Underwater Communication Technology Using Li-Fi

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Abstract- Underwater Communication is mainly used by submarines, underwater drones (UUVs) and drives to exchange messages and control signals. Since normal radio and satellite waves cannot travel effectively through water, underwater communication uses sound waves (acoustic signals) (1) as the main medium. Other methods like optical (light-based) (2) and electromagnetic (radio or magnetic) communication are also used for short-range and special operations. We can also communicate using infrasonic signal for better communication (3)(4)(5).

I.INTRODUCTION

Underwater communication has many uses like Acoustic, Optical or Magnetic signals to transmit data through water overcoming challenges like adsorption, scattering and multi path dispersion. Key Physical Properties of Water Affecting Acoustic Communication are Speed of Sound: Approximately 1500 m/s in seawater, faster than in air (~343 m/s), but much slower than electromagnetic waves. Sound speed varies with water temperature, salinity, and depth. Typically, sound speed decreases with depth due to temperature but increases at deeper depths due to pressure, forming sound channels that guide waves over long distances. Underwater communication is extremely important for a naval base because it forms the main link between the base and its underwater units such
as submarines, underwater drones, and divers.

II.TECHNIQUES AND METHODS USED IN NAVAL BASE

1. Acoustic Communication: Uses sound waves to send messages underwater. It is the main communication method for submarines and underwater vehicles. It works over long distances and is used in sonar systems and underwater networks.
2. Optical (Laser/LED) Communication: Uses blue or green light to transfer data at very high speed (up to Gbps) for short distances. It is used for diver-to-vehicle or UUV-to-submarine communication.
3.Electromagnetic (VLF/ELF) Communication: Uses very low frequency (VLF) and extremely low frequency (ELF) radio waves that can penetrate seawater slightly. It allows naval bases to send coded messages to deep submarines.
4. Magnetic Induction (MI) Communication: Uses magnetic fields produced by coil antennas for short-range links. It is used for diver communication and docking operations.
5. Fiber Optic and Tethered Communication: Used in Remotely Operated Vehicles (ROVs) and underwater monitoring systems. Fiber cables provide very high-speed and reliable data transfer.
6. Underwater Sensor Networks (UWSNs): A network of acoustic sensors and modems placed under the sea for surveillance, target tracking, and environmental monitoring. Data is sent to surface buoys and then to satellites.
7. Hybrid Communication Systems: Combine acoustic, optical, and RF technologies to get better performance, range, and data speed. Used in modern submarines and AUVs for flexible operations.

UNDERWATER COMMUNICATION USING INFRASONIC WAVES

Our idea is to send messages underwater using infrasonic frequencies (below 20 Hz). These waves travel very far with less loss, which makes them perfect for underwater communication.
1. Sending the Signal:
We first convert the message into digital form. Then we use low-frequency transmitters (transducers) to send it as infrasonic waves. To make the signal stronger and reduce noise, we use modulation methods like FSK or PSK.

2. Signal Travel Underwater:

The waves move through a special layer in the ocean called the SOFAR channel, where sound travels the farthest with minimum energy loss. We also keep track of temperature, pressure, and salinity, since these can affect how far the sound travels.

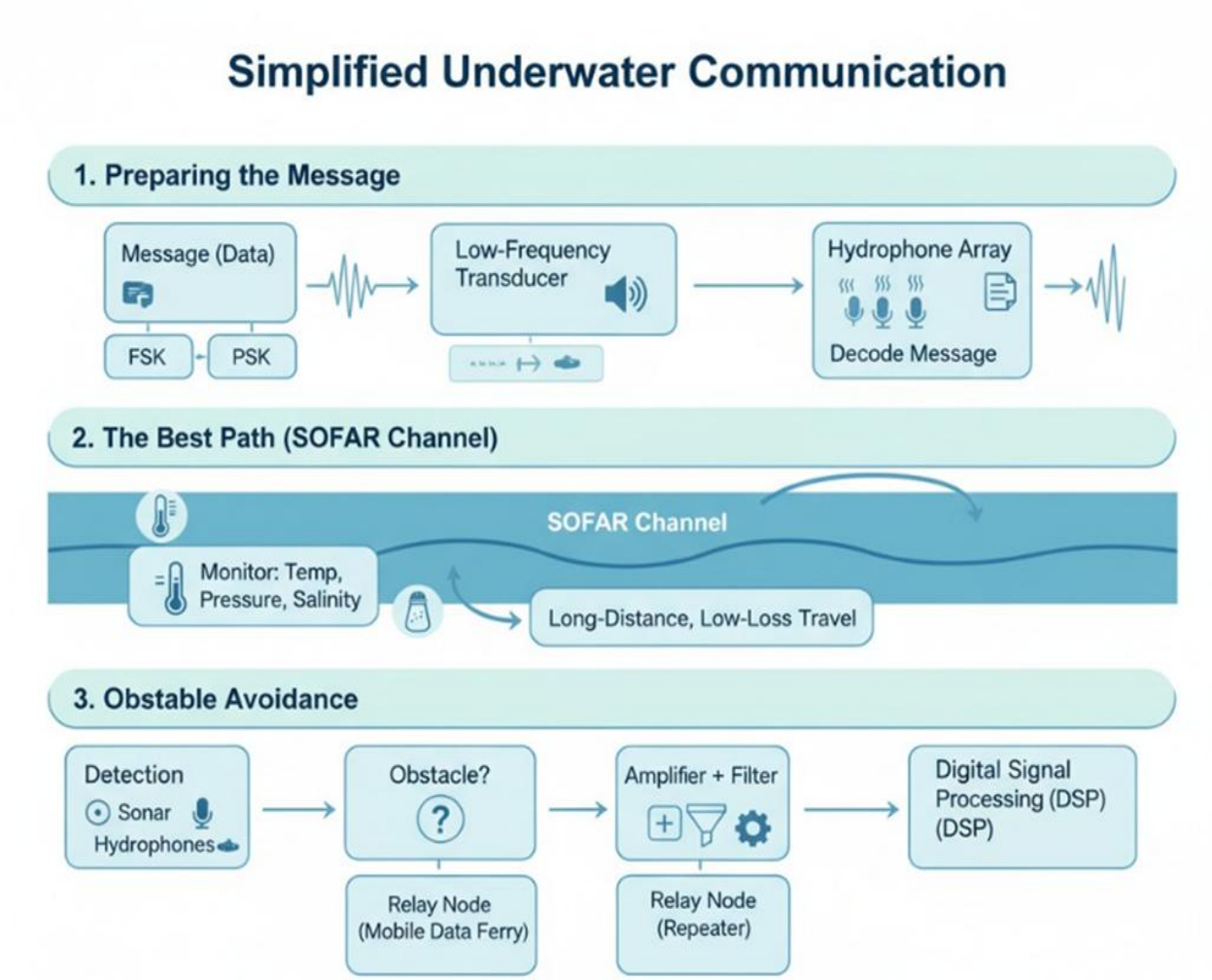
3. Avoiding Obstacles:
While travelling, the signal might hit rocks, marine life, or other barriers. So, we place sensors and hydrophones to detect such obstacles. If something is in the way, the system can change the signal's direction or use an AUV (Autonomous Underwater Vehicle) to relay the signal around it.

4. Receiving the Message:
At the receiver side, hydrophones pick up the weak infrasonic waves. The signal is then amplified and filtered to remove noise. After that, it goes through digital processing to decode the message correctly.

5. Handling Interruptions:
If a stone or sea creature blocks the path, the system will: Detect it using sonar, Redirect the signal, Or use a nearby relay node to pass the message. This ensures the message still reaches safely without much delay.

6. Real-Life Examples:
SOSUS network: used by navies for deep-sea listening. AUV-based relays: help pass data between far-away underwater stations. Digital signal processing (DSP): used to correct errors and noise in long transmissions.

BLOCK DIAGRAM



1.Preparing the Message: Data is encoded using modulation techniques like FSK (Frequency Shift Keying) or PSK (Phase Shift Keying). The encoded message is sent via a Low frequency Transducer. A Hydrophone Array receives the acoustic signal and decodes the message.
2.The Best Path (SOFAR Channel)**:** Messages travel through the SOFAR
(Sound Fixing and Ranging Channel), a layer in the ocean where sound travels long distances with minimal loss. Environmental factors like temperature, pressure, and salinity are monitored to maintain optimal communication.
3.Obstacle Avoidance Sonar and Hydrophones detect potential obstacles. If an obstacle is present Use a Relay Node (Mobile Data Ferry) to bypass it.
4.Real-World Application: Naval Surveillance (e.g., SOSUS systems), Underwater Data Networks using AUV (Autonomous Underwater Vehicle) relays, oil and gas monitoring in underwater environments

USING LI-FI FOR INFRASONIC SIGNALS

Li-Fi acts as a data courier, not the actual infrasonic carrier. Li-Fi is for fast data transfer, infrasound is for long range underwater communication
1. Record the infrasonic signal
2. Digitize it (convert it to data).
3. Transmit the data via Li-Fi light modulation.
4. Reconstruct the infrasonic waveform at the receiver end (e.g., via a speaker or transducer).
So, Li-Fi can carry the data representing an infrasonic signal — but cannot physically transmit infrasonic waves through the medium itself.

SUMMARY

Just like whales use low-frequency sounds to communicate, humans use infrasonic waves (below 20 Hz) for underwater communication. These low-frequency signals can travel long distances in water with very little energy loss. Sound moves faster and farther in water than in air, making it ideal for deep-sea communication. Infrasonic signals are less affected by noise, rocks, or marine life, ensuring clear transmission. They are used by the Navy and researchers for secure underwater messaging and navigation. This technology helps submarines and ocean sensors stay connected even at great depths. Overall, it combines natural principles and modern science for efficient ocean communication.

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