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Review

Routing protocols based on protocol operations for underwater wireless sensor network: A survey

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ABSTRACT

Underwater Wireless Sensor Network (UWSN) is the well interesting area for research community due to its versatile applications like: ocean monitoring, underwater mineral extraction, tactical surveillance, marine internal wild life, offshore explorations and ocean monitoring. Majority of the researchers have used deployment and topological structure of the terrestrial Wireless Sensor Network (WSN) for UWSN but almost these kinds of structures are failure due to the environmental conditions of underwater environment. This research article covers the dynamic structure, route discovery, route maintenance and data forwarding mechanisms of routing protocols based on protocol operations. This research further covers the analytical analysis and numerical simulations results of the routing protocols based on protocol operations and will guide to the researcher to further research in the area of routing protocols.

Contents

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1. Introduction

Recently the Underwater Wireless Sensor Network (UWSN) area is the major focus of research community due to its versatile applications like: ocean monitoring, marine internal wild life, underwater mineral extraction, and offshore exploration [1–4]. The sensor device collects the information from the bottom of the sea water and transfer that information to the sink nodes deployed on the water surface and sink nodes further transfer that data to the onshore data center for further rectification [5–8]. The underwater sensor network resembles with the terrestrial networks, when we differentiate between UWSN and terrestrial wireless sensor network; the UWSN exhibits some unique individualities like: acoustic communication, high bit error rate, limited storage power of sensor devices, low bandwidth and high latency [9–12]. Radio Frequency (RF) signaling is not feasible for underwater wireless sensor network due to attenuation [13]. The acoustic signaling is a better solution for underwater environment because acoustic signaling speed is 1500 m/s [14]. However underwater sensor network faces the many more challenges like: acoustic signaling has the limited bandwidth due to the water current, dynamic network topology due to the node movement on water pressure, effect on acoustic channel due to path loss, noise and Doppler spread and link between sensor nodes remain highly prone [15].

The above discussed challenges also creating the complexity to design the routing protocol in underwater environment. Majority of the researchers have designed the routing protocols like: location based, localization free, multipath, geographic, clustered based, routing protocols based on mobility and routing protocols based on protocol operations. This research article covers the routing protocols which are based on protocol operations; the category further classified into table driven, source initiated and data aggregation. This research article will help the researchers to find proper gap to promote further such kind of category. This survey article further consists on: Section 2 covers the background and literature review, Section 3 covers the analysis through analytical method, Section 4 covers the analysis through numerical simulation method, Section 4 covers the open research issues, and Section 5 is the conclusion and future work.

2. Background and literature review

The design of routing protocol in underwater environment is the complicated task because in underwater environment the static topology is not valid due to continuous movement of water. The design of dynamic topology is the best solution in underwater environment; however the dynamic topology also faces the serious issues due to the water current and limited bandwidth of acoustic channel [16–20]. Majority of the researchers have designed the routing protocols based on dynamic topology but still the research is needed to resolve the many more problems. This article focuses the issues of routing protocols based on protocol operations; which is further classified into source initiated, table driven and data aggregations. The classification is listed below:

i. ICRP
ii. LASR
iii. Pack Cloning
iv. TCBR
v. H2-DAB
vi. Multi-path VS
vii. DUCS
viii. Multi Sink

2.1. Information carrying routing protocol (ICRP)

ICRP is source initiated and table driven routing protocol [21]. The authors claimed that the ICRP is energy efficient, scalable and real time routing protocol which carries the control packets for information sharing through data packets. This routing protocol is localization free and only small numbers of sensor nodes are involved in the routing. In ICRP the source node is responsible for route discovery mechanism through data packets, if the route is not established the source node will carry the data packets with route discovery message. When all the nodes will receive this message than these nodes will also establish the reverse route for the acknowledgement, when source node will receive the acknowledgement through reverse route than the successful packets delivery will be considered. The use of routes depends on time priority and if the route is not used for transmission is called the route life time. If the route life time remains larger means it is valid or even remain unused. The route life time validity is depend upon TIMEOUT; if the threshold exceeds the TIMEOUT the route will become invalid.

The ICRP faces some serious issues: (i) in underwater environment the architecture given by authors' is not valid due to continuous movement of water. (ii) If the intermediate nodes have not the route information than these nodes will transfer the data packets to the destination and in resultant the destination will not accept the data packets and in resultant the drop of the packets will occur and also the energy level of these nodes will also be wasted. (iii) In underwater environment due the water pressure the route may be broken within 2 to 3 sec.

2.2. Location-aware routing (LASR)

LASR is the location based routing protocol and the revised form of the DSR (Dynamic Source Routing) protocol [22]. The LASR is the source initiated routing protocol and based on protocol operation. The LASR protocol has used the two extra methods; one is the location awareness and second is the link quality metric. In location awareness method; the authors have designed the local network topology which uses the implicit information for transmission. The local network topology consists on tracking system and time-of-flight for range and transmission process. The authors have also used the TDMA technique for medium access control. The link quality metric uses the DSR for hop count and powerful computational methods are adapted for the improvement of link quality. LASR has used the robust link quality for hop count, the link quality is consists of two end points, link quality metric and time stamp. The link quality has also used the Expected Transmission Count (ETX). The ETX can be calculated as given in Eq. (1).

$$\mathrm{ETX} \triangleq \frac{1}{(1-\mathrm{FER})^2}. \tag{1}$$

In Eq. (1) FER denotes the Frame Error Rate. The link quality protocol header is consists on octal 12-bit. The time stamp factor is used for new data link. LASR also guarantees for state less link type data can correctly be discarded through some mechanism. LASR has used the five protocol options for node forwarding; the functionality of protocol options is described below.

a. ***Explicit acknowledge***: When LASR sent a message or protocol option that must be acknowledged; this acknowledgement process is called *explicit acknowledgement*.
b. ***Route request:*** On arrival of packets the *route request* option will carries a route along with link quality and time stamp from originator to the last hop.
c. ***Route reply:*** It carries the route qualities and time stamp analogous to DSR.

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