Routing Protocol to Increase Data Packets Transmission in Under Water Sensor Networks

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***Abstract:** Underwater wireless sensor networks consist of a certain number of sensors and vehicles that interact to collect data and perform collaborative tasks. The sensor network consists of static and mobile underwater sensor nodes. The nodes communicate point-to-point using a novel high-speed optical communication system integrated into the TinyOS stack or other small operating system, and they broadcast using an acoustic protocol integrated in the OS stack. The sensor nodes have a variety of sensing capabilities, including cameras, water temperature, and pressure. The mobile nodes can locate and hover above the static nodes for data mulling, and they can perform network maintenance functions such as deployment of sensor nodes, relocation of sensor nodes, and recovery from failures. Underwater wireless sensor networks have been used widely in many applications where sensor nodes collaborate with each other to execute monitoring tasks with reliability and energy-efficiency In this work, we will design a routing protocol that will enhance the packet transfer rate from nodes to base station using hierarchical routing technique. The proposed work is to design a routing protocol which will enhance packet transfer rate and the results will be compared with other routing protocols of same category like LEACH.*

1. INTRODUCTION

Energy saving is a major concern in UWSNs because sensor nodes are powered by batteries and it could be difficult to replace or recharge batteries in aquatic environments. In acoustic networks the power required for transmitting is typically about 100 times more than the power required for receiving [1]. The design of robust, scalable and energy-efficient routing protocols in this type of networks is a fundamental research issue. Most existing data forwarding protocols proposed for ground-based sensor networks cannot be directly applied because they have been designed for stationary networks [2-4]. The existing multi-hop ad hoc routing protocols are not adequate because they employ flooding techniques for packet routing (at least during the route discovery mechanism) that would lead an UWSN easily to energy exhaustion because in UWSNs the medium is highly variable and the routing overhead due to updates could be very high [5].

2. SYSTEM ARCHITECTURE

In Figure 1, we see four different types of nodes in the system. At the lowest layer, the large number of sensor nodes is deployed on the sea floor (shown as small yellow circles). They collect data through attached sensors (*e.g.*, seismic) and communicate with other nodes through short-range acoustic modems. They operate on batteries, and to operate for long periods they spend most of their life asleep. Several deployment strategies of these nodes are possible; here we show them anchored to the sea floor. (They could also be buried for protection.) Tethers ensure that nodes are positioned roughly where expected and allow optimization of placement

for good sensor and communications coverage. Node movement is still possible due to anchor drift or disturbance from external effects [6].
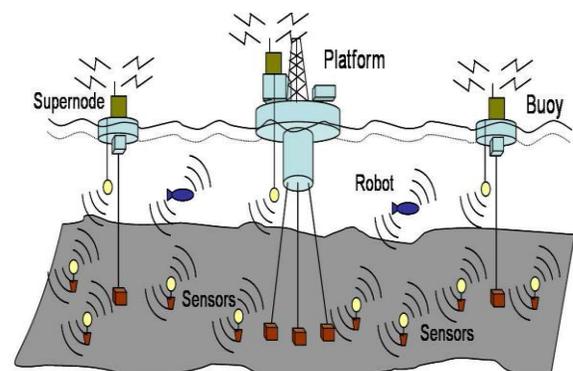

Figure 1: Underwater Sensor Network Architecture [6]

2.1 Challenges and Issues

Major challenges in the design of underwater acoustic networks are [7]:

1. Propagation delay is five orders of magnitude higher than in radio frequency (RF) terrestrial channels and variable;
2. The underwater channel is severely impaired, especially due to multipath and fading problems.
3. The available bandwidth is severely limited.
4. High bit error rates and temporary losses of connectivity (shadow zones) can be experienced.
5. Underwater sensors are prone to failures because of fouling and corrosion.

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6. Battery power is limited and usually batteries cannot be easily recharged, also because solar energy cannot be exploited.

The issues are:

1. MAC layer: In network packets are move from one layer to another layer because of MAC layer. Underwater nodes have extremely-limited bandwidth, long delay so they share available resources. Medium access control layer is used to access the underwater acoustic channel [7]. MAC layer schedules each node to access physical medium. MAC layer also setup some parameters and determine resources that physical layer could have.

2. Network layer: Network layer contain the information about the routes. It's responsible for the routing packets and it contains the information of path between sender nodes to destination node. It is having two routing methods one is virtual circuit routing and the second is packet switch routing [8]. In first, the network use virtual circuits to decide the path between sender and receiver. And in second one every node that is part of transmission has its own routing decisions. Now the packet switching has further two types. One is proactive routing and another is reactive routing.

3. Physical layer: Physical layer link with basic hardware and hardware transmission technologies. UAN is unique because of physical channel [9]. For underwater channel electromagnetic wave band have high attenuation but go through only small parts of long-wave bands. So here we need a large antenna and high transmission power. The communication is done in underwater with acoustic signal because acoustic signals can travels at long distance in underwater.

4. Application Layer: Application layer provides the network management protocol. This layer is used for the problem partitioning and resource allocation [10]. It s also use for Synchronizing communication, detecting resource availability and identifying communication partners.

3. ALGORITHM FOR POWER EFFICIENT HIERARCHICAL ROUTING

[1] Initially, base station is at position 310 X 310 and 200 nodes are setup in a particular region (300 x 300) and each node has equal energy (1 joule).

[2] In round 1, Cluster Head will be created according to probability condition.

[3] The decision of each node to become cluster head is taken based on the suggested percentage of cluster head nodes *p*. A sensor node chooses a random number, *r*, between 0 and 1. If this random number is less than a threshold value, *T (n)*, the node becomes a cluster-head for the current round. The threshold value is calculated based on an equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes

that have not been selected as a cluster-head in the last $(1/P)$ rounds, denoted by G. *T (n)* is given by:

$$T(n) = \begin{cases} \dfrac{p}{1 - p * (r \bmod \dfrac{1}{p})} & if\ n \in G, \\ 0 & \text{otherwise} \end{cases}$$

(1)

[4] Optimal number of cluster heads is estimated to be 10% of the total number of nodes. and,

Threshold energy (E_T) =

$k*(E_{Tx}(l,d) + E_{Rx(l)} + E_{DA} + Eamp)$ (2)

Here, Threshold energy is the energy needed to transmit data from cluster head to base station.

Then, Nodes sends the data to their respective cluster heads and energy consumption will be calculated.

$Enode = k*(E_{Tx}(l,d) + Eamp)$ (3)

[5] Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated for each node and cluster heads.

$Ecluster = k*(E_{Tx}(l,d) + E_{Rx(l)} + E_{DA} + Eamp)$ (4)

[6] In round 2, the nodes will become cluster heads according to probability condition i.e. according to minimum distance from base station and threshold energy.

[7] After selection of cluster heads, Nodes sends the data to their respective cluster heads, that will be selected according to the minimum distance of a particular node from cluster heads and energy consumption will be calculated.

[8] Cluster Head will aggregate the data and send it to the base station and energy consumption will be calculated.

[9] This process will be repeated until the whole network gets down or number of rounds finished.

[10] Performance will be evaluated according to parameters like network lifetime, energy dissipation, no. of data packets sent etc.

4. IMPLEMENTATION AND RESULTS

4.1 Parameter Value

Network field: 300x300m

N (Number of nodes): 200

Initial energy: 1 Joule

Eelec (E.Dissipation for ETx&ERx):50 nJ/bit

ε fs (free space): 10 pJ/bit/m^2

εmp (Multipath fading): 0.0013 pJ/bit/m^4

EDA (Energy Aggregation Data):5 nJ/bit/signal

Data packet size: 4000 bits

Tool used for implementation: MATLAB 7.6.0

4.2 Results

Figure 2 shows the deployment of nodes and base station in a particular region. The region we have taken for simulation is
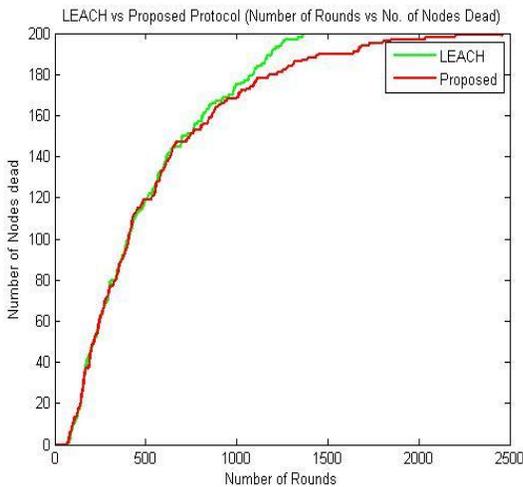
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300m x 300m. The 'o' symbol denotes the nodes and 'x' symbol denotes the base station (sink). The position of nodes is taken similar in LEACH as well as in proposed protocol.
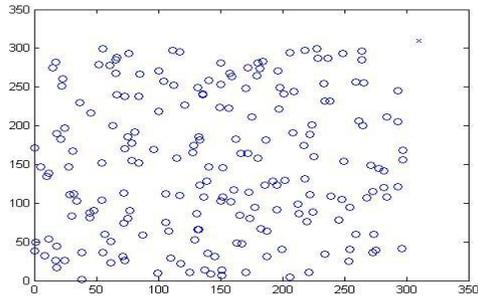

**Figure 2:** Deployment of nodes and base station

Figure 3: Number of Rounds vs Number of Nodes Dead

Figure 3 shows the comparison of routing protocols LEACH and Power Efficient Hierarchical Routing (proposed routing technique) in terms of Number of nodes dead. Figure 3 shows the overall lifetime of the network. Here, we observe that proposed routing technique performs better as compared to LEACH protocol.
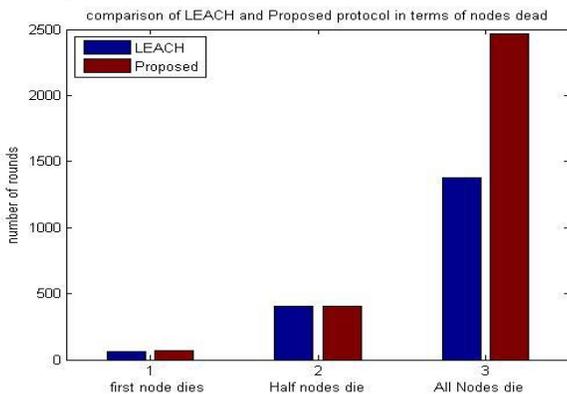

Figure 4: Comparison of Network Lifetime LEACH and proposed routing technique

Figure 4 also shows network lifetime with the help of BAR graph. Figure 4shows exactly in which round the first node died, 50% nodes of the network died and whole network died. It can be observed from the figure 4 that proposed power efficient hierarchical routing technique performs better as compared to LEACH.
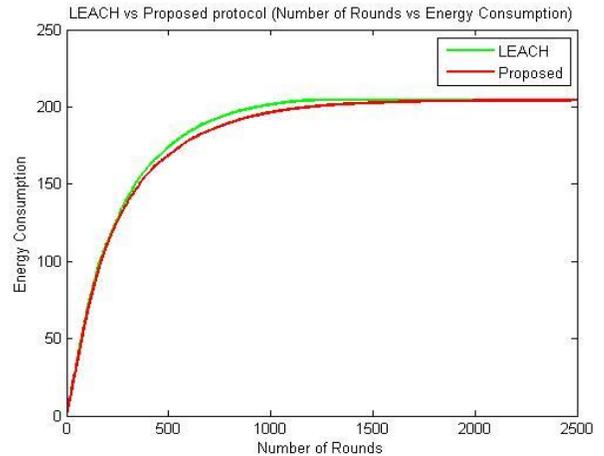
Figure 5: Number of Rounds vs Energy Consumption

Figure 5 shows the lifetime of the network. It shows that how energy of the network consumes step by step and finally whole network goes down. It can be observed from the figure 5 that, proposed power efficient hierarchical routing technique consumes less energy and sustain more number of rounds as compared to LEACH protocol.
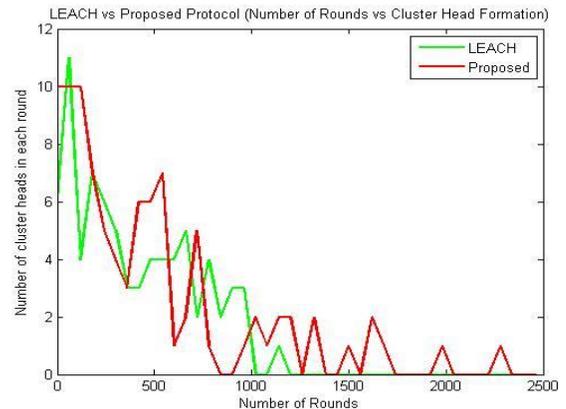
Figure 6: Number of Rounds vs Number of Cluster head in each round.

Figure 6 shows the cluster head formation in each round. Overall, both protocols have comparatively equal number of cluster heads. But proposed routing is showing more stability as compared to LEACH protocol. So, proposed routing technique will enhance the lifetime of the network.

Figure 7 shows how much data will be sent from nodes to SINK or Base Station. From figure 7, we can observed that, in LEACH protocol data sent to base station is relatively less as compared to proposed routing technique.

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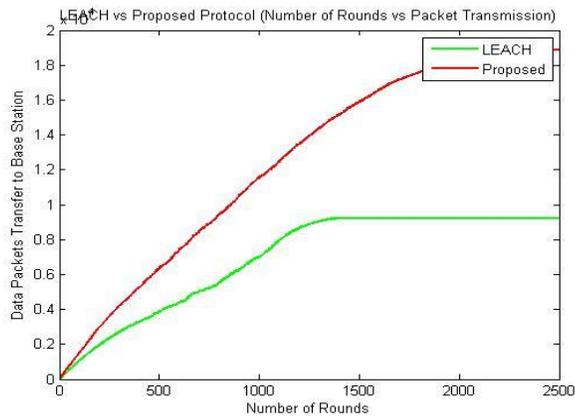
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Figure 7: Number of Rounds vs Data Packets sent

5. CONCLUSION AND FUTURE SCOPE

This new routing protocol named Power Efficient Hierarchical Routing Protocol (proposed routing technique) which is hierarchical routing. In proposed routing technique, the base station first collects information about the logical structure of the network and residual energy of each node. So, with the global information about the network base station does cluster formation better in the sense that it has information about the residual energy of each node. Finally, proposed routing technique is compared with already developed routing protocol Low Energy Adaptive Clustering Hierarchy (LEACH) by the help of MATLAB. A comparison between two is done on the basis of energy dissipation with time, data packet sent and the system lifetime of network.

In WSN, hundreds or thousands of sensor nodes are randomly scattered in the sensor field. These nodes sense the data and send this sensed data to the cluster head (in case of hierarchical routing) or directly to the base station according to the TDMA (time division multiplexing access) given by cluster head or base station respectively. But there is no security and authentication while communicating. So this can be another research area where this can be considered. So in future, security can be applied to proposed routing technique.

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