Methodology for the Perseverance to Node Mobility Issues in Underwater Sensor Network (UWSN)

Gulista Khan
Faculty of Engineering
Teerthanker Mahaveer University
Moradabad, U.P., India
gulista.khan@gmail.com

Dr. R. K. Dwivedi
College of Computing Sciences and IT
Teerthanker Mahaveer University
Moradabad, U.P., India
dwivedi.rakesh02@gmail.com

Wajid Ali
Landmark Technical Campus
AKTU
Amroha, U.P., India
Er.wajid.ali@gmail.com

***Abstract*—**Now a days, Wireless Sensor Network (WSN) is effecting each and every area of life. Underwater Sensor Network (UWSN) is a great development in WSN. UWSN is the foremost research area because of its advantages in seismic monitoring, study of flora and fauna, defense services, weather monitoring, pollution monitoring etc. UWSN is experiencing many challenges in its deployment, routing, communication due to terrible underwater environment. One major challenge is the use of acoustic signal because in UWSN we cannot use radio signals. Some other limitations are propagation delays, larger distance, 3D architecture, node mobility due to water etc. In this paper we have reviewed various existing methods for node mobility based on vector, AUV, path and clusters and proposed a new approach for communication in underwater environment by giving solution to the node mobility issue in 3D based deployment. Proposed approach is using Euclidean distance formula and OSPF dynamic routing, executed and compared with previous algorithms with significant improvement.

Keywords- *UWSN, Node Mobility, Euclidean Distance, Shortest path calculation, OSPF.*

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I. INTRODUCTION

WSN consists of a large number of sensors to sense and forward the sensed data to the sink node directly or by some hop. Sensor nodes have one transmitter, receiver, sensing unit and memory. It is having limited power and recharging of sensing units is impossible. So our aim is to communicate the information with less power consumption. In last few decades researchers are working on it, they worked to improve the working of UWSN, to make its routing more attractive. UWSN is totally different in communication with WSN as it is incorporated so many new challenges than WSN. WSN is mainly using Radio Frequency (RF) to transmit data, which is not suitable for UWSN because of high attenuation. Optical signals are also unsuitable in UWSN because of high refraction and reflection in water. Therefore acoustic signals are the only choice for UWSN. For designing a routing protocol for this we must consider four features: (1) Power constraint; in UWSN nodes are having limited power and recharging the nodes in water is not possible. If we brought the sensors to the ground for recharging and then fix it back to water depth. This process is very much costly and we can deploy new nodes in this cost. So Energy is one big constraint. (2) Low bandwidth; in underwater sensor networks bandwidth is very much less i.e. less than 100 KHz. (3) Localization; in UWSN we could not use any positioning technology unlike WSN. We must need a better localization technique for UWSN. (4) Node Mobility; In UWSN nodes are moved out with water currents, so a fixed topology cannot work with it, a dynamic routing is needed which changes periodically with node movement.

All the routing techniques available for WSN cannot be directly applied to UWSN because of differences in both.
Mostly routing techniques use the minimum path algorithms for the routing purpose. In this technique the nodes fall on the shortest path will be exhaust soon. Some algorithms proposed to increase the lifetime of nodes and maximize the network coverage. However less energy consumption does not lead to prolong the network lifetime every time. Consideration of residual energy is also a major factor in prolonging the lifetime of nodes.

In this paper we are proposing a routing algorithm to enhance lifetime of nodes, minimize the end to end delay. The basic structure of algorithm having three considerations: (1) Sensor nodes senses the data and design a data packet which travel to the next hop for forwarding of packet. (2) It is using an adaptive algorithm that uses the residual energy and the delay in consideration; if residual energy is sufficient greater than threshold then shorter delay path is used if residual energy on this path is less than the threshold then longer path with high delay is used. (3) Considering delay related cost as well as energy related cost.

In next section we discussed some related work to the proposed algorithm, then in further sections algorithm is proposed followed by experimental results and conclusion.

II. LITERATURE REVIEW

Hot research topic in Underwater Sensor networks is the routing protocol [1-14]. Various techniques have been developed for UWSN which claims to decrease the energy consumption, decrease the end to end delays and improve the network lifetime.

In [15] author proposed queen-bee evolution algorithm (QEGA), this algorithm proposed a routing algorithm which considers the energy consumption rate. This provides a good solution for the network lifetime very quickly. But it does not consider the residual energy concept.

In [16] author proposed one energy saving algorithm based on Vector based forwarding. This considers the residual energy factor. VBF used the routing pipe, the nodes in the routing pipe was able to forward the data. Now in energy saved VBF, the nodes having higher residual energy in the pipe is able to forward the packets towards the sink.

In [17] an adaptive power controlled routing algorithm is proposed, this scheme does not require any information regarding location. In this technique nodes are fixed at various layers (concentric layers). In this nodes are able to adjust their transmission powers. It is based on the residual energy of the node. Data is forwarded from various nodes to the sink node. If node found the intermediate node in between the path towards the sink node, transmission power is decreased. If no node is found in the path then transmission power is increased. This algorithm gives the high delivery ration but does not balance the energy because if multiple nodes forward the same packet then they will exhaust soon.

In [18] Q-learning based routing algorithm is proposed. In this approach next hop for data forwarding is chosen by node itself by getting the residual energy of next hop. Node having highest residual energy is taken as the next hop, to increase the network lifetime. Each node calculates the residual energy of the neighbours and decides for the next hop. This will leads for the higher consumption of energy.

In [19] authors proposed an algorithm which selects the next hop node with minimum delay. In [20], author proposed an algorithm which forwards the data packet on the path chosen among the multiple nodes. The nodes having lesser end to end delay and higher priorities are selected as the next hop node. This technique has proved to be very giving good throughput but it is not satisfying end to end delay. In [21-24] authors have discussed various routing algorithms.

III. Proposed Methodology

A. Mechanism

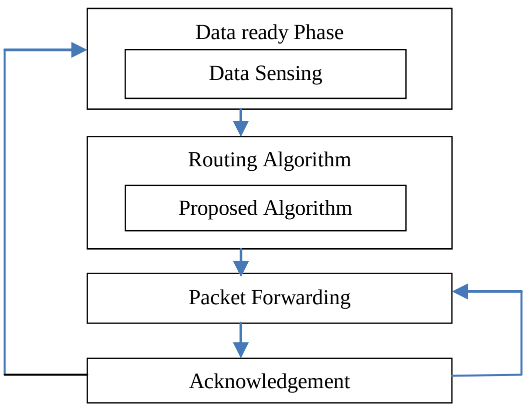

Figure 1. Mechanism of Proposed algorithm

B. Initialization phase

Preliminaries: Threshold energy is the energy value set for the nodes to participate in the route construction.

1) *Assign address to each node using the function address.*
2) *Start loop from Set i=1*
3) *Receive initialized information such as*
4) *Node is assigned energy Node[i].energy-> ienergy*
5) *Assigned power as Node[i].tpower ->tpower*
6) *Assigned frequency as Node[i].freq ->frequency*
7) *Assigned depth as Node[i].depth -> depth*
8) *Repeat step 2 to 6 until i ! = no_of_nodes*

C. Algorithm Steps

1) Deployment

Nodes are deployed on the network area. Deployment can be done by any method. It can be done randomly or can be have some special technique. In random network deployment technique nodes are dropped from the helicopter to the area. Adjust their height as per the weight associated with it. Also adjust their dimensions as per the knowledge of network area information stored in it. After fixing their locations nodes have to register themselves to the sink node. We considered if network area is large then we need more than one sink node where nodes transfer the data. Location of the sink nodes are fixed at water surface. Sink node do the registration process to get the knowledge about the network nodes.

2) Registration

Sink node sends a registration message <$Sink_{Id}$, $Sink_{Tx}$, $Message_{Pkt,}$$Node_{id}$> the nearest node, the nodes who listens to this message assigned themselves the $node_{id}$ and send the message to the next node by increasing the id by 1. Node registration process is done layer by layer. Highest $node_{id}$ means higher depth node. Likewise all the nodes get registered with the current sink node. In case of large area more than one sink node is present and do the same registration process like sink1.In this algorithm firstly a HELLO packet is transferred from the sink to the neighbour node. OSPF packet is saving the neighbour information in its packet. This packet is forwarded from sink node to neighbour node and it assign node is 1 to itself. Then forward the same to the next neighbour node, which receives it and assigns itself node id 2 and forward to its adjacent node.

Figure is showing the node registration process of sink node 1. Whole network area is divided into three tiers. Sink nodes are for the sensing of the particular tier. Like Sink $node_1$ is responsible of sensing the $tier_1$. $Sink_1$ starts registration process by sending a hello message of OSPF to its neighbour node. Neighbour of $Sink_1$ is S_1N_1. S_1N_1assign itself the node id 1 and forward the hello message to its neighbour based on 3D Euclidean distance calculation. Likewise S_1N_2 node id is assigned. This process goes to the highest depth node. And acknowledgement is send back to the sink node about the registration process.

Table 1: Neighbour Table

Neighbour List S_1N_{12}	S_1N_{13}, S_1N_{14}, S_1N_{10}, S_1N_9
Neighbour List S_1N_{10}	S_1N_{11}, S_1N_8, S_1N_{12}, S_1N_9, S_1N_{14}
Neighbour List S_1N_8	S_1N_{10}, S_1N_{11}, S_1N_7, S_1N_6, S_1N_5
Neighbour List S_1N_5	S_1N_3, S_1N_4, S_1N_7, S_1N_6
Neighbour List S_1N_4	S_1N_3, S_1N_5
Neighbour List S_1N_3	S_1N_3, S_1N_1, S_1N_2
Neighbour List S_1N_1	$Sink_1$, S_1N_3, S_1N_2

 ISSN: 2454-4248
78 – 82

Table 2: Routing Table

Routing Table S_1N_{12}	Routing Table S_1N_7	Routing Table S_1N_5
S_1N_{10}	S_1N_5	S_1N_4
S_1N_8	S_1N_4	S_1N_3
S_1N_5	S_1N_3	S_1N_1-> $Sink_1$
S_1N_4	S_1N_1-> $Sink_1$	
S_1N_3		
S_1N_1-> $Sink_1$		

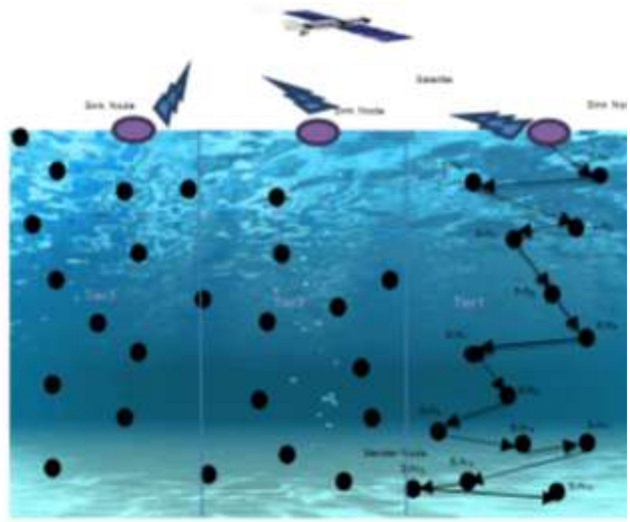

Figure 2. Registration process of nodes by Sink node

Once the nodes deployed successfully, they are into the ready phase where sensors can sense the environment for which they are fixed.

4) *Routing Information*

We are considering the homogeneous nodes. If we use the clustering algorithm here then the nodes act as the cluster node will be exhaust soon. So in spite of using any clustering algorithm we are using path discovery algorithm done periodically with the movement of nodes. For path discovery we are using OSPF (Open Short Path First) dynamic routing algorithm. When all the nodes are assigned the node ids. Routing algorithm starts. OSPF is the improvement over RIP protocol. It establishes the route during the assigning the node ids to all the nodes. In this if a node drifts away from its location. Then OSPF immediately detects the changes. The changed information is sent to all the nodes so they all have the same information. Also only the changed part is sent to all nodes instead of sending all the routing information.

In this figure routing process is shown. Whenever a sensor node has data to send it forms a vector from itself to the sink node and forms a cylindrical routing pipe around the vector. In routing pipe we apply the OSPF algorithm to find out the shortest route. Whenever this node has data to send to the sink it follows the same path. If there is any change in topology due to node movement then OSPF will update it to the entire node. Its routing is based on the three tables: neighbour table, routing table and topology table.

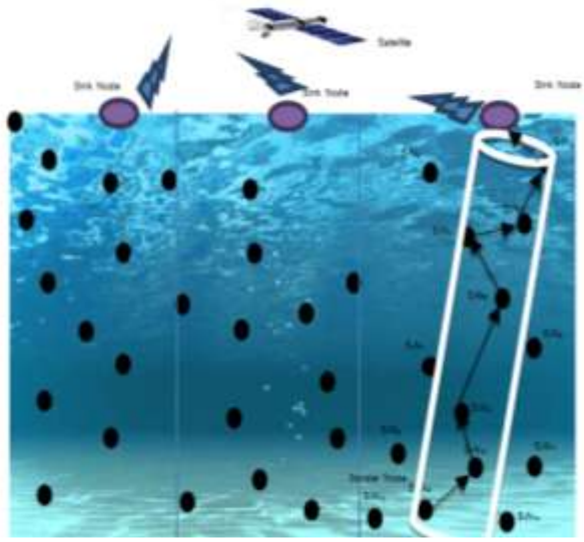

Figure 3. Routing Scenario of Proposed Algorithm

Neighbour Table of S_1N_{12} (Sensor Node) is defined with the transmission range of S_1N_{12}. The nodes fall in the transmission range of sensor node are considered its neighbour node and included in the neighbour table. Table 1 is showing the neighbour table and Table 2 is showing the routing table. Topology is showing in the figure 3.

In the routing table almost all the sensor nodes having route to sink node through S_1N_1. In this way S_1N_1 will be exhaust very soon. So for the route establishment we consider the residual energy also. Every time in route establishment check the residual energy of all the nodes. Is residual_energy<= threshold_energy of any node then that node will not be considered in the route establishment. That node will be do the sensing and data forwarding only and participate in route establishment if it has some data to send.

IV. EXPERIMENTAL RESULTS

As concern with the simulation parameters, Table 3 is showing the parameters.

Table 3: Parameters Setting

Parameter	**Value**
Initial energy	70 J
Transmission Range	250m
Data Packet Size	64 bytes
Packet Size	2000 bits
Sensing Area	50*50*50
BS(X,Y)	50,175
Number of Nodes	25,50,75,100
Transmission Energy	$E_{TX}=b*E_{elec}+b*d*E_{amp}$
Reception Energy	$E_{rc}=b*E_{elec}$
Processing Energy	$E_{proc}=b*N_c*C_{avg}V^2_{sup}+b*V_{sup}*(I_0*e^{Vsup/Np*Vt})*Nc/f$

ISSN: 2454-4248
78 – 82

Figure 4 is showing the overall network lifetime. It is the graph between the no of nodes and no of rounds. Figure showing the comparison of our proposed algorithm with previously known algorithm with significant improvements.

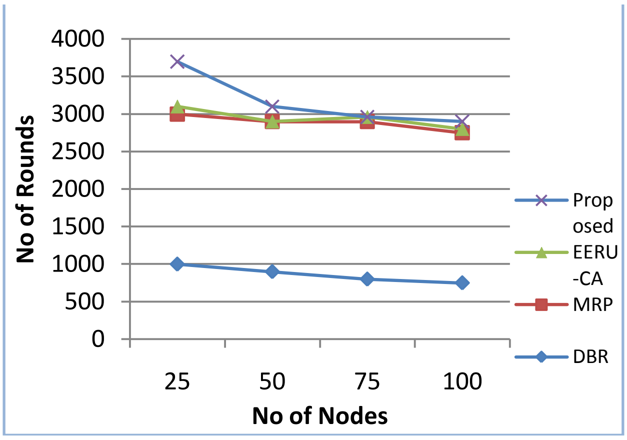

Figure 4. Network Lifetime v/s No of Nodes Comparison

Figure 5 is showing the energy consumption. It is the graph between the no of nodes and the energy consumption. Figure displays the comparison of our proposed algorithm with previously known algorithm with significant improvements.

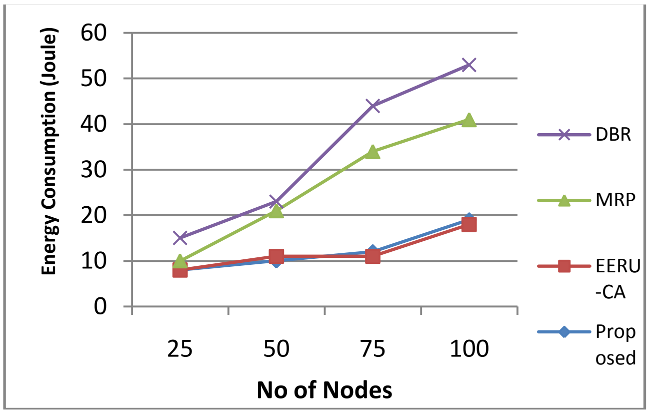

Figure 5. Energy Consumption (Joule) v/s No of Nodes comaparison

V. Conclusion

The previously proposed 2D approaches are having restriction of node mobility in of real time problem. In this paper we have proposed a routing algorithm which considers the node mobility also. It is proven to be robust approach for real time environment underwater. For distance calculation it is using Euclidean 3D distance calculation formula. For routing it is using OSPF routing algorithm. Our approach provides effectual communication in minimum energy consumption maintained under dynamic underwater environment. Network is connected in the whole process. Without affecting the network communication. Algorithm is simulated in MATLAB and compared with well known algorithms EERU-CA, MRP and DBR showing the overall improvements in terms of network lifetime and propagation delay.

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