Deep-ocean Data Acquisition Using Underwater Sensor Networks

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ABSTRACT

The traditional approach of ocean data acquisition, based on the deployment of battery operated stations with sensors for data recording during some programmed time for later recovery, has several drawbacks that may be overcome with the use of Underwater Sensor Networks (UWSN). In this work we investigate the feasibility of UWSN for deep-ocean data acquisition. The limitations of acoustic channel are discussed and taken into account to analyze the feasibility of this class of network for one important application, deep-ocean current monitoring. Also, we propose a method for UWSN synchronization based on the tide variations.

KEY WORDS: Underwater; acoustic; sensor; network; synchronization; tide.

INTRODUCTION

There is an increasing interest in acquiring oceanographic data due to the importance of the ocean to different aspects of human life. Navigation, fishing, ecology, weather influence and support for petroleum offshore exploration are some of the examples of this importance. Nevertheless, although covering more than 70% of the Earth surface, the oceans are not well known due to their dimensions, difficulties of data acquisition and the high costs of maritime equipment and operations.

The traditional approach for data acquisition and ocean monitoring is based on several sensors gathered in one station operating on batteries. This station is left in the ocean in the place of interest and keeps recording data during some programmed time, which may last several days, weeks, or even months. At the end of the programmed time the station is recovered for data upload, processing, and analysis.

This kind of data acquisition has been used for long time but it has severe drawbacks: it is limited to one point of survey, it does not allow the monitoring of data quality during the mission, it has limited storage capacity and the acquisition parameters must be established at the beginning of operation and must remain unchanged until the end of the mission. Moreover, it is not possible to guarantee the sensors health during the mission. Frequently, we only discover at the end of the mission, that some sensors have failed and have recorded no data. For shallow waters, there are experiences connecting cables from the sensor station to a radio-equipped surface buoy to transmit sensors data to a land station in real time, but this solution is still limited to one point of survey. Furthermore, for deep-water there is the operational complication of long cable lengths.

The use of UWSN may overcome the drawbacks of this traditional way of ocean data acquisition but, although UWSN has been pointed out as solution for a lot of applications, some precautions must be taken in the analysis of its feasibility. To start with, there is a problem with the physical medium.

Although underwater communication may be accomplished through optic or electromagnetic waves, the effective technology for UWSN is acoustic. Therefore, the acoustic channel limitations must be taken into account on application feasibility analysis. In this work we discuss these limitations and show the feasibility of UWSN for sea current monitoring. Sea current monitoring is one of the most important underwater parameter, due to its influence on the weather and on the planning and execution of petroleum offshore exploration (Brown, Nicholas, Driver, 2005).

We also propose a method for nodes synchronization based on tide variations, even for deep-ocean scenarios. UWSN synchronization is challenging. The solutions known are based on periodical acoustic message exchanges between neighbor nodes, which consume energy. Tide variations may be passively monitored by all UWSN nodes to get a rough, yet reliable synchronization.

This work is organized as follows: Section UNDERWATER SENSOR NETWORKS describes those sensor networks, their possible topologies and a common architecture. Section UNDERWATER COMMUNICATIONS focuses on the underwater acoustic channel. In section APPLICATIONS REQUIREMENTS, we review important