ORIENTAL JOURNAL OF COMPUTER SCIENCE & TECHNOLOGY
An International Open Free Access, Peer Reviewed Research Journal
Published By: **Oriental Scientific Publishing Co., India.**
www.computerscijournal.org

ISSN: 0974-6471
June 2013,
Vol. 6, No. (2):
Pgs.85-91

Comparative Study of Routing Protocols in Pollution Monitoring System Based on Underwater Wireless Sensor Networks

MOHAMMED NAJM. ABDALLAH*[1] and AHMED MOSA DINAR[2]

Computer Eng., University of Technology, Baghdad, (Iraq).
Corresponding author E-mail :*mustafamna@yahoo.com, [2]ahm_alzubydi84@yahoo.com

(Received: June 01, 2013; Accepted: June 10, 2013)

ABSTRACT

In this paper, an investigation for the facts about what is the robust and energy efficient routing protocol in underwater wireless sensor networks by comparing between three routing protocol are Vector-Based Forwarding Protocol (VBF), hop-by-hop vector-based forwarding (HH-VBF) and Vector-Based Void Avoidance (VBVA). The typical physical layer technology for underwater networks is acoustic communication compared with electromagnetic waves and optical waves. Energy constraint, long delay and limitation in bandwidth are greater challenges in underwater acoustic sensor networks for monitoring and other applications.in this paper present the performance evaluation of these protocols in term of energy consumption ,average end-to-end delay and Packet delivery ratio. Comparison is carried out by using Aqua-Sim simulators for underwater sensor networks and NS2 based simulator installed in Linux environment.

Key words: Underwater Wireless Sensor Networks, Vector-Based Forwarding Protocol (VBF), Hop-by-Hop Vector-based Forwarding (HH-VBF) and Vector-Based Void Avoidance (VBVA).

INTRODUCTION

Water quality monitoring is essential to control physical, chemical and biological characteristics of water. in example, a water for drinking should not containing any chemicals that may be detrimental to the health and water for irrigated agriculture purposes must be low in sodium and water for industry applications must be low in certain inorganic chemicals. Water quality monitoring can help with water pollution detection and discharge of toxic chemicals and contamination in water[1]. There are several parameters can monitored such as Potential of hydrogen (pH), Dissolved oxygen (DO), Temperature, Conductivity/TDS and Turbidity. Thus, underwater wireless sensor network contain number of sensor each one to monitor specific pollutant these sensors are connected together by acoustic signal.

Electromagnetic waves communication and optical waves is not the best candidate for underwater communication. Water propagation characteristics that dictate electromagnetic waves deployment over long distances through the waters of the sea only conductive in additional low frequencies (30–300 Hz). This requirement requires large antennae and high transmission power, which are not suitable for the deployment

of sensor networks. In contrast to electromagnetic waves, Optical waves are not suffering from these highly attenuation. However, optical wave communication under water suffers from significant scattering. Therefore, optical waves are only used for short-range communication in the underwater environment. So, linking in underwater networks is depending on acoustic communication[2].

The network layer function is finding a way from source to the destination taking into account many characteristics of the channel such as long propagation delay and energy of the nodes. There was an extensive studying to find the path from the source to the destination in various gateways of the UWSNs. These protocols can be classified into three different groups: proactive, reactive and geographical routing[3]. From[4,5,6] an appropriate of proactive and reactive protocols with UWSNs is too weak Memory and energy reasons for incompatibility of proactive protocol with UWSN. Reactive protocols are unsuitable for underwater networks because of high latency, asymmetrical links and topology and so the higher delay to create the path, being further amplified in this environment because the slower propagation in acoustic signals. Thus, from[7] the geographical routing protocols are energy efficient and scalable. For these reasons the most suitable approach using in UWSNs is geographical routing protocols. So, in this paper later we will give a brief on some routing protocols designed to UWSNs topologies most of them take into consideration the limitation in energy.

In this paper we offer a comparison between three routing protocols (VBF,HH-VBF and VBVA) in term of energy consumption, average end-to-end delay and Packet delivery ratio. Comparison is carried out by using Aqua-Sim simulators for underwater sensor networks and NS2 based simulator installed in Linux environment.

The paper is organized as follow: Related work in the section (2), Description of the routing Protocols in section (3) Performance Evaluation and Simulation in section (4) and finally, conclusion and future work in section (5).

Related Work

In this section, we offer three existing Geographic-based protocols for UWSNs

In[8] proposed the routing protocol called Vector-Based Forwarding (VBF). In VBF, each packet holds the location of the sender (SP), the target (TP) and forwarder (FP). These packets are passing through various paths called “routing pipe” from a source to a target node, this property makes it a strong against failure that may be occur in sending packets. A localization, distribution and self-adaptation algorithm is offer by the strategy of this protocol to improve the performance of VBF. This algorithm allows the nodes to assess the importance of passing packets and deleted the low important packets leading to low energy consumption.

In[9], offer an adaptive location-based routing protocol, named as hop-by-hop vector-based forwarding (HH-VBF). It uses the concept of a “routing pipe”, the same as (VBF) protocol[10]. Differ from the native policies of VBF protocol. HH-VBF proposed using of a routing pipe for each forwarder in the network, rather than a source-to-sink routing vector. By establishing the hop-by-hop vectors. It can solve two main drawback of VBF: first, the data is very small deliver ratio for dispersed networks. Second, highly sensitive to the threshold of “routing pipe” radius.

In[11] proposed a void avoidance protocol, called Vector-Based Void Avoidance (VBVA), to addressing the routing void problem in UWSNs. VBVA supports two mechanisms, vector-shift and back-pressure, to overcome voids problem. VBVA address the problem of routing void on request and thereby does not need to know the structure of the network details void advance. Thus, VBVA is a powerful and first for dealing with solving mobile and the three-dimensional void problems in UWSNs.

In this paper, a comparison and assessment of the performance of the aforementioned protocols to get the optimal protocol in our monitoring system by using UAWSN, is presented.

Description of the Protocols

VBF

From[8], VBF is robust, scalable and energy efficient. This is mainly in "routing pipe" approach. There is no need for Information Service on the nodes, except only a small part of the nodes. Also, the packets are passing through repeated and Dovetailed paths from a source to a sink; therefore VBF is robust against losing packets and the frailer can be occur on nodes.

The routing in VBF routing protocol

In VBF, each packet holds the location of the sender (SP), the destination (TP) and forwarder (FP). Each packet contains a RANGE field. The packet that reaches the area defined by its TP, that packet was controlled by the RANGE field. The routing pipe is the vector from the sender (SP) to the destination (TP) and the radius of the pipe is illustrated in the RADIUS field. Routing in VBF is embarked by query packets. VBF routes various queries in deferent ways[8]:

Sink Initiated Query

Two types of such queries: location-dependent query, in this type the sink is interesting in some limited area and knows the position of that area; the other type of this query is location-based query, in which the sink needs to know some types of data or information regardless of its position.

Source Initiated Query

When a source is starting to transmit, firstly sets a coordinate system itself and floods a packet called "DATA READY" to the network. Thus, each node and sink can calculate its position in the source-based coordinate system. The sink sends source location to its coordinate system, and sends a location-based packet to source to give it permission for computing its location in the sink-based coordinate system for following communications.

VBF Algorithm

While a node receiving packet, it first calculates its position and compute if it is in the routing pipe. If it exists; the node holds the packet for a time called *Tadaptation,* it was determined as below:

$$T^{adaption} = \sqrt{\alpha} X t^{delay} + (r - d/\upsilon 0) \quad ...(1)$$

Where α is the desirableness factor, T^{delay} is a maximum delay, v0 is the propagation speed of acoustic signals in water (1500m/s), and d is the distance between node and the forwarder. The theoretical analysis can be found in[10].

HH-VBF

Drawbacks of VBF

Two main problems in VBF routing protocol[9]:

The data is very small deliver ratio for dispersed networks, if nodes fall under these pipes, the data packets can't be forwarded to the sink until paths may exist out of pipe. These paths do not exist in VBF, which negatively affects packet delivery ratio. Fig 1 demonstrates the influence of fixed routing pipe on VBF. Packets from nodes *A* and *C* are unable to reach the sink because no nodes exist in the pipe.Highly sensitive the "routing pipe" radius threshold.

HH-VBF Protocol Overview

Problems solutions in VBF, offered a protocol, named as Hop-by-Hop Vector-Based Forwarding (HH-VBF).HH-VBF uses the routing vector notion similar the VBF protocol. But, HH-VBF uses various virtual pipes from forwarders nodes to the sink instead of use single vector in VBF. Thus, each node can be making the adaptation for the packet routing decisions depends on its current position. From this characteristics will get the following interests: (1) No need to increase the radius of pipe after the transmission range to enhance performance in routing, because of there is routing pipe for each node. (2) HH-VBF Strengthens packet delivery ratio compared with VBF, because of In dispersed networks, While the number of nodes qualified be small, HH-VBF can find a data delivery path as long as there exists. Also, HH-VBF less than VBF in sensitivity to routing pipe radius threshold.

Routing In HH-VBF Protocol

In HH-VBF[10], the routing pipe is redefining to be a virtual pipe from source to the sink instead of single vector pipe. This policy allows for finding

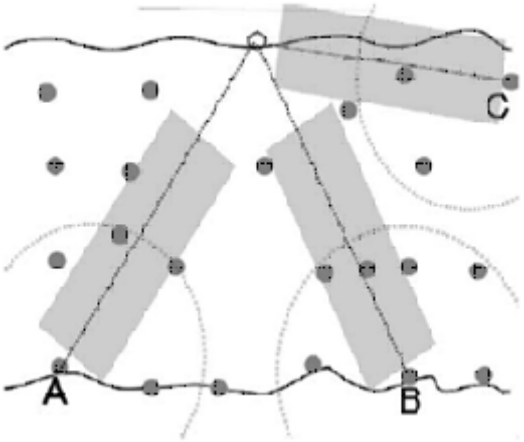


Fig. 1 : VBF using single routing pipe

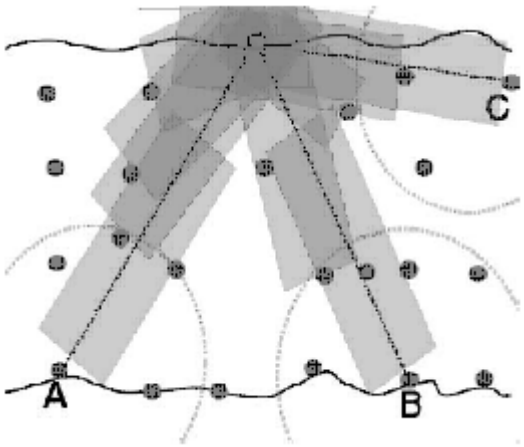


Fig. 2 : HH-VBF with per-hop vector computing

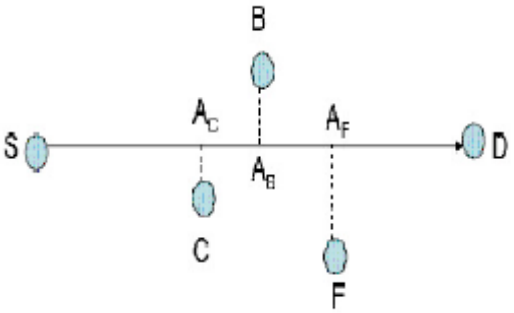


Fig. 3 : An example of void node

a routing path in expanded manner when compared it with VBF. Suppose a node N receives a packet from the source or any through node S. after receive the packet, the N calculate the vector from the S to the sink. That way offer to the forwarding pipe changing each hop in the network, for this reason named as hop-by-hop vector based forwarding (HH-VBF). Upon a reception calculates the vector from its sender to the sink, it compute its distance to that vector. If the distance is less than the predefined threshold, it is drop the packet. Time period is representing a node carries the packet before forwarding it. The self-adaption algorithm in HH-VBF is different from that in the original VBF. Due to effective suppression strategy package approved in VBF, can select just a few paths to route packets. That can cause problems in dispersed networks. To improve the delivery ratio in dispersed networks, introduced some repetition control in the self-adaption procedure for HH-VBF. In HH-VBF[10] when a node receives a packet, it first carries the packet for certain time period suit with its desirableness factor (the same VBF). Therefore, node has small desirableness factor will send first. In this manner, each node in the neighborhood can hear the same packet several times. HH-VBF allows each node to calculate its distances to the different vectors from the forwarding packets to the sink. If the smallest distances of them are stay greater than smallest distance threshold already calculated, this node will forward the packet; else, it drops the packet. Clearly, the largest threshold is, the nodes will be permit to forward packets. So, HH-VBF can control forwarding redundancy by tuning that smallest distance threshold. Each node stay uses the self-adaptation algorithm to reduce excessive packets. Fig. 2 shows a high quality concept of HH-VBF using the same network setting as VBF. As shown, in HH-VBF, nodes A and C can access to the sink by using way that are not allowed with VBF[9].

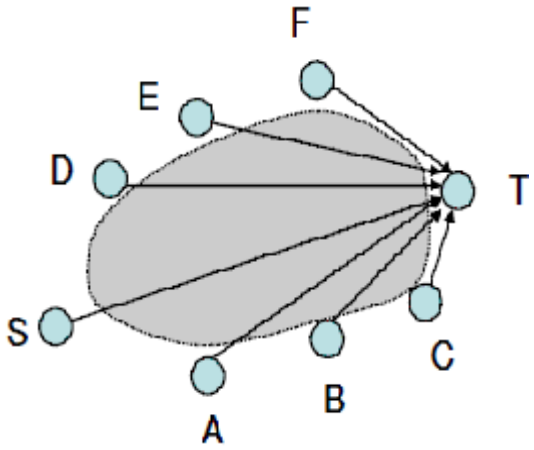
VBVA

VBVA is expansion of VBF routing protocol. In the absence of void, the routing in VBVA the same as routing in VBF. If a void is exist, VBVA use one of the two mechanisms that have (vector-shift mechanism or back-pressure mechanism to overcome the void.

Void Detection

A node detects the existence of a void by hearing packet transmission of the adjacent nodes[11].We refer to the starting point and the ending point of the vector by S and T respectively. In any node N, we define the advance of node N on the forwarding

(a) Vector shift mechanism



(b) Back pressure mechanism

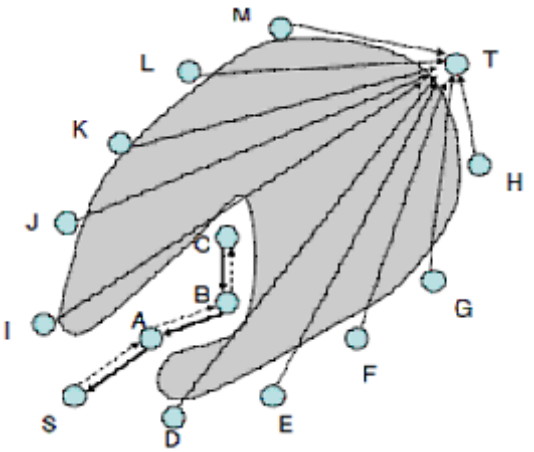


Fig.4 : Two mechanisms of VBVA

vector of the packet is the projection of the vector SN on the forwarding vector ST. We call a node a void node if all the advances of its neighbors on the forwarding vector carried in a packet are smaller than its own advance. As shown in Fig. 3, the forwarding vector of a packet is ST, and the advances of nodes B, C and F on the forwarding vector are named as AB, AC and AF, respectively. As shown in Fig 1, all the adjacent of node F have smaller advances than F on the forwarding vector ST. Therefor node F is a void node.

VBVA mechanisms

There are two mechanisms are used in VBVA for overcoming the void:

Vector-Shift Mechanism

When a node identified the void node for a packet, it will try to avoid the void by shifting the forwarding vector of the packet. To accomplish this, sending broadcast message contain a vector-shift packet by node to all its neighbor nodes. Upon receive this message; each node outside the forwarding pipe trying to forward its data packet to a new vector from them to the sink. Fig.4 (a) shows this mechanism[11].

Back-Pressure Mechanism

Node that finds out of end node, it sends a controlling packet, called BP (Back Pressure) packet. Upon receiving a BP packet, every neighboring node tries to shift the forwarding vector of the corresponding packet if it has never shifted the forwarding vector of this packet before. Otherwise, the node broadcasts the BP packet again. The BP packet routed in reverse side move from the sink until it reaches a source node that can act the vector shifting to pass the packet towards sink. Fig. 4(b) shows an example for the back-pressure process.

Performance Evaluation and Simulation

In this section, we evaluate the performance of VBF, HH_VBF and VBVA routing

Table1. Simulation Parameters

Topology area	500 m * 500 m
Topology depth	500 m
Transmission power	2 watt
Receive power	0.1 watt
Idle power	0.001 watt
Maximum transmission range	100 m
MAC protocol	Broadcast
Bandwidth	Bandwidth 10 Kbps
Frequency	25 kHz
Channel	Underwater channel
Propagation	Underwater propagation
Antenna	Omni-directional
Maximal speed	5 m/s
Minimal speed	0 m/s
Packet size	50 bytes
Simulation time	500 second

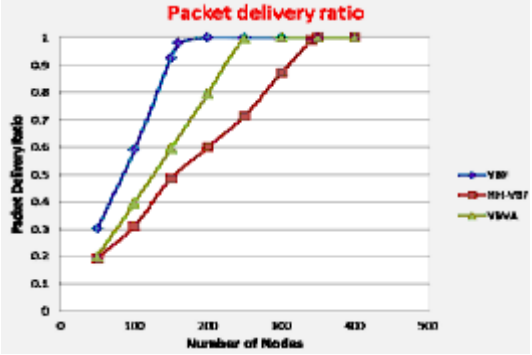


Fig. 5 : Packet Delivery Ratio

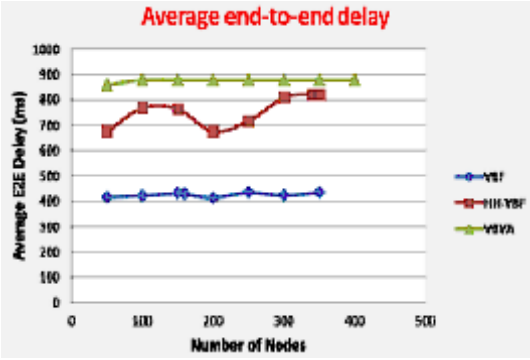


Fig. 6 : Average End-To-End Delay

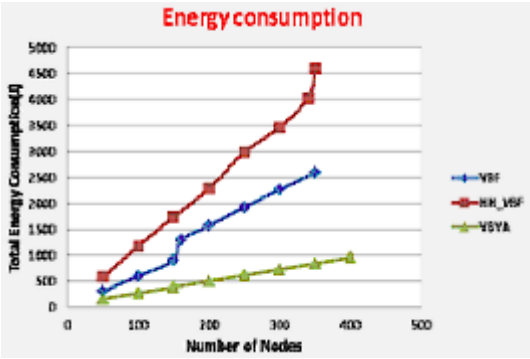


Fig. 7 : Energy Consumption

protocols. All simulations are performed using the Network Simulator NS2[12] with an UWSN simulation package (called Aqua-Sim) extension[13]. Using table (1) as parameters in all simulation scenarios. We use the broadcast MAC protocol, this protocol suitable for geographic routing protocols especially VBF[14]. In Broadcast MAC protocol, a node that has packets to send, it first senses the channel. If empty, it broadcasts the packets. Else, it backs off and dropping the packets if the node backs off 4 times. The source location is (490, 490, 500) close to the one corner, while the sink location is (10, 10, 0) close to opposite corner at the surface. All other nodes are mobile between them. Each node randomly chosen destination and moving towards that target. As soon as it reaches the target node, it randomly chooses a new target and it is moving in a new direction.

Performance Metrics

We propose three metrics

Packet Delivery Ratio

The ratio of the number of success packets that received at the sinks to the total number of generated packets at the source node.

Average End-to-end Delay

Defined as the average time taken by a packet for traveling from the source node to the sinks node.

Total Energy Consumption

Defined as the total energy consumption in delivering packet, including transmitting, receiving, and idling energy consumption of all nodes in the network.

As we can see in fig.5 the VBF protocol we can achieve highest delivery ratio in a number of nodes less than number of nodes in the HH_VBF and VBVA protocols. Therefore, nodes that achieve 100% packet delivery ratio are considered the optimum number of nodes to obtain high success rate. In fig.6 when compared between protocols in term of e2e delay, found the VBVA protocol is higher one Because of the effort in the mechanical to prevent voids. In Fig.7 the important parameters (energy consumption) we compared. As we see it is VBVA protocol is the lowest energy consume because of less number of forwarder used in this protocol which leads to reduce the transmitted power and subsequently reduced total energy consumption.

Depending on the type of system used in pollution monitoring as possible to assess any protocols is appropriate in our work. Are these data to be monitored is the high sensitivity and importance, how many nodes you want to use, Is

the delay does not affect the monitoring process, Loss of some packets as possible to affect the validity of the information and other things can deduced and find solutions to the problems of these systems in the next section, depending on the results of the comparisons.

CONCLUSION

In this paper, we present a Performance assessment of important three routing protocols for underwater acoustic wireless sensor networks. We have carried assessment by using Aqua-Sim simulators and found it achieves most of the protocols parameters. We packet Delivery Ratio, average end-to-end delay and total energy consumption as our performance evaluation parameters. Our conclusions are, if the number of pollutants is 50 or less, the VBF protocol is the most appropriate protocol than the rest For it was bring to me a system less energy consumption, less delay and high packet delivery ratio In addition, we will use the fewest number of node to achieve 100% success rate will therefore get a less expensive system and overcome the problem of use redundant node to achieve the same purpose. But if the data that monitored is sensitive in terms of delay we will use the VBVA and HH-VBF protocols more suitable than VBF protocol. If the monitoring systems have a large number of nodes, is best to use VBVA Protocol to overcome the problem of charging and recharge for long periods the fact that VBVA Protocol is high energy-efficient. Thus, I suggest to our monitoring system that we use the VBF routing protocol.

In future work we plan to manipulate the architecture of VBVA protocol to make it higher packet delivery ratio and less e2e delay to achieve more energy efficient and high data rate routing protocol.

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