Design of a new MAC protocol for underwater acoustic network

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ABSTRACT

This paper deals with a new MAC protocol for underwater acoustic networks. The proposed MAC protocol has a cluster structure with a master node and multiple slave nodes. In addition the proposed MAC protocol consist of a hybrid network structure that combines a contention free period based on TDMA (Time Division Multiple Access) with a contention period. The protocol we propose provides the following: a beacon packet for supervising the network, a guard period time between time slots to avoid packet collision, the time tag for estimating the propagation delay with a master node, the time synchronization of nodes, the entering and leaving of network, and the communication method among nodes. In this paper, we propose a basic concept for a new hybrid MAC protocol and show the example of adaptation for AUV which is the representative mobile device of underwater acoustic network.

KEY WORDS: Underwater acoustic network; MAC; contention based MAC; TDMA; a hybrid MAC, contention-free MAC, underwater MAC

INTRODUCTION

With an increasing interest to the ocean, the demand for exploration of natural undersea resources and gathering of scientific data is increasing. Compared to traditional approaches for ocean-bottom or ocean-column monitoring which deploys oceanographic sensors, record the data, and recover the instruments, underwater acoustic network are formed by establishing two-way acoustic links between various instruments such as unmanned or autonomous underwater vehicles and mobile/fixed sensors. Underwater acoustic network can establish real-time communication between the underwater instruments and a control center within a network configuration.
Some of the many potential applications using underwater acoustic network include oceanographic data collection, pollution monitoring, the seafloor exploration, ocean disaster prevention, and tactical surveillance applications for the national defense [Akyildiz et al, 2005].
Despite the many applications where underwater acoustic network can be used, underwater networking is a rather unexplored area. Only a few experimental implementations of underwater acoustic network have

been reported in the last few years. The United States plays a leading part in researching underwater acoustic network. Some typical projects include, the Autonomous Oceanographic Sampling Network (AOSN) [www.mbari.org/aosn], the Front-Resolving Oceanographic Network with Telemetry (FRONT) [Rice et al, 2001],[Rice, 2005], and the Persistent Littoral Undersea Surveillance Network (PLUSNet) [Stewart, 2006].
The research of network MAC protocols in underwater environments is subject to restriction   because the underwater channel is characterized by long propagation delay and it reduces the throughput of the networks. Currently, with the expansions of research projects in the underwater communications field, the fundamental research efforts in underwater protocols are also in progress. Recently, the general contention-based schemes such as ALOHA, Slotted-ALOHA, and CSMA/CA used in IEEE 802.11 have been studied for its uses in underwater acoustic networks [Guo et al, 2007], [Chirdchoo et al, 2007]. Hybrid TDMA-CDMA clusters with MACA-style RTS/CTS/DATA handshakes is used in SEAWEB project which is the most extensive and longest-running series of underwater acoustic networking deployments [Partan et al 2005]. Freitag, et al[Freitag et al, 2005] describe a single-hop, star-topology AUV network for Mine Countermeasures (MCM) operations, use a central gateway buoy provides remote operator control of the AUVs (Autonomous Underwater Vehicles) using TDMA with low rate commands sent to the AUVs. AÇar and Adams [AÇar et al, 2006] describe ACMENet, which uses a centralized TDMA protocol, with adaptive data rates and power control. Salvá-Garau and Stojanovic [Salvá-Garau et al, 2003] describe combined TDMA-CDMA clusters with in-cluster communication using TDMA and inter-cluster communication using CDMA.
Existing TDMA protocols in underwater environments have the structure of cluster network consisting of a master node and slave nodes, are studied for oceanographic environment monitoring with periodically sending data to a master node. It has the some limitations for entering of a new node to existing network and data communication among nodes. And, the network performance of throughput and delay in contention-based MAC protocols for underwater acoustic networks is very poor. It's so difficult to effective implementation.
Therefore, in this paper, we propose a new hybrid MAC protocol which combines contention-free MAC scheme based on TDMA with contention-based MAC scheme for underwater acoustic network.