A Survey on Routing Protocols for Underwater Sensor Networks

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Abstract—**Different routing protocol perform different role in the underwater sensor network. All routing perform each and specific task into underwater sensor network which responsible for networking problems issue that is why this is the latest way of research. Routing term derived from "route" that means a path a way that perform different terms in underwater sensor network problem related issue. The best part is today many routing protocol are present in the underwater wireless sensor network. Some different attributes comes underwater wireless sensor network like likes high bit error rates, limited band-width, 3D deployment and high propagation delay. This paper is referring to as helpful for giving brief overview about each and every protocol and responsible for entire underwater wireless sensor network.**

Keyword: Underwater sensor network, routing protocol

I. INTRODUCTION

In our earth 25% covered by human being and remaining space is covered by water that could be river and oceans also. In underwater wireless sensor network much small water living thing like fish, crocodile and many more. Suppose a scientist work on particular a particular thing so some special devices should be in underwater wireless sensor network that can work in underwater wireless sensor network system which should be able to interact within underwater. Today increasing the demand some special routing protocol which can work into underwater wireless sensor network. For the current point of research scenario underwater sensor network with some different routing protocol available that play some specific role in the underwater wireless sensor network that why some scientists are working

for developing algorithm. Underwater routing sensor network not only helpful for giving high reliability which should be able to control high reliability of information sent to the SINK node but also its delay relatively low. Underwater sensor network able to perform operation into long terms non time critical aquatic monitoring applications where GPS support is not require. The architecture of routing protocols easily adapt to changing topology. Reduce energy consumption and the network nodes network conflicts as much as possible. Some main challenges are also including for routing protocol underwater sensor network that challenges are High propagation delays, Node mobility, Error prone acoustic underwater channels, Error prone acoustic underwater channels, Error prone acoustic underwater channels. According to this paper it's not only useful for giving information about routing protocol for underwater sensor networks but also helpful for working scientist and those people who are involving in research activities and is also useful for giving correct way which one is correct routing protocol underwater sensor network and which one is perfect for project that can be easily identify by this paper. [1]

II. DESIGN COMPONENT FOR UNDERWATER SENSOR NETWORK

Some factors like transmission loss, multipath, noise, propagation loss these are four major problems which comes in underwater sensor network.[13]

A. Transmission loss [13]: Transmission loss is combination of geometric spreading and attenuation. It has independent of frequency. Geometric spreading is expansion of wave fronts that increase the

propagation distance. Basically attenuation provoked by increases with distance and frequency, absorption due to conversion of acoustic energy into heat.

B. Noise [13]: It is divided into two ways as ambient noise and manmade noise. This in mainly focus on the shipping activity and machinery noise.

C. High delay [13]: The propagation speed in the underwater sensor magnitude is less than compare to the radio channel.

D. Multipath[13]: Basically this term is refer to as more than one way for degradation of the acoustic communication signal that generates that is refer to as Inter Symbol Interference. The more than one geometry based on the link configuration. There are two channels like vertical channel and horizontal. Horizontal channels may have long more than one way spreads whereas Vertical channels may have little time dispersion.

III ROLE OF UNDERWATER SENSOR NETWORK

Underwater sensor network able to perform operations in wide range of applications that application are perform different in underwater sensor network some applications likes mine reconnaissance, distributed tactical surveillance, seismic monitoring, ocean sampling networks, equipment monitoring, environmental monitoring, assisted Navigation, Disaster prevention and undersea explorations these all are the advantages of the underwater sensor networks. Since no system is perfect, therefore, even with all the above mentioned advantages of the system, a few disadvantages still exit like costly devices, more power requirement, Intermitted memory, Spatial correlation.

A. Fastest way for finding underwater information [1]: Underwater sensor is the latest and fastest way of finding information which is available in underwater sensor network. This information is not only helpful for human being but also responsible for researchers.

B. Monitor the environment & climate [13]: Most of researchers want to know about what is happing inside the water. It is depend on the situation suppose if water is less so need for monitoring. But if water is More like a ocean so monitoring is mandatory because without monitoring we can never ever

analyze the problems. Underwater sensor network system able to solve the problem those problems are part of climate. Underwater sensor network play major role in detect climate change, improve weather forecast. Basically underwater sensor network not only monitor the climate but also helpful in nuclear, chemical and biological activates.

C. Underwater device monitor system [13]: For monitoring the underwater sensor network where as costly devices are there all these devices are more costly that is play safety role in underwater sensor network.

D. Undersea Explorations [13]: Underwater sensor network perform operation into determine the paths for laying undersea cables, remove underwater reservoirs.

E. Ocean Sampling Networks [13]: Autonomous underwater vehicles able for cooperative adaptive sampling of the 3D coastal ocean environment.

F. Disaster Prevention [13]: Underwater sensor network system able to perform seismic activity that starts from remote locations which provide tsunami warnings to coastal areas.

G. Assisted Navigation [13]: Underwater sensors are able to perform bathymetry profiling, also able find locate dangerous rock, submerged wrecks.

IV PROBLEM IN UNDERWATER SENSOR NETWORK

A. More expensive Devices [13]: Underwater sensor devices are more costly. And no more supplier are provides these such kind of devices because these are devices are part of research oriented activity. Underwater sensor devices are not easily available in the market.

B. High power require for communication [13]: In underwater communication more power require because for exchanging data inside in water need more electricity require.

C. Hardware Protection requirement [13]: Inside the water lot of underwater devices are available not only for monitoring but also scientific work also there that is why more security is require inside the water for safety of the underwater components.

D. Intermitted data transfer [13]: Compare to terrestrial sensor network system where very small memory. But in underwater sensor network data transferring could be create big interrupt at the time.

E. Reading problem in space sensors [13]: Generally terrestrial sensors are related to each other. But In underwater sensor network it may not be possible in higher distance sensors but unlikely it could be co-related in higher distance among sensors.

F. More sparse deployment [13]: In underwater sensor network the deployment is often sparser but compare to terrestrial sensor networks are densely deployed.

G. Propagation delay [13]: This is also a major problem which comes underwater sensor networks time. Propagation delay is orders of magnitude higher than in Radio Frequency variable and terrestrial channels.

H. Impaired channel [13]: The underwater channel is impaired because of multipath and fading.

J. Fouling and corrosion [13]: Underwater sensors are prone to failures because of fouling and corrosion.

K. Localization [11]: Localization is the challenging factor that is require for data labeling while some time critical applications require data without time delay.

L. High Maintenance [11]: Underwater sensors demands are increasing because for underwater sensors are very costly which are not easily available in the market and underwater sensor supplier and consultants are not available everywhere that is why cost is increasing. Underwater sensors are too costly because for underwater sensor networks high maintenance is required.

F. Temporary losses [13]: For the connectivity time packet sending time it could be loss between the data transmission.

M. High bit error rates [13]: In underwater sensor network high bit error rates mostly come at the time of duration.

N. Reliability [11]: This is one of the major design issues for reliable delivery of sensed data to the surface sink is a challenging task compare to forwarding the collected data to the control center.

O. Limited battery power [13]: Battery power is the major issues which mainly comes underwater sensor network because many underwater devices working throw the battery suppose if a underwater sensor device is not working so underwater charging is not possible or it may not be charged.

P. Limited bandwidth size [13]: In underwater sensor another problem is issue is related to bandwidth because bandwidth size is limited.

VI DESIGN ISSUE FOR ROUTING PROROCOL UNDERWATER SENSOR NETWORK

The main issues for development for routing protocols for underwater sensor network. *[1]*

A. Harsh deployment environment is the major challenging factor which comes under routing protocol for underwater sensor network.

B. Bandwidth capacity is low because routing protocol for underwater sensor network comes from high bit error rates.

C. Another problem related to low energy problem. For each battery energy is require.

D. Node mobility is also another concern which comes under routing protocol for underwater sensor network because if they are not anchored at the bottom of the sea. This situation conclusion in a dynamic topology

E. Radio single are not efficient compare to routing protocol for underwater sensor network. Because it provides high propagation delays.

F. High propagation delays are the major factor of routing protocol for underwater sensor network.

VII. DIFFERENT ROUTING PROTOCOL IN UNDERWATER SENSOR NETWORK

There are ten different routing protocols available for underwater sensor network.(a) Vector-Based Forwarding Protocol or location-based routing protocol, (b)Robustness Improved Location

protocol,(c) Depth-Based Routing protocol, (d) Hop-by-Hop Dynamic Addressing Based protocol,(e) Focused Beam Routing Protocol,(f) Path Unaware Layered Routing Protocol,(g)Adaptive Routing protocol,(h)GPS-free Routing Protocol, (i) A Low Propagation Delay Multi-Path Routing Protocol,(j) Pressure Routing Protocol. There is brief overview about common routing protocol underwater sensor network.

VIII. Routing Protocols for underwater sensor network

A. Vector Based forwarding protocol: [2] [11]:

VBRP this protocol is known as location based routing protocol. This is designed for underwater sensor network. Basically it refer to as the problem which helpful to improve the low delay and successful rate. For the current point of research scenario underwater sensor network with vector routing forwarding protocol. Its architecture depend upon underwater sensor network and it just a location based protocol which play major role in the underwater sensor network.VBF refer to as vector based routing forwarding protocol. Sometimes VBF also refer to as routing pipe which is perform a specific task for built connection between source, destination and packet delivery. The data packet is collection of the aim, location of the sender, forwarder and range field. VBF also refer to as routing pipe which is perform a specific task for built connection between source, destination and packet delivery. Robustness, energy efficiency, High success of data delivery and energy efficient these four feather comes under location based protocol which are not available in underwater sensor network that is why a novel routing protocol known as VBF. This protocol is helpful for packet carry routing related information and no state information is require at nodes as well as scalable in terms of network size. In VBF only those nodes close to the routing vector are involved in data forwarding. Therefore it is efficient. Moreover our self adaption algorithm allows a node to estimate its importance in its neighborhood and thus adjust its forwarding policy to save more energy.VBF utilities path redundancy (Controlled by the routing pipe radius) to provide robustness agent

packet loss and node failure. The simulation results have demonstrated the proving performance of VBF.

B. Robustness Improved Location protocol [3]:

RILP This protocol is also same as location based routing protocol and also designed for underwater sensor network as well as its behaving like VBF. This is known hop to hop vector based forwarding protocol But this protocol is much better than location based routing protocol. One major problem which comes in location based routing protocol that is (i) low data delivery in sparse network, (ii) too sensitive to routing pipe radius. Above these two problems are removed in robustness improved location protocol that's why some researcher mostly prescribe this protocol. Another main comparison between both of location based routing protocol and vector based forwarding protocol hop to hop vector based forwarding protocol is enhances data delivery ratio in sparse networks compared with VBF that is conduct simulations to evaluate Hop to Hop Vector Based Forwarding protocol and the results show that Hop to Hop Vector Based Forwarding yields much better performance than VBF in sparse networks. In addition, HH-VBF is less sensitive to the routing pipe radius threshold. HH-VBF, an enhanced version of the VBF routing protocol for Underwater Sensor Networks. The new proposal introduces a hop-by-hop approach, which is simple while novel and it can significantly improve the robustness of packet delivery in sparse networks: enhancing the data delivery ratio while taxing less energy.

C. Depth-Based Routing protocol [8]:

DBRP refer to as depth based routing protocol. It is behaving like greedy algorithm in which each sensor separately. Each sensor depend on it is depth and the depth of the previous sender, able to make the overall result on whether to forward a packet. For example suppose a node data sent its broadcasts. So here are many neighboring nodes calculate their depths and helpful to create a depth a difference with the sending node upon receipt of the data packets. Nodes which have lesser depths compare than the sender accept these data packets, while other nodes simply discard them. Aqua-Sim define terms to for simulations, authors use NS2 include underwater sensor network

simulation packages extension. It's useful for performance of the packet delivery ratio, performance of average end-to-end delay, performance of total energy consumption. Some different comes here depth based routing protocol where each node should have equipped with a depth sensor, which one hand can increase the cost while on the other hand can increase energy consumption. Another drawback refers to as broadcasting which helpful to step up the complexity of the routing due to making more nodes candidate for forwarding the data packets. Third drawback is the dramatic change of performance as node density varies. This protocol is combination of sent packet and the route discovery. After all nodes deployed in the water, they will start to detect their underwater depth; and start the route discovery process to choose their next hop nodes. Overall Conclusion is packet from the source node through the multi hop sends to sink node.

D. *Hop to Hop Dynamic Addressing based Routing protocol [6]:*

Efficient communication is the major problem in underwater sensor network. Radio signal cannot spread well in deep water, and replace radio signal with the acoustic channel. This replacement solution in many effects like high error probability, low bandwidths and high latency due to less propagation speeds. A novel routing protocol called Hop by hop dynamic addressing based for critical underwater monitoring missions. This protocol applies on multi sink architecture and also energy efficient, scalable and robust. This protocol also helpful for design monitoring underwater missions. The aim of hop by hop dynamic addressing based routing protocol helpful for maximize the delivery ratio, optimize energy consumption and minimize the message latency.

E. *Focused Beam Routing Protocol for Underwater Acoustic Networks [16]:*

For the current point of research scenario underwater sensor network with Focused Beam routing protocol. The focused beam routing protocol works on Sparce network. According to this routing protocol there are one mobility static nodes. There are location information require own location and sink location. Basically Focused Beam routing protocol works on geographic routing. This is known as scalable routing technique that depends upon the location information. Focused Beam routing protocol where static and mobile underwater acoustic networks can work without any clock synchronization. According to performance if we are considering different node densities and network loads so a discrete event underwater acoustic network simulator should be used. First of all we will observe the impact of node density on the performance and results we can compare with Dijkastra's shortest path algorithm. The technique should be able to dynamically discover minimum energy routes with the minimum network knowledge. According to performance wise con gets bigger energy consumption is reduced. Routing protocol helpful to verifying number of nodes randomly positional within 200 km2 grid area, 4 sinks located at comers.

F. *Path Unaware Layered Routing Protocol [5]:*

This routing protocol just combination of two phases one is called layering phase and second is called communication phase. Communication phase helpful to define on fly that come from source to sink node across the concentric layers. Another layering phase helpful to focus on layers of spheres is formed around the sink node with each node belonging to only one of the spherical layers. There are choosing radiuses of spheres because that based on packet delivery latency and probability of successful packet forwarding that's why this knows as layering phase.

g. *Adaptive Routing protocol [9]:*

The aim of Adaptive Routing protocol helpful to fulfill different application demand and also helpful to accomplish a good trade-off among delivery ratio, medium end-to-end delay and energy consumption for all packets. There is a key idea resource reallocation and exploit message redundancy means multiple copy of same message. The outcomes of Adaptive routing protocol achieve a good performance trade-off among delivery ratio, medium end-to-end delay and energy consumption and different packet delivery according to application requirements. According to performance wise

medium end to end delay is high and packet delivery ratio should be good for important packages.

G. GPS-free Routing Protocol [7]:

This GPS-free Routing Protocol is created for underwater sensor networks. This is known as Distributed Underwater Clustering Scheme. It is also helpful to compensate the high propagation delays of the underwater medium and minimizes the proactive routing exchange. According to performance wise this protocol good packet delivery ratio for dense network. This protocol is scalable and helpful to good performance of proposed scheme. This protocol helpful to achieves a very high packet delivery ratio when it considerable to reduce the network overhead and also increase the throughput. The GPS-free Routing Protocol uniformly distributed n nodes like N=100 volumes is 75X75X20000 cubic meter. The mobility pattern randomly walks speed 0 to 5 m/s. The rate of this protocol is 6.6 Kbit/s.

I. A Low Propagation Delay Multi-Path Routing Protocol [15]:

This protocol is known as multi path touting protocol. A Low Propagation Delay Multi-Path Routing Protocol forms a route from source to the destination which consists of n numbers of multi-sub paths during the routing path structure. Multi sub paths are helpful for sub paths form sender to its two-hop neighbors thru a relay node in the neighborhood of both sender and receiver nodes. Basically this approach is useful to keep data collision at receivers since they receive packets from different relay nodes.

J. Pressure Routing Protocol [14]:

This protocol works in underwater sensor network. Pressure Routing Protocol is hydraulic pressure depend on whatever cast routing protocol that applies the pressure levels other way we can say that the depth information to search paths for forwarding packets from source to the surface buoys. The Pressure Routing Protocol produced a novel opportunistic routing approach that has an efficient underwater dead end recovery mechanism along with the clustering of the nodes   and co-channel interferences.

IX   Table description

Routing protocol for underwater sensor networks are of various kinds that cater to various different needs of researchers and scientists. Since each of these have a unique set of advantages and disadvantages, it becomes necessary for us to understand which of these might suit a particular scenario best. Thus, in order to solve these basic issues of being able to find the correct protocol a combined study has been presented in the table below. This simple yet functional comparison would enable everybody related to the domain to find the exact set of protocols and solve a major issue that arises at a basic level.

TABLE I   **Comparison table routing protocol for underwater sensor network**

Routing Protocols for Underwater Sensor	*Advantages*	*Disadvantages*
Vector based forwarding Protocol	(1)Robustness. (2)Energy Efficient. (3)High success of data delivery.	(1)Low Bandwidth. (2)High latency. (3)Node floats mobility. (4)High error Probability. (5)Low data delivery in sparse network compare to robustness improved location protocol. (6)Too sensitive to routing pipe radius. (7)Delay efficiency, delivery ratio, performance and reliability are low.
Robustness Improved Location based routing	(1)High data delivery in sparse network. (2) Less sensitive to the routing pipe radius threshold. (3)Much better performance and reliability than VBF in sparse networks. (4)Transmission range should be maximum pipe always every node should have own pipe.	(1)Not able to explore an adaptive design for unevenly distributed networks. (2)Not able to add a feedback mechanism to detect and Avoid voids in the network. (3)Energy efficiency is low.
Depth based Routing	(1) Multiple-sink underwater sensor network architecture without introducing extra cost. (2) Not necessitate full dimensional location information of sensor nodes.	(1)In case of acoustic channels, radio-frequency has o lot lower several orders of magnitudes longer propagation delay and o lot lower bandwidths. (2)Batteries are stranger to recharge. Underwater sensor nodes, Land based sensor nodes both are commonly power supplied by batteries or interchange in hash underwater environments. (3)Not energy efficient.
Dynamic Hop-by-Hop Dynamic Addressing Based (H2-DAB) Routing Protocol	(1) In this protocol node movements with water currents can be handled. (2)no need to maintain complex routing tables, (3)No need to differentiated hardware or new type of nodes. (4)Multiple sink architecture is also available.	(1) When choosing a forwarder node, the sender may not have a response from its neighbors especially in sparse networks. To solve this problem, the protocol waits for a certain time that means time delay also and then forwards the packet to a neighbor who is at the same depth. This will cause high end-to-end delay that will also face. (2)Critical underwater monitoring.
Focused beam routing protocol	(1) This is a discrete event underwater acoustic network simulator which is useful for network loads. (2)This protocol considering different node densities. (3)This is a scalable routing technique which is based on positioning data.	(1)This protocol is not more reliable compare to HH-VBF. (2)Bandwidths efficiency is not good.
Path Unaware Layered routing protocol	(1)Fixed routing table (Optional). (2)Average delay, High delivery rate as well as localization or synchronization. (3) Successful packet transmission rate is much better than Shortest path algorithm. (4) This protocol analyzes the packet transmission success rate for various success rate for various probability of forwarding threshold values.	(1)The ring radius value affects the delivery rate to the extent that when delivery rate decreases. (2)Success rate is not possible. (3)Route length is also not possible. (4)Statistical analysis of route duration is not possible.
Adaptive Routing Protocol	(1)The basic reason for using this protocol is to achieve a different set of services for different data packet types based on priority and to provide an optimal mix of services with respect to	(1)Not able to use water current movement models for more naturalistic environment. (2)Not able to analyze the performance. (3)Not able to dynamically adjust the weights in packet priority calculation according to network terms. (4)Not good performance. (5)Delivery efficiency is not good.

	delivery ratio, energy consumption and average delay. (2)Its satisfy applications requirements, end to end delay, energy consumption; achieve a good trade off among delivery ratio. (3)Delivery ratio is high. (4)This protocol is energy efficient, bandwidth efficient and reliable.	
GPS-free Routing Protocol	(1)Maintain Communication quality. (2)Minimizes the proactive routing message exchange. (3) Guard time values to minimize data loss (4)Reduces the network overhead and continue to growth throughput consequently. (4)This protocol compensates the high propagation delays of the underwater medium using a continually adjusted timing advance merge with guard time values to minimize data loss. (5)Good performance and Scalable. (6)High packet delivery ratio.	(1)Delivery efficiency is too less. (2)Reliability is too less compare to other routing protocols. (3)Performance is not much better than other protocols.
A Low Propagation Delay Multi-Path Routing Protocol	(1)This protocol is much better than HH-VBF and VBF because it has higher throughput. (2)It uses many matrix operations that lead to high energy consumption.	(1)No seek for more effective RWA. (2)Not able to optimize more aim which should be helpful for underwater sensor network.
Pressure Routing Protocol	(1)I n this protocol there is a mechanism that choose the subset of forwarders which maximizes greedy progress yet limiting co-channel interferences that's know as novel opportunistic routing mechanism. (2)One another method in this protocol that out performs recently proposed approaches that is known as efficient underwater dead end recovery method. (3)The outcomes of this protocol confirmed the proposed protocols can effectively handle the challenges. (4)It has lower end to end to end delay compare to DBR. (5)Excellent performance, delivery ratio, delay efficient.	(1)Much higher cost in packet transmission. (2)Bandwidth efficiency and energy efficiency is not much good.

. CONCLUSION

This paper performs major task routing protocol for underwater sensor network and play major role in research. In this paper Routing protocol for underwater sensor network is major research issue, which is helpful to solving networking interrupts,

which generally comes into underwater sensor network and also provide platform for finding suitable routing protocol for specific purpose. The best part is that, this paper is fully supported for finding correct routing protocol for underwater sensor network projects and some challenging research projects which should be useful for entire underwater sensor network system. A complete comparison of various routing protocol has also been done. All advantages as well as disadvantages has also been shown that in turn would allow the readers to find the requirement specific details about the topic.

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