Volume : 3 | Issue : 4 | May 2013 ISSN - 2250-1991

Research Paper Engineering

A survey of Underwater Acoustic Networks: Architecture, Applications, Issues

* Iva Chauhan ** Lahar Shah *** Prof. Priyanka Dashrathsinh Puvar **** Prof.Bhagirath Prajapati

*, **, ***, **** Computer Engineering Dept, ADIT, V V Nagar

ABSTRACT

With the advances in acoustic modem technology that enabled high-rate reliable communications, current research focuses on communication between various remote instruments within a network environment. Research on underwater networking has become an interesting, attractive and challenging field today due to its support to the applications like, oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention and assisted navigation. We can define underwater acoustic networking as the enabling technology for this applications.Underwater acoustic(UWA) networks are generally configered by acoustically connecting ocean-bottom sensors, autonomous underwater vehicles, and a surface station, which provides a link to an on-shore control center. The goal of this paper is to survey the existing network technology, architecture and components used to form underwater networks. Also the key fundamentals about underwater network IP based cameras, which are able to be conected to internet and contain built-in web servers are detailed here. Also unmanned or autonomous underwater vehicles (UUVs, AUVs), which are equipped with sensors and enable the exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions, are discussed here.

1. INTRODUCTION

Underwater network is practically unexplored as compared to the terrestrial wired and wireless networks. Underwater networking is a rather unexplored area although underwater communications have been experimented since World War II, when, in 1945, an underwater telephone was developed in the United States to communicate with submarines. Underwater networks are nowadays quiet useful in many water related applications like oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications etc. To support these applications, there is a need to enable underwater communications among underwater devices. And for underwater communication underwater devices like underwater sensor nodes and vehicles must have self-configuration capabilities. They must be able to coordinate their operation by exchanging configuration, location and movement information, and to convey monitored data to an onshore station. Again there can be two aspects for developing underwater networking. One is for wired networks and another for wireless networks. Wireless underwater acoustic networking is the enabling technology for applications listed above. This paper explains underwater networking in detail by exploring architecture, requirements to form UWN, applications of UWN, Challenges of UWN and issues in UWN. Examples of some existing UWNs are also discussed.

2. OVERVIEW OF UNDERWATER ACOUSTIC SENSOR NETWORK

Underwater acoustic (UWA) networks are generally formed by acoustically connected ocean-bottom sensors, autonomous underwater vehicles, and a surface station, which provides a link to an on-shore control center. The traditional approach for ocean-bottom or ocean-column monitoring is to deploy oceanographic sensors, record the data, and recover the instruments. This creates long lags in receiving the recorded information. Also, if a failure occurs before recovery, all the data is lost. So the solution for these applications is to establish real-time communication between the underwater instruments and a control center within a network configuration. This type of network can be formed by establishing two way acoustic links between various autonomous underwater vehicles (AUVs) and sensors. The network is then connected to a surface station and is further connected to internet. Thus data or information can be extracted from multiple distant underwater instruments [1]. Since data is transferred to the control station when it is available, data loss is prevented until a failure occurs.

Acoustic Propagation Basics

Underwater acoustic communications are mainly influenced by:

- Path loss
- Noise
- Multi-path
- Doppler spread
- high andvariable propagation delay

All these factors determine the temporal and spatial variability of the acoustic channel, and make the available bandwidth of the Under-Water Acoustic channel (UW-A) limited and dramatically dependent on both range and frequency [2].

3. UNDERWATER NETWORK ARCHITECTURE

In order to apply underwater network techniques, we need a definite architecture or a common framework which is accepted globally. However, no such thing exists for underwater acoustics to unify the proposed schemes into a functional underwater network. The availability of such a framework accelerates the pace of research in underwater acoustic networking [3]. The UNA takes into account underwater networking needs and is specific enough to allow easy integration between implementations of different layers by different research groups. At the same time, the architecture is flexible enough to accommodate different application requirements and new ideas [8]. There are basically two types of architectures as explained below.

3.1 Two-dimensional Architecture

These are constituted by sensor nodes that are anchored to the bottom of the ocean.

ISSN - 2250-1991

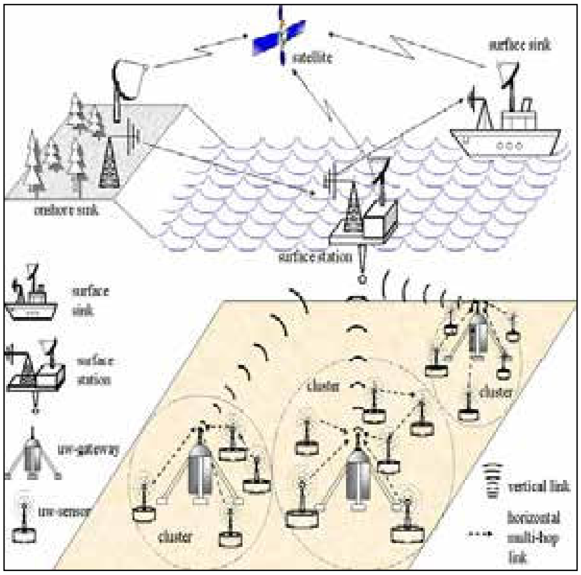

Figure 1: Architectures for two-dimensional UW-ASNs [1]

As shown in Fig-1, underwater sensors may be organized in a cluster-based architecture, and be interconnected to one or more underwater gateways (uw-gateways) by means of wireless acoustic links. Uw-Gateways are network devices responsible for conveying data from the ocean bottom network to a surface station using vertical link. The surface station is equipped with an acoustic transceiver, which may be able to handle multiple parallel communications with the uw-gateways, and with a long-range radio transmitter and/or satellite transmitter, which is needed to communicate with an onshore sink and/or to a surface sink. Sensors can be connected to uw-gateways via direct links or through multi-hop paths [9]. This architecture is mainly designed for networks whose main objective is to monitor the ocean bottom [9], environmental monitoring [2] or monitoring of underwater plates in tectonics.

3.2 Three-dimensional Architecture

As shown in Fig-2, in this architecture sensors float at different depths to observe a given phenomenon. One possible solution would be to attach each sensor node to a surface buoy, by means of wires whose length can be regulated to adjust the depth of each sensor node. Although this is easy and quick way for deploying network but it can be easily detected and deactivated by enemies in military settings.

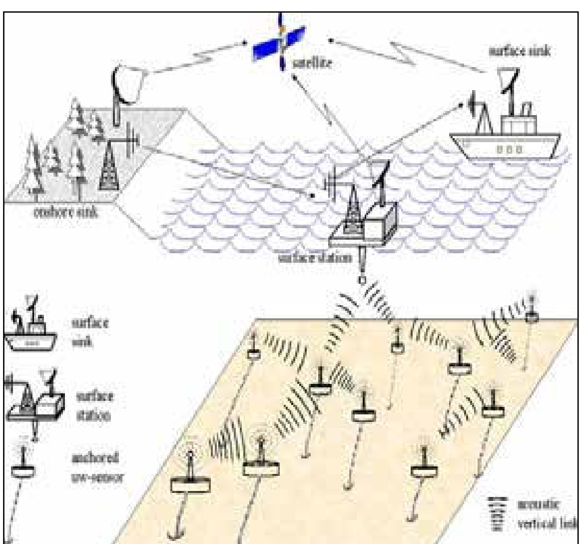

Figure 2: Architectures for three-dimensional UW-ASNs[1]

So another approach is to anchor winch-based sensor devices to the bottom of the ocean, as depicted in Fig-2. Each sensor is equipped with a floating buoy that can be inflated by a pump. The buoy pulls the sensor towards the ocean surface. The depth of the sensor can then be regulated by adjusting the length of the wire that connects the sensor to the anchor, by means of an electronically controlled engine that resides on the sensor.

This architecture is designed for networks suitable to detect and observe phenomena in the three-dimensional space that cannot be adequately observed by means of ocean bottom sensor nodes.

4. UNDERWATER NETWORK CAMERA

The resources used in architecture are mainly protocols but with the advance of technologies in almost all fields, nowadays many companies are trying to make such cameras which are equipped with internet server connections and software for connecting to internet and getting the information underwater along with transmitting the required information. Many water-proof cameras are developed which are much useful in various underwater applications. Manta Network's Underwater Internet Camera system (UWIP- Cam™) is the world's first underwater camera that is able to be controlled at depths of several hundred feet from anywhere on the globe over the Internet.

The AquariCam model can be placed at depths of up to 30 feet and 300 feet away from the Internet connection. The Ethernet cable with PoE (Power over Ethernet) is making underwater connections and camera removal possible. Optional wireless transmitters can extend the range to more than 600 feet. The AquariCam has built-in Internet servers which connect to high-speed Ethernet networks.

Figure 3: AquariCam Model

It uses standard internet protocols for command, control and video delivery, and is addressable from wherever Internet is available. The pan, tilt and an 18x optical zoom can be controlled from a standard web browser from anywhere in the world. The viewing software has a unique feature that allows control of the camera simply by clicking on the panorama image. The camera can be programmed to record selected time intervals and with various camera recording paths.

Once the network connection is established, images and video from the camera can be efficiently streamed over the network. The main purpose of our writing about this type of camera is to carry out research for using such cameras for underwater network architecture and to equip them with such protocols and establish a framed and accepted architecture with cameras and cables so that all the techniques and applications of underwater networks can be carried out efficiently. Now a days there are many types of underwater camera available in market based on different technology. One of them is Ethernet cameras as shown in Fig-5.

Figure 4: Ethernet HD camera

5. UNDERWATER NETWORK APPLICATIONS

The above topics are detailed about the reason, architecture and devices related to underwater networks. Now we will see some of the applications and usefulness of underwater networks. Underwater sensor nodes will find applications in oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications. This technology will enable the exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions [2]. AUVs can function without tethers, cables or remote control, and therefore they have a multitude of applications in oceanography, environmental monitoring, and underwater resource study [2]. The current development of underwater sensing and communication systems will produce scientific, economic and social benefits. New applications will be enabled such as deeper ocean observation, environmental monitoring, surveying or search and rescue missions [4]. Summing up with all the applications and their devices, it is believed that there would be a ‘digital ocean’ with many of AUVs, cameras, sensors, robots, etc who would be surveying through the ocean each and every moment and giving information [4].

6. UNDERWATER NETWORK ISSUES

Alongwith the development of underwater network, issues also come up which should be focused and handeled by efforts. Issues in underwater networking are discussed as follow.

6.1 Physical Channel

Radio waves are extremely strongly attenuated in salt water [5][6]. The speed of sound underwater is approximately 1500 m/s, which is lower than the speed of light. This leads to large propagation delays and relatively large motion induced Doppler effects. Phase and amplitude fluctuations lead to a high bit error probability relative to most radio channels, requiring forward error correction (also called error correction coding).

In addition, the acoustic channel has strong attenuation with increasing frequency, leading to very limited bandwidth. Multipath interference is common in underwater acoustic networks, causing frequency selectivity of the channel. This frequency dependent interference is generally time varying due to surface waves or vehicle motion, causing fading [5][7].

6.2 Technological Limitations

Standard acoustic transducers cannot simultaneously transmit and receive. Underwater network communications are therefore almost always half-duplex. Furthermore, transducer sizes are proportional to wavelength, and due to space constraints, small AUVs are often restricted to use higher center frequencies, generally above 10kHz. Another issue is, it is easy for small AUVs to transmit at high data rates but harder for them to receive at high rates.

6.3 Energy Efficiency

Energy is limited in both terrestrial and underwater sensor networks. In energy constrained underwater system environment it is very important to find ways to improve the life expectancy of the sensors. Compared to the sensors of a terrestrial Ad Hoc Wireless Sensor Network (WSN), underwater sensors cannot use solar energy to recharge the batteries, and it is difficult to replace the batteries in the sensors [10]. Due to energy problem life time of every individual sensor will decrease gradually. As results of this at one point of time the number of sensor nodes that stop working increases with a lengthened deployment time. Therefore the coverage area of WSN will shrink. It is challenge for researchers to improve efficiency. Therefore new, energy efficient protocols must be developed for all of the UWSN nodes’ functions. To increase network lifetime, energy must be saved in every hardware and software solution composing the network architecture. One way to resolve the battery problem is for the UWSN sensor to generate energy by itself. This can be achieved by using chemistry or mechanical methods such as current movement [10].

7. CONCLUSION

With this paper we conclude that as the research about acoustic sensor networks, its architecture and their usages is carried out in detail in past some years, by combining its knowledge with the idea of underwater IP based cameras and use them for underwater networks (which is in recent trend of research in field of networking) we can build a framed architecture acceptable by all applications of underwater networks. To support this objective we can also develop new protocols which can be helpfull to deal with the issues in current UAN(Underwater Acoustic Networks).

REFERENCES

[1] Ethem M. Sozer, Milica Stojanovic, and John G. Proakis, Life Fellow, IEEE “Underwater Acoustic Networks” from IEEE JOURNAL OF OCEANIC ENGINEERING, VOL. 25, NO. 1, JANUARY 2000. [2] “Underwater acoustic sensor networks: research challenges” by Ian F. Akyildiz , Dario Pompili, Tommaso Melodia. [3] An article on “An Architecture for underwater networks” by Mandar Chitre, Shiraz Shahabudeen, John Potter -Acoustic Research Laboratory, National University of Singapore, Lee Freitag-Woods Hole Oceanographic Institution, Ethem Sozer, Milica Stojanovic -Massachusetts Institute of Technology. [4] Ra´ul Palacios Trujillo, “Interference Cancellation and Network Coding for Underwater Communication Systems”. [5] “A Survey of Practical Issues in Underwater Networks” by Jim Partan1,2, Jim Kurose1, and Brian Neil Levine1 Department of Computer Science University of Massachusetts, Amherst, MA, 2Department of Applied Ocean Physics and Engineering, Woods Hole Oceanographic Institution, Woods Hole, MA. [6] F.Schill, U.R.Zimmer, and J.Trumpf, “Visible Spectrum Optical Communication and Distance Sensing for Underwater Applications”. In Proc. Australasian Conf. Robotics and Automation, 2004. [7] M.Stojanovic. Recent Advances in High-Speed Underwater Acoustic Communications. IEEE J. Oceanic Eng.,21(2):125–136, Apr. 1996. [8] An Architecture for Underwater Networks by Mandar Chitre, Shiraz Shahabudeen, John Potter at Acoustic Research Laboratory, National University of Singapore. [9] An article on “Three-dimensional and two-dimensional deployment analysis for underwater acoustic sensor networks” by Dario Pompili , Tommaso Melodia , Ian F. Akyildiz, 23rd july, 2008. [10] Energy Efficiency in Underwater Sensor Networks: a Research Review by K. Ovaliadis, N. Savage and V. Kanakaris, Department of Electronic and Computer Engineering, University of Portsmouth, Portsmouth, UK. Received 11 March 2010; Revised 30 April 2010; Accepted 20 June 2010