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Review on Underwater Sensor Networks: Applications, Research Challenges and Time Synchronization

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Abstract **- Earth is covered with 70% of water that could be river and ocean also. The underwater sensor network technology become more and more popular for monitoring oceans. This paper is a literature review of underwater sensor network, different architectures for two-dimensional and three-dimensional underwater. We are highlighting main applications and challenges of underwater sensor networks and the need of time synchronization schemes for Underwater Sensor Networks.**

Keywords: Underwater Sensor Network, Monitoring, Oceans, Synchronization

I. INTRODUCTION

Sensor networks influenced many areas like engineering, science, industry, and government with their strength to bring computation and sensing into the real world. The capability to have small devices physically distributed near objects being sensed brings new opportunities to observe and act on the world. Wireless information transmission under the ocean is one of the leading technologies for the development of future ocean observation systems and sensor networks. of underwater sensing has many industrial Applications[1] from oil field to aquaculture, and include device monitoring[4], pollution control, recording climate , and prediction of natural hazards, search and survey missions, and marine life study . Underwater Sensor Networks consist of a variable number of sensors and vehicles that are deployed to perform integrated monitoring tasks over a given area. To achieve this goal, sensors and vehicles self structure in an autonomous network which can adapt to the characteristics of the ocean environment.

Underwater networking is an unexplored area but underwater communications have been experimented since Second World War, in 1945, an underwater telephone was developed in the United States to communicate with submarines. Acoustic communications [5] are the typical physical layer technology in underwater networks. There is a need to deploy underwater networks that will enable real time monitoring of selected ocean areas, remote configuration and communication with onshore human operators. This can be obtained by connecting underwater devices by means of wireless links based on acoustic communication. Many researchers are presently working in developing networking solutions for terrestrial wireless ad hoc and sensor networks. However there exist many recently developed network protocols for wireless sensor networks, the specific characteristics of the underwater communication channel capacity, such as limited bandwidth and variable delays, require for very efficient and more reliable new data communication protocols still there is a need for future development in underwater sensor networks.

II. SYSTEM ARCHITECTURE

There are different types of architectures [2][3]for Underwater Sensor Networks, depending on the application. First we review the general architecture we envision for UWSNs. We start by considering the rough capabilities of an individual underwater sensor node, how it communicates with its environment, other underwater nodes, and applications. Figure 1 shows general system logic. We see four different types of nodes in the system. At the bottom layer consists large number of sensor nodes to be deployed on or near the sea floor. They have normal price, computing capacity, and storage. They collect data with their sensors and interact with other nodes of short-range underwater modems. They have batteries, but for long time operation they spend most of their life inactive. At the first layer are one or more control nodes with Internet connections to perform possible human operators. These control nodes may be placed on an off-shore or on-shore platform with power; we expect these nodes to have a large storage space to buffer data, and access to electrical energy. Control nodes will interactive with sensor nodes directly, or via a relay node a sensor node with underwater modems that is connected to the control node with a wired network. In large networks, the third type of nodes, called super nodes, have fast access speed networks.

These super nodes allow much faster network connection to creating multiple data collection centers for the underwater network. Finally, however robotic submersibles are not the focus of the present work, we see them interacting with our system via acoustic communications. In the figure 1, dark blue ovals show multiple robots servicing to the platform. The computing power present in each node of a current sensor networks are varies large, from 8-bit embedded processors, 32-bit embedded processors about as powerful as typical PDAs, Since underwater monitoring missions can be very high cost due to the high cost of underwater devices, deployed network is important it should more reliable, so as to avoid failure of monitoring missions due to failure of single or multiple devices. The network capacity is also affected by the network topology. The capacity of the underwater channel is limited; it is very important structure of the network topology.

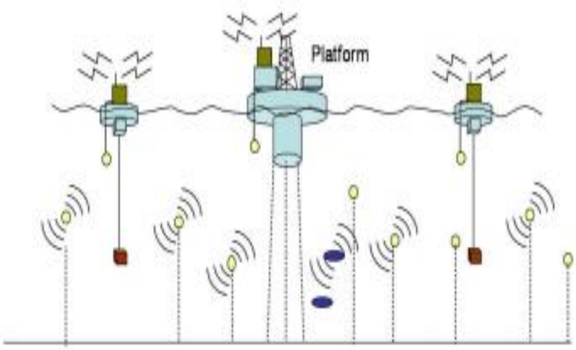

Fig 1. General System UWSN

There are several different architectures for UWSNs, depending on the application:

- **Two-dimensional UW-ASNs for ocean bottom monitoring:** These are formed by collection of sensor nodes that are represent to the bottom of the ocean. This represents the environmental monitoring.
- **Three-dimensional UW-ASNs for ocean column monitoring:** These networks include the sensors whose depth can be controlled, and may be implemented for surveillance applications, water streams, pollution,
- **Three-dimensional networks of Autonomous Underwater Vehicles** (AUVs) **:** These networks having fixed portions composed of primary sensors and mobile portions formed autonomous vehicles.

2.1 Import differences between terrestrial and underwater sensor networks:

A. Cost: Underwater sensors are more costly devices than terrestrial sensors.

B. Deployment: The deployment is dispersed in underwater networks

C. Spatial Correlation: While the readings from terrestrial sensors are generally correlated, this is rarely happen in underwater networks due to the high distance among sensors.

D. Power: More power is needed in underwater communications due to higher distances and to more complex signal processing at the receivers.

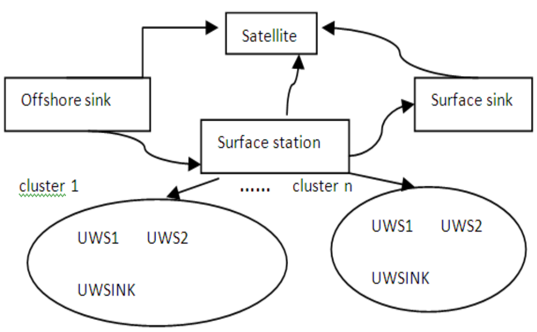

Fig 2. 2D Architecture of Underwater Sensor Network

III. APPLICATIONS

Underwater operations remain quite limited by comparison. Remotely controlled submersibles are often employed, but as large, active and managed devices, their deployment is temporary with micro-habitat monitoring, structural monitoring[6], wide-area environmental systems and Industrial applications such as oilfields and production lines use extensive equipment.

1. Finding underwater information: Underwater sensor is the latest and fastest way of finding information which is available in underwater sensor network this information is not only useful for human being but also responsible for researchers.

2. Disaster Prevention: Disaster prevention is also very important feature of underwater sensor network system can perform seismic activity which provide tsunami warnings to coastal areas.

3. Ocean Sampling Networks: Autonomous underwater vehicles are capable for interactive adaptive sampling of the 3D coastal ocean environment. In 3D environment. We can place the sensors in various depths in ocean. So we can sense the ocean area at different depth.

4. Environmental Monitoring: Environment monitoring is one of the most important applications of UWSN. In environment monitoring include pollution monitoring, monitoring of ocean currents, and improve weather forecast are other possible applications.

5. Mine Reconnaissance: The simultaneous operation of multiple AUVs with acoustic sensor can be used to detect mine like object.

6. Distributed Tactical Surveillance: AUV and fixed underwater sensor can monitor areas for surveillance, intrusion detection systems .AUV applicable to a number of applications, like seismic monitoring, device monitoring and leak detection, and support for underwater robots.

IV. MAJOR CHALLENGES OF UWSN

1. More costly devices: Underwater sensor devices are more costly. And supplier are not provides such kind of devices because these are devices are part of research oriented activity [7] [17]. Underwater sensor devices are not available easily in the market.

2. Hardware Protection requirement: The underwater devices are extremely expensive. So device protection is required against water.

3. Needed high power for communication: In underwater sensor communication need more power because the data as transfer in water medium [9] takes more. So, in water more electricity is requiring for data exchanging. Communication among UWSNs is usually the biggest challenge facing UWSNs. Point out that path loss noise, multi-path, high propagation delays, can significantly degrade the underwater communication channel.

4. one way communication: Another problem is that standard water transducers cannot simultaneously transmit and receive. Hence underwater network communications are always 1-way.

5. Propagation delay: The propagation delay is major problem in underwater sensor network. The propagation in underwater is higher order of magnitude than radio frequency in terrestrial sensor network

6. Localization: Localization means find the location of sensor in UWSNs so; localization is another important problem yet to be solved. Localization is the challenging issue that is require for data labeling while some time critical applications need data without any time delay.

7. Limited battery power: UWSN lifetime is an area of extensive research. UWSNs suffer from a sensor's pollution and corrosion. Electronics components, such as the battery, tend to decrease strength faster under extremely low temperatures found in deep underwater. As it leads to, the USWN lifetime is much less. In underwater sensor battery has limited power. A shorter lifetime of battery increases the replacement costs because the underwater sensor battery is not chargeable

8. Bandwidth size limitation*:* In the underwater sensor network bandwidth limited, this is a big problem.

9. Reliability: This is one of the major design issues for reliable delivery of sensed data to the surface sink is a challenging[4][7] task compare to forwarding the collected data to the control center.

10. Temporary losses: Temporary losses mean the packet losses when connectivity time and packet sending time.

V. NEED OF TIME SYNCHRONIZATION UWSN

Time synchronization very important for distributed network systems .There are many time synchronization protocols [10]have been proposed for terrestrial Wireless Sensor Networks (WSNs). But those cannot be directly applied to Underwater Sensor Networks (UWSNs). Many localization schemes[11] assume that nodes are synchronized. Time synchronization is difficult to achieve in underwater scenario due to long distance delay and variable sound speed. As radio signals cannot propagate underwater, so GPS service is also not available.

Clock offset and skew are the two main challenges are faced in synchronization of distributed clocks[13]. First, they must by synchronize to a single common event in exact time or offset, and second, clocks are not perfect and run at minutely different, one must determine the skew of a given clock relative to some absolute frequency. Since Different booting time between each node is also regarded as a main factor in time-sync problem and it is commonly called offset, there must be some way for distributed computers to determine a common offset. Offset can be determined by a single message interchange. Time in most modern, inexpensive computers is derived from oscillating frequency of a quartz crystal. Due to external environment variation[14] in temperature, humidity, minor manufacturing differences, and variations in crystal oscillation frequency. Thus, even nodes that are synchronized to a common offset will drift out of synchronization over time.

VI. CONCLUSION

In this paper we are discussed main applications, challenges and need of time synchronization for Underwater Sensor Networks (UWSNs) and also we focused on general, 2D and 3D architectures. UWSNs large research scope area has recently increasing attention from both academia and industry. Many researchers are presently working in developing networking solutions for terrestrial wireless ad hoc and sensor networks but those are not applicable directly.

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