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Underwater Wireless Sensor Monitoring and Tracking Framework: Dolphin Preserving in the Ganges

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Abstract

Underwater Wireless Sensor Networks (UWSNs) is a framework to provide a collaborative task with the help of a various type of nodes. It will perform tasks over a particular area depending upon various applications. The applications are broadly categorized in three different types like monitoring, tracking and actuating. Our main focus to monitor and track Ganges Dolphin, as it is the property of our country. We observers we have around 3000 dolphin in the Ganges, and every year it reduces more than 10% due to various threats like pollution, dams, and fishers hunting. We provide a framework that will monitor dolphin in a region and track the current position as well as persevering from threats. In Underwater we have used various types of nodes that are deployed underwater as well as surface, 3-D architecture scenario, and node deployment fashion and node distribution technique.

Keywords: Underwater Wireless Sensor Networks, Deployment Scheme, Node distribution, Dolphin Monitoring system

INTRODUCTION

Underwater Wireless Sensor Network (WSN) consists of different types of nodes [1] depending upon the surface. These are Anchor Node, floating nodes, Autonomous Underwater Vehicles (AUVs) [2], Surface Sink and Onshore Sink.

Underwater Communication Architecture is of three types. Static two-dimensional UW-ASNs is specially used for bottom monitoring. It is with the help of sensor nodes placed in bottom of the surface with the help of Anchor node send the information to the base station [1]. The application may be environmental monitoring and finding obstacles in the bottom. Static three-dimensional UW-ASNs is used for monitoring the column of the ocean. UWSN is useful for surveillance and tracking system like fish movement, Military application, floating folks, pollution, and depth of water and geochemical process. This architecture includes a depth based sensor, Anchor node, and Surface Sink. A three-dimensional network of Autonomous Underwater Vehicles (AUVs) consists of basically two types of nodes. Fixed anchor node and moveable AUVs. AUVs are used to monitor and track the information and anchor node is collecting and forwarding these to the base station.

In Underwater we can commutate through a various medium like Acoustic, Electromagnetic and Light. Depending upon applications, the medium can be chosen as it plays an important role and every medium has its limitations. Acoustics Communications are suitable when we are covering long distance like surveillance and tracking system. In deep water, acoustic are best suited as it works in very low frequency (30-300 Hz). Moreover, we have to be careful as the speed of sounds depends on temperature and pressure of the water. The salinity of the water also affects the speed of sound. The good Performance reduces the signal bandwidth (~K Hz) and transmission rates. In Electromagnetic Medium is having a higher carrier frequency and provides higher bandwidth (~M Hz). But this medium performs well in short distance application. As we know, the speed of EM wave is almost four times than the Acoustics, so EM is very impressive for fast communication. Delay in this medium also less as it provides high speed. We have taken care of the acoustic noise and turbulence due to tidal waves which degrade performances of EM medium. In Light-medium the main focus on clear water and when nodes are very tightly aligned. Light is heavily absorbed with the increasing of the depth of the water. Light is also very effective for short communication and provides a fast speed. In short distance, light-medium provides gigabytes per second in compare to EM.

Table 1. Comparison analysis of various medium [3]

Parameters	Acoustic	Electromagnetic	Light
Speed	Less	High	>Electromagnetic
Depth	Deep Water	Deep and Shallow Water	Clear Sallow Water
Bandwidth	Less	>Acoustic	>Electromagnetic
Distance	Large Distance	Short Distance	Very Short Distance
Frequency	Less	>Acoustic	>Electromagnetic

In UWSN, deployment of nodes in three-dimensional spaces is an important factor to maximize the coverage and enhance the performances of the network. Applications highly depend on nature of node deploy techniques. Here node deployment can be classified broadly into two categories like static and distributed. In static, the node is placed in a predefined place to monitor application. Nodes cannot change the position as architecture already defined accordingly. In distributed deployment nodes [4] are deployed initially either random, uniformly or Gaussian distribution. Later nodes are capable of moving with the help of AUVs to track the target. The static nodes can be, either one of the deployment schemes like circle

grid, a triangular grid, cube grid or hexagon grid depending upon the application and target area.

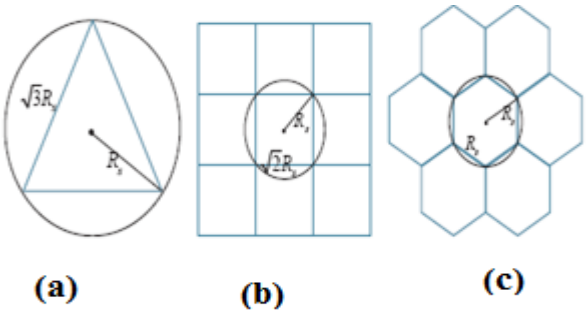


Figure 1. a) Triangular Grid b) Cube Grid c) Hexagonal Grid

The various application fields where UWSN need to developed and face the challenging as [1]:-

1. Ocean sampling networks [5], [6].
2. Environmental monitoring [7].
3. Undersea explorations.
4. Disaster prevention [8].
5. Assisted navigation.
6. Distributed tactical surveillance [9].
7. Mine reconnaissance.

Dolphin is in the category of mammals, and they are not breathing in the water. So after 30-120 seconds, they must appear in the surface the dolphin in the Ganges named as "Susu" [10]. They produce sound when they are breathing. The Susu's are following a seasonal pattern. It moves towards upstream when water level increases and entered into the smaller stream, here are the few characteristics of Susu's as - The size of female dolphin is quite larger than male and maximum for the female size of 2.67 m where males are about 2.12 m. The color of the dolphin is grey with brown. The smaller size in black but when they grew the color became lightning. The social structure of the large group earlier but the recent day's it found in the smaller group. They can use maximum 28-30 year of life and maturity at arises in 10 years of age. Their diet includes a variety of fish, namely prawns, clams, catfish, freshwater sharks, gobies, and carp. The current population of Susu's much-reduced range, as well as they, are divided, isolated groups. The lowest estimate for the total population is 1,200–1,800 individuals. Population size decreased, but still, it has sufficient in the Ganges [10]. From 1980's to 2014's it reduced almost 1500 Susu 's. The reason behind that instead of Climate changing, pollution, chemical reaction, Quantity and quality of water. But most factor is a consideration and can be avoided is Fishery by-catches.

RELATED STUDY

Tsuyoshi Suzuki et al. proposed a WSN system [11] to achieve coral ecological system activities. They defined the prototype of the node to gather information and hardware configured accordingly. By capturing an image with the help of sensor node it sends to the central server for further processing. The here stationary system used for coral observation. Experimental set up to observe a colony of reef-building coral along the coastal area in Japan by using the prototypes.

Nader Mohamed et al. developed monitoring underwater pipeline infrastructures [12]. The paper also focuses on reliability, challenges, and enhancement in their network architecture. A comparative study also based on characteristics like advantages, disadvantages and reliability evaluation has done. List of reliability factor considered as Connectivity of the Network, Continuous of Power Supply and Network Security. The power supply provided with the help of various sources as Solar Energy, Pipeline Flow Energy, and Other External Energy. They have shown the impacts of wired, wireless and integrated architecture.

Nam-Yeol Yun et al. described the analysis of ocean environment give details of ocean exploration [13]. They had described about a factors that effects environmental variables like movements of nodes by an ocean current, corrosion by salt water. Apart from that also includes factors like attenuation of the radio wave, sensor node deployment difficulties. It is obvious that data collection and gathering in UWSN is a challenging task through ocean communication. They have considered this challenge in compared to terrestrial and build a monitoring system to overcome these problems. They have done Gyeongpoho which is similar to the ocean environment monitoring system. This paper shows how to overcome the problems of UWSN.

Yun Wang et al. [14] has proposed node distribution model where truncated Gaussian distributed WSN. This distribution is quite effective in Intrusion detection probabilities at different locations. In Gaussian distribution distributing Sensors are denser near the target location. So the probability is high to get accurate information. The authors have shown that the performance proposed distribution gives better than a uniform distribution. This distribution with the network parameter like some sensors, sensing range, deployment deviation shows an improvement to achieve maximum allowable intrusion detection as well as intruder's starting position. Single sensing as well as multiple sensing models also decribed by the authors. The Gaussian distribution is completely targeted oriented model where the main focus is to detect all intrusion and malicious node.

PROPOSED WORK

Assumptions:

1. Various types of node are in consideration as Sensor Node, Anchor Node, Base station and AUVs. Sensor nodes are floating and collecting information. Anchor node acts a cluster head to forward the information to the base station. AUVs [2] can move which is attached to an unnamed vehicle. The base station is communicated with real-world through the internet, and it placed on the top of the surface of the water. It has central data store which is used to store and process capability of information.

2. In the beginning sensor node placed as per uniform distribution as it can cover uniformly and its best suited as per our requirements.
3. We have assumed the range of sensor node [15] up to 30 m apart from that target is not able to detect.
4. Each sensor has Omni directional antenna.
5. The deployment is 3-D static underwater communication.

Node Deployment:

The various node deployment schemes [16], [17] discussed to increase the communication coverage and lifetime [18]. We have mathematically calculated for every scenario about the covered area, uncovered area and total no of anchor node requirements. In result section, we have discussed in details of the circle, triangle grid, cube grid and hexagonal grid [19].

We have focused on simple queue grid for monitoring, and if we need for full coverage, then no of the anchor will be double as mathematically shown. But keeping consideration that dolphin is moving so after a short interval of time it will be trace by a particular anchor. If our target area is more sensitive in that case, we will twice the no of anchor node to meet the situation as per queue grid scheme with full coverage scheme.

Architecture:

Here we have used Static three-dimensional UW-ASNs to monitor the dolphin in a particular region.

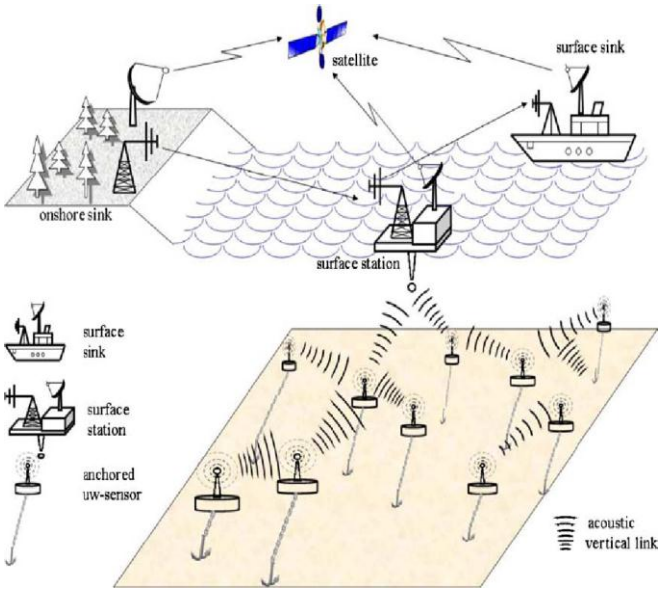


Figure 2. Static three-dimensional UW-ASNs [1]

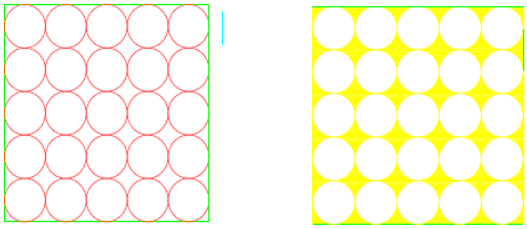
Node distribution:

We have taken care of consideration for distribution of sensor node as well. As we know deployment scheme and node distribution pattern fully depends on the type of application and target area.

We have analyzed three different type of node distribution, and after that, as per our requirements, we have best-suited one of them chosen. Here we have observed the network lifetime of a Normal distribution, Uniform distribution and exponential distribution in 500 x 500 areas. We vary the sensor node from 0 to 100 with the interval of 10. Base station kept in the center of the area and with the increases of the density of nodes, the lifetime also increased significantly in a normal distribution. Lifetime increased due to more no of sensors around the base station in a normal distribution. In exponential distribution with the increasing of sensor node also the lifetime remain same as base station surrounds few nodes. In a uniform distribution, the lifetime can extend up to some extent, but after that even we increased the no of sensor node still network lifetime remain same.

Deployment Scheme:

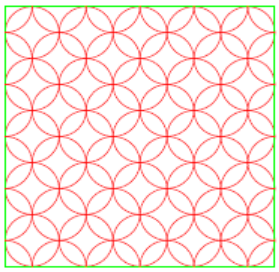
1. Cube grid Deployment



a) b)

Figure 3. a) Cube grid deployment b) Uncovered area
Total Area = (150 x 150)=22500 sq.m
Circle diameter = 30 m
Total no of circle = 25
Area of one circle = 706.86 sq.m
Covered area by the circle = 17671.5 sq.m
Uncovered area = 4828.5 sq.m

2. Cube grid with full coverage



Total Area = (150 x 150)=22500 sq.m
Circle diameter = 30 m
Total no of circle = 61
Area of one circle = 706.86 sq.m
Covered area by the circle = 100%
Uncovered area = NIL

Figure 4. Cube grid with full coverage

Localization Scheme:

We have studied various localization scheme in the underwater scenario and based on our application domain Localized chain [20] construction scheme is best suited. The author proposed for large-scale wireless sensor networks which perform based on tessellation-chain based. In this scheme, energy consumption is very less and is based on Voronoi based. Voronoi is large target area divided into small pieces as result throughput of increased consequently lower interference. Time complexity also maintained due to chain based scheme compared to another scheme. Further data are collecting and storing also faster due to chaining. The author uses the concept of localization chain to find the location using tessellation method. In this author taken consideration of various energy efficient routing protocols like CHIRON, ECR, and EBCRP [20].

Data Collection Method:

The data collection is an important part of which entire working of the framework depends. More significant way data store and will enhance the monitoring and tracking system. Here we have used the data collection method which is based on coded cooperative OFDM [21]. These techniques based on the selective relay and dynamic sensor network but it work in static as well with its same performance. In this techniques coverage, consistency and efficiency already analyzed and shows its strength.

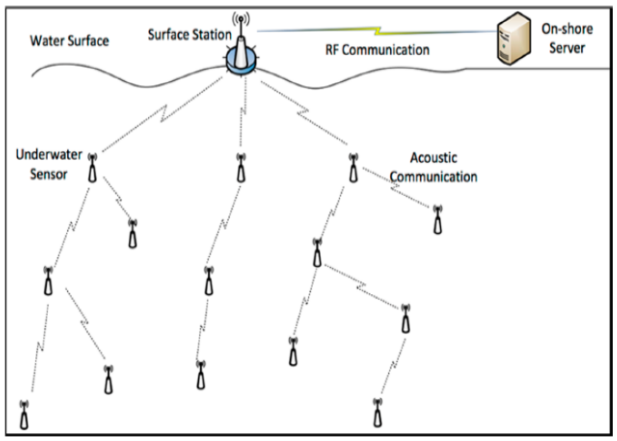


Figure 5. Data collection model [21]

Workflow Diagram:

Initialize every sensor node with the following parameters as:

1. Communication Range
2. Power
3. Bandwidth
4. Other setup parameters.

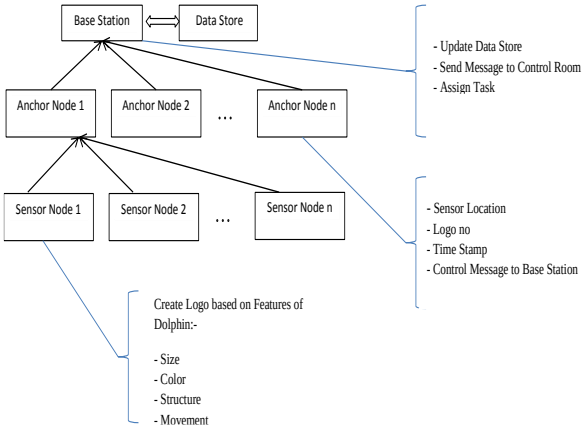


Figure 6. Monitoring and tracking system model

Algorithm:

The entire framework working as :

Step 1. Initialize Various Sensor nodes (No of the sensor node, Anchor Node, Base Station and Data Store) and set the logo accordingly

Step 2. Create a logo for every dolphin by considering following characteristics (Size, Color, Structure, Movement, and sound)

Step 3. The Assumptions keep under consideration to avoid uncertain activity.

Step 4. Sensor node sent the information to their anchor when any logo detected.

Step 5. An anchor node collects all logo and remove duplicate and send the same to the base station.

Step 6. Base station checks all logo in the data store and finds any missing at any point in time. If any logo missing then immediately send alert control room with last updated location to recover. Control room updated information if recovered otherwise trap the Fish Catchers.

RESULT ANALYSIS

We have created a scenario for Normal distribution, Uniform distribution and exponential distribution where the network area is 500x500. Total sensor node deployed is 100 and base station set in the corner and middle of the region. **Fig 7.** a) Normal distribution model b) Uniform Distribution Model c) Exponential Distribution Model shows the node deployment. Depending upon application and target we have to choose the distribution model. Our monitoring system is very closely related with Normal distribution. We are more focused on to extend cover of the entire network area and maximize the no of tracking dolphins.

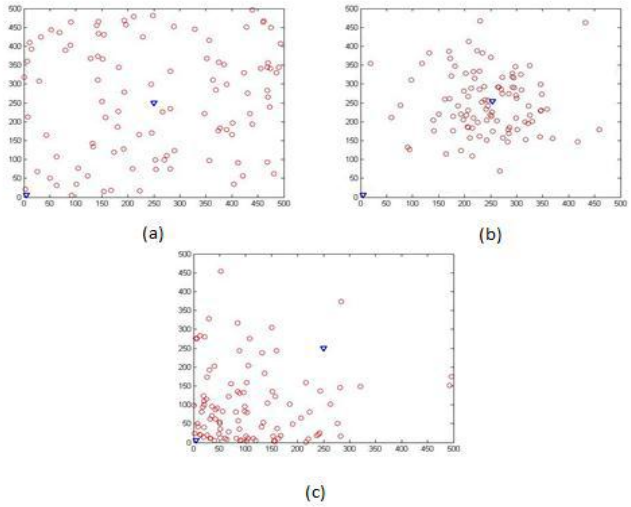


Figure 7. a) Normal distribution model b) Uniform Distribution Model c) Exponential Distribution Model

Here the comparative analysis of three different distribution techniques and we observed the lifetime of the network from **Fig 8**. We have set the network area is 500x500 and no of sensors varying from 0 to 100 with 10 node increased in each interval. In Normal distribution and Uniform distribution, we observed the lifetime increases with the increasing of sensor node density. After some time it is almost stationary as the battery power of base station reducing. So if we need to extend the lifetime of the network constantly then energy of base station should keep stationary. We observed that the gap between Normal and Uniform distribution because of in normal distribution the probability of sensor node is around the center. This is the reason the energy is balancing energy between nodes. In exponential distribution the lifetime remains same with the increasing of node density. The reason behind this is the nodes are exponentially distributed towards origin point.

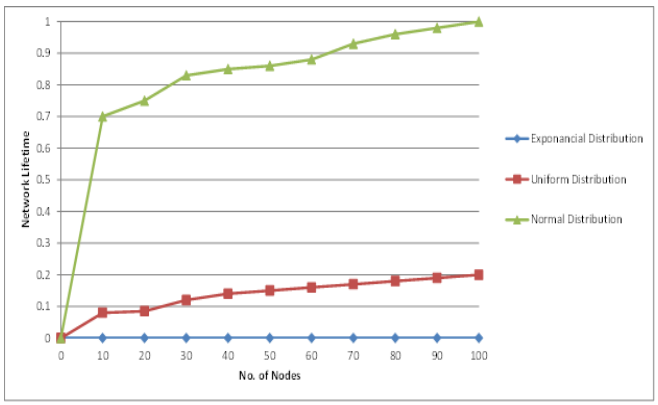


Figure 8. Performance of various distribution models

CONCLUSIONS

Dolphin is wealth for our country and to preserve these mammals is a challenging task in Underwater. We have a lot of limitations to build up communication network to overcome challenges as well as resource constraint. As per our requirements, we have set up the underwater network by setting up communication architecture, node types, deployment scheme and distribution of sensor nodes to fulfill the goal. Our 3-D static network covers entire region and node deployment in the various scheme also give a full coverage or up to a certain level as we describe in the result section. Our system not only to monitor the movement of a dolphin as well as to protect from Fisher by catchers. The control room will monitor closely with the information provided by the base station and periodically update the same to constant the system. Our node distribution also shows a significant towards our target and to maximize the coverage.

FUTURE WORK

Also to our work, it can be extended or more precisely concentrate the target area in future.

1. We have taken into consideration of static 3-D architecture later it may be extended into dynamic 3-D architecture will be more effective.
2. Dolphins are found in clear water, so light-medium for communication give accurate result but to cover a large distance acoustic medium taken into the picture. But the speed of acoustic medium again a challenging task.
3. When we focus on maximizing coverage, we need to increase the no of anchor node, but in our application, it is not so prone to cover 100%. So the cost of the network is also a challenging while we look for covering the entire area.
4. We mainly focused on protecting dolphin from a man-made attack like fish bycatch and Accident by ship. So in future, we can extend to give protection from like pollution control, water level, chemical reaction, damps and barrage related issues.

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