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A pairwise, cross-layer, time-synchronization framework for mobile underwater sensor networks to estimate the doppler shift.

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Abstract:
Time Synchronization in wireless networks is extremely important for basic communication, but it also provides the ability to detect movement, location, and proximity. The synchronization problem consists of four parts: send time, access time, propagation time, and receive time. Time synchronization is an important task in Wireless sensor Networks (WSNs), because in most of the applications in WSNs need accurate time in nodes. A WSN consists of sensor nodes, which have the capability sense the data from its neighbouring area and process the data and forward it to other sensor nodes. Underwater wireless sensor network (UWSN) is a type of WSN, which is deployed in underwater. Time synchronization protocols have been introduced for WSNs, but none of them can be applied directly to UWSNs as most of these protocols do not consider the delay during propagation, limited band width, high error rate and mobility of nodes. Therefore to overcome these problems, new time synchronization methods have been introduced for UWSN. This paper examines the benefits, applications, challenges of time synchronization UWSN and also gives comparative study recent time synchronization methods in UWSN.

Keywords: ***Time synchronization, WSNs, UnderWater, Bandwidth, Data.***

Introduction:

The definition of time synchronization does not necessarily mean that all clocks are perfectly matched across the network. This would be the strictest form of synchronization as well as the most difficult to implement. Precise clock synchronization is not always essential, so protocols from lenient to strict are available to meet one's needs.

There are three basic types of synchronization methods for wireless networks. The first is relative timing and is the simplest. It relies on the ordering of messages and events. The basic idea is to be able to determine if event 1 occurred before event 2. Comparing the local clocks to determine the order is all that is needed. Clock synchronization is not important.

The next method is relative timing in which the network clocks are independent of each other and the nodes keep track of drift and offset. Usually a node keeps information about its drift and offset in correspondence to neighboring nodes. The nodes have the ability to synchronize their local time with another nodes local time at any instant. Most synchronization protocols use this method.

The last method is global synchronization where there is a constant global timescale throughout the network. This is obviously the most complex and the toughest to implement. Very few synchronizing algorithms use this method particularly because this type of synchronization usually is not necessary.

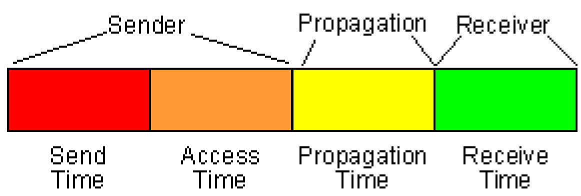

Figure 1 - Breakdown of packet delay components

As shown in figure 1, all the wireless synchronization schemes have four basic packet delay components: send time, access time, propagation time, and receive time. The send time is that of the sender constructing the time message to transmit on the network. The access time is that of the MAC layer delay in accessing the network. This could be waiting to transmit in a TDMA protocol. The time for the bits to by physically transmitted on the medium is considered the propagation time. Finally, the receive time is the receiving node processing the message and transferring it to the host. The major problem of time synchronization is not only that this packet delay exists, but also being able to predict the time spent on each can be difficult. Eliminating any of these will greatly increase the performance of the synchronization technique.

As illustrated there are many different variations of time synchronization or wireless networks. They range from very complex and difficult to implement to simpler and easy to implement. No matter the scheme used, all synchronization methods have the four basic components: send time, access time, propagation time, and receive time.

Underwater networking is a rather unexplored area althoughunderwater communications have been experimented since World War II, when, in 1945, an underwater telephone was developed in the United States to communicate with submarines. Acoustic communications are the typical physical layer technology in underwater networks. In fact, radio waves propagate at long distances through conductive sea water only at extra low frequencies (30-300 Hz), which require large antennae and high transmission power. Optical waves do not suffer from such high attenuation but are affected by scattering. Moreover, transmission of optical signals requires high precision in pointing the narrow laser beams. Thus, links in underwater networks are based on acoustic wireless communications.

The traditional approach for ocean-bottom or ocean column monitoring is to deploy underwater sensors that record data during the monitoring mission, and then recover the instruments. This approach has the following disadvantages:

- Real time monitoring is not possible. This is critical especially in surveillance or in environmental monitoring applications such as seismic monitoring. The recorded data cannot be accessed until the instruments are recovered, which may happen several months after the beginning of the monitoring mission.
- No interaction is possible between onshore control systems and the monitoring instruments. This impedes any adaptive tuning of the instruments, nor is it possible to reconfigure the system after particular events occur.
- If failures or misconfigurations occur, it may not be possible to detect them before the instruments are recovered. This can easily lead to the complete failure of a monitoring mission.
- The amount of data that can be recorded during the monitoring mission by every sensor is limited by the capacity of the onboard storage devices (memories, hard disks, etc.).

Therefore, there is a need to deploy underwater networks that will enable real time monitoring of selected ocean areas, remote configuration and interaction with onshore human operators. This can be obtained by connecting underwater instruments by means of wireless links based on acoustic communication.

Many researchers are currently engaged in developing networking solutions for terrestrial wireless ad hoc and sensor networks. Although there exist many recently developed network protocols for wireless sensor networks, the unique characteristics of the underwater acoustic communication channel, such as limited bandwidth capacity and variable delays, require for very efficient and reliable new data communication protocols.

Major challenges in the design of underwater acoustic networks are:

- Battery power is limited and usually batteries can not be recharged, also because solar energy cannot be exploited;
- The available bandwidth is severely limited;
- Channel characteristics, including long and variable propagation delays, multi-path and fading problems;
- High bit error rates;
- Underwater sensors are prone to failures because of fouling, corrosion, etc.

Related Work

In recent years, there is growing interest in time synchronization for underwater wireless sensor networks. However, the research is still limited. From literatures, TSHL is designed to estimate skew and offset by using one-way and two-way communications respectively for the high latency networks. However, a common assumption of the constant propagation delay during the message exchanges in static networks is not applicable in mobile networks. MU-Sync is a cluster-based protocol, in which the cluster head is responsible for starting the time synchronization process and for calculating the skew and offset for all nodes within the cluster. MUSync performs twice linear regression. For the first linear regression , the cluster head estimates skew to reduce the effect of skew during the processing time of the neighboring node. For the Second linear regression, the skew and offset are estimated. Although, MU-Sync is designed to solve the long and dynamic propagation delay, the calculation of propagation delay from half of the round trip time is inaccurate.

Mobi-Sync is different from the previous methods. The MobiSync structure consists of three types of nodes, namely surface buoy, super node and ordinary node. The surface buoys are equipped with GPS to obtain the global time. The super nodes are assume to be able to communicate with surface buoys in real time. In practice, this assumption is not realistic. The ordinary nodes will synchronize with the super nodes by spatial correlation of velocity of the super nodes. To achieve good time synchronization, it required minimum three or more super nodes. D-Sync and DA-Sync utilize the Doppler shift to estimate velocity of the nodes. In D-Sync, the estimated velocity is used for estimating the propagation delay. Since there is error in the estimated velocity, it will certainly result in error in the estimation of the propagation delay. On the other hand, DA-Sync the estimated velocities are leveraging by Kalman filter before used in the propagation delay estimation. However, the leveraging process requires a good precision in the velocity measurement. This is difficult to archive.

Existing System:

- Existing time-synchronization schemes use half of the round trip time to calculate one way propagation delay.
- Due to the node mobility, propagation delays on the way forth and back are not necessarily identical, especially when nodes move at high speed.
- This issue severely decreases the accuracy of most time synchronization approaches.

Disadvantages of Existing System:

- Both accuracy and energy efficiency is less.
- Long propagation delay.

Proposed System:

- In this paper, we propose a novel time-synchronization scheme, called DA-Sync, which is a fundamental cross-layer-designed time-synchronization protocol specific for mobile UWSNs.

- DA-Sync provides a fundamental method to synchronize two sensor nodes, i.e., an ordinary node and a reference node.

- The scheme proposes a framework to estimate the doppler shift caused by mobility, more precisely through accounting the impact of the skew.

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DA-Sync that is Doppler assisted time synchronization scheme uses a pair wise cross layer time synchronization approach for under water sensor networks. Compared to the other synchronization approaches DA-Sync works in physical MAC cross layer. In DA-Sync the Doppler shift that is the relative changes in velocity has been estimated and then the accuracy in synchronization is maintained by employing a kalman filter. In order to measure the relative velocity of the sensor nodes they use Doppler scaling factor estimation algorithm which are further refined by a kalman filter in order to improve accuracy. Advantages of this approach is that accuracy of the propagation delay estimation is tremendously improved when compared to the other approaches as it incorporates the relative moving velocities between these nodes. Whereas the previous approaches used half of the round trip time to estimate the propagation delay. Also it uses the MAC layer time stamp information's to reduce the non-deterministic errors in the time synchronization.

Advantages of Proposed System:

- Different algorithms have different sync message (including request and response messages) packet sizes since they need to carry different amounts of information.
- High accuracy and high energy efficiency.
- Reduce the nondeterministic errors that are commonly encountered by time synchronization algorithms which rely on message exchanges.

Conclusion:

In all wireless networks, the major problem for synchronization protocols is the variance in the send time, access time, propagation time, and the receive time. Elimination or the ability to accurately predict any of these greatly increases the effectiveness of the synchronization protocol. In this paper, we present DA-Sync, a time synchroniza-tion protocol developed for mobile underwater network. We have shown that the benefits, applications, challenges of time synchronization UWSN and also gives comparative study recent time synchronization methods in UWSN.

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