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Underwater Wireless Communication

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Abstract:

Wireless communication is gaining lots of importance and especially underwater wireless communication is flourishing every day. In this paper, the necessity of underwater wireless communication and the features of acoustic waves, the working of various sensor networks and its architecture; and hardware components involved are studied. Collection of oceanographic data, AUV's (Autonomous Underwater Vehicle) [10], underwater radio and its application obstacles involved during propagation of signals in underwater wireless communication are analysed and compared for further studies.

Keywords — **Wireless Communication, Underwater Communication.**

I. INTRODUCTION

According to the basic principles of physics and engineering different wave forms have their own characteristics. Each wave forms are studied, interpreted, compared with that of the underwater wireless communication. Here, underwater sensor networks are recommended to enhance and improve communication network efficiently which will enable to have effective wireless communication in underwater. In future, to overcome the limitations of signal propagation a real-time monitoring of audio and video signals are overviewed for further recommendations.

Electromagnetic waves [1] are synchronized oscillations of electric and magnetic fields that are perpendicular to each other and they propagate in vacuum and air at the speed of light, and act as a carrier signal in transmitting signal along a communication path. It is mostly carried out on terrestrial regions. But, in underwater channel, information is not carried by electromagnetic waves. Hence, acoustic waves (sound waves) is the mostly preferred to transmit signals underwater. In earlier days cables were used to establish high speed communication. Hence to overcome the burden and cost of heavy cables, wireless communication is introduced. Acoustic waves [2] are the type of sound waves which are of the form of longitudinal waves which propagate by adiabatic compression and decompression.

Our planet Earth has two thirds of water. There is a need for underwater wireless communication for various applications, like pollution control, offshore oil, collection of scientific data from layers of the earth, for national security and defence.

Underwater wireless network is affected by Marine environment because of noise, limited bandwidth and power resources. So, sensor technology and wireless communication will enable environmental monitoring to gather oceanographic data, archaeology, Search and Rescue Mission.

II. MAIN FEATURES OF ACOUSTIC PROPAGATION

In Underwater acoustic communications are affected by multipath propagation namely; path loss,

noise, Doppler spread, and high variable propagation delay. When the operation is over several kilometres, long range systems are used and they have a bandwidth of few kHz, while short range system operating over several meters may have more than a hundred kHz of bandwidth [3].

Sl No	Bandwidth for Different Ranges		
	Systems	**Range (km)**	**Bandwidth(kHz)**
1	Very long	1000	<1
2	Long	10—100	2—5
3	Medium	1—10	=10
4	Short	0.1—1	20—50
5	Very short	<0.1	>10

Tab 1: Available bandwidth for different ranges in UW Acoustic channels [4]

In under water acoustic networks, sensor nodes are connected to underwater vehicles and surface station and it is linked to on-shore station. It is a collaborative monitoring task.

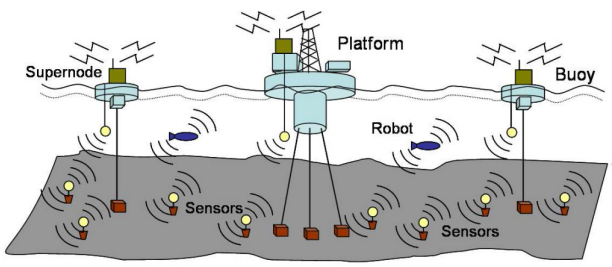

Fig. 1 Surface location with sensor nodes placed underwater

The acoustic channels impose many constraints which affect the design of underwater communication system. These systems depend on many features like path loss which accounts to transmission distance and signal frequency. The frequency of signal determines the absorption loss and it keeps increasing with distance and the availability of bandwidth. Telephone modems allow computers to transmit and receive information over telephone lines to overcome these digital data is used their modems convert digital data into underwater sound signals. These signals are transmitted between two submerged submarines or with surface ship. We can send texts and pictures as we send and receive email. It is accurate and quite effective; and only drawback is it is slower compare to cable connection on land. Acoustic communication technology is also used to locate or search objects. A Robot crawler is used, which has a camera, a digital signal processing unit and a Modem. The Robot sends an acoustic signal to ship or on-shore base station. The photos can be compress and transfer image to an acoustic signal to the receiver. By this technology thousands of dollars can be saved that are blindly used in archaeological expeditions.

III. SOUND PROPAGATION CHARASTERISTICS IN UNDERWATER

In sea, sound is propagated in multiple paths and it depends on speed of sound and the location of the source and receiver. These multipath propagations are affected by Time variation, Signal availability, Strength of the signals, bandwidth and attenuation. Prorogation transmission suffers loss because of surface reflection, surface duct and bottom bounce.

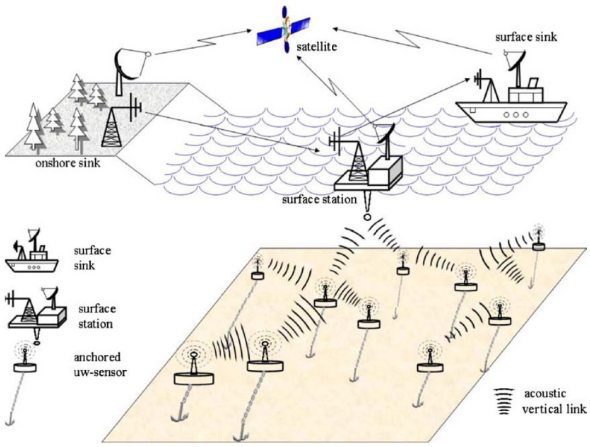

Fig. 1 UW wireless communication Horizontal and Vertical direction

A group of sensor nodes are enclosed to the bottom of the ocean with deep ocean anchors. Underwater sensor nodes are interconnected to one or more underwater sinks by means of wireless acoustic links. Underwater sink to communicate with sensor

nodes, send commands and configure data to the sensors. From Sensor to communicate with underwater sink. Vertical transceivers deep 10 km. surface station is equipped with acoustic transceiver. A long ranged RF/satellite transmitter to communicate with the onshore to surface sink. In underwater signals are propagated with the help of piezoelectric transducer which generate electricity, when subjected to pressure change. Underwater wireless communication are not quick and it will not wait for responses, because acoustics signals are slower than radio waves; as it takes 2 sec to travel back and forth across a 1.5km distance.

Because of various factors like refraction, absorption and scattering of signals through water attenuation takes place. As the distance of the signal propagation increases, the bandwidth keeps decreasing. Graph shows the relation between bandwidth and distance of the signal waves.

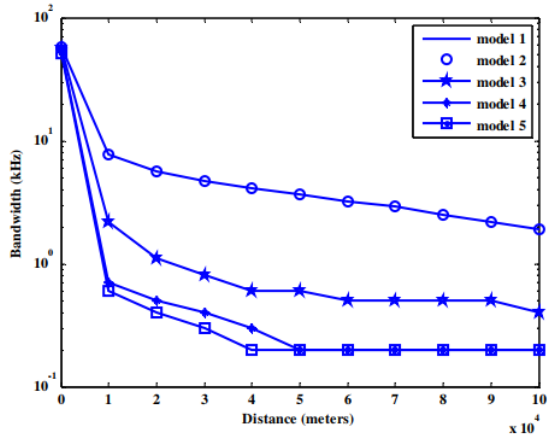

Fig. 3. Bandwidth vs distance (3dB bandwidth definition)

Attenuation is the gradual loss in intensity as signal moves through a medium. Attenuation occurs greater in liquid than air, and very high reflection of signals underwater.

Different types of nodes are placed, sensor nodes are placed at the sea floor. They collect data through sensors and communicate with other nodes. The locations of placing the nodes are decided,

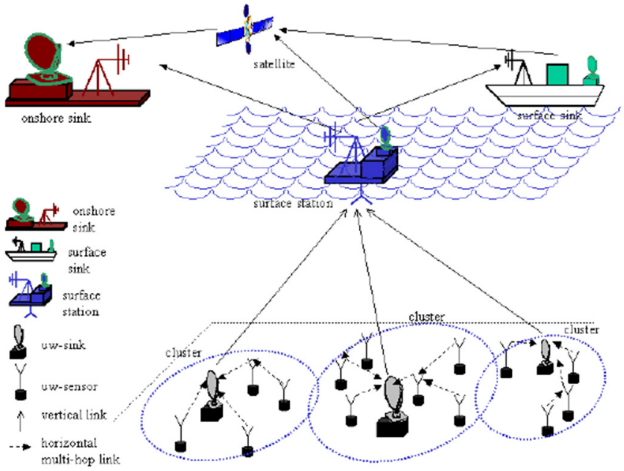

Fig.3 2D Architecture of UW wireless network

according to the coverage of the signals through short range acoustics modems. They are functional through batteries. When the surface of the water is connected to Internet, the top layer is connected with many control nodes. Control nodes are usually placed on an off shore platform. They have a large storage capacity. There are special types of Control nodes which are directly connected to the sensors nodes using acoustic modems through cables. When the network is very large, another type of nodes, called Super nodes is employed. In this type of network, super nodes can access very high speed networks system and can transmit data to the basic station in an effective manner.

An alternative medium to communicate with help of signals can be with the help of optical fibre cables. Optical fibre cables are used to transmit and receive signals at the speed of light, which is $3x10^5$ km/sec, and it is the same speed of Electromagnetic waves or carrier waves on terrestrial surface and in space. Here signals are communicated using light as medium to send or receive data. So these type of OFC [5] cables may be used on the water surface and between land and on the water surface stations with the help of nodes. OFC follows the basic principle of physics on the theory of total internal

reflection and critical angle. Here the speed of signals is very much faster as compared to the speed of sound as it is only $1.5x10^3$ m/s. Hence, the need for the use of super nodes for better connectivity of signals is highly essential. Super nodes have very high connectivity and can collect multiple data in an efficient manner. According to, [6] this theory, it states that no system can exceed 40km x kb/s the maximum propagated range x rate product.

V. MAJOR CHALLENGES WHILE DESIGNING ACOUSTIC NETWORK COMMUNICATION SYSTEM

There is a severe degradation acoustic signals, as it generates inter symbol interference(ISI), It is a form of distortion of signal and the symbol refers to the interference with subsequent symbols, here it is the effect of noise and causes unreliable in communication [7]. Since it has multipath in propagation and fading causes loss in connectivity. The bandwidth is very much limited [8]. There is delay in propagation of signals of higher magnitude when compared with the terrestrial channels where it uses radio frequency which is a very high speed of propagation of signals.

Due to various factors and characteristics of Underwater channels there are lots of temporary loss in connectivity and High bit errors and even shadow zones [9] can be experienced. As there is a lack of power resources underwater, hence maintenance of battery power is very complicated and there is no provision of solar energy to recharge the batteries. Sensors prove to be failure because of corrosion and frequent wear and tear.

VI. CONCLUSION

Wireless communication on the terrestrial locations is carried out through electromagnetic waves and it is not conducive to use EMW in underwater wireless communication. Due to the advancement in communication system, there is very much need of wireless communication system network through underwater. As there is lot of hindrance in communicating underwater, because of various factors which are involved in aquatic channels like chemical, oil ore and different aquatic lives. Hence, the most flexible way of communicating in underwater is through acoustic waves which are in the form of sound waves. In underwater wireless communication system, we use nodes and super nodes to communicate in an effective manner.

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