A Survey on Applications and Challenges of Underwater Wireless Sensor Node

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Abstract: *— Wireless Sensor Node (WSN) is used to receive & transmit data and is often placed in remote areas. WSN can be used for terrestrial (TWSN) and underwater communication (UWSN). Underwater wireless sensor network has emerged as one of the important research areas for the conservation and exploitation of the ocean. Underwater sensor nodes are used in various applications like oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications. Moreover, unmanned or autonomous underwater vehicles (UUVs, AUVs) equipped with sensors will enable the exploration of natural undersea resources and gathering of scientific data in collaborative monitoring missions. But there are many technical and research challenges in UWSN that need to be attended. In this paper we present the literature survey on different applications and challenges of UWSN.*

Keywords - *WSN [wireless sensor node], TWSN [terrestrial wireless sensor node], UWSN [underwater sensor node].*

I. INTRODUCTION

Wireless sensor network is a booming area for research and development. A sensor node in a network is capable of performing different operations like processing, gathering sensory information and communicating with other connected nodes in the network. The typical architecture of wireless sensor node is shown in the fig 1.Wireless sensor nodes are used for terrestrial and underwater applications. Terrestrial sensor nodes are used to monitor, detect and track various environmental phenomenon and events. The development of the miniature sized WSN with low power consumption facilitated TWSN to broaden their research to underwater techniques. Underwater wireless sensor network consist of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring tasks over a given area. UWSN are used in many applications

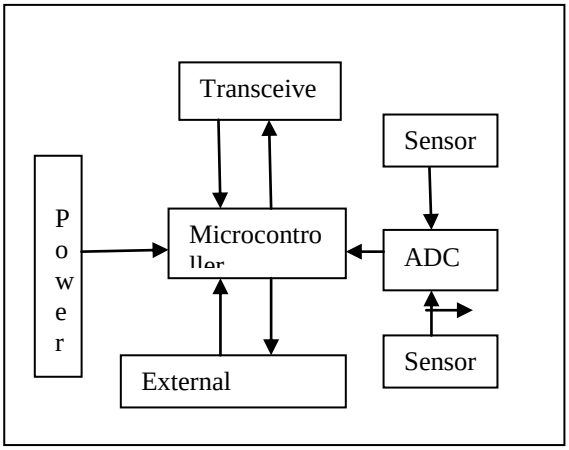

Fig 1.Typical architecture of wireless sensor node

TWSN and UWSN have extreme ecological differences in which these two networks operate. TWSN uses RF communication and is operated at the transmission rate of Gigabits/sec. The transmission delay through air and environmental noise is less in RF communication. But RF communication cannot be used in underwater because it has very limited RF wave transmission i.e. 5kb/s and 20kb/s. Hence we prefer to use audio communication in underwater. Since it is reliable, robust and transmission rate of sound in water is 1481 m/s whereas in air it is 343.2m/s. Therefore acoustic communication provides best solution for underwater applications.Though underwater communication provides enormous information about environmental conditions but it faces many technical issues and research challenges like large propagation delay, low bandwidth and dynamic nature of the work. Apart from all these issues energy is the main concern as the batteries used to power up the sensor nodes are difficult to recharge and replace in aquatic environment .So designing energy efficient UWSN is challenging.

This paper gives the detailed survey on various applications and research challenges of UWSN. The flow of this paper is as mentioned below

I. Literature Survey:

"Underwater Acoustic Sensor Networks: Research Challenges". This paper investigated several features of underwater acoustic communication. In this paper the author explained various architectures and characteristics of UWSNs along with the main challenges for the development of efficient networking solutions. But this paper lags to discuss about the energy efficient solution to the network. [1]

"Challenges: Building Scalable Mobile Underwater Wireless Sensor Networks for Aquatic Applications" The author of this paper explained about the Challenges in Building Scalable Mobile Underwater network. This paper also suggested an important scheme known as Mobi-Sync. This Mobi-Sync takes into consideration the spatial correlation parameters among the mobility pattern of neighboring UWSN to estimate the long propagation delay accurately [2].

"Underwater Sensor Networks: Applications, Advances and Challenges" summarized the applications, advances and challenges of UWSN. The authors discussed different communication protocols for underwater communication. This paper also briefs different methodologies related to acoustic propagation design and operation of communication networking protocols at various layers. [3]

"Enhancing the Reliability of Head Nodes in Underwater Sensor Networks". This paper proposed methodology to enhance the reliability of master nodes in UWSN. This paper discussed methodologies and algorithms for the secure cooperation of team of autonomous mobile UWSN connected with acoustic communication network. The design of a security suite for reducing the communication overhead introduced by security in terms of number and size of messages is also discussed. [4]

"Research Challenges and Applications for Underwater Sensor Networks" This paper explored applications and challenges of UWSN. The author highlighted potential applications to off-shore oilfields for seismic monitoring, equipment monitoring and underwater robotics. He identified research areas in short range acoustic communication MAC, time synchronization and localization protocols for high latency acoustic networks. [5]

"The Study Paper on: Problems in Underwater Wireless Sensor Networks "This paper presented study paper on applications and problems of UWSN. They also explained UWSN is used in many applications both for civil and military purpose along with technical and practical challenges that need to be overcome .[6]

"Design and Implementation of Omni directional Underwater Acoustic micro-modem based on low power Microcontroller" This paper designed and implemented Omni-directional underwater acoustic microchip modem to satisfy the requirements of compact and low power consumed UWSN. For fast digital domain signal processing and support flexible interfaces with other peripherals an ARM cortex-M3 is embedded in the micro-modem. [7]

"Self Powered Wireless Ocean Monitoring Systems"In this paper author has designed and implemented self powered ocean monitoring system which generate renewable solar energy from a device at sea surface and share the energy with underwater nodes. They developed acoustic modem for wireless communication and presented experiments in a pond to verify the performance of the modem. Efficient energy management, movement of underwater nodes and energy transfer is left as future work. [8]

"Multi-Source Energy Harvesting System for Underwater Wireless Sensor Networks" This paper provides reliable and efficient power supply for UWSN.The author proposed multisource energy harvester system which manages energies from microbial fuel cell. Analytical expressions are obtained for proposed system and validated using extensive simulations but here the electrodes may get rust due to continuous movement of nodes underwater [9].

"Energy Efficiency and Reliability in MAC "This paper presents a survey on energy efficient reliable MAC and routing protocols in UWSNs. Since underwater nodes are battery operated, low capacity and experiences high propagation delay which results in loss of large volume of packets in underwater communication. The authors also discussed different types of energy-efficient and reliable routing protocols [10].

The above research papers discussed about various challenges and applications of underwater wireless sensor nodes and some energy efficient techniques.

III. APPLICATIONS OF UWSN

The typical architecture of underwater sensor network is shown in the above fig2.The broad range

of applications for underwater acoustic sensor networks are.

Ocean Sampling Network: New robotic vehicles with advanced ocean models like AUV 's and network of sensors observe and predict the characteristics of the oceanic environment

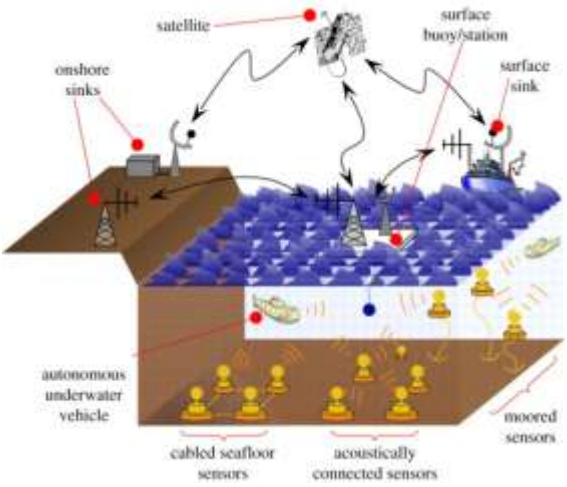

Fig2.Courtesy [3]: Architecture of underwater sensor network

Environmental Monitoring:

With the rapid development of society and the economy, an increase number of human activities have gradually destroyed the marine environment. So marine monitoring is a vital problem. Wireless sensor node has recently been considered as an alternative for monitoring marine environment. They have number of advantages such as unmanned operation, easy deployment, real time monitoring and relatively lower cost.

Undersea Explorations: There are large numbers of minerals present underwater which is required to be explored such as oil and gas. Underwater cables are deployed which brings some of the basic social necessitates such as oil, gas pipelines and fibre optic cable

Disaster Prevention: Underwater earthquakes, Volcanoes and Tsunami are the natural disasters and cause danger to the living things. These natural calamities can occur anytime and anywhere on the surface. So UWSN offers wide range of applications for management and recovery of such disasters.

Assisted Navigation: Underwater environment is extremely uneven, unexplored, random and dark with increasing depth. In such environment there is need of assistance for navigating the boats, ships and explorers. In order to locate, guide and navigate there is a need of assistive technologies, system and application which could be used in underwater.UWSN can be used to provide assistive navigation system

Distributed Tactical Surveillance: Nowadays ocean monitoring system gather the information from ocean surface, coastal lines. UWSN can be deployed to perform collaborative monitoring tasks in ocean environment.

Mine reconnaissance. The multiple Autonomous Underwater vehicles with acoustic and optical sensors can be used to assess rapidly environmental variations and detect mine-like objects.

IV. Major Challenges in Underwater Sensor Network

There are many technical and research challenges for the efficient working of underwater sensor node. Few of the major challenges are listed below

- The available bandwidth is strictly limited.
- Due to multipath fading the underwater channel is severely damaged.
- Compared to terrestrial sensor network propagation delay in underwater sensor network is of higher magnitude.
- High bit error rates and temporary losses of connectivity.
- Battery power is limited and usually batteries cannot be recharged.
- Solar energy cannot be exploited in underwater.
- Underwater sensors are prone to fail because of fouling and corrosion.

The major limitation of using wireless sensors nodes for underwater communication is its battery backup. The battery backup of the underwater nodes will be limited and once the charge drains off the battery will be a scrap. This drawback was overcome in one of the research paper by using induction method but the hardware required for designing the system was more. A multisource energy system for UWSN is proposed in a recent paper but the sources were prone for corrosion. Few energy efficiency MAC and routing protocols were developed.

V. CONCLUSION:

UWSN is widely growing field due to its varied range of applications in management, control and surveillance in selected portions of deep oceans. We have discussed various methods proposed by researchers for different applications. We also discussed various applications and challenges of UWSN. To make UWSN robust and reliable it is necessary to design a power system that provides a continuous power to UWSN increasing the life time and minimizing the maintains cost.

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