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Survey on Geographic Routing Protocols in Underwater Wireless Sensor Network

Sandhya M, Noella Michael Baretto, Vijayalaxmi R Patil

***Abstract*— Unlike Terrestrial Wireless Sensor Network(TWSN), Underwater wireless sensor network(UWSN) have different characteristics such as narrow bandwidth, long propagation delay and high packet loss. Hence, routing protocols used for terrestrial sensor network are not applicable in underwater network. This paper presents a detailed survey of geographic routing protocols used in underwater wireless sensor network and are compared based on their requirements and performance.**

***Index Terms*— Acoustic Communication, UWSN, Routing Protocols, BASE_ANGLE, Vector Pipe**

I. INTRODUCTION

More than 70% of the earth surface is covered by water. Wireless Sensor Network(WSN) are the distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, etc., it enables wireless communication, sensing and automation and pass their data to all the other desired location via the network. WSN has become a very powerful technique for many applications.

Underwater environment is much different from terrestrial as underwater wireless sensor network consists of number of sensors that perform a desirable task over a given area. TWSN operate in an environment dominated by radio frequency communication [5]. Yet, it is not an optimal communication channel for underwater applications because RF wave propagation is limited in underwater.

Underwater network communication uses acoustic technology. Acoustic communication is a technique of sending and receiving the message below water [3]. Underwater communication is difficult due to multi-path propagation variations and small bandwidth. In underwater communication there are low data rates compared to terrestrial communication, since underwater communication uses acoustic waves, instead of electromagnetic waves. Acoustic communication offers longer range but it has a limitation due to error rate, bandwidth capacity and temporary losses of connectivity.

II. GEOGRAPHIC ROUTING PROTOCOLS IN UWSNS

Routing is a major issue for any network. Routing protocols discover and maintain the routes during the transmission of data packets. This section, discusses major geographic routing protocols for underwater environment.

A. Vector based forwarding routing protocol(VBF)

VBF (vector based forwarding) is the first routing protocol proposed for underwater sensor networks. In UWSN, the VBF protocol will access the position information of each node by creating vector pipe from source to destination to find the forwarder.

Fig.1 illustrates the basic idea of VBF. Node S1 is source and S0 is destination. Routing vector is given by $\overline{S1S0}$. Data packets are forwarded from S1 to S0. Forwarders along the routing vector form a routing pipe with a pre-controlled radius (i.e., W in the figure). If a node determines that it is close to the routing vector, it puts computed position in the packet and continues forwarding the packet. Otherwise, the packet is discarded. In this way in sensor network all the packets are forwarded from "routing pipe" [9].

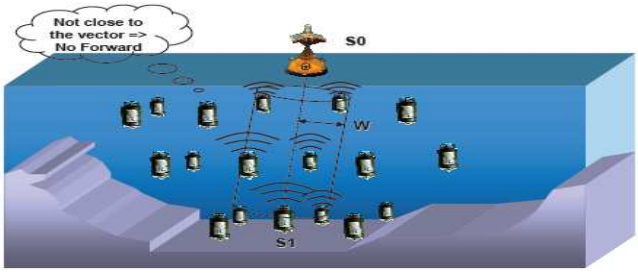

Fig.1: View of VBF in UWSN.

B. Hop- by- Hop VBF(HH-VBF)

In order to increase the robustness and to overcome the problems of VBF, an enhanced version of VBF called HH-VBF has been proposed [8]. Same concept of routing pipe is used here, but instead of single routing pipe, HH-VBF defines a per hop virtual pipe for each forwarder. HH-VBF can find data packets as long as single node is available within the communication range.

C. Focus beam routing protocol (FBR)

In order to decrease the unnecessary flooding [6],FBR protocol was proposed for acoustic network. In this technique, every node has its own location information and the source node knows about the information of the destination. Routes are established dynamically during the traversing of the data packet.

Sandhya M, M.Tech Students, Dept of ISE, DR.AIT, Bangaluru, India
Noella Michael Baretto, M.Tech Students, Dept of ISE, DR.AIT, Bangaluru, India
Vijayalaxmi R Patil, Assistant Professor, Dept of ISE, DR.AIT, Bangaluru, India

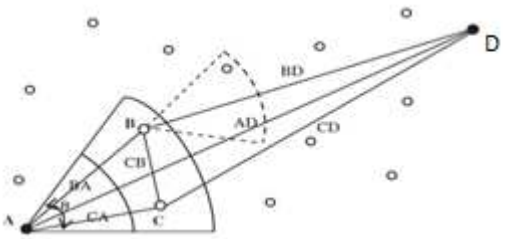

Fig 2: Illustration of FBR routing protocol

Fig 2 shows the data forwarding technique used in FBR. Node A has a data packet that needs to be sent to the destination D. Node A multicasts a RTS (request to send) packet to all neighboring nodes at the lowest power level. When all the nodes that receive RTS packet, it will calculate location to the line AD. After the calculation, the nodes that lie within ±θ/2 are considered as next hop candidates.FBR assumes that the destination is fixed and its location is already known, which reduces the flexibility of the network.

D. Directional flooding routing protocol(DFR)

The existing routing protocol does not guarantee data delivery. In order to increase the reliability [4], DFR protocol was proposed. It assumes that every node knows about its location, location of one hop neighbor and the location of the final destination.

In Fig 3, flooding zone is decided by angle between FS and FD, where F is forwarding node, S, D are source and destination node respectively. After receiving the packet, F finds the forwarding packet dynamically by comparing with angle called BASE_ANGLE which is included in the received packet. This angle helps to find a flooding zone dynamically.

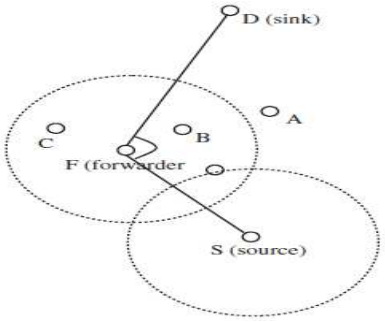

Fig 3: An example of packet transfer in DFR

E. Depth based routing protocol(DBR)

For location based routing techniques, full dimensional location information of the sensor nodes are needed. Instead DBR [7] requires only the depth information of the sensor nodes. When a node has to send a packet, it will calculate its depth position and the value will be placed in the header of the packet to be transmitted. The receiving node will calculate its current depth position and forwards the packet if its depth is smaller than the value embedded in the packet. Otherwise the packet is discarded. Forwarding of packet in broadcast fashion causes performance degradation of the network.

F. Sector based routing with destination location prediction(SBR-DLP)

Most of the existing routing scheme assumes that the destination is fixed and its location is already known to all the nodes in the network. This assumption may not be suitable for fully mobile networks. In [2], a routing algorithm called SBR-DLP is proposed which helps to route a data packet in a fully mobile underwater acoustic network, where the intermediate nodes and destination can be mobile. The SBR-DLP is a location-based routing protocol where sensor nodes need not to carry neighbor information. It is assumed that every node knows its own location information and pre-planned movement of destination nodes. Data packets are forwarded to the destination in a hop-by-hop fashion in order to avoid flooding.

G. Hop by hop dynamic address based routing protocol(HH-DAB)

Most of the routing protocols proposed for UWSNs require some special network setups, while some protocol asks for special hardware like every node should be equipped with depth or pressure sensor, which increases the cost of the network. By considering these issues, the authors in [1] have proposed a dynamic addressing based routing protocol H2-DAB, which solves the problem of continuous node movements. Dynamic addresses are used for sensor nodes, so that sensor nodes will get new addresses according to their new positions at different depth intervals. In this technique, multiple surface buoys are used to collect the data at the surface. Remaining nodes are deployed at different depth levels from the surface to the bottom. Nodes nearer to the surface sinks have smaller addresses, and these addresses become larger as the nodes go down towards the bottom.

H. Location based Clustering Algorithm for Data Gathering (LCAD)

A clustering algorithm based on the geographical location of the sensor nodes in 3-DHierarchical network architecture called LCAD have proposed in[10].

In this protocol, the entire network is divided into 3-dimensional grids as shown in Fig 4. The vertical transmission range is around 500 m; the size of each grid is set approximately to30mx40mx500m.A grid comprises of a single cluster. The data communication is composed of three phases:

(i) Set-up phase ,where the cluster head is selected.

(ii)Datagatheringphase,wheredataissentbythenodesinthecl ustertothecluster head.

(iii)Transmission phase, where the data gathered by the cluster heads is transmitted to the base station.

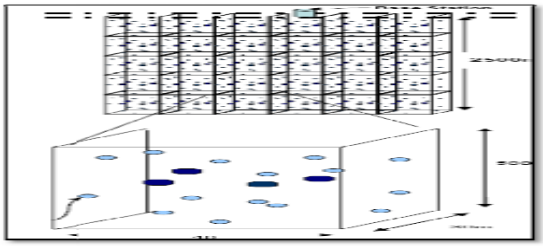

Fig 4: Architecture used in LCAD protocol with the projection of a single grid.

I. Reliable and Energy Balanced Algorithm(REBAR)

Reliable and energy balanced algorithm routing (REBAR)[11] is a location based routing protocol that

focuses on energy consumption, delivery ratio and handling void problem. Sphere energy depletion model is used by REBAR to analyze the energy consumption of no desin UWSNs.

The routing process of REBAR consists tha technden the network has a constrained radius which is concerned with its distance to sink .The source calculates a directional vector from its destination. The packet is assigned with a unique identifier(ID), which is composed of the source ID and a sequence number. Each receiver maintains a buffer to record the ID of recently received packets.

In order to ensure that the packets are forwarded towards the sink, the following scheme is adopted. When a neighboring node of the source node receives a packet for the first time, it first compares its distance to sink width. It drops the packet if (di−d) is greater than a threshold. This comparison ensures that packets are transmitted in the right direction. If the calculated distance to the vector v by the receiver is larger than its constrained radius, the packet is dropped. Otherwise, the receiver forwards the packet. Fig.4 depicts the illustration of the routing process of REBAR.

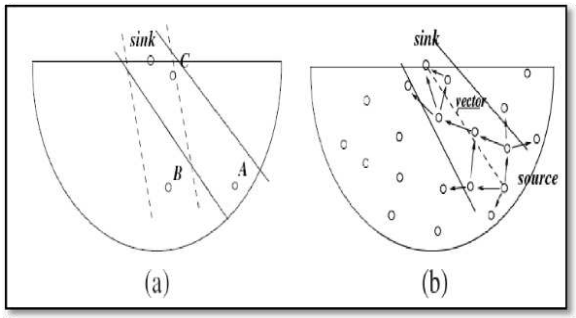

Fig 5: Routing process of REBAR

III. COMPARISON BETWEEN THE GEOGRAPHIC ROUTING PROTOCOLS

Protocol	Energy Efficiency	Delivery Ratio	End to End/ Hob by Hop	Delay	Packet overhead
VBF	Medium	Medium	End to End	Medium	Low
HH-VBF	Medium	High	Hop by Hop	Medium	Low
FBR	Medium	Medium	Hop by Hop	High	Medium
DFR	Medium	Medium	Hop by Hop	Medium	Low
DBR	Medium	Medium	Hop by Hop	Medium	Low
SBR-DLP	High	Medium	Hop by Hop	High	Low
HH-DAB	High	Medium	Hop by Hop	High	Low
LCAD	High	High	Hop by Hop	Low	Low
REBAR	High	High	Hop by Hop	Low	Low

IV. CONCLUSION

All protocols designed for wireless sensor networks have the common objective of maximizing the network lifetime. Most of the protocols require the location information of the nodes to calculate the distance. In this paper an overall view of the UWSN and different geographic routing protocols has been presented depending on their requirements and they can handle dynamic network.

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