Survey on Design of Routing Protocol for Underwater Acoustic Sensor Network

Ekta yadav[1], Ms. Sumit[2]
Student[1], Asst. Professor[2]
Gurgaon institute of technology and management, MDU University, Rohtak, Haryana India
ekta12371@gmail.com, sumitmalik97@gmail.com

Abstract: The myriad barriers to underwater communication provide a new set of challenges for network protocols. Routing protocols which operate in underwater ad hoc networks must react quickly to changing conditions without significant increase in packet overhead or congestion. Dynamic Source Routing Protocol provides a framework for accomplishing these goals. In this thesis we present the Acoustic Routing Protocol, which implements this framework and enhances upon it. It uses a limited propagating route request which we call a Route Recovery to quickly and inexpensively recover from routing errors. A C++ based network simulator was constructed in order to test and compare the protocols. Statistics were calculated based on packets delivered, total transmissions, and time to recover from a route error as measurements of protocol effectiveness. This paper mainly introduce the basic concept, main advantages and network structure of underwater wireless sensor network and stress on analyzing the relative characteristics of the QoS routing protocol of current underwater wireless sensor. routing protocol selects the routing mechanism of a route or a dynamic routing protocol covering all kinds of QoS parameters according to the available network resources.

Keywords: Underwater acoustic network sensor, underwater networking, acoustic communication.

Introduction

In computer systems, communication takes place between stationary nodes with propagation delays of only a few microseconds. New technologies have been made available that allow for high bandwidth pipes even in consumer networks. The protocols that have been designed for these networks take advantage of the speed of communication to make it reliable and robust as well. However, these technologies become useless if they are placed in another medium, specifically water. The problem at hand is finding an acceptable communication technology and a set of protocols to facilitate the communication of Autonomous Undersea Vehicles (AUV). We have considered the attributes of both the medium and the network we intend to create in it.

The objectives of underwater transmission are:

The first is to decrease the time taken to recover from an error.

The second is to maintain a comparable end-to-end packet delivery ratio and total transmissions used to deliver packets and for routing overhead. Underwater wireless sensor network possesses the advantages which cannot be overtaken by the traditional sensor technology.

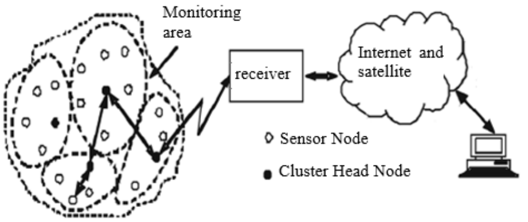
Underwater sensor network mainly consists of some intensive, low-cost and distributed randomly nodes. And its particular self-organism and fault-tolerant ability guarantee that the whole network system will not break down after some nodes get damaged due to the hostile attack.

Distributing the nodes can realize the multi-angle andmulti-dimensional information combination so as to improve the data collection efficiency and obtain the more accurate information.

Underwater sensor network uses the sensor node closed to the target to improve SNR (Signal to Noise Ratio) of receiving signal and the detecting performance of the system.

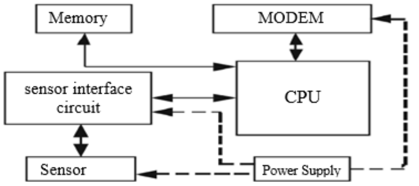
Underwater Sensor Network Structure

According to some relative research wireless sensor network has three kinds of basic primitives, that is, Target, Sensor Node and Observer Node. And the typical wireless sensor network structure is displayed as Picture1: Target is the source of signal and in general the number is one or more than one; Sensor Node is the monitor of the signal and usually the nodes are connected by wireless multi-hop mode which have no center while the number of the nodes is one or more; Observer Node is the receiver and controller of the signal and in charge of monitoring and transmitting signals, sending request to network and so on. Though there are lots of observer nodes, the number of efficient nodes is limited. At the network, Sensor Node has a multi-hop transmission along the sensor backbone nodes (cluster head) after detecting the data. During the process of transmission, monitoring data might be managed by several nodes. After the multi-hop transmission, it goes from routing to sensor route and lastly to server by Internet or the satellites. And then the users dispose and manage the sensor network as well as announce the monitoring task and record the monitoring data through the server. In addition, this paper stresses that routing is a process which transmits the efficient nodes information to observer nodes.



Picture 1 Wireless sensor network structure chart

Generally, underwater sensor node mainly consists of a master controller or CPU, which connects the sensor through the interface circuit and stores in memory after receiving the data of the sensor and then deals with these data and sends to the other network nodes by the MODEM. Its inner structure is displayed as picture 2:



Picture 2 the inner structure of an underwater sensor node

There are two kinds of sensor nodes at the current network, Sink node and ordinary sensor (UW sensor node).Sink node's managing, storing and communication capabilities are all strong .The sink node, which is deployed on the water surface in general, is in charge of connecting sensor network and external network, announcing the monitoring task and reflecting the situation to the external network while the ordinary sensor is deployed at the interested 3D area underwater with a weak managing and storing capability.

Previous work-

Theoretical development describes the proposed protocol, which adapts the principles of DSR for use in the underwater environment. The Acoustic Routing Protocol (ARP) utilizes a new mechanism called Route Recovery, which provides a fast and inexpensive method to recover from routing errors due to topology change or intermittent failure.

Examples are provided to demonstrate the strengths of the Acoustic Routing Protocol in direct comparison to Dynamic Source Routing.

The objective of this study is to discern an appropriate routing protocol for communication among fleets of autonomous vehicles in an underwater environment. DSR is a simple protocol which lays the groundwork for the desired application, but it was designed for low latency electromagnetic networks and must therefore be modified to facilitate the high latency of underwater communication. Flooding employed by Route Discovery and Route Maintenance is a major concern in an environment with a high cost per packet. The proposed Acoustic Routing Protocol (ARP) improves upon DSR's Route Maintenance with the goal being quicker recovery from errors as well as fewer total transmissions. The mechanism which we have developed for this purpose is called Route Recovery.

The Route Recovery mechanism functions as follows:

Instead of propagating Route Errors back to the source and allowing rediscovery to occur there, the node creating the error attempts a single Route Request with a time to live (TTL) set based on the number of remaining nodes on the original source route. The theory behind initiating the route repair from the source of the error as opposed to the source of the original route is based on the fact that in a wireless network the connectivity of the nodes is dependent on physical locality. The next shortest path to the destination is likely to pass through or near the error source since it is likely to be in between the source and destination. The other reason to start the recovery at the error source is that the transmissions used to return back to the original traffic source are costly in the underwater environment. A TTL field in the route header is used to limit the propagation of the recovery transmission to the local area around the error source. A TTL is an integer valued field set in the packet's header which is initialized to a predetermined value and then

decremented at every hop which forwards the packet. Once the TTL reaches zero, the node receiving the packet ceases forwarding it and drops the packet. TTLs are used in many networks to prevent an example unbounded exponential propagation of every packet. In this case, since packet transmission underwater is expensive, we use TTL to decrease the overhead associated with Route Discovery.
However, a full Route Discovery is still used in the case where local Route Recovery is not economical due to an error occurring at great distance from the destination.
It is also used to initialize a node's view of the network prior to transmitting data packets of a Route Recovery.

Review of literature and recent work
Before presenting some of the recent research papers, we would like to point out the concern proposed work of the simulator program which was written for this project. The use of object oriented methodologies is discussed and the ways in which they improve the extensibility and ease of use of the program are demonstrated. An emphasis is placed on the principles of polymorphism and inheritance. The program is shown to use Model View Controller architecture. Event based processing is shown to be used through a simple Queuing architecture. The program is configurable using the XML configuration files to analyze the various topologies and communication parameters. Design decisions are explained with regards to the implementation of the OSI model for network communication.

Dynamic Source Routing Dynamic Source Routing (DSR) is a network layer protocol designed for use in ad-hoc networks with mobile nodes and multiple hops between end-nodes. It has been tested successfully on a network composed of laptop computers carried by automobiles in a circular path between two stationary nodes. The mechanisms and descriptions of the DSR protocol that we present and discuss in this chapter are based on the paper by David Johnson, David Maltz, and Josh Broch and the DSR RFC. DSR uses source routing, so packets are transmitted with the entire route record, not just the source and destination. The decision of which path to use through the network is made at the source node, rather than distributed through the network at each node in between the source and destination.

Route Discovery Process in the Route Discovery is broadcast, a node may learn and cache any number of routes to multiple destinations as a result of a single Route Discovery. A Route Reply typically follows a route found in the routing table of the destination node. However, if the routing table does not contain a route back to the source, then a new Route Discovery is initiated with the source and destination reversed. To prevent infinite recursion of Route Discoveries, the Route Reply is appended to each Route Request. In cases in which networks have links that are guaranteed to be bi-directional, the destination node may reverse the accumulated route record, cache it, and use it to send the Route Reply. Each intermediate node may also cache a route to previous nodes in the route record. Nodes that overhear the request but are unable to forward it may also cache a route back to the source.

Conclusion
The original purpose of this study was to create a routing protocol which could meet the communication needs of an ad hoc network of autonomous undersea vehicles. These vehicles by definition operate in an environment which provides numerous obstacles to communication. Therefore the routing protocol designed for use with these vehicles has to be reactive and adaptable to frequent topology changes. Dynamic Source Routing is the most suitable starting point for such a study, as it is designed in a simple manner to avoid the unnecessary overhead which is associated with many other RF wireless routing protocols. We have designed the Acoustic Routing Protocol which uses DSR as a framework and adds the Route Recovery mechanism to facilitate quicker and less expensive responses to errors. We created a C++ based network simulator which implements each of these protocols and provides a medium in which to test these and other protocols using variable topology and traffic settings. The simulator makes use of object oriented methodology and the Spring framework to allow for easy runtime adjustment of settings and replacement of protocols. We ran numerous tests and compiled data from the results using statistical analysis tools which are built into the simulator architecture. Additionally, a random waypoint mobility model and an underwater physical layer with random packet lost were implemented in order to test the protocols under error prone conditions. . The data shows that ARP reacts more quickly to routing errors than DSR, particularly given a highly volatile topology. Because of the high latency of the underwater environment, and the independent nature of the AUVs, gaps in network availability are extremely costly. While a small percentage of reduced reliability and increased total packet transmissions was required to reach this goal, the drawbacks are outweighed by the benefits, particularly in rapidly changing topologies.

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