# Blockchain-driven submersible wireless data transmission with li-fi technology

[1]Mohanapriya. R, [2] Bhuvaneshwari. M, [3]Kayalvarshini. D, [4]Mahalakshmi. R

[1]Associate Professor, Paavai Engineering College, Pachal, Namakkal.

[2,3,4] UG Students, Paavai Engineering College, Pachal, Namakkal

**ABSTRACT:**

Underwater Wireless Networks (UWNs) are essential for applications like maritime safety, environmental monitoring, and resource exploration. This project proposes a Blockchain-Assisted Security Framework tailored for fisherman monitoring in underwater environments. The framework addresses critical challenges such as secure communication, data integrity, and real-time monitoring of fishermen's safety in marine operations. Integrating Arduino-based sensors, including heartbeat and temperature sensors, the system tracks fishermen's health and environmental conditions, ensuring safety in adverse situations. Block chain technology enhances the framework by providing a decentralized, immutable ledger for storing health and sensor data, ensuring tamper-proof records. Smart contracts automate alerts for abnormalities, such as elevated heart rates or extreme water temperatures, triggering immediate rescue actions when needed. The system's energy-efficient design incorporates lightweight cryptographic algorithms and optimized data transmission protocols to suit underwater constraints. Simulation results demonstrate the framework's capability to ensure secure communication, effective health monitoring, and rapid response to emergencies, making it a reliable solution for fisherman safety and maritime operations.

**KEYWORDS:** Underwater communication, wireless optical communication, scuba diving, heart beat sensor.

## I.INTRODUCTION:

Underwater wireless information transmission is of countless importance to the military, industry and the scientific community. So as to facilitate all these activities, there is a rise in the number of unmanned vehicles or devices deployed underwater, which require high bandwidth and high capacity for information transfer underwater. Within the previous couple of years, the interest towards optical wireless communication has increased for terrestrial, space and underwater links as it is capable of providing high data rates with low power and mass requirement. Many of researchers have administered work for terrestrial and space links, however underwater optical wireless links are relatively less explored because it is tougher than atmospheric links. The main difficulty for reliable underwater communication is due to wide selection of physical processes in various sorts of underwater environments starting from shallow coastal water to deep sea or oceans. Optical communication may be a budding technology to understand underwater wireless communication.

The experiment of underwater optical communication within the laboratory is different within the real water environment because the physical scale is restricted. Although since recent several decades, artificial scattering agents are conditioned to recreate underwater optical communication channels under different water quality conditions, but the similarity between experimental water and natural water isn't reliable, like the similarity in frequency domain characteristics. Facing the problem of alignment caused by uncertainty of the position of transmitter and receiver, poor mechanical stability along with the complexity of water environment, the transmission characteristics of underwater optical communication signals under alignment conditions are difficult to get within the natural seawater environment.

An acoustic communication has been developed for the underwater wireless sensor network because of its relatively low attenuation, but the bandwidth of the underwater acoustic channel is restricted, making it less favorable for data-intensive applications. Besides, the slow propagation of underwater sound also results in a considerable delay within the underwater communication link. Underwater sensors cannot share data with those ashore, as both use different wireless signals that only labor in their respective mediums. Radio signals that travel through air die very quickly in water. Acoustic signals, or sonar, sent by underwater devices generally reflect off the surface without ever breaking through. This causes inefficiencies and other issues for a diversity of applications, such as ocean exploration and submarine-to- plane communication. So as to beat the disadvantages in the underwater acoustic communication, a replacement approach which is in the most rising area of research is that the underwater wire-less optical communication. Initial research has begun to determine an immediate

communication link between the satellite or aircraft and the underwater vehicle. Recently, underwater wireless optical communication using cheap light-emitting diodes and laser diodes also has been researched. Comparing the light sources utilized in these underwater wireless optical communication systems, it is apparent that the LD out- performs light-emitting diodes in terms of knowledge rate. Although it is difficult to transmit long distance, it is possible to unravel the matter of interference between symbols associated with multi-path propagation and therefore the security problem associated with eavesdropping employing a point-to-point method that exploits the laser's characteristics of strong directivity at a brief distance. The blue green laser has the minimum energy fading within the sea, whose fading rate is approximately 0.155-0.5 dB/m. Hence, exploiting the low absorption window of seawater within the blue–green portion of the electromagnetic spectrum, underwater wireless laser communication is estimated to play an important role by offering secure, efficient, and high data rate communication within short distances.

Normally sea navigators or fisherman require an additional support from the land when something uncharacteristic things happen within the sea, we have to pass the message to them. With development of the technologies our people can predict what happen in the sea, but to transfer these messages to sea navigators or fisherman is difficult. So as to avoid these issues we introduce an enhanced system named under water data communication. This paper discusses about the underwater data communication system used for transferring messages to sea navigators or fishermen and also as we can monitor their health conditions. We use water data communication module to get the text and sensor readings to the ground from navigator and this will help us to avoid the undesirable death of navigators undersea. Since the conditions of underground water even temperature, pressure may vary in any condition; it also contrasts the body temperature, blood pressure of navigator. So if it lowers or higher during a wide selection, it cause even the death of the navigator. It also provides the needed medical aid to the concerned person. It is applicable for staffs of forces, marine drivers and other people who participate in water entertainments. This is often what we have accomplished with wireless underwater communications. As against hardwired communications which confines you to the length of a cable, wireless communications provide you the facility to communicate with your buddy, or top side, with ease and freedom to easily dive. Wireless underwater communications are a stimulating and easy way to freely stay connected underwater.

## II. MATERIALS AND METHODS:

### 1. Existing method

Air-water communication plays a critical role in enabling efficient underwater operations such as environmental monitoring, surveying, and coordinating heterogeneous aerial and underwater systems. Traditional wireless communication techniques primarily focus on a single physical medium, limiting their ability to achieve high-bandwidth bidirectional communication across the air-water interface. Recent advancements have explored bidirectional, direct air-water wireless communication using laser light, which adapts to water dynamics through ultrasonic sensing and precise 3D steering enabled by MEMS mirrors and passive optical elements. Experimental results have demonstrated static throughputs of up to 5.04 Mbps, zero-BER transmission ranges of up to 6.1 m in strong ambient light, and connection time improvements of 29.5% to 47.1% during wave dynamics. Underwater wireless communication (UWC) networks, which are integral to Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs), environmental monitoring, navigation, and exploration, have garnered significant attention in recent years. However, many UWC systems rely on battery-powered devices, where battery replacement or recharging poses a major challenge. Given that the reliability of UWC networks hinges on limited energy storage, energy-efficient communication has emerged as a key requirement. While considerable research has focused on extending communication range and increasing data rates, energy efficiency in UWC has only recently gained traction. Existing methods address energy efficiency through various approaches: optimizing physical layer technologies for power savings, implementing energy-efficient Medium Access Control (MAC) protocols, designing adaptive routing mechanisms, and employing efficient localization techniques. Additionally, alternative energy sources and harvesting methods have been explored to address the power constraints of UWC networks. Future research directions emphasize the integration of blockchain technologies for secure data management, the widespread adoption of the Internet of Underwater Things (IoUT), and the development of more robust and energy-efficient communication frameworks tailored to underwater environments.

### 2. Proposed System

The proposed system integrates blockchain technology, Li-Fi communication, and underwater sensors to create a secure framework for underwater wireless networks. Underwater sensors, including temperature and heartbeat sensors, along with an emergency buzzer, monitor environmental conditions and diver health, and issue alerts in emergencies. Sensor data is securely transmitted to a Data Aggregation Node (DAN) using underwater wireless communication protocols. The DAN encodes this data into optical signals, which are transmitted to a surface station using Li-Fi technology. The surface station decodes the signals, validates the data, and stores it in a blockchain ledger, ensuring tamper-proof and secure storage. Blockchain smart contracts manage data authentication, validation, and emergency alert handling, while the decentralized ledger provides an immutable record of all communication events. In emergencies, the buzzer triggers priority alerts, ensuring rapid response. This system leverages the high-speed and energy-efficient capabilities of Li-Fi, combined with blockchain's robust security, to enable real-time monitoring, data integrity, and efficient emergency management for underwater wireless networks.

## 3. Methodology

The methodology of blockchain-assisted security framework for underwater wireless sensor networks (UWSNs) integrates temperature and heartbeat sensors, a buzzer as an emergency switch, and Li-Fi technology for secure and efficient communication. The system architecture consists of sensors for data acquisition, a Li-Fi communication network for high-speed data transmission, and a blockchain to ensure tamper-proof and immutable data logging. The workflow begins with sensors collecting environmental or physiological data, which is transmitted using Li-Fi to nearby nodes, where it is verified and recorded on the blockchain. Emergency alerts triggered by the buzzer are prioritized and propagated throughout the network for immediate action.

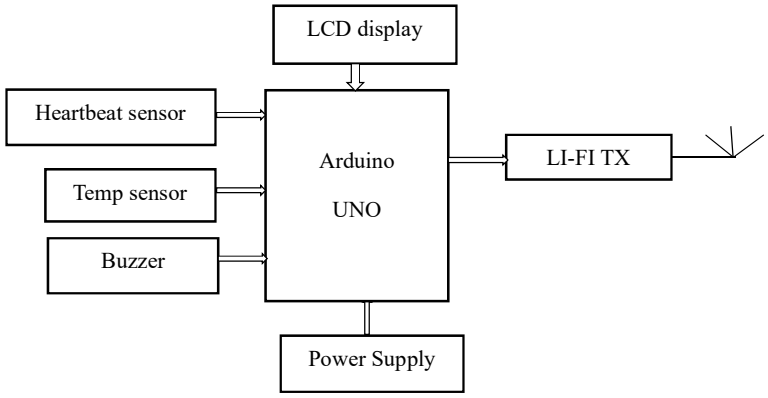
- **Data Tampering:**
  One significant threat in blockchain-assisted underwater wireless sensor networks (UWSNs) is data tampering, where malicious actors attempt to alter sensor data during transmission or manipulate blockchain records. This compromises the integrity of critical information, such as temperature or heartbeat readings, leading to inaccurate environmental monitoring or emergency responses.

  **Solution:** The use of cryptographic hashing algorithms, such as SHA-256, ensures that each data block is uniquely and immutably recorded in the blockchain. Any alteration to the data will result in a mismatch of hash values, making tampering immediately detectable. Additionally, digital signatures are employed to authenticate the source of data, preventing unauthorized nodes from injecting false information. These measures, combined with blockchain's inherent decentralized structure, ensure robust protection against data manipulation in UWSNs.

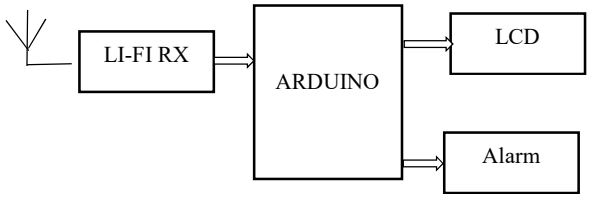
- **Communication Interference:**
  In UWSNs using Li-Fi for underwater communication, signal interference caused by environmental factors such as turbidity, light scattering, and wave dynamics can disrupt data transmission. This leads to delays or loss of critical sensor data, undermining the system's reliability.

  **Solution:** To mitigate communication interference, adaptive modulation techniques are used in Li-Fi systems to dynamically adjust to environmental changes. For example, employing Orthogonal Frequency Division Multiplexing (OFDM) enhances signal resilience by efficiently handling multipath propagation. Additionally, redundant communication paths and error-correction protocols ensure data packets are successfully delivered even in adverse conditions. By integrating these solutions, the framework maintains high communication reliability, ensuring secure and timely blockchain updates in underwater environments.

## 4. Proposed Block Diagram




**Block diagram of transmission module**




**Block diagram of receiver module**

**Li-fi technology**

The Li-Fi (light fidelity) technology was proposed by the German Scientist namely Harald Haas. The main function of this technology is to transmit the data via light. This technology is idyllic for high-speed wireless communication in a restricted region, and it offers many benefits over Wi-Fi technology such as high bandwidth, ease of use, efficiency, and safety. These systems can communicate from street lights to auto-piloted cars using their headlights. As the light speed is superior hence the data communication speed is also faster in the existing system. Furthermore, this technology can be implemented for speedy data access for the laptops, and gadgets that will be transmitted during the beam in a room.

Li-Fi system mainly includes two parts namely the transmitter and receiver. The input signal at the transmitter section can be modulated with a specific time period then send the data using LED bulbs in 0's and 1's form. Here, the flashes of LED bulbs are denoted with 0's and 1's. At the receiver end, a photodiode is used to receive the LED flashes strengthens the signal & gives the output.

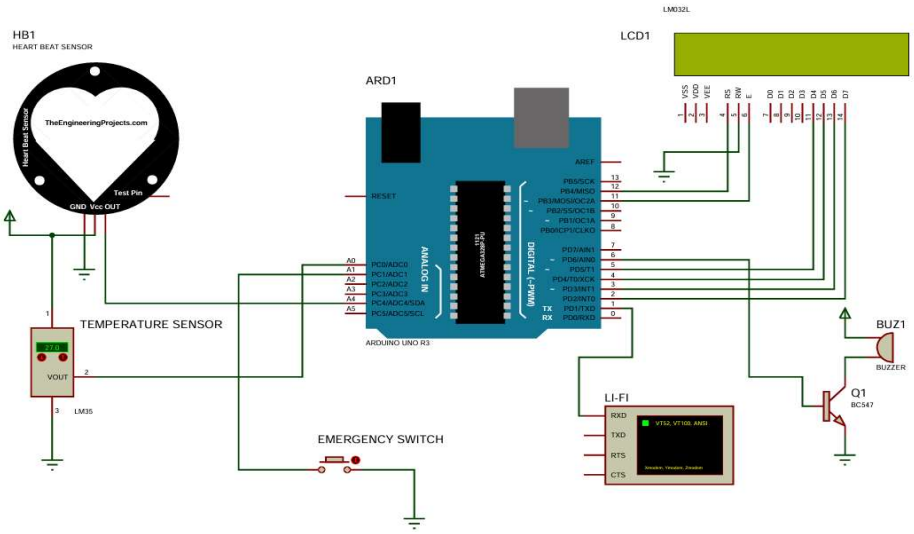
The block diagram of Li-Fi system is shown below, and the transmitter section includes the input, timer circuit, an LED bulb. The input of the transmitter can be any kind of data like text, voice, etc. The timer circuit in this section is used to provide the necessary time intervals among every bit, and these are transmitted to the receiver end in the form of LED flashes.

The receiver section includes photodiode as well as amplifier. Here, photodiode receives the LED bulb flashes then changes the flashes into electrical signals. Finally, the amplifier receives the signals from the photodiode and amplifies to provide the output.

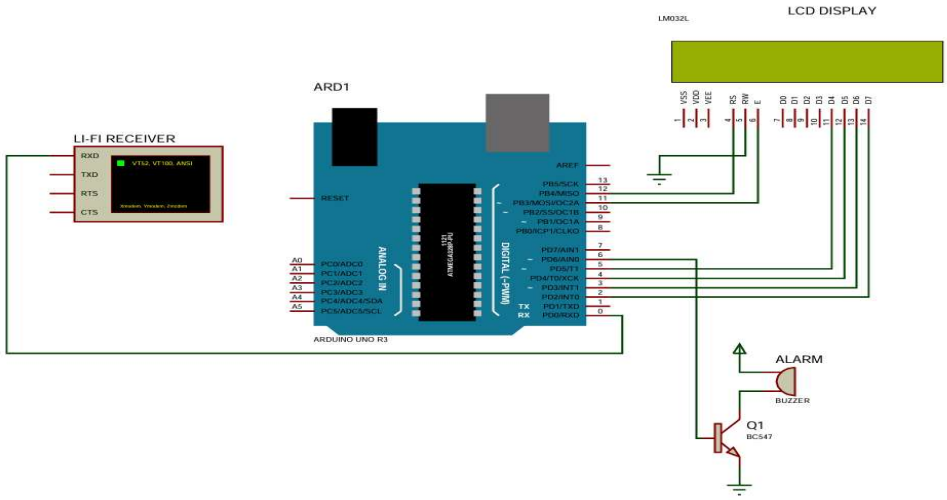
Li-Fi is a VLC (visible light communications) system and the speed of this system is very high. Li-Fi uses normal LEDs to allow the data to transfer and increase the speed up to 224 Gigabits/sec. The data transmission of this technology can be done via illumination. The essential devices of this system are the bright light emitting diodes. The ON/Off activity of LEDs permits a type of data transmission in the form of binary codes but the human eye cannot recognize this transform & the bulbs appear with a stable intensity.

**III. SIMULATION OUTPUT:**

TRANSMITTER




RECEIVER




It is designed to monitor and secure data transmission. It takes input from a heart beat sensor as well as temperature sensor and displays the value in the LCD display. This system uses Li-Fi technology to

display both normal and abnormal ranges for these parameters, ensuring real-time monitoring and secure communication.

- ❖ Temperature Sensor: Reads values from 20 to 50 degrees Celsius.
- ❖ Heartbeat Sensor: Reads values up to a maximum of 120 beats per minute.
- ❖ Li-Fi Virtual Terminal: Displays the same values as LCD

**IV. RESULT AND DISCUSSION:**

The results of our Blockchain-Assisted Security Framework for Underwater Wireless Networks, integrated with heartbeat and temperature sensors, demonstrate a robust and secure system for monitoring underwater environments. The heartbeat and temperature sensors accurately tracked physiological data, while the blockchain ensured the integrity and security of the sensor readings by preventing tampering and unauthorized access. The alarm system, triggered by deviations from normal sensor values, responded with minimal delay, providing real-time alerts for potential hazards. The combination of decentralized data storage and real-time monitoring proved effective in ensuring the security and safety of underwater personnel and devices, with the potential for further optimization in terms of scalability, energy efficiency, and real-world deployment.

**V. CONCLUSION:**

In conclusion, the system successfully demonstrated the capability to monitor underwater conditions, transmit data securely, and handle emergencies efficiently. The combination of Li-Fi and blockchain technology enabled real-time data processing and robust security, making the framework highly effective for underwater wireless networks. Future enhancements focusing on blockchain efficiency and adaptability in challenging conditions could further improve system performance and applicability.

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