

ABSTRACT

The advance of the Internet of Underwater things, smart things are deployed under the water and form the underwater wireless sensor networks (UWSNs), to facilitate the discovery of vast unexplored ocean volume. A routing protocol, which is not expensive in packets forwarding and energy consumption, is fundamental for sensory data gathering and transmitting in UWSNs. To address this challenge, this paper proposes Enhanced CARP (E-CARP), which is an enhanced version of the channel-aware routing protocol (CARP) developed to achieve the location-free and greedy hop by-hop packet forwarding strategy. In general, CARP does not consider the reusability of previously collected sensory data to support certain domain applications afterward, which induces data packets forwarding which may not be beneficial to applications. Besides, the *PING-PONG* strategy in CARP can be simplified for selecting the most appropriate relay node at each time point, when the network topology is relatively steady. These two research problems have been addressed by our E-CARP. Simulation results validate that our technique can decrease the communication cost significantly and increase the network capability to a certain extent.

KEYWORDS: Energy efficient routing protocol, underwater wireless sensor networks

I. INTRODUCTION

All content should be written in English and should be in 1 column.

The advance of sensing technologies, sensor networks have been used to support widespread domain applications, and underwater wireless sensor networks (UWSNs) has recently been attracted significant attention and considered as a promising alternative to explore the underwater environment. The smart underwater physical objects, called sensor nodes, are sense and record current and historical information about underwater environment. In fact, the knowledge about the underwater environment is negligible compared with that of land. Since the ocean plays more and more important roles in human's life, discovering the vast unexplored ocean volume becomes critical and urgent from the last decades. Generally, smart underwater physical objects, called sensor nodes, sense and record current and historical information about underwater environment. These underwater objects interconnect with each other, and forward sensory data to the sink nodes, which are usually son buoys on the water surface. These underwater objects interconnect with each other, and forward sensory data to the sink nodes.

The world-wide network of smart interconnected underwater objects establishes the Internet of Underwater Things (IoUT) to collaboratively study the vast unexplored ocean volume. IoUT supports applications in scientific, industrial, military, home security, and other domains. Different from terrestrial WSNs [6],[11], acoustic signals, rather than radio frequencies, are adopted in UWSNs for wireless communication [5] which suffers from limitations including long and variable propagation delay, narrow bandwidth, slow power signal attenuation, high error rate, noise etc. Therefore, link quality is an important factor to be considered when forwarding packets to sink nodes [2].

A routing protocol, which is not expensive in packets forwarding and energy consumption, is fundamental for sensory data gathering and transmitting in UWSNs. Therefore, to address this challenge, proposes Enhanced CARP (E-CARP), which is an enhanced version of the channel-aware routing protocol (CARP) use, to achieve the location-free and greedy hop-by-hop packet forwarding strategy. In general, CARP does not consider the reusability of previously collected sensory data, while E-CARP allows the caching of sensory data at the sink

node, for avoiding extra data packets forwarding in the network. Besides, the PING-PONG strategy in CARP can be simplified using proposed E-CARP by broadcasting EPING control packet for selecting the most appropriate relay node.

This means that packets routing in an end-to-end manner may not be energy efficient when the network topology may change frequently and dramatically, while greedy hop-by-hop routing is assumed as a more appropriate strategy [8]. Therefore, this paper aims to propose a location-free and energy efficient routing protocol, where packets are forwarded in a hop-by-hop fashion from source sensor nodes to the sink node. As presented in the Channel-Aware Routing Protocol (CARP) [4], “in the quickly varying conditions of the underwater channel, fact that two nodes can exchange short control packets correctly, may not be sufficient to guarantee that longer data packets are also going to be safely delivered”. Generally, CARP is a location free and greedy hop-by-hop routing protocol, whose performance is proved better than FBR [12]. Therefore, sensory data may not need to be forwarded to the sink node always at every time point. Taken these into consideration, we propose E-CARP, which is an enhanced version of CARP, to provide a more energy efficient routing protocol in UWSNs. Generally, Enhanced CARP (E-CARP) tries to avoid the forwarding of control packets when selecting relay nodes, and to reduce the routing of sensory data packets to the sink node. These strategies may decrease the energy consumption when the environment to be monitored is relatively steady

II. ECARP PROTOCOL

This section introduces E-CARP, which is an enhancement upon CARP, to develop a location-free and greedy hop-by-hop routing protocol for forwarding packets from sensor nodes to the sink node in an energy efficient manner.

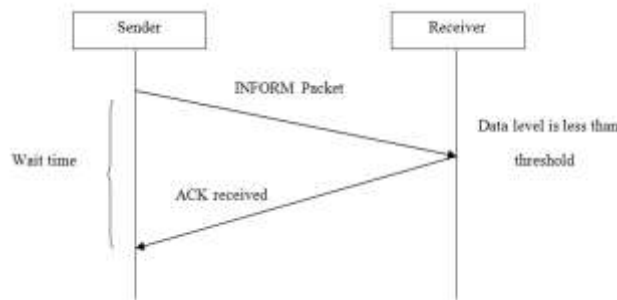


Fig.1. Control Packet Forwarding

Case I

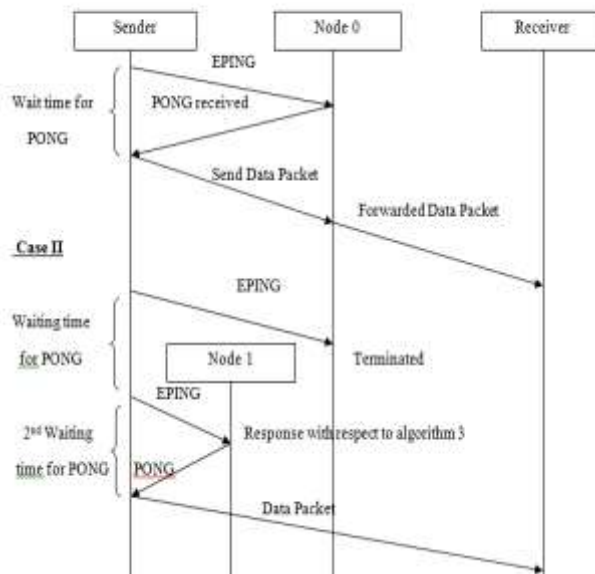


Fig.2. Relay Node Selection and Data Packet Forwarding Strategy

Specifically, Section A. introduces the network initialization and the sensory data cache scheme in the sink node. Section B presents control and sensory data packets forwarding strategy, and Section C. proposes the relay node selection mechanism for forwarding packets.

A. Network initialization:

- The network is initialized and hop counting is computed for all sensor nodes.
- At the network initialization stage, no packets have been forwarded

B. Control & Data Packets Forwarding:

- The threshold is pre-determined according to the requirement of certain applications.
- Sensor node detects its sensory data which is required to be routed to a relay node only when the bias between sensor data and the value cached at sensor node is more than the pre-specified threshold.
- Otherwise INFORM control packet is forwarded to relay node and acknowledged ACK control packet is expected to be returned from the relay node.
- If ACK has not been received within certain time duration, then INFORM control packet should be resend.

C. Relay Node Selection:

- When the monitored ocean volume is relatively steady and the network topology does not change significantly, a sensor node which was chosen as the relay node at the preceding time point is highly possible to be the relay node at this moment.
- After network initialization every sensor node replies a PONG control packet when sensor node broadcasts a PING control packet and relay node is selected according to sensor nodes replying PONG control packets.
- EPING is broadcasted to neighboring sensor node and it contains two additional fields, which is different from the PING control packet.
- The sensor node determines whether a PONG control packet should be replied or not, upon received EPING for appropriate selection of relay node.

III. IMPLEMENTATION AND EVALUATION

For underwater communication world oceanographic simulation system (WOSS) libraries are required which includes shallow water, fading channel, losses model. Installation of WOSS is done along with NS-2 miracle & dessert. We have established link between various combinations of nodes for UW communication testing purpose. Script is written for testing CARP & ECARP routing protocol.

Steps for script are:-

1. Load all underwater libraries.
2. Set routing protocol and MAC layer for UW communication.
3. Configure node and declare nodes with their positions in ocean.
4. Establish CBR connection.
5. Establish end to end connection.
6. Start application.
7. Evaluate performance.

Environment Setting

During the simulation following parameters or environment setting is used-

Table 1-Environment settings

Sr	Parameter & Specification	Setting
1	Routing protocol	CARP protocol & ECARP Protocol
2	MAC	Underwater CSMA Aloha
3	No of nodes	10,20,30,40,50
4	Packet size(bytes)	125 bytes
5	Rate of CBR(seconds)	60s.
6	Frequency	25KHz
7	Bandwidth	5KHz

Experimental Evaluation

Table 2-Node wise analysis for Packet delivery ratio-

FOR PDR		
No of Nodes	CARP	ECARP
10	54.64	68.30
20	55.8792	71.64
30	36.3125	43.75
40	27.1016	35.66
50	23.4314	29.66

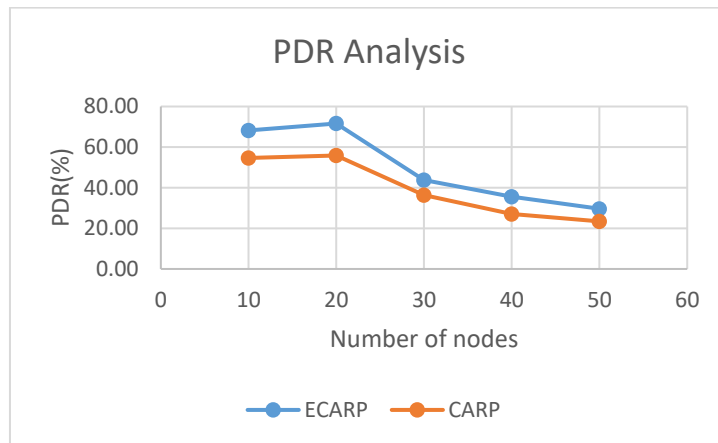
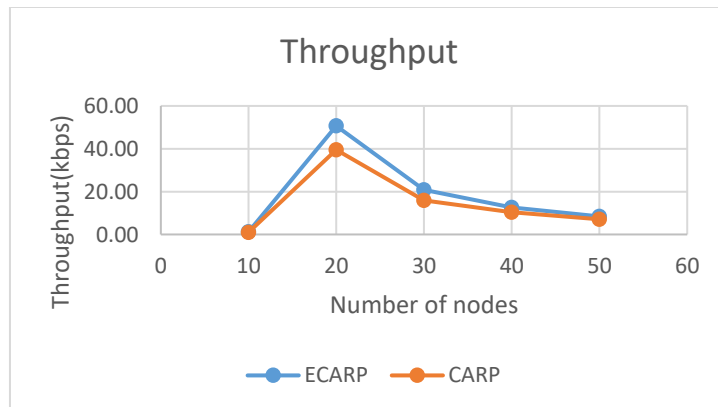


Fig.1. Comparison of Packet delivery ratio (PDR) between two protocols i.e. ECARP & CARP. This figure shows that the energy consumption decreases to a certain extent, when the no of nodes increases.

Table 3-Node wise analysis for throughput -

For	Throughput	
No of Nodes	CARP	ECARP
10	1.008	1.26
20	39.5226	50.67
30	15.8536	20.86
40	10.3074	12.57
50	7.0135	8.45



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 ICTTM Value: 3.00

Fig.1. Comparison of Throughput between two protocols i.e. ECARP & CARP. This figure shows that the performance is better in ECARP than CARP protocol. When no of nodes increases mean throughput decreases. But ECARP protocol is better than CARP protocol.

IV. CONCLUSION

The advent of the Internet of Underwater Things, smart things form underwater wireless sensor networks (UWSNs), for gathering and transmitting sensory data to the sink node. CARP does not consider the reusability of sensory data collected previously by domain applications in the following time points, which induces sensory data packets forwarding which may not be beneficial to certain applications. Therefore, E-CARP allows the caching of sensory data at the sink node, for avoiding these data packets forwarding in the network. CARP requires to reply a *PONG* control packet whenever receiving a *PING* control packet, when selecting the most appropriate relay node for packet forwarding. In this paper we compare ECARP & CARP Protocols. These are evaluated for various network parameters and among those parameters we find out performance on the basis of Throughput and Packet Delivery ratio (PDR).

Throughput is defined as the total no of packets delivered over the total simulation time, and throughput increase when network connectivity is better.

Packet delivery ratio (PDR) is the ratio of actual packet delivered to total packets sends.

Simulation results validate that our E-CARP can decrease the communication cost and increase the network capability to a large extent, especially when the ratio of packet size between control packets and sensory data packets is relatively large.

V. REFERENCES

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