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A SURVEY ON UNDERWATER WIRELESS COMMUNICATION

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ABSTRACT: - It has been seen in the last 30 years that due to many applications in marine research, oceanography, marine commercial operations, the offshore oil industry and defense, acoustic communication is growing its interest. In this paper, we aim to provide study of underwater acoustic communication network and channel, underwater sensor network (2 and 3 dimensional sensor network). In our earth 75% of the area covers the water in the form of river and ocean. The underwater sensor network are enable to growing technology and become more and more popular for monitoring in vast area of oceans. A variable number of sensors are involved in underwater sensor Networks that are deployed to perform monitoring tasks over a given area of ocean.

KEYWORDS: - *UWSN, Underwater Acoustic Network, UW-ASN, 2D and 3D UWN*

I. INTRODUCTION

Acoustic communications is a technique of sending and receiving message below water. There are several ways of employing such communication in which the most common is using hydrophones. Acoustic signals are only physical feasible tool which works in underwater environment. On the other hand EM wave can only travel in water with short distance due to absorption effect and high attenuation in underwater environment. It is given that the absorption of electromagnetic energy in sea water is about $45\times f$ dB per kilometer, where f is frequency in Hertz [1]. Underwater Acoustic Network consisting of Underwater Acoustic Sensor Networks and Autonomous Underwater Vehicle Networks, are defined as networks that composed of two or more than two nodes, and communicate by acoustic signals for the purpose of underwater applications.

In recent past the disasters took place made humans needs to monitor the oceanic environments for scientific, environmental, military etc. The industries are showing interest to perform these monitoring tasks by using sensor nodes under water. For these applications the Wireless Underwater Acoustic Networking is the vast technology. Under Water Acoustic Sensor Networks (UW-ASN) consists of a variable number of sensors and vehicles that are being deployed to perform collaborative monitoring tasks over a given area in the ocean. To achieve this task, sensors and vehicles self-organize in an autonomous network that can use the characteristics of the ocean environment. The above described features enable a broad range of applications for underwater acoustic sensor networks, which includes-

(a) Ocean Sampling Networks: Networks of sensors and AUVs, such as the Odyssey-class AUVs, can perform synoptic, cooperative adaptive sampling of the 3D coastal ocean environment.

(b) Pollution Monitoring: and other environmental monitoring (chemical, biological, etc.).

(c) Distributed Tactical Surveillance: AUVs and fixed underwater sensors can collaboratively monitor areas for surveillance, reconnaissance, targeting and intrusion detection systems.

II. ACOUSTIC COMMUNICATIONS & IT'S BASICS

The underwater acoustic communications are influenced by many loses such as path loss, Doppler spread, multi path, noise and high and variable propagation delay. All above factors determine the spatial and temporal variability of the acoustic channel, and make the available bandwidth of the underwater acoustic (UW-A) channel limited and dramatically dependent on both frequency and range. The long range systems operating over several ten kms may have more than a 100 kHz , while a system having short-range and operating over several tens of meters may have more than a hundred kHz bandwidth. These both factors lead to low bit rates. With the comparison of terrestrial radio channel the communication range is reduced. Underwater acoustic communication link is classified according to their range as very long, medium and short, and very short links [2]. Acoustic links are also roughly classified as horizontal and vertical according to the direction of the sound ray. As shown after, the characteristics of propagation also differ consistently, especially with respect to time dispersion, delay variance and multi-path spreads.

III. SYSTEM ARCHITECTURE

Figure 1 shows a diagram of our current network design. We anticipate a tiered deployment, where some nodes have greater resources.

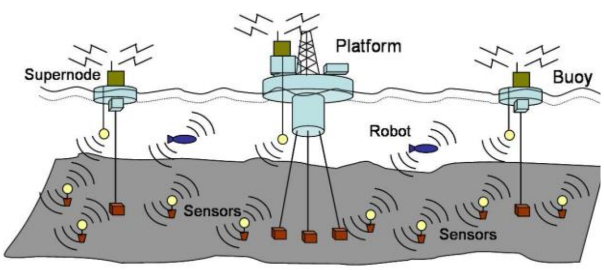

Fig1. One possible approach to network deployment

In Figure 1, there are four different type of nodes in the system. on the sea floor there are large no. of sensors that are deployed at the lowest level (shown as small yellow circles). They data is collected through attached sensors (*e.g.*, seismic) and communicate with other different nodes through short-range acoustic modems. They are operated on batteries and in order to increase the time spam, they spend most of their life asleep. There are several deployment is possible for communication; here showing that they are anchored to the sea floor (for protection they could be buried) for good sensor and communications coverage nodes are positioned roughly where expected and allow optimization of placement. There is possibility of node movement due to anchor drift or disturbance from external effects. By using distributed localization algorithms we expect nodes to be able to determine their locations.

Top layer consists of one or more control nodes which have connections to the Internet. The node shown on the platform in Figure 1 is this kind of node. The control nodes may be on shore or off shore with power, these nodes having large storage capacity to buffer data and to ample electrical power. Control nodes will communicate directly with the sensor nodes connected with wires.

In the large network, we use a kind of nodes called super nodes. It has access to high speed networks, and it can be used to relay data very efficiently. Two implementations are employed first involves attachment of tethered buoys with regular nodes; buoys are equipped with high speed radio communications to the base station as shown in the figure.

Fiber optic cables are used to connect the nodes to base station can be an alternative implementation. Super nodes are used to allow much richer network connectivity. It creates multiple data collection points for the underwater acoustic network. Although robotic submersibles are not the focus on this current work, we see here the interaction of our system via acoustic communications. In the above figure, dark blue fishes uses as multiple robot.

IV. TWO-DIMENSIONAL UNDERWATER SENSOR NETWORKS

The possible architecture for 2D underwater networks is shown below in Fig. 2. There are a set of sensor nodes that are attached to the bottom of the ocean with deep ocean anchors. The wireless acoustic links interconnects the UW sensor nodes to one or more underwater sinks, that are network devices in charge of relaying data from the ocean bottom network to a surface station. The UW-sinks are equipped with two acoustic transceivers, namely a vertical and a horizontal transreceiver to achieve the above objective. The UW-sink uses the horizontal transceiver to communicate with the sensor nodes as follows:

i) Sending commands and configures data to the sensors (UW-sink to sensors)
ii) Collects monitored data from sensors to UW-sink.

The UW-sink also uses the vertical trans receiver to relay data to a surface station. Since the ocean can be as deep as 10 km, the vertical transceivers are used for deep water applications in long range. The surface station is equipped with an acoustic transceiver that handles multiple parallel communications with the help of deployed UW-sinks. It is also furnished with a long range RF or satellite transmitter that communicates with the onshore sink (os-sink) or to a surface sink(s-sink). The sensors are connected to UW-sinks via direct links or through multi-hop paths [3]. In the former case, the gathered data is directly sent by each sensor to the selected UW-sink.

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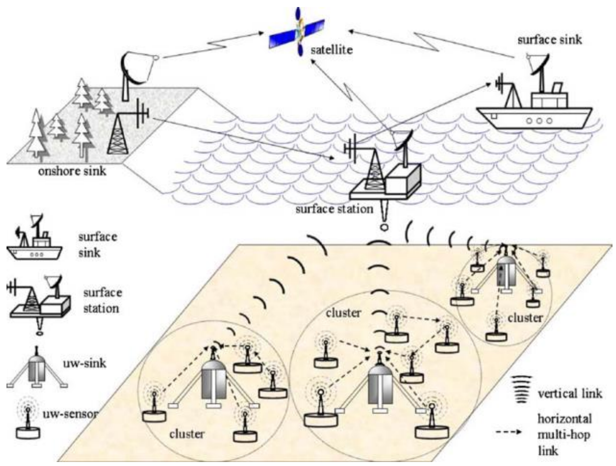

Fig 2. Architecture of 2D Underwater Sensor Network

Although it is the simplest way to network sensors, it is not much energy efficient, since the sink may be far from the node and the power necessary to transmit may decay with powers greater than two of the distance. In case of multi-hop paths, the data produced in terrestrial sensor networks by a source sensor is relayed by intermediate sensors until it reaches the UW-sink. This increases network capacity and energy savings, but increase the complexity of the routing functionality as well. In fact, every network devices takes part in a collaborative process whose objective is to diffuse topology information such as efficient and loop free routing decisions can be made at each intermediate node usually. This process involves computation and signaling. Capacity and energy are precious resources in underwater environments. In UWASNs the objective is to minimize the signaling overhead necessary to construct underwater paths and deliver event features by exploiting multi-hop paths at the same time.

V. THREE-DIMENSIONAL UNDERWATER SENSOR NETWORKS

3D underwater networks detect and observe phenomena that can't be adequately observed by means of ocean bottom sensor nodes, i.e., to perform cooperative sampling of the 3D ocean environment. In 3D underwater networks, the phenomenon is observed using sensor nodes make float at different depths. The solution is to attach each UW-sensor node to a surface buoy, whose length can be regulated for adjusting the depth of each sensor node. However, in military the multiple floating buoys may obstruct ships navigation on the surface or can be destroyed or detected by the enemies. This solution develops the quick and easy arrangement of the sensor network. These are the reasons to implement a different approach. In this, the sensor devices are anchored to the bottom of the ocean. In this architecture, depicted in Fig. 3, each sensor nodes are anchored and equipped with the buoys, which can be inflated by the pump. The buoy pushes the sensor towards the ocean surface. The depth of the sensor can then be regulated by adjusting the length of the wire that connects the sensor and the anchor, with the help of an electronically controlled engine that reside on the sensor. With this architecture many challenges arise, that need to be solved for enabling 3D architecture, which includes:

Sensing coverage: - According to their sensing ranges, the sensors should collaboratively regulate their depth to achieve full column coverage,. Thus, it must be possible to obtain sampling of the desired phenomenon at all depths.

Communication coverage:- Since there is no motion of UW-sink in three dimension underwater networks, sensors relay the information to the surface station through multihop paths. Hence, network devices should coordinate their depths in such a way that the network topology is always connected, i.e., there is always atleast one path between sensor and the surface station.

VI. APPLICATIONS

Way to Find the Information: - The underwater sensor is the fastest and latest way to finding information in the underwater sensor network. It is not only useful for human being Fastest but also responsible for researchers [9].

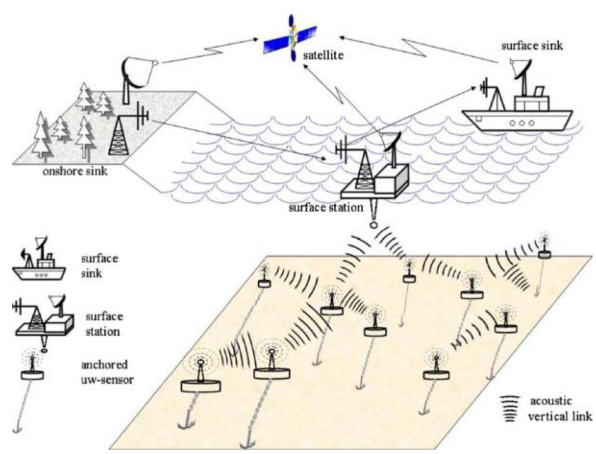

Fig 3. Architecture Of 3D Underwater Sensor Network

- **Disaster Prevention:-** Disaster prevention is also very important characteristics of underwater sensor network. It is able to perform seismic activity which provides tsunami warnings in coastal areas [9].

- **Ocean Sampling Networks: -** Autonomous underwater vehicles able to corporative adaptive sampling of the 3D coastal ocean environment. In 3D environment we can arrange the sensor in different depth in ocean, so we can sense the different depth in ocean [10].

- **Environmental Monitoring: -** It is one of the most important applications of UWSN. It includes pollution monitoring, monitoring of ocean current, improve weather forecast are other possible applications [10].

VII. ADVANTAGES

- Can be used to provide early warnings of tsunamis generated by undersea earthquakes.
- It avoids data spoofing or data lost.
- It avoids privacy leakage.
- Pollution monitoring.

VIII. DISADVANTAGES

- Costly devices.
- Hardware protection requirement.
- Needed high power for communication
- Limited battery power.
- Bandwidth size limitation.

IX. CONCLUSION

In this paper, we have studied about the architecture of underwater acoustic sensor network (2D and 3D architecture), monitoring and applications of sensor networks. It also made attempt to the efficient approach of the acoustic channel networking. In this, there is also advanced deployment of the acoustic communication. Here the present limitations are overcome and advanced technology for oceanographic research are implemented and cope up with the environmental effects on the noise performance of the acoustic systems to complete with the future challenges like effective transmission of the audio and video signals etc.

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