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COMPARATIVE STUDY OF LOCALIZATION ALGORITHM WITH TETRAHEDRON DEPLOYMENT SCHEME IN UNDERWATER WIRELESS SENSOR NETWORK

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ABSTRACT

Underwater Wireless Sensor Networks (UWSNs) are generally deployed over a large sea area and the nodes are usually floating. This paper aims at analysing the node deployment strategies on localization performance in underwater wireless acoustic sensor networks (WASN). The objective of this paper is to achieve application dependent target sensing and communication coverage with minimum number of sensor nodesusing tetrahedron deployment scheme and different localization algorithms are compared for efficient localization.Thevarious localization algorithms such asparticle swarm optimization (PSO), location dispatch based on command nodes (LDBCN) and Dive and rise(DNR) are compared in terms of coverage area, network lifetime, energy consumption, localization error.The simulation result showsthat DNR algorithm provides the better results in terms of network connectivity and energy consumption.

Keywords- Deployment, localization, energy consumption

I. INTRODUCTION

In the recent years there has been an accumulative interest in the development of Underwater Wireless Sensor Networks (UWSNs) .UWSNs exhibit several architectural differences with respect to the terrestrial ones, which are mainly due to the transmission medium characteristics and the signal to transmit data (acoustic ultrasound signals). Basically, a sensor node in UWSN is formed by the backing among several network nodes that establish an acoustic link that are bidirectional and maintains the network. Since acoustic signals are mainly used in UWSNs, the key aspects taken into reason involved in the propagation of acoustic signals in underwater wireless sensor network environment are: (1) the propagation speed of sound,(2) phase and magnitude fluctuations lead to higher bit error rates,(3) bandwidth constraint; (4) interference in multipath .acoustic communication in underwater is severe due mainly to the surface tides or receptacle activity, this becomes a severe problematic to attain better bandwidth efficiency.

The main difference between terrestrial sensor networks is the terrestrial sensor networks are designed to operate on the land. It needs air as communication channel forcommunication. A distinctive terrestrial sensor network composed of transmitter and receiver part. It uses electromagnetic radio waves for booming the data or voice.The underwater sensor networks are intended to function in under water. Water is used as communication channel for communication. A typical underwater sensor network composed of transmitter and receiver part. Electromagnetic radio waves, optical waves and acoustic waves are used for communication. EM waves

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propagate at longer distances through conductive sea water at very low frequencies (i.e. 30 to 300Hz). This needs large antenna and high power for transmission. Hence it is not ideal for underwater communication. In contrast to EM waves, optical waves do not suffer from very high attenuation. However optical communication in under water suffers from scattering loss andmoreover it needs high accuracy narrower laser beams for carrying the information. In underwater environment optical waves are used for short range communication.Due toseveral limitations and drawback of electromagnetic(EM) waves, the Opticalwaves,acoustic waves are used for communication in underwater sensor based networks. The underwater applications are classified as monitoring, disaster, military, assisted navigation, sports which will have a great impact on the underwater and provide benefits to humans.

The underwater monitoring applications are used to monitor the underwater environment, properties, and its characteristics. The monitoring applications include water quality,habitat monitoring & monitoring underwater explorations. Monitoring the quality of water differs from canals to ocean. In ocean monitoring is based on using sensors integrated with AUV. The AUV is responsible for collecting the water samples and the information is transmitted to the base station [1]. Water basednatural disaster will produce huge destruction to the earth and also more dangerous to the water habitat. Hence disaster monitoring and preventive mechanism are very necessary. UWSN monitoring has a wide variety of applications such as floods, underwater volcanic eruption, tsunami and oil spills. The system designed for the issue of flood monitoring & alarming with the help of UWSN [2] consists of sensor module, observatory module, and transponder module. The sensor module will gather information related to underwater parameters such as level, thrust, and intensity of water. The transponder module is used for relaying information in case of flood. The observatory module is used for observing the information and predicts the flood.UWSN are used to assist military applications and lead to economic solution to protect naval forces. Different sensors such as cameras, imaging sensors and metal detectors with AUV are used to find underwater mines, securing ports, submarines and surveillance. In mine detection[3] the system is designed in which the AUV is employed with a sensor. The sensor is capable of producing very high resolution images that will help in localizing the underwater mines. The possibility of error is reduced by capturing the same area with multiple view.

II. RELATED WORKS

A three dimensional deployment space is the important characteristics of UWSN. Architecture of underwater network varies from network to network and so it isapplication dependent.A general architecture of underwater sensor network is shown in Fig. 1.1 UWSN consists of sensor nodes, super nodes, base station, autonomous underwater vehicles (AUV), remotely operated vehicles (ROV) controlled by a base station etc.

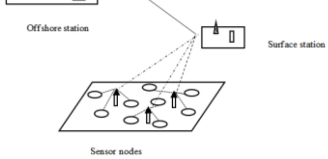

Fig 1.1 UWSN Architecture

Sensor nodes collect data by monitoring underwater deployment area and use acoustic link to relay that data to sea floor base station. Base station uses acoustic signals to communicate with underwater nodes and use radio signals to relay data to a user station for processing. Power management is a critical issue in underwater wireless sensor network hence the sensor node should be energy efficient. The other critical issues of underwater wireless sensor networks are synchronization of time, localization of node, protocol used for routing .Extensive research has focused on node deployment algorithmsin UASNs, the majority of which aim at achieving high network connectivity and coverage, minimizing the number ofsensor nodes and their energy consumption.A good deployment strategy will provide the fundamental support for many network services such as topology control and routing. There are three different types of deployment scheme [9] used in UWSN they are random deployment, cube deployment, tetrahedron deployment. The random deployment is simple but cause a major issues such as partition of network and more energy consumption. In cube deployment the anchor nodes are placed in a prepositioned cubes and hence more anchor nodes are needed to cover a large volume. The tetrahedron deployment scheme outperforms the other two deployment scheme.To resolve the node deployment problem, a tetrahedron deployment scheme is used to achieve large coverage area.

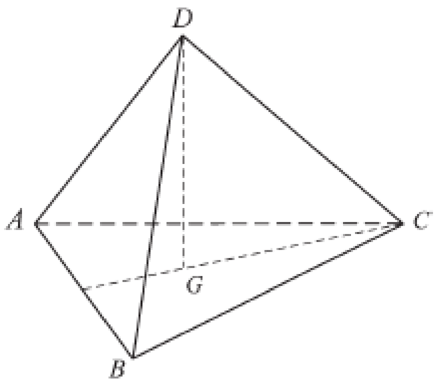

Fig 1.2 Tetrahedron Deployment

The data sensed by the node is only meaningful when sensor node localization is done properly. There are many localization challenges in [7] underwater wireless sensor network.

2.1 Node Deployment: Deployment of sensor and reference nodes is difficultand costly in deep sea environment.

2.2 Node mobility: Due to water current and other disturbances the underwater sensor nodes get drifted and hence the speed of the water current is variable hence it is difficult to predict the location of the node.Theposition estimation will go wrong if a node gets moved during localization process.

2.3 Variation in Signal Strength*:* Strength of acoustic signal gets affected by many factors like Doppler shift, multipath propagation, attenuation and external noise.

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2.4 Synchronization of time: Many localization schemes assume that nodes aresynchronized. Time synchronization is difficult to achievein underwater scenario due to long propagation delay andvariable sound speed. As radio signals cannot propagateunderwater, so GPS service is also not available.

III LOCALIZATION ALGORITHM

Localization algorithms are classified into three categories. (1) In stationary localization algorithms, all sensor nodes are static. They are attached to surface buoys or ocean floor units which have fixed locations. (2) In mobile localization algorithms, all sensor nodes are mobile. They freely drift with water currents or use propelled equipment's, e.g., Autonomous Underwater Vehicle(AUV), to control their movements. (3) In hybrid localization algorithms, stationary and mobile sensor nodes coexist. Thesethree categories are further divided into subcategories of centralized and distributed localization schemes.In centralized localization algorithms, the location of each unknown node isestimated by a base station or a sink node. These two categories are further divided into subcategories of estimation-based and prediction-based algorithms. Estimation-based algorithms use current information to compute the location of a node, while prediction-based algorithms aim at predicting the location of a node at the next time instant, using previous and current location information. In distributed localization algorithms,each underwater unknown node collects localization information and then runs a location estimation algorithm individually.

3.1 PARTICLE SWARM OPTIMIZATION

The localization algorithm that use reference nodes are classified into: range based schemes and range free schemes.in range based schemes to estimate the location of the nodes in the network the precise distance or angle measurement are calculated. To estimate their distance to other nodes the range based schemes that relay on range/bearing information that use time of arrival (TOA), angle of arrival (AOA) or received signal strength indicator. The range free schemes do not use range i.e., they do not make use of techniques such as AOA, TOA. However only the coarse estimate of nodes location is calculated in the range free schemes. Particle swarm optimization (PSO) is a multi-step localization algorithm and it is divided into beacon node localization and unknown node localization. The flow diagram of PSO is shown in fig 1.3.By measuring the distances from the nodes to the buoys the beacon nodes are located. The next moment the location of the unknown nodes are predicted by estimating the speed of the movement of the nodes. In particle swarm optimization (pso) each node keeps track of its best solution i.e., best solution and best value of any node i.e., global best.

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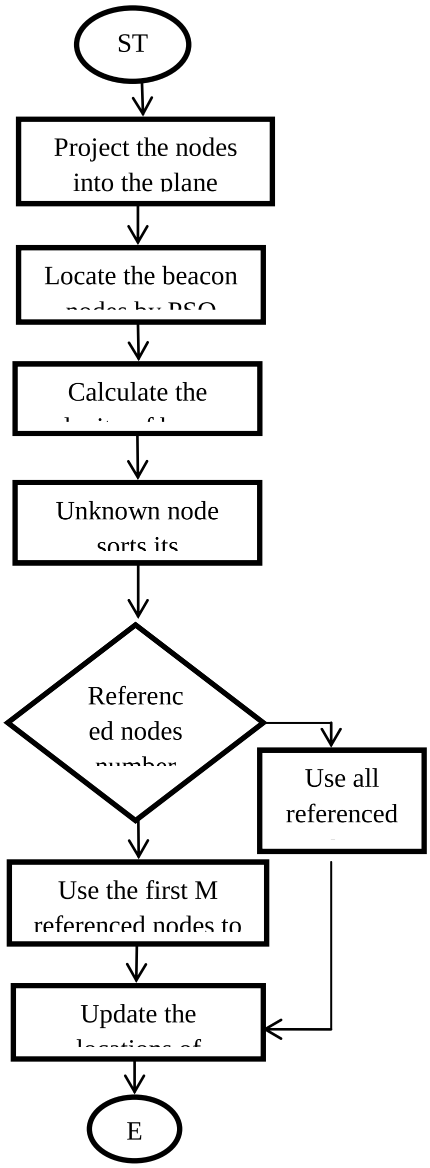

Fig 1.3 Flow Diagram of PSO

Each node tries to modify its position using the following information the current positions, the distance between the current position and the personal best, distance between the current position and global best. The beacon nodes broadcast a packet in the network after getting their velocities, and the packetcontains the identity, velocity and time identification information. Time identification represents the moment of positioning for this node. Since all the nodes cannot complete their positioning at the same time, the referenced nodes selected should be in the same positioning round as the unknown nodes, that is to say they should have the same time identification. The unknown node W receives the packets from different beacon nodes, and it will sign the beacon node which has the same time identification as a referenced node. Finally the list of reference nodes will be set up, and it includes the identity, velocity, time identification information, and the received signal strength

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3.2 Location Dispatch Based On Command Nodes(Ldbcn)

The sink node and the command nodes are used to determine the location of the common nodes. LDBCN algorithm is used to preserve energy of the common nodes The major difference between the PSO and LDBCN is that PSO has only one sink node which corrects and analyses the information from other nodes. The flow diagram for LDBCN is given in Fig 1.4. In LDBCN the sink node are randomly scattered on the surface of water.

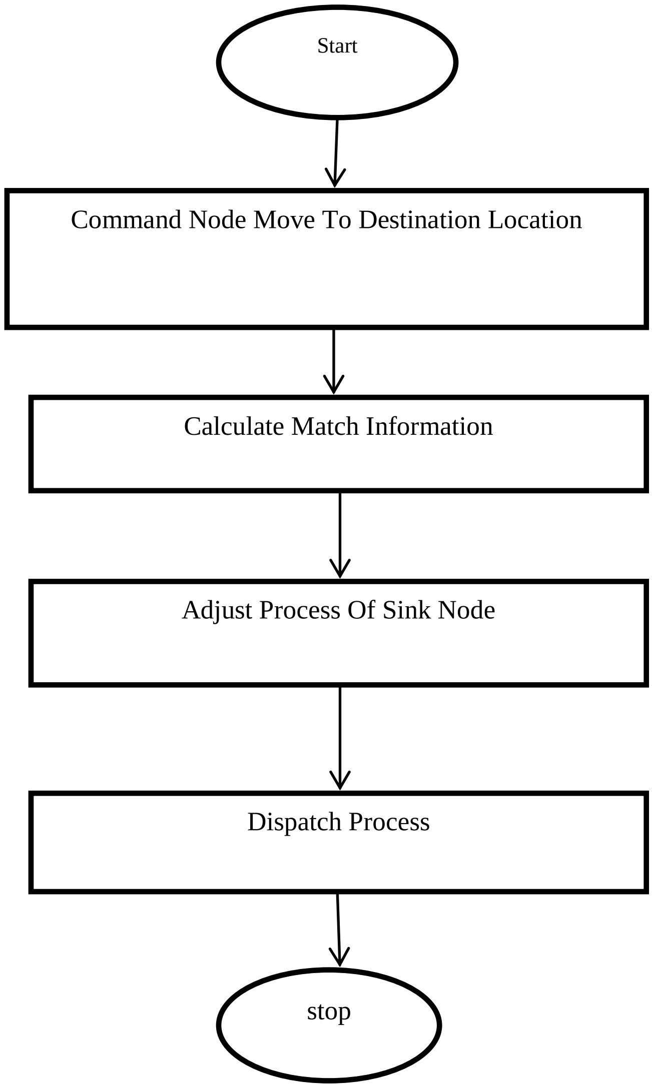

Fig 1.4Flow Diagram of LDBCN

The other type of node is the command node used for network connectivity and also to report to the location of the common nodes. The command nodes are also randomly distributed on the surface of the water and then the command nodes are moved to the predetermined locations to connect with the sink node.The common nodes are used for monitoring purposes and the common nodes are also divided into two types, one is coverage node and the other is connectivity node. The coverage node is used to improve the overall network coverage rate. To make the whole network fully connected the connectivity nodes are used. The destination locations of the common nodes, command nodes and the sink nodes are stored in the memory of the nodes. This process helps to preserve the energy of the node when it moves from the initial random position to the corresponding destination.The command nodes report to the common nodes to choose thedestination location from the destination set for the common node to preserve the total energy.Theconnectivity rate of the network is defined as the ratio M to N where M is the number of common nodes that can communicate with the sink node with sink hop or multi hop, and N is the number of common nodes.

Connectivity rate= M/N

If the network connectivity rate is 1 the network achieves full connectivity so that all the common nodes can communicate with the sink node. The destination set of locations of the nodes are calculated with the help of GFCND algorithm. The locations of the nodes are set into memory of the nodes and these nodes are scattered on the surface of the water by plane or ships. When the command nodes moves to the destination locations, the total distance covered by all the common nodes will be too large. By using the dispatch algorithm the distance covered by all the common nodes to reach the destination is reduced. The process of LDBCN is the sink node and command node move to their destinations. The common node sends their register information to the nearest command nodes, if there are more than one command node then the common node select the command node with the smaller ID. Each command nodes knows the number of the common nodes and the destination locations. Each command node selects the correct destination location from the common node.

3.3 DIVE AND RISE POSITIONING (DNR)

DNR positioning is a localization scheme that works in a large scale networks which consider mobility and establishes minimal message exchange. DNRbeacons which are low-cost, mobile nodes that can sink down with the weight force and can bubble up with a bladder. Their coordinates are learnt through GPS before sinking and distribute this information as they are diving. The sensor nodes receive messages from DNR beacons and estimate their coordinates using either bounding box or triangulation algorithms [8]The trade-off between message overhead and the cost of usinglarge number of anchors can be solved by using few, inexpensive, mobile beacons. Considersimple devices that can dive with the help of extra weight. When they reach a certain depth, the weight is released and they rise/emerge with the help of a bladder. DNR beacon when floating above the water is responsible for getting its GPS coordinates and while diving it broadcasts its coordinates. We assume that pressure sensors are equipped in the sensor nodes.Thedepth (z coordinate) are known with the help of pressure sensor and estimatingthe x-y coordinates is appropriate to determine their location. Thevalue of the z coordinate is maintained in DNR beaconvia pressure sensors. DNR beacons broadcast messages to the sensor nodes.Byusing the time of arrival of these messages range measurement is done. Assuming the nodes are synchronized, sensor nodes can estimate their coordinates by hearing broadcast messages from DNR beacons. Theratio of localized nodes are studiedunder two different localization techniques; bounding box and triangulation. The triangulation method gives best results as it does not depend on anchor nodes.

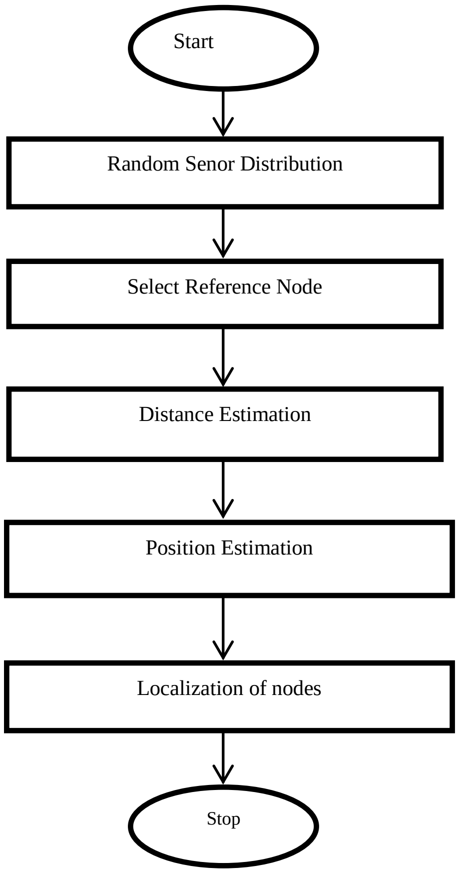

Fig 1.5 Flow Diagram of DNR

IV. SIMULATION RESULTS

In this section the simulated output for particle swarm optimization (PSO),location dispatch based on command nodes (LDBCN), dive and rise (DNR) algorithm are compared. The parameters compared are network lifetime, network coverage, energy consumption

4.1 Cluster Head Selection

The cluster head is selected in the tetrahedron shape. The cluster head collects data from nearby sensor nodes and forwards to the nearby cluster head or base station.

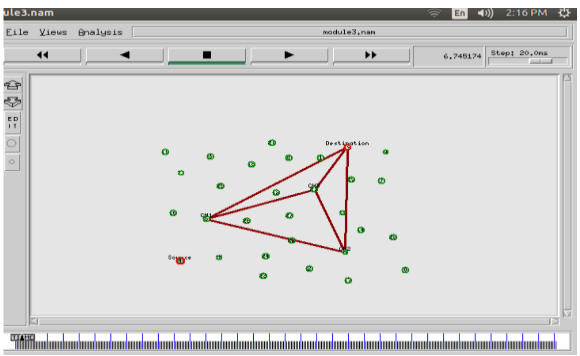

Fig1.6 Cluster Head Selection

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4.2 Distance Calculation

The distance between the each and every nodes is calculated with the Euclidean distance calculation

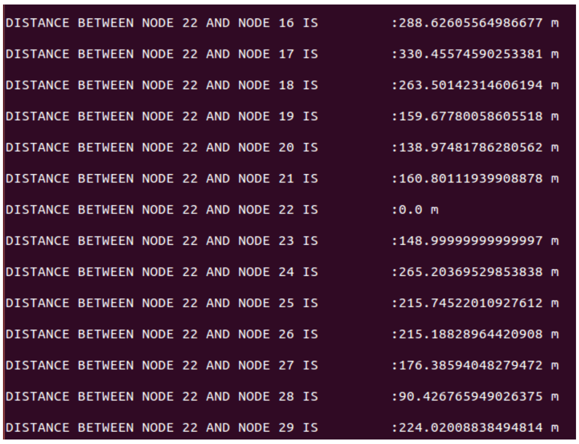

Fig 1.7 Distance Calculation Between Nodes

4.3 ENERGY CONSUMMPTION

Energy consumption is an important factor to evaluate the localization methods and it mainly depends on the average communication takes among the sensor nodes. The energy consumption is measured with the average communication cost parameter i.e., defined as the ratio between the overall messages exchanged in the network to the number of effectively localized sensor nodes

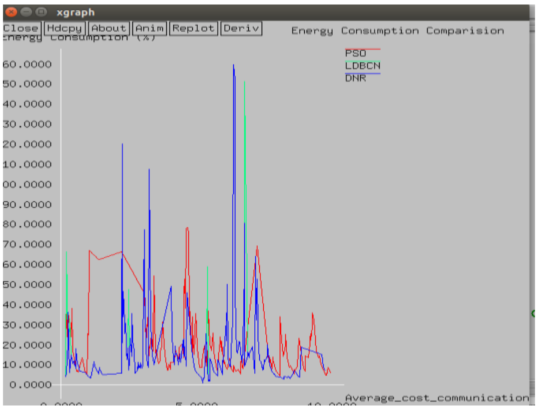

Fig 1.8 Energy Consumption

4.4 NETWORK LIFETIME

A lack of network lifetime may lead to an undesirable sub networks which may not be able to pass the information to the sinks.Network lifetime is the ratio of the number of sensornodes that can communicate with other sensor nodes to the total number of sensor nodes

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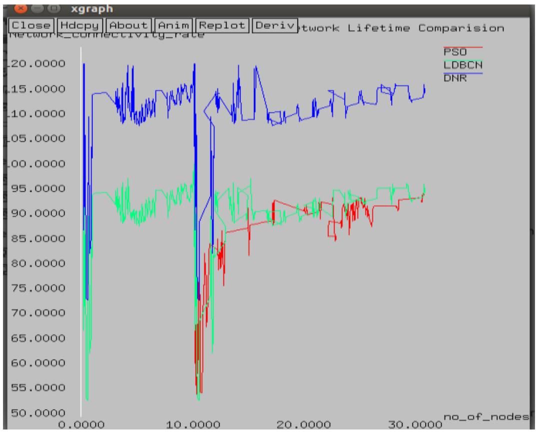

Fig 1.9 Network Lifetime

4.5 NETWORK COVERAGE

The network coverage rate changes with the proportion of beacon nodes. when the beacon node proportion is higher, then the anchor node localize the unknown node with increase in network coverage and less localization error. The dive and rise positioning algorithm covers large volume compared with the other two algorithms which is shown in Fig 1.10

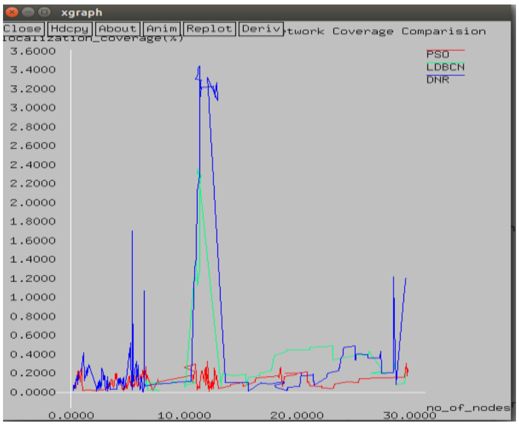

Fig 1.10 Network Coverage

V.CONCLUSION

DNR-Positioning is able to solve the localization problem in underwatersensor networks without any expensive hardware. Moreover, when compared to PSO and LDBCN no message exchange is required. Sensor nodes are able to learn their coordinates just by listening. This passive learning results in saving energy and reducing communication cost. DNR beacons can readily work with MAC protocols that assume sleep/wakeup cycles. In addition, the performance can be improved by simply adding message exchange among neighbour sensor nodes after waking up. However, DNR beacons need to surface to get GPS coordinates and they are subject to more complex currents.

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