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Research paper

Design and analysis of VBF and EEVBF routing protocols for energy efficient underwater communication

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Abstract

Major constrain in Acoustic communication network is the consumption of energy by senor nodes. The need to regulate the energy consumption of senor nodes relay mainly on underwater applications like disaster prevention, tsunami warning and other environmental moni-toring, where the sensor need to transmit the sensed data constantly to the control station for critical analysis. This paper mainly focuses in designing a routing protocol that can challenge a better life expectancy of underwater sensor nodes. From the broader area of research in UWSN, VBF routing protocol gives a promising performance in term of increase in data throughput, PDR and energy consumption. Hence an energy efficient vector based forwarding protocol (EEVBF) is designed which can efficiently regulates the energy consumption when compared to VBF. Based on simulation results, the performance analysis of data throughput, packet delivery ratio, and energy consumed using aquasim network simulators.

Keywords: *BER; Data Throughput; Energy Consumption; EEVBF; PDR; VBF; UWSN*

1. Introduction

Underwater communication networks are the important means to achieve marine monitoring, data acquisition and strategic communication, but its performance is degraded by the characteristics of underwater acoustic channel. A precise, real time & continuous monitoring systems like UWSN is needed for various oceanographic applications[1]. The traditional approach for the underwater monitoring has several drawbacks, to ensure maximum efficiency, a good communication system is need to be developed which can overcome various challenges faced in underwater channel modelling[2]. After a detailed survey in underwater routing protocols, the vector based forwarding protocol is found to be best suited for underwater sensor network.[3] It is a location based routing protocol, where each packet carries the position of the target, the forwarder and the sender along with two fields to maintain the node mobility. The forwarding path in VBF is specified by the routing vector from the sender to the destination target. When packet is received, the relative position to the forwarder is computed by the node by measuring its distance and also by the angle of arrival. The RADIUS field is responsible for checking the presence of the forwarder node within a particular distance and the RANGE field is used to control the flooded packets at specific area.[4] There is increase in energy consumption because too many nodes involves in data forwarding. So a modified concept of VBF called energy efficient vector based forwarding is proposed here in which each node is allowed to estimate the density in its neighborhood based on local information and packets are forwarded adaptively so the efficient energy consumption is achieved using self-adaptation algorithm [5], [6].

2. Underwater wireless communication network & challenges

A complete layout of the physical properties and critical issues of different signal propagations used for UWSN is discussed in this section. Underwater Sensor Networks' (UWSN) is made up of many sensor nodes and Underwater Vehicles (AUVs), which make it possible to record climate changes, conduct search & survey missions, tactical surveillance, pollution control, study of marine life, and early predication of natural disturbances in the ocean.[7] Scenario of underwater communication network with different sensor nodes is shown in fig.1.

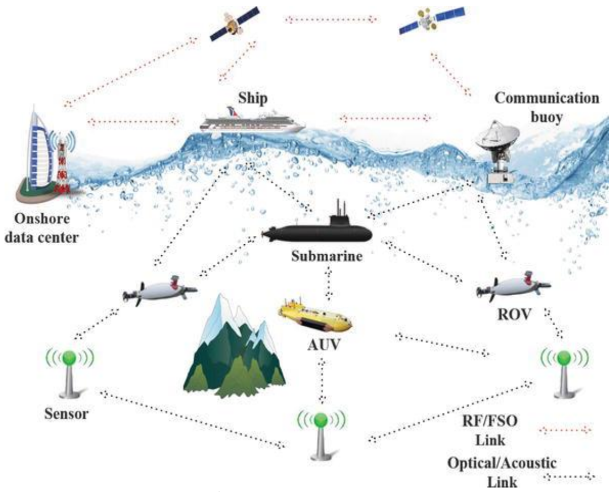

Fig. 1: Scenario of Underwater Communication Network.

Every sensors act as node in the network and it is consists of sensors, ROV's, Ship as sink node, base station and AUV. All the nodes involves in data transmitting and receiving. The ocean environment itself challenges the construction of UWSN and is difficult to implement for application purposes. The data transmission is limited by many characteristics that include high error probability, limited bandwidth capacity, fouling, and corrosion, temporary losses of connectivity, large propagation delays, high bit rate errors and limited battery power. Since the underwater channel has limited bandwidth, and high frequency signal is easily absorbed due to salinity and other ocean parameters.[8] Hence acoustic signal is the best suited for data communication. The next major issue is channel modeling; it is used to predict the signal loss between the transmitter and the receiver.

The primary sources affecting the channel modeling are ambient noises. All the background noise in ocean like wave sound, marine life & other man made noises are grouped as ambient noise. The proposed idea is to design an acoustic communication system with efficient routing protocol, which can perform better in achieving high throughput, good PDR with efficient and minimize use of batter power there by achieving efficient energy consumption.

3. Proposed methodology

The proposed network model is deployed with both fixed and dynamic nodes as shown in fig.2. The proposed network structure consists of five anchoring nodes (transponders), two static vessels (transceivers) at the water surface and one dynamic node. From the area of literature study Vector based routing protocol (VBF) is found to be best-suited for underwater environment in MAC layer.[9]

A new concept is proposed here, i.e by modifying the existing VBF using self-adaptation algorithm. It constructs a pipe that utilizes the nodes between the source and destination, searches for the forwarder to send the data packets from current nodes to the neighboring nodes. Thus by selecting nodes that are more desirable, helps to further reduce the energy consumption of nodes.[10] Fig. 3 shows the concept of self-adaptation theory for VBF protocol with respect to sink and source node. The success rate of delivered data is dependent on node density. The computation process is very simple and if there exists one path in routing pipe, then the data packet are successfully delivered as specified by routing protocol and vector[6], [11].

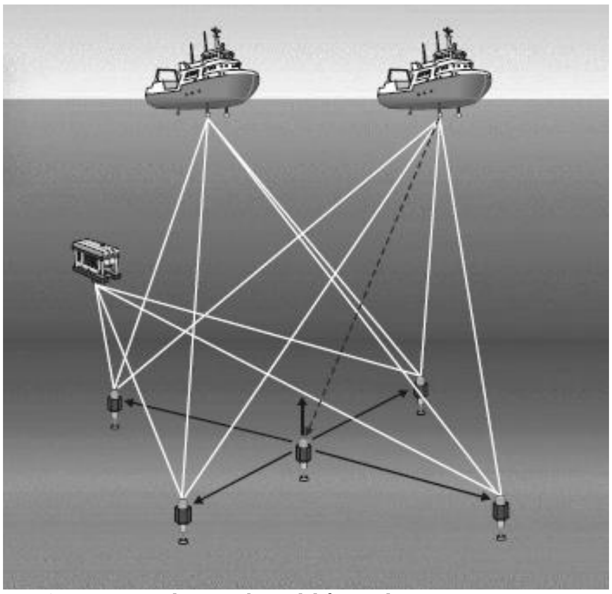

Fig. 2: Proposed Network Model for Underwater Environment.

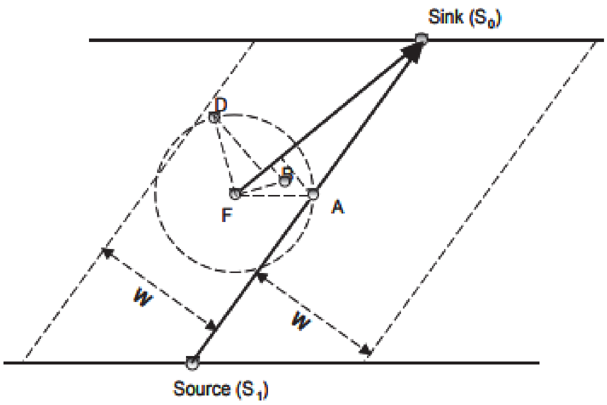

Fig. 3: VBF with Self-Adaptation.

4. Performance analysis

This section gives a broad analysis of the evaluation process of proposed system through a fine tool like Aquasim. It is extensive of NS-2 tool specially designed for underwater network communications. The performance metrics like PDR, data throughput along with energy consumption of VBF protocol and proposed EEVBF is compared based on the simulation outputs. The total simulation time is 30s and the initial energy is 50 Joules. The nodes are randomly fixed and are chose to transmit the sensed data to the neighbor nodes based on its position tracking principle [12][13].

The simulation result of energy consumption of the VBF & EEVBF is shown in fig 4 & fig. 5.

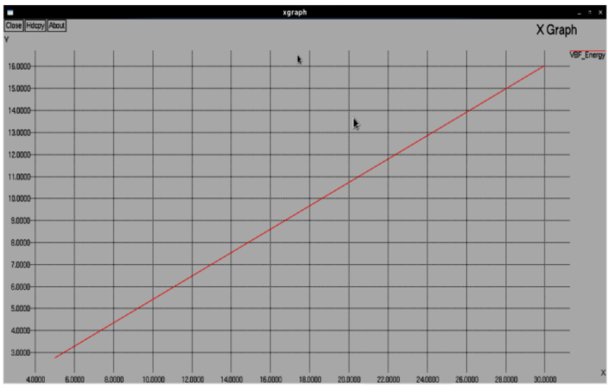

Fig. 4: Energy Consumption of VBF.

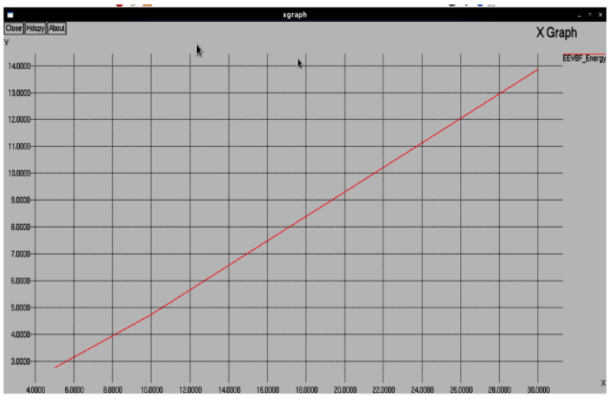

Fig. 5: Energy Consumption of EEVBF.

The results clearly shows that the energy consumption of VBF is high when compared to EEVBF.The tabulation of energy consumed by the nodes at different interval of time is given in table 1.

Table 1: Performance Analysis of Energy Efficiency for VBF & EEVBF

TIME (sec)	VBF (joules)	EEVBF (joules)
5	2.7561	2.75569
10	5.41691	4.7359
15	8.07188	7.03431
20	10.7234	9.31393
25	13.385	11.5972
30	16.0411	13.8754

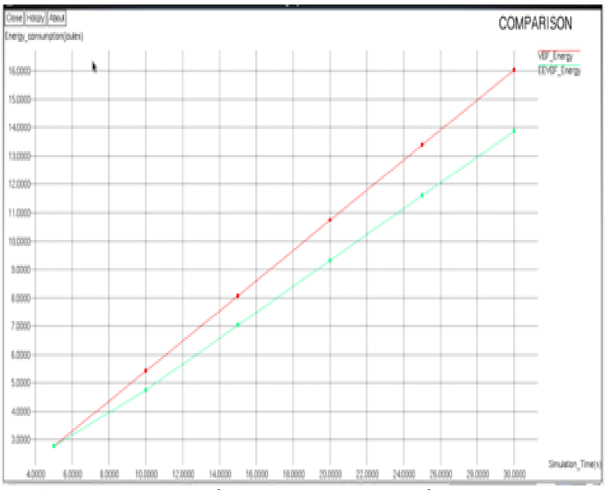

Fig. 6: Comparison of Energy Consumption of VBF & EEVBF.

From fig. 6, it is easily understood that when the data is transmitted from one node to nearest node and as the simulation time increases, the energy consumption also steadily increases for both protocols. From the performance analysis, the energy consumed by VBF for 30secs is 16.0411 joules where as the energy for EEVBF is 13.8754 joules. Critical analysis shows that EEVBF protocol is found to be very efficient than the conventional VBF in Underwater communication network.

4.1. Packet delivery ratio for VBF & EEVBF

The performance of VBF and EEVBF protocol in term of packet delivery ratio is studied with respect to simulation time.

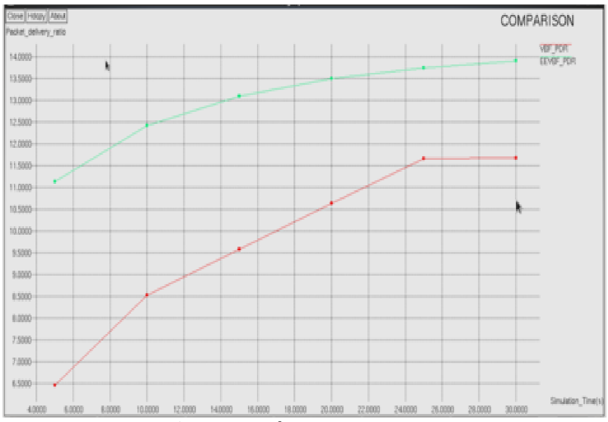

Fig. 7: PDR for VBF & EEVBF.

The graphical outcome as shown in fig. 6 shows that Packet delivery ratio varies in accordance with the simulation time. In VBF protocol, the packets transmitted is 18.0724 for 30secs and received packets is 13.9128 at time interval of 30s. Whereas in VBF protocol received packets are 11.6744. Table 2 represents a detailed comparison at different time interval.

Table 2: Performance Analysis for PDR

Time (sec)	VBF	EEVBF
5	6.4528	11.1309
10	8.5325	12.4234
15	9.5843	13.0975
20	10.6299	13.4955
25	11.6568	13.748
30	11.6744	13.9123

4.2. Performance of data throughput for VBF & EEVBF

Throughput is the maximum rate of production. The throughput for VBF is having maximum rate of 485.25kbps for 30sec, but the maximum throughput for EEVBF is 750.80kbps.

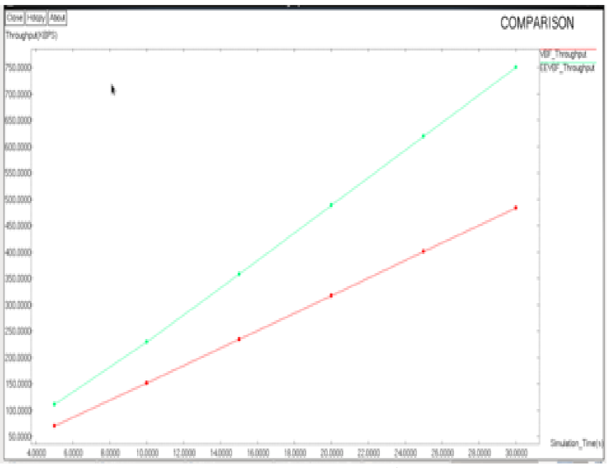

Fig. 8: Energy Consumption of EEVBF.

Table 3 gives the comparison of data throughput of proposed methodology and the existing method. The simulation output is obtained at different time interval.

Table 3: Comparison of Data Throughput for VBF & EEVBF

Time (sec)	VBF(kbps)	EEVBF(kbps)
5	69.75	110.71
10	152.26	229.41
15	234.90	358.09
20	317.69	488.77
25	400.47	619.90
30	483.25	750.80

5. Conclusion & future work

The performance evaluations of both the routing protocols are completed. The comparison of the simulation results shows that EEVBF gives better efficiency in energy consumption when compared to VBF protocol. The performance of other parameter analysis also concludes that EEVBF is performs better, because of its high Data throughput, good packet delivery ratio (PDR) and Packet Delay when compare with VBF. This improvement is achieved by using Self-adaption theory. The results also conclude that EEVBF will be predominant for high data transmission in underwater environment because of its good energy efficiency. A detailed study of different propagation models with inclusion of ambient noise and by tuning the proposed algorithm in order to achieve better BER and good Data throughput with good energy efficiency will be the future work.

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