Chapter 5

A Review on Localization Techniques in Underwater Acoustic Sensor Networks (UASN)

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ABSTRACT

The development of underwater acoustics was initiated by sonar technologists to train sonar operators and to predict sonar performance. The traditional approaches of ocean monitoring have drawbacks of real time monitoring, online system configuration, storage capacity and failure detection. To overcome these drawbacks an extensive research work is being carried out by many promotional bodies and prominent researchers to promote the advances and applications of underwater features. Recent advancements in sensor technologies have explored the unexplored applications and help to monitor and forecast the ocean openings. Underwater acoustics plays important role in monitoring systems, seismic monitoring, ocean sampling networks, undersea discoveries, catastrophic prevention, environmental monitoring etc. It is highly desirable to know the location in every application. Localization plays vital role in each and every application. This chapter discusses various techniques which are experimented and tested for different architectures in underwater acoustic sensor networks.

INTRODUCTION

More than two third of earth’s surface is covered by oceans with an average depth of 3700m, and they contain 97% of the earth’s water, but most oceans have not been explored till to now. In recent times, Underwater Acoustic Sensor Networks (UASN) is attracting more attention of oceanographers and researchers for a wide spectrum of oceanographic applications. UASN is a multi-functional water envi-
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Environment monitoring network composed of large various underwater acoustic sensors which are freely suspended in ocean. This kind of infrastructure less deployment forces the nodes to disperse freely on the 3D space of the ocean floor. This UASN can collect hydrological data such as temperature, pressure, PH value, salinity, alkalinity and so on. UASNs have been widely applied in many fields, such as military (Naval) applications, environmental pollution monitoring, disaster (tsunami) forewarning, ocean life monitoring systems, and hazard monitoring (Guangjie, Aihua, Chenyu, Yan, & Joel, 2014).

In all these applications, the observed information must be associated with a location to provide proper view of the observed phenomena. Localization is considered as a basic capability of underwater devices if it is tracking a target, exploring resources, monitoring the underwater environment. In terrestrial WSNs, GPS is the commonly used method to localize the nodes which is impracticable in UASN as these signals cannot propagate in water. Long antennae and high propagation power required to propagate radio signals for longer distances through water due to low frequency between 30Hz and 300Hz (Han, Jiang, Shu, Xu, & Wang, 2012). The variable speed of sound and the node mobility caused by water current pose new challenges to localization issues in UASNs. Hence communication between deployed underwater nodes and surface nodes uses acoustic communication for underwater data transmission.

Underwater acoustic networks operate under certain constraints and challenges (Akyildiz, Pompili, & Melodia, 2005), which are produced by the extreme conditions of water environment and the restrictions of the acoustic signal:

- **Disturbance and Noise**: Inherent characteristics of ocean water such as salinity, temperature, and pressure influences the underwater acoustic communication and channel along with disturbances such as path loss and multipath. All these cause the propagation path to intricate with temporal and spatial variation. Meanwhile, the channel is subjected to manmade and ambient noise, which produces uncertain perturbations to the system constantly.
- **Poor Link Quality**: The acoustic channel for underwater has low link quality and the connectivity is not reliable because the communication link suffers from various disturbances, noise and leads to the high error rates.
- **Long Latency**: The physical transformation of communication from RF to acoustics changes the signal propagation speed from light to sound, which indicates the propagation delay is five orders of magnitude longer under the water than in the air. Therefore, time synchronization is essential for designing routing or localization techniques.
- **Limited Bandwidth and Low Data Rate**: The available bandwidth of the acoustic channel is limited, particularly under long-range transmission and hence, the data rate is very low.
- **Mobility Model**: Acoustic nodes are movable in nature due to the water current. If periodic observation is not provided then the location may become invalid. Hence localization technique should incorporate proper mobility model.

Additionally, the hardware, which is more complex and expensive than terrestrial sensor nodes, should be fully protected against extreme underwater environment, such as marine corrosion. These limitations of underwater acoustic channels make it a more challenging task to design localization protocols. Every localization protocol should fulfil some properties such as high accuracy, wide coverage, low communication cost etc.

Localization techniques can be categorized according to Input Data (range-free and range-based), Accuracy (fine grained and coarse grained), Positioning (relative and absolute), Node placement (mobile and...