Minimization of Energy Hole in Under Water Sensor Networks (UWSNs)

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Abstract: ***The major difference between underwater sensor network and terrestrial sensor network is use of acoustic signals as communication medium rather than radio signals. The main reason behind this is the poor performance of radio signal in water. UWSNs have some distinct characteristics which makes them more research oriented like large propagation delay, high error rate, low bandwidth and limited energy. UWSNs have their application in the field of oceanographic, data collection, pollution monitoring, off shore exploration, disaster prevention, assisted navigation, tactical surveillance etc. In UWSNs the main advantages of protocol, design is to a reliable and effective data transmission from source to destination. Among those energy efficiency plays an important role in underwater communication. The main energy sources of UWSNs are batteries, which are very difficult to replace frequently. Two popular underwater protocols are DBR and EEDBR. DBR is one of the popular routing techniques, which don't use the full dimensional location information. In this research work, we use an efficient area localization scheme for UWSNs to minimize the energy hole created. Rather than finding the exact sensor position, this technique will estimate the position of every sensor node within certain area. In addition to that we introduced a RF based location finding and multilevel power transmission scheme. Simulation results shows that our proposed scheme produces better result than its counter parts.***

Keywords: Under water senor, Routing Protocols, Depth Based Routing, forward directed graph, path optimization

1. Introduction

Sensor network have many revolutionizing benefits in the area of science, industry and government like structural monitoring, industrial applications etc. A wireless sensor network (WSN) [23] consists of randomly distributed sensor nodes in a given area to monitor physical or Environmental conditions, such as temperature changes, sound, pressure, etc. The main working principle of WSN is to collect data from group of objects distributed in a given area and send those collected data to a main location. Now a day's some bi-directional sensor is used. The WSN has many applications in military applications such as battlefield surveillance. Each sensor network node has many parts such as a microcontroller, an electronic circuit for interfacing with the sensor and an energy source, usually a battery, a radio transceiver with an internal antenna or connection to an external antenna. The major benefits of terrestrial senor networks are self-configuration maximizing the utility of energy consumed. The sensor networks are consisting of low cost nodes, dense deployment, and short range, multi-hop communication [22]. The earth is a planet with 70% of the surface covered by water. Underwater Acoustic Sensor Network (UWASNs) are mainly consists of maximum number of sensors on and underwater which can communicate through acoustic links. Like terrestrial WSNs, underwater sensor networks provide several advantages in terms of coverage, cost, and deployment. Because of their limited propagation power, radio signal (range is 50-100cm) is not suitable for underwater communication so we prefer to use acoustic communication for underwater sensor network because of long propagation range. By the advancement and growth of micro electro mechanical system (MEMS) technology and wireless communication technology, WSNs are very attractive for numerous fields. Pre requisites for UWSNs application are network efficiency and reliability in terms of high throughput, energy conservation, and low bit error rate (BER) and reduced delay. There is some distinct feature of UWSNs, which makes them popular now days are like low available bandwidth, large propagation delay, highly dynamic network topology and high error probability. Typical frameworks of UWSNs are composed ofa sink node, underwater sensor nodes, surface station etc. Acoustic signals are used for communication medium in underwater environment. The harsh underwater environment and unique characteristics of acoustic signals impose many research challenges for effective data routing in UWSNs. Sensor nodes consume more energy due to typical underwater environment condition where replacement or re changing battery is not possible.

Section 2 presents a survey of the related works, and gives an overview on some concepts which is required for the future work on energy hole minimization in under water sensor network. Section 3 presents the proposed path optimization algorithm for energy hole minimization and network life time enhancement. Section 4 presents the simulation and results of the proposed method. Section 5 concludes the discussion and gives a direction to future research in this issue, which we have discussed.

2. Related Works

Pompili, *et. al.*, have proposed two communication architectures [9] for **UW-ASN** i.e. two dimensional architectures where sensor nodes are anchored to the bottom of the ocean and the three-dimensional architecture, where sensor nodes are float at different ocean depth covering the entire ocean volume. These proposed communication architectures provide guidelines on how to choose optimal sensor deployment surface area under ocean, provide an estimate of the number of required redundant sensors, robustness of the sensor network to node failure.

Xie, *et. al*., have proposed a novel routing protocol, called Vector Based Forwarding (**VBF**) [2] which is basically a position based routing approach in which only a small number of the nodes are involved in routing. It provides scalable, robust and energy efficient routing. VBF also use a localized and distributed self-adaptation algorithm which discard the low benefit packets thus reduce energy consumption of the network. VBF is a novel protocol designed to address the routing challenges in UWSNs. It has high success of data delivery, scalable, robust and energy efficient

Zhou *et. al*., have proposed the localization problem [4] in large scale **UWSNs** which can be solved by a hierarchical approach in which the complete localization process is divided into two sub process that is anchor node localization and ordinary node localization. For ordinary node localization, a novel distributed method based on 3-dimensional Euclidean distance estimation is used. A recursive location estimation method, which also investigated the tradeoffs among the node density, the localization error, the localization coverage, the anchor percentage and the communication, cost in this approach.

Chandrasekhar *et. al*., have proposed an efficient Area Localization Scheme (**ALS**) [5] for underwater sensor networks. Global Positioning System (**GPS**) can't be used for locating nodes in UWSNs because the high frequency radio waves are absorbed by the water and can't travel so far in underwater. The ALS provides the location of a sensor within a certain area rather than the exact position. The sensors in this scheme simply record the signal levels received from reference nodes, while the sink nodes carry out most of the complex computations. By modifying system parameters, the granularity of the area estimates can be increased easily

Yan, *et. al*., have proposed a efficient depth based routing (**DBR**) [7] protocol which does not require full dimensional location information of the sensor nodes in any area. In this protocol, depth of sensor nodes can be easily obtained with an inexpensive depth sensor that can be equipped in every underwater sensor node.

Wahid, *et. al*., have proposed an energy efficient localization free protocol [8] in which a sender based approach for routing is used where the sender decides a set of next forwarding nodes in order to reduce redundant transmission. In EEDBR, sensor nodes hold the packet for a certain time before forwarding. There is a concept called holding time, which is defined as amount of time, the sensor nodes hold the packets before forwarding them to next hop. This holding time is based on residual energy of the senor nodes. A node having high residual energy has holding time less than the node having low residual energy. Therefore, the node with high residual energy forwards the packet, and the low energy nodes suppress the packet transmissions upon overhearing the transmission of the same packet. Due to this energy balancing, the sensor nodes consume their energy parallel, and none of the sensor node's battery is exhausted earlier than others. Hence, the overall network life-time is improved.

Ahmed, *et., al.*, have proposed a new clustering technique of routing layer communication i.e. a Density controlled Divide and Rule (**DDR**) [15] in which we found two types of node distribution. Distribution where nodes are arranged uniformly in the network. Another distribution where nodes are randomly distributed in different segments of network to control the density. In DDR we have tried to overcome the problem of coverage hole and energy hole through density controlled uniform distribution of nodes in different segments of network. Optimum number of CHs in each round helps to achieve balanced load distribution

Jornet, *et. al*., have proposed **FBR [**8] routing methodology which evaluates senor nodes performance when coupled with power control system. This proposed technique has an assumption that senor nodes have knowledge of their own location information which is justified in underwater system. This approach is proposed for energy efficient multi hop communication in underwater acoustic environment. It was shown that, by properly coupling routing and MAC functionalities with power control, routes can be established on demand with a minimum impact on the network performance.

3. Proposed Protocol

In underwater sensor network as the data passes through one or multiple sensor nodes, the energy consumption of the node differs from the other nodes. Therefore, the node with excessive load would quickly lose their battery power and may stop functioning. There may be other reason for which node may die like software bugs, loss of energy and other destructive agents. These dead nodes are considered as hole. This may be the reason of packet loss. To overcome this problem in this section we have introduced an efficient path optimization protocol. It will reduce the dead node counts ultimately decrease the energy consumption of underwater network and increase the network lifetime. Stability of the network will also increase. The chance of network failure will be reduced. Efficient use of energy is challenging task in UWSNs. Due to non-uniform distribution of the nodes in the network, energy holes are created. Energy holes make data routing failure when nodes transmit data back to the base station. In the existing protocol which we have discussed previously, an energy efficient routing technique for UWSNS has been proposed. In that research article pick back technique has introduced, rather than that RSSI based location identification

3.1 Drawbacks of DBR and EEDBR protocol

DBR and EEDBR use the efficient energy consumption method. In the previous chapter, we have discussed the routing strategy, which uses the energy efficient routing to decrease the energy consumption and increase the network lifetime. There may be some gap in the DBR and EEDBR protocol, which are discussed as follow;

- The two basically used underwater protocol DBR and EEDBR based on the assumption that the senor node which are present on the bottom of the underwater area can sense data only and all other nodes in underwater area will act like relay nodes. However, in practical there may be some application as if monitoring mission in which the sensing of the ocean depth is required that means the nodes must have both sensing and relaying capabilities. This leads to the improvement of these two protocols.
- The well-known underwater protocol DBR and EEDBR execute KAP for the process of information sharing and residual energy updating. This process a tradeoff between node energy values to next hop residual energy value. By frequent execution of KAP there may be depletion of nodes and energy hole creation.
- The protocol DBR and EEDBR use fixed power level for data transmission. When the network density increases, the nodes near vicinity of forwarder nodes waste the energy because of the residual energy.

3.2 Proposed Method

Efficient use of energy is challenging task in UWSNs. Due to non-uniform distribution of the nodes in the network, energy holes are created. Energy holes make data routing failure when nodes transmit data back to the base station. In the existing protocol, which we have discussed previously, an energy efficient routing technique for UWSNS has been proposed. In that research, article pick back technique has introduced, rather than that RSSI based location identification mechanisms [1] is used. It is easy to find the distance between source and destination node once the nodes became aware of the location of other nodes, which are near to their communication range. Multilevel power transmission is used to identify the location of the nodes in underwater environment. In this multilevel power transmission acoustic modem are used which increase the cost of the underwater network and the energy consumption of the network.

To overcome this problem, we intend to apply a new technique i.e. efficient path calculation mechanism to save energy. Nodes deployment is the first step in establishing the sensor network. Sensor nodes are battery powered and randomly deployed in target area. The deployment may be static may be dynamic basing upon the network topology required for the research work. After the deployment sensor network cannot perform manually. Optimizing the energy consumption is one of the major tasks in WSNs is to prolong the network lifetime. To address these issues much work has been done in this area during the last few years. If the sensor nodes are deployed uniformly, the sensor nodes near the sink send their own data as well as the date collected by other nodes away from the sink in multi-hop WSNs. In this case, the sensor nodes near the sink consume more energy than the node away from sin and die more quickly. As a result, the network will disconnect when 90% of nodes are alive having sufficient energy left unused. In this work, we investigate and try to remove the energy hole problem. We analyze the energy imbalance in these protocols and present an efficient path calculation mechanism to enhance the network lifetime for many to one WSNs. We Further we conduct extensive simulations to investigate and confirm the performance of these techniques. Simulation results show the network lifetime and the total number of nodes in the network area use to enhance the network lifetime.

Unbalanced energy consumption is a major issue in UWSNs when nodes are randomly deployed in sensor networks. Sensor nodes in the network behave as a data originator and data router. Nodes near the sink have a greater load of data and consume more energy than nodes away from a sink. Therefore, nodes near the sink deplete more energy and die quickly than other nodes, leading what is called energy hole problem (EHP) [12] around the sink. In this situation, no more data will be transmitted to the sink. So the network lifetime ends due to more depletion of energy near the sink. More sensor nodes due to dense deployment in any region may overlap and increase the hardware cost. However, dense deployment is another reason behind the creation of holes in UWSNs. In all current routing schemes using optimal path routing method, intermediate nodes in the routing path deplete their energy more quickly, which expand the area of an energy hole.

3.3 Flow Chart for the Proposed Protocol

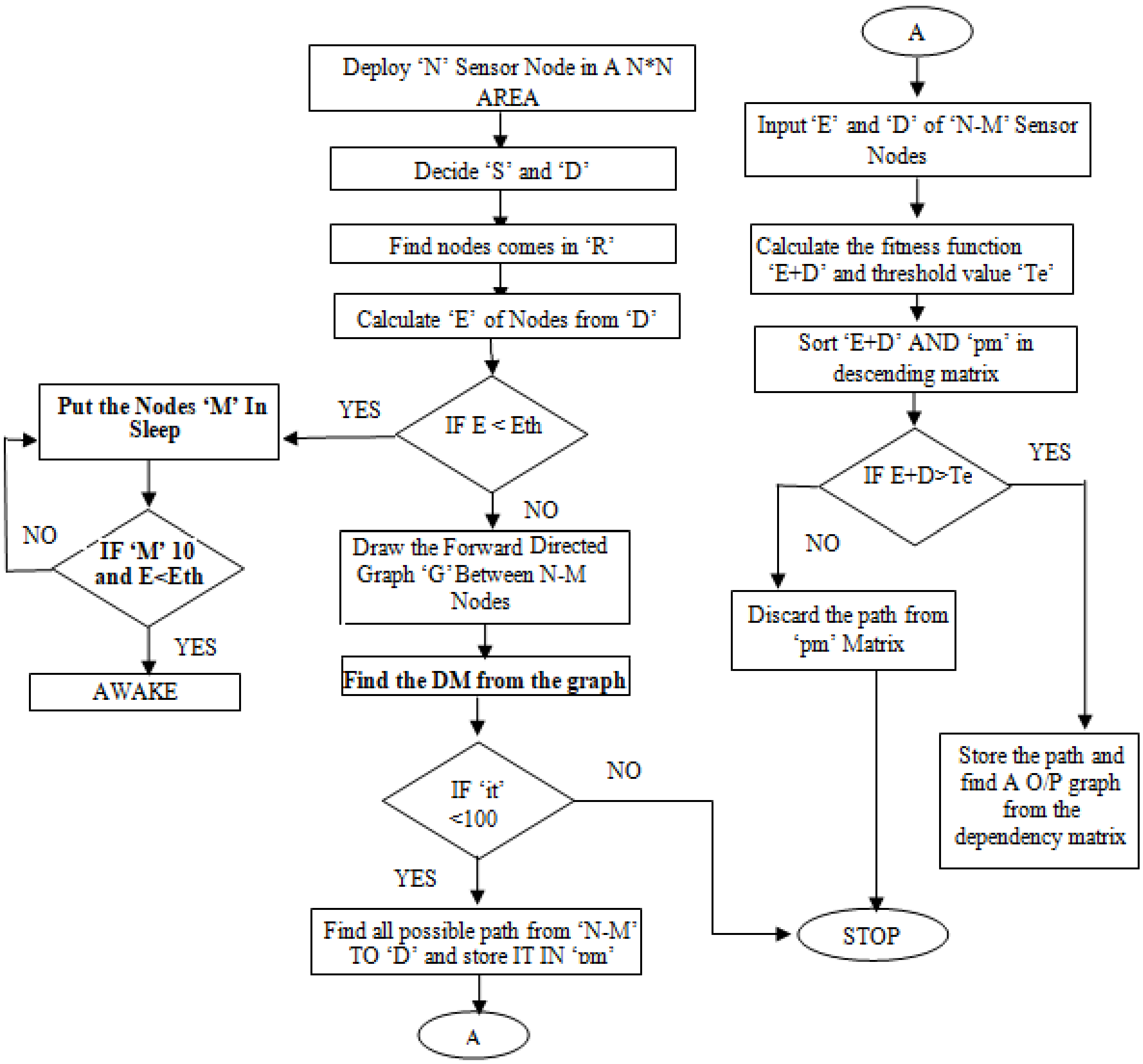

Figure 3.3: Flow chart of the proposed protocol

Working Principle

Each node in the underwater sensor network has their own energy value. We will consider the hop count of each node as their depth value. There is a threshold energy value for all the sensor nodes. In our proposed path optimization technique, we will consider depth + energy value as our fitness function to our algorithm. We will apply sleep-awake technique to reduce the number of node in the communication. We chose a one particular graph to demonstrate our proposed algorithm. In our proposed method, we chose a particular destination node 'D' for the selected graph. All other nodes present in that graph may be selected as relay nodes. Node having energy value less than the threshold value will be put in a sleep mode. Rest other nodes which we will select as relay node will find the entire possible path to transmit data to the destination node and store it in a matrix. We have already stored the energy value of each node in matrix format. Suppose we will take 50 iterations. For that, we will store the energy and depth value of each path from source node to destination node in another matrix. After that, we will sort the matrix in descending order. Considering the matrix, we will also sort the path matrix format. As we have a threshold value for our fitness function, the value of depth +energy if less than threshold value will be rejected. So the path from a selected source to destination will be reduced. Likewise, the node having energy less than threshold value will be discarded. However, the path from source node to the destination node has reduced, the load on the node having less than threshold energy value will be reduced. On each iteration different path from source node to destination node will be discarded, likewise different node through the path will also be discarded. So the chance of creation of energy hole will be reduced. Ultimately, the network life time will be improved. Underwater sensor node gain energy from the environmental source.

Network Architecture

We consider the scenario where sensor nodes are deployed randomly in a given under water region (Fig 3.3 (a) will show the deployment of sensor node in area). Generally, less than 100 meters is the communication range of WSN nodes. You can change the transmission range of a WSN node by changing the setting in nodes. We will calculate the communication range of each deployed sensor nodes and store the value in a matrix. They will connect the nodes present in a common communication range by a forward directed graph.

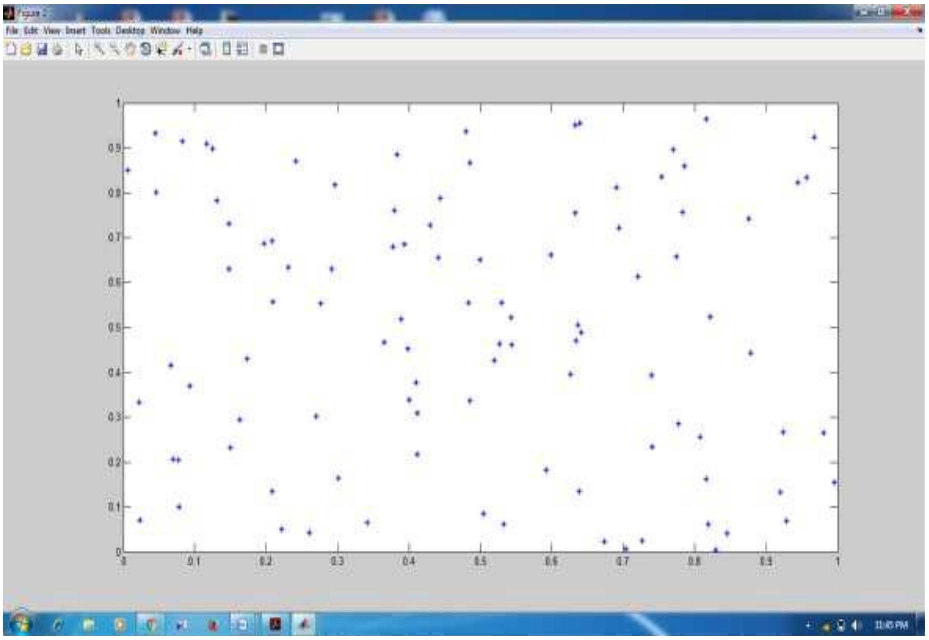

Figure 3.3 (a): Underwater Sensor Node Deployment

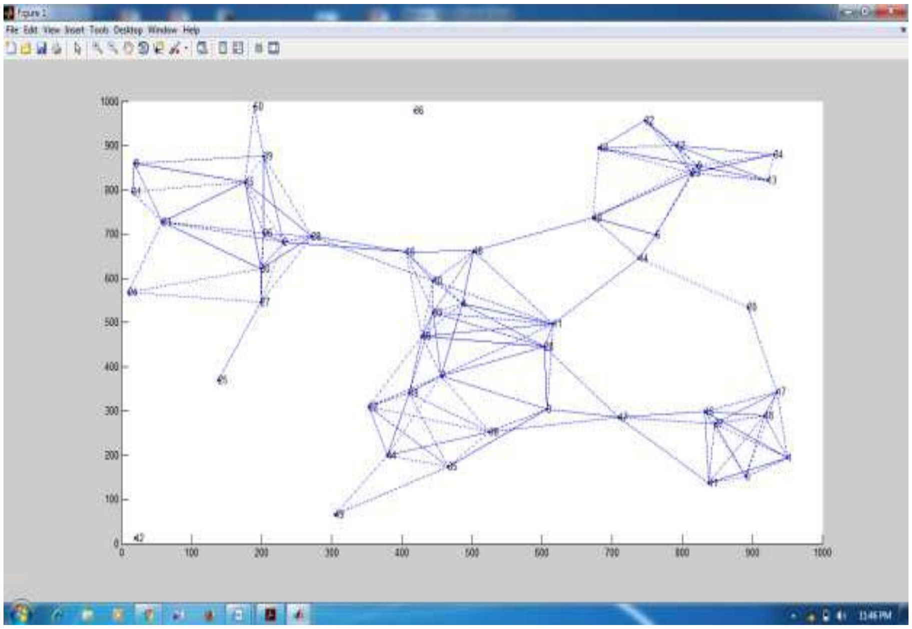

Figure 3.3 (b): Creation of Forward Directed Graph

3.4 Comparison Table

The below mentioned table will give us a comparison of several parameters such as network lifetime, energy consumption, stability and packet received at sink.

Table: Parameter Comparison of Protocols

Protocol Name	Network Lifetime	Energy Consumption	Stability	Packet Received at Sink
DBR (Existing)	Low	High	Less stable	High
EEDBR (Existing)	Low	Moderate	Less stable	Moderate
Path optimized protocol (Proposed)	High	Low	More stable	Low

4. Conclusion and Future work

The main aim of our work is to find an optimized path among number of path present from source node to destination node in order to optimize the energy consumption. If the energy consumption of the network is reduced, then the creation of energy hole will be reduced. Because energy holes are created due to the excessive load on a single node at the time of packet transmission from source node to destination. Removal of energy hole will maximize the network life time. Network lifetime may be maximizing due to decrease of number of dead nodes. Stability of the network will increase ultimately. Due to the frequent execution of KAP in DBR and EEDBR the energy hole is creation is very fast. In our protocol, the path is optimized so that the load on the nodes also decreases. Therefore, the creation of energy hole will also reduce. We have also used a sleep awake mechanism in our protocol design. Because of that, number of node selected for transmission will be decreases amount of time. We have also taken a threshold energy value to check whether the node is eligible for packet forwarding or not.

Research is always a tradeoff between gain and loss. As we have used multi-level power transmission, acoustic modem the cost of the network is very high. If the power level is varying very frequently then the energy consumption is high. Therefore, we will have to develop a protocol in MAC layer with constant power transmission level in future.

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