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Collision Free Packet Data Transmission with Packet Data Transmission without Collision by Using CTS and CFS via Fusion Centre

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Abstract:

This article considers the joint problem of packet scheduling and self-localization in an underwater acoustic sensor network with randomly distributed nodes. In terms of packet scheduling, our goal is to minimize the localization time, and to do so we consider two packet transmission schemes, namely a collision-free scheme (CFS), and a collision-tolerant scheme (CTS). The required localization time is formulated for these schemes, and through analytical results and numerical examples their performances are shown to be dependent on the circumstances. When the packet duration is short (as is the case for a localization packet), the operating area is large (above 3 km in at least one dimension), and the average probability of packet-loss is not close to zero, the collision-tolerant scheme is found to require a shorter localization time. At the same time, its implementation complexity is lower than that of the collision-free scheme, because in CTS, the anchors work independently. CTS consumes slightly more energy to make up for packet collisions, but it is shown to provide a better localization accuracy. An iterative Gauss-Newton algorithm is employed by each sensor node for self-localization, and the Cramér Rao lower bound is evaluated as a benchmark.

Keywords -- **Under water acoustic network, localization, Packet Scheduling.**

1. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

1. LITERATURE SURVEY

In this paper [7] among the large number of contributions concerning the localization techniques for wireless sensor networks (WSNs), there is still no simple, energy and cost efficient solution suitable in outdoor scenarios. In this paper, a technique based on antenna arrays and angle-of-arrival (AoA) measurements is carefully discussed. While the AoA algorithms are rarely considered for WSNs due to the large dimensions of directional antennas, some system configurations are investigated that can be easily incorporated in pocket-size wireless devices.A heuristic weighting function that enables decreasing the location errors is introduced. Also, the detailed performance analysis of the presented system is provided. The localization accuracy is validated through realistic Monte-Carlo simulations that take into account the specificity of propagation conditions in WSNs as well as the radio noise effects. Finally, trade-offs between the accuracy, localization time and the number of anchors in a network are addressed.

In this paper [8] we consider the anchor placement problem in localization based on one-way ranging, in which either the sensor or the anchors send the ranging signals. The number of anchors deployed over a geographical area is generally sparse, and we show that the anchor placement can be formulated as the design of a sparse selection vector. Interestingly, the case in which the anchors send the ranging signals, results in a joint ranging energy optimization and anchor placement problem. We make abstraction of the localization algorithm and instead use the Cramer-Rao lower bound (CRB) as the performance constraint. The anchor placement problem is formulated as an elegant convex optimization problem which can be solved efficiently.

In this paper [10], we present a silent positioning scheme termed as UPS for underwater acoustic sensor networks. UPS relies on the time-difference of arrivals measured locally at a sensor to detect range differences from the sensor to four anchor nodes. These range differences are averaged over multiple beacon intervals before they are combined to estimate the 3D sensor location through trilateration. UPS requires no time-synchronization and provides location privacy at underwater vehicles/sensors whose locations need to be determined. Simulation study on the position error of UPS under acoustic fading channels indicates that UPS is an effective scheme for underwater vehicle/sensor self-positioning.

In this paper[12], we present a novel technique for localizing an event of interest in an underwater environment. The network consists of randomly deployed identical sensor nodes. Instead of proactively localizing every single node in the network as all proposed techniques set out to do, we approach localization from a reactive angle. We reduce the localization problem to the problem of finding 4-Node Coverage, in which we form a subset of nodes such that every node in the original set is covered by four nodes belonging to this special subset - which we call the anchor nodes for simplicity. This subset of anchor nodes behaves like a backbone to the localization process. We show that in terms of energy consumption, this localization technique far surpasses others in terms of energy efficiency.

In this paper [13], Multiple access with collision avoidance (MACA) is a popular medium-access control (MAC) protocol for terrestrial networks (e.g., 802.11). Underwater acoustic networks (UANs) differ from terrestrial networks as they are characterized by long propagation delays and higher data loss. Most of the published analysis for

MACA in terrestrial networks ignores these factors, and, therefore, cannot be directly applied to UANs. As a result of the high data loss in UANs, it is common to implement reliability at a link level, rather than end-to-end acknowledgements. Keeping this in mind, we present a Markov chain analysis for a reliable variant of the MACA protocol for ad hoc UANs and derive closed-form expressions for mean service time and throughput. We show that the network performance is vastly improved with a few changes to the protocol, and propose a novel MACA-based protocol for use in UANs. For best performance, the protocol parameters such as batch size and backoff window have to be optimally chosen. We show that an optimum batch size minimizes the total waiting time. Finally, we compare our analysis results with experimental results obtained from a deployment of a small UAN.

2. EXISTING SYSTEM

Due to the challenges of underwater acoustic communications such as low data rates and long propagation delays with variable sound speed, a variety of localization algorithms have been introduced and analyzed in the literature.Although a great deal of research exists on underwater localization algorithms, little work has been done to determine how the anchors should transmit their packets to the sensor nodes. In long base-line (LBL) systems where transponders are fixed on the sea floor, an underwater node interrogates the transponders for round-trip delay estimation. In the underwater positioning scheme, a master anchor sends a beacon signal periodically, and other anchors transmit their packets in a given order after the reception of the beacon from the previous anchor. The localization algorithm addresses the problem of joint node discovery and collaborative localization without the aid of GPS.

The algorithm starts with a few anchors as primary seed nodes, and as it progresses, suitable sensor nodes are converted to seed nodes to help in discovering more sensor nodes.In previous work, we considered optimal collision-free packet scheduling in a UASN for the localization task in single-channel (L-MAC) and multi-channel scenarios (DMC-MAC). In these algorithms, the position information of the anchors is used to minimize the localization time. In spite of the remarkable performance of L-MAC and DMC-MAC over other algorithms (or MAC protocols), they are highly demanding.

The disadvantage of the existing system is:

- ❖ GPS signals (radio-frequency signals), however, cannot propagate more than a few meters, and underwater acoustic signals are used instead.
- ❖ In addition, radio signals experience negligible propagation delays as compared to the sound (acoustic) waves.
- ❖ There is no guarantee that it will perform satisfactorily for the localization task.
- ❖ The main drawback of L-MAC or DMC-MAC is that they require a fusion center which gathers the positions of all the anchors, and decides on the time of packet transmission from each anchor.
- ❖ In addition, these two collision-free algorithms need the anchors to be synchronized and equipped with radio modems to exchange information fast.

3. PROPOSED SYSTEM

In this paper, we also consider packet scheduling algorithms that do not need a fusion center. Although the synchronization of the anchors which are equipped with GPS is not difficult, the proposed algorithms can work with asynchronized anchors if there is a request from a sensor node. We assume a single-hop UASN where anchors are equipped with half-duplex acoustic modems, and can broadcast their packets based on two classes of scheduling: a collision-free scheme (CFS), where the transmitted packets never collide with each other at the receiver, and a collision-tolerant scheme (CTS), where the collision probability is controlled by the packet transmission rate in such a way that each sensor node can receive sufficiently many error-free packets for self-localization.

The advantage of the proposed system is:

- Assuming packet loss and collisions, the localization time is formulated for each scheme, and its minimum is obtained analytically for a predetermined probability of successful localization for each sensor node.
- A shorter localization time allows for a more dynamic network, and leads to a better network efficiency in terms of throughput.
- It is shown how the minimum number of anchors can be determined to reach the desired probability of selflocalization.
- An iterative Gauss-Newton self-localization algorithm is introduced for a sensor node which experiences packet loss or collision. Furthermore, the way in which his algorithm can be used for each packet scheduling scheme is outlined.
- The Cramer Rao lower bound (CRB) on localization is derived for each scheme. Other than the distance-dependent signal to noise ratio, the effects of packet loss due to fading or shadowing, collisions, and the probability of successful self-localization are included in this derivation.

4. MODULE DESCRIPTION

4.1 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.

4.2 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 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.

4.3 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

4.4 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., qjpackets 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 qjcan 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 lth measurement obtained from the $j$thanchor is related to the sensor's position x.

5. SCREENSHOTS

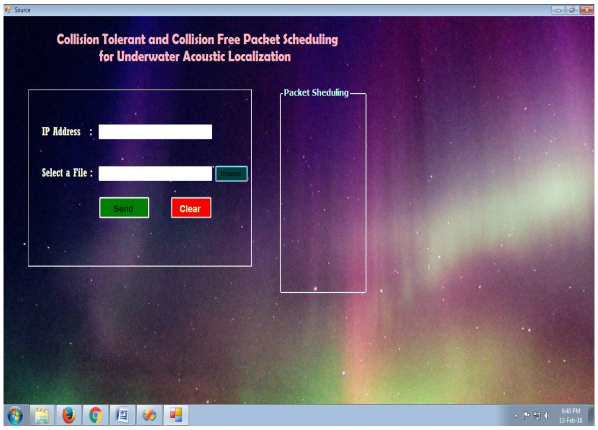


Fig 6.1 Packet Scheduling Login page

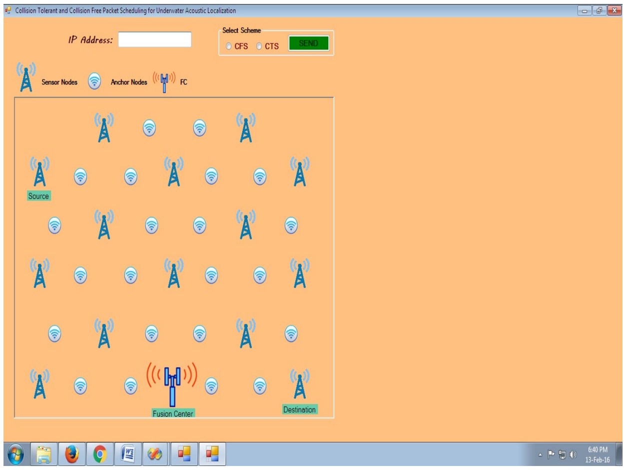


Fig 6.2 Initialization page with source and destination

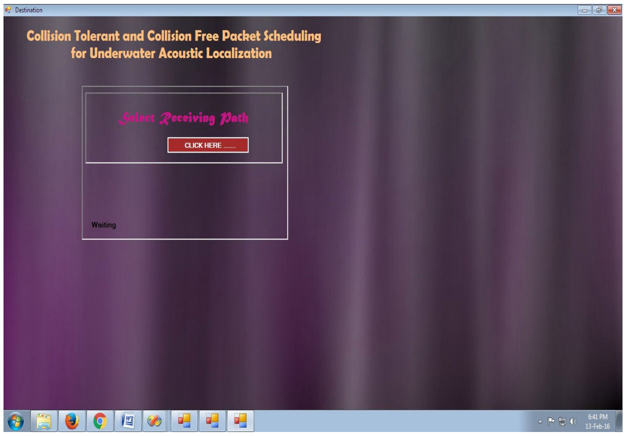
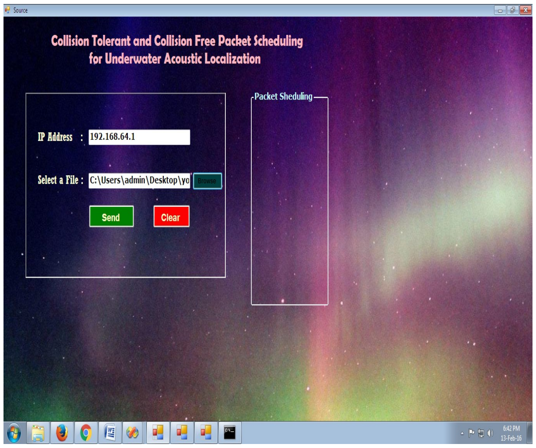


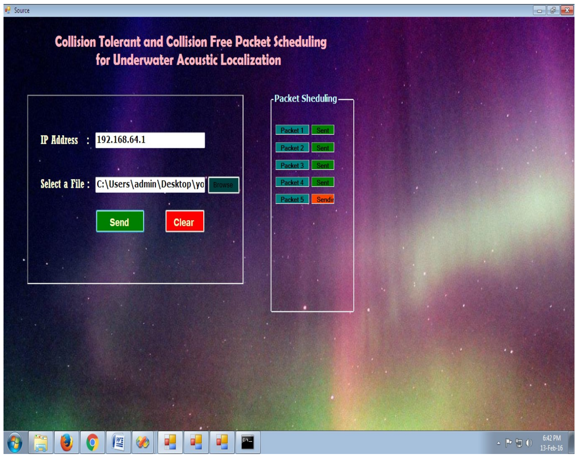
Fig 6.3 Select Receiving path



IP Address : 192.168.64.1

Select a File : C:\Users\admin\Desktop\yo

Fig 6.4 Enter IP address and Select a path

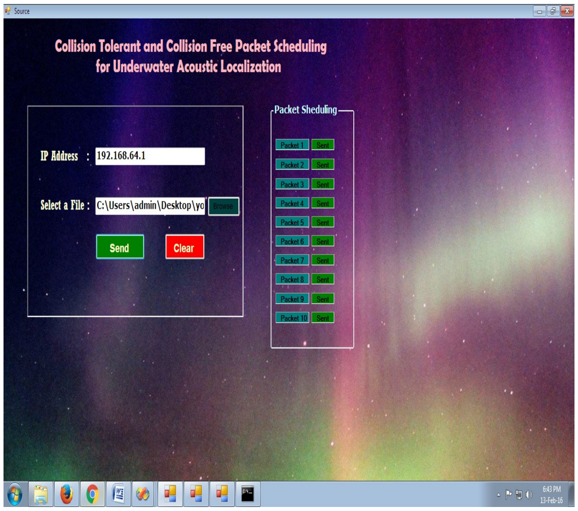


IP Address : 192.168.64.1

Select a File : C:\Users\admin\Desktop\yo

Packet 1 Sent
Packet 2 Sent
Packet 3 Sent
Packet 4 Sent
Packet 5 Sendi

Fig 6.5 Packet Sending Information



IP Address : 192.168.64.1

Select a File : C:\Users\admin\Desktop\yo

Packet 1 Sent
Packet 2 Sent
Packet 3 Sent
Packet 4 Sent
Packet 5 Sent
Packet 6 Sent
Packet 7 Sent
Packet 8 Sent
Packet 9 Sent
Packet 10 Sent

Fig 6.6 Packet sending information from 1 to 10

IP Address: 192.168.64.1

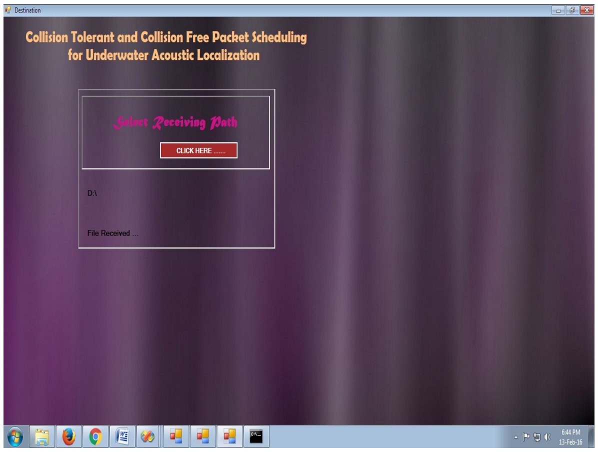
● CFS ○ CTS

Fig 6.7 Enter IP address and select a scheme

IP Address: 192.168.64.1

● CFS ○ CTS

Fig 6.8 Packet Sending from source to destination



D:\

File Received ...

Fig 6.9 Files received

6. CONCLUSION AND FUTURE WORK

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 center. 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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