A Survey on Underwater Sensor Network Architecture and Protocols

Rakesh V S
4th SEM M.Tech, Department of Computer Science
MVJ College of Engineering
Bangalore, India
raki.rakesh102@gmail.com

Srimathi C
Assistant Professor, Department of Computer Science
MVJ College of Engineering
Bangalore, India
srichennaa@gmail.com

Abstract: **Underwater sensor networks (UWSNs) are becoming popular everyday due to their ability which makes them to be deployed under adverse environmental conditions. UWNs are the enabling technology for wide range of applications like pollution monitoring, nutrient production, oil retrieval and transportation. The use of acoustic communication underwater environment posses many interesting challenges. Because of high transmission power, energy consumption is more, making medium access protocol a primary focus point for reducing energy consumption. However sensed data can be interpreted meaningfully when referenced to the location of the sensor, making localization an important problem. In this paper, we give a survey on the architectural view and protocols used for underwater sensor networks.**

Keywords- Underwater sensors, underwater networks, MAC protocol, routing protocol

I. INTRODUCTION

Earth is largely covered by water. This is largely unexplored area and recently humans are showing interest towards exploring it. Many disasters that took place in recent past made humans to greatly monitor the oceanic environments for scientific, environmental, military needs etc., in order to perform these monitoring task industries are showing interest towards deploying sensor nodes under water. Also advancements in technology helped to use many novel networking schemes. Sensor network greatly influence different areas of technologies like science, industries and government. This is because of availability of low powered processing, storage units and micro electrical and mechanical systems used in the construction of onboard sensing units.

Wireless underwater networking is the enabling technology for underwater applications. The sensor networks deployed underwater consists of numerous numbers of sensor nodes and underwater vehicles, which helps in monitoring over a given area. But to achieve these objectives sensors and vehicles should have self organizing ability in an autonomous network that can adapt to differing characteristic of underwater environment.

II. UNDERWATER SENSORS

Underwater sensors consists of sensors to measure the quality of water and helps in studying its characteristics such as temperature, density, acidity etc., the internal architecture is shown in Fig. 1.

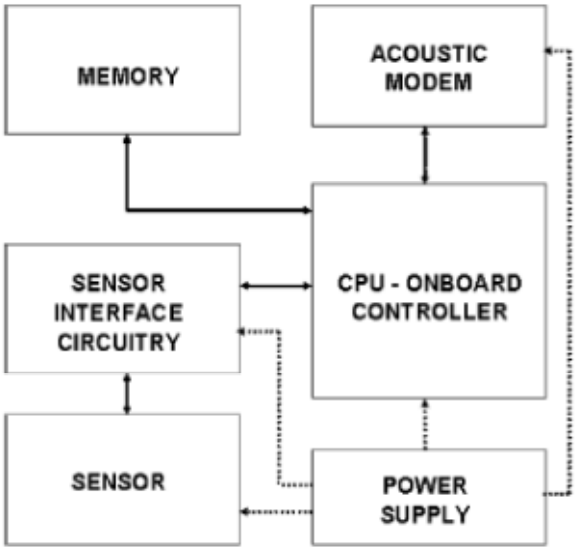

Fig 1. Internal architecture of underwater sensor node

It consists of an onboard controller interfaced with sensors through a sensor interface circuitry. This controller receives the data sensed by the sensor and stores it in memory, processes it and sends to other network using the acoustic modem. These are usually mounted on a frame which is protected by PVC housing

III. COMPARISON OF UWSNs WITH TERRESTRIAL NETWORK

Underwater sensor networks mainly differ in the communication media employed for information transmission. But there are many other differences as summarized in table 1.1.

Table 1.1. Comparison of UWSNs with terrestrial network

Parameter	Terrestrial Network	UWSNs
Communication method	Makes use of Electromagnetic waves	Acoustic channels are deployed
Deployment	Densely deployed	Sparsely deployed
Power	Power required is less	Power required is more and complex
Node mobility	Predictable	Prediction is difficult
Memory	Limited storage capacity	Requires more memory as caching of data is required
Spatial correlation	Readings taken are correlated	Readings are not correlated
Cost	Less expensive	More expensive

IV. UNDERWATER NETWORK ENVIRONMENT

The network consists of underwater local area networks called as clusters or cells. Each cluster consists of sensors and sinks, with sensors connected to sinks within each cluster. These connections are direct paths or multiple hops. The sample network environment is as shown in Fig 2. The information shared at each sink within cluster is sent to surface stations using the vertical link. These surface stations are equipped with acoustic transceivers which handles multiple parallel communications with the deployed underwater sinks.

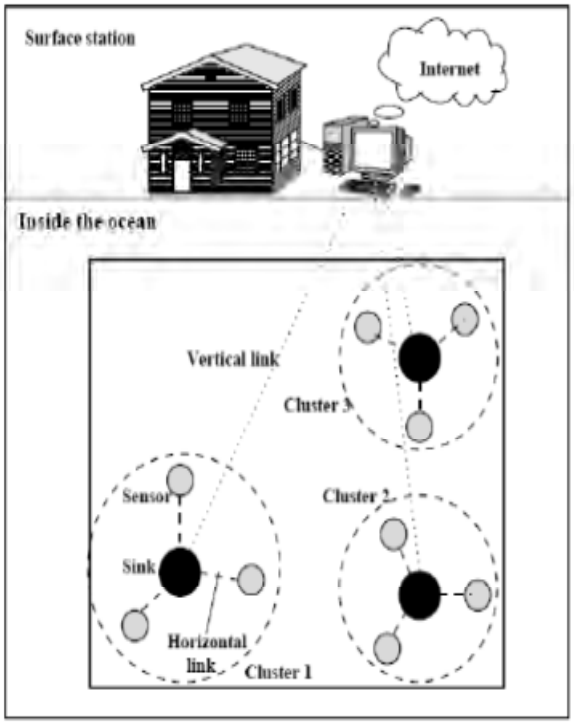

Fig 2. Underwater network environment

V. NETWORK COMPONENTS OF UNDER WATER SENSORS

Sensor network consists of group of sensor nodes that are anchored to the bottom of ocean with deep ocean anchors which are in turn connected to one or more underwater gateways by means of acoustic link. To observe different phenomenon taking place underwater the sensor nodes are made to float at different depths.

The underwater gateways are equipped with two acoustic transceivers, vertical transceiver and a horizontal transceiver. Horizontal transceiver is used to communicate with the sensor nodes to send commands and configuration data to the sensors and to collect the monitored data. Vertical transceiver is used for communication from underwater gateway to surface station.

The communication between the sensors and from sensor to underwater gateway can be accomplished by direct link or multi-hop paths. Direct link communication can be accomplished easily but it is not energy efficient. On the other hand in multi-hop paths, communication is through multiple sensors there by resulting in power saving and in turn increases network efficiency.

VI. UNDERWATER COMMUNICATION ARCHITECTURE

Network topology usually is a crucial factor that determines the energy consumption, capacity and reliability of a network. Therefore network topology must be carefully designed and after deployment it must be optimized suitably and often whenever possible. Some of the architectures supporting underwater sensor networks are static two dimensional underwater acoustic sensor networks, static three dimensional underwater acoustic sensor networks and three dimensional networks of autonomous underwater vehicles as described in [1].

- Static two dimensional UW-ASNs: these are constituted by sensor nodes that are anchored to the bottom of the ocean. Applications of this include environmental monitoring.
- Static three dimensional UW-ASNs: these include networks of sensors and may be used for surveillance applications or monitoring of ocean phenomenons like water streams, pollution.
- Three dimensional networks of AUVs: these networks include fixed portions composed of anchored sensors and mobile portions constituted by autonomous vehicles.

VII. UNDERWATER SENSOR NETWORK PROTOCOLS

A. *MAC Protocols*

Underwater sensor networks largely deployed due to the lower sensing range, necessitating achieving an efficient medium access protocol subject to power constraint. The two MAC protocols that we deal with in this paper are:

- Sensor MAC
- Wise MAC

Sensor MAC: The basic idea behind S-MAC protocol is synchronization among the nodes and various periodic sleep-listen schedules based on this synchronization. In order to set up a common sleep schedule, neighboring nodes form a virtual cluster. If two neighboring nodes reside in two different virtual clusters, they wake-up at listen periods of both clusters. Another important feature of S-MAC is the concept of message passing in which long messages are divided into frames and sent in a burst [4].

Advantages

- Energy waste is reduced.
- Implementation is simple.
- Time synchronization overhead is prevented.

Disadvantages

- Increases collision probability.
- Decreases efficiency.
- Idle listening.

Wise MAC: Wise MAC protocol makes use of non-persistent CSMA with preamble sampling, to decrease idle listening. In preamble sampling technique, a preamble precedes each data packet for altering the receiving node. Here if a node finds the medium busy after it wakes-up and samples the medium, it continues to listen until it receives a data packet or the medium becomes idle again [4].

Advantages

- Performance is better under variable traffic conditions.
- Power consumption can be reduced.

Disadvantages

- Latency is high.

B. *Routing Protocols*

Entire network performance is based on the routing protocol design. The two routing protocols that we deal with in this paper are:

- Hierarchical state routing protocol.
- Gradient Based Routing.

Hierarchical state routing protocol (HSR): HSR is based on multilevel clustering. Each level has its leader. In this each node maintains data about its peer topology. HSR table consists of every nodes hierarchical address and also indicates its location. This reduces the routing table size. But the process exchanging some information will lead to the complexity.

Gradient Based Routing: Gradient is defined as difference between the heights of two neighbor nodes. With this routing, each node knows the minimum number of nodes to the sink which is called as height of node [5].

VIII. PROTOCOL STACK FOR UNDERWATER SENSOR NETWORKS

A protocol stack for under water sensor should combine power awareness and management and promote co-operation among the sensor nodes. Fig 3 depicts the protocol stack for underwater sensor networks.

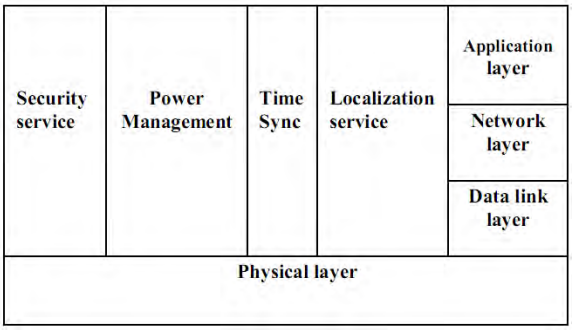

Fig 3. Protocol stack

The stack consists of physical layer, data link layer, network layer and application layer functionalities. The protocol stack should also include a power management plane, a coordination plane and a localization plane.

The power management plane is responsible for network functionalities aimed at minimizing the energy consumption. The coordination plane is responsible for all functionalities that require coordination among sensors. The localization plane is responsible for providing absolute or relative localization information to the sensor node when needed by the protocol stack or by the application

IX. CONCLUSION

Underwater networks of sensors have the potential to enable unexplored applications. These potential applications will be made viable by enabling communications among underwater devices. Underwater Acoustic Sensor Networks will consist of sensors and vehicles deployed underwater and networked via acoustic links to perform collaborative monitoring tasks. In this paper, we have presented the basic conceptual architecture of underwater acoustic sensor network. Also we presented protocols used for underwater sensor networks.

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