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Efficient Packet Scheduling and Localization in Underwater Acoustic Sensor Networks

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ABSTRACT

The objective of this paper is to reduce the localization time in underwater acoustic sensor network. We consider a packet transmission scheme such as collision tolerant scheme (CTS) for reduce the localization time. The localization time is determined by these scheme and numerical results. The collision tolerant scheme can require shorter localization time when the packet formation time is short and the operating area is large (above 3km) and the average probability of packet loss is not close to zero. The implementation is more complex because the anchors work independently. The collision tolerant scheme provides more localization accuracy.

Keywords: Localization, Scheduling, Collision and Under water acoustic sensor network.

1. INTRODUCTION

The underwater acoustic sensor networks are expected to handle many task automatically. It is used to enable application such as tsunami monitoring, oil field inspection and shoreline surveillance. The sensor node can measure the various environmental parameters such as pressure, temperature and encode them into packets, then exchange it with other sensor nodes. The packet has to be labeled with id of the sensor node, location and the time. The sensor nodes must know their position which is an important task.

The challenges of underwater acoustic sensor networks are low data rate and high propagation delay. The terrestrial wireless sensor networks can be equipped with GPS module which cannot propagate more distance but the acoustic (sound) signal can propagate more distance. An underwater sensor node determine its location by measuring time of Arrival (ToA) to several anchors with known position.

The localization can be affected by many factors such as number of anchors, noise, constellation and their relative position of the sensor nodes, propagation loss and fading. The underwater localization algorithms is to determine how the anchors should transmit their packets to the sensor nodes. In long base-line (LBL) systems the transponders are fixed on the sea floor, and the sensor node interrogates the transponders by round-trip delay estimation.

In the underwater positioning scheme a master anchor sends a beacon signal periodically, after the reception of beacon signal, the remaining anchors should transmit their packets in a given time period

In reactive localization an underwater sensor node initiates the transmission by sending a “hello” message to the adjacent anchors and those anchors that receive the message then transmit their packets to other nodes. The underwater sensor nodes can use MAC protocols such as T-Lohi there is no guarantee for better localization accuracy.

In underwater acoustic sensor networks (UASN) the anchors are equipped with half-duplex acoustic modems, and can broadcast their packets based on collision-tolerant scheme (CTS), where the collision probability is controlled by the packet transmission rate. In that way the sensor node can receive sufficiently many error-free packets for localization. When localization time is short then the network can be more dynamic, and leads to a better network efficiency in terms of throughput.

2. SYSTEM MODEL

We consider a UASN consisting of M anchors and N sensor nodes. The anchor index starts from 1, whereas the sensor node index starts from $M + 1$. Each anchor in the network encapsulates its ID, its location, time of packet transmission. The attained localization packet is broadcast to the sensor network based on a given protocol, e.g., periodically, or upon the reception of a request from a sensor node.

- Anchors and sensor nodes are equipped with half-duplex acoustic modems, i.e., they transmit and receive not at same time.
- Anchors are placed randomly floating on the sea or in ship surface, and have the ability to move within the operating area. The anchors are equipped with GPS to govern their positions and it will be broadcast to the sensor nodes.
- It is assumed that the probability density function (pdf) of the distance between the anchors is known, $f_D(z)$. The sensor nodes are located randomly in an operating area according to some probability density function and the sensor nodes can move in the area, during the localization process, their position is

assumed to be constant. The pdf of the distance between a sensor node and an anchor is $g_D(z)$.

- In the localization algorithms a sensor node determines its distance from several anchors via ToA (time of arrival). Each sensor node can determine its location if it receives at least K different localization packets from K different anchors. The value of K depends on the geometry (2D or 3D) and other factors such as depth of the sensor node or speed of sound signal. The value of K is 3 for a 2D operating environment with known sound speed and 4 for a 3D operating environment.

- The sensor nodes can be equipped with pressure and temperature sensors.

- The localization can be done in two ways such as periodic or on demand localization.

Periodic localization:
In periodic localization all the nodes in the network including anchors and sensor nodes are synchronized with each other. In this approach, after the arrival of a packet from the jth anchor, the mth sensor node can determine its distance from that anchor by time of arrival (ToA) method.

On demand localization:
In this method the network can be synchronous or asynchronous. The sensor node transmits a high power frequency tone before the request packet. The tone wakes up the anchors from their idle mode, and puts them into the listening mode. We assume that all the anchors have been correctly notified by this frequency tone. After the anchors have received the wake up tone, they reply with localization packets.

Collision tolerant packet scheduling:
In the packet transmission scheme the collision probability is controlled by the packet transmission rate. It can avoid the need for coordination among anchor nodes. In a collision-tolerant packet scheduling (CTS), anchors work independently of each other. During a localization period or upon receiving a request from a sensor node, they transmit randomly.

Localization process:

- In the proposed method all the transmitters are time synchronized with each other.

- The localization time is the time to find the location of the sensor node which needs to be minimized. Here we consider 4 anchor device which is connected with GPS which provides location data. They are broadcasted.

- The packet labeled with Id, location and time.

ID	Location	Time of data transmission

Fig.1. Localization packet format

- Since both the anchors and nodes are time synchronized devices they have specific time slots for data transmission that is in such a way that other nodes data will not collide with each other.

- The anchor nodes send data such as ID, Location and time of data transmission.

- ID will specify the Anchor device.

- Location will specify the GPS co-ordinate of the Anchor.

- Time of transmission will specify the time in which the data has been transmitted.

- By using the method of triangulation the distance between the anchor and the node can be calculated.

- Since all the four anchors transmit data in specific time slots and the distance from the anchors and the node is calculated in which the data is triangulated to give the correct location of the node.

3. RESULTS
This results shows that time of arrival method is efficient for localization as compared to other methods. The results reveal that time of arrival method achieves better accuracy and localization process can be done rapidly. The localization can be by time of arrival and triangulation techniques. This energy overheads should be strictly managed because underwater sensor nodes directly depend on energy conservation to extend their life time.

Fig.2 shows that the transmitted signal of three anchor nodes.

For determining position of the anchor nodes.

Fig.3 shows that time of arrival error and it is the error due to time of arrival from three anchors. It is the time delay present in the transmitted signal.

By using this delay time we find the distance between anchor and sensor node. Then find the location of the sensor node.

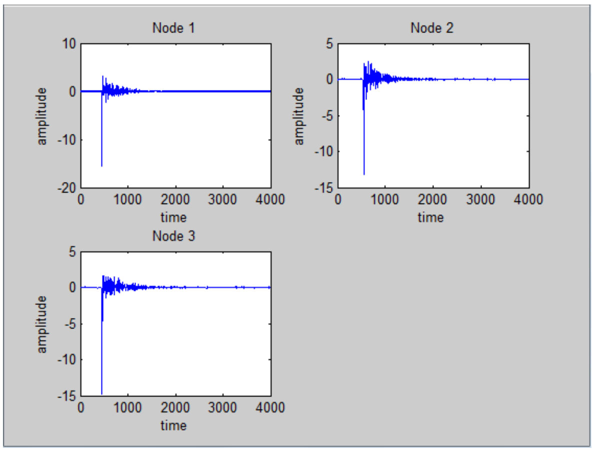

Fig 2. Transmitted signal

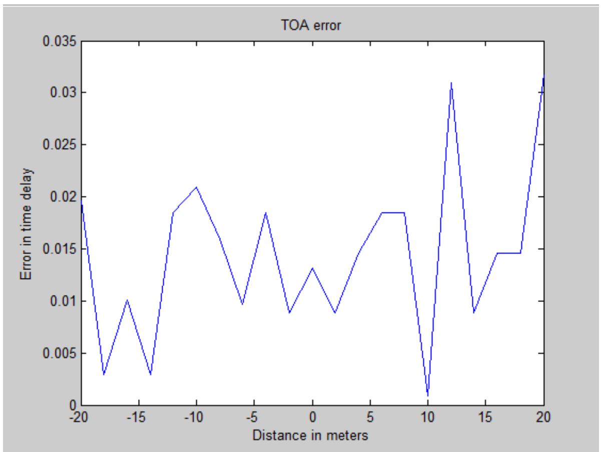

Fig 3. TOA error

Fig 4 shows that root mean square error. It is error due to environmental conditions of the sea, speed of sound signal, water density.

By using this error we have to find the distance between anchor and sensor node. Then find the location of the sensor node.

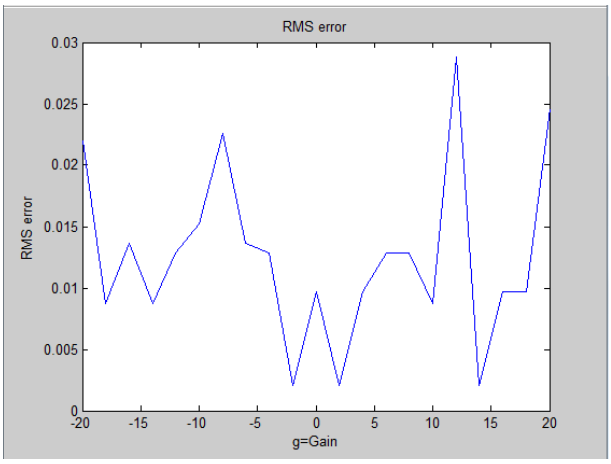

Fig 4. RMS error

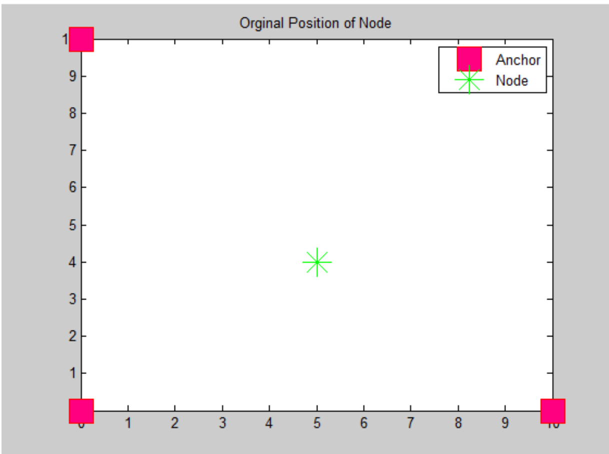

Fig 5. Original position of node

Fig 5 shows that the original position of the sensor node by using three anchor nodes.

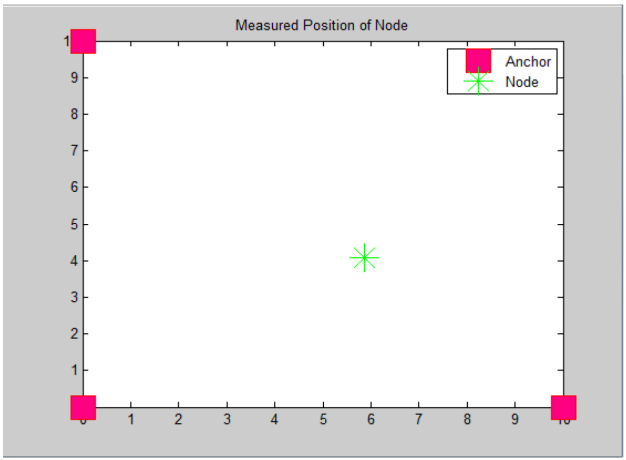

Fig 6. Measured position of node

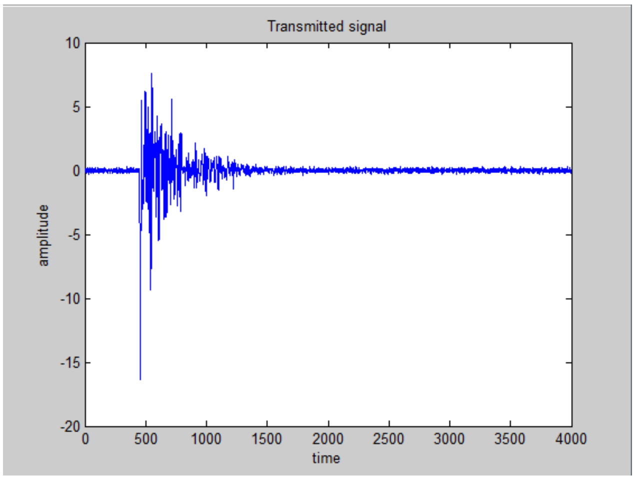

Fig 7. Transmitted signal

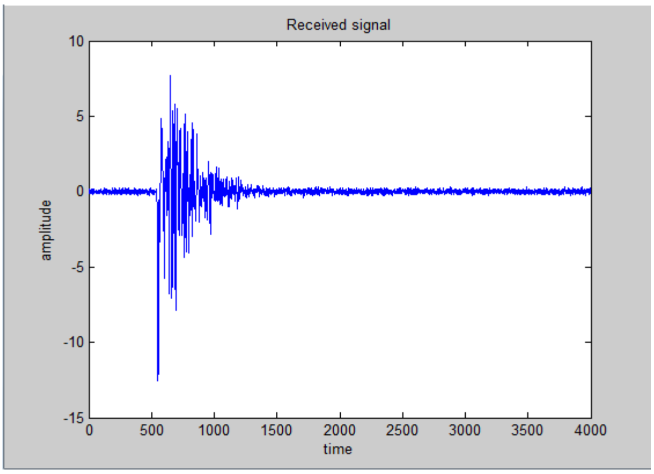

Fig 8. Received signal

In fig 7 and 8 shows that the transmitted and received signal of single anchor node.

4. CONCLUSION

In underwater acoustic sensor network consist of sensor nodes and anchors. To find the location of the sensor node by time of arrival and triangulation method. As compared to time of flight method it is better one. The accuracy and the time required to find the location of the sensor node can be reduced. The simulation results shows that the time of arrival is better for dynamic network.

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