Ritu Goyat et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 5, Issue 2, June 2018, pp. 16-20

Reliable and Power Efficient Routing in Underwater Sensor Networks

Ritu Goyat*, Aakanksha Mahajan**

MTech Research Scholar*, Computer Science and Engineering Department, PIET College, Samlkha, Panipat, Haryana, India

Assistant Professor**, Computer Science and Engineering Department, PIET College, Samlkha , Panipat, Haryana, India

Abstract: **The sea is a fascinating large expanse of water that has always attracted people who wanted to solve its mysteries. The oceans alone cover 70% of our planet and along with rivers and lakes are critical to our well-being. For centuries the access of human beings to the sea was limited to the surface or the nearby water, because the researchers had to use wire-line instruments and sampling equipment located at the sea surface. 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.**

I. INTRODUCTION

Underwater acoustic network are formed by establishing two ways acoustic link between various instruments such as autonomous and sensors [1]. To increase the operation range of autonomous underwater vehicles. It consists of a variable number of sensors and vehicles that are deployed to perform collaborative monitoring tasks over a given area. To achieve this objective, sensors and vehicles self-organize in an autonomous network which can adapt to the characteristics of the ocean environment. In this research various applications of underwater acoustic network are considered like better communication in which we focus on the information exchange between communicating nodes. The application [2] of underwater acoustic network is environmental monitoring. It’s also used in underwater explorations. They can be easily done by UANs but difficult for human due to high water pressure. UANs are also used in Disaster prevention. It’s done by deploying acoustic sensor network in remote locations. The different underwater activates like ocean related disaster, tsunami are easily monitored by UANs. There are some challenges [5] in the design of underwater acoustic networks.

1.1. Challenge in UWSN: The radio wave band frequency is restricted due to absorption in under water. The bandwidth of underwater acoustic channels working over several kilometers is about several tens of kbps, whereas short-range systems over several tens of meters can reach at hundreds of kbps. The path loss, noise, multipath, and Doppler spread affect the underwater acoustic communication channels. All these factors generate high bit-error and propagation delay.

1.1.1 Energy efficiency in UWSN: The major difficulty in deploying UWSN is energy efficiency[3], [5] because in case of terrestrial sensor networks battery failure can be identified easily and replaced easily but in case of underwater sensor networks frequent replacement of battery is tedious, hence the battery lifetime should be maintained for long period. In each sensor node for longtime communication the battery life should be maintained similar to the other nodes so that the sensor node will equally participated in the network.

1.1.2 Reliability and data security: Another two major issues are reliability and scalability[4], [5] of sensor nodes. A reliable network should be scalable network. Each network of sensor nodes should be capable of providing equal performance to all sensors which are present or going to be added in the network which is firmly known as scalability and also equal performance in sensor nodes will surely provide reliable data communication. Both reliability and scalability depend upon the performance of the routing protocol which is used in the network for routing purpose so that equal preference to each node in a network will improve the reliability and scalability of the network. Data security is another major issue. Data integrity is the most important phenomena in all types of communication. Some effective cryptographic schemes need to be employed to improve the data security.

Thus, it is widely accepted that conventional routing protocols are not appropriate for UWSN, and it calls for customized on the fly routing algorithms[11]. In addition, in UWSN each node plays the role of a router and has limited battery energy. Therefore, it is very important to use energy efficiently in under water networks. In order to maximize the lifetime of networks.

- Traffic should be sent via a route that can avoid nodes with low energy, while minimizing the total energy spent in transporting packets from source to destination.
- Each node's transmission range should be optimized properly to avoid early nodes' failure which may lead to network partition.

II. System Architecture

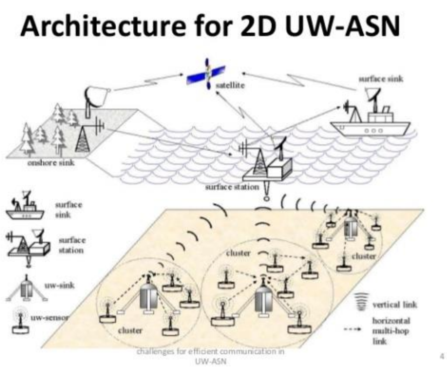

Figure 1 Underwater Sensor Network Architecture [6]

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].

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;
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.

III. 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:

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

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.

4. 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.

IV. Implementation and Results

4.1 Parameter Value

Network field: 300x300m
N (Number of nodes): 300
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

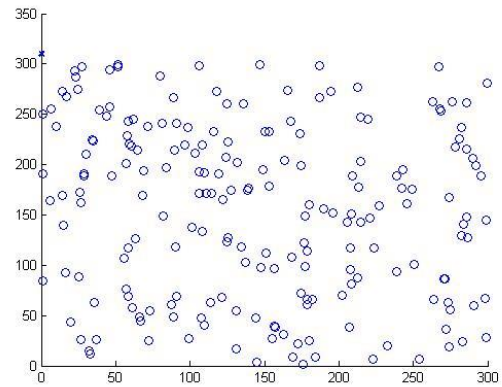

Figure 2 Deployment of nodes and base station

Figure 2 shows the deployment of nodes and base station in a particular region. The region we have taken for simulation is 300m x 300m. The 'o' symbol denotes the nodes and 'x' symbol denotes the base station (sink) placed (0,310). The position of nodes is taken similar in LEACH as well as in proposed protocol.

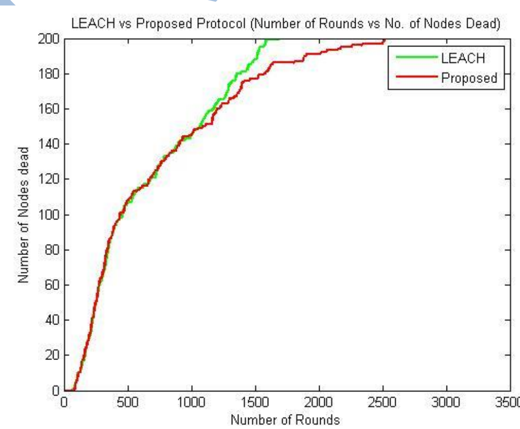

Figure 3 Number of Rounds vs Number of Nodes Dead

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 can observe that proposed routing technique performs better as compared to LEACH protocol.

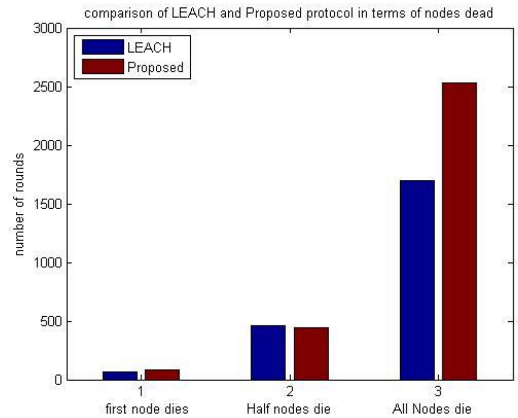

Figure 4 Comparison of Network Lifetime LEACH and proposed routing technique

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.

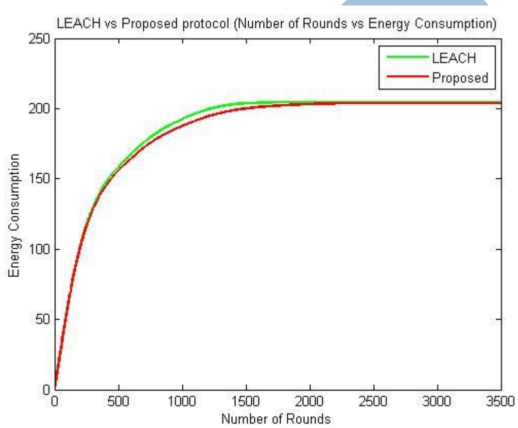

Figure 5 Number of Rounds vs Energy Consumption

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.

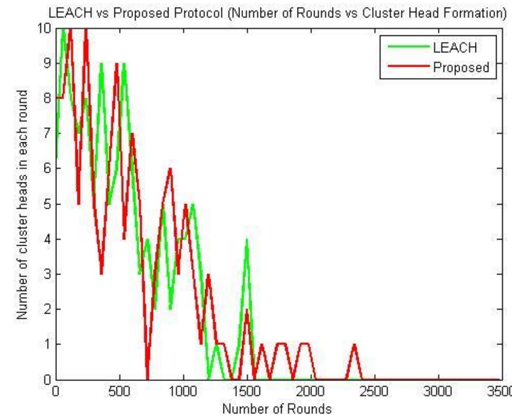

Figure 6 Number of Rounds vs Number of Cluster head in each round.

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.

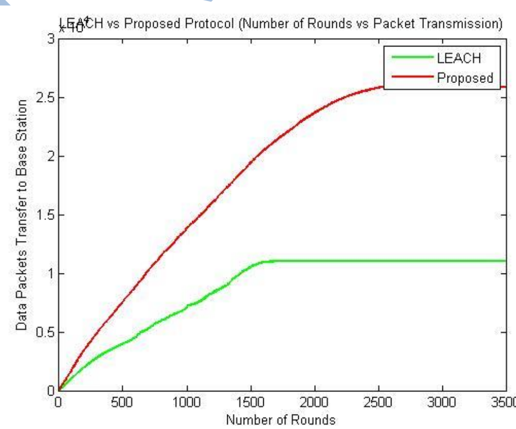

Figure 7 Number of Rounds vs Data Packets sent

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.

V. 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.

References

[1] Abdul Wahid, Kim Dongkyun, "Analyzing Routing Protocols for Underwater Wireless Sensor Networks", *International Journal of Communication Networks and Information Security (IJCNIS)* Vol. 2, No. 3, December 2010.

[2] Yibo Zhu, Zhong Zhou, Zheng Peng, Michael Zuba, Jun-Hong Cui, "An efficient geo-routing aware MAC protocol for underwater acoustic networks", *ICST Transactions on Mobile Communications and Applications*, Volume 11, Issues 7–9, July–September 2011.

[3] Abdul Wahid and Dongkyun Kim, "An Energy Efficient Localization-Free Routing Protocol for Underwater Wireless Sensor Networks", *Hindawi Publishing Corporation International Journal of Distributed Sensor Networks*, 2012.

[4] I. Vasilescu, K. Kotay, and D. Rus , "Data Collection, Storage, and Retrieval with an Underwater Sensor Network", 2005 ACM.

[5] Michele Zorzi, *Fellow*, *IEEE*, Paolo Casari, "Energy-Efficient Routing Schemes for Underwater Acoustic Networks", *IEEE journal on selected areas in communications*, VOL. 26, NO. 9, DECEMBER 2008.

[6] N. Nicolaou, A. See, P. Xie, J.-H. Cui, D. Maggiorini, "Improving the robustness of location-based routing for underwater sensor networks", *Proceedings of IEEE OCEANS'07*, Aberdeen, Scotland, June 2007.

[7] D. Pompili, T. Melodia, I.F. Akyildiz, "Routing algorithms for delay insensitive and delay-sensitive applications in underwater sensor networks", Proceedings of ACM Conference on Mobile Computing and Networking (MobiCom), Los Angeles, CA, September 2006.

[8] M. Abolhasan, T. Wysocki, E. Dutkiewicz, A review of routing protocols for mobile ad hoc networks, Ad Hoc Networks 2 (1) (2004) 1–22.

[9] P. Bose, P. Morin, I. Stojmenovic, J. Urrutia, Routing with guaranteed delivery in ad hoc wireless networks, ACM Wireless Networks 7 (6) (2006) 609–616.

[10] Xiaobing Wu, Guihai Chen and Jinming Chen, "Energy-efficient and Topology-aware Routing for Underwater **Sensor Networks", *IEEE,* 2010.**

