Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 5, June 2021: 5215-5235

Current challenges and Major Security Issues Underwater Wireless Sensor Networks

Ahmed Adem ,

Computer Science,Samara University, aniadem.adem0@gmail.com,Ethiopia

Kelil Ali Ebrahim,

Computer Science, Samara University, kelilaliebrhm@gmail.com,Ethopia

Dr.Sheik Saidhbi,

Associate Professor,Department of Computer Science Samara University sfajj.syed@gmail.com,Ethopia

Abstract

Our planet is covered by 70 to 75% of water and underwater much marine life is being living and surviving a life. Underwater Wireless sensor networks (UWSNs) has implemented underwater from many challenges occur in transmission to monitored data and several components deployed in a specific acoustic channel like vehicles and sensors. To achieve this, sensors and vehicles self-standardized in an autonomous network which can adapt the features of the oceanographic environment. Due to the peculiar harsh characteristics of the underwater environment, some anti-characteristics will seriously interfere with reliable data communication, transmission rates, communication range, throughput and packet routing information of underwater sensor networks. And also vulnerable to attacks due to the high bit error rates, large propagation delays and insufficient bandwidth of acoustic medium. Harsh underwater environment to perform data monitoring and data collection tasks of underwater that can be remotely access system and users of marine life as well as acoustic. In this paper, I summarized key challenges and security issues in implementing UWSN devices and an overview of latest paper research enhancing function and dimension topology's in UWSNs.

Keywords: underwater communication, underwater wireless sensor networks, security, topology like (1D,2D,3D and 4D) dimension of UWSNs, DOS, AFLA, MUWSN, UA-MAC, CDMA and AUVS.

Introduction

First of all, it need to be justify the wireless technology by its real and specific definition, its functionality, working and the enhanced version of this technology by its different applications working in different fields. Therefore, in general it can be said that wireless sensor network is a network in which many sensors are attached in a network on the different locations and communicate wirelessly from different location [17]. Wireless sensor networks (WSN) are one of most compelling emerging technologies and made up of a large number of inexpensive devices that are networked via low power wireless communications. The WSN networking capability that fundamentally differentiates a sensor network from a mere collection of sensors, by enabling cooperation, coordination, and collaboration among sensor assets [1], [14], [12], and [4].

There are two types of these wireless sensor networks, which is Unstructured Wireless Sensor Network and Structured Wireless Sensor Network. In unstructured WSN nodes are densely collected and having Ad-hoc type of deployment and also it has difficulty in maintenance of the network. In structured WSN the nodes are distributed scarcely and less deployed, deployment is preplanned and maintenance of the network is low. Now, what actually UWSN means. Is this technology being the enhanced term of wireless sensor network or it just different from that?

As it is known that the planet earth is covered with 70% of water rest is covered with dense forests and land where life exists and underwater a huge amount of unexploited resources are lies under the water which can be used to be explore to the technology by the successful key skills to implement and execute them. These advance technologies have driven the potential outcomes to do the submerged investigations utilizing sensors at all levels, which were impractical already. This technology is a combination of remote innovation with to a great degree little micromechanical sensor innovation having shrewd detecting, communication capabilities and intelligent computing [17].

Wireless ad hoc and sensor networks have been experiencing a modernization that guarantees a momentous impact on humanity. Both networks plot many research oriented challenging problems due to essential many special attributes and some obligatory constraints. Efficient communication is probably the most critical issue in wireless ad hoc and sensor networks, because mobile devices are usually moving erratically due to which route breakdown occurred. The infrastructure control techniques grant each wireless device to accommodate its transmission range narrowly and privilege certain neighbors for communication. There exist several infrastructure control techniques such as topology control designs, localized geometrical structures, dynamic cluster techniques, position-based routing, and power management protocols. However, most of the proposed infrastructure control algorithms were only applied to two-dimensional (2D) networks where all nodes are distributed in a 2D plane. In practice, the wireless ad hoc and sensor networks are often deployed in three-dimensional (3D) fields, such as sky space or atmosphere, that is, airborne ad hoc networks (AANETs) and sensor nodes in ocean, that is, underwater wireless sensor networks (UWSNs).

UWSNs are composed of different kinds of static and mobile sensor nodes to collectively perform monitoring tasks over a 3D space. In UWSNs, sensor nodes communicate with each other via unique characteristics acoustic signals and therefore encounter large propagation delay, high error rate, and multipath effects. Furthermore, Doppler's effect also occurred due to the relative motion of transmitter or receiver with the water current. Besides these communication channel related challenges, UASNs are also energy limited. The energy restricted UWSNs nodes are difficult to supplement energy as underwater nodes are costly to operate. Therefore, to make UWSNs energy efficient, node deployment algorithms need to address the adverse physical channel conditions and water mobility. Thus, infrastructure strategies support many essential network services such as network topology control and routing to increase the network performance. Due to the mentioned challenges, UWSNs call for novel protocols and infrastructures. The network design and management protocols are closely related to the network infrastructure, and various UWSN infrastructures have been discussed in the literature [10].

As needs be, UWSN is developing as an empowering innovation for underwater investigation. This is a network, which distributed its sensors nodes underwater to sense the properties related with the water such as its quality, temperature and its pressure. In other words, UWSN is a system of self-ruling sensor hubs, which are spatially appropriated underwater to detect the problems and specially the problems. The detected information or can be said the data be used by assortment of utilizations that can be utilized for the advantage of people. The sensor hubs, stationary or portable, are associated remotely by means of correspondence modules to exchange different occasions of intrigue. Now when it comes to the data transmission, this technology is fundamentally finished with an arrangement of hubs transmitting their information to light door hubs transmitting their information to closest waterfront observing and control station likewise called remote station. Water waves are low recurrence waves, which offer little transmission capacity however have long wavelengths and waves can travel long separations and are utilized for transferring data over kilometers [17].

1.1 General Overview of Underwater Wireless Sensor Networks

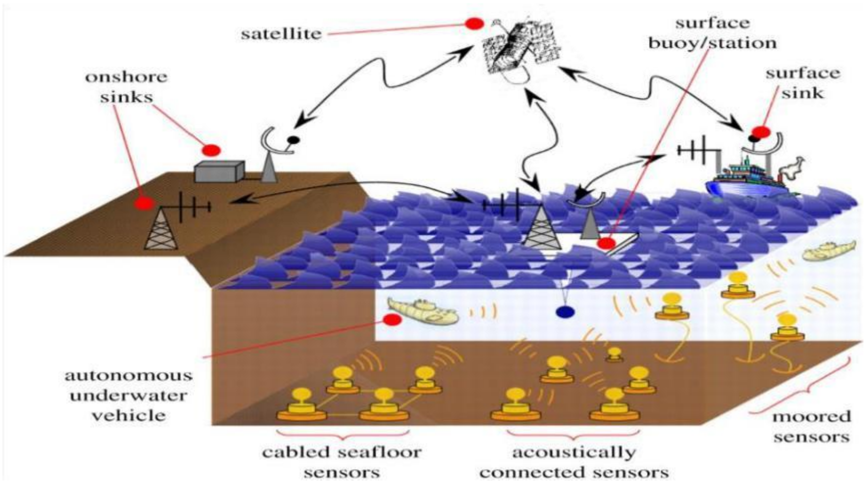


Figure 1: Overview of Underwater wireless sensor network

Technique of sending and receiving message under the utilization of sound propagation in underwater environment is known as acoustic communication. UWSNs have number of vehicles and sensors that deploy in a specific area to perform collaborative monitoring and data collection tasks. Underwater Sensor Networks support a wide variety of applications; for example, applications of ocean monitoring, resource exploration, aquatic surveillance, military [7], [8], [13], [16], [19] and [21] and river, sea pollution discovery, oceanographic data compilation, river, and commercial exploit the aquatic environment in harsh underwater environment [1], [14], [12], and

[3]. Underwater Sensor Networks can be utilized in any scenario from underwater warfare to the monitoring of environmental conditions [14] and [22].

Variable characteristics of underwater environment have become a challenge for utilizing acoustic channel. For example, multipath propagation results in fading and phase fluctuations; Doppler Effect is observed due to the movement of both the sender and receiver nods. Underwater sensor networks nodes are not static like ground-based sensor networks nodes. Instead, they move due to different activities and circumstances of underwater environment, usually 2-3m/sec with water currents [7], [8],

[13], [16], [19] and [21]. And water waves are low recurrence waves, which offer little transmission capacity however, have long wavelengths and waves can travel long separations and are utilized for transferring data over kilometers [1], [13], [16], and [6].

Different protocols regarding land-based sensor networks are, for example, Directed Diffusion, Gradient, Rumor routing, TTDD, and SPIN. However, because of mobility and rapid change in network topology these existing grounds based routing protocols cannot perform efficiently in underwater environment. Optimal packet size is depending on protocol characteristic like offered load and bit error rate. Poor packet size selection decreases the performance of the network throughput efficiency, latency, and resource utilization and energy consumption in multihop underwater networks can be greatly improved by a using optimum packet size.

The important contributions of this work are not only to highlight the deep and shallow ocean characteristics, but also to present the effect of temperature in acoustic communication and effect of temperature in noise, errors and protocols due to variation in environmental factors. In addition, classification of routing protocols for UWSNs and their comparison in terms of bounded latency, multipath, load balancing, energy consumption, geographic information, communication overhead, and time complexity. Similarly, data delivery ratios for single and multipath and the strengths and weaknesses of MAC protocols, with the used topology, are compared [19].

As shown in Figure 1, UWSNs are composed of several components: onshore sink, surface buoy, underwater sink node, and underwater sensor nodes. Moreover, satellite, vessel, and autonomous underwater vehicles (AUVs) can be used to expand the sense and communication range. Underwater sensor nodes monitor physical or environmental conditions, such as pressure, sound, temperature, etc. and cooperatively transmit data to the underwater sink node. The data are transmitted to a surface buoy via wired link, and finally received at an onshore sink or surface sink via radio communication [3] There are three different architectures for UWSNs. Static two-dimensional architecture: all the nodes are anchored to the ocean floor. The underwater sink node collects data from sensor nodes by the horizontal transceiver. Then, it relays data to surface by the vertical transceiver or wired link. Static three-dimensional architecture: underwater nodes are anchored to the seabed and fitted out with floating buoys. The buoy pays the sensor towards the water surface. The lengths of the cables are different for the required depth of sensor nodes. Three-dimensional architecture with AUVs: as discussed above, AUVs can be used to expand the sense and communication range. The AUVs could be considered as super nodes, which have more energy, can move independently, and could be routers between fixed sensors, managers for network reconfiguration, or even a normal sensor.

In UWSNs, to prolong the lifetime of whole network, cluster-based network architecture is widely used. A cluster-head (CH) node is elected to be the sink-node of the cluster, which aggregates and relays packets intra-cluster and inter-cluster. Hence, the energy consumption of CH is greater than

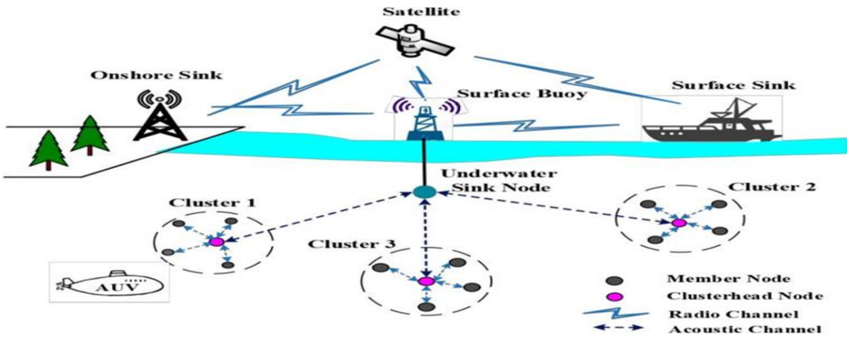


Figure 2: Underwater wireless sensor network (UWSN) architecture.

Existing research on UWSNs is mainly focused on communication, self-organization, processing capabilities, cover ability, connectivity, adaptability and low energy consumption. Unfortunately, this existing research is constrained in terms of countering security threats in UWSNs because the resources are much more constrained while the security situation is more server-based due to the particularities and networking environments [3].

1.2 Acoustic Communication in UWSN

RF waves have been given away for use in underwater network due to severe attenuation, and the constraint of extreme transmission power. Optical signals can be considered as an alternative to achieve high data rate whereas they suffer from rapid scattering and absorption while being used for long-distance communications. Optical waves can be used for networks where the nodes are placed in close proximity with no obstructions. In contrast, acoustic waves can support underwater communication over long-range links as their susceptibility to absorption is relatively low. Thus, this is the preferred technology to develop reliable UWSN. The acoustic signal communication underwater can afford an average propagation delay of 1500 m/s whereas terrestrial network provide RF communication at the speed of light. However, the acoustic speed depends on the salinity, temperature and pressure of the water medium. Underwater acoustic links can be categorized depending on their communication ranges as stated in Table 1 [23].

Table 1: Classifications of Underwater Acoustic Links

Link Type	**Range (km)**	**Bandwidth (kHz)**
Very short	< 0.1	>100
Short	0.1–1	20–50
Medium	1–10	≈ 10
Long	10 – 100	2 – 5
Very long	1000	<1

The issues such as high propagation latency, multipath fading, signal attenuation as well as Doppler effects are dominant in the underwater acoustic communication. The transmission loss and spatio-temporal variability of the underwater channel is determined by all the above factors and limited to the bandwidth of the underwater acoustic channel [23]. The contributions of this seminar paper are as follows:

- In this seminar, the special particularities and constraints of UWSNs and underwater acoustic channels are presented and we will discuss in detail.
- Based on the different research analyses, we will conclude that UWSNs are vulnerable to various threats and attacks and security issues.
- Threats and attacks in UWSNs are classified and discussed in this seminar paper. In addition, denial of service (DoS) attacks and feasible countermeasures layers are analyzed in detail.
- Compared with WSNs, some especial security requirements of UWSNs and existing security mechanisms and specific protocols we will presented.

Literature Survey

2.1 Architecture of UWSNs

Underwater network's physical layer utilizes acoustic technology for communication. Designing the network topology requires significant devotion from designer, because underwater network performance is generally depending upon topology design. Network reliability should increase with efficient network topology and network reliability should also decrease with less efficient topology. Energy consumption of efficient network topology is highly less as compared to incorrect and less efficient topology design of underwater network. Underwater sensor networks architecture [8], [12], [13], [14], [16], and [17].is shown in Figure 4.

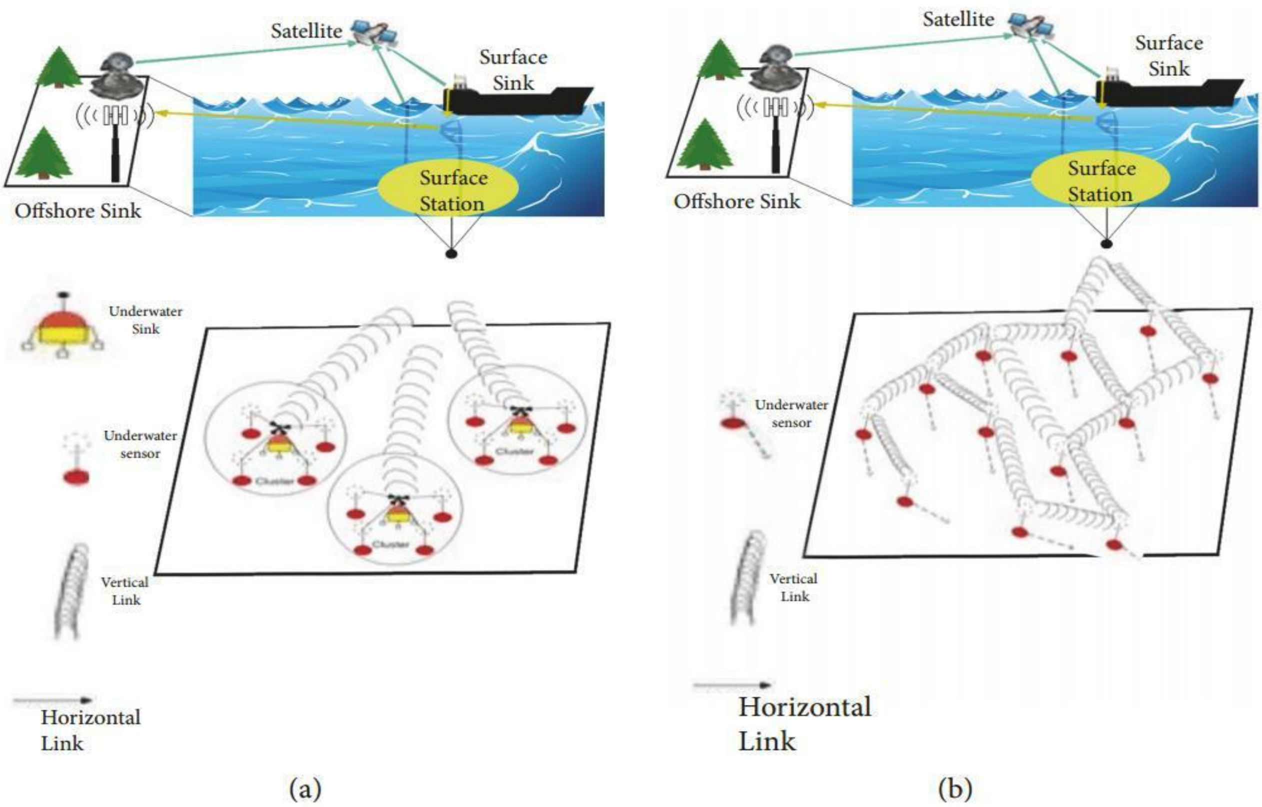


Figure 5: Two- and three-dimensional networks architecture for UWSN regarding communication given in (a) and (b), respectively

In UWSN, the deployment methodology is a key feature in defining the energy efficiency, capacity and consistency of the network. The primary focus of an efficient architecture is to maximize the network lifetime by efficiently managing the overall or individual energy usage of sensor nodes. Hence, the network architecture and post-deployment management should be carefully engineered

as much as possible. This section outlines the different communication architectures available in UWSN.

A two group classification of deployment architectures can be made according to the mobility behavior of UWSN nodes:

1. Static UWSN in which sensor nodes are usually deployed to the ocean bottom with the support of anchors;

2. Mobile UWSN which contains free-floating sensor nodes.

In static architecture, the sensor nodes are considered to be static or passively mobile with the help of anchors. The network can be constructed either in two-dimensional space (for ocean floor monitoring), or in three-dimensional space (for ocean-column examination). Two-dimensional static deployment supports grid, cluster, tree, or line-relay topologies. In contrast to static deployment, in a mobile architecture, the nodes can be allowed to move freely and organize themselves to enable communication with peer nodes.

The mobile UWSN can be further classified into two categories according to the application requirements.

1) Mobile Architectures for long-term time-insensitive applications: Energy efficiency is an essential factor to be considered in the protocol design of networks which are designed for long-term monitoring purposes. These networks encounter more delays as it collects data, relays to intermediate sink nodes which will process the information locally and then transmit to surface sinks. Typical applications include oceanic explorations, marine habitat monitoring, deep-ocean archaeology, vibration predictions, pollution alert and oil/gas field monitoring.

2) Mobile Architectures for short-term time-sensitive applications: These architectures should work with lesser delay such that they can forward the events directly to surface sinks using multi-hop communication paths. Typical applications may be ocean resource discovery, disaster prevention, anti-submarine military operation and lost treasure detection [23].

The communication architecture of UWSNs has to be engineered carefully according to the application's specifications so that it will enable high energy efficiency at an acceptable throughput. Generally, the UWSN applications are classified into two major categories.

Table 2: comparison of uwsn vs wsn

Characteristic Feature	Terrestrial WSN	Underwater WSN
Deployment Strategy	Dense / Sparse as per Application Requirements	Sparse
Spatial Correlation	Likely to happen	Not possible due to Sparse Deployment
Communication Method	Radio Frequency	Acoustic Signal
Propagation Speed	3×10^8 m/s	1500 m/s
Mobility	Optional	Continuous Mobility due to Water Currents
Power Consumption	Low	Very high
Bandwidth	20 kHz – 300 GHz	(0-400) kHz
Environmental Interference	Less	High Interference
Cost	Less	Expensive
Memory	Limited	Needs more storage

2.1.1 The 1D-USWN Architecture

One-dimensional-(1D-) UWSN design alludes to a system where the sensor hubs are conveyed self-governing. Every sensor hub is a remain solitary system itself, in charge of detecting, preparing, and transmitting the data to the remote station. In 1D-UWSN the hubs can convey utilizing acoustic, Radio Frequency (RF), or optical correspondence. In addition, the topological idea of 1D-UWSN is star where the transmission over the sensor hub and the remote station is continued a solitary jump. [19]. Autonomous Underwater Vehicle (AUV) which can plunge into the water, sense and collect the underwater physiognomies, and then rise up, relay the information to the remote station. bb

3: Procedures, Setup, Manufacturing, and Fabrication

UWSNs is working on harsh working environment, so there are some especial particularities and constraints, which are outlined as below.

3.1 Particularities and Constraints

1. Extremely Limited Resources: Underwater sensor nodes are extremely limited in hardware resources, including energy, computational capability and storage space. Due to higher distances and to more complex signal processing at the receivers to compensate for the attenuation of the signal, the power consumed for underwater acoustic communication is much higher than in terrestrial radio communication.

Underwater sensor nodes are deployed in shallow or deep water, where it is inconvenient to charge or replace the nodes' battery. To prolong the network lifetime, the computational capability and storage space are constricted. Hence, virtually all current researches for UWSNs focus on saving energy consumption at the expense of capability and security.

2. Unreliable Communication Channel: Underwater acoustic channel is temporally, spatially variable, bandwidth limited and dramatically depends on both transmission range and frequency. The farther the communication distance, the lower the bandwidth of acoustic channels, most acoustic systems operate below 30 kHz. The underwater acoustic channel is significantly affected by water temperature, path loss, noise, multipath and, Doppler effect. All these factors cause high bit error and delay variance, which result in packet loss probability and high node failure rate [21].

3. Long and Variable Propagation Delay : The propagation speed of underwater acoustic wave is approximately $1.5 * 10^3$m/s, which is five orders of magnitude lower than the radio propagation speed ($3 *10^8$ m/s) in air.

Moreover, the speed is affected by some factors including the temperature, depth, and salinity, which can be calculated by the equations below:

$$V1 = 1449.2 + 4.6T + 0.055T^2 + 0.00209T^3 + (1.34 - 0.01T)(S - 35) + 0.06D \quad (1)$$

$$V2 = 1449 + 4.6T + 0.055T^2 + 0.003T^3 + (1.39 - 0.012T)(S - 35) + 0.017D \quad (2)$$

$$V3 = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T)(S - 35) + 0.016D \quad (3)$$

$$V4 = 1448.96 + 4.591T - 0.05304T^2 + 0.0002374T^3 + (1.34 - 0.0102T)(S - 35) \quad (4)$$

$$+0.0163D + 1.675 \times 10^{-7}D^2 - 7.139 \times 10^{-13}TD^3$$

$$V5 = 1492.9 + 3(T - 10)4.6T - 0.006(T - 10^{-2}) - 0.04(T - 18)^2$$

$$+(S - 35)(1.39 - 0.01T) + D/61 \quad (5)$$

The speed is affected by some factors including the temperature (T) is temperature in degrees Celsius, depth (D) is depth in meter, and salinity (S) is salinity in parts per thousand, And also

depend on (d) is distance between sender and receiver in meter because of = , *h*

4. Limited Bandwidth and Low Data Rates: The available bandwidth of underwater acoustic channels is limited and depends on both transmission range and depth. for long range communication in deep water, the available bandwidth ranges from 500 Hz to 10 kHz; for medium range communication in shallow water, the available bandwidth ranges from 10 to 100 kHz; and for short range communication in deep water, the available bandwidth ranges from 100 to 500 kHz. The available bandwidth becomes much wider with the decrease of communication range, especially at ranges less than 100 m. In many

UWSN applications including AUV control, a larger communication range is more important than a higher transfer rate.

Table 3: Communication bandwidth.

	Long Range	**Medium Range**	**Short Range**
Communication Range	20–2000 km	1–10 km	<1 km
Working Environment	Deep Water	Shallow Water	Deep Water
Available Bandwidth	500 Hz–10 kHz	10–100 kHz	100–500 kHz
Data Rate	<10 kb/s	<50 kb/s	>100 kb/s

5. Transmission Loss: The energy of acoustic signal may be attenuated and absorbed by the medium. The transmission loss includes spreading loss and attenuation loss. Spreading loss (SL) is the power loss during the spreading period from source node to destination node. In the spreading period, the acoustic wave front will occupy a larger and larger surface area, and therefore the wave energy in each unit surface becomes less and less. According to the source and working environment, the spreading power loss can be modeled by two methods, this are spherical spreading and cylindrical spreading.

As shown in Table 7, the acoustic wave loss model includes spherical wave loss model and cylindrical wave loss model

Table 4: Acoustic wave loss model.

Shape	**Signal Source**	**Working Environment**	**Spreading Loss**
Spherical Wave Loss Model	point source	deep water	proportional to the square of the distance
Cylindrical Wave Loss Model	long line source	shallow water	proportional to the distance

Spreading loss can be calculated with the following formula:

SL = d × 10 log r……………………………(12)

where d is the spreading factor that describes the loss model, and r is the range in meter.

SL id directly proportional to d and r, where d is the spreading factor that describes the loss model, and r is the range in meter. Loss model it may be 1 or 2 spherical and cylindrical spreading for a practical underwater application respectively.

6. Attenuation loss (AL): during the propagation period, the energy of an acoustic wave would be converted to other forms (e.g., heat) and absorbed by the transmission medium. Moreover, the attenuation loss is dependent on frequency. Hence, the absorption coefficient a(f) can be used to express and calculate the absorption loss, and the f is the frequency of the acoustic wave. The a(f) can be expressed empirically, using Thorp's formula as:

$$\begin{cases} 10\log a(f) = 0.11\frac{f^2}{1+f^2} + 44\frac{f^2}{4100+f^2} + 0.000275f^2 + 0.003f \geq 0.4 \\ 10\log a(f) = 0.002 + 0.11\frac{f^2}{1+f^2} + +0.11f^2 f < 0.4 \end{cases} \quad (13)$$

where a(f) is in dB/km, and f is in kHz.

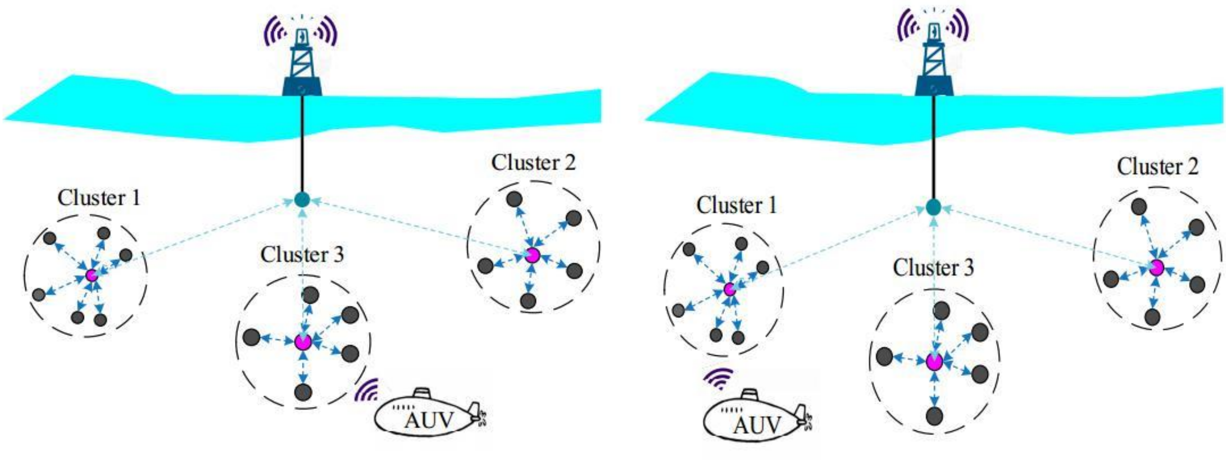
The transmission loss TL can be calculated as follows:

$$TL = SL + AL = d \times 10 \log r + r \times 10 \log a(f) \quad (14)$$

7. Multipath and Doppler Effect: In the deep water environment, the medium is homogeneous and surface and bottom reflections may be neglected. But in the shallow underwater environment, the transmission distance is larger than the water depth; moreover, depending on the depth of the water, the factors (e.g., acoustic speed, temperature, salinity, turbidity) are different. Hence, the shallow water environment can be divided into many layers from surface to bottom.

The magnitude of the Doppler effect is proportional to the ratio a = v/c, where v is the relative speed between sending node and receiving node and c is the speed of underwater acoustic wave. This effect causes distortion in two ways: spreading the received signal bandwidth B to (1 + α) B which is referred to as the motion-induced Doppler spreading, and shifting the reception frequency f by an offset of a f which is referred to as Doppler shifting. The Doppler effect and time synchronization can influence localization accuracy.

8. Dynamic Network Topology: The terrestrial sensor nodes are densely deployed, in underwater, the deployment is deemed to be sparser, due to the cost involved and to the challenges associated to the deployment itself. Majority of underwater sensor nodes are mobile due to water flow. To monitor and communication region, widely used in many applications like, (AUVs) Autonomous Underwater Vehicles [9], [20], and [22].



(a) (b)

Figure 13: Cluster UWSNs with autonomous underwater vehicles (AUVs); (a) AUV joins Cluster3; (b) AUV joins Cluster1

The AUVs may frequently join and exit the cluster or network, which will also result in a highly dynamic topology. As shown in Figure 2a, to communicate with a surface statin or on-shore sink, the AUV joined Cluster 3 as a member node to transmit packets via Cluster 3. As shown in Figure 2b, due to the movement, the AUV was out of the communication range of Cluster 3, the AUV exited and then joined Cluster 1 as its member node. The movement of the AUV led to variation of the network topology [9], [20], and [22].

4: Methodology

Because of dynamic network topology underwater sensor nods deployment is challenged while the terrestrial sensor nodes are densely deployed. And also the majority challenge underwater sensor nodes are mobile due to water flow.

The variations of the network topology mentioned above may change routing and influence the accuracy rate of data transmission which can affect the overall performance of the network. In particular, in some underwater application in AUVs due to the high mobility of cooperation within the nodes and designing adaptive protocols can be major challenge [9], [18], and [22]. Data which is transmitted on the channel is must be secure so by the qualities of this technology and its channel, UWSN are powerless against vindictive assaults. Underwater interchanges cannot utilize Radio Frequency (RF) signals. Since they have a gigantic constriction in the underwater medium. In this way, acoustic signals are utilized submerged. Resource restricted portable devices are not able to provide heavily computation and communication load. During in-network aggregation, enemies can without difficulty change the intermediate aggregation outcomes and cause the final aggregation result deviate from the true value very much. Without security of data integrity, the data aggregation consequence is not reliable [11] and [13].

Acoustic channel is highly variant because of unique challenges, e.g., narrow bandwidth, long propagation delays, variable speed of sound, refection, refraction, and large propagation losses. These unique challenges also create problems regarding media access control protocols. Media Access Control protocols have two main categories these are scheduled protocols and contention-based protocols [8], [12]- [14], [16], and [17]. And also other challenges Power Conservation, Topology Design, Antenna Design, Environmental Extremes [14] and reliability and efficient utilization of acoustic communication link, optimal packet size selection for communication, distributed localization, environmental effects, media access control [8] and [9], [12]- [14], [16], and [17].

Sensor nodes is useful only when localization is involved in it and large numbers of terrestrial localization schemes are available but because of unique challenges (sensor nodes movement with ocean currents, high cost of senor nodes, global position system inapplicability, and limited battery power) of underwater sensor networks they cannot be utilized directly.

Security Issues of UWSNs requirement like, (confidentiality, authentication, integrity, Freshness, availability, isolation, self-stabilization, and survivability), security mechanisms like, (key management, intrusion detection, trust Management, localization security, synchronization security, and routing security) [9], [18] and [22]. And major issues, e.g., energy conservation and mobility regarding underwater sensor networks, create unique challenges for designing of routing protocols and make all existing ground-based routing protocols (proactive and reactive) inadequate.

4.1 Challenges and Security Issues in Underwater Wireless Sensor

Underwater environment required such protocols that are efficient in energy consumption, manage random variation in topology, and consider asymmetric links and huge propagation delay [9], [18] and [22].

Environmental effect: marine organisms are affected due to anthropogenic sound which is emitted in underwater environment, in various ways; e.g., organs of hearing are affected in shape of hearing loss; high potential sound waves which are received by marines can injure and also can become the cause of their death speed of sound is not constant in ocean. Frequency utilized by artificial acoustic systems is overlapping with natural acoustic systems, for example, marine mammals.

RF Budget Link, is the difference between the transmitted power and receiver sensitivity. The field mentioned above measurements reveal attenuations of 40 dB/decade occurring in harsh environments, even with line-of-sight. The standard RF budget link of Zigbee/802.15.4 and Bluetooth are 85 dB and 75 dB, respectively, which is sufficient for short-range applications. However, for long-range applications and robust links with safety margins, an RF budget link at least 110 dB is recommended. Power amplifiers should be avoided in low power consumption. Lowering the data rate to increase the receiver sensitivity is a will be the right choice [9].

Designing a highly utilizable channel is a great challenge, due to the characteristics of underwater environment, for example, multipath propagation which results in fading and phase fluctuations. **Doppler Effect** is another problem which is observed due to the movement of both the sender and receiver nods. Speed of sound and underwater noise are, further, factors which influence the performance of acoustic channel, due to bandwidth dependency upon the transmission distance, we get huge throughput if messages are forwarding using multichip instead of transmitting straight forwardly using one long single hop [8], [12]- [14], [16], and [17].

Network Deployment: The UWSN nodes are very expensive and hence it will be cost effective to construct a sparsely deployed network rather than a dense system as in terrestrial networks. **Topological Changes:** In UWSN, the sensor nodes cannot be static, they subject to continuous mobility due to the impact of water currents which causes frequent changes in topology. **Communication Method:** UWSN rely on acoustic communication since it provides long range at a lower rate of absorption in water medium as compared to RF and optical signals. However, acoustic communication poses constraints like path loss, high bit error rate and increased delay. **Propagation Latency:** In UWSN, the acoustic signal speed is nearly 1.5×10^3 m/s, five times lesser than the speed in terrestrial network which in turn increases the propagation latency. Also, the sound velocity is getting affected by water parameters, which makes the acoustic channel to experience variable amount of propagation delay.

Frequency Shifting: The relative mobility of source and sink nodes in UWSN contributes to the changes in channel response which results in frequency shifting.

Cost: UWSN nodes are more expensive because of their complex transceiver design and they also need protective measures against fouling and corrosion.

Bandwidth: Acoustic signals in UWSN offer very less bandwidth in the range of (0 – 400) kHz

[10] which in turn depends on transmission range and depth of the water medium

Power Consumption: Comparing to RF signal, acoustic communication requires ten times more transmission power for data exchange in UWSN. Complex signal processing of UWSN nodes also consumes more power in relation to terrestrial network.

Memory: In UWSN, the signal connectivity subjects to frequent interruptions due to shadow zones. So, it needs to reserve more data in order to prevent the loss of significant information. **Equipment Damage:** UWSN nodes are vulnerable to routine underwater damages, for example, seaweed deposition on camera lens and salt accretion, will affect the efficacy of sensors and so forth.

In spite of the unique characteristic constraints, UWSN have the promise of revolutionizing many areas of science, industry, defense and so on. Still, there are many networking challenges that hinder the implementation of underwater applications. The following section discusses the significant challenges of underwater wireless sensor network.

Limited Resources: UWSN nodes require advanced signal processing methods to compensate for the attenuation in the underwater environment. Due to sparse deployment and intricate signal processing, they require more bandwidth, storage space and battery capacity for efficient operation. But, the UWSN are extremely limited in hardware resources thus imposing a challenge for execution of applications.

Unreliable Acoustic Channel: The nature and physical characteristics of the underwater medium makes the communication channel spatially and temporally variable. The reduced signal velocity and its dependency on water strictures, leads to increased propagation delays. Huge delays in the control packets' propagation impairs the MAC schemes, and hence more collisions are likely to happen which in turn reduces the throughput.

Mobility Prediction: Underwater sensor nodes are subject to continuous mobility, whereas the prediction of mobility pattern is complex in UWSN as compared to terrestrial network due to unpredictable variations in density and flow of water.

Localization: Location information is crucial in many applications of UWSN like event detecting, tracking, monitoring, etc. Moreover, it is also useful to enhance the performance of networking

protocols like routing. But, it is an additional challenge to accurately locate nodes in ocean sensor networks due to the following reasons – GPS signal cannot travel through water, Precise range estimation is difficult because of varying acoustic speed, Deployment in 3D requires more anchor nodes to estimate the location.

Synchronization: Time synchronization provides central support for many UWSN protocols and applications. Terrestrial synchronization algorithms are not appropriate for underwater network due to its distinct features like, physical change from RF to acoustics, increased propagation delay, high bit error rates and limited battery. Traditional GPS systems also may not be a desirable solution while considering the size, cost, power consumption and poor signal reception under the water. The energy efficiency of underwater sensor network is often having a straight correlation with the accuracy of protocol implementation.

Since centralized processing is infeasible in UWSNs; distributed networking schemes must be accomplished through optimal deployment of sensors close to the area of interest. Collaboration of information collected from different sensors throughout the network requires precise time synchronization of the sensors themselves. Also in underwater sensor network, time and space are closely intertwined. Due to the privation of accurate path loss models in UAWSN and the hardware cost limitations, underwater localization always rely on time based range estimation which requires precise time synchronization in the network.

Synchronization is also a major requirement while designing an efficient MAC protocol for UAWSN since the duty cycling approaches cannot provide effective operation of sensor networks with time uncertainty between sensor nodes. The uniform notion of time plays a major role in TDMA, without which it is not possible for the UWSN nodes to share the medium in time domain and hence to eradicate collisions thereby conserving energy. In underwater sensor network, accurate estimation of varying delay becomes a challenging task for fine-grained synchronization. Also, node mobility makes it to employ frequent resynchronization.

Security: In UWSN, it is hard to protect each node and detect malicious nodes. Hence, security mechanisms need to be pre-configured in the sensor nodes. Also, it is mandatory to realize and reconfigure a security system periodically which is a challenging task in underwater network bb

Routing Issues is a major issue that is affecting underwater sensor However, due to the mobility and very rapid change in “network topology” make, these existing ground-based routing protocols are insufficient for underwater environment [8], [12]- [14], [16], and [17].

Another challenging task in UWSNs and AANETs is the efficient routing to delivery sensed data packets from a source node to a destination node via multihop relays. Despite the fact that the

actual wireless sensor node deployment is usually conducted in a 3D space, few routing protocols have been designed for efficient data delivery in a 3D environment. Traditional 2D wireless ad hoc routing requires each node to retain a large amount of routing states, which is not scalable for large 3D wireless networks. In this section, we focus on examining and reviewing of different 3D position-based, greedy, randomized, mapping, and hybrid routing techniques to achieve sustainability and scalability in large-scale 3D UWSNs and AANETs. One of the most challenging issues for 3D wireless ad hoc and sensor networks. Due to the unique 3D challenges, the existing 2D MANET and WSN routing solutions cannot satisfy all the 3D requirements. Peer communication is required for collective distribution and collision avoidance of multinodes systems. However, it is also possible to use AANET and UWSN to gather information from the respective environment. All the collected data are routed to a limited set of directly connected nodes. Developing new routing algorithms that can support peer communication and converge cast traffic at the same time is still an open issue. Furthermore, data centric routing is a promising approach for 3D wireless networks [10].

5: Result Analysis & Discussion

5.1 Related work for this tittle

Presently underwater communication system utilizes electromagnetic, optics, and acoustic data transmission techniques to send data among different positions. Electromagnetic communication technique is affected by conducting nature of seawater while optic waves are applicable on very short distance because optic waves are absorbed by seawater. Acoustic communication is only one technique that has better performance regarding underwater communication due to less attenuation in seawater. Natural acoustic systems and artificial acoustic systems both use acoustic channel in case of underwater environment. Both acoustic systems heavily utilize middle frequencies; because of that their communication affects each other, as they use same frequencies. Still, acoustic channel spectrum is not utilized efficiently [8], [12]- [14], [16], and [17].

Cognitive Acoustic (CA) as a promising technique is the technique has the capability to wisely sense whether any part of the spectrum is engaged by any other and also has the capability to change their frequency, power, or even other operation parameters to temporarily use the idle frequencies without interfering with other networks [18] and [22]. Acoustic channel is highly variant because of unique challenges, e.g., narrow bandwidth, long propagation delays, variable speed of sound, refection, refraction, and large propagation losses. These unique challenges also create problems regarding media access control protocols. Media Access. Control protocols have two main categories these are scheduled protocols and contention-based protocols. Scheduled protocols avoid collision among transmission nodes, while in contention-based protocols nodes compete each other for sharing a single channel. Scheduled based protocols, for example, Time Division Multiple Access (TDMA), are not efficient due to large propagation delays; frequency division multiple access (FDMA) is not suitable due to the narrow bandwidth; and Code Division Multiple Access (CDMA) is suitable for underwater acoustic networks.

Acoustic Channel Access Control method (UA-MAC), to improve channel utilization in dense Mobile Underwater Wireless Sensor Networks (MUWSN). Aim is to solve the difficulties like, time schedule to access the channel, hidden terminal problem, and end-to-end delay. Information regarding sensor nodes is useful only when localization is involved in it. Large numbers of terrestrial localization schemes are available but because of unique challenges (sensor nodes movement with ocean currents, high cost of senor nodes, global position system inapplicability, and limited battery power) of underwater sensor networks they cannot be utilized directly the provide a mechanism of localization which is known as Anchor-Free Localization Algorithm (AFLA). This algorithm has ability of self-localization for anchor-free sensor nodes.

Major issues, e.g., energy conservation and mobility regarding underwater sensor networks, create unique challenges for designing of routing protocols and make all existing ground-based routing protocols (proactive and reactive) inadequate. Underwater environment required such protocols that are efficient in energy consumption, manage random variation in topology, and consider asymmetric links and huge propagation delay that is present a protocol which is known as Level-

Based Adaptive Geo-Routing (LBAGR) that divides communication traffic into four categories. Speed of sound increases due to increase in the temperature of ocean and decreases in colder oceans. Temperature of sea surface is much higher as is compared to the bottom temperature [8], [12]- [14], [10], [16], and [17].

Topology control for 3D wireless ad hoc and sensor networks has been widely studied recently and different topologies were proposed to achieve the coverage and connectivity of the desired network. Although the nodes are located in a 3D environment in real UWSN and AANET applications, most of the existing studies assume 2D topology structures. The UWSN and AANET studies have shown that the behaviors of different components in 3D environment are totally different from the behaviors in 2D, which can affect the physical topology directly [10].

Earlier attempts to analyze UWSN behavior were based on the technology developed for terrestrial WSNs. Despite similar functionality, the design of appropriate network architecture for UWSNs is complicated by the conditions of communication system and, as a consequence, the overall network is required to supply an appropriate network service for the demanding applications in such an unfriendly submarine communication environment.

As delay-tolerant applications are the major intention of UWSN, the notable proposals in underwater routing protocols investigate the lack of global load balancing in the network to obtain extended lifetime of network. An efficient technique in localization-free category is depth-based routing protocol (DBR), based on data forwarding through low-depth sensor nodes. Energy-efficient depth based routing (EEDBR) scheme is a constructive framework for maximizing the network lifetime by utilizing both depth and residual energy of the sensor nodes. It minimizes the end-to-end delay along with better energy consumption of the low-depth nodes. Both of these techniques attempt to deal with minimizing the load on medium-depth sensor nodes in dense conditions.

In [5] and [15] this paper, two different partner node selection criteria are implemented and compared. The authors have considered source node depth threshold (dth), potential relays depth, and residual energy (Re) as one criterion and signal-to-noise ratio (SNR) of the link connecting source node with relay or destination as another criterion for selection parameters. In [5] and [15] a communication path-based routing protocol by the name of relative distance-based forwarding (RDBF) is presented which aims to provide transmission efficient, energy-saving, and low delay routing. The authors utilize a fitness factor to measure and judge the degree of appropriateness for a node to forward the packets. Only a small fraction of nodes are involved in forwarding process, which reduce the energy consumption and end-to-end delay. RDBF also controls the transmission time of multiple forwarders to reduce the redundancy. In [6], the authors have addressed the problems of localization by expressing underwater transmission loss via the Lambert W function. Real device implementation demonstrated the accuracy and efficiency of the proposed equation in distance calculation, computation stability, and shorter processing time. The simulation results show that Lambert W function was more stable against errors than Newton-Raphson inversion

Another study proposes a clustering scheme in that promises to overcome the UWSN confines by resolving the transmission of redundant data in the network. The protocol works in rounds, with

each round consisting of four phases, utilizing suitable mechanisms in each round. The proposed clustering scheme promises to reduce network consumption and increase network throughput. Moreover, the minimum percentage of received data at the base station is also guaranteed. The research paper in [15] tackles the problem of tracking underwater moving targets. For three-dimensional underwater maneuvering target tracking, the interacting multiple model method is combined with the particle filter to cope with uncertainties. Simulation results show that the proposed method is a promising substitute for traditional imaging-based or sensor-based approaches [5] and [15].

5.2 Conclusion

In this paper, I have review several techniques of underwater sensor networks. The objective of the reviewed techniques is to overcome the underwater challenges and to give directions to future researchers. I have presented future directions which are still not yet explored in this research area. Underwater network depending upon topology design for network reliability to increase with efficient network topology. 3D-UWSN topology best network reliability, because of the organization of the sensors at variable statures, and portable UWSNs. Sensor are extremely limited in hardware resources and it is difficult to propagation delay and transition loss in acoustic channel.

A better communication technique can be proposed by considering environmental effect during communication. In the development of underwater communication technique utmost care must be taken regarding the life of marine animals and their communication. The deep digging out in the areas regarding nonlinear sound propagation of acoustic signals can be more useful for designing future communication techniques. the future identified research areas include cognitive networks area and underwater spectrum for their efficient use and major challenges for the design of cognitive acoustic network.

underwater acoustic channel transmission Error occurred in many factors that affected by such kind of parameter, water temperature, low speed of acoustic wave, ambient noise, transmission loss, multipath effect, and Doppler effect. And all these factors may cause delay variance and bit error, which result in high bit error rate and packet loss probability in UWSNs. The underwater acoustic channel has the character of an open channel, which is shared by all nodes within the communication range. In this case, an attacker can passively intercept and analysis acoustic signals, and even worse actively disrupt network services such as localization, time synchronization and routing. Hence, it is a great challenge to design an effective secure protocol to protect UWSNs from eavesdropping and other malicious attacks.

UWSNs nodes are waterproof, compact and sophisticated in nature and nodes could be physically damaged to be invalid and are also vulnerable to marine organism. As mentioned above, sensor nodes may be deployed at harsh and unattended deep sea, which means that it is unable to guard each node from potential physical damages. These changes of the network topology may change the data routing and influence the accuracy rate of data transmission

For long range communication, the maximum data rate is approximately 10 kb/s. For medium range communication, the maximum data rate is approximately 50 kb/s. For short range communication, the maximum data rate can reach more than 100 kb/s. One of the most convincing architectures for WSN is a deployment architecture Clustered-based topology, where multiple nodes within each local region report to different cluster-heads.

In 3D applications use different types of data such as target images, acoustic signals, or video captures of a moving target. These applications require different high levels of reliability. Such reliability is not fulfilling with the existing transport layer protocols. With the growing 3D applications, new 3D UWSNs and AANETs have been developed and deployed in recent years. Due to the distinctive features of 3D wireless ad hoc and sensor networks and the complex deployment environment in 3D ocean spaces and sky spaces, various efficient and reliable 3D communication and networking protocols have been proposed.

I properly describe UWSNs and AANETs and present several application scenarios of both networks. Furthermore, we present an overview of the most recent advances in network design principles for 3D wireless ad hoc and sensor networks, with focuses on deployment, localization, topology design, routing design, and communication protocols. We have a strong belief that more promising developments and significant improvements of 3D wireless networks will be achieved in the near future. This will greatly enhance human's abilities in investigation and manipulation of the 3D environment.

Literatures reveal that UWSN deployment is very challenging as it is a key factor in determining the energy consumption and coverage of the network. The main challenges of network deployment are the cost, the computational power, the memory, the communication range and, most of all, the limited battery capacity. In this paper, we have proposed an efficient heterogeneous 4-dimensional acoustic communication architecture for UWSNs considering the energy and delay as the main factors. Static deployment algorithms in general intend at maximizing network coverage with less number of nodes. But the results will not be accurate in such cases whereas sensor nodes deployed using normal distribution will provide better results about the target. Also, mobility caused by water current cannot be neglected in UWSN.

5.3 Future work

Utilization of cooperation strategy and SNR enhances the network lifetime, improves the PDR, and reduces the overall network energy consumption. This is especially beneficial for delay-sensitive and time-critical applications. Transmission schemes without cooperation are based on channel estimation that improve the received packet quality at receiver node; however, transmission with one path can be affected when the channel quality changes. Relay selection mechanism considers the instantaneous link conditions and distance among neighboring nodes to successfully relay packets to destination in the constrained UWA environment. Variations in depth threshold increase the number of eligible neighbors, thus minimizing critical data loss in delay-sensitive applications. Characteristics of single-hop and multihop communication schemes have been utilized to reduce path-loss effects and increase network lifetime. Optimal weight computation and role of cooperation not only provide the load balancing in the network, but also give proficient improvement in the network stability period.

In general, WSNs future made based on environmental characteristics in acoustic channel and cost is yet challenge to build for WSNs in this environment.

5.4.Reference

1. Abdellah Chehria, (2020) 'Enhancing Energy Efficiency of Wireless Sensor Network for
2. Mining Industry Applications' pp(261-270), University of Quebec in Chicotimi Quebec, G7H2B, Canada. 1
3. Babar Shah and Ki-Il Kim (21 July 2014) "A Survey on Three-Dimensional Wireless Ad Hoc and Sensor Networks" Department of Informatics, Engineering Research Institute, Gyeongsang National University, Jinju 660-701, Republic of Korea Correspondence should be addressed to Ki-Il Kim; kikim@gnu.ac.kr [Accessed 03th June 2021]
4. Guang Yang and Lie Dai (13 November 2018) 'Challenges, Threats, Security Issues and New Trends of Underwater Wireless Sensor Networks', School of Information Science and Electrical Engineering, Shandong Jiaotong University, Jinan 250357, China; dailie@sdjtu.edu.cn [Accessed 29th May 2021]
5. Hasna Chaibi, (2020) 'Enhancing Energy Efficiency of Wireless Sensor Network for Mining
6. Industry Applications' pp(261-270), SIRC/LaGes-EHTP, EHTP Km 7Route El Jadida, Oqsisi, Morocco).
7. http://dx.doi.org/10.1155/2015/891410 [Accessed 12th May 2021]
8. http://www.ijstr.org/final-print/jan2020/Energy-Efficient-4-dimensional-Heterogeneous-Communication-Architecture-For-Underwater-Acoustic-Wireless-Sensor-Networks-.pdf [Accessed 27th May 2021]
9. Khalid Iqbal, (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges', Pattern Recognition, Images and Data Engineering (PRIDE) Lab,
10. Department of Computer Science, COMSATS University Islamabad, Attock 43600, Pakistan.
11. Khalid Mahmood Awan (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges' Internet Communication & Networks (ICNet)
12. Research Lab, Department of Computer Science, COMSATS University Islamabad, Attock 43600, Pakistan.
13. Lie Dai, 'Challenges, Threats, Security Issues and New Trends of Underwater Wireless Sensor Networks"School of Information Science and Electrical Engineering, Shandong Jiaotong
14. University,Jinan 250357, China; dailie@sdjtu.edu.cn [Accessed 20th May 2021]
15. **M. Saranya Nair, K. Suganthi** Volume 9, Issue 01, (JANUARY 2020) "Energy Efficient 4-Dimensional Heterogeneous Communication Architecture For Underwater Acoustic Wireless Sensor Networks" international journal of scientific & technology research, ISSN 2277-8616
16. Mahsa Teymourzadeh and Roshanak Vahed, 'Security in Wireless Sensor Networks: Issues and Challenges' Faculty of Engineering, Department of Computer Engineering, Islamic Azad University Khorasgan, Iran.
17. Nadir Hakemc (2020) 'Enhancing Energy Efficiency of Wireless Sensor Network for Mining Industry Applications' pp(261-270), Université du Québec en Abitibi-Témiscamingue, Val d'Or, QC, J9P 1Y3, Canada.

18. Peer Azmat Shah, (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges' Pattern Recognition, Images and Data Engineering (PRIDE) Lab, Department of Computer Science, COMSATS University Islamabad, Attock 43600, Pakistan.
19. Rachid Saadane, 'Enhancing Energy Efficiency of Wireless Sensor Network for Mining
20. Industry Applications' pp(261-270), SIRC/LaGes-EHTP, EHTP Km 7Route El Jadida, Oqsisi, Morocco.
21. S. Ahmed et.al (2015), "Co-UWSN: Cooperative Energy-Efficient Protocol for Underwater WSNs" Article ID 891410, pp 1-16
22. Saira Gillani, (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges', College of computing and informatics Saudi Electronic University, Jeddah, Saudi Arabia)
23. Sarvesh Kumar, Bersha Kumari, and Harshita Chawla (2018), 'Security Challenges and Application for Underwater Wireless Sensor Network ', vol. 2, 15-21, Jayoti Vidyapeeth
24. Women's University Jaipur, Rajasthan.
25. Soulmaz Alibeygi, 'Security in Wireless Sensor Networks: Issues and Challenges' Faculty of Engineering, Department of Electronic Engraining, Islamic Azad University Shahrekord, Iran.
26. Waqas Ahmad, (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges, Internet Communication & Networks (ICNet) Research Lab, Department of Computer Science, COMSATS University Islamabad, Attock 43600, Pakistan.
27. Ying-Gao Yue, 'A comprehensive survey on the reliability of mobile wireless sensor networks:
28. Taxonomy, challenges, and future directions' Department of Communication Engineering, Sichuan University of Science & Engineering, No. 188, University Town, Lingang Economic-Technological Development Area, Yibin, Sichuan 644000, People's Republic of China.
29. Yunyoung Nam, (1 January 2019), 'Underwater Wireless Sensor Networks: A Review of Recent Issues and Challenges', Department of Computer Science and Engineering, Soonchunhyang University, Asan 31538, Republic of Korea.
30. Zhiqiang Wei (13 November 2018) 'Challenges, Threats, Security Issues and New Trends of Underwater Wireless Sensor Networks', College of Information Science and Engineering,
31. Ocean University of China, Qingdao 266100, China; weizhiqiang@ouc.edu.cn [Accessed 12th May 2021]
32. Saranya Nair M[1], and Suganthi K[2] (2020) "a comprehensive study on communication
33. Architectures, applications, challenges And protocol stack of underwater Acoustic wireless sensor networks " [1,2]Assistant Professor, School of Electronics Engineering, Vellore Institute of Technology, Chennai Campus Email: [1]saranyanair.m@vit.ac.in, [2]suganthi.k@vit.ac.in, vol 7, issue 19, Issn- 2394-5125
34. Zhou, H., Wu, H., Jin, M.A robust boundary detection algorithm based on connectivity only for 3D wireless sensor networks Proceedings of the IEEE Conference on Computer Communications (INFOCOM '12) March 2012.