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CHALLENGES IN UNDERWATER ACOUSTICS SENSOR NETWORKS

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ABSTRACT

The Underwater Acoustic Sensor Networks (UWASN) are a collection of underwater sensors that collect data for uncharted areas of seas and rivers. UWASN is made up of a variety of floating and anchoring sensors, sinks, and vehicles that are dispersed over a study region. The key characteristics of UWASN include node mobility for floating, data gathering and recording capacity, and battery-operated autonomous vehicles. Optical waves, radio waves, electromagnetic waves, and acoustics are all used to communicate amongst underwater equipment. Acoustic communication is the most suitable of them since it can convey digital information over an underwater channel and travel over larger distances. There are two types of communication: single and multiple hope. However, while transferring data from end nodes to sink nodes underwater, we employ multi-hop communication. Limited bandwidth, multipath fading, restricted battery, limited data capacity, and propagation latency are all difficulties for UWASN. As a result, we focused on a variety of difficulties and obstacles in underwater wireless sensor networks for acoustic communications in this study.

KEYWORDS: *Acoustic Waves, Channel Modeling, Path Losses, Networks, Underwater Communication.*

1. INTRODUCTION

The Underwater Acoustic Sensor Network (UWASN) is made up of several types of wireless sensors and vehicles that are deployed underwater to collect scientific data for synergistic operations as depicted in Figure 1. UWASN[1] are mostly utilized for monitoring, data collection, pollution and climate monitoring, and navigational assistance. The UWASN can counteract their transference by commuting their configuration, position, and movement information, as well as broadcasting surveyed evidences to a nearby ground station, i.e. they must develop self-contoured competence. Some sensor components designed to allow azimuthally Omni directional audio communications are covered by bottom-mounted instrument frames to safeguard sensors and modems from possible trawling gear impact in regions where fishing is frequent.

Figure 1: Demonstration of working of underwater acoustic communication (Source: Google)

Figure 2 depicts the UWASN architecture. It contains a primary controller unit, or CPU, that is coupled to a sensor interface circuitry that is used to investigate marine science. The controller includes inbuilt storage where the received data from the sensor may be saved before being processed by an acoustic microprocessor. PVC enclosure protects the electrically installed frames.

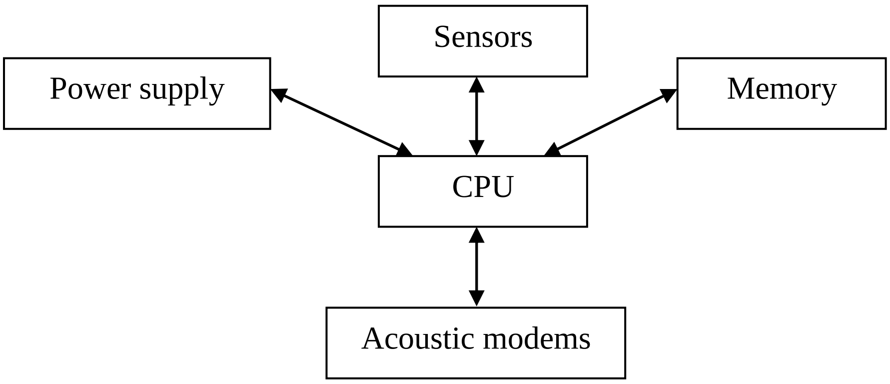

Figure 2: Basic architecture of UWASN

Underwater communication is accomplished via optical, radio, electromagnetic, and acoustic waves. When wired communication is required, optical and radio waves can be utilized, however, when wired construction is required underwater, heavy cables are needed, and route loss, wire breakage, and data transmission over longer distances are not conceivable. Electromagnetic waves may be employed at very low levels since they have a limited propagation distance. Acoustic waves[2], on the other hand, are employed for improved communication and data transmission from one node to another because they may enable high-speed communication between nodes and can transport digital data over the channel.

2. DISCUSSION

There are two ways to communicate: single hope and multiple hoping. Between the destination and the host, there is only one hop. Numerous hops refers to the presence of multiple hops or nodes between the host and destination in underwater communication in the vertical direction for the transmission of digital data.

1. **Cost-effectiveness:** When compared to underwater sensors, terrestrial nodes are relatively inexpensive. The reason for this is the intricacy of underwater transceivers, as well as the hardware protection required in such a harsh environment. Because vendors place a low value on scale economies, underwater sensors are prohibitively costly.

2. **Power:** Because radio frequency waves are used underwater in various physical structures or designs, underwater communications require a lot of power.
3. **Deployment:** Because of the expense complexity, the deployment of underwater sensor networks is sparser than that of earth-bound sensor networks, where sensors are installed lethargically.
4. **Geographical Correlation:** According to previous research, terrestrial sensors can be readily linked spatially, but this is not achievable in underwater acoustic sensor networks due to the higher distance between sensors.
5. **Memory:** In comparison to terrestrial sensors, which require limited store capacity, underwater sensors require sensors with greater capabilities for data caching.

At the bottom, the sensor nodes that constitute a group are anchored. The Underwater Gateways [3](UW- Gateways) are connected to these nodes through wireless acoustic connections. UW-Gateways are network devices that interact by transferring data from one station to another. They are equipped with two acoustic transceivers, a vertical and a horizontal transceiver, for this process. The UW-gateways use the vertical link to relay information to the outside terminal. The horizontal transceiver is used to communicate for the following purposes:

1. Sending data to sensors in response to orders, i.e. from UW-gateway to sensors; and
2. Collecting supervised details, i.e. from sensors to UW-gateway.

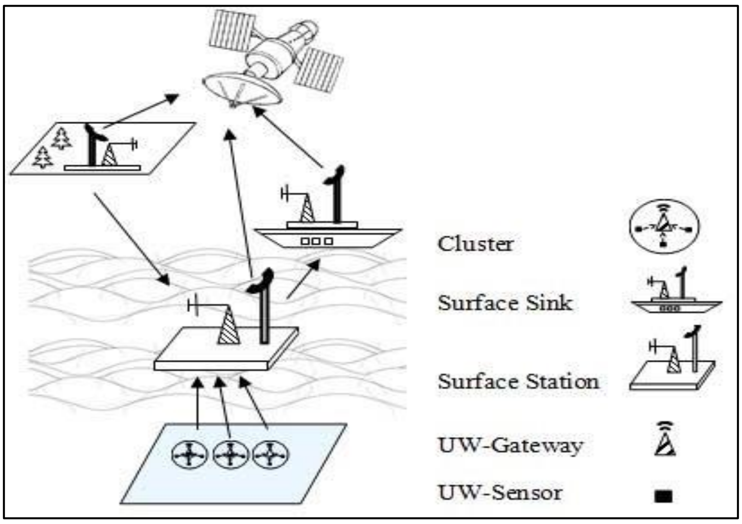

Figure 3: Two dimensional development of underwater acoustic sensor network.

Long range vertical transceivers are essential when dealing with diverse deep water applications as depicted in Figure 3. Because there are numerous simultaneous communication links with deployed UW-gateways, the outside terminal is equipped with an acoustic signal detecting device and a long-range RF to send data to an onshore sink (OS-sink) or a surface sink (S-sink). In shallow water, however, sensors placed at the bottom can interact with the surface buoy directly.

Multipath[4] exists in UWAC because to the underwater channel's temporal variance characteristic, resulting in ISI. This destroys the data being transferred, resulting in mistakes at the recipient. The primary flaw in high-speed UWAC has been recognized as ISI. In single input single output (SISO) instances, a large portion of the transmitting power is focused away from the receiver, resulting in substantial performance loss. In UWAC, this method is commonly employed to correct for the ISI caused by multipath propagation. Effective equalization strategies must be utilized to overcome channel fluctuations in UWAC.

Typical underwater frequencies range from 10Hz to 1 MHz. Sound propagation[5] is typically impossible at frequencies lower than 10Hz, while frequencies greater than 1MHz are rarely employed. The receiver detects the interchanging compressions and rarefactions in a sound wave delivered underwater. Inter Symbol Interference (ISI)[6] and frequency selective fading will result from the multipath issue in underwater acoustic communications (UWAC). Time spread [7]is caused by UWAC's multipath feature. ISI arises when the temporal spread exceeds the symbol duration. Digital modulation techniques are used to improve communication quality and efficiency.

Communicating underwater has become the newest day difficulty due to the negative impacts of time and frequency dispersion. Time spreading is caused by attenuation and reflection loss, in addition to the arrivals of numerous delay routes. The relative velocity between the transmitter and receiver causes Doppler shift[8], which affects frequency spreading[9]. The propagation speed is the primary difference between RF and UWAC channels.

The high delay spread, Doppler spread, and frequency dependency of propagation loss are all factors that contribute to the UWAC's complexity. Acoustic signals in water are usually impacted by interference generated by reflection from the ocean surface and ocean bottom. The signal propagates via numerous reflections from the water surface and the rocky ocean bottom, as seen alongside direct Line of Sight (LOS) transmission[10] between the Tx and Rx. Additional spreading occurs as a result of the harsh dispersion of these two surfaces.

3. CONCLUSION

The working method in underwater acoustic sensor networks was addressed in this study (UWASN). During the investigation on UWASN, it was discovered that while research has progressed substantially in recent years, a number of obstacles need to be resolved. The different problems that arise during certain underwater monitoring applications are explained below. We thought there was a need for new theoretical models to be developed.

As a result, we outlined a number of issues that must be addressed in order to create competent and decisive underwater acoustic sensor networks, as well as an optimized communication architecture that is adaptable to the characteristics of UWASN for data monitoring and recording in an underwater setting. We're also encouraged to extend the area to include autonomous deployment and stationary configurations, as well as high-performance to low-cost operations. The final goal of this study is to create a more sophisticated communication system for better monitoring and exploration.

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