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Energy Efficient Mobicast Protocol for Underwater Sensor Networks

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ABSTRACT: Underwater Wireless sensor networks (UWSN) consist of a variable number of Sensors and Vehicles that are deployed to perform collaborative monitoring tasks over a given area. Sensors and vehicles are self-organize in an autonomous network which can adapt to the characteristics of the ocean environment. In this limited energy of the sensors and the ocean current are the major issues. The Autonomous underwater vehicles (AUV) form a series of zones with the nearby nodes and travel a predefined path to collect the details in each zone. To save power only the sensors in the current zone is wakeup and all other sensors are in the sleep mode. This method involves the following two steps. First Autonomous underwater vehicles gather messages from nodes within 3D zone of reference. After that they wake up the sensor nodes in the next 3D zone which is called the zone of forwarding (ZOF). For this wakeup purpose all the sensors in the intersection area of the nearby zone are used which consumes more energy and lead to message overhead. The proposed work aims to a energy efficient mobicast protocol with dynamic head node to wakeup the sensors in the corresponding zone. This reduces the number of messages used for the wakeup the sensors in the next zone. The simulation results from AquaSim provides empirical analysis and energy efficiency of sensor nodes.

KEYWORDS: Underwater wireless sensor networks, routing, mobicast protocol, energy

I. INTRODUCTION

In an Underwater Sensor Network an arbitrary number of sensors are geographically distributed under the ocean in a given area to collaboratively collect and relay data to a centralized sink. Such networks are used for time sensitive applications such as disaster prevention, coastline protection, etc. and for time-insensitive applications such as monitoring of habitat counts, ocean temperature and carbon dioxide levels. These sensors are battery operated. Since they are not easily accessible after deployment, recharging or replacing their batteries is difficult. Hence minimizing energy usage across all layers in the protocol stack becomes essential for such networks.

Underwater sensor networks are different from terrestrial wireless sensor networks (WSN) in many aspects. Underwater sensor networks consist of a set of floating sensor nodes whereas in WSN the sensor nodes are static. The topology of underwater sensor network is changeable due to ocean current. The topology of wireless sensor network is stable. The propagation delay of underwater sensor network is longer when compared to that of the wireless sensor network. Underwater sensor network is deployed under three dimensional plane whereas wireless sensor network are deployed on a two dimensional plane.

The underwater sensor network to monitor the environmental parameters under seawater. Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System is used that provides improved location accuracy. The remotely operated vehicles which are controlled from the ship or AUV which can navigate to deep water autonomously based on a given set of rules or instruction. Here the sensors, anchors and ROV/AUV collect information from seabed and report to operation vessel.In the underwater sensor networks directly transmitting the sensed data to the control station on the ocean surface takes a long routing path and always results in inaccurate sensed data due to the hole problem. To improve the accurate sensed data the AUV is used. The AUV travels a predefined path and collect data from the sensor nodes and report to the control station. The Autonomous Underwater vehicles rely on local intelligence. It is Less dependent on communications from online shores. The AUV Control strategies (autonomous coordination obstacle prevention).

A new multicast communication paradigm called "spatiotemporal multicast" or "mobicast" was recently investigated in wireless sensor network. The mobicast is a Routing protocol based on mobility to improve throughput and efficiency. In this the Autonomous underwater vehicle gathers messages from nodes within 3D Zone of reference in the first step. After that they wake up sensor nodes in the next 3D zone avoiding topology holes. In the underwater sensor networks the sensor nodes are not stable. They move and change their location due to wave and ocean current. The information from these sensors are not collected by AUV which results in inaccurate sensed data.This problem is called as hole problem and it can be overcomed by expanding the zone based on the speed and current location of the sensor nodes.

II. RELATED WORK

Underwater Wireless Sensor Networks (UWSNs) are built up of sensor nodes that are deployed in an underwater environment and are capable of monitoring their nearby. Sensor node is a small device having limited energy stored in form of battery and has limited memory. The main work of sensor node is to sense the data from its surroundings and process that data with the help of sensing unit and processing unit respectively and to manage the energy dissipated for all such processes and units with the help of power unit. A spatiotemporal characteristic of a mobicast is to forward a message to all nodes that will be present at time t in the forwarding zone .Yuh-Shyan Chen .[1] proposed a mobicast routing protocol which is used to avoid the hole problem. In this paper, a geographic zone, called as 3-D zone of relevance (3-D ZOR), is prescribed by an AUV to collect sensed data from all sensor nodes located in 3-D ZOR.The AUV constructs a series of 3-D ZORs over different intervals must wake up send sensed data to the AUV. To save power and send sensed data to the AUV, sensor nodes in 3-D ZOR must be waken up and keep active mode to wait for the arrival of AUV.Stefano Basagni *et al.*[1] proposed a paper Maximizing the Value of Sensed Information in Underwater Wireless Sensor Networks. This paper presented a mathematical model and a distributed heuristic for path finding for a AUV collecting data with decaying value from nodes of a UWSN. The heuristic drives the AUV to visit the node that greedily maximizes the Value of Information of the data delivered to the sink. Our ILP model considers realistic data communication rates, distances and surfacing constraints. Yassin *et al*[2] proposed a paper explore a delay-constrained energy optimization for routing in underwater acoustic sensor networks. Specifically it propose an offline Mixed Integer Linear Programming based routing algorithm that enables computation of delay constrained energy efficient routes. This does not include TDMA schedule computation based on the optimal route-set and the investigation of a Decentralized algorithm to solve the delay-constrained energy optimization problem. Zhong Zhou *et al.*[3] proposed a Efficient Multipath Communication for Time-Critical Applications in Underwater Acoustic Sensor Networks. This paper, propose a new scheme, called multipath power-control transmission (MPT), for time-critical applications in underwater sensor networks. It combines power control with multipath routing and packet combining at the destination. Cruz *et al*[4] proposed Implementation of an Underwater Acoustic Network using Multiple Heterogeneous Vehicles. This paper describe the implementation of an underwater acoustic network to support the operation of heterogeneous systems, including AUVs, ASVs, and more devices. It does not consider about the issues of underwater sensor networks which includes energy efficiency ,propagation delay and ocean current. Pu wang *et al.*[5].

Proposed Enhancing the Reliability of Head Nodes in Underwater Sensor Networks. A check pointing scheme for the head nodes to quickly recover from a head node failure. Experimental results show that the proposed scheme enhances the reliability of the networks and makes them more efficient in terms of energy consumption and the recovery latency compared to the previous scheme without check pointing. In this Problem occurs if there is communication error between two nodes. All nodes are fixed (i.e., This paper do not consider node mobility) The failure rate (λ) is based on a Poisson distribution. Sanjay *et al.*[6] Proposed a 2-D geocast routing protocol with hole detection in USNs to provide the data dissemination in target region. The source node delivers the data to a target region using a greedy forwarding technique. When the data delivers into the target region, the first node which receives the data serves as a root to construct a multicast tree for the target region. However the routing path, the target region and the hole in a 3-D USNs are variform, which needs to be further investigated. Walker *et al*[7] Proposed a varying

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solution in the underwater environment, A traveling AUV roams around in a USN and collects sensed data from those sensor nodes, and then the AUV uploads collected data to base station. Walker shows the AUV is feasible and useful to distributed collect data in the UW environment.

III. METHODOLOGY

In the existing work sensor nodes are randomly deployed in the ocean. Sensor nodes may be drifted by ocean current. We assume each sensor node can know its location by range free localization techniques

3.1 Range free localization techniques

Range free localization technique is simple when compared to range based localization techniques. These are Hop count based schemes. It first employs a classical distance vector exchange so that all nodes in the network get distances in number of hops. Each node maintains a table and exchanges updates only with its neighbor.

3.2 Basic idea

Our mobicast protocol enables the AUV to collect sensed data in from those sensor nodes which usually stay at sleep mode for power saving in the 3-D USN; meanwhile, the hole problem and the ocean current effect are also considered. To successfully collect sensed data, the AUV delivers a mobicast message at time t to wake up all sensor nodes which will be present at time *t* +1 within ZOR3t+1. To overcome the hole problem and wake up all sensor nodes within ZOR3t+1, ZOF3t+1 is used to cover the potential 3-D hole and discover the routing paths for the mobicast message delivery.

3.3 Mobicast Routing Protocol

In this section, we describe how an AUV collects sensed data from sensor nodes with our mobicast protocol. Our mobicast protocol is split into three phases, 3-D ZOR*t* initiation phase, 3-D ZOF*t*+1 creation phase, 3-D ZOR*t*+1 collection phase.

3.3.1 3-D ZORt initiation phase

Sensor nodes located within ZOR3*t*should send the sensed data to AUV. To collect sensor data from all sensor nodes in the USN, AUV should continuously create a series ZORt at different time t.

3.3.2 3-D ZOFt+1 Creation Phase

To wake up sensor nodes located in the ZOR3t+1, ZOF3t+1 is necessary to create at time *t*. Sensor nodes within ZOF3t+1 should deliver the mobicast message to wake up those sensor nodes will be present within ZOR3t+1. To improve the successful delivery rate, ZOF3t+1 is divided into m identical segments and each segment can adaptively expand based on the network density and velocity of the ocean current to use more sensor nodes for mobicast message delivery.

3.3.3 3-D ZORt+1 Collection Phase

After all sensor nodes within ZOR3t+1 were waked up, the AUV can collect the sensed data from all sensor nodes within ZOR3t+1 at time t +1.

IV. SYSTEM MODEL

The sensor nodes are randomly deployed in the underwater sensor network. The control station should collect the sensed data from all the sensors deployed under water. The direct communication between the sensors and the

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control station takes a long routing path and results in inaccurate sensed data.The Autonomous Underwater vehicle is employed to collect data from the sensors under water. The AUV is prescribed a predefined path. The AUV forms a series of successive zones when travel through the predefined path. Since the sensors are employed with limited battery power only sensors in the current zone should be wake up and all other sensors are in the sleep mode.

In the existing system the sensors in the intersection area of the two successive zones are used to wake up the sensors in the next zone. Since the sensors in underwater changes the locations there may be a chance of more number of nodes intersection area. This results in more energy consumption for wakeup procedure and results in redundant information.

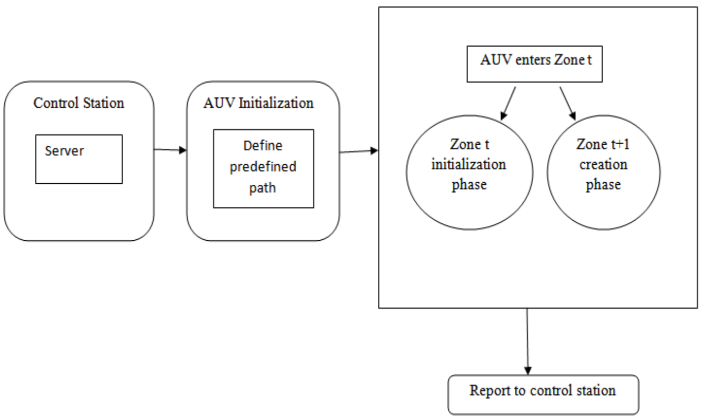

Figure 1 System Framework

In our proposed work the sensor nodes should share their location and energy level periodically. Based on the energy the node with higher energy level is chosen as the head node in each zone. The head node should always in the wakeup mode. This node is used to wakeup the sensors in that zone. This reduces the energy consumption and message overhead.

V. FRAMEWORK

5.1 Aquatic Zone formation (Model creation)

In this module the sensor nodes are deployed in the underwater environment. Among them one node should act as the AUV. Each sensor node has a location and unique ID. The sensor nodes should share their location and ID periodically with their neighbors

5.2 Swarm (Moving group) creation

In this module the sensors nodes are grouped as clusters based on their location. The AUV should travel a predefined path and collect the information from the sensors and report the result to control station. Only the sensors in the current zone should be wake up and all other sensors are in the sleep mode. The sensor nodes are wake up be the nodes in the intersection area of the two zones. The AUV should not wait for the sensors to wake up since it is continuously moving. The nodes in the zone t+1 should be wake up when the AUV is in the zone t and wait for the AUV.The AUV should report the result of all the sensor information to the control station.

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5.3 ZONET Phase (Zone expansion)

In this module the zone is expanded based on the drift speed the sensor node. The position of the sensor in the underwater sensor network is not static. Due to ocean current the position is changed. In such may be chance of hole problem in which the information from some the sensors are missed by the AUV which results in inaccurate sensed data. In order to avoid the hole problem based on the location and speed of the sensor node the zone is expanded in such a way that it should cover all the sensors in that zone.

5.4 Spatiotemporal Routing

In this module a dynamic head node is elected in each zone, The nodes in each zone periodically share their location, ID and energy level with their neighbors. Based on the energy level the node with highest energy level is chosen as the head node. The AUV first send the wake up message to the head node of the first zone. After waking up the sensor in that zone the head node send the wake up message to the head node of the next zone. This process is repeated until the AUV collect the information from the sensors in all the zones throughout its path.

5.5 Performance Evaluation

The performance is evaluated for Swarm creation and spatiotemporal Routing. The performance is evaluated in terms of energy, message overhead and throughput.

V. CONCLUSION

The energy efficient mobicast protocol is used to reduce the energy consumption of the sensor nodes in the underwater sensor network. The limited energy of the sensors and the ocean current are the major issues in underwater sensor networks. Here the Autonomous underwater vehicle is used to collect the data from sensors which are deployed in underwater. The proposed work dynamically chooses a head node with highest energy to wake up the sensors in the next zone. It reduces the number of messages used for the wake up process. In order to consume less energy the sensors in underwater will go to sleep state after the autonomous vehicle crossed the particular zone. It also overcome the hole problem due ocean current effect by expanding the adaptive segments based on the drift speed and current position of the sensor node. The performance is evaluated in terms of energy, packet delivery ratio and throughput.

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