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Performance Evaluation of Underwater Sensor Networks

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ABSTRACT

Recent improvements in wireless communications and acoustic technology have enabled the use of sensor networks in underwater Surface. Underwater Sensor Networks is an emerging field which requires research in the field of routing and channel access. Applications Using offshore exploration, assisted navigation, Oceanographic data collection and tactical surveillance applications use underwater sensor networks. Some applications such as disaster prevention require minimum delay in data gathering. And also care must be taken to make sure that the energy expenditure of an underwater sensor node is minimal because replenishment of a sensor node is not cost-effective. Simulation results have demonstrated that information-directed routing is a significant improvement over a previously reported 3DUT algorithm, 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 holes.

General Terms
Underwater Sensor Networks, 3DUT Algorithm, AODV Protocol.

Keywords
Acoustic sensor networks, Ad hoc Network, AODV Routing, Target Localization.

1. INTRODUCTION

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.

Wireless sensor networks are similar to the sensor networks in which sensor nodes communicate without cables and have all the capabilities of a basic sensor network [6] which enables the use of sensor networks in environments which are not user-friendly such as dense forest, military areas and area which cannot be easily reached by humans? Many new technologies in the wireless communications lead the way to the development of low-cost, multi-functional, small sensor nodes. Each sensor node should have a self organizing capability so that in the case of failure it can place itself in a position such that it is connected to the network. The deployment of sensor nodes is dense and random in the case of terrestrial environment.

Underwater sensor networks are a collection of sensor nodes which communicate among them through the emerging underwater acoustic communication technology. In Underwater networks, Acoustic communications is the typical layer technology. There are some reasons that acoustic communication technology was chosen for the communication in underwater. Radio waves propagate through conductive sea water at extra low frequencies (30-300Hz) which requires large antennae and high transmission power. Scattering is most important factor which made the use of optical waves inefficient. Obviously, acoustic communication technology is the best choice when compared to the radio waves and optical waves. Acoustic modem is the most important technology used by the wireless sensor networks in underwater to communicate among them.

Static Two-dimensional UASN (Underwater Acoustical Sensor Networks) is a collection of sensor nodes that are anchored to the bottom of the ocean-bed [4]. By the means of wireless acoustic links the sensor nodes are connected to one or more sinks. These sinks in turn have vertical and horizontal transceivers. The horizontal transceiver is used to collect the data from the sensor nodes. The vertical transceiver is used to send the collected data to the surface station. These nodes and sink are immovable.

Static Three-dimensional UASN is a collection of sensor nodes that are connected to the bottom of the ocean-bed by tethers. Tethers are used to control the depth of the sensor nodes so that it can adjust their depth in order to sense at different depths and to maintain the connectivity to the network in case of link failures. The two most important features of this type of network are sensing and communication coverage.

Sensing coverage of a given geographical ocean column must be covered by the sensor nodes collaboratively functioning at different depths. Communication coverage should be achieved by the sensor nodes in order to relay the Information sensed to the surface station and to maintain their connectivity to the network always by adjusting their depths.

2. 3D UNDERWATER TRACKING ALGORITHM

3DUT is a two-phase algorithm. During the first phase, passive listening, sensor nodes listen to the underwater environment for potential targets. Once the noise that is radiated from a target has been detected, the second phase of the algorithm, active ranging, is initiated [4]. To localize the target, 3DUT selects a projector node, which periodically sends pings, and the nodes use the To A of the pings and their echoes to localize the target. By using the pings from the projector node, synchronization between the sensors is not necessary. The target is assumed to be a point target so that the echoes are isotropic-ally radiated. During tracking, there is only one designated projector node, which can change with respect to the movement of the target. The ping contains a ping label *l*, which is used to identify the ping used in ranging calculations, once the projector has received the echo. It calculates its distance to the target.

2.1 Three-Dimensional Underwater Target Tracking (3DUT) Scheme

To save energy, the nodes which are not located at the network edge have low duty cycles. The nodes which are at the boundary of the sensing region have higher duty cycles in order to detect the target entering into the sensing region immediately. Therefore, to avoid rapid energy depletion of boundary nodes due to continuous surveillance, 3DUT employs an adaptive procedure to find, designate, and activate new boundary nodes [4]. Furthermore, 3DUT does not depend on the number of nodes. The algorithm runs even if the number of sensor nodes changes. However, 3DUT can only track one target at a time. Moreover, the tracking accuracy is heavily influenced by the target's velocity.

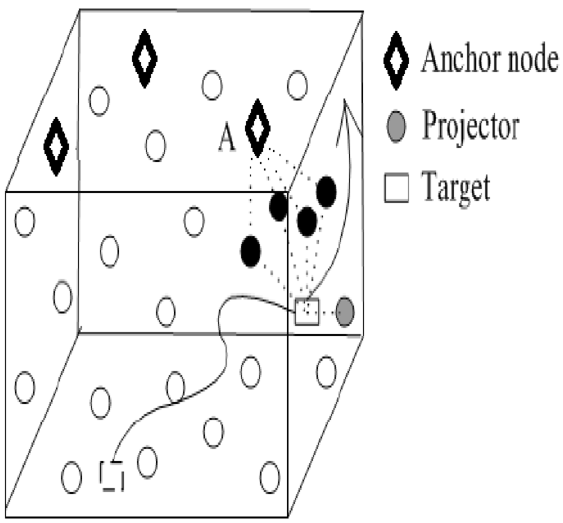

Figure 2.1.1 Three-Dimensional Underwater Target Tracking.

2.2 BND

The aim of BND is to keep the sensor network closed and bounded by the high-duty-cycle sensors [1][4]. If nodes are not designated and assigned as boundary nodes, the target may not be detected or tracked due to the low duty cycles of non boundary nodes.

When a boundary node is about to run out of energy, it sends a failure alarm message to the sink node. After this message has been received or after the localization algorithm has been run, the sink node runs the BND algorithm to find the new boundary nodes.

2.3 AUV-Aided Localization Technique

The sensor nodes are dropped into ocean and move with water currents. The AUV traverses the UWSN periodically following a predefined trajectory (a lattice-like and an Archimedean spiral trajectory). Moreover, all nodes can communicate (Omni-directionally) with the AUV. The AUV can surface to obtain its coordinates by [1] GPS, then dives to a predefined depth (provided by pressure sensors) and starts exchanging three types of messages with unknown nodes: wakeup, request and response. "Wakeup" messages are sent by the AUV as it enters the network to declare its presence to unknown nodes in its communication range. Unknown nodes that receive "wakeup" respond with a "request" message to commence range measurement. The "request/response" messages are exchanged between the AUV and unknown nodes to estimate their positions according to the round trip time. Then, localization is investigated using two methods, bounding-box and triangulation. Bounding box method draws a rectangular region with the intersection of the distance estimates. The positions of unknown nodes are obtained by applying the distance measurements as constraints on the X and Y coordinates of unknown nodes.

3. AODV

The Ad hoc On Demand Distance Vector (AODV) routing algorithm [3] is a routing protocol designed for ad hoc mobile networks. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Whenever a node wants to send a packet to some destination node, it firstly checks its routing table to determine if there is an active route to that node. If so, it forwards the packet to the next hop node towards the destination. However, if such a route does not exist, the node just broadcasts a Route Request (RREQ) to all its neighbors. The RREQ packet carries the source node IP and the current sequence number, as well as the destination node IP address and the last known sequence number. Also, each RREQ has a broadcast ID and a time to live (TTL) identifier.

When an intermediate node receives a RREQ, it firstly checks whether it has seen the request before by noting the source IP address and broadcast ID pair. If the RREQ is fresh, it records the information, sets up a reverse route entry for the source node in its routing table, in order to build a route for the Route Reply (RREP) message, and forwards this RREQ to its neighbors'. However, if the node has seen the request before, it just discards the packet. It is forwarded by the intermediate nodes. However, only one reverse route is initiated by each node. The RREQ propagates through the network until it reaches the destination or a node with a fresh route to the destination. Then the node sends a RREP packet back to the source. All the intermediate nodes receiving a RREP update their routing table information with the latest destination sequence number.

4. PERFORMANCE EVALUATION

We analyze the performance of the 3DUT algorithm with respect to the speed of sound, localization error, errors in distances between the nodes and the target, the number of nodes, and duty cycle. We deploy a simulation environment using ns-2 and distribute 50 sensors to an area of 1000 m × 1000 m ×1000 m. We set the signal propagation speed to 1500 m/s

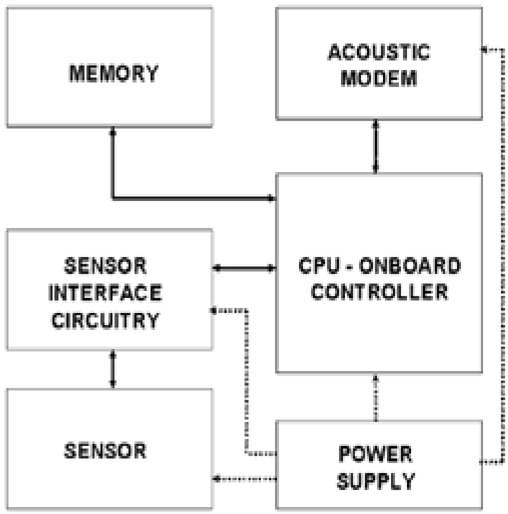

Fig 4.1 Internal architecture of an underwater sensor node.

It consists of a main controller/CPU which is interfaced with an oceanographic instrument 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. We 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 tracking error is given as

$$E_{Avg} = \frac{1}{N}\sum_{i=1}^{N}\left[(x_i' - x_i)^2 + (y_i' - y_i)^2 + (z_i' - z_i)^2\right]^{1/2} \quad \textbf{(1)}$$

Where *EAvg* is the average error, *N* is the number of collected target location data, (*xi*, *yi*, *zi*) is the real location of the target, and (*x'i* ,*y'i*, *z'i*) is the calculated location of the target.

Our proposed method for optimizing a route in [3] MANETs is called Shrink Mechanism. In shrink mechanism, the active route is maintained by using a special packet that is called shrink packets. The Shrinking mechanism is activated only after the routing protocol has been established a route between source and destination. Once the connection has been established, and for as long as the connection is active, the source node periodically sends a special Shrink packet towards the destination node, which triggers the shrinking operation at each node it traverses.

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.

The source node of the connection initiates the shrinking process when a certain fixed amount of data traffic has been sent on the connection. In our experiments, we consider connections that carry CBR traffic and the shrinking process are initiated every time a specified number (p) of data packets have been sent. We can avoid keeping a data packet counter at each node for each destination by implementing the counters probabilistically: each source node may initiate the Shrink packet with probability 1/p whenever it sends a data packet.

A natural question that arises concerns the effect of the choice of p on the performance of the optimization scheme. This is just one of the questions we will investigate in the subsequent sections, where we will consider p = 4, 8, 16, 32. In general we will denote the Shrinking mechanism when p =α as Shrink (α).

To achieve our proposed scheme, we have to minimize a 2-hop connection to 1-hop connection by eliminating a redundant node.

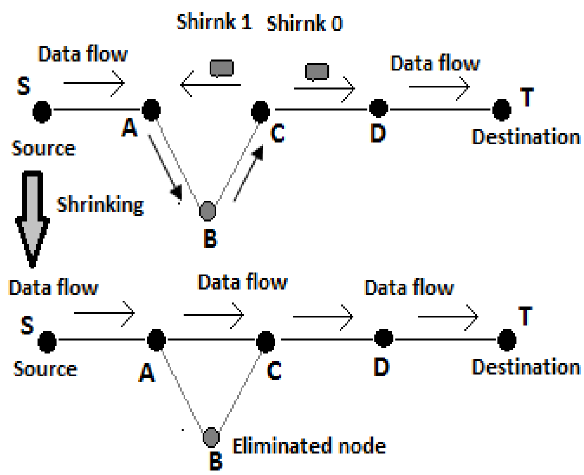

Fig.4.2 Shrink Mechanism

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.

5. SIMULATION RESULTS

In this section, we present in detail the simulation results of the AODV Protocol defined in Section 3.0.

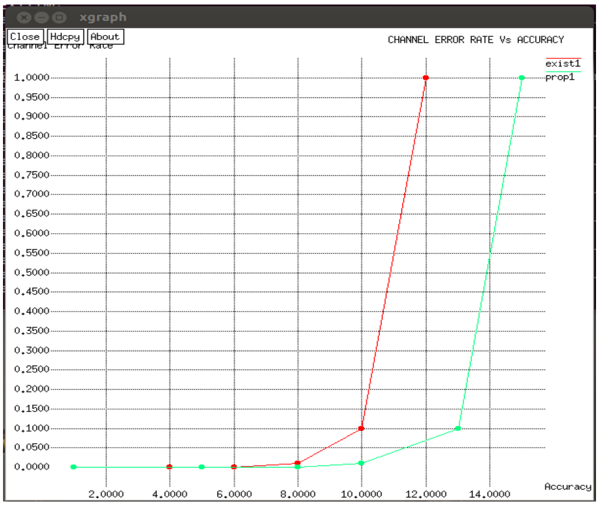

Figure 5.1 Channel Error Rate Versus Accuracy

Using Accuaracy in Acoustical sensor depended on Channel error rate and send the data from source to destionation.

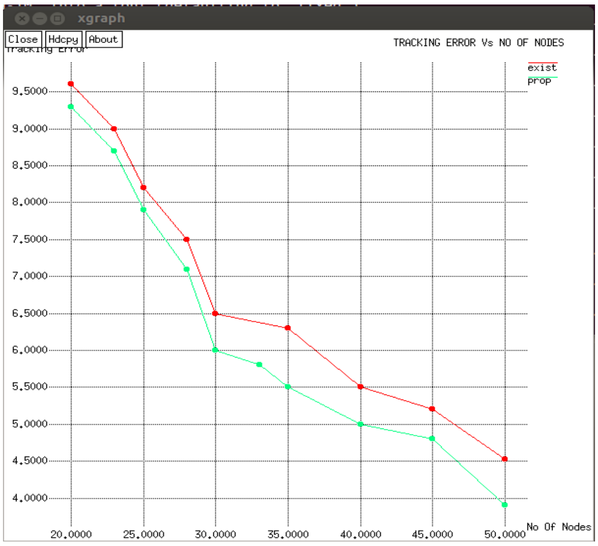

Figure 5.2 Tracking Error Versus No of Nodes

No of Nodes are incressed the Tracking Error Will reduced at Accuracy of data transefering time by using 3DUT

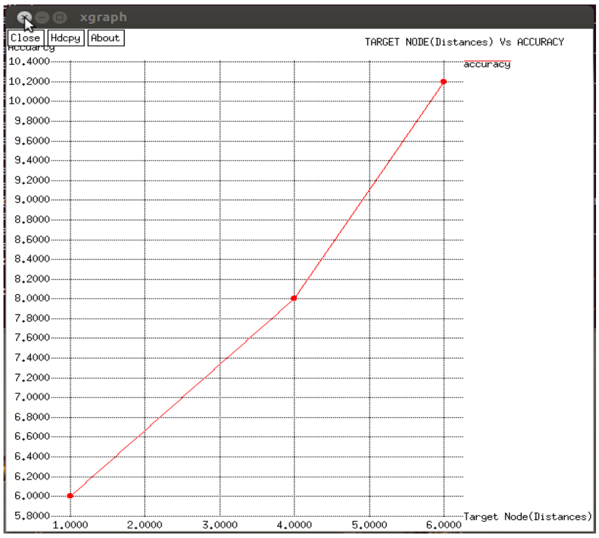

Figure 5.3 Node(Distances) Versus Accuracy

By Using Aodv Protocal we find Shortest path and send the data from source to destionation (existing system using minimum 7m maximum 30m)

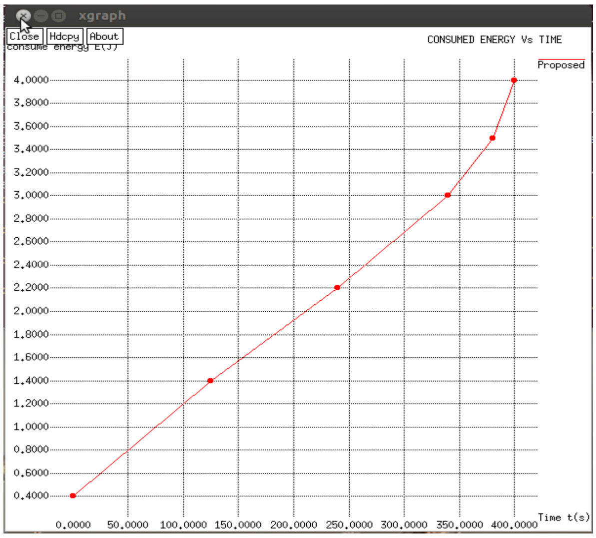

Figure 5.4 Time Versus Consumed Energy

Energy Consumed Vs Time For Varying during using AODV result in less energy consumption,the energy consumption decresed by an average value of 4%(Existing system as 6%).

6. CONCLUSION

In this paper, the problem of data gathering with minimum delay under different node failure probabilities in underwater acoustic sensor networks is studied. A routing scheme is proposed which is basically a distributed routing scheme but implemented with features of centralized routing. Some features like distributed path repair algorithm helps the scheme to locally repair the links and to withstand in cases of node failures and link failures. Each node in the proposed distributed routing scheme chooses its next hop based on the position of the surface station. They sink and the propagation delay with its neighbors. This helps the routing to choose the path faster and also enables a faster recovery in case of failure. The delay is not optimal but when comparing the high data accuracy rate and Consumed Energy, the delay difference is negligible. Form the graphs drawn above it is clear that, there is high data acceptance rate, low control overhead and negligible delay difference. The proposed routing scheme was shown to achieve the performance targets of the underwater environment. By using AODV protocol the average energy Consumption decrease by 4%. The Simulation result has shown the Data transform and Maximum tracking less than others.

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