Implementation on Design of Routing Protocol for Underwater Acoustic Sensor Network

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Abstract: Underwater acoustic networks have the potential to support a large variety of applications, such as mining equipment and environmental monitoring. Although underwater acoustics has been studied for decades, underwater networking and protocol design is just beginning as a research field. One critical tool used for the design and testing of new protocols is a network simulator. Simulators to be useful tools, accurate models of both the channel and the modem need to be implemented. In this paper we present the design and implementation of our interface and channel model for underwater acoustic networks in the network simulator. We show that the models accurately predict the channel conditions and interface costs by comparing them to previously published numerical predictions of channel state. Finally, we present a case study of a protocol designed and simulated using model. With the advances in acoustic modem technology that enabled high-rate reliable communications, current research focuses on communication between various remote instruments within a network environment. Underwater acoustic (UWA) networks are generally formed by acoustically connected ocean-bottom sensors, autonomous underwater vehicles, and a surface station.

Keywords: Acoustic network, underwater communication, routing protocol, simulator.

Introduction

Underwater acoustic communication is a technique which enables devices to exchange data wirelessly in the water. Since the radio frequency commonly used for terrestrial communication networks is not transmitted very far in a water medium due to severe absorption and scattering, sound and ultrasonic waves having frequencies under 100 kHz are typically used as a carrier. For several decades, the main applications of underwater acoustic communication have been limited to deep sea probes and exploitation of offshore oil fields, requiring acoustic modems which consume high power but support long working ranges. Quite recently, underwater wireless sensor networks (UWSN) have arisen as a promising field in research and development, driven by the expansion of applications including data collection and pollution monitoring for the conservation of ecological systems in fresh water and sea water, tactical surveillance, data transfer for unmanned underwater vehicles, and other scientific purposes. Some initial studies on small-scale underwater modems have been described. The first low-power modem, named CORAL, comprised a micro-controller unit (MCU), analog circuitry and piezo-transducer having a resonant frequency of 1.7 kHz. The modem was tested in a small water tank and verified one-way communication at the distance of 20 cm. Another low-power modem developed by Willet was equipped with speaker and microphone and only tested in air environment. In both acoustic modems, transmission data rates and bit error probability were not reported. We implemented bidirectional acoustic modems equipped with piezo-transducers and verified a working distance of 30 m and a data rate of 5 kbps in a pond. The above mentioned early stage modems are meaningful from the viewpoint that they verified the feasibility of compact and low-power acoustic modems, however they could not be utilized in real underwater applications since they were equipped with piezo-transducers whose use is generally restricted to onshore communication systems.

One full-scale modem for UWSNs was developed by the Woods Hole Oceanographic Institution (WHOI), and was called a micro-modem. The dimensions of base board are 114 mm and 44 mm in length and width, and the whole modem consists of a stack of boards. The modem supports a variety of data rates, ranging from 80 to 5,400 bps depending on the power consumption that ranges from 50 W to 100 W.

Routing Protocol for Underwater Sensor

According to the angle of discovering strategies by routing, wireless sensor routing can be divided into active routing and passive routing.Active routing can also be called as table driven routing whose nodes usually exchange routing information through periodically broadcasting routing information grouping to discover the routing on this basis activity. Therefore, its advantage is the delay is short only if existing the routing destined for destination node as the nodes need to send the data grouping; its disadvantage is the high cost and the source waste caused by building or rebuilding some inefficient and unwanted routing as updating the current topology structure information. Thus, for the moment, active routing is not suitable for wireless sensor routing protocol. Another kind of routing is based on the principle of labor-saving which means the routing discovery will be started only when the routing node without destining for destination one. Its advantage is that it can save a lot of sources and costs without building or rebuilding the inefficient routing. However, because passive routing will be started only when there is no destination node and keep waiting in the middle as sending the data grouping, the data will be delayed. The passive routing protocol based on the usage of passive routing's advantage is a type of routing protocol owned particularly by the Ad-hoc network with the advantage of reducing routing consumption and improving network's handling capacity.

At present, the wireless sensor routing protocols applied widely are mostly passive routing protocol. However, the active routing is more suitable considering about the characteristic of strong real-time performance and short routing delay required by underwater wireless transmission network for a large scale of hygrometry monitoring. And this research attempts to adopt multi-hop distributed network topology structure and chooses the QoS routing protocol of underwater transmission network in terms of the adaptability of the algorithm in consideration of the limited amount of energy of the underwater nodes and the large energy consumption of the communication of underwater nodes to study the low energy consumption routing protocol of underwater sensor network under the restrain of multi QoS parameters and verify its efficiency by simulation verification.

Routing Algorithm on under water sensor Based on Colony

Typically QOS path optimization algorithm will be used in several common genetic algorithm can quickly and efficiently obtain good stability approximate optimal path genetic factors as well as particle swarm algorithm based on improved particle swarm optimization algorithm to model solved, not only significantly improve the convergence rate, better path solving for underwater wireless network constructed for this paper, the use of ant colony optimization algorithm. This research is started for the purpose of applying the underwater sensor for hydrometry monitoring which is a task required of strong real-performance and great energy consumption. The colony algorithm adopted in this research is a swarm intelligence algorithm simulating the collective behavior of the real ants in nature. And its fundamental is to make ants' behavior of looking for the way forward by releasing pheromone and then confirm the positive feedback system of the individual pathfinding according to the strength of the pheromone and finally find out the best routine in the system through all systems of individual path finding among the colony.

The basic steps of algorithm of ant colony optimization at underwater wireless sensor network are as follows:

Step 1: at the beginning, NC=O, that is to say, the searching time is 0 at the very start and the pheromone concentration of all paths are set as the initial value while the individual in the ant colony starts to look for paths.

Step 2: during the process of pathfinding of any ant k (k=1,2,……, m) in the colony, we should calculate the probability of choosing the next hop node j from node i according to the type of (3-6) and add node j to $tabu_k$ so as to avoid repeating this node and save energy.

Step 3: When the ant find the Sink node, it calculate the pheromone of different paths in terms of type of (3-15) to search for the optimal solution and then realize the pheromone renewal.
Step 4: Record the optimal solution obtained from the calculation of successor ants, NC=NC+1.
Step 5: If coming out the optimal solution, the progress should be ended and output the optimal value; but if the optimal solution till cannot be calculated, we should be back to the step 2 and repeat the cycle till work out and output the optimal value.
And the realization process of pseudo code of QoS algorithm of ant colony optimization at underwater wireless sensor is described as follows:

(1) Set the initialization
NC=0 ;
//set cycle counter
$\tau_{ij} = C$;
//set the amount of initial pheromone on each edge
C
$\Delta\tau_{ij} = 0$;
//the amount of initial increment on each edge 0
S=1 ;
//S is taboo index, the initial $tabu_k$ in Tabu List is

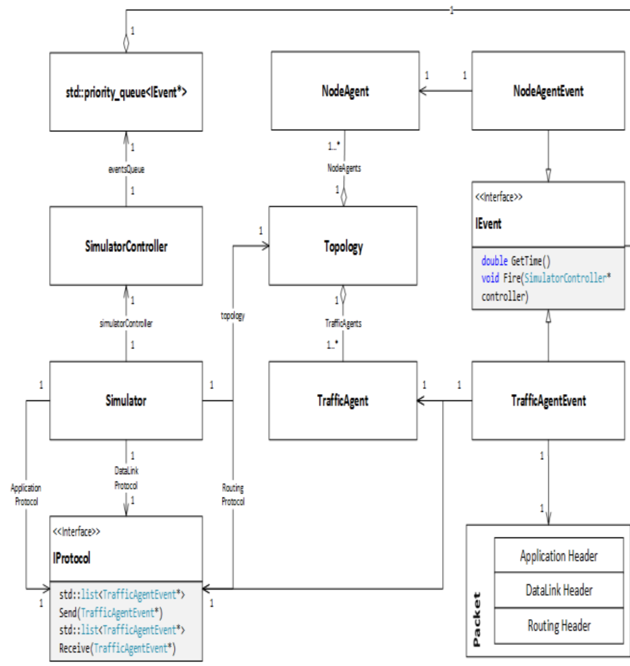
for k=1 to m do
//put each ant randomly at each node
End for
(2) process of pathfinding
for k=1 to m do;

Simulator Verification

The simulator stores each protocol and calls its send or receives method based on events that occur in other protocols or in the simulator's initializing method. The simulator code has references to the specific protocols used for the simulation. All protocols are stored as the abstract Protocol object, or as in the case of the routing protocol, a more specialized abstract extension of the Protocol class is used to tailor a set of protocols to a specific layer and allow for more layer specific functionality.

Simulator Class Diagram

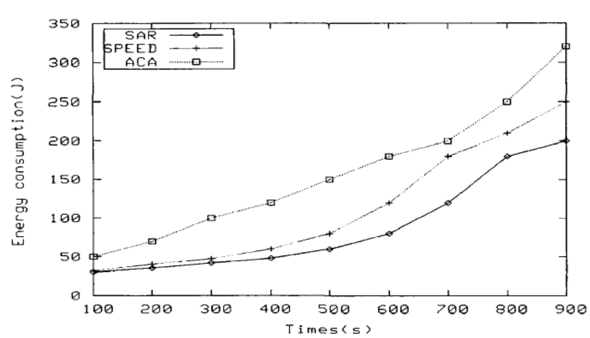
The relationships of the classes in the model are outlined in the UML class diagram pictured. Each packet corresponds to a set of event objects which represent the handling of that packet by a specific protocol at a specific node agent. These events are stored in a priority queue object which is sorted based on the time the event is set to occur. The Simulator contains references to all protocols, the topology and the simulator controller. The Simulator Controller contains reference to the event queue (C++ SLT's priority_queue) for holding all the events generated till now which sorts its contents based on the time parameter in each Event object. The Simulator Controller class runs a loop which pulls the first event from the queue and processes it through the appropriate protocol and as a result generates future events. Each protocol also contains a reference to the topology to allow it to make determinations about the location of nodes and calculate their impact on events generated by that protocol. The time associated with an event is determined by the protocol which generates it. In the case of inter-node communication, an event is generated for every node in range of communication. The group of nodes in range, and the arrival time at each node, is determined based on the topology model. Any implementation of a topology model must provide an implementation of the Node Agent class and that implementation must contain a method providing the location of a n ode at any given time, which is used by the data link layer protocol to determine the time at which a receive event occurs at that node.



Simulator Class Diagram

SAR algorithm is the first routing protocol which possesses awarenesson the path. Besides, Speed protocol is a real-time routing protocol supporting soft it has built pieces of paths from source nodes to Sink nodes with the advantage of less energy consumption comparing with the Least Energy Consumption Measurement Protocol which only considers about the energy consumed real-time communication service on the basis of Stateless Non-deterministic Geographical Forwarding (SNGF) Mechanism with the advantage of reducing the delay and routing void [18].

Currently, there are a lot of simulation environments of wireless sensor network, and this research choose NS-2 simulation tool to evaluate the performance of simulation routing protocol of wireless sensor [19]. In this experiment, we assume that there are 50 nodes being distributed randomly in the 500*500 monitoring area and at random pick out the source node and the target node. The communication scale of nodes is 60m and the initial energy is 10J while the speed of periodic data packet produced by each node is 10packet/s. In the comparison of energy consumption, the result of the simulation of them three is as follows:



Energy consumption algorithm

Conclusion

The research of underwater sensor network is developing. This article firstly states the basic concept of underwater wireless sensor network and analyzes the advantages and different service types of different network system further. And then combine the underwater environment characteristics with the current sensor level to put forward the routing protocol based on the ant colony which is suitable for the underwater sensor network application. In addition, this paper describes the model of the routing protocol based on the ant colony in detail and then do the simulation experiment by comparing the ACA, SAR and SPEED algorithm in terms of measurements, that is energy consumption . And the experiment proofed that the real-time performance of protocol is stronger than the other two while its energy consumption is larger. Finally, the paper expects the research direction in the future to offer some thinking for the further study of underwater wireless sensor. We believe that there is an extremely wide prospect for the routing protocol based on the ant colony.

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