Time Synchronization in Underwater Sensor Networks Using AODV Routing

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ABSTRACT: Underwater sensor networks stems from the potential to use long term sensing devices to monitor the large mass of oceans on the planet . To accomplish this, the sensor nodes must have the ability to self-configure the communication network and provide energy-efficient data transmission. To this end, researchers have began devising MAC-layer protocols that minimize energy consumption for data transmission. Simulation results have demonstrated that information-directed routing is a significant improvement over a previously research as measured by sensing quality such as localization, tracking accuracy and using Ad hoc network communication quality such as success rate in routing around sensor nodes.

Keywords: Acoustic sensor networks, Ad hoc Network, AODV Routing.

1.INTRODUCTION

Underwater Sensor Networks (UW-SNs) consist of a number of sensors and vehicles(Unmanned Underwater vehicle(UUV), Autonomous Underwater Vehicle(AUV), etc.) which perform collaborative monitoring tasks over a given area. Relatively easy deployment, maintenance and low cost make UWA-SNs an ideal solution for a variety of applications in the complex underwater environment, such as disaster prevention, undersea exploration and assisted navigation. Sensor network is a collection of large number of sensor nodes which are designed to perform a collaborative monitoring task such as detection, tracking, or Classification over a given geographical area. The whole network has a single objective of performing a specific task. Each node in the network contributes to the task by sensing and transmitting the sensed information to the sink or by just forwarding the information sensed by the other node in the network.

The traditional approach in the underwater sensor networks requires deployment of the sensor nodes, collection of data through the sensor nodes and retrieval of the sensor nodes. This is considered to be unsuitable for the underwater sensor networks, because there is no real-time monitoring, failure detection, storage extension, and lack of on-line system configuration. The data recorded cannot be accessed until the sensor nodes are retrieved from the area where they have been deployed. Failure of nodes cannot be detected in order to maintain the connectivity. Once the memory of a sensor node full, it cannot sense further. No inter-action and adaptive sampling can be done here. In fact, providing scalable and efficient routing service in UWSNs is very challenging due to the unique characteristics of underwater sensor networks. First of all, radio does not work well in water because of its rapid attenuation. Thus acoustic communications are usually adopted in underwater environments. Acoustic channels often feature low bandwidths and long propagation delays. Thus a routing protocol with long end-to-end delays or high bandwidth

A requirement is not a good choice. Secondly, most nodes in a UWSN can move passively with water currents (except that some gateway nodes are fixed at the water surface or anchored at the bottom), resulting in highly dynamic network topology. To handle dynamic networks, existing routing protocols for land-based (static) sensor networks need to update routing information periodically, which introduces significant communication overhead. Thirdly, similar to land-based sensor nodes, underwater sensor nodes are usually powered by batteries, which are even harder to recharge or replace in hash underwater environments. Thus, energy efficiency is another important concern for UWSN routing. In short, a routing protocol designed for UWSNs should consider all these factors: long propagation delays, low communication bandwidths, dynamic topology, and energy efficiency.

Unique characteristics of underwater acoustic sensor networks

Communication Media: Underwater communication system [19] involves transmission of information using any media either acoustic waves, electromagnetic waves or optical waves. Each of the techniques have their own advantages and limitations. Acoustic communication is the most versatile and widely used technique in underwater due to low attenuation in water.

Transmission loss: It consists of attenuation and geometric spreading. The attenuation is mainly provoked by absorption due to conversion of acoustic energy into heat, and increases with distance and frequency. The geometric spreading refers to the spreading of sound energy as a result of the expansion of the wave fronts. It increases with the propagation distance and is independent of frequency.

***Noise*:** It can be classified as man-made noise and ambient noise. The former is mainly caused by machinery noise (pumps, reduction gears, power plants), and shipping activity (hull fouling, animal life on hull, cavitation), while the latter is related to hydrodynamics (movement of water including tides, current, storms, wind, and rain), and to seismic and biological phenomena.

Multipath: Multipath propagation may be responsible for severe degradation of the acoustic communication signal, since it generates Inter Symbol Interference (ISI). The multipath geometry depends on the link configuration. Vertical channels are characterized by little time dispersion, whereas horizontal channels may have long multipath spreads. The extent of the spreading is a strong function of depth and the distance between the transmitter and the receiver.

Challenges in underwater acoustic sensor networks

Major challenges encountered in the design of underwater acoustic networks are as follows

1 The available bandwidth is severely limited.

2.The underwater channel is impaired because of multi-path and fading.

3.Propagation delay in underwater is five orders of magnitude higher than in Radio Frequency (RF) terrestrial channels, and variable.

4 High bit error rates and temporary losses of connectivity (shadow zones) can be experienced.

5 Underwater sensors are characterized by high cost because of extra protective sheaths needed for sensors and also relatively small number of suppliers (i.e.not much economy of scale) are available.

6.Battery power is limited and usually batteries cannot be recharged as solar energy cannot be exploited.

7. Underwater sensors are more prone to failures because of fouling and corrosion.

2. RELATED WORK

There has been an intensive study in routing protocols for terrestrial wireless ad hoc [9] and sensor networks [10] in the last few years. Because of the unique characteristics of the propagation of acoustic waves in the underwater environment, however, there are several drawbacks with respect to the suitability of existing terrestrial routing solutions for underwater networks. Routing protocols are usually divided into three categories, namely *proactive*, *reactive*, and *geographical* routing protocols.

Proactive protocols **(e.g., DSDV, OLSR)** provoke a large signaling overhead to establish routes for the first time and each time the network topology is modified because of mobility, node failures, or channel state changes, as updated topology information has to be propagated to all network devices. In this way, each device is able to establish a path to any other node in the network, which may not be needed in UW-ASNs. Also, scalability is a critical issue for this family of routing schemes. For these reasons, proactive protocols are not suitable for underwater sensor networks.

Geographical protocols **(e.g., GFG, PTKF)** are very promising for their scalability feature and limited required signaling. However, Global Positioning System (GPS) radio receivers, which may be used in terrestrial systems to accurately estimate the geographical location of sensor nodes, do not work properly in the underwater environment. In fact, GPS uses waves in the 1.5 GHz and those waves do not propagate in water. Still, underwater sensing devices need to estimate their current position, irrespective of the chosen routing approach.

Some recent work proposed network-layer protocols specifically designed for underwater acoustic networks. In[13], a routing protocol is proposed that autonomously establishes the underwater network topology, controls network resources, and establishes network flows, which relies on a centralized network manager running on a surface station. Although the idea is promising, the performance of the proposed mechanisms has not been thoroughly studied. In [15], a vector-based forwarding routing is developed, which does not require state information on the sensors and only involves a small fraction of the nodes. The algorithm, however, does not consider applications with different requirements. The protocols, which rely on controlled broadcasting with no power control, have been compared in static as well as mobile scenarios in terms of different end-to-end networking metrics (packet delivery ratio, packet delay, and energy consumption), leading to the following conclusions: 1) The three versions of the protocol outperform solutions that do not fully exploit neighbor knowledge in the design phase; 2) In a static environment, no version is optimal for all the metrics considered; 3) The higher the mobility, the lower the amount of information needed for making good routing decisions.

3. ARCHITECTURE AND NETWORK MODELS

It consists of a main controller/CPU which is interfaced with an oceanographic instrument[15] or sensor through a sensor interface circuitry. The controller receives data from the sensor and it can store it in the onboard memory, process it, and send it to other network devices by controlling the acoustic modem. The electronics are usually mounted on a frame which is protected by PVC housing.

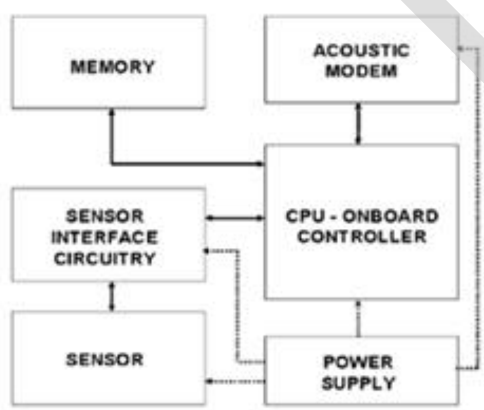


Fig 4.1 Internal architecture of an underwater sensor node.

So present the accuracy performance as the tracking error with respect to different metrics such as the number of nodes, underwater speed of sound, channel error rate, delay variance, localization error, and errors in distances between the nodes and the target.

The purpose of this method is to minimizing the active connection path length by eliminating a redundant node. Our proposed method has many potential advantages including:

i) It reduces the end-to-end delay incurred by packets by decreasing the number of hops on the path.

ii) It increases spatial reuse and network capacity, and provides energy savings by removing unnecessary transmissions.

iii) It makes the connection more resilient to breakages due to node mobility.

By using AODV, source node makes a connection to target node. After a connection establishing process, source node sends data packets at a constant bit rate of N packets/seconds. Due to node movement, network topology usually changes with time that makes a new topology structure have not an optimal path. To optimize the path length of new topology structure, the source node triggers shrink process that sends a Shrink-0 packet to the next hops in connection path same as data packet to be sent.

The Ad-hoc On-Demand Distance Vector Algorithm

Proposal can be called a pure on-demand route acquisition system; nodes that do not lie on active paths neither maintain any routing information no participate in any periodic routing table exchanges Further a node does not have to discover and maintain a route to another node until the two need to commu- nicate, unless the former node is offering its services as an intermediate forwarding station to maintain connectivity between two other nodes.

When the local connectivity of the mobile node is of interest, each mobile node can become aware of the other nodes in its neighborhood by the use of several techniques including local no system wide broadcasts known as hello messages The routing tables of the nodes within the neighborhood are organized to optimize response time to local movements and provide quick response time for requests for establishment of new routes The algorithm's primary objectives are:

1.To broadcast discovery packets only when necessary.

2.To distinguish between local connectivity management (neighborhood detection) and general topology maintenance

3To disseminate information about changes in local connectivity to those neighboring mobile nodes that are likely to need the information.

AODV uses a broadcast route discovery mechanism[18]as is also used (with modifications) in the Dynamic Source Routin(DSR) algorithm[19] Instead of source routing, however AODV relies on dynamically establishing route table entries at intermediate Nodes. This difference pays off in networks with many nodes, where a larger overhead is incurred by carrying source routes in each data packet.

3.1. Route Discovery

The Path Discovery process is initiated whenever a source node needs to communicate with another node for which it has no routing information in its table. Every node maintains two separate counters- a node sequence number and a broadcast_ id. The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbors.The RREQ contains the following fields.

< source addr_ source sequence_#, broadcast id_Dest_ addr, dest _sequence _#, hop_ cnt >

The pair < source addr_ broadcast_ id > uniquely identifies a RREQ_ broadcast_ id is incremented whenever the source issues a new RREQ. Each neighbor either satisfies the RREQ by sending a route reply (RREP) back to the source or rebroadcasts the RREQ to its own neighbors after increasing the hop_ cnt Notice that a node may receive multiple copies of the same route broadcast packet from various neighbors_ When an intermediate node receives a RREQ,if it has already received a RREQ with the same broadcast id and source address, it drops the redundant RREQ and does not rebroadcast it If a node Can not satisfy the RREQ,it keeps track of the following information in order to implement the reverse path setup as well as the forward path setup that will accompany the transmission of the eventual RREP.

1 Destination IP address
2 Source IP address
3 Broadcast id
4 Expiration time for reverse path route entry
5 Source node's sequence number.

Pocket Format:
Routes in AODV are discovered and established and maintained only when and as long as needed. To ensure loop freedom sequence numbers, which are created and updated by each node itself, are used. These allow also the nodes to select the most recent route to a given destination node. In packet formate information are store in a node , one are communicate with one another node i.e. neiburering node so in that time that node status is sleep/ awake condition So that time synchronization table are store the status about the nodes.

3.2. Route Table Management

The source and destination sequence Numbers are the useful information is also stored in the route table entries and is called the soft-state associated with the entry. The expiration time depends upon the size of the ad_hoc network. Another important parameter associated with routing entries is the route caching timeout or the time after which the route is considered to be invalid in each routing table entry the address of active neighbors through which packets for the give destination are received is also maintained a neighbor is considered active (for that destination) if it originates or relays at least one packet for that destination within the most recent active timeout period. This information is maintained so that all active source nodes can be notified when a link along a path to the destination breaks .A route entry is considered active if it is in use by any active neighbors. The path from a source to a destination which is followed by packets along active route entries is called an active path. Note that as with DSDV all routes in the route table are tagged with destination sequence numbers which guarantee that no routing loops can form even under extreme conditions of out-of-order packet delivery and high node mobility a mobile node maintains a route table entry for each destination of interest. Each route table entry contains the following information,

-Destination
-Next Hop
- Number of hops (metric)
- Sequence number for the destination
- Active neighbors for this route
- Expiration time for the route table entry

Each time a route entry is used to transmit data from a source toward a destination the timeout for the entry is reset to the current time plus active route timeout. Route Table entry to make route maintenance easier after link breakage. To prevent storing information and maintenance of routes that are not used anymore each route table entry has a lifetime. If during this time the route has not been used, the entry is discarded.

3.3 Route Maintenance

When a route has been established, it is being maintained by the source node as long as the route is needed. Movements of nodes effect only the routes passing through this specific node and thus do not have global effects. If the source node moves while having an active session, and loses connectivity with the next hop of the route, it can rebroadcast an RREQ. If though an intermediate station loses connectivity with its next hop it initiates an Route Error (RERR) message and broadcasts it to its precursor nodes and marks the entry of the destination in the route table as invalid, by setting the distance to infinity. The entry will only be discarded after a certain amount of time, since routing information may still be used.

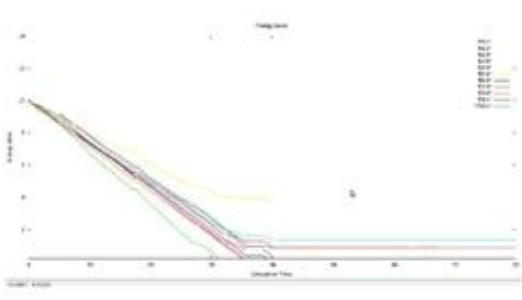
4 SIMULATION

***ENRGY CONSUMPTION FOR SLEEP MODE*:**

Underwater sensor networks should have super nodes every few tens of nodes to help minimize the time for data collection, depending on the application. Networks of mobile unmanned vehicles will likely be even more sparse, due to the high cost of building and deploying them. This poses an immediate difference with radio networks. Each node in an underwater sensor network is likely to be vital to the connectivity of the network. Therefore, any method that attempted to keep a backbone awake at all times would likely have all of the nodes awake 100% of the time.

Furthermore, any sort of randomized wakeup sequences would also perform poorly due to this expected low node density. On the other hand, methods that build paths on-demand also are not ideal. First, most of these schemes increase the delay until a node can receive data. The effects of this sort of delay increase are magnified in an event driven network, where timely delivery of packets could be critical. Second, many of these schemes require a sender to transmit a wakeup beacon in such a way that it is guaranteed to be received, often by repeated transmission. But for acoustic modems, transmission is much more expensive than any other mode, causing such beaconing to potentially outweigh the savings gained by being in sleep mode.

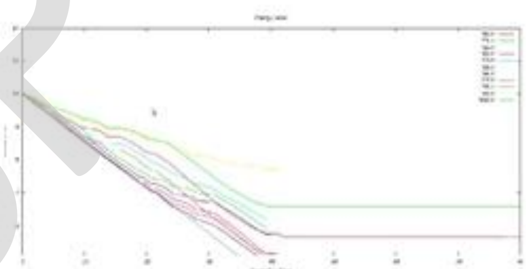
Essentially, any on-demand scheme must have a way to wake up a sleeping node. Most of these schemes use some type of low duty cycle wakeup for nodes to listen for incoming transmissions .Senders are required to transmit a beacon, or request to transmit, in such a way that the intended receiver is guaranteed to hear it.



Graph 1: Sleep mode energy consumption of node

ENRGY CONSUMPTION FOR WITHOUT SLEEP MODE:

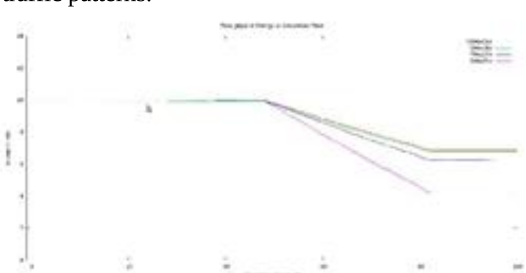
The main contribution of this work is a preliminary evaluation of idle-time power Management techniques for underwater sensor networks. Through an analysis of the energy consumption of various modes for acoustic modems, we show that for sensors that transmit data with a period on the order of minutes to a few hours, idle-time power management techniques that increase the needed transmission time may perform poorly. As an alternative, we investigate the use of a wakeup mode. Wakeup modes for radios are not a new idea, but they have not yet been widely adopted due to the fact that their implementation requires new hardware and this technology may not be mature enough. However, in this paper we argue for the use of wakeup modes in acoustic modems. To this end, we present an evaluation of four protocols via simulation, demonstrating that the use of an ultra-low power wakeup mode consistently results in the greatest energy savings.



Graph 2 : Without Sleep mode energy consumption of node

ENERGY ANALYSIS :

The goal of the following evaluations is to determine when a wakeup state is preferable to a sleep cycling solution for underwater sensor networks. There are a number of ways to evaluate the impact of protocols on energy consumption in a sensor network. One method is to evaluate the total energy consumption in the network for various traffic patterns.



Graph 3: Quality of Energy consumption

5.CONCLUSIONS

The proposed algorithm in this paper is completely AODV Routing based. It helps to reduce the energy consumption because the node status is sleep-wake up during packet transmission .So an underlying concept in this paper is efficient use of energy.

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