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A Survey on Underwater Wireless Sensor Network

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Abstract: *In our earth 75% covered by water that could be river and ocean also. The underwater sensor network are enabling technology and become more and more popular for monitoring vast area of oceans. Underwater sensor Networks consist of a variable number of sensors that are deployed to perform monitoring tasks over a given area. The UWSNs provide countinuous monitoring for various applications like ocean sampling network, pollution monitoring, submarine detection,disaster prevention,etc.*

In this paper, the internal architecture of underwater sensor, the literature of underwater sensor network, different architectures for two-dimensional and three-dimensional underwater sensor networks are discussed, we also discussed the application and main problem or issue in underwater sensor network.

Keywords*: UWSN,UW-sink,AUV,UUV,Routing*

1. INTRODUCTION

The cram of Underwater Wireless Sensor Networks as a research field has grown extensively in recent years offering a huge number of proposal to resolve the communication between the nodes and protocols for information exchange networks[1].

Using WSN networks, we can able to pick a lot of values which is used for new purposes like measuring the relief of the ocean (bathymetry), seafloor shape registering, search for geological resources (i.e. oil, gas, etc.), detecting and tracking fish banks, submarine archaeology, etc[2-4]. These were the main underwater acoustic application mainly use for the exploration of seafloor and fishery with sonar devices. In the 90's the researchers became aware of a new feature applicable to underwater communications, multipoint connections could be capable of translating the networked communication technology to the underwater environment[5-7].

Wireless terrestrial networking technologies have experienced a considerably development in the last fifteen years, not only in the standardization areas but also in the market deployment of a bunch of devices, services and applications. Among all these wireless products, wireless sensor networks are exhibiting an incredible boom, being one of the technological areas with greater scientific and industrial development step[8]. Recently, wireless sensor networks have been proposed for their deployment in underwater environments where many of applications such us aquiculture, pollution monitoring, offshore exploration, etc. would benefit from this technology [9]. Despite having a very similar functionality, Underwater Wireless Sensor Networks (UWSNs) exhibit several architectural differences with respect to the terrestrial ones, which are mainly due to the transmission medium characteristics (sea water) and the signal employed to transmit data (acoustic ultrasound signals)[10].

Then, the design of appropriate network architecture for UWSNs is seriously hardened by the conditions of the communication system and, as a consequence, what is valid for terrestrial WSNs is perhaps not valid for UWSNs. So, a general review of the overall network architecture is required in order to supply an appropriate network service for the demanding applications in such an unfriendly submarine communication environment.

Major challenges in the design of underwater acoustic networks [11] are:

- Battery power is limited and usually batteries cannot be recharged because solar energy cannot be exploited.
- The available bandwidth is severely limited.
- The channel suffers from long and variable propagation delays, multi-path and fading problems.
- Bit error rates are typically very high.
- Underwater sensors are prone to frequent failures because of fouling, corrosion, etc.

2. SYSTEM ARCHITECTURE

The general architecture we envision for an underwater sensor network. Figure 1 shows a diagram of our current tentative design. I anticipate a tiered deployment, where some nodes have greater resources.

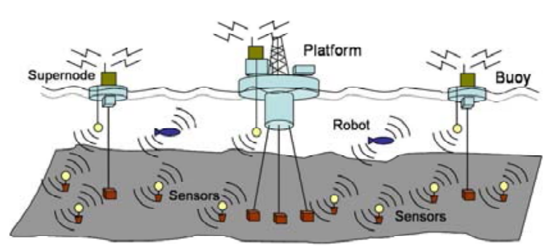

Fig. 1. One possible approach to network deployment.

In Figure 1, shows four different types of nodes in the system. At the lowest layer, the large number of sensor nodesare deployed on the sea floor (shown as small yellow circles).

They collect data through attached sensors (*e.g.*, seismic) and communicate with other nodes through short-range acoustic modems. They operate on batteries, and to operate for long periods they spend most of their life asleep.

Several deployment strategies of these nodes are possible; here I show them anchored to the sea floor. (They could also be buried for protection.) Tethers ensure that nodes are positioned roughly where expected and allow optimization of placement for good sensor and communications coverage. Node movement is still possible due to anchor drift or disturbance from external effects.

I expect nodes to be able to determine their locations through distributed localization algorithms. At the top layer are one or more control nodes with connections to the Internet. The node shown on the platform in Figure is this kind of node. These control nodes may be positioned on an off-shore platform with power, or they may be on-shore; I expect these nodes to have a large storage capacity to buffer data, and access to ample electrical power.

Control nodes will communicate with sensor nodes directly, by connecting to an underwater acoustic modem with wires. In large networks, a third type of nodes, called *supernodes*, can be deployed. Supernodes have access to high speed networks, and can relay data to the base station very efficiently.

We are considering two possible implementations: first involves attaching regular nodes to tethered buoys that are equipped with high-speed radio communications to the base station, as shown in the figure. An alternative implementation would place these nodes on the sea floor and connect them to the base station with fibre optic cables. Super nodes allow a much richer network connectivity, creating multiple data collection points for the underwater acoustic network.

Finally, although robotic submersibles are not the focus of the current work, we see them interacting with our system via acoustic communications. In the figure, dark blue “fishes” represent multiple robots.

CPU capability at a node varies greatly in current sensor networks, from 8-bit embedded processors, such as Berkeley Motes to 32-bit embedded processors about as powerful as typical PDAs, such as Intel Stargazes to 32- or 64-bit laptop computers. We see Stargaze-class computers as most appropriate for underwater sensor networks for several reasons.

Their memory capacities (64MB RAM, 32MB flash storage) and computing power (a 400MHz XScale processor) is sufficient to store and process a significant amount of data temporarily, while their cost is moderate (currently US$600/each). Although Moteclass computers are attractive in cost and energy performance, their very limited memory (4–8kB of RAM and 64–1024MB of flash storage) is a poor match for the requirements of underwater applications that we are considering (see Section III).

In a harsh underwater environment, we must anticipate that some nodes will be lost over time. Possible risks include fishing trawlers, underwater life, or failure of waterproofing.

I therefore expect basic deployments to include some redundancy, so that loss of an individual node will not have wider effects. In addition, we expect that we will be able to recover from multiple failures, either with mobile nodes, or with deployment of replacements.

Operating on battery power, sensor nodes must carefully monitor their energy consumption. It is essential that all components of the system operate at as low a duty cycle as possible.

In addition, we expect to coordinate with the application to entirely shut off the node for very long periods of time, up to days or months. I also expect to build on techniques for long-duration sleep (for example, [33]). We describe some of our work on energy management in Section V.

Communications between nodes is an important focus of our work, because we see a large gap between our target deployment and currently available commercial, long-range, high power, point-to-point, acoustic communications.

3. NETWORK MODEL IN UWSN

A network model between two nodes in UWSN environment is shown in Figure 2. The network is composed of underwater sensor nodes, underwater sink node and Surface sink node. The underwater sensor nodes are deployed to the bottom of the monitored environment such as ocean and river.

While underwater sink nodes take charge of collecting data of underwater sensor deployed on the ocean bottom and then send to the surface sink node. Lastly, surface sink node is attached on a floating buoy with satellite, radio frequency (RF) or Cell phone technology to transmit data to shore in real time.

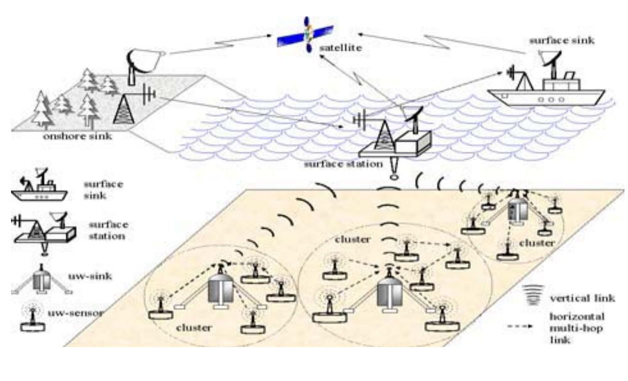

Figure 2: Underwater sensor networks

The depth of the fresh water for this research is lower than 100 m while the range between two nodes is about 6m until 20m for short range communication.

The MAC protocol is very important in ensuring data reliability to the underwater sensor network. Different applications required different requirements on MAC protocol. In this project, the aim is to design a MAC protocol for long term applications such as water quality monitoring for agriculture purposes. This application is not sensitive to end-to-end delay because the communication link of UWSN is using RF electromagnetic waves that have high propagation speed which is 3×108 m/s.

Hence, the propagation delay is very low and can be ignored. The most important goal of MAC protocol for such underwater sensor network is to solve the data packet collision efficiently in terms of energy consumption. Another goals of the designing MAC protocol in this project are to achieve guarantee high network throughput, low energy consumption and low channel access delay.

A reason why current terrestrial Radio Frequency (RF) based MAC protocol cannot be used directly in UWSN because of the harsh physical characteristics of underwater Channel. Currently, the existing MAC protocol for UWSN is using acoustic as a link for communications.

There has no existing MAC protocol that can be adapted in UWSN using RF electromagnetic link. This project will be developed a MAC protocol that can be adapt in UWSN for shallow water environment using RF electromagnetic link. A major difference between RF and acoustic propagation is the velocity of propagation. Radio waves travel at the speed of light as mentioned above. The speed of sound in water is around 1500 m/s, and it varies significantly with temperature, density and salinity, causing acoustic waves to travel on curved paths.

4. DIFFERENT TYPES OF COMMUNICATION SIGNALS

Present underwater communication systems involve the transmission of information in the form of sound, electromagnetic (EM), or optical waves. Each of these techniques has advantages and limitations.

A. Acoustic communication

Acoustic communication is the most versatile and widely used technique in underwater environments due to the low attenuation (signal reduction) of sound in water. This is especially true in thermally stable, deep water settings. On the other hand, the use of acoustic waves in shallow water can be adversely affected by temperature gradients, surface ambient noise, and multipath propagation dueto reflection and refraction. The much slower speed of acoustic propagation in water, about 1500 m/s (meters per second), compared with that of electromagnetic and optical waves is another limiting factor for efficient communication and networking. Nevertheless, the currently favourable technology for underwater communication is upon acoustics.

B. Electromagnetic (EM) waves

On the front of using electromagnetic (EM) waves in radio frequencies, conventional radio does not work well in an underwater environment due to the conducting nature of the medium, especially in the case of seawater. However, if EM could be working underwater, even in a short distance, its much faster propagating speed is definitely a great advantage for faster and efficient communication among nodes.

C. Optical Wave communication

One of the biggest sources of noise for underwater optical communications in littoral regions is the presence of sunlight. While the sun produces anywhere from 10,000-100,000 lx most LEDs, used for transmission in digital communication will be on the order of 100 lx.

This means that the signal strength is substantially smaller than the noise created by ambient light. Furthermore, simply by tilting the receiver even slightly there might be a large change in incident light on the photodiode and ultimately a different current running through it. Many optical modems use a high pass filter technique to differentiate ambient level from signal.

Since typically PPM is used there is a very high frequency component on the edges of each pulse whereas the ambient is changing at a very low frequency. Using a high pass filter will remove the ambient light level however it comes at a cost of imposing a frequency requirement on the signal to be transmitted.

5. PROBLEM IN UNDERWATER SENSOR NETWORK

A. More costly devices : Underwater sensor devices are more costly. And no more supplier are provides these such kind of devices because these are devices are part of research oriented activity. Underwater sensor devices are not easily available in the market[12].

*B. Hardware Protection requirement :*The underwater devices is more expensive . So device protection or hardware protection is required against water[12].

C. Needed high power for communication: In underwater sensor communication require more power because the data transfer will done in water medium.So,in water more electricity is require for data exchanging. Communication among UWSNs is probably the biggest challenge facing UWSNs. point out that path loss (attenuation and geometric spreading), noise (man-made and ambient), multi-path, high propagation delays, and Doppler spread, can significantly disrupt or degrade the underwater communication channel. Another problem is that standard acoustic transducers cannot simultaneously transmit and receive. Underwater network communications are therefore always half duplex[13].

G. Propagation delay: The propagation delay is major problem in underwater sensor network. The propagation of acoustic channels in underwater is order of magnitude higher than radio frequency in terrestrial sensor network[13].

H. Localization: Localization means find the location of sensor in underwater sensor network. So, localization is another major problem yet to be solved. Localization is the challenging factor that is require for data labelling while some time critical applications require data without time delay[13].

I. Limited battery power: UWSN lifetime is an area of extensive research. UWSNs suffer from a sensor's fouling and corrosion . Electronics components, such as the battery, tend to degrade faster under extremely low temperatures such as the one found in deep underwater. As a consequence, the USWN lifetime is much shorter than the lifetime of a comparable TWSN. In underwater sensor battery has limited power. A shorter lifetime increases the replacement costs because the underwater sensor battery is not chargable [13].

J. Bandwidth size limitation: In the underwater sensor network bandwidth is another big problem. Because bandwidth size is limited[14].

K. Reliability : This is one of the major design issues for reliable delivery of sensed data to the surface sink or water surface is a challenging task compare to forwarding the collected data to the control center or on-shore station[14].

F. Temporary losses: Temporary losses means the packet losses when connectivity time and packet sending time[14].

6. MAJOR APPLICATIONS

Sensor networks can be used in a variety of different applications, as it is done by radio frequency air networks[13-15]. The following are some of the major areas:

- Environmental Monitoring. Pollution is nowadays one of the major problems, oil spills from ships or broken tubes can make a lot of harm to the marine biological activity, the industry and tourist places. Monitoring ecosystems can help understanding and predicting the human and climate or weather effect in underwater environment.
- Underwater Navigation. The sensor used to make routing, identifying hazards on the seafloor, rocks or shoals in shallow water,
- Assisted Navigation. Sensors can be placed to identify hazards on the seabed, locate dangerous rocks or shoals in shallow waters, mooring positions and drawing the bathymetry profile of the area.
- Underwater Discovery. Underwater wireless sensor networks can be used to find oilfields or reservoirs, locate routes for placing connections for intercontinental submarine cables. Also they could seek for shipwrecks or archaeology or lost sink cities.
- Prevention of natural disaster. By measuring the seismic activity from different remote location the sensors could alert to the coast places by detecting tsunami or submarine earthquakes alarms.
- Underwater Autonomous Vehicles (UAVs). Distributed sensor in movement can help monitoring area for surveillance, recognition and intrusion detection.

7. CONCLUSION

Underwater Acoustic Wireless Sensor Networks is still budding and following the path of Radio Frequency in Terrestrial Networks. In this article, an overview of the state of the art in underwater acoustic sensor network. i summarize the challenges posed by the peculiarities of the underwater channel with major reference to monitoring applications for the ocean environment.

I also analyze characteristics of the underwater channel and outlined future research directions for the growth of effective and trustworthy underwater acoustic sensor networks.

The ultimate objective of this article is to encourage and specify the importance of research efforts to lay down fundamental basis for the growth of new advanced communication techniques for efficient underwater communication and networking for improved ocean monitoring and exploration applications.

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