A Multi-Layered Energy Efficient Approach for Performance Aware Internet of Ocean Things

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Sinan Adnan Diwan
Computer science and Information Technology College, Wasit University, Wasit, Iraq
sdiwan@uowasit.edu.iq

Abstract—Over seventy-one percent of the Earth's surface is covered by oceans, a vast body of water that is sometimes divided up into smaller bodies of water called seas. Research in this area is focusing on the significant advantages of an undersea or ocean-based environment, which is impacted by the ocean's temperature. Freshwater lakes and rivers cover less than 1% of the Earth's surface. So, ecosystems are damaged and modern technology must be developed so that climate and other elements may be regulated. The Internet of Underwater Things is cutting-edge technology in the ocean and underwater environments (IoUT). It's a network of underwater items that can be used to monitor large, undiscovered aquatic areas with a real-time Internet connection. There are several uses for IoUT, including in the military, strategic fields, climate research, and thermal pollution monitoring. With the use of the World Wide Web, Ocean of Things (OoT) devices may communicate in real-time using this technology. An IoUT is one of the most important IoT areas where a dynamic network is built and many advantages are reaped from the process. Using a multi-dimensional method for cumulative performance in the marine and undersea objects area, this research publication presents use examples for IoUT. Many significant applications and real-world domains are demonstrated to interface with crucial IoUT components. The proposed approach is making use of a multi-hop and metaheuristic-based approach for the effectiveness and overall performance of IoUT. As there are so many challenges in IoUT including frequent battery reduction and energy issues, there is a need to integrate the multi-layered approach. The presented approach is effective in terms of fewer packet losses, high throughput, and minimum energy consumption.

Keywords—internet of underwater things, internet connected underwater acoustic networks, IoUT, marine applications, ocean of things

1 Introduction

Open the Oceanography has gained a lot of interest in the 21st century because of the abundance of resources found under the ocean's surface, which scientists are examining in depth. Internet of Underwater Things (IoUT) is described as a network of smart underwater gadgets that are connected. IoUT has several practical applications, including environmental monitoring, underwater exploration, and disaster mitigation. Because of these applications, the Internet of Things (IoT) is seen as a potential technology for building smart cities [1-4]. Underwater Wireless Sensor Networks are a developing area that may provide a network solution to support the Internet of Underwater Things (IoUT) (UWSNs). Long propagation times, bandwidth limitations, and limited reliability separate the UWSNs from the more common Territorial Wireless Sensor Networks (TWSNs). Because of these unique qualities, IoUT would be unable to function properly [5, 6]. Ocean conditions have made it more difficult to give electricity to distributed marine equipment. The Ocean Kinetic Energy Harvester (OKEH) has made significant progress in powering ocean sensors with blue energy captured from the ocean. As electroactive polymers and triboelectric nanogenerators improve, so do a variety of related projects [7]. To have a better understanding of the future of the OKEH, this study is attempting to address a few of those issues. Using OKEHs (high entropy energy), this work reveals that TENG is successful at extracting low-frequency, low-amplitude and stochastic wave energy [8].

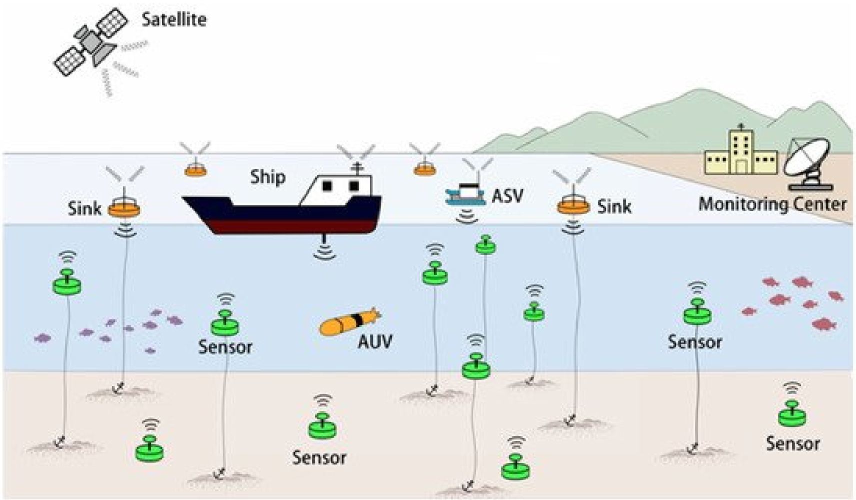

Fig. 1. A typical scenario of IoUT

Table 1. Key differences in TWSNs and UWSNs

Features	TWSNs	UWSNs
Mobility (of Nodes)	Depend on Applications	High
Transmission	Range 10 m–100 m	100 m–10,000 m
Reliability (of Links)	Depend on Applications	Low
Transmission	Media Radio Wave	Sound Wave
Difficulty to Recharge	Depend on Applications	Difficult
Propagation Speed	300,000,000 m/s	1500 m/s

2 Related work

IoUT applications that may be utilized to monitor water quality include thermal pollution measuring [7], pressure monitoring [8], and temperature monitoring [9, 10]. All aspects of IoUT-related applications and use cases have been thoroughly explored. Another idea is to use UWSNs to monitor oil and gas pipelines [8]. Environmental information software and systems are desperately needed in smart cities throughout the world. In [9], you may get more information about Indian environmental monitoring systems. Wireless sensor networks can be used to provide a river water supply this safe to drink. Due to a nationwide groundwater monitoring infrastructure, groundwater can be tracked at any time and at any location in India. The design of sensors for water pH monitoring is also presented in this research.. The pH level of drinking water can be used as an indicator of its quality. A Zigbee-enabled sensor will be used to transmit pH values wirelessly to the station's central processing unit. The initiative outlined in [11] focuses on monitoring the ocean for contamination before it occurs. Instead of long-range underwater communication, this study focuses on short-range multi-hop communication under water. Long-distance transmission can also be avoided by using a narrower range, which allows for more efficient use of acoustic bandwidth. For one reason, the short range of acoustic transmitters makes them more affordable than long-range modems. In order to extend the life of underwater sensor networks, the authors have developed a synchronisation approach that improves the quality of service (QoS). Using an underwater temperature and luminescence (brightness) monitoring system, the coralline barrier in Queensland, Australia, is being tracked. Writers have developed a mechanism that can be employed in the real world. From sensors to sinks to the control centre to the display, they designed and built the whole environmental monitoring system themselves. Local transmission between sensor nodes should use a power-aware TDMA protocol, according to the authors, in order to keep the network's robustness and adaptability. These uses of oil and gas are emphasised in [8]. In light of the tremendous development in wireless communication technology, the authors believe there is much possibility for improvement in oil and gas processing technologies. The authors take a look at an oil and gas pipeline monitoring system from this vantage point and make a recommendation. We propose a wireless sensor network-based system for monitoring oil and gas pipelines in the United States. Pipeline health information may be provided across a large area using this way Sensor networks submerged in the ocean can be used to monitor the underwater environment, characteristics, traits, or any other object of interest [7]. The authors devote a lot of time to each of the three groups of individuals who have paid attention to the underwater environment. This includes water quality and habitat monitoring as well as undersea exploration monitoring. Aims to establish cutting-edge communication solutions for real-time ocean exploration through the use of technologies like [12, 13]. An ocean exploration architecture based on UWSNs has been proposed by the authors. undersea resources will be studied using video recorder-equipped sensors. The Internet of Things (IoT) relies on the Internet as a communication and networking channel. IoT connectivity relies heavily on distant devices, even though NFC, Bluetooth, and other mobile communication may play a role. Isn't it conceivable to delve much deeper into the ocean's layers? It's not hard to imagine instances when internet access is limited since civil engineering and maritime industrial locations are part of our IoT strategy. Only passing fishing boats and the occasional electric eel inhabit the gloomy waters of the North Sea and Bering Strait. Situated intelligent wireless sensors, devices, and transmission units, known as SIoT, are built into regionalized zones and released for human (or, in this case, computer brain) consumption and analysis. The SIoT is distinct from the IoT since it has a water-to-air border zone rather than a wired network. The Internet of Things also has a problem with slow data transfer speeds (IoT). Technology in this sector is capable of monitoring a variety of parameters, including temperature, motion (to track hardware wear and tear), rotational position, and accelerometer data [14-16].

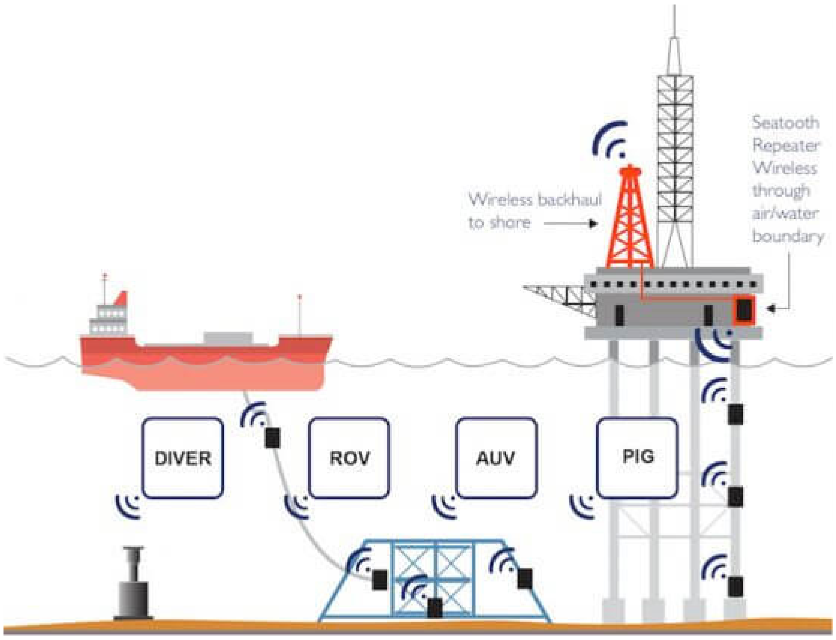

Fig. 2. Seatooth technology in SIoT

The subsea Internet of Things (IoT) has smart, wireless devices that might provide operational information, such as speed, condition, and diagnostics. Technology must be matched with appropriate application cases. Wired and wireless connectivity technologies may be used to link subsea Internet of Things systems. Radio, acoustic, and optical wireless technologies all function well together [17]. An autonomous and driverless underwater vehicle, ROV, or AUV, is not the only way to gather sensor data in the Subsea Internet of Things (SIOT), Hyland is quoted as stating. Types of sensors use local processing of data to perform efficient control procedures. The trade-offs between time and cost are effectively managed by efficient sub-surface structures. AUV data collection over 6 to 12 months is perfectly adequate for several asset integrity applications that do not demand real-time management, as he went on to explain. The Internet of Things may allow autonomous underwater vehicles to connect, collect data, and transmit it to control centers above the sea (IoUT). For example, the data may be used to investigate shipwrecks, detect tsunami warning signs, monitor animal health, and construct real-time interactive aquatic education and archaeological expedition applications, in addition to efficient resource management on our planet planets world. In order to provide operational information, such as performance, condition, and test results, down below the seabed, the Subsea Internet of Things (SIoT) is a community of wireless sensors and smart devices. Undersea interaction via the flow and water interface is the emphasis of SIot as opposed to the Internet of Things (IoT). SIoT systems based on smart, wireless devices employ Seatooth radio and Seatooth Blended technologies.

Sensors in SIoT systems often include temperature, flow, vibration, corrosion, and video. Sensor nodes that are connected wirelessly exchange data that has been processed. SIoT systems may be used for a variety of purposes, including environmental monitoring, oil and gas production optimization, and maintaining the integrity of submerged assets.

The Internet of Things (IoT) and Cloud Computing have many similarities. The Internet of Things (IoT) and the Cloud are also growing more popular in tandem. For SIoT systems, a novel architecture, known as "subsea cloud computing," was created to manage large data amounts. Cloud computing frameworks have been adapted for the underwater environment. Fog computing or Edge computing is a term that describes how the main emphasis remains at the edge. Algorithms are used to filter through a big amount of data in order to improve production.

With a seamless connection between the IoT, SIoT, data centers, analytics processors, and corporate software applications, the Subsea Internet of Things has the potential to significantly advance the Internet of Things.

In his description of the SIoD, science and tech expert Steven Kear explains the acronym's meaning. She is presently in charge of an IoTUK/Digital Catapult LPWAN Accelerate project as a supervisor.

Traditional Internet-of-Things (IoT) techniques like attenuation, low efficiency, and high prices are avoided by a network of devices built for subaquatic applications that employ diverse communication technologies (such as ultra-low frequency, long-wave, acoustic and optical) to circumvent these issues. If the SIoT is properly implemented, it may help industrial enterprises and other subsea areas.

3 Research methods and contribution

A multi-hop, energy-efficient, and reliable method is developed for underwater wireless sensor networks and incorporated with the scaled associations as well for overall effectiveness. The author uses the notion of a data aggregator as a super node to gather the information from standard IoT devices and transfer it to a floating sink, which in turn arranges the data from the aggregator and delivers it to the satellite, so conserving even more energy. ' Data can be transferred to the base station even if the data accumulator fails since all network nodes are linked and all data may be included in the base station. We're boosting data transmission speeds by using acoustic signals. Tidal energy may be converted into electricity to keep our sensor batteries fully charged and remove the requirement for a consistent power source for improved applications and performance. Simulating IoUT situations for overall accuracy is a multi-step process that takes into account aspects such as power and high data traffic beneath the sea. The aqua nodes are evaluated from multiple dimensions so that the integration factors with other devices including satellite and base station on ship will be there with higher degree of performance so that the aqua nodes may be integrated with other devices like satellites and base stations on ships with a better degree of performance, they are assessed in several aspects.

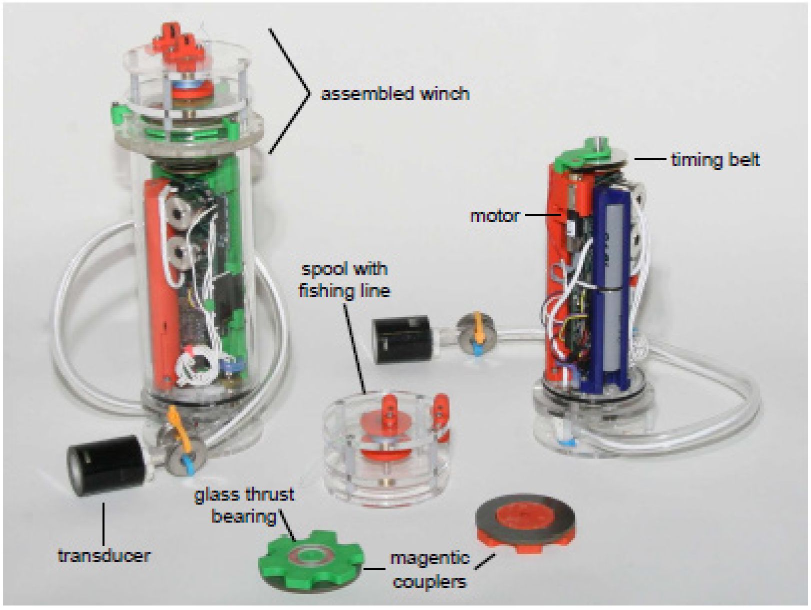

Fig. 3. AquaNode in underwater network

3.1 Details the components of the proposed work

Compared to other microcontrollers, Arduino is tougher and can operate over a larger voltage range. With a 0.5 V difference in voltage, your Raspberry Pi is at risk of overheating. It has a straightforward layout, which means there are fewer places for things to go wrong. The IDE, on the other hand, is rather nice and makes programming a breeze. Arduino, on the other hand, is more suited for controlling sensors and actuators in a home automation project. Raspberry Pi may be written in several languages, starting with Python, and has a link to the outside world [Bluetooth, wifi]. You may not be able to rely only on the microcontroller if your code is sophisticated and huge. Microcontrollers like Arduino and computer systems like Raspberry Pi are commonly used in home automation applications. Consequently, underwater vehicles serve a significant role in the surveillance, protection, and maintenance of the Aquatic Ecosystem, which is contaminated by leaks in oil spills, accidents caused by ships, and so on. Hence, monitoring the aquatic ecosystem may make use of characteristics such as temperature and pressure. Displaying these parameters is done by using the Tmp106 thermometer and MPL115A1 pressure sensor. The dc motors powered by driver IC L293D move the thrusters, which are utilized to move in the desired direction. Magnetic compass HMC6352 and Accelerometer MMA7361 are used to manage the vehicle's speed and direction, respectively.

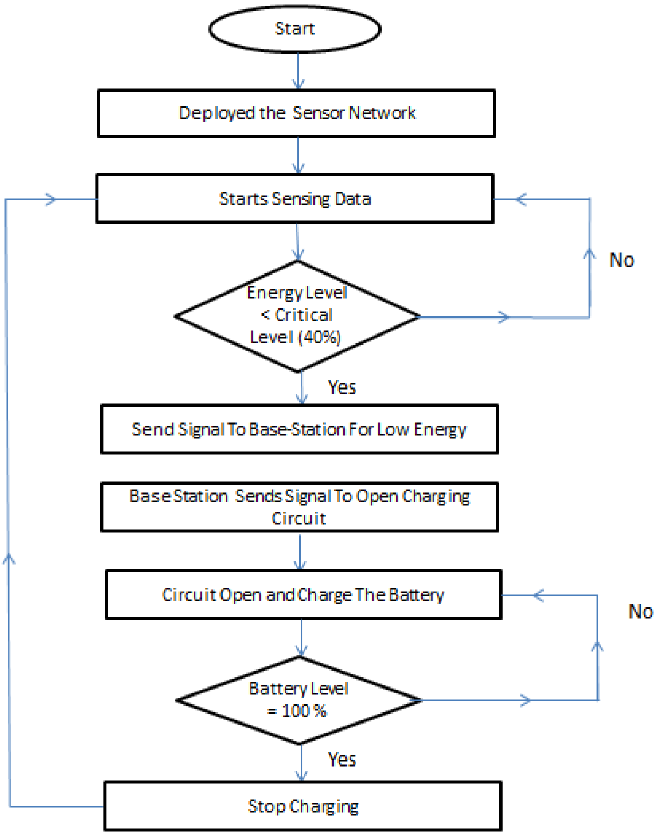

Fig. 4. The flowchart of the proposed work

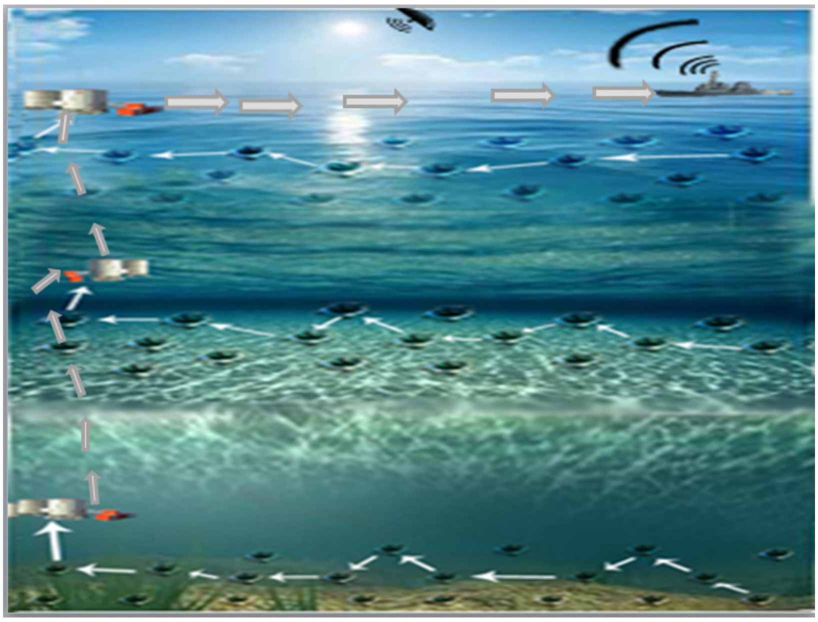

Fig. 5. Communication in IoUT with assorted sensors

4 Results and discussion

4.1 Features of the proposed method and the results obtained in comparison with existing

The proposed method is energy aware and making use of multi-layered approach for energy efficiency and overall optimization. In underwater sensor networks, energy is a critical limitation. It is recommended in this approach that tidal energy be converted into electrical energy and used to power the underwater sensors instead of utilising Li-Ion batteries, which would deplete the sensors' available energy supply. The sensors will be placed at random and connected to the data aggregator node at the lowest level. Every sensor node will have a first shortest path constructed between them. Data from each sensor will be sent to the data aggregater at that level once they have completed the shortest path. Once the data aggregators receive the data, they send it to their respective data aggregators at the bottom and top levels via acoustic communication. The data aggregators then send the data to the floating sink, which in turn sends the data to the satellite. Finally, the user receives it from their satellite. The depth-adjustment method is exclusive to sensors on the middle level. With this, the network may be expanded. It is the same network topology as the bottom level, with these sensor nodes connected directly to a data aggregator node at this level. If our data aggregator fails in the event of a disaster, we are employing the depth adjustment mechanism to fix the problem. After that, the sensors will descend and establish a wireless link with the sensors, taking the data with them. The data will then ascend and be sent to the aggregator's layered data. If the data aggregator in the middle layer fails, these depth adjustment nodes will use a depth adjustment method to move data from the bottom layer nodes to the top layer data aggregator by moving down and then up, as all of the nodes are mounted on AUVs.

4.2 Limitations of this study

The presented work is working on particular scenarios and the limited number of sensors. The implementation patterns can be extended to multiple scenarios with increasing number of sensors so that multi-dimensional evaluation can be done.

4.3 Disadvantages of this study can be noted and how can they be eliminated in the future

As the work is focused on energy, the work can be extended with other parameters including security, multi-way integrity, and others. All of the implementation possibilities are tried out, and the outcomes are recorded along with the simulation efforts. Multiple simulation settings are used to examine the cumulative effects of energy and throughput parameters.

Figure 6 presents the energy levels from implementation patterns. In addition, the performance is analyzed on simulation patterns.

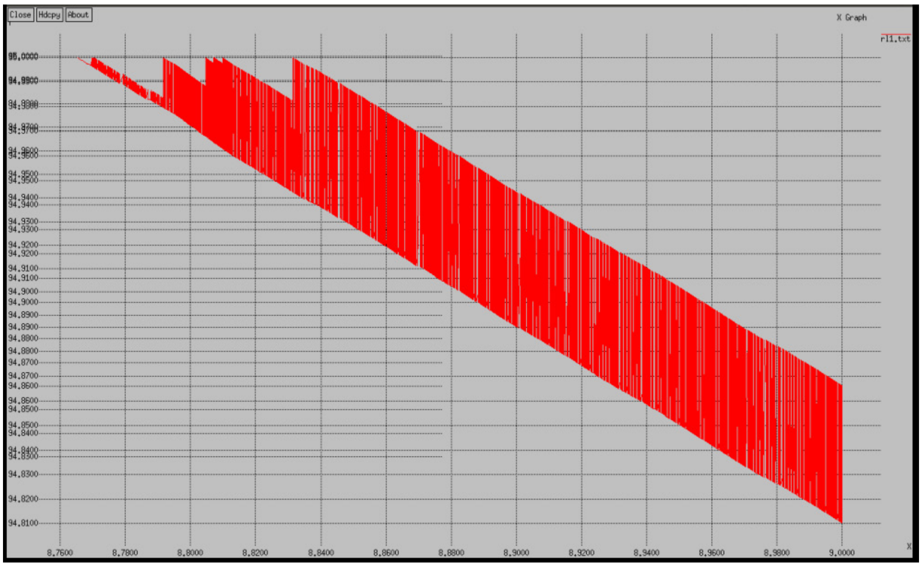

Fig. 6. Energy levels and performance aspects

There are three Aquanodes (sensor nodes) on each level, and we used data aggregators to transfer the data from one level to another, meaning that the data gathered at the bottom level by data aggregator will be transferred to a second aggregator, and so on, for energy conservation in sensor nodes, as shown in the Figure 7.

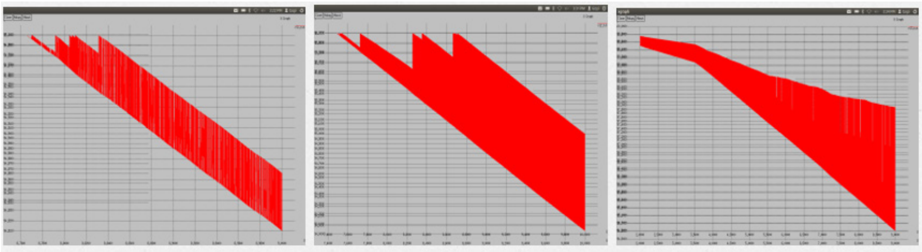

Fig. 7. Energy consumption multiple (top, middle and bottom) levels

Table 2. Comparison of the security, Packets Loss between the existing approach and proposed work

Security in Existing Approach	Security in Proposed Approach	Packets Loss in Existing Approach	Packets Loss in Proposed Approach
86	88	21	1
84	91	17	2
78	94	27	2
67	99	20	1
54	99	21	5

Because acoustic transmissions in UWSNs use less bandwidth than radio transmissions, the transmission rate is greater. Because of the restricted capacity of UWSNs, data transmission rates tend to be poor (approximately 10 kbps). This has resulted in an emphasis on the efficient use of bandwidth by IoUT [17, 18]. It is difficult to recharge underwater sensors in UWSNs because of their submerged position. The IoUT must also take into account the expense of recharging the underwater sensors' batteries. UWSNs are mobile by definition. UWSN sensors may be shifted by water currents, which might present difficulties in terms of network structure. IoUT's rapid changes are a problem to deal with [19]. Due to its almost endless potential, the Internet of Things (IoT) has been more popular over the last decade. People's everyday lives have already been made simpler by these technologies in developed countries. Underwater networks have been discovered by scientists in recent years to be useful for several reasons. The "Internet-of-underwater-things" is a network of connected underwater gadgets (IoUT). The subsea systems described above have recently shown a lot of promise for IoUT. ' Some examples of how IoUT may be utilized in a variety of sectors include smart buildings, preventative systems, marine life supervision, off-shore investigation, undersea lost-treasure realization, and sports. These are only a few examples from a broad range of industries. It is challenging to use IoUT systems for underwater communication because of their unreliable link layer, unstable radio signals, and limited bandwidth, as well as inherent noise, poor transmission rate, and slow propagation speed. Channel modeling, optimal routing, security, confidentiality, communication costs, communication bandwidth, packet error probability, packet latency, and energy consumption are some of the subjects covered. To make IoUT management more secure, deployable, and inexpensive, several researchers throughout the globe are working to enhance them. Using auditory signals comparable to those employed by marine species, but at lower strengths and wave frequencies, the robots avoid disturbing them. Due to this, there will be a decrease in transmission speeds and a reduction in bandwidth. It has been shown that underwater drones can transmit and communicate data in real-time as well as basic commands by the group [20]. An Esperanto-like language called Janus is used by the drones to converse with one another. Drone prototypes developed in the eastern Mediterranean helped find a lost cargo container at the Porto port in the past (Portugal). Because of their short range and wide array of available technologies, optical communications are well-suited for use in a wide range of aquatic situations. Tests will be conducted in a range of maritime environments now that the testbeds are up and running. These include shallow water in the Atlantic and Mediterranean Seas as well as deep water in the Black Sea.

5 Conclusion

Small research laboratories to medium-sized harbors to huge, undiscovered waters might be transformed by the Internet of Underwater Things (IoUT), a game-changing proposal. Examples include collecting real-time aquatic information, enabling naval warfare applications, maritime security, and natural disaster prediction and control through the Internet of Underwater Things (IoUT). In the field of underwater monitoring, the word "IoUT" refers to a network of linked underwater equipment used to maintain tabs on what goes on below the surface. The IoUT design incorporates electromagnetic induction, optical wavelengths, radio waves, and acoustic waves. Research, commercial and naval uses might be disclosed in this new communication environment. A new and interesting paradigm for autonomous underwater vehicles (AUVs), which may communicate data to control centers via regular internet speeds using low-cost technologies in the Blue Economy sector. Future digital infrastructure is expected to be able to handle higher data speeds, lower power consumption, and better connectivity than previous generations due to the technology's potential to support these attributes as well as a wider area of coverage and lower latency.

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7 Author

Sinan Adnan Diwan, Asst. Prof. Dr. and Dean College of Science and Information Technology, Wasit University, Iraq. His Bachelor's degree in Computer Science from Baghdad University College of Science, Iraq. His Master's degree in Computer Science from Al-Mustansria University. Iraq. His Ph.D. degree in Information Technology from Limkokwing University of Creative Technology, Malaysia (sdiwan@uowasit.edu.iq).

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