IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Special Issue || Dec. 2019 || PP 31-38
International Conference on Management Practices, Innovations & Research 2019

Geographic and Opportunistic Routing for Underwater Wireless Sensor Network

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Abstract: *Underwater Wireless Sensor Network (UWSN) as it is emerging to be a promising mechanism for discovering the underwater environment efficiently. Geographic routing is considered the promising routing protocol for UWSNs. Geographic routing relies on geographic position information, hence the data packets are sent using its geographic location of the destination instead of the destination network address. Geographic routing protocol suffers from a drawback called communication void region. The basic idea of DBR is to forward data packets greedily towards the water surface. To maintain explicit paths to route data along communication void regions. These approaches cause an overload in the underwater acoustic channel leading to excessive packets collisions. GEDAR uses the greedy forwarding strategy to advance the packet, at each hop, towards the surface sonobuoys. GEDAR overcomes the problem of the void region by depth adjustment technology. GEDAR removes the void nodes through depth adjustment topology controlling mechanism. 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. GEDAR improves the network performance when compared with existing underwater routing protocols. GEDAR improves the network performance when compared with existing underwater routing protocols for different scenarios of network density and traffic load.*

I. Introduction

Underwater Wireless Sensor Network (UWSN) is emerging to be a promising mechanism for discovering the underwater environment efficiently.It is atype of ad hoc networks that have been suggested as a powerful technology for monitoring lakes, rivers, seas, andoceans. UWNS are self-organized network, which consists of sensors that perform collaborative monitoring tasks over a body of water. UWSNs are used for scientific, military and commercial applications. The data collected by the sensor nodes are sent to sink and then gets forwarded to the base station through radio waves. Electromagnetic waves, optical waves and acoustic waves have been successfully used in UWSNs. Radio waves are affected by high attenuation in water, thus requiring high transmission power. Optical waves are rapidly scattered and absorbed in water. Acoustic waves help communications over long distance as they have relatively low absorption. As shown in Fig. 1 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 [1]. It will transfer the data from sonobuoy to monitoring centre. UWSNs consist of one or more sink nodes and lots of sensor nodes. The sink nodes are deployed on the surface of water with the help of the floating buoy or the anchor. The sink nodes are equipped with both acoustic and radio (e.g., Wi-Fi or Satellites) transceivers. These sink nodes use acoustic modem for communication with the sensor nodes to receive the data packets, while they can communicate with each other by radio links to forward the data packets collected from sensor nodes to the onshore data centre or the research ship.

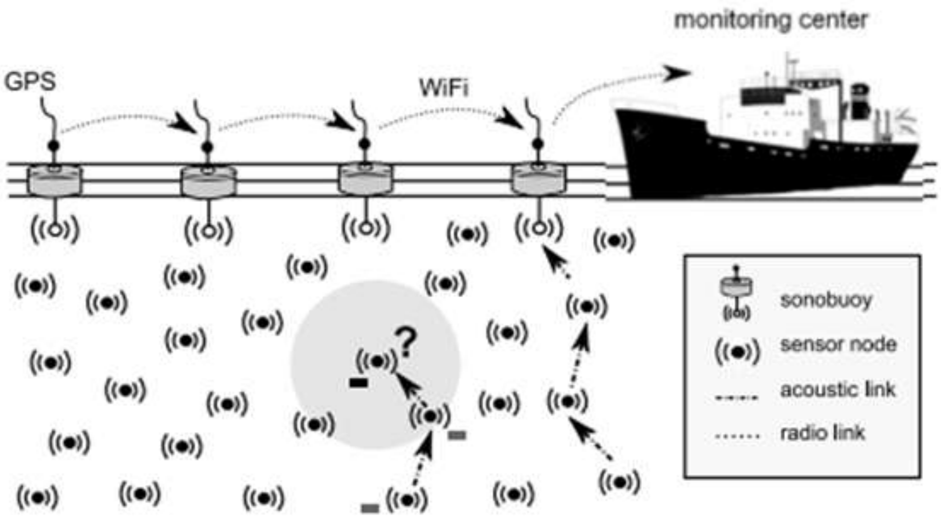

fig 1 Architecture of UWSN [1]

Geographic and Opportunistic Routing Protocol

The process of forwarding data from source nodes to a sink when nodes are mobile is a very challenging task and the major concern is to save energy and to handle the node mobility. Geographic routing[2] is considered the promising routing protocol for UWSNs. Geographic routing relies on geographic position information, hence the data packets are sent using its geographic location of the destination instead of the destination network address. Geographic routing also called as position based routing. It does not require the establishment or maintenance of complete routes to the destinations. There is no need to transmit routing messages to update routing path status. Route decisions are made locally. At each hop, a locally optimal next hop node which is the neighbour closest to the destination is selected to continue forwarding the packet.

In opportunistic routing[3], each packet is broadcast to a forwarding set composed of several neighbours. The packet will be retransmitted only if none of the neighbours in the set receive it. Opportunistic routing work together with geographic routing to improve delivery. It reduces the number of possible retransmission, energy cost involved in that retransmission and helps in decreasing the number of possible collision.

Void Nodes

Geographic routing protocol suffers from a drawback called communication void region[4]. Void means some area of network might not occupy with node. Void node may be formed by cluster of nodes whose energy is depleted or whose components are physically destroyed. It may also be generated by some obstacles of radio signals or blocks where no node exists in the forwarding region of a node. The void node is determined when node fails to forward data packets. The communication void region occurs whenever the sender is the closest one to the destination and cannot send the packet directly to it. The node located in a communication void region is called void node. It is somehow manageable to overcome the problem of communication void nodes through the use of message transmission procedures for discovery and to maintain explicit path to reach the destination.

To maintain explicit paths to route data packet along communication void regions. These approaches cause an overload in the underwater acoustic channel leading to excessive packet collisions. Moreover, as the number of hops increases when data packets are routed along paths with void nodes. These approaches leads to high end to end delays, low data packets delivery ratio and high delays lead to losses to real time water applications.

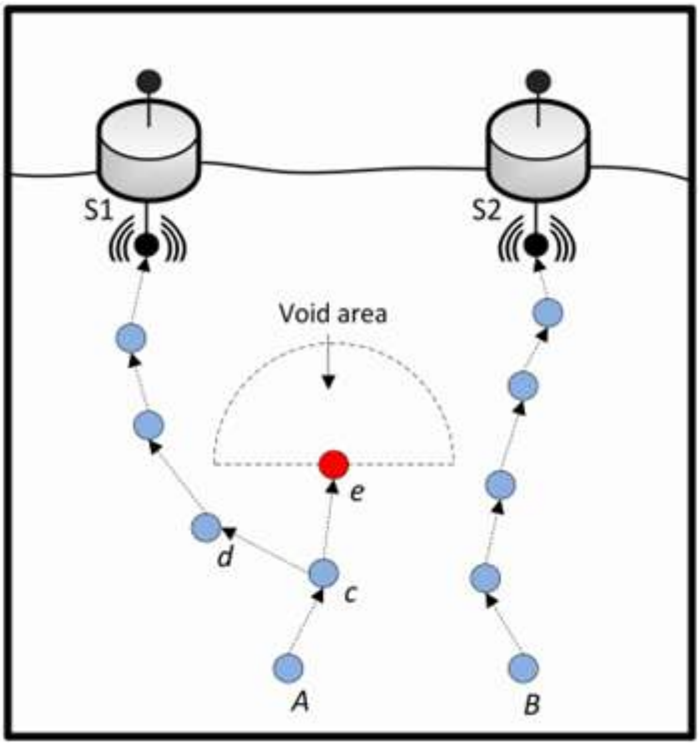

Fig2 Void area with respect to destination S1 and S2[4]

As depicted in Fig 2, node e is a void node since it has no neighbouring node closer to the sinks S1 and S2 than itself. Thus, in a greedy-forwarding strategy, the packet is dropped if node e is selected as the next forwarding node instead of node d, which has a valid path to a sink. Without resolving this issue, data packets may drop in the network, wasting the network resources such as energy and bandwidth. Moreover, the void problem is more challenging as it is unpredictable as to when and where a void may occur due to dynamic nature of operating environment.

Classification of Routing Protocols for UWSN

There are various routing protocols used in underwater wireless sensor network[5]. Fig 3 summarized various mechanism used for existing routing protocols. Routing protocols can be classified as data-centric, hierarchical and location based according to the network structure.

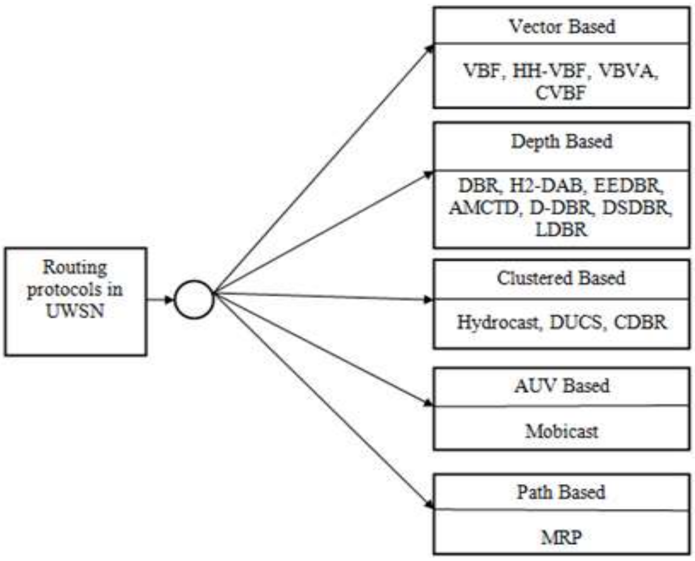

Fig 3 Classification of Routing Protocols for UWSN

Depth-based routing (DBR) protocol [6] is an opportunistic routing protocol for underwater sensor network, which provides good performance both under high and low node mobility scenarios. DBR protocol is the first underwater sensor network routing protocol that uses node depth information to route data packets. DBR does not require full dimensional location information of sensor nodes. Instead, it needs only local depth information, which can be easily obtained with an inexpensive depth sensor that can be equipped in every underwater sensor node.

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. 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. After the holding time, the packet is broadcast if the node has not received the same data from a neighbour. The impacts of nodes movement on the void area have not been investigated thoroughly.

Problems in Existing System

The problems in existing system are as under:

- This can be expensive in terms of energy since the high energy cost of underwater acoustic communication and the impairments of the acoustic channel.
- Moreover, as packets will be routed through more hops to circumvent the communication void region, the acoustic channel can be overloaded, increasing the average end-to-end delay and reducing the packet delivery ratio due to more collisions and retransmissions.
- The impacts of nodes movement on the void area have not been investigated thoroughly in the literature. The void area is continuously reshaped or move with the water current. The void-handling techniques also suffer from lack of a realistic model for node mobility.

Geographic and Opportunistic routing with depth adjustment-based topology control for communication recovery (GEDAR)

Geographic and opportunistic routing with depth adjustment-based topology control for communication recovery (GEDAR) [7]. Geographic based protocol leverage the location information of sensor nodes to forward packets from a source node to a destination node. Geographic routing has been proposed for wireless adhoc and sensor network. It does not need any establishment and end to end routing path. GEDAR is a 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. GEDAR overcomes the problem of the void region by depth adjustment technology. GEDAR removes the void nodes through depth adjustment topology controlling mechanism [8]. GEDAR moves the void node through new selection of depth with greedy forwarding algorithm.

GEDAR takes the advantage of greedy opportunistic forwarding to improve data delivery ratio. A greedy opportunistic forwarding strategy applied for next hop forwarder selection. The main is to advance the packet towards some sonobuoys in each hop. With the capabilities of depth adjustment, the problem of void region can be addressed. Therefore the connectivity between the source node and the sink can be ensured. GEDAR is geographic and opportunistic protocol that tries to deliver a packet from a source node to some sonobuoys. It uses 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 packets when it get stuck at a void node.GEDAR overcomes the problem of the void region by depth adjustment technology. The proposed routing protocol employs the greedy forwarding 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.

Recovery Mode

A recovery mode procedure [9] based on the depth adjustment of the void node is used to route data packet when it get stuck at a void node. In the recovery mode, the void node changes its status, stops beaconing, sends a void node announcement message to announce its void node condition to the neighborhood and schedules the procedure to calculate its new depth. When a neighbor node receives a void node announcement message, it removes the sender from its neighbor table and from the updated neighbor table, determines whether it is a void node or not. If the receiver node will not be a void node, it replies the received message with a void node announcement reply message containing its location information and the location of its neighbors. Otherwise it will start the void node recovery procedure.

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.

The impacts of nodes movement on the void area have not been investigated thoroughly. The void area is continuously reshaped or move with the water current. With a cross-layer design [10], the number of collisions can be managed more efficiently over the MAC layer, while the results of some tasks, such as beaconing, can be shared between layers. Dealing with a void area within a geocast region is a challenging issue. The existing model involves many relay nodes to cover the geocast region with a larger area. Hence, we design the new void-handling techniques to further decrease the number of involving nodes.

Modules Description

In our simulations, 32 sensor nodes are deployed and the number of sonobuoys is 6. They are randomly deployed in a region the size of 2265 X 1000.

1. Neighbors Candidate Set Selection

Whenever a sensor node has a packet to send, it should determine which neighbours are qualified to be the next-hop forwarder. GEDAR uses the greedy forwarding strategy to determine the set of neighbours 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 neighbour candidate set is determined as follows. Let ni be a node that has a packet to deliver, let its set of neighbours be and the set of known sonobuoys Si(t) at time t. We use the packet advancement (ADV) metric to deter-mine the neighbours able to forward the packet towards some destination. The packet advancement is defined as the distance between the source node S and the destination node D minus the distance between the neighbours X and thus, the neighbour's candidate set in GEDAR is given as:

$\mathbf{Ci} = \{\mathbf{n_k} \in \mathbf{N_i}(\mathbf{t}): \exists \mathbf{s_v} \in \mathbf{Si}(\mathbf{t}) |\ \mathbf{D}(\mathbf{n_i}, \mathbf{s_i^*}) - \mathbf{D}(\mathbf{n_k}, \mathbf{s_v}) > 0\}$, [10]

Where D (a, b) is the Euclidean distance between the nodes a and b and $\mathbf{s_i^*} \in \mathbf{S_i}(\mathbf{t})$, is closest sonobuoy of ni as:

$\mathbf{s_i^*} = \mathbf{argmin}_{\forall \mathbf{s_j} \in \mathbf{s_i(t)}} \{ \mathbf{D}(\mathbf{n_i}, \mathbf{s_j}) \}$, [11]

2. Next-Hop Forwarder Set Selection

GEDAR uses opportunistic routing to deal with under-water acoustic channel characteristics [12]. In traditional multi hop routing paradigm, only one neighbour is selected to act as a next-hop forwarder. If the link to this neighbour is not performing well, a packet may be lost even though other neighbour 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 neighbours. The packet will be retransmitted only if none of the neighbours in the rest receive it. Opportunistic routing has advantages and dis-advantages that impact on the network performance. It 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 neighbouring nodes should wait for the time needed to the packet reaches the furthest node in the forwarding set. For each transmission, a next-hop forwarder set F is determined. The next-hop forwarder set is composed of the most suitable nodes from the next-hop candidate set Ci so that all selected nodes must hear the transmission of each other aiming to avoid the hidden terminal problem.

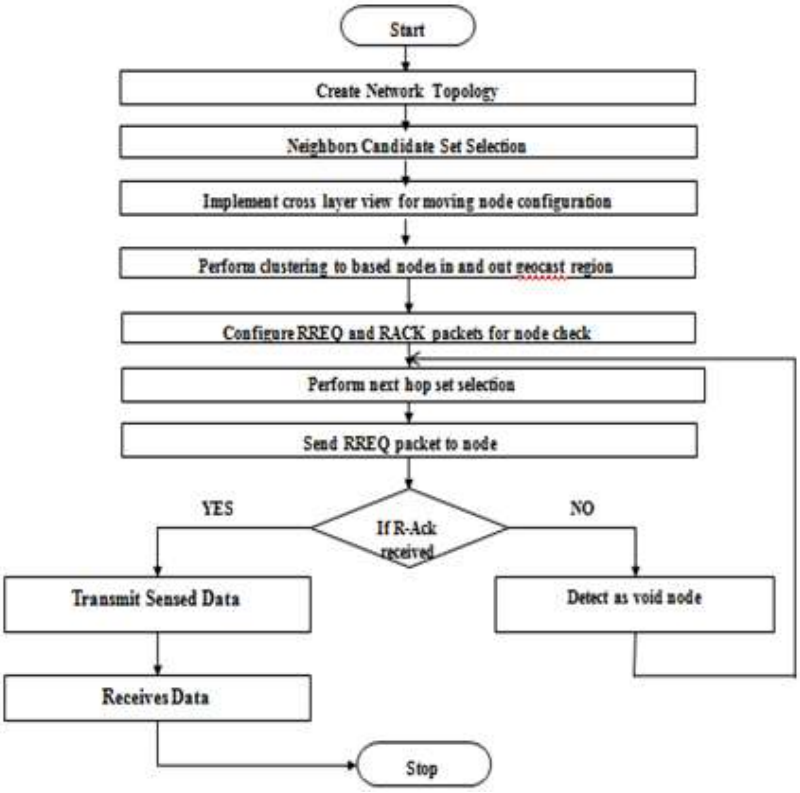

Fig 4 Proposed Workflow Diagram

Result Analysis

This section depicts the simulation analysis of the proposed model which evaluates the difference between DBR routing protocol 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 analyses the performance of GEDAR protocol in terms of the packet delivery ratio, end-to-end delay, energy consumption .The simulation results are explained below:

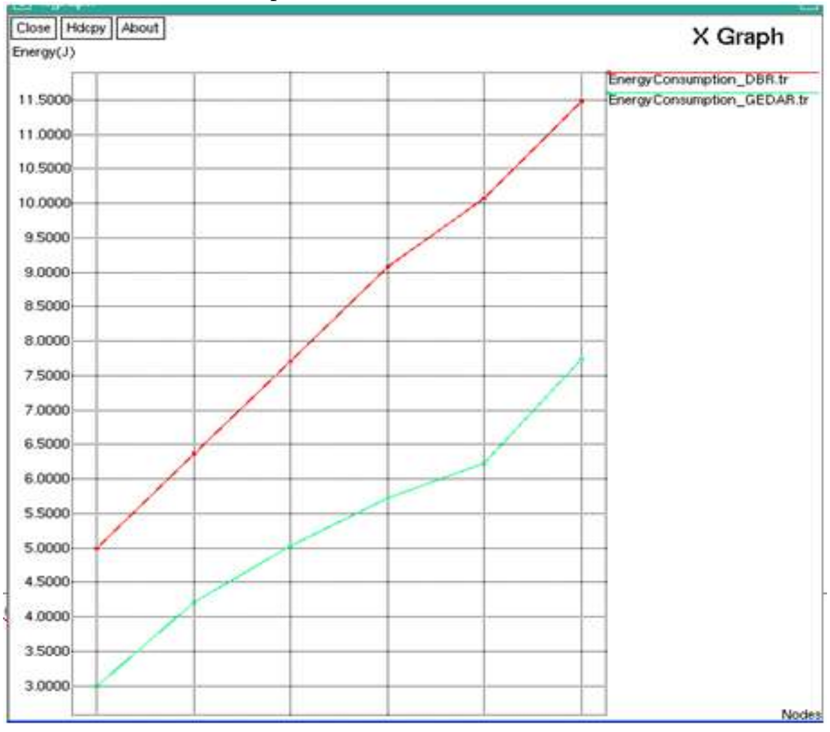

Fig 5 Energy Consumption Ratio

The energy per delivered data packet per node is presented in fig 5 GEDAR consumes less energy as compared to DBR routing protocol. Energy consumption is defined as the energy consumed by each nodes in the underwater environment. It is measured in mill joules (mj). Selecting a large radius may involve many nodes in packet forwarding moreover, it cause increases duplicated packets, which at the end leads to more energy waste. On the other hand, lower radius causes more packet failures. To desire this, in dense networks, the number of forwarding nodes has been slightly raised or held constant by GEDAR, to control the energy dissipation. Fig. 7.1 presents the energy consumption per node with different node densities.

Fig 6 Packet delivery ratio

The packet delivery ratio (PDR) is presented in fig. 6 the overall trend for all protocols is an increase in PDR when the network density increases. In GEDAR, the packet delivery ratio is better than DBR. This happens due to the use of depth adjustment-based topology control mechanism proposed to deal with communication void regions. In this new methodology, the underwater channel is not overloaded with extra transmissions of control and data packets to discover and maintain explicit paths to circumvent void regions, resulting in less interference. DBR presented the lower packet delivery ratio due to the lack of communication void region recovery procedure

Fig 7 End to end delay

Fig. 7shows the average end-to-end delay. Average End-to-End delay is defined as the average delay time taken for packet creation and successful delivery of packets to the destination node. The average end-to-end delay for all protocols decreases by increasing the number of nodes, because the forwarding node can find more qualified nodes in its neighbourhood. This feature of GEDAR increases its delay despite the use of reachability information. Furthermore, in GEDAR, each node can hold a packet with less average holding time due to the fact that candidate nodes are closer to each other on average.

II. Conclusion and Future Scope

In this system we work on recovery and detection of void nodes. We review some routing protocols of underwater wireless sensor network. We enhance the performance of routing protocol during packet delivery with cross layer design. And investigate the impact of nodes movement because ofvoid nodes. We work on geocast region to further decrease the number of involving nodes. We proposed GEDAR routing protocol to improve the data routing in underwater sensor networks. Furthermore, GEDAR improves the network performance when compared with existing underwater routing protocols. It will make the depth adjustment of void nodes. 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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