Under Water Sensor Networks – A critical Survey and study of the design, applications and challenges

Haseeb.V.V [1], Noufal.K.P [2]

[1]*Research & Development Centre, Bharthiar University, Coimbatore, N.A.M. College, Kallikkandy, Kannur, Kerala*

[2]*N.A.M. College, Kallikkandy, Kannur, Kerala*

Abstract - In the recent times sensors are intruding into all kinds of environments. The Underwater wireless sensor networks (UWSNs) are sensor networks of a number of sensor nodes deployed under water. They are capable of Communicate with each other. About 70% of the earth was covered by water and hence major portion of the resources are hidden under the water. The use of Underwater Sensor Nodes(USN) is a very important move towards exploration of the hidden underwater resources. When compared with the sensor nodes used on earth USNs are expensive, big in size and consume more power because of the specific conditions in the underwater environment hence the design of the USNs need special attention while designing. The challenges in this type of communications are limited bandwidth, high propagation delay and signal fading. It should also be borne in mind that very un favorable environmental conditions may cause the nodes to be more prone to failure. Submarines nodes must be able to configure and automatically adapt to the hostile environment of the ocean. As for the energy part, as with the above-mentioned types of previous WSN, these nodes are equipped with limited battery, cannot be changed or recharged. Conservation of energy in this type of networks Techniques for underwater communication and efficient network routing are applied. Underwater sensor networks (UWSN) emerged as a new alternative technology for surveillance and underwater exploration applications, including scientists, commercial and military. In this paper we conduct a study on the design issues of the underwater nodes and the challenges faced by the USNs in use. We also focus on the effectiveness of the communication, performance and the issues of design in this perspective.

Keywords - Underwater Sensor Nodes, Design, survey.

I. INTRODUCTION

A. Back ground

In the recent times the effective design and implementation of Wireless sensor networks has become a leading area of research. A sensor is a device that reacts and responds and identify an input from a physical or environment condition. The output of a sensor is generally an electrical signal that will be transmitted to a controller for further processing. A wireless sensor Network can be defined as a network of devices that can communicate information gathered from the from the environment through a wireless link. In such communication the date is communicated through a series of nodes. The WSNs are used to monitor the environmental parameters like pressure, temperature etc. to a data centre.

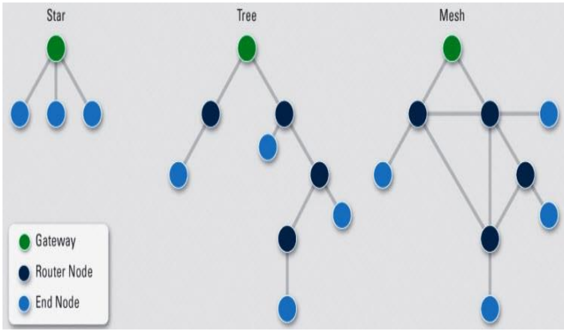

Fig.1: Wireless network Topologies.

B. Under water Sensor Networks

Under water Sensor Networks(UWSN) is a leading research area that draws the attention of the researchers and the industry. Oceans, rivers and lakes are important for life on the earth and monitoring this environment is expensive and difficult. Ocean bottom sensor nodes can be used to study and monitor the Oceanographic data. Autonomous under water vehicles fitted with the sensors explore natural underwater resources. The communication channel can also be used for the transfer of control signals from the control station to nodes of subterranean and subterranean sensors that allow the interactive control of the descent of red submarine sensors. UWSN have many advantages over traditional instrumentation techniques. Graves of sensitivity nodes can detect shortly after the fact that one can wait until the end of the mission [1]. UWSN technology has faced many technical challenges. In addition to the usual design challenges facing terrestrial wireless sensors, UWSN has addressed some unique challenges. Subterranean and submarine sensory networks can not be used for electromagnetic waves for long range communication to rapid absorption in water. Acoustic waves are generally considered the practical solution for UWSN communication. The dependence of UWSNs on underwater acoustic communications is difficult to achieve [2]. The stories like the upper levels of variation of the temperature, the pressure, the gradients of the salinity and the turbulence induced by the currents, added more restrictions to the ring of small band available for communication. Underwater wireless networks, as an emerging technology, have attracted a growing number of researchers and have the promise of allowing many commercial applications, such as underwater monitoring of the environment, exploration under -marine and tactical monitoring, underwater environments for applications. Underwater wireless networks, but they are very promising, are difficult to develop because of the unique characteristics of the underwater environment. Since electromagnetic waves do not travel very far in water, wireless networks often have submarine acoustic channels [3]. It has low propagation of signal speed, propagation delay, limited bandwidth and a high probability of error due to multipath propagation and discoloration. This is complicated by the particular time and dynamics of the underwater environment leading to unstable communication channels and highly intermittent connectivity. Due to the challenges mentioned above, new design philosophies are needed and significant development efforts for both acoustic communication devices for network software submarines are needed.

Underwater acoustic modems are physical layer devices for underwater communications. Most existing commercial acoustic modems have very low data rates that make underwater wireless networks costly due to additional costs. And therefore, point-to-point communication is widely used . Recently, there has been increasing interest in the application of multi-carrier modulation as orthogonal frequency division multiplexing (OFDM) in submarine acoustic communications, which can provide much higher speed data. This makes it more affordable to enjoy the benefits of underwater wireless networks. The design of the network protocol stack is another key to implementing wireless sub-element. The network protocol stack hosts a number of protocols to provide services, including media exchange, reliable routing discovery and data transfer. Despite significant success in developing the network protocol stack in terrestrial networks, has become limited in the design and implementation of protocol stacks for wireless networks operate underwater. The absence of a mature, robust and flexible protocol stack causes two major problems that hinder the development of underwater wireless networks. On the one hand, the existing stack protocol structures make it impossible to implement and experiment new protocols for the actual submarine network nodes network, as developers need to respond to the hardware details of the network nodes and process each Layer network protocol stack. On the other hand, there is no standard platform to compare the results of different protocols in a fair and efficient manner. Therefore, the lack of a flexible protocol stack structure is a key to the development and rapid deployment of wireless underwater obstruction networks [3].

Thus, as will be explained in the following sections, unlike other networks, WSN has its own limitations and design constraints. With respect to these limitations, we can mention power, short-range transmission, bandwidth and reduced processing and limited storage capacity at each node. In addition, design constraints are application dependent and are directly related to the supervised environment. The learning environment plays a key role in determining the size of WSN, the deployment schema, and the network topology. Network size varies with the environment: while in indoor environments some nodes are needed to form a network in a limited space outside they may need several nodes to control large areas. Applications WSN and communication protocols are mainly focused on providing a high energy efficiency, since the sensor nodes are equipped with small batteries that are generally difficult to replace. Therefore, while traditional networks aim to achieve a predetermined level of quality of service in the WSN protocols focus on energy conservation [2].

Structured and unstructured are two types of WSN. A structured WSN consists of a sensor array with a set of dense nodes that can be deployed randomly in the environment. Once deployed, the network is unattended fulfilling the functions for which the design. In this type of WSN both maintain network functions such as connectivity and fault detection, it is difficult because of the large number of nodes present. Moreover, in the networks of structured sensors, all or some of the nodes are placed at predetermined positions [4]. The advantage of this type of network is that nodes can be deployed at lower cost of network management and maintenance. Also, fewer nodes are needed in the deployment because they are placed at specific locations to ensure the desired coverage while random deployments can be uncovered regions. The current state of sensor technology allows the design and development of various WSN applications. The sensor nodes available on the market include generic (multipurpose) nodes and gateways[6]. The task is to take generic nodes to measure the supervised environment. It can be equipped with a variety of detection devices that can measure many physical attributes such as light, temperature, humidity, barometric pressure, speed, acceleration, acoustic, magnetic field, etc [7]. Generic node gateway nodes collect data and transmit it to the base station. These nodes can have a greater processing capacity, an important source of energy and a greater transmission range. Generally, to form a combination of generic deployed WSN nodes and gateways. In addition, the base station is responsible for establishing communication with external networks such as the Internet, allowing WSN remotely controlled.

The rapid adoption of underwater wireless sensor networks (UWSNs) in several applications is due to various practical reasons. The main reasons include the ease of deployment, ability to operate in harsh environments, high levels of reliability, and solid performance. Due to their distributed nature and the ability to collaborate, UWSNs can sometimes sense events that ordinary systems cannot. As an example, if a single soil moisture sensor is deployed in the field, we can learn about the soil moisture at that point. If we increase the number of sensors deployed, distributing them across a wider landscape, an entire topography of the soil moisture emerges, i.e., we obtain a holistic view of soil moisture variations in that landscape[8]. In short the data collected from a distributed UWSNs can be used to monitor and possibly improve the system in which the WSN is deployed. The UWSN technology captures red and submarine sensory nodes, so that the nodes of sensors allow to transmit data in real time to the control station at sea or in earth for an immediate analysis. The sensor nodes available in the market include generic nodes and gateways. The task is to take generic nodes to measure the supervised environment. It can be equipped with a variety of detection devices that can measure many physical attributes, such as light, temperature, humidity, barometric pressure, speed, acceleration, sound, magnetic field, and so on. Compared with existing underground monitoring strategies, WUSNs have the advantages in timeliness of data, ease of deployment and data collection, concealment, reliability, and coverage density. A wide variety of novel and essential applications are enabled by WUSNs, including: ˆ Intelligent Irrigation: With the real time monitoring of the soil moisture, temperature, among other soil properties, the WUSNs can accurately determine when and where to irrigate the crops.

C. The architecture of the Underwater Sensor Node

The Underwater Sensor node can be viewed as the integration of five major components a Processing Unit, a Power supply unit, a Depth control Unit, a Communication Unit and a Sensing Unit as shown in Figure - 2. The primary responsibility of the Processing unit is to control and coordinate the actions of all the other units and implementation of algorithms. The power supply unit is responsible for the uninterrupted supply of reliable power and also control the energy consumption. The Depth Control unit determines the depth in which a particular node is to be operated depending on the characteristics of the water column. As all the nodes are provided with the depth control unit, this unit decides the depth in which an individual node should operate. The communication Unit is responsible for the communicating with the nodes in the network. While doing so it has to perform the communication in a power effective way[7]. The sensor unit consist of analog and digital sensors. The analog sensors convert electrical signals and digital sensors produce digital output stream. The UWSN node senses various water parameters hence the sensor unit is integrated with the p^H sensors, Conductivity sensors, Dissolved Oxygen sensors, Temperature sensors and turbidity sensors etc.

Another important component but not integrated into the architecture is that the Housing. This housing provides a safe and secured deployment of the UWSN node under water.

In the UWSNs synchronization is an important factor so that the communication will be taken place intact. In the node this is achieved through the real time clocks.

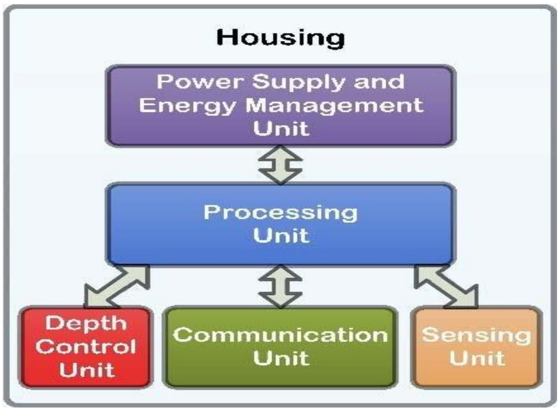

Fig.2: Architecture of Underwater sensor.

1. **Applications of UWSNs**:
   UWSNs are now a days are widely used in the underwater studies, ocean studies, study of the aquatic environment, exploration of the resources, deep sea surveillance etc. Comprehensively the applications UWSNs are identified as Monitoring, Disaster, Military, assisted navigation etc.
   The UWSNs intended for monitoring are responsible for monitoring of underwater environment and monitor important parameters like water quality, under water habitat and resources etc. The most important application of the UWSNs is Disaster studies[5]. With the advent of technological advancements UWSNs are widely used for the forecasting of underwater volcanoes Tsunamis, etc. UWSNs are critically used in military applications for navigation.
2. **Challenges in the Underwater Sensor Networks**
   Even though UWSNs are promising and critically useful in underwater applications, these networks suffer from a number of challenges. One among them is that these sensors are deployed in the depths of the sea, they face unpredictable water activities and varying underwater pressures. Due to the unpredictable underwater environment, it is very difficult to deploy them underwater in wireless mode. The underwater sensor networks suffer from the less scope for scalability for covering wider areas under sea[9]. The acoustic communication is not as reliable and faster as terrestrial communication. Due to the turbulence under water, the locations of the nodes keep on changing from time to time and hence results in unreliable communication. The power source for the nodes is very limited and changing the batteries or recharging them is a difficult.

IV. CONCLUSION

After a careful study, it is observed that the UWSNs technologies are growing rapidly and gaining importance. Due to the challenges it is facing, maximum care must be taken to implement the networks underwater. Even though the technology has grown drastically, some of the challenges faced by the UWSNs are still persists. Research should be focussed on the issues that restrict the performance of the UWSNs.

V. REFERENCES

[1]. Akyildiz, I.F. and Stuntebeck, E.P., 2006. Wireless underground sensor networks: Research challenges. *Ad Hoc Networks*, *4*(6), pp.669-686.

[2]. Akyildiz, I.F. and Vuran, M.C., 2010. Wireless sensor networks (Vol. 4). John Wiley & Sons.34(6), pp.1908-1927.

[3]. Akyildiz, I.F.; Pompili, D.; Melodia, T. Underwater acoustic sensor networks: Research challenges. Ad. Hoc. Netw. 2005, 3, 257–279.

[4]. Benson, B. Design of a Low-cost Underwater Acoustic Modem for Short-Range Sensor Networking Appications. Ph.D. Thesis, University of California, San Diego, CA, USA, 2010.

[5]. Heidemann, J.; Stojanovic, M.; Zorzi, M. Underwater sensor networks: Applications, advances and challenges. Philos. Trans. R. Soc. A 2012, 370, 158–175.

[6]. Stojanovic, M.; Preisig, J. Underwater acoustic communication channels: Propagation models and statistical characterization. IEEE Commun. Mag. 2009, 47, 84–89.

[7]. Garcia, M.; Sendra, S.; Atenas, M.; Lloret, J. Underwater Wireless Ad-Hoc Networks: A Survey. In Mobile Ad Hoc Networks: Current Status and Future Trends; CRC Press: Boca Raton, FL, USA, 2011; Chapter 14, pp. 379–411.

[8]. Martinez, J.J.; Myers, J.R.; Carlson, T.J.; Deng, Z.D.; Rohrer, J.S.; Caviggia, K.A.; Woodley, C.M.; Weiland, M.A. Design and Implementation of an Underwater Sound Recording Device. Sensors 2011, 11, 8519–8535.

[9]. Lloret, J.; Sendra, S.; Garcia, M.; Lloret, G. Group-based Underwater Wireless Sensor Network for Marine Fish Farms. In Proceedings of IEEE Global Communications Conference (IEEE Globecom 2011), Houston, TX, USA, 5–9 December 2011.