Optimization Routing Schemes for Ultra low Power Consumption in Underwater Sensor Network

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ABSTRACT- Energy efficiency is a central challenge in sensor networks, as battery replacement is costly and often difficult in inaccessible deployment regions, So in this paper, we first completely analyzes the basic vector based forwarding protocol and depth based routing protocol, then proposed a new routing protocol. To save energy we use beacon- enabled mode (sleep mode) using IEEE 802.15.4. Simulation results using MATLAB are shows that the proposed routing protocol significantly reduces energy consumption and increase the packet delivery ratio of the underwater sensor networks compared to the VBF and DBR protocols.

Keywords--- Acoustic Communication, UWSN, routing protocol, energy efficiency

I.INTRODUCTION

Underwater acoustic sensor networks (uw-asn) consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring task over a given area. To achieve this objective, sensors and vehicles self-organize in an autonomous network which can adapt to the characteristics of the ocean environment.

Major challenges in the design of underwater Sensor networks are [1]:

- The available bandwidth is severely limited.
- The underwater channel is severely impaired, especially due to multi-path and fading.
- Propagation delay in underwater is five orders of magnitude higher than in radio frequency (RF) terrestrial channels, and extremely variable.
- High bit error rates and temporary losses of connectivity (shadow zones) can be experienced, due to the extreme characteristics of the underwater channel
- Battery power is limited and usually batteries cannot be recharged, also because solar energy cannot be exploited.
- Underwater sensors are prone to failures because of fouling and corrosion.

Currently, many routing protocols are available for terrestrial wireless sensor networks. However, specific properties of underwater medium make existing routing protocols inappropriate for under water. The main challenges in developing efficient routing protocols for underwater environments are:

- High propagation delays: The radio signals do not work efficiently in under water and this problem encourages use of acoustic communication instead. The main problems with the acoustic channel, however, are low bandwidths and long propagation delays.
- Node mobility: Due to water currents, nodes can fluctuate or move if they are not anchored at the bottom of the sea. This situation results in a dynamic network topology. Moreover, autonomous underwater vehicles and robots used for exploration and controls can be utilised to route and mulling data.
- Error prone acoustic underwater channels: Since the acoustic channels have very low bandwidth capacity, they suffer from high bit error rates.
- Limited energy: Like in terrestrial wireless sensor networks, majority of sensor nodes

The paper is organized as follows: A brief introduction with related works of terrestrial sensor network and underwater sensor networks protocols is presented in Section II. In Section III describes the design of our novel proposed protocol in detail. Simulation and results are discussed in Section IV. Finally, conclusions are made in Section V.

II.RELATED WORK

In this section, we review some typical routing protocols in terrestrial sensor networks and underwater sensor networks.

A. Routing in Terrestrial Sensor Networks

In last few years, many energy efficient routing protocols have been proposed for terrestrial sensor networks, such as Directed Diffusion [11], Two-Tier Data Dissemination [24], GRAdient [25], Rumor routing [4], and SPIN [9]. In the following, we brief these protocols and discuss why they are not suitable for the underwater sensor network environments.

Directed Diffusion is proposed in [11]. In the target application scenario, the sink floods its interest into the network, and the source node responds with data. The data are first forwarded to the sink along all possible paths. Then, an optimal path is enforced from the sink to the source recursively based on the quality of the received data. Directed Diffusion works well in low dynamic networks, where most nodes are stationary and forwarding paths are relatively stable. However, if we apply Directed Diffusion in UWSNs, it will consume a large amount of resource (including energy) to maintain the forwarding paths due to node mobility.

In the Rumor routing algorithm [4], both event notifications and data queries are forwarded randomly. The successful data delivery depends on the chance that these two types of forwarding paths interleave. In stationary networks, it is most likely that these paths will meet since they are relatively stable. However, in underwater sensor networks, this is unlikely to happen. Even in networks with low mobility, the instability of forwarding paths is worsen by the low propagation speed of acoustic signals.

SPIN (Sensor Protocol Information via Negotiation) is proposed for low data rate networks [9]. When a node wants to send data, it broadcasts a description message of the data, and each neighbour decides whether to accept the data based on its local resource condition. Once again, the high propagation delay in UWSNs makes this protocol's throughput low. Moreover, flooding in SPIN depletes the energy of the network, especially for medium or high data rate networks.

TTDD (Two-Tier Data Dissemination) addresses the problem caused by mobile sinks. [24] In this protocol, the source sensor initiates the process to construct a grid covering the whole field. Data and queries are forwarded along the cross points in the grid. The impact of the sink mobility is confined within each cell. When most nodes in the network are fixed, it costs less energy to maintain the grid. However, the overhead to maintain the grid will increase significantly when most nodes are mobile (for example, in UWSNs).

GRAdient broadcast is a robust data delivery protocol proposed in [25]. In GRAdient, a cost field is built in the whole network by the sink, which has the lowest cost. Data packets are forwarded along the direction from higher cost nodes to lower cost nodes. The width of the path is controlled by the credits of each packet. In this way, GRAdient improves robustness. However, in UWSNs where sensor nodes are mobile, the protocol will consume a large amount of scarce energy to update the cost field in order to keep relatively accurate paths from the source to the sink.

In short, the routing protocols for UWSNs have to address the node mobility issue at minimum energy expenditure. However, existing routing protocols designed for terrestrial sensor networks can not satisfy this requirement.

B. Underwater acoustic sensor network routing protocols

Providing scalable and efficient routing services in underwater sensor networks is very challenging due to the unique characteristics of UWSNs. Some routing protocols have been proposed to address the challenging problem in UWSNs. However, most of them assume that the full-dimensional location information of all sensor nodes in a network is known in prior through a localization process, which is yet another challenging issue to be solved in UWSNs. We also give a brief review on VBF, DBR to lay the foundation for our proposal.

VBF

Vector-Based Forwarding (VBF) protocol addresses the node mobility issue in a scalable and energy-efficient way. VBF is Geographical routing protocol i.e., each node selects its next hop based on the position of its neighbours and of the destination node. In VBF, each packet carries the positions of the sender, the target and the forwarder (i.e., the node which forwards this packet). The forwarding path is specified by the routing vector from the sender to the target. Packets are forwarded along redundant and interleaved paths (routing pipes) from a source to a destination node, being robust against packet loss and node failure. Jointly with the routing strategy, a localized and distributed self-adaptation algorithm is proposed to enhance the performance of VBF. This algorithm allows the nodes to weigh the benefit of forwarding packets, reducing energy consumption by discarding low benefit packets. [2]

DBR

DBR well utilizes the general underwater sensor network architecture: data sinks are usually situated at the water surface. Thus based on the depth information of each sensor, DBR forwards data packets greedily towards the water surface (i.e., the plane of data sinks). In DBR, a data packet has a field that records the depth information of its recent forwarder and is updated at every hop. The basic idea of DBR is as follows. When a node receives a packet, it forwards the packet if its depth is smaller than that embedded in the packet. Otherwise, it discards the packet. Obviously, if there are multiple data sinks deployed at the water surface, as in the multiple-sink under-water sensor architecture, DBR can naturally take advantage of them. Packets reach any of the sinks are treated as successfully delivered to the final destination since these water-surface sinks can communicate with each other efficiently through radio channels, which have much higher bandwidths and much lower propagation delays. [5]

III.PROPOSED PROTOCOL

In this section we describe the proposed routing scheme which is used to reduce the energy consumption of the nodes near the sink. It will try to enhance the reliability and effectiveness of data routing in the network since the underwater wireless link is error-prone and the long acoustic communication duration makes retransmission very ineffective. It is an improvement of VBF. Basic concept is same as in VBF. The distance from source to sink is calculated & routing pipe will be created in the direction of sink which is nearer to source. In this technique radius of pipe is not constant but in VBF routing pipe radius is constant. In proposed routing scheme, routing pipe will be narrow near the sink so that less number of nodes involved in the transmission near the sink. That's why it balance the energy consumption of nodes and PDR increases of whole network.

PROPOSED ALGORITHM

1. Let L*B*H be the cubic volume of water body representing wireless sensor network
2. Let following be the traffic calculation parameters
- P_S=Size of packet
- P_N=No. of packets
- Sum P_S=Sum of packet send at any given time 't'
- Sum P_R= Sum of packet received at any given time 't'
- Sum P_D= Sum of packet dropped at any given time 't'
- PDR=Ratio of packet received to packet send
- PLR=100-PDR
3. Let following be the energy consumption parameters
- E_{TX}=energy in sending
- E_{RX}=energy in receiving
- E_{BX}= energy in backend circuitry
- E_{IX}= energy in ideal
4. 4.Let following be the parameters to be used for distance calculations
- C=0.5,Gamma=0.2,d_{max}=30,r_{max}=10
5. 5.For loop each sensor node in water body
6. For loop each sensor node in network service area
7. While total energy > 0
8. if residual energy of source > 0
9. Do distance calculation as follows.
- Distance between source node and sink
- Distance between each node and sink
- Calculate dynamic threshold as follows:

$$r_{ns} = (1-c*(1-\gamma)*(d_{max}-d_{ns})/ d_{max})* r_{max}$$

$$thr_{ns}=\beta(\sqrt{d^2_{ns}+ r^2_{ns}}- d_{ns})$$

where d_{ns}=distance between node to sink

10. if Distance between (d_{ns}-d_{sos}) is less than dynamic threshold.
- d_{sos}= distance between source node to sink
11. Check active and sleep mode
- If (active mode=true)
- Continue transmission
- Else
- Send Beacon message to all nodes that are not in routing path
12. calculate traffic i.e PDR,PLR
13. calculate energy consumption
14. end
15. end
16. end
17. end
18. end

IV. Simulation and results

In this section, we evaluate the performance of the proposed approach through the simulations in MATLAB We compare the proposed protocol with VBF, DBR protocols. The simulation parameters used in the experiment is shown in Table I.

TABLE 1

Parameters	Values
Routing protocols	VBF, DBR, Proposed protocol
Network area	100m*100m*100m
No. of nodes	250
Routing pipe radius	25m
Transmission range	20m
Topology	Mesh
Traffic type	CBR
Packet size	2 byte
Data rate	250kbps

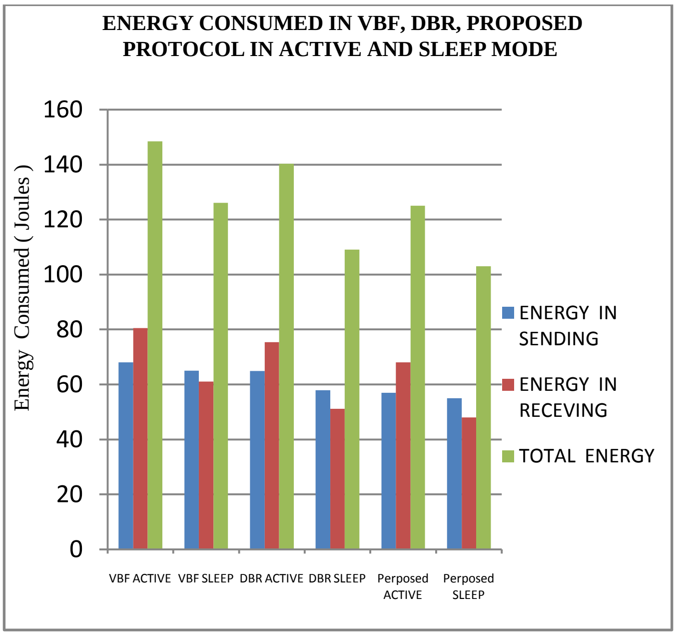

Fig 2 Graph of energy consumed by VBF, DBR, and Proposed Algorithm

Fig 2 represent the total energy consumed by VBF, DBR and proposed protocol to transfer data to sink. In packet transmission total energy consumed by VBF active is 148.5j, by VBF sleep is 126.1j, by DBR active is 140.28j, by DBR sleep is 109.06j & by proposed protocol active is 125j, by proposed protocol sleep is 103j. DBR consume less energy than VBF because it uses five sinks over the surface so data will reach to sink by changing less number of hops. Proposed protocol Consume less energy than VBF and DBR because it uses adaptive radius of routing pipe. Also show sleep mode consume less energy in all protocols compared to active mode.

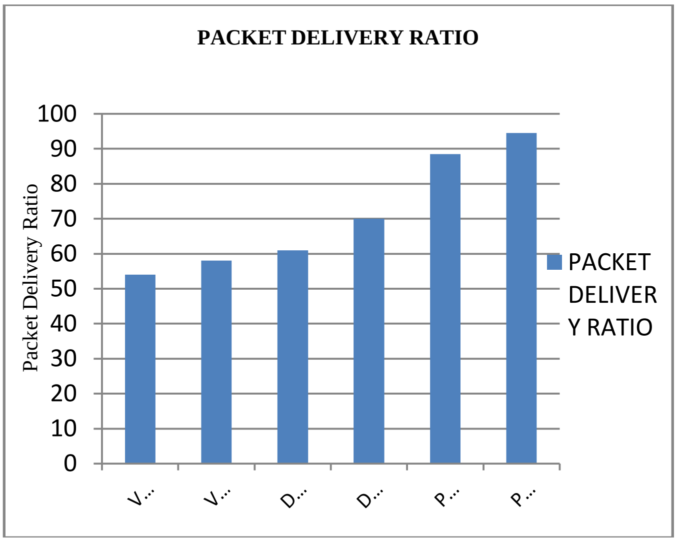

Fig 3 Graph of Packet Delivery Ratio of VBF, DBR and Proposed Algorithm

Fig 3 Show PDR in active and sleep mode of all protocols. It is clear from the following fig. PDR increases more in proposed protocol compared to VBF & DBR

V. CONCLUSION AND FUTURE SCOPE

Conclusion

We have implemented three routing protocols VBF, DBR and Proposed Protocol.VBF is the first effort to apply the geo-routing approach in underwater sensor network. It consumes more energy than DBR because it changes large number of hops to transmit data from source to sink. In VBF header field is also large in size. So actual data to transfer is of small size in packet. DBR consume less energy than VBF because it uses 5 sinks over the surface. Proposed Protocol increase the PDR and Reduce the energy consumption. Comparatively to VBF and DBR.

Future scope

This work can be extended to deal with moving nodes and for better results in terms of energy efficiency. It can be implemented with nano sensors.

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