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Underwater Acoustic Networks – Issues and Solutions

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Abstract- **Underwater Acoustic Networks (UANs) are very unique and can be deployed for commercial and military applications. The research of UANs attracts increasing attention in recent years. This survey paper first introduces the concept of UANs, and then reviews some recent developments within this research area. It also lists some practical and potential research issues of UANs, ranging from energy saving and deployment to different layers. Finally, some suggestions and promising solutions are given for these issues.**

***Index Terms*—Underwater Acoustic Networks, Underwater Acoustic Communications, Energy Efficiency, Medium Access Control, Cross Layer Design**

1. INTRODUCTION

Two thirds of the earth surface is composed of water. Compared with our human being's familiarity with land, there are still many un-explored areas underwater. This needs significant research efforts.

The research of Underwater Acoustic Networks (UANs) is attracting attention due to their important underwater applications for military and commercial purposes. More and more research interest and efforts are shifting to this area in recent years. The broad applications of UANs include but not limited to:

- Information exchange among nodes that are within the range of the network, or outside the network with the help of, e.g., a gateway, or a switch center. The primary design goal of communication networks is for exchanging information. In an UAN, exchanging information among nodes is one of its essential applications. An example is that underwater Internet, in which users can share information without tether, will become realistic instead of just a dream, if UANs are deployed. Another important application is real-time communication with submarines and autonomous underwater vehicles in network configurations [33].
- Information collection for oceans, lakes, and rivers. For example, synoptic and cooperative adaptive sampling of 3D coastal ocean environment [24] was performed by Odyssey-class AUVs [25]. Such kind of activities could improve human ability to observe and predict the characteristics of ocean/lake/river environment.
- Surveillance. It includes surveillance, reconnaissance, targeting, and intrusion detection. By using different types of sensors, an UAN can achieve more accurate and classification of low signature targets compared with traditional surveillance systems.
- Environmental monitoring. Pollution in near-shore oceans is an urgent issue and needs close watch. UANS can perform different kinds of pollution monitoring, e.g., chemical, biological, nuclear, and oil-leakage pollutions in bays, lakes, or rivers [26]. UANs can also be used to monitor ocean currents and temperature change, e.g., the global warming effect to ocean.
- Underwater explorations. Underwater explorations are difficult for human beings due to the high water pressure, unpredictable underwater activities and vast size of unknown area. UANs can help us explore the underwater world that we are not familiar with. Such kinds of activities include exploring minerals and oilfields, determining routines for laying undersea cables, etc.
- Disaster prevention. By deploying Acoustic Sensor Networks in remote locations to monitor undersea activities, ocean-related disaster like tsunami and sea-quake can be warned to coastal areas in real time when it happens [27].
- Mine detection. An UAN can detect mine efficiently by using acoustic sensors and optical sensors together. An AUV network infrastructure is introduced for mine countermeasure operations in [28].

From a communication system aspect, underwater environment is much different from its ground-based counterpart. Correspondently, the research of UANs becomes different and exhibits certain unique features. It is because:

1) Acoustic signal is the only physical feasible tool that works in underwater environment. Compared with it, electromagnetic wave can only travel in water with short distance due to the high attenuation and absorption effect in underwater environment. It is found that the absorption of electromagnetic energy in sea water is about $45\times\sqrt{f}$ dB per kilometer, where f is frequency in Hertz; In contrast, the absorption of acoustic signal over most frequencies of interest is about three orders of magnitude lower [31].

   Optical signal is strongly scattered and absorbed underwater [29]. There are some investigations about utilizing optical signal for underwater applications. However, they find out that optical signal can only pass through limited range in very clean water environment (deep water, for example) [23]. Thus, it is not a proper tool for long-distance transmission underwater, or in a not-so-clean water, e.g., shallow water, environment.

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