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AN ACOUSTIC SENSOR FOR TRANSMISSION IN UNDER WATER ENVIRONMENT

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Abstract - ***Underwater wireless communication is the one of the familiar method is used for data transmission high rate with higher reliability ratio. This wireless transmission traverse through ocean is one of the enabling technology for the development for easy way of transmission. In which it controls by using Acoustic Modems. In this technology are due to need of conventional large, expensive and it needs an individual ocean for monitoring equipments. This UWSN also be mobile, with sensors attached to AUVs, low-power gliders or unpowered drifters. This Mobility is useful to maximize sensor coverage with limited hardware, but it raises challenges for localization and maintaining a connected network. We proposed some technique for using efficient reliability, and better communication. It is used to finding accurate location for the node using different techniques. Some techniques are used to eliminate the errors, finding the distance of the destination place. It's having different characteristics like low bandwidth, high latency, limited energy, high error probability and node float mobility. In this features can be satisfied by using several protocols that has been developed in the networks. The design of each protocol follows certain goals like reduction of energy consumption, improvement of communication latency, achievement of robustness and scalability etc. This paper examines about protocols and algorithmic description of the current research in UWSN.***

Key Words: *Underwater Sensor Network, Acoustic communications, Transmission,*

I. INTRODUCTION

In this world one third of water is covered in world. Nowadays so many researches are going to be held on oceanic transmissions. The Underwater Acoustic Network is enchanting attention due to their important for UWSN basically used for military and broad commercial purposes.

The Underwater Acoustic Networks are very different that can be deployed military applications and commercial applications. This research can go to be held many unsolved issues. By using AUVs, and UUVs are equipped with underwater sensors that also be visualized to find application in determined the natural facts of Oceanic resources and gathering scientific data to be monitored. The number issues can be addressed using underwater sensor networks its effective technology can be determined many solutions. Its various technologies like localization, energy efficient are due to overcome many problems like scattering of node, high attenuation and absorption effect.

The high dense of salty water, electromagnetic signals, optical signals and radio waves that can be transmitted for long distances in underwater and it can be scattered many ways. Due to this situation can be handled by using many techniques example Acoustic communication used to transmitted data easily in such underground environment. In underwater sensor nodes are required multi-hop networks because sensor nodes are larger in size it consumes high power and replacement of nodes or batteries. It is not easy for replacing nodes and batteries it consumed multi-hop networks where transmit data to one or more time it penetrate downward at the surface level. The sinking of data can be moved forward the received information to onshore control stations. The routing protocols that require higher bandwidth result in large end-to-end delays and are not suitable for these environments. Some of the challenges in under water communication are propagation delay, high bit error rate and limited bandwidth.

ARCHITECTURE OF UNDERWATER WIRELESS SENSOR NODES:

The architecture for an underwater sensor networks design is more tentative and its nodes have a great resource. The four different types of nodes in this Architecture.

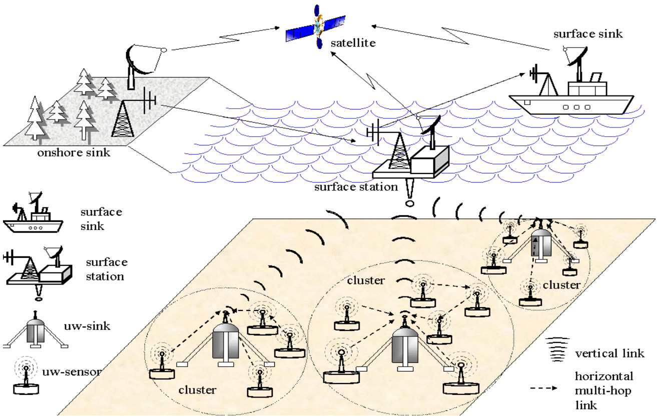

Fig 1.1 : Underwater Sensor Architecture

The lowest layer is the large number of sensor nodes are deployed on the sea floor. They collect data through attached sensors and communicate with other nodes through acoustic sensor modems. It operates on batteries and to operate for long periods if they spend most of their life as dead. It is used to allow optimization results for good sensors and communication coverage. These nodes are able to determine their locations through distributed localization algorithms.

The top layer contains more than one control nodes with connections. This node may be positioned on an off-shore platform with power or may considered on-shore also that expects a node to have a large storage capacity to buffer data, and access that enough to satisfy electrical power. Control nodes will communicate with sensor nodes directly, by connecting to an underwater acoustic modem with wires.

The large networks are third type of nodes called as super nodes that can be spread over the area. It access very efficiently and it works at high speed networks to relay data to the base station very efficiently.

It focused to attach usual nodes to the limits of resources to the node buoys that are helpful to make high speed radio communication to the base station. Then it is also having other implementation to be focused that would place these nodes on the sea floor and connect them to the base station with the help of fiber optic cables. The super nodes are allowed to create as much higher network connectivity, creating multiple data collections points for UAN.

Difficulties of Underwater sensor networks are in harsh underwater environment, it may look forward that some nodes will be lost over time. We may take some risk factors are include for this time like fishing trawlers, underwater life, or failure of waterproofing , sinking of sensor nodes etc., It also expect some redundancy, so that loss of an individual node will not have wider effects. It will be able to replace from multiple failures either with mobile nodes needs to be expected to recover it. The expected sensor nodes and battery powers are carefully monitor their energy consumption.

II. RELATED WORK

2.1 UNDERWATER COMMUNICATIONS AND NETWORKING TECHNOLOGY

In this technology we have discussed about the multi-technology issues of layers like Physical layer, Medium access control and resource sharing, Network layer, Network services, sensing and application techniques, Hardware platforms, Test beds, simulators and models.

Physical layer:

In this physical layer it can be worked in outside the water, the electromagnetic spectrum used for communications in that electromagnetic frequency making acoustic waves to promote choice for underwater communications besides some distances. It can be described in several stages for reproduce on acoustic waves in the frequencies for communication. Essentially attenuation describes the power loss that a tune at frequency as it travels from one location to another.

Stages of Physical layer:

First stage it takes into fundamental loss that occurs over a transmission period. Second stage it can take in the site-specific loss due to surface-bottom reflections and refraction that occurs as sound speed changes with depth and provides a more detailed prediction of the acoustic field around a given transmitter. Third stage addresses the apparently random changes in the large-scale received power that causes by slow variations in the propagation medium.

Its need a separate stage of modeling is required to address the small-scale, fast variations of the instantaneous signal power

2.2 MEDIUM ACCESS CONTROL LAYER:

MAC protocols are used to manage access to the communication medium in which it is relay for short range underwater acoustic sensor networks, scalability, energy efficient reliable MAC protocol, latency and slotted FAMA and low-power acoustic modem for dense underwater sensor networks. MAC protocols are mainly used to avoid collisions. Usually an improper management transmission medium, collision of unrequested communications may decompose overall network performance. For example of MAC protocols are TDMA (Time-division multiple accesses used in slotting time) and CSMA (Carrier sense multiple access used in sensing the channel prior to transmission.

The long propagation delays of data transmission those network suffer from space uncertainty to find the locations of the receivers and their possible interferers. This problem is commonly known to space-time or spatio-temporal uncertainty. The long propagation delay can contain another problem are spatial unfairness. MAC protocols are subdivided, contention-free and contention-based schemes.

Contention-free schemes assign different frequency bands, time slots or codes and different users communication medium. Contention-based MAC protocols are due to avoid the pre-allocation of resources by allowing nodes to compete with each other and obtain medium access on demand. In this MAC protocol are used for good reliable transmission and it is widely accepted, it's not entirely accurate because this different protocols are shared characteristics of both schemes.

Some challenges can be overcome for this MAC protocol like,

1. The limited bandwidth available
2. The huge propagation delay
3. The high cost of available hardware
4. The limited battery power

Network layer:

The network layer is due to fix the route can be used to transmit the messages within the network. The messages can be transmitted into reserved path should follow the data packets from the source that uses the underwater acoustic sensor networks used on the onshore sink. The underwater acoustic networks are working in different nature of environment and applications, several drawbacks and suitable existing solutions can be described in this protocol.

The network layer routing protocols are usually divided into three categories like: proactive, reactive and geographical routing protocol.

Proactive protocols:

I try to reduce the message sizes using virtually induced to discover a new route for transmission. It is used to update the routing information at all times from each and every node that can be maintained by using these protocols. These protocols insist to establish routes for every time the network topology is modified because of node failures or mobility and updating topology has also be propagated to all the nodes. Each node is able to establish a path to any other node in the network; it may not be needed in underwater acoustic sensor networks.

Reactive protocols:

The node initiates a route discovery and maintaining the path procedure until reach destination. In these protocols are more suitable for dynamic environments it is able to incur higher latency and still require source-initiated flooding of control packets to establish paths.

Geographical Routing Protocols:

It may establish source and destination path by which the action for mechanical of lever localization information. Each and every node selects its neighbour node for transmit the data to the destination node. The localization information can be obtained in the underwater environment with limited energy expenditure it cannot be calculated accurately. The ad-hoc networks are helps to perform routing function for this routing protocols and it decide to send single packet separately by using virtual circuit under the underwater acoustic sensor networks routing techniques. It may helps to lead to more efficient paths to transmit the data.

Transport layer

A transport layer protocol is needed to achieve a reliable collective transport of event features. It also performs flow control and congestion control. In this protocols are due to save suffer sensor resources and increase network efficiency. These protocols applications had guaranteed to identify correctly to that features which estimated the sensor network.

A reliable transport protocol had guaranteed that the applications are able to correctly identify the event features estimated by the sensor network. Congestion control are helps to prevent the network from excessive data congested with respect to the network capacity , it has flow control which is needed to avoid that network devices with limited memory.

UNDERWATER ACOUSTIC COMMUNICATIONS:

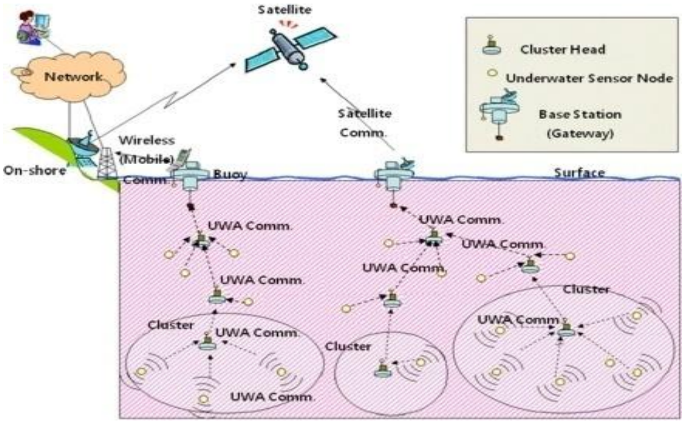

Fig1.2: Acoustic Communication

The oceanic underwater exploration can be grown in monitoring underwater mediums for scientific explorations, commercial exploitation, and attack protection. Underwater acoustic communications depends on path loss, noise, multi-path, Doppler spread, and high and variable propagation delay. It establishes the temporal and spatial variability of the acoustic channel.

The acoustic network depends on both range and frequency. The self-organizing network of mobile sensors produces better supports in sensing, monitoring, surveillance, scheduling, underwater control, and failing tolerance.

Characteristics of Underwater acoustic Communications:

The Acoustic links are classified into vertical and horizontal, for the direction of the sound rays. The acoustic communications are firmly with respect to time dispersion, multi-path spreads, and delay variance.

Path loss:

Attenuation: Conversion of acoustic energy into heat in which increases with distance and frequency. It is used to scattering, reverberation, refraction and dispersion.

Geometric Spreading: used to spread sound energy and it increases the propogation distance and is independent of frequency.

Noise:

Man Made Noise: It caused by machinery noise and shipping activity.

Ambient Noise: It is related to hydrodynamics, seismic and biological phenomena.

Multi-path:

Multi-Path Propagation: It is responsible for severe degradation of the acoustic communication signal, hence it generates Inter-Symbol Interference.

Multi-Path Geometry: It depends on the link configuration. Vertical channels are characterized by little time dispersion, horizontal channels may have extremely long multi-path spreads, whose value depend on the water depth.

High delay and delay variance:

Delay:

The underwater acoustic channels that propagate speed using five orders of magnitude lower than in the radio channel. This large propagation delay can reduce the throughput of the system considerably.

Delay variance:

The very high delay variance is even more harmful for efficient protocol design. It prevents from accurately estimating the round trip time, key measure for many common communication protocols.

Doppler spread:

It causes degradation in the performance of digital communications. High data rate communications that causes many adjacent symbols to interfere at the receiver that needs sophisticated signals.

Limitations of generalized Applications of Underwater Acoustic networks:

Data transmission from one node to another within the range of networks by using gateways etc., Data collection from oceanic environment like ocean, river and lake. Achievements: It includes supervision, a preliminary survey of an area, targeting nodes and intrusion detection determined by the UAN.

Monitoring environment: It is used for monitoring every movement and issues can be recovered immediately by using UAN. It can perform different kinds of pollutions like chemical, biological, nuclear, and oil leakage pollutions in bays, lakes, or rivers. It is also monitored temperature changes and any biological facts. Exploration of the Ocean: If the human beings are very hard to detect the underwater behaviours because of very high pressure, and vast size of unknown area. The UAN can explore oceanic undefined factors like minerals, oil fields, routing the nodes etc., It helps to prevent many disaster like Tsunami, sea-quake etc.,

Challenges in Underwater Sensor Networks:

Need to impact less expensive devices, to obtain robust and nanosensors. The devices can be cleaned in certain interval of time that mechanisms are against corrosion, fouling to be done in underwater devices. Need to protect biological factors like chemical, physical and biological parameters for underlying marine usage system. Sensors need to be stable in which its high ranges of temperature it needs to be robust.

The bandwidth availability is strictly limited. Temporary loss and errors of transmission bits of connections are taught to be experienced. The underwater channels are to make worse because of fading and multi-path transmission. Usually underwater marine usage battery power is limited and usually batteries cannot be recharged. The underwater sensors are more bending forward are the reasons for failures because of fouling and corrosion.

PROBLEM IN UNDERWATER SENSOR NETWORK

A. More costly devices

Underwater devices are more costly and the equipments are different when compare to wireless communication devices. Hence these devices are work in heavy radiations and it's needed to monitoring these equipments how it works.

B. Hardware protection requirement

The underwater device is more expensive. So device protection or hardware protection is required against water.

C. Needed high power for communication

In underwater acoustic sensor communication requires more energy because the data transmit in underwater environment. That transmission needs more electricity is requiring for data exchanging. Acoustic communications is most probably to face many challenges in marine systems. Example to deal the challenges are Point out that path loss (attenuation and geometric spreading), noise (man-made and ambient), multi-path, high propagation delays, and Doppler spread, can significantly disrupt or degrade the underwater communication channel.

D. Propagation delay

The propagation delay is major problem in underwater sensor network. The propagation of acoustic channels in underwater is order of magnitude higher than radio frequency in terrestrial sensor network.

E. Localization

Localization means find the location of sensor in underwater sensor network. So, localization is another major problem yet to be solved. Localization is the challenging factor that is require for data labelling while some time critical applications require data without time delay.

F. Limited battery power

In underwater sensor network transmission need more power for data transmission. In these needs lifetime battery but it has limited power. It suffers from a sensor's fouling and corrosion. In underwater sensor battery has limited power. A shorter lifetime increases the replacement costs because the underwater sensor battery is not chargeable.

G. Bandwidth size limitation

In underwater sensor network bandwidth is another big problem. Because bandwidth size is limited.

H. Reliability

This is one of the major issues for reliable delivery of sensed data to the surface sink or water surface is a challenging task compare to forwarding the collected data to the control centre or on-shore station.

I. Temporary losses

It means the packet losses when connectivity time and packet sending time.

III. SYSTEM IMPLEMETNATION

The Monterey-Miami Parabolic Equation model is used to predict underwater acoustic propagation using a parabolic equation, which is closer to the Helmholtz equation (wave equation); this equation is based on Fourier analysis. The sound pressure is calculated in small incremental changes in range and depth, forming a grid. It incorporates randomness and wave motion to the approximation using a dynamic propagation loss calculation. The authors show that small changes in depth and node distances can lead to big differences in the path loss as a result of the ocean wave motion impact on acoustic propagation. The propagation loss formula based on the MMPE model is the following one:

$$PL(t) = m(f,s,d_{A,}d_B) + w(t) + e()$$

Where:

- PL(t): propagation loss while transmitting from node A to node B.
- m(): propagation loss without random and periodic components; obtained from regression using MMPE data.
- f: frequency of transmitted acoustic signals (in kHz).
- dA: sender's depth (in meters).
- dB: receiver's depth (in meters).
- r: horizontal distance between A and B nodes, called range in the MMPE model (in meters).
- s: Euclidean distance between A and B nodes (in meters).
- w(t): periodic function to approximate signal loss due to wave movement.
- e(): signal loss due to random noise or error.

The m() function represents the propagation loss provided by the MMPE model. According to the data's logarithmic nature, a nonlinear regression is the best option for providing an approach to the model based on the coefficients supplied by the preliminary model. The proposed expression to calculate this function is the following one:

$$m(f,s,d_{A,}d_B)=$$

$$\log\left(\left|\frac{(\frac{s}{0.914})^{A0}(d_A)^{A9}s^{A7}((d_A-d_B)^2)^{A10}}{(s*d_B)^{10A5}}\right|\right)$$

$$+(f^2(\frac{A1}{1+f^2}+\frac{40}{4100+f^2}+0.00275)+0.003)*(\frac{s}{914})+A6*d_B+A8*s$$

The w() function considers the movement of a particle that will oscillate around its location in a sinusoidal way. That movement is represented as circular oscillations that reduce their radius as the depth of the particle increases.

The length of that radius is dependent on the wave energy and is related to the wave height. Common waves have hundreds of meters of wave length and have an effect up to 50 meters of depth.

For the calculation of the effects of the waves, we will consider:

$$w(t) = h(l_w,d_B t, h_w,T_w)\ E(t,T_w)$$

Where:

- w(t): periodic function to approximate the lost signal by the wave movement.
- h(): scale factor function.
- l_w: ocean wave length (meters).
- d_B: depth of the receiver node.
- h_w: wave height (meters).
- T_w: wave period (seconds).
- E(): function of wave effects in nodes.

This function contains the elements that resembled the node movement, first calculating the scale factor h() and then the wave effect in a particular phase of the movement. The scale factor calculation is as follows:

$$h(l_w,d_B t,h_w,T_w) = \frac{(h_w(1-(\frac{2d_B}{l_w})))}{0.5} * \left|\sin(\frac{2\pi(\mathrm{mod}\,T_{w)}}{T_w})\right|$$

The e() function represents a random term to explain background noise. As the number of sound sources is large and undetermined, this random noise follows a Gaussian distribution and is modeled to have a maximum 20 dB at the furthest distance. This function is calculated by the following equation:

$$e() = 20(\frac{s}{s_{\max}})R_N$$

Where:

- e(): random noise function.
- s: distance between the sender and receiver (in meters).
- smax: maximum distance (transmission range).
- h_w: wave height (in meters).
- RN: random number, Gaussian distribution centred in 0 and with variance 1.

EVALUATION RESULT:

The simulation framework is based on OPNET, MATLAB and the Bellhop ray tracing tool, and uses information related to underwater scenario characteristics like bathymetry, salinity, and seafloor composition, found at real worldwide locations that are downloaded from NOAA and GEBCO worldwide ocean databases. This information is combined with the OPNET network scenario module in order to create the corresponding environmental files.

The *.ray file contains the ray coordinates and we can clearly see the behaviour of the rays and the reflections along the scenario in Figure 6.11, which will be very different depending on the proximity to the surface of source node, and the height and length of the waves, the shape of the bottom depth and the types of sediment that can be found in the scenario location.

The *.shd file contains the acoustic pressure, which can be calculated in a coherent, incoherent or semi-coherent way. Figure 6.12 shows a coherent execution. The pattern of the pressure fits with the ray plot.

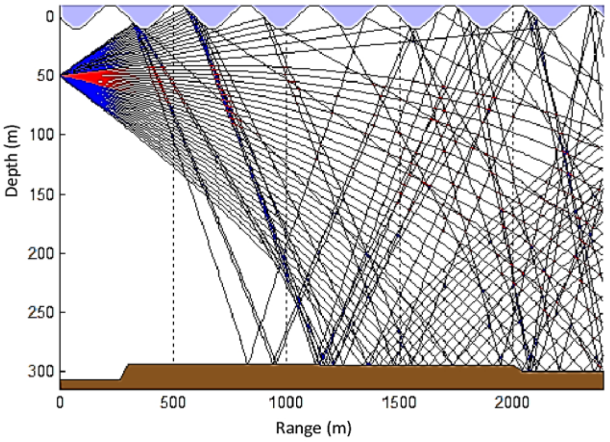

Fig : Plotting ray files (with ATI and BTY also)

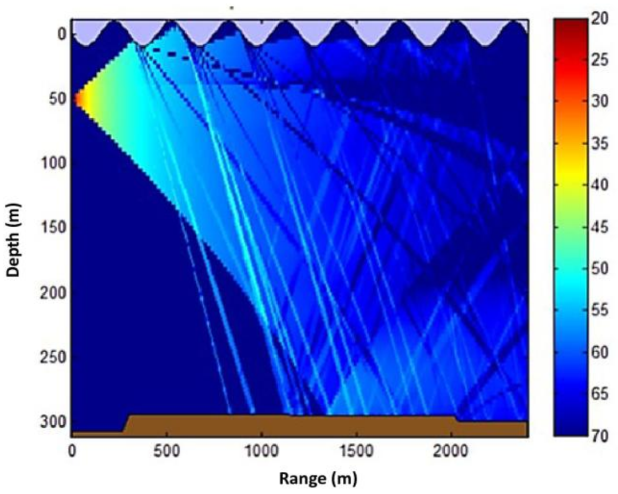

Fig : Plotting SHD file (with ATI and BTY)

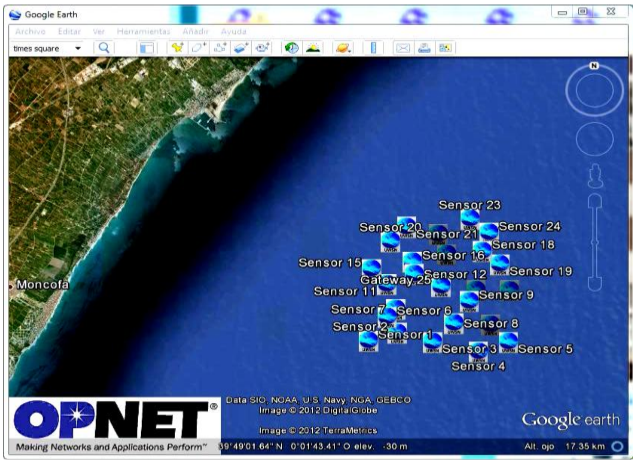

Fig : Google Earth network deployment

the OPNET deployment in Google Earth where a real 3D vision of the network topology may be displayed, so the real distance of the nodes to the sea floor can be checked and a better node deployment could be done.

For testing the simulator, the same node deployment network (shown in Figure 6.16) within a range 5000 meters has been placed at several world locations. The depths of the nodes will vary depending on the scenario we simulate, depending if we are in a shallow or deep part of the ocean.

Here we show the results for three different locations.

- Valencia - Spain
- Hawaii - USA
- Random location – Atlantic Ocean

VALENCIA – SPAIN

The first one is placed at coordinates 39°48'13.14"N and 0° 4'34.53"W. The node depth varies from 5 to 20 meters, with the wave height of 0.5 meters and wave length of 80 meters. This is an example of shallow waters with a low altimetry shape. The sediment floor of the bottom of the scenario is gravel. We can see the node deployment in Google Earth and the result for the Bellhop ray execution. The result is a slow variation of the depth in the scenario as the nodes are father from the coast and how the rays reflect a great number of times in the bottom and the ceiling. It is very important to appreciate that the attenuation values in Figure 7.2 vary not only with thedistance but also with the depth. This is valuable information that has been deprecated in many simulator proposals.

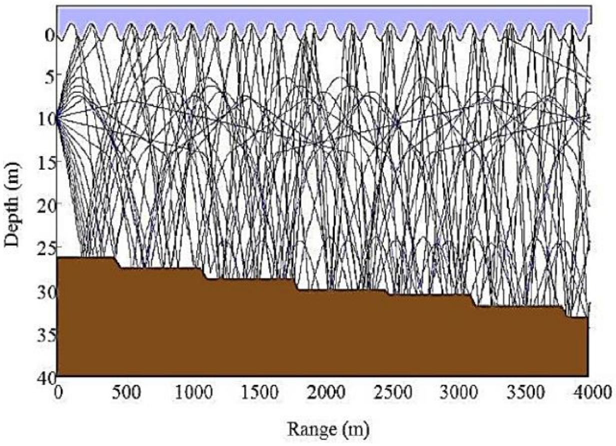

Fig: Bellhop ray result in Valencia

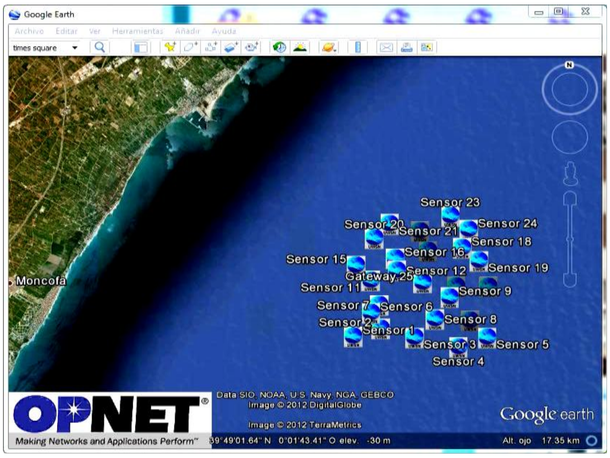

Fig : Nodes in Valencia

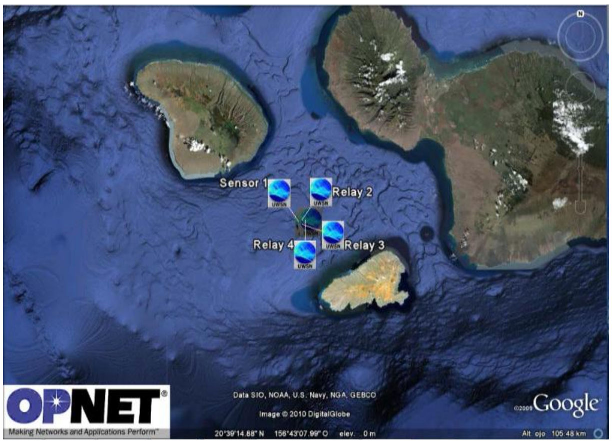

Fig : Nodes in Hawaii

Fig : Nodes in the Atlantic Ocean

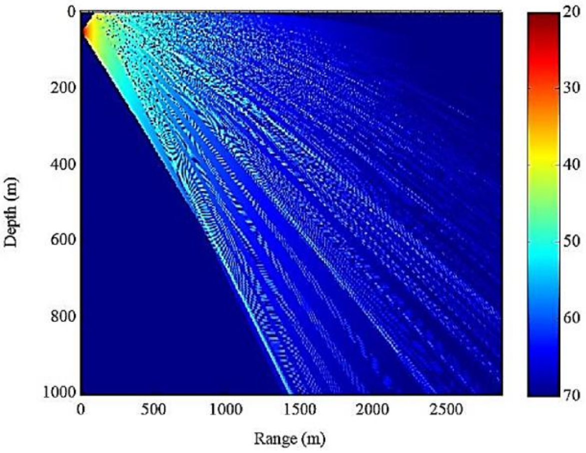

Fig : Transmission loss (dB) in the Atlantic Ocean

CONCLUSION

In this paper, we presented in an underwater acoustic sensor network communications. It describes the underwater monitoring application for oceanic environment. In this paper defined as an acoustic sensor can be transmit data very effectively and efficiently. It discussed about the limitations and broad applications of underwater Acoustic sensor communications. It describes what are all problems occurred at the time of transmission and it can defined it how to solve these difficult situation. The physical, transport, MAC layer, and Network layers are explained how it works an architecture of 2D and 3D. The localization algorithm used to express that have large coverage, low communication overheads, high accuracy and low deployment cost. This paper has summarized our ongoing research in underwater sensor networks, including potential applications and research challenges.

Future Work

Currently, there is a lot of work related to MAC layer proposals since this is one of the more sensible parts of UWSN architecture. It seems that distributed CDMA-based schemes are the candidates for underwater environments, but it depends on many factors, such as the application and network topology. Also, MAC protocols should be designed by taking energy consumption into account as a main design parameter.

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