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IMPROVED MOBICAST ROUTING PROTOCOL TO MINIMIZE ENERGY CONSUMPTION FOR UNDERWATER SENSOR NETWORKS

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ABSTRACT

Investigation of a mobicast, also called a mobile geocast, problem in three-dimensional (3-D) underwater sensor networks (USNs), which focuses to overcome the hole problem and minimizes the energy consumption of the sensor nodes while maximizing the data collection is achieved. All underwater sensor nodes are randomly distributed in a 3-D underwater environment in the sea to form a 3-D USN. Here, Considered a mobile sink or an autonomous underwater vehicle (AUV), all these possible sensor nodes which are near the AUV form a 3-D geographic zone called a 3-D zone of reference (3-D ZOR). In this, the AUV follows a user-defined route and continuously gathers data from sensor nodes within a series of 3-D ZORs for various time spans. The main problem in this is how to collect data from sensor nodes effectively within a 3-D ZOR while those sensor nodes are in sleep mode for a long period. The Mobicast routing protocol relies on mainly two phases. Out of these phases, the very first phase consists of collecting data within a 3-D ZOR. In the second most phase those sensor nodes in the next 3-D ZOR are to be wake up that are to be queried meanwhile topology holes are avoided if possible. In order to save power, only sensor nodes in a 3-D ZOR are instructed to enter the active mode in order to deliver sensed results to the AUV. To fulfil the criteria related to the characteristics of USNs, a mobicast routing protocol is developed in 3-D USNs. The design challenge for it is to develop a power-saving mobicast protocol in 3-D USNs to overcome the unpredictable 3-D hole problem. Apart from this to solve main problem named as the hole problem, an “apple slice” technique which is used to develop multiple segments to surround the hole and to assure routing path continuity.

Keywords*: Underwater wireless sensor networks, routing, WSN, Mobicast protocol .*

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1. 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 always battery operated. As they are not easily accessible after deployment, recharging or replacing their batteries is very 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 composed 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.

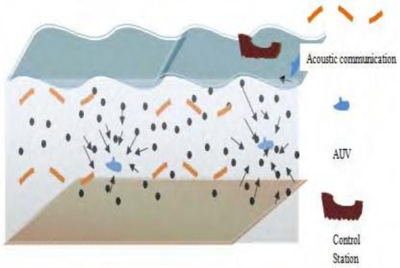

Figure 1. Underwater Wireless Network

The Sensor nodes deployed in an underwater environment intended for collectively monitoring the ocean environments. To communicate with the sensor nodes and to gather the sensed data at sink node, the underwater sensor network uses the acoustic communications because of harsh environments. Acoustic signal is the only communication medium that might work well in underwater environment. Compared to RF communications in terrestrial wireless sensor networks the sound has better dissemination characteristics in ocean environments, hence it is the most adopt proficiency for underwater communications. The USNs differ from the terrestrial wireless sensor networks in a variety of ways [13][14], such as Communication mode, Power, Expenditure, Deployment, Node Mobility, Memory, and Spatial Correlation.

The foremost threats in the creation of underwater acoustic networks are as follows [13]:

• Usually the battery powers in USNs are not rechargeable because the solar power cannot be utilized.
• The bandwidth available in marine environments is extremely low.
• Due to Ocean Current effect the network breakages are occurred.
• The Underwater Sensors are high cost because it needs extra protective sheaths and only limited suppliers.
• Long and variable propagation delays, fading and multi-path problems are occurred in USNs.
• Sensors in Underwater environments are prone to failures because of fouling, corrosion, etc.
• High Bit error rates.

Generally the AUV is equipped with communication devices used to communicate with sensor nodes which are equipped with acoustic transceivers. In USNs, the spatial and temporal communication paradigm is one major issue to collect data from sensor nodes. Hence, the spatiotemporal solution for Underwater Sensor Networks is used to maximizing the data collection while reducing the power consumption. Because of critical challenges of Underwater Sensor Networks, the data collection and power savings are most important concerns. The Mobicast or Mobile Geocast is used to deliver data with spatiotemporal paradigm, which is suitable for AUV to collect the sensed data from sensor nodes

1.1 System Model

In this work, sensor nodes are randomly deployed in the ocean. Sensor nodes are drifted by ocean currents. The AUV travels along a user-defined route with a constant velocity and collects sensed data from sensor nodes in a series of 3D ZORs. The AUV should accomplish the route before a user-defined response time, and then the AUV returns to a control station and reports the collected data. Sensor nodes usually stay at sleep mode for power saving. If the AUV wants to successfully collect sensed data, sensor nodes should be waked up first. Since the AUV should accomplish the route before the user-defined response time, the AUV cannot stop its movement to wait for a sensor node to wake up. Hence, sensor nodes should be waked up first while the AUV is approaching. This is, sensor nodes located at right place and at right time should be waked up to send sensed data. Define 3D ZORt (3D zone of relevance) and 3D ZOFt+1 (3D zone of forwarding). Let Ni denote as the ID of a sensor node, where i = {1, 2, ..., i, i + 1, ..., n}. The 3D ZORt is a geographic zone created by the AUV at time t to indicate which sensor node should send the sensed data to the AUV.

Definition 3D ZORtor ZOR3 t (3D zone of relevance): Given an AUV, 3D ZORt is a 3D spherical region determined by AUV at time t, such that sensor node Ni must transmit the sensed data to AUV at time t, where Ni is located within the 3D ZORt. The center location of 3D ZORt is the same with the location of AUV, moving at the same speed as AUV, and toward the same direction with AUV.

1.2 Basic Idea

To ensure that sensor nodes within ZOR3 t+1 can be waked up for sensed data delivery, two steps are used. The first step is to determine the size of ZOF3 t+1. A large size of ZOF3 t+1 can overcome the hole problem and achieve higher successful delivery rate but consumes much power. On the other hand, a small size ZOF3 t+1 may not overcome the hole problem. Therefore, the size of ZOF3 t+1 should be carefully considered. To overcome the 3D hole in ZOR3 t+1, the drifted distance of sensor nodes is the major concern. ZOF3 t+1 should be capable of covering a sensor node even if the sensor node is drifted by the ocean current. Therefore, the size of ZOF 3 t+1 is determined by the velocity of ocean currents and the network density. The size of ZOF3 t+1 is equal to the size of ZOR3 t+1if there is no ocean current in ZOF3 t+1. If there exists an ocean current in ZOF3 t+1, the size of ZOF3 t+1 is enlarged to cover the drifted sensor nodes based on the velocity and direction of the ocean current If the network density is getting lower in ZOF3 t+1, ZOF3 t+1 expands to a larger size to cover more sensor nodes for route discovery. Thus, mobicast routing protocol used to dynamically estimate the accurate ZOF3 t+1 to successfully deliver mobicast messages to wake up all sensor nodes in ZOR3 t+1 for data collection. The hole problem and the ocean current effect are also taken into consideration.

2. 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. 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 wake 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 an 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. Puwang 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 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.

3.METHODOLOGY

In the existing work sensor nodes are randomly deployed in the ocean. Sensor nodes may be drifted by ocean current. 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, it describe how an AUV collects sensed data from sensor nodes with our mobicast protocol. Our mobicast protocol is split into three phases, 3-D ZORt initiation phase, 3-D ZOFt+1 creation phase, 3-D ZORt+1 collection phase.

i. D ZORt initiation phase
Sensor nodes located within ZOR3tshould 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.

ii. 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.

iii.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.

4.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 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

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intersection area. This results in more energy consumption for wakeup procedure and results in redundant information.

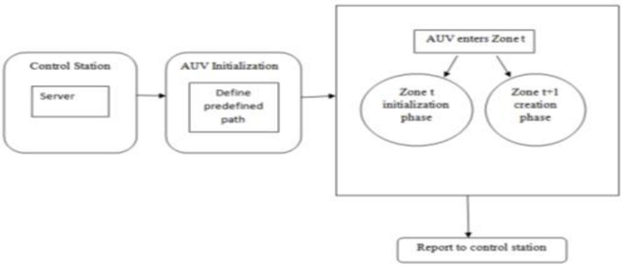

Fig .2 System Model

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 wake up the sensors in that zone. This reduces the energy consumption and message overhead.

5.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 neighbours.

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.

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.

6. CONCLUSION

To reduce the energy consumption of the sensor nodes in the underwater sensor network the energy efficient mobicast protocol is used. The major issues in underground wireless sensor network, to achieve the goal are the limited energy of the sensors and the ocean current. In this the Autonomous underwater vehicle is used to gather the data from sensors which are to be deployed in underwater. To wake up the sensors in the next zone, the proposed work dynamically chooses a head node with highest energy. It also reduces the number of messages used for the wake up process. To consume less energy the sensors in underwater enter into sleep state only after the autonomous vehicle crossed the particular zone. To avoid and 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 message overhead, power consumption , energy, packet delivery ratio and throughput.

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