Schedule Based Collision Free MAC Protocol for Underwater Acoustic Wireless Sensor Networks

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ABSTRACT

***Abstract*- Underwater Acoustic Sensor Networks (UW-ASNs) utilize acoustic waves as a means of communications and are, accordingly, faced with problems of high propagation delays, low bandwidth, and significant transmission power consumption. This unique situation makes the existing MAC protocols designed for radio networks either unpractical or not energy efficient for underwater sensor networks. To this end, we propose a schedule based MAC protocol that uses scheduling algorithms both at sender and receiver nodes. Minimal number of overhead control messages and novel scheduling strategy of the proposed protocol allows increasing the number of concurrent transmissions within a network while excluding the likelihood of data packets collisions.**

***Keywords*- underwater, acoustic wireless sensor networks, schedule, MAC, collision avoidance, medium access control.**

1. INTRODUCTION

Unlike terrestrial wireless networks that mainly rely on radio waves for communications, underwater acoustic sensor networks (UW-ASNs) use acoustic wave which is possessed of quite narrow available bandwidth and high propagation delay. In particular, the amount of available bandwidth depends on both the communication range and the carrier frequency [1], an underwater acoustic network that operates over several tens of kilometers may have a bandwidth of only a few kilohertz, while a short-range network operating over several tens of meters may have more than a hundred kilohertz of bandwidth [1, 2]. The long propagation delay, on the other hand, is a result of the low speed of acoustic wave in underwater environment. In general, we assume that the speed of acoustic wave is approximately 1500 m/s, which is five orders of magnitude slower than radio waves. Underwater acoustic communication experience severe transmission loss due to multi-path, signal attenuation, geometric spreading and noise that is coming from marine life, human aquatic activity, and natural phenomena such as storms.

All these undesirable conditions for acoustic channel create a big challenge in developing a robust medium access control (MAC) protocol for UW-ASNs. The main task of a MAC protocol here is to prevent simultaneous transmissions that lead to packet collisions. In designing a MAC protocol for UW-ASNs, collision avoidance mechanism is a must-have feature since a packet collision leads to a packet retransmission, which is very costly in term of bandwidth and transmission power. In addition to the collision avoidance capability, the designed MAC protocol for UW-ASNs must also take into consideration limited battery resources of autonomous sensor nodes [2]. It introduces another challenge for researchers to obtain long operating time without sacrificing system performance.

In this paper we propose a Schedule Based Collision Free MAC protocol with collision avoidance mechanism. The aim is to develop a new multi-access protocol for UW-ASNs. The protocol is based on a scheduling algorithm that prevents any overlaps and collisions. Proposed protocol, unlike other MAC protocols, should conserve more battery power at nodes by significantly reducing number of retransmissions and overhead control packets.

The remainder of this paper is organized as follows. In Section 2 we briefly review related works. Section 3 introduces proposed schedule based collision free MAC protocol. Finally, Section 4 draws the conclusion and future work.

2. RELATED RESEARCHES

Recently, various schedule based and reservation based MAC protocol solutions have been proposed for UW-ASNs.

Slotted floor acquisition multiple access (FAMA) protocol was proposed by M. Molins and M. Stojanovic [3]. Slotted FAMA avoids packet collisions without requirements on the packet size and reduce excessive waste of overhead control packets by slotting the time for each packet.

UW-MAC, a distributed MAC protocol for underwater acoustic sensor networks, was proposed by D. Pompili et al [4]. It is transmitter based CDMA schemes that incorporates a closed-loop distributed algorithm to set the optimal transmit power and code length. It is proven that UW-MAC manages to simultaneously achieve high network throughput, limited channel access delay, and low energy consumption.

A. Cho et al [5] have proposed a BTB-TDMA, Block Time Bounded Time Division Multiple Access, protocol for UW-ASNs consisting of mobile underwater nodes. The BTB-TDMA protocol provides underwater nodes with the scheduling algorithm that gives time bound for data transfer with a unit of time block in order to reduce overall delay and avoid packet collisions among underwater nodes.

In the most recent study, Queen-MAC, a quorum-based energy-efficient MAC protocol was proposed by G. Ekbatanifard et al [6]. Queen-MAC independently and adaptively schedules nodes wake-up times, decreases idle listening and collisions, increases network throughput, and extends network lifetime.

3. PROPOSED PROTOCOL

In this section, we first brief the basic ideas of the proposed MAC protocol and its overall model.

3.1. Overview

In general, proper network topology is an important factor in shaping the energy consumption, the capacity and the reliability of the UASWN [1]. For our proposed MAC protocol we exploit static two-dimensional architecture for UW-ASNs. Underwater sensor nodes are interconnected to each other and can be connected to underwater sinks (uw-sinks) via direct links or through multi-hop paths. The data produced by a source sensor is relayed by intermediate sensors until it reaches the uw-sink. This results in energy savings and increased network capacity since direct links connections reduce network throughput because of increased acoustic interference due to high transmission power.

The basic idea of the proposed protocol is to utilize a schedule table at each underwater sensor node that will keep all the timing and reservation information. When a node (i.e., sender) wants to send data to another node (i.e., receiver), the protocol employs an AD message based approach to synchronize, in a distributed way within a network, data transmissions to avoid data collisions.

The proposed protocol has three phases, namely, announcement period, schedule synchronization and periodic operation. The first two phases are used to synchronize nodes within a neighborhood and the third one is for actual data sending operations.

Fig. 1 shows an example of a transmission time chart of the proposed MAC protocol. P1 is an announcement phase, beginning of any data sending, where sender nodes S1 and S2 send AD MSG to receiver node R1. AD MSG includes such information as data sending start time, transmission duration and estimated arrival time. During schedule synchronization phase P2 receiver node R1 whether, if there is no collisions with existing schedules, just updates schedule table with new entry according to information from AD MSG; or, if a collision detected, sends back modified schedule information MOD MSG with new start time of data sending to prevent collision.

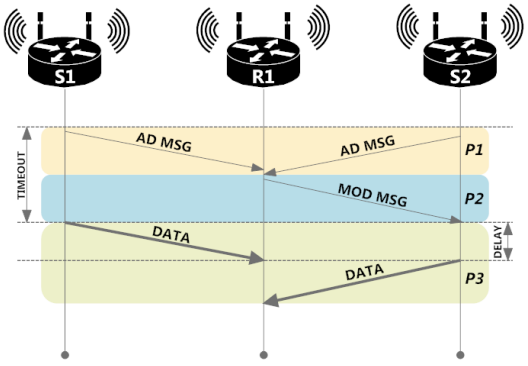

Figure1. Transmission time chart of the proposed protocol

After TIMEOUT time, when no MOD MSG received from R1, sender node S1 starts transmission of data according to initial schedule times. Sender node S2, in its turn, updates its schedule table with new sending times and sends data after DELAY time created by scheduling algorithms.

3.2. *Model*

General operation steps of sending and receiving of the proposed protocol model can be seen in Fig. 2.

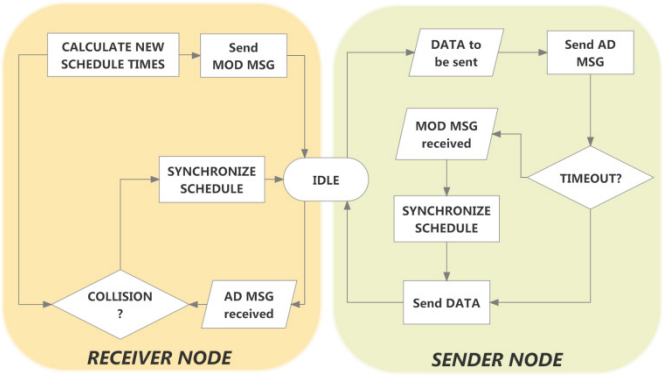

Figure 2. Overall flow chart of the proposed protocol

4. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a schedule based MAC protocol with collision avoidance mechanism for UW-ASNs. This approach utilizes scheduling algorithms in order to prevent any collisions and data retransmissions, and therefore conserve more battery power.

There are several directions for future work. Performance of the proposed protocol must be thoroughly studied and evaluated using simulations to such metrics as throughput, end-to-end delay, collision rate and energy consumption. Also, it is crucial to solve problems of idle listening and overhearing as two of the main energy-waste activities of the MAC protocol for UW-ASNs are idle condition and overhearing [7].

5. ACKNOWLEDGEMENT

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