priority node. The most important aspect of the GEDAR is its novel void node recovery methodology. Instead of the traditional message based void node recovery procedure, we propose a void node recovery depth adjustment based topology control algorithm. The idea is to move void nodes to new depths to resume the geographic routing whenever it is possible. To the best of our knowledge, this work is the first that considers depth adjustment node capabilities to organize the network topology of a mobile underwater sensor network to improve routing task. Simulation results showed that GEDAR is able to reduce the amount of void nodes through the depth adjustment-based void node recovery strategy. Consequently, GEDAR improves the packet delivery ratio and decreases the end-to-end delay for the critical scenarios of low and high densities and diverse network traffic load, when compared with the state-of-the art routing protocols and the simple geographic and opportunistic routing (GOR) without any recovery mode.

II. RELATED WORKS

Underwater mobile sensor networks have recently been proposed as a way to explore and observe the ocean, providing 4D (space and time) monitoring of underwater environments. The main challenge of pressure routing in sparse underwater networks has been the efficient handling of 3D voids. In this respect, it was recently proven that the greedy stateless perimeter routing method, very popular in 2D networks, cannot be extended to void recovery in 3D networks. Available heuristics for 3D void recovery require expensive flooding.

In this paper, we propose a Void-Aware Pressure Routing (VAPR) protocol that uses sequence number; hop count and depth information embedded in periodic beacons to set up next hop direction and to build a directional trail to the closest sonobuoy. The contribution of this paper is twofold: 1) a robust soft-state routing protocol that supports opportunistic directional forwarding; and 2) a new framework to attain loop freedom in static and mobile underwater networks to guarantee packet delivery.

Underwater sensor networks have recently been proposed as a way to observe and explore the lakes, rivers, seas, and oceans. However, due to characteristics of the acoustic medium, efficient protocols for delivering data must exist. In this work, we propose a novel geographic routing protocol with network topology control for underwater sensor networks, that adjusts the depth of the nodes in order to organize the network topology for improving the network connectivity and forward data where the greedy geographic routing fail.

The proposed protocol is the first geographic routing protocol for underwater sensor networks that considers the sensor node vertical movement ability to move it for topology control purpose. Thesimulation results show that, with the topology control, the fraction of disconnected nodes and nodes located into communication void regions, are drastically reduced and consequently the delivered data rate is improved. It achieves more than 90% of data delivered even in hard and difficult scenarios of very sparse or very dense networks.

Underwater Acoustic Networks (UANs) are a transformative technology that is helping expand military, commercial and scientific applications in deep sea environments. The nature of network deployment in these deep sea environments has spurred a new paradigm in network routing known as pressure routing. Pressure routing is based on geographic routing but only uses limited location information, namely depth information, to route data from the sea floor to the surface.

Recent work has shown that existing pressure routing protocols are vulnerable to malicious intrusions. In this paper we propose a resilient pressure routing protocol that seeks to reduce the effectiveness of malicious attackers, such as spoofing attacks. We evaluate our proposed protocol in a simulation environment and show that it reduces the effectiveness of spoofing attacks and maintains routing performance with minimal trade-off.Routing data in UANs is a primary concern, especially since sensor nodes can be deployed over large spatial areas and can be passively moving due to ocean currents.

Underwater sensor networks are necessary to detect and track unknown targets in the maritime environment. Localization of sensors becomes a crucial problem. This paper presents a new method based on multi-objectivization to localize the sensors using triaxial magnetometers. In this localization system, a DC current-carrying solenoid coil serves as a magnetic source and the inertial magnetometer measure the three-component of magnetic flux intensity.

Then, the localization problem is translated into a multi-objective optimization problem by minimizing each error function. Without using depth sensor, it is difficult to find the global optimum of the functions due to the homogeneous magnetic field. Accordingly, we propose a hybrid algorithm using improved non-dominated sorting genetic algorithm and linear multi-metering method to determine the sensor position. To reduce time consumption during the optimization process, a simplified discrete model of the magnetic field is derived.

Underwater acoustic channel imposes many challenges into underwater networks communication, such as high bit error, temporary losses of connectivity due to shadow zones, limited bandwidth capacity and communication signal spreading over large areas. Opportunistic routing is a new routing paradigm that allows more than one node to forward a packet by taking advantage of the broadcast medium and overhearing of the packet transmission. In this paper we investigate the tradeoffs present in opportunistic routing for underwater networks.

In one hand opportunistic routing may increase the time it takes to receive a packet, since there is an increase in delay to allow all the nodes that are possible forwards to receive the packet. On the other hand, opportunistic routing can help mitigated underwater challenges, by providing gain in packet reception and channel utilization. We provided an analysis of underwater channel utilization efficiency in opportunistic routing. We evaluated the performance on random deployments, showing that by using opportunistic routing we have a gain in packet reception and channel utilization in underwater networks.

III. EXISTING SYSTEM

Depth-based routing (DBR) routing protocol is the first underwater sensor network routing protocol that uses node depth information to route data packets. The basic idea of DBR is to forward data packets greedily towards the water surface. Thus, packets can reach multiple data sinks deployed at the water surface. During the forwarding, the current sender broadcasts the packet. After receiving it, if the receiver is closer to the water surface, it becomes qualified as a candidate to forward the packet. Otherwise, it will discard the packet. Each qualified candidate will forward the packet in a prioritized manner if its distance to the current forwarder is at least d_{th} and it has not previously sent this packet previously. Node priority is given by means of the holding time. The farther the candidate node is on the current forwarder, the lower is its holding time.

IV. PROPOSED SYSTEM

In proposed system, GEDAR is an any cast, geographic and opportunistic protocol that tries to deliver a packet from a source node to some sonobuoys. During the course, GEDAR uses the greedy forwarding strategy to advance the packet, at each hop, towards the surface sonobuoys. A recovery mode procedure based on the depth adjustment of the void node is used to route data packet when it get stuck at a void node. The proposed routing protocol employs the greedy for-warding strategy by means of the position information of the current forwarder node, its neighbors, and the known sonobuoys, to determine the qualified neighbors to continue forwarding the packet towards some sonobuoys. Despite greedy forwarding strategy being a well known and used next-hop forwarder selection strategy, GEDAR considers the any cast nature of underwater routing when multiple surface sonobuoys are used as sink nodes. Furthermore, GEDAR is opportunistic routing aiming to mitigate the effects of the acoustic channel. Thus, a subset of the neighbor nodes is determined to continue forwarding the packet towards some surface sonobuoy (next-hop forwarder set). The research challenge of OR next-hop forwarder set selection is how to determine a list of neighbors such that the hidden terminal problem is reduced. The next hop forwarder set selection mechanism of GEDAR considers the position of the neighbors and known sonobuoys to select the most qualified candidate neighbors. When a node is in a communication void region, GEDAR moves it to a new depth to resume the greedy forwarding strategy. To the best of our knowledge, GEDAR is the first routing protocol proposed for mobile underwater sensor networks to consider the depth adjustment capability of the sensor nodes to deal with communication void region problem. The motivations for the use of this new paradigm are threefold. First, the node depth adjustment technology is already available. Second, the communication task in the underwater sensor network is highly expensive. Third, the cost needed to move the nodes to new depths is diluted along the network operation when compared with the case where the node must route data packets along more hops.

Void node recovery procedure is used when the node fails to forward data packets using the greedy forwarding strategy. Instead of message-based void node recovery procedures, GEDAR takes advantage of the already available node depth adjustment technology to move void nodes for new depths trying to resume the greedy forwarding. To advocate that depth-adjustment based topology control for void node recovery is more effective in terms of data delivery and energy consumption than message-based void node recovery procedures in UWSNs given the harsh environment and the expensive energy consumption of data communication.

4.1 SYSTEM ARCHITECTURE

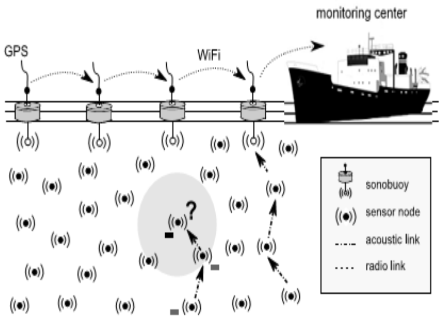


Figure 4.1 System architecture

In this proposed method consider an underwater wireless sensor network, sensor equipped aquatic (SEA) swarm architecture, as shown in Fig. 4.1. In this architecture, we have a large number of mobile underwater sensor nodes at the ocean bottom and sonobuoys, also named sinks nodes, at the ocean surface. They move as a group with the water current. Our model consists of a set N ¼ Nn [Ns of nodes with a communication range of rc, so that Nn represents the set of sensor nodes, and Ns is the set of sonobuoys. The sensor nodes Nn ¼ fn1; n2; . . . ; njNnjg are randomly deployed in a geographic area of interest D 2 R3 to provide 4 D (space and time) monitoring. Each node is equipped with various sensor devices and with a low bandwidth acoustic modem which is used to periodically report the sensed data to the destinations (sonobuoys). Underwater sensor nodes can adjust its depth by means of inflatable buoys or winch based apparatus. In a buoyancy-based depth adjustment system, a buoy can be inflated by a pump, bladders or other device to change the buoyancy of the float relative to the water. This system does not use propulsion mechanisms, reducing the energy cost to the depth adjustment. In winch-based apparatus, sensor nodes are attached to surface buoys or anchors by means of cables.

4.3. MODULES

- Topology Creation
- Enhanced Beaconing
- Neighbors Candidate Set Selection
- Next-Hop Forwarder Set Selection

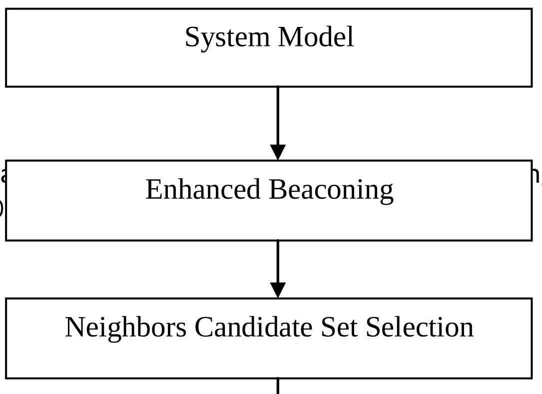


Fig 4.2 modules

MODULES DESCRIPTION

4.3.1 Topology Creation

In our simulations, few number of sensor nodes are deployed and the number of sonobuoys is 6. They are randomly deployed in a region the size of 2265 X 1000. In each sensor, data packets are generated according to a Poisson process with the same parameter to very low traffic load; to simulate a mobile network scenario, considers the effect of meandering sub-surface currents (or jet streams) and vertices. We set the main jet speed range from max 5 m/s to min 2.70 m/s.the nodes have a transmission range (rc) of 250 m and a data rate of 50 kbps.The size of the packet is deter-mined by the size of the data payload and by the space required to include the information of the next-hop forwarder set.

4.3.2 Enhanced Beaconing

Periodic beaconing plays an important role in GEDAR. It is through periodic beaconing that each node obtains the location information of its neighbors and reachable sonobuoys, where each node can be informed beforehand concerning the location of all sonobuoys (as long-term underwater monitoring architecture is formed by static nodes attached to buoys and/or anchors), we need an efficient beaconing algorithm that keeps the size of the periodic beacon messages short as possible. For instance, if each node ni embeds its known sonobuoy locations $|S_i|$ together with its location, the size of its beacon message in the worst case, without considering lower layer headers, $2(m+n) \times |N_s| + 2m + 3n$ bits,where m and n are the size of the sequence number and ID fields, and each geographic coordinates, respectively. Given that the transmission of large packets in the underwater acoustic channel is impractical, we propose an enhanced beacon algorithm that takes this problem into consideration. Similarly, each sensor node embeds a sequence number, its unique ID and X, Y, and Z position information. Moreover, the beacon message of each sensor node is augmented with the information of its known sonobuoys from its set $S_i(t)$.Each node includes the sequence number, ID, and the X, Y location of the its known sonobuoys. The goal is for the neighboring nodes to have the location information of the all reachable sonobuoys. GPS cannot be used by underwater sensor nodes to determine their locations given that the high frequency signal is rapidly absorbed and cannot reach nodes even localized at several meters below the surface. Thus, each sensor node knows its location through localization services. Localization services incur additional costs in the network. However, the knowledge regarding the location of sensor nodes can eliminate the large number of broadcast or multicast queries that leads to unnecessary network flooding that reduces the network throughput. In addition, the location information is required to tag the collected data, track underwater nodes and targets, and to coordinate the motion of a group of nodes. In order to avoid long sizes of beacon messages, a sensor node includes only the position information of the sonobuoys it has not disseminated in the predecessor round (lines 5-12). Whenever a node receives a new beacon message, if it has come from a sonobuoy, the node updates the corresponding entry in the known sonobuoy set $S_i(t)$ (line 20). Otherwise, it updates its known sonobuoys |Si| set in the corresponding entries if the information location contained in the beacon message is more recent than the location information in its set Si. For each updated entry, the node changes the appropriate flag L to zero, indicating that this information was not propagated to its neighbors (line 25). Thus, in the next beacon message, only the entries in $S_i(t)$ in which the L is equal to zero are embedded (lines 7-10). We add random jitters between 0 and 1 during the broadcast of beacon messages, to mini-mize the chance of both collisions and synchronization. Moreover, after a node broadcasts a beacon, it sets up a new timeout for the next beaconing.

4.3.3Neighbors Candidate Set Selection

Whenever a sensor node has a packet to send, it should determine which neighbors are qualified to be the next-hop forwarder. GEDAR uses the greedy forwarding strategy to determine the set of neighbors able to continue the forwarding towards respective sonobuoys. The basic idea of the greedy forwarding strategy is, in each hop, to advance the packet towards some surface sonobuoy.The neighbor candidate set is determined as follows. Let ni be a node that has a packet to deliver, let its set of neighbors be and the set of known sonobuoys $S_i(t)$ at time t. We use the packet advancement (ADV) metric to deter-mine the neighbors able to forward the packet towards some destination.

4.3.4 Next-Hop Forwarder Set Selection

GEDAR uses opportunistic routing to deal with under-water acoustic channel characteristics. In traditional multihop routing paradigm, only one neighbor is selected to act as a next-hop forwarder. If the link to this neighbor is not performing well, a packet may be lost even though other neighbor may have overheard it. In opportunistic routing, taking advantage of the shared transmission medium, each packet is broadcast to a forwarding set composed of several neighbors. The packet will be retransmitted only if none of the neighbors in the set receive it. Opportunistic routing has advantages and disadvantages that impact on the network performance. OR reduces the number of possible retransmissions, the energy cost involved in those retransmissions, and help to decrease the amount of possible collisions. However, as the neighboring nodes should wait for the time needed to the packet reaches the furthest node in the forwarding set, OR leads to a high end-to-end latency.

V. SIMULATION & RESULTS

The simulation result shows the nodes present in the communication network.

The proposed and evaluated the GEDAR routing protocol to improve the data routing in underwater sensor networks. GEDAR is a simple and scalable geographic routing protocol that uses the position information of the nodes and takes advantage of the broadcast communication medium to greedily and opportunistically forward data packets towards the sea surface 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.

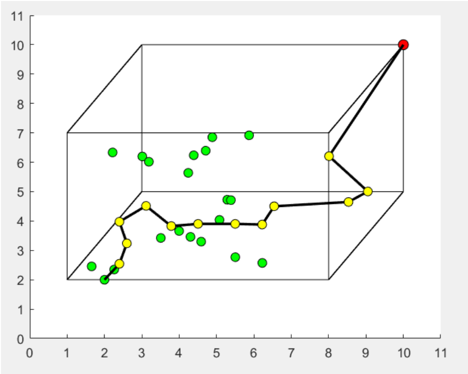


Fig: 5.1 Nodes in the network

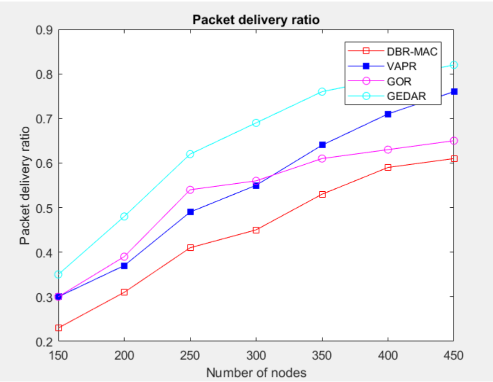
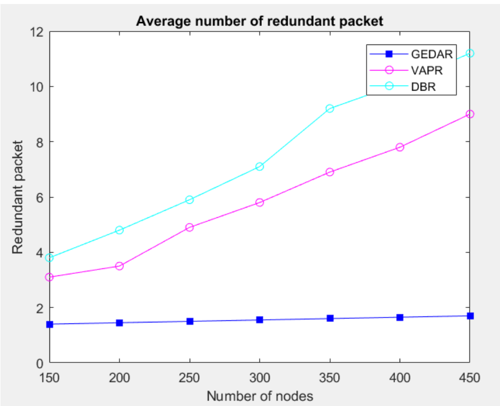


Fig: 5.2 Packet delivery ratio



Fig; 5.3 Average number of redundant packet

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.

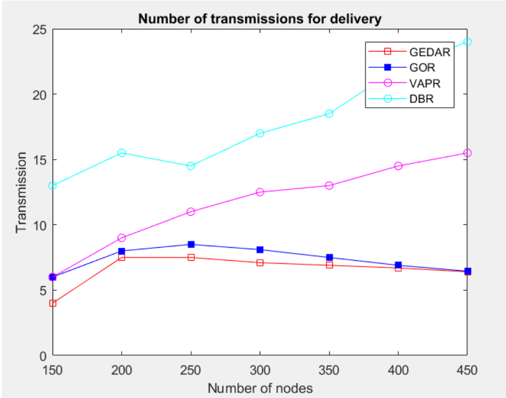


Fig: 5.4 Number of transmissions for delivery

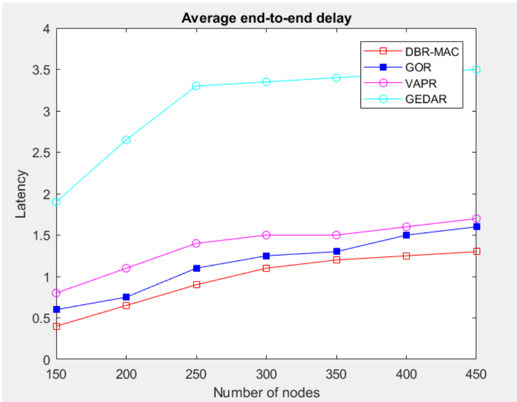


Fig: 5.5 Average end-to-end delay

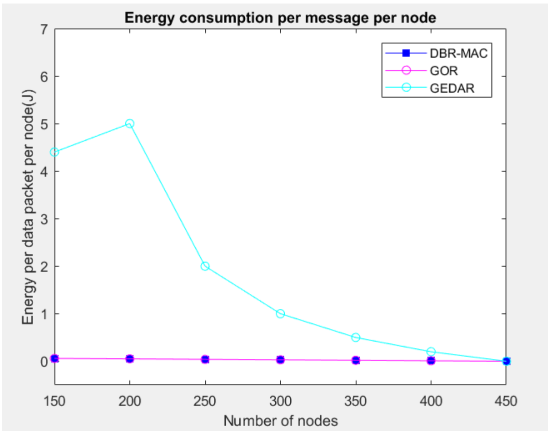


Fig 5.6 Energy consumption per message per node

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 to 58 percent for medium density scenarios as compared with GUF and reduces these nodes to approximately 44 percent as compared with GOR. Consequently, GEDAR improves the network performance when compared with existing underwater routing protocols for different scenarios of network density and traffic load.

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