

# An Overview of Energy Efficient Routing Protocols for Acoustic Sensor Network

V. P. Dhivya, R. Arthi

**Abstract**—Underwater acoustic network is one of the rapidly growing areas of research and finds different applications for monitoring and collecting various data for environmental studies. The communication among dynamic nodes and high error probability in an acoustic medium forced to maximize energy consumption in Underwater Sensor Networks (USN) than in traditional sensor networks. Developing energy-efficient routing protocol is the fundamental and a curb challenge because all the sensor nodes are powered by batteries, and they cannot be easily replaced in UWSNs. This paper surveys the various recent routing techniques that mainly focus on energy efficiency.

**Keywords**—Acoustic channels, Energy efficiency, Routing in sensor networks, Underwater Sensor Network.

## I. INTRODUCTION

THE sea is an entrancing large expanse of water that has always concerned people who wanted to solve its mysteries. Currently there is a growing need of underwater monitoring, but the available technologies do not calculate the demanding requirements such as dynamic topology, less battery power [1]. Association of nodes that collect data use point to point communication [2], [3]. In aquatic environments, batteries powered sensor nodes and it is not easy to replace or recharge. So energy saving becomes an important concern in UWSNs. The power needed for receiving data packet is 100 times less than the transmitting process [4].

The power management is a major challenge which can be in the criteria of computation power and battery power. To overcome this challenge network can use a large number of lower sensors with minimal energy consumption by the capable use of the memory and the power. Clustering of the nodes in sensor network aid in mainly data aggregation and also to remove the collision of data generated from the various nodes [5]. When compared to terrestrial networks, electromagnetic waves cannot propagate in underwater sensor networks.

Various characteristics of the electromagnetic and acoustic channels are mainly used for communication in Underwater. Environmental monitoring, underwater exploration, tactical surveillance and mine detection are some of the applications of the underwater sensor networks. In UWSNs, consider two

different scenarios: Deep and shallow water. Shallow water indicates that the depth is lower than 100m, while deep water is used for deeper ocean [5]. The analysis had proven that the routing protocols depend on the clustering scheme to save energy and confirm a better performance in shallow water.

Different protocols have been designed to satisfy the various requirements of the acoustic communication such as bandwidth efficiency, delay efficiency, reliability and delivery ratio, cost efficiency. Here energy efficiency is considered and mainly depends on many metrics which should be measured while scheming the protocol.

## II. RELATED WORK

Energy efficient routing protocols are basically designed for sensor networks and most of these methods are not directly applicable to USN. Many challenges are focused in UWSNs and due to little protocols available for energy efficiency the research effort is progressively getting slow towards creating protocols [5]. The main goal is to create awareness of the various challenges that persist in UWSNs. A survey, focus on the energy efficient network protocol is attempted for the sources of power consumption along with conservation mechanism. This paper basically focused on the study of energy efficiency techniques used in underwater sensor network.

### A. Vector Based Forwarding (VBF)

UWSNs bring many challenges to the network protocol design which are overcome by introducing novel routing protocol called VBF. VBF mainly aims to provide scalable, robust and energy efficient routing. It deals with a routing problem in UWSNs and basically an integration of localization and routing. Localization and routing are performed at the same time [6].

In fundamental nature, VBF is a geographic routing approach and it does not require any state information on the sensor nodes because only a small number of nodes are taken placed during the packet forwarding. Data packets are transmitted along redundant and interleaved paths which help to tackle the problem of packet losses and node failures.

The concept of a vector like a virtual routing pipe is proposed and all the available packets are transmitted through this pipe from the source to the destination. A node which is closer to this pipe or “vector” can able to forward the packet [7]. Every packet contains a RANGE field that can be used by sensor nodes to decide if they are closing sufficient to the routing vector and suitable for packet forwarding [5]. Additionally, we develop a localized and distributed self-

Mrs.V.P.Dhivya, Assistant Professor, is with the Department of Information Technology, K. S. Rangasamy College of Technology, Namakkal District, Tamil Nadu India (Mobile: 9443696777; e-mail: dhivyavp2014@gmail.com)

Ms. R.Arthi, Post Graduate Scholar, is with the Department of Information Technology, K. S. Rangasamy College of Technology, Namakkal District, Tamil Nadu India (Mobile: 9994138751;e-mail:santhirajarthi@gmail.com)

adaptive algorithm to enhance the act of VBF. The self-adaptation algorithm permits the nodes to evaluate the benefit to forward packets and mainly reduce energy consumption by removal low benefit packets [6].

#### *B. Energy Optimized Path Unaware Layered Routing Protocol for Underwater Sensor Networks (E-PULRP)*

A Path Unaware Layered Routing Protocol (PULRP) was proposed for both 2D non-uniform distributions of underwater sensor nodes [8] and 3D UWSN with a uniform distribution of sensor nodes [9]. In underwater, sensor node consists of a limited quantity of battery power, so it can easily get exhausted and replacing of node is very difficult in UWSN. To overcome, E-PULRP was proposed for closely deployed 3D UWSN [10]. E-PULRP protocol is independent towards the location information, time synchronization or fixed routing in distributed manner [5].

E-PULRP algorithm consists of two phases, communication phase and Layering phase. In layering phase, layered architecture is developed with the intermediate/sink node at the center and sensor nodes covering different layers around it. Around the sink node form a same hop count layer and contains set of concentric shells. The layering structure makes sure that the packet is transmitted towards the sink node. In communication phase, packets are forwarded from source to sink node using selected intermediate relay nodes. Each layer, the intermediate relay node is identified and named as potential relay nodes. In order to achieve the energy optimization, on the fly routing protocol have been proposed in UWSN [11].

#### *C. A Mobile Delay-Tolerant Approach (DDD)*

In Underwater sensor environment consist of many challenging and promising applications. In UWSNs, acoustic modems require high power and become more critical when compared to traditional sensor networks. To overcome of this problem Delay-Tolerant Data Dolphin (DDD) have been proposed [12].

In DDD, mobility of collector node is called Dolphin. In that stationary sensor node can sensing the information that can be harvested by dolphins. DDD scheme used to avoid energy expensive multi-hop communication and every sensor node tries to transmit the collected data to the nearest dolphin with one-hop distance [7]. Dolphin nodes are assumed based on large memory and energy conserves. Hence, they will collect and store the event that will occur in the field. Finally, it will upload their memory to a near-shore base station for data delivery process [12]. The dolphin admits its occurrence by sending beacons to the sensors. Once the sensor identifies the presence of dolphin the data is forwarded to the dolphin. Once the dolphin reached the distance of the sink node, it will easily deliver all the collected data. Minimizing the number of dolphins deployed in UWSN is a vital need for reducing the cost of the networks. Each dolphin consists some amount of collected data, when reducing the dolphin node easily affect the collection of the data [5].

We calculate the efficiency of this protocol by adding the lifetime, thereby minimizing the energy consumption based on the delivery ratio and delay. The dolphin is placed at one hop distance in that sensed data minimize the energy consumption by sensing the data [5].

#### *D. Distributed Minimum-Cost Clustering Protocol (MCCP)*

In UWSNs, node clustering problem is formulated into cluster-centric, cost based optimization, trouble with an aim to get better energy efficiency and extend the lifetime of the network. For this intention, cost metric includes the three parameters that are most related to the energy status of the cluster, which includes the remaining energy of the cluster head and its cluster members; the sum of energy consumption of the cluster member for sending data to the cluster head; cluster head and UW sink have a relative location between them. To overcome formulating a problem, a new distributed clustering protocol called minimum-cost clustering protocol is proposed [13].

In MCCP, minimum-cost clustering algorithm (MCCA) was proposed based on selecting clusters. In this system all available sensor nodes are candidates and suitable to construct their neighbor set and their exposed neighbor set. Then each candidate finding the combination of elements in its uncovered neighbor set and also producing its potential clusters [14].

In UWSN, the average cost of that particular cluster will be evaluated and broadcasted to all the candidates within the range of 2-hop with its cluster-head ID [7]. It includes two stages of the process: In the initialization stage where the candidate cluster is selected and execution stage, candidate node with minimum cost is selected as the cluster head. Finally MCCP is compared to against the HEED protocol in ad-hoc networks and it represents to be more energy efficient [5].

#### *E. Temporary Cluster Based Routing (TCBR)*

In underwater sensor networks, many multi-hop routing protocols have been proposed and main problem occurs in multi-hop routing where nodes around the sink drain consumes more energy and leads to die early. To overcome this problem and make energy consumption further equal throughout the network proposed a Temporary Cluster Based Routing [15].

In TCBR, multiple sink nodes are deployed on the water surface which is used to collect data packets from various fields. Packets can be received by using radio communication. It includes two types of nodes: ordinary node and courier node. Ordinary node which is used to sense the event occurring, collect information and tries to forward some packets to a nearer courier node. Less number of courier nodes will be used and they can use to sense as well as receive the data packets from the various ordinary nodes and then finally forward those to surface sink [7]. Only a small number of courier nodes are required to complete the equal energy consumption task. Courier node can collect data from the communication range of every sensor node. Since all the

sensor nodes will keep their data packets in an inadequate buffer until a courier node reaches them [16].

#### *F. Location-Based Clustering Algorithm for Data Gathering (LCAD)*

The main source of energy consumption for a sensor is Data transmission phase. Indulgence of energy through the data transmission is proportional to the distance occur between the sender and the receiver. And includes another problem with the multi-hop approach is that around the sink node, large number of data packets are draining their energy. To overcome of these two problems, cluster based architecture for three dimensional underwater sensor networks was proposed [7].

The sensor nodes are deployed in some fixed relative depths from each other. All sensor nodes are planned in cluster format with multiple cluster heads. Cluster head is selected based upon the position of the sensor in the cluster. In LCAD, the entire network is divided into three dimensional grid. In this communication process is listed out in three stages: the cluster head is selected in the setting up stage, where in data collection stage data can send it from the node form same cluster to the cluster head. Finally, at transmission stage, all data are gathered from cluster head transmitted to the base station using Autonomous Underwater vehicles [17].

#### *G. Reliable and Energy Balanced Routing Algorithm (REBAR)*

In Underwater, movements make the positive factor which is useful to balance energy depletion in the network. Nodes can be moved into the network and start to alternate around the sink node. The energy balanced routing algorithm tries to solve the problem of network partitioning by changing the position of the node. Sometimes frequent node is involved to forward a data that leads to die earlier. In this process, assume that every node knows its location and the location of the sink, but they planned an adaptive scheme which includes data propagation range used to balance the energy consumption throughout the network [7]. It will consume high energy in wide broadcast network. Every sensor node has different communication radii; it depends upon the distance between the sink and nodes. Energy is reduced using small values of node which is near to the sink.

In underwater sink node is fixed and stationary at the center of the surface and remaining sensor nodes are deployed randomly. Each sensor node contains unique ID and has a fixed range. In that, assuming every node knows its location and location of sink through multi-hop routing.

The concept of changing node position has a problem in REREAR. In simulation results, gives a positive sign of movement of nodes and assumed as nodes know their current location information and final destination [7]. Sometimes large movement of nodes also affects network performance while nodes need to update their location movement often. Movements will occur in both vertical and horizontal directions were as a bottom node move to the surface and it will come back to the bottom.

In the real setting it is not possible, but in simulation has been focused on delivery ratios and energy consumption with various node speeds. Finally, it will not provide any information about end-to-end delays.

#### *H. Energy-Efficient Routing Protocol (EUROP)*

Underwater Sensor nodes are designed with battery power and it cannot be easy to replace; therefore Power efficiency has become a critical issue for these environments. To solve this problem, we developed an energy-efficient routing protocol called EUROP. It is used to reduce the amount of energy that consumed in the routing process [7].

An energy efficiency protocol can be divided into three based on the techniques they are in the plan, such as: Transmission relay based protocol, vector routing protocol and clustered protocol. Transmission relay protocols are mainly based on the various sets of nodes called as relay nodes and considered to be interfaced nodes between the sink and source. The Vector routing protocols help in avoiding the network wide calculation and routing table. Clustering is a most productive attempt in Energy Efficiency [5]. The pressure sensor will be suggested as a significant indicator to get its node depth position.

Using Pressure sensor, which eliminates the requirement of hello messages and helpful for increasing the energy efficiency. These sensor nodes are deployed in various depths in various locations to observe the event occurring. The length of wire can be adjusted to synchronize the depth of the sensor node. Different depth of sensor nodes will form layers, and communicate with the help of acoustic channel. The depth sensor node is introduced to eliminate control packets and increase energy efficiency [7].

### III. SUMMARIZATION OF ENERGY EFFICIENT ROUTING PROTOCOLS

Table I shows the review of different energy efficient routing protocols for UWSNs. It's mainly based on techniques and characteristics of various protocols. The main aim of this review is to understand the concept of various routing protocols that are available in UWSNs.

### IV. CONCLUSION

Underwater sensor networks contain the unique behavior of dynamic topology and due to these routing sensor networks become a more challenging issue. In this paper, we have reviewed on energy efficiency routing techniques that are exploited to save energy and also increase the lifetime of deployed nodes. It has been confirmed that the clustering scheme depends on the scalability of nodes. The paper may serve researchers who are focusing on developing a routing algorithm for the USN.

TABLE I  
REVIEW OF DIFFERENT ENERGY EFFICIENT ROUTING PROTOCOLS IN UWSNS

Protocol	Hop-by hop / End-to-end	Clustered / Single entity	Energy efficiency technique	Energy Efficiency	Single / Multisink	Scalability
<b>VBF</b>	End-to-end	Single entity	Vector Routing	High	Single-sink	Provide scalability
<b>E-PULRP</b>	End-to-end	Single entity	Transmission relay	High	N/A	Supports scalability of network
<b>DDD</b>	Single hop	N/A	Clustering	Average	N/A	Supports scalability
<b>MCCP</b>	Hop-by-hop	Clustered	Based on transmission relay distance and clustering	High	Multi-sink	It supports scalability of the network
<b>TCBR</b>	Hop-by-hop	Clustered	Clustering	Average	Multi-sink	It supports scalability of the network
<b>LCAD</b>	Hop-by-hop	Clustered	Transmission relay and clustering	Average	Single-sink	Supports scalability
<b>REBAR</b>	Hop-by-hop	Single entity		Average	Single-sink	Supports scalability
<b>EUROP</b>	Hop-by-hop	Single entity		Average	Single-sink	Supports scalability

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**Mrs. V. P. DHIVYA** is Assistant Professor of Department of Information Technology at K.S.Rangasamy College of Technology, Tamilnadu, India. She is also a research scholar under Faculty of Information and Communication Engineering in Anna University, Chennai. She received her Bachelor of Engineering Degree in Computer Science and Engineering in 2002 and Masters Degree in Computer Science and Engineering in 2009. After graduation, she joined as lecturer and has experience of ten years in the teaching field. Her research mainly focuses on pervasive computing and also in underwater sensor networks, mobile adhoc networks.



**Ms. R. Arthi** holds a B. Tech degree in Information Technology from C.Abdul Hakeem College of Engineering and Technology, affiliated to Anna, University of Technology Chennai, Tamil Nadu, India in 2013. Now she is an M.Tech student of Information Technology department in K.S.Rangasamy College of Technology. She has presented two papers in the National level technical symposium.. Her interest area covered in Data structure and Computer Networks (Wireless Sensor Networks).