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Cooperative Collision Free Packet Scheduling for Under Water Acoustic Sensor Network Localization

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ABSTRACT*:* This article deals with the dual problem of inaccurate localization and navigation of packets in the underwater acoustic sensor network between the anchor nodes. The packet get transmitted to the anchor nodes using two scheme such as collision tolerant scheme (CTS) and collision free packet scheduling(CFS).We are mainly focusing on minimizing the localization time so the coverage area and throughput get increased. In the collision tolerant scheme the anchor nodes work independently .so it consume more energy but CTS provide better localization in a minimum localized time with less complexity. In this Gauss Newton algorithm is employed to the every anchor nodes for the self-localization.

KEYWORDS: Acoustic sensor network Collision tolerant, Collision free packet schemes, self-localization.

1. INTRODUCTION

After the implementation of the autonomous underwater vehicles (UAV) the network is fully paving its way towards the underwater acoustic sensor networks (UASN) .It enable the application such as oceanographic data collection, Tsunami monitoring, disaster prevention ,tactical surveillance etc. In the underwater system every node should transmit it location and time to the neighbor node in the network. Major drawback on the underwater acoustic communication is low data rates and the propagation delay with variable sound speed. The range of GPS signal (Radio Frequency) is low in the underwater, so the underwater acoustic sensor is used as instead. The node location is determined by the time of flight (ToF) and also calculating the average distance between the two nodes. Accuracy factor of the self localization is determined by the number of anchors, position of the sensors node and finger printing is a technique employed to self-localization.

In the underwater system the nodes are arranged in the long base line (LBL).where the transponder is placed on the sea-floor and the underwater sensor communicate with the transponder with the round-trip estimation. In the underwater the master node send beacon signal periodically after the receiving the beacon signal the other anchor node start transmitting the data packets with the previous node. The pros of the algorithm are that reflect the problem faced by the joint node discovery and the collaborative localization without the use of GPS. In this algorithm some anchors are primary seed nodes and necessary sensor nodes are converted to the primary seed nodes, which enhances larger sensor networks. It works on the broadcasting command packets, where the nodes the time of flight. The performance is calculated by set-up time and coverage area, where the collision and shadowing is not taken into the account for the optimum localization. In this system by transmitting “good bye” by the help of the existing method such as MAC protocol it will not perform high effectively while the carrier sense multiple access (CSMA) perform better than the existing protocol.

In the previous study they considered collision-free packet in the UASN for the localization in single-channel (L-MAC) and the multiple scenario’s (DMC-MAC).It provide remarkable performance but it need a fusion centre , falls as a major drawback in this protocol. The fusion centre will carry the address of the anchors and decide the time of the data transmission from each other. And additional to that synchronization is needed and uses radio modem as medium. In

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this paper we are considering the packet scheduling algorithm, it doesn't require the fusion centre and a-synchronization of node is provided, hence the working on the GPS is not difficult. In this system we assume Single hop UASN and they provide half-duplex. The scheduling of packets takes in two scenario's: a collision free packet (CFS),where there is no collision during the transmission and collision Tolerant scheme (CTS) there is some tolerable acceptance of the collision can occur at the sensor node and receive many error-free packets for self-localization.

• The minimum value of the packet loss, collision and localization time is analytically obtained for each sensor nodes on reducing the localization time the dynamic network can be achieved and increases the throughput value.

• The Gauss Newton self localization algorithm is established to every sensor nodes, which contain packet loss and collision.
• Cramer-Rao lower bound is derived to calculate the value of the packet losses and the probability of the self – localization is determined.

II.NETWORK NODES

USAN consists of numerous sensor and anchor nodes. The anchor node shares its location &time for packet transmission with neighboring nodes. The system structure is specified as

- Anchors nodes and sensor nodes are in half duplex.
- They are randomly placed within the coverage are of the network with respective probability density function.
- It is a single hop network
- The transmission distance gives the signal strength and the distance between the anchor and the sensor nodes gives the probability for packet loss.

The localization algorithm for the sensor nodes depends on two algorithms. The sensor nodes find its distance between the anchor nodes via Round trip delay estimation and Time of flight. The algorithm for localization is either *Periodic* or *on demand* basis.

2.1. Periodic Localization

This method may be employed if all the nodes are synchronized with each other. The distance of the sensor node from the anchor is estimated as

$$\hat{d}_{m,j} = c(\hat{t}^{R}_{m,j} - t^{T}_{j}) \qquad (1)$$

Where,
c=sound speed,
t^{T}_{j}=anchor node's packet transmission time
$\hat{t}^{R}_{m,j}$=estimated time at which the packet is received at the sensor node
The estimated time is related with the arrival time by

$$\hat{t}^{R}_{m,j} = t^{R}_{m,j} + n_{m,j} \qquad (2)$$

Where $n_{m,j}$zero mean Gaussian noise .There is is no compulsion for the sensor nodes to be synchronized and so they can find the time difference easily.

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2.2. On-Demand Localization

This method applies for both synchronous and asynchronous network nodes. A wake up tone of high power frequency is sent to the anchor node to set it listening mode. After receiving the wake up tone the anchor node sends a localization packet which includes the time $t^{\wedge R}_{m,i}$, at which the wake up tone is received and the time t^{T}_{i} at which the localization

packet is sent. Considering this the sensor node estimate it's round trip time to the anchor. It is given as

$$t^{\wedge RTT}_{m,j} = \left(t^{R}_{m,j} - t^{T}_{m}\right) - \left(t^{R}_{j,m} - t^{T}_{j}\right) + n_{j,m} + n_{m,j}$$

(3)

t^{T}_{m} = time of transmission of the wake up tone from sensor node to the anchor

Estimated distance is given as

$$d^{\wedge}_{m,j} = \frac{1}{2} c t^{\wedge RTT}_{m,j} \qquad (4)$$

The sensor node estimates its location without initiating another localization task. The time within the sensor nodes receive K different data packets from K anchors are known as localization time.

III. PACKET SCHEDULING

3.1. Collision free packet scheduling

Collision free packet transmission is discussed below, where a single hop network is established for the sequence of anchor indices, and the each node should transmit the packet after the receiving from the previous one. In additional to that the localization time get reduced after the optimal ordering the sequence, to obtain the fusion centre. If the information is not transmitted then the anchor nodes send the ID numbers. In the case of the packet loss the subsequent anchor will not the time of transmissions. So the anchor node waits for a predefined time till they receive the packet from previous node.

System Model

In the First module, we develop the System Model. We consider a UASN consisting of M sensor nodes and N anchors. The anchor index starts from 1, whereas the sensor node index starts from N + 1. Each anchor in the network encapsulates its ID, its location, time of packet transmission, and a predetermined training sequence for the time of flight estimation. The so-obtained localization packet is broadcast to the network based on a given protocol, e.g., periodically, or upon the reception of a request from a sensor node. The system structure is specified as : Anchors and sensor nodes are equipped with half-duplex acoustic modems, i.e., they cannot transmit and receive simultaneously. Anchors are placed randomly on the surface, and have the ability to move within the operating area. The anchors are equipped with GPS and can determine their positions which will be broadcast to the sensor nodes. We consider a single-hop network where all the nodes are within the communication range of each other. The received signal strength (which is influenced by pathloss, fading and shadowing) is a function of transmission distance. Consequently, the probability of a packet loss is a function of distance between any pair of nodes in the network.

Collision-Free Packet Scheduling

In this module, we develop the Collision-free localization packet transmission module, where it is shown that in a fully-connected (singlehop) network, based on a given sequence of the anchors' indices, each anchor has to transmit

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immediately after receiving the previous anchor's packet. Furthermore, it is shown that there exists an optimal ordering sequence which minimizes the localization time. However, to obtain that sequence, a fusion center is required to know the positions of all the anchors. In a situation where this information is not available, we may assume that anchors simply transmit in order of their ID numbers. In the event of a packet loss, a subsequent anchor will not know when to transmit. If an anchor does not receive a packet from a previous anchor, it waits for a predefined time (counting from the starting time of the localization process), and then transmits its packet.

Collision-Tolerant Packet Scheduling

In this module we develop the Collision-Tolerant Packet Scheduling. To avoid the need for coordination among anchor nodes, in a collision-tolerant packet scheduling, anchors work independently of each other. During a localization period or upon receiving a request from a sensor node, they transmit randomly, e.g., according to a Poisson distribution with an average transmission rate of λ packets per second. Packets transmitted from different anchors may now collide at a sensor node, and the question arises as to what is the probability of successful reception. The average received signal strength is thus different for different links (this signal strength, along with a given fading model, determines the probability of packet loss).

Self-Localization Process

In this module we develop the Self-Localization process. We have seen that a sensor node requires at least K distinct packets (or time-of-flight measurements) to determine its location. However, it may receive more than K different packets, as well as some replicas, i.e., qj packets from anchor j, where j = 1, . . . ,N. In this case, a sensor uses all of this information for self-localization. Note that in the collision-free scheme, qj is either zero or one; however, in the collision-tolerant scheme qj can be more than 1. Packets received from the jth anchor can be used to estimate the sensor node's distance to that anchor, and the redundant packets add diversity (or reduce measurement noise) for this estimate. In the next two subsections, we show how all of the correctly received packets can be used in a localization algorithm, and how the CRB of the location estimate can be obtained for the proposed scheduling schemes. After the anchors transmit their localization packets, each sensor node has Q measurements. Each measurement is contaminated by noise whose power is related to the distance between the sensor and the anchor from which the measurement has been obtained. The measurement obtained from the jth anchor is related to the sensor's position x.

IV. CONCLUSION

We have considered two classes of packet scheduling for self-localization in an underwater acoustic sensor network, one based on a collision-free design and another based on a collision-tolerant design. In collision-free packet scheduling, the time of the packet transmission from each anchor is set in such a way that none of the sensor nodes experiences a collision. In contrast, collision-tolerant algorithms are designed so as to control the probability of collision to ensure successful localization with a pre-specified reliability. We have also proposed a simple Gauss-Newton based localization algorithm for these schemes, and derived their Cramér-Rao lower bounds. The performance of the two classes of algorithms in terms of the time required for localization was shown to be dependent on the circumstances. When the ratio of the packet length to the maximum propagation delay is low, as it is the case with localization, and the average probability of packet-loss is not close to zero, the collision-tolerant protocol requires less time for localization in comparison with the collision-free one for the same probability of successful localization. Except for the average energy consumed by the anchors, the collision-tolerant scheme has multiple advantages. The major one is its simplicity of implementation due to the fact that anchors work independently of each other, and as a result the scheme is spatially scalable, with no need for a fusion centre. Furthermore, its localization accuracy is always better than that of the collision free scheme due to multiple receptions of desired packets from anchors. These features make the collision-tolerant localization scheme appealing from a practical implementation view point. In the future, we will extend our work to a multi-hop network where the communication range of the acoustic modems is much shorter than the size of the operating area.

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