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Enhanced VBF for Delay-aware Routing in UWSNs

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Abstract— There are many challenges in wireless ad-hoc and sensor networks that are depending on new applications of these networks. The solutions of these challenges are a vital research area in communications. In brief we can say three problems for them: communication traffic, energy consumption and routing security. In this paper we analyze performance improvement of an underwater sensor network for dense mode applications that via creation of forbidden regions in spherical divisions, delay of links has decreasing and so traffic efficiency of network has enhancement, totally. This statement is valid if and only if packet delivery ratio (PDR) has no slump in its performance. It is explicit that non-essential nodes deletion from packet forwarding process often named as routing algorithms in network theory and this is imperative than flooding packet forwarding (therefore routing is efficient packet forwarding). Also in dense usages smart nodes omission although causes PDR being perfect but energy consumption and network reliability as its achievement have enhancement and actually it is logical. But in this literature our goal is not energy consumption and that is providing of low delay connection in network. Deletion process as 30% from depth finally causes delay improvement, however energy consumption and PDR are not worse than their previous conditions.

Keywords— Underwater Wireless Sensor Networks (UWSNs), Dense Applications, Distributed Routing, Source Routing.

I. INTRODUCTION

Today, wireless networks are used for underwater applications. Monitoring below the water surface of seas and oceans is of great importance because of the different applications in military, environmental and industrial. For example, there is need to underwater observatory facilities to track submarines and environmental monitoring to identify sources of pollution are usages that need to monitor the subsurface. Other applications can be noted are to monitor below the level of the sea to discover the natural resources such as oil, gas and minerals. To monitoring these applications, it is necessary to have sensors below the water surface. since these monitoring are used widely below the water there needs to be placed many of these sensors (sonar, optical instruments, laser, magnetic, etc.) there and because of accurate analysis of the outputs of these sensors, it is necessary to network them with each other so they can exchange information.

Since the establishment of a centralized network, wired or wireless network under the water especially in deep places is very expensive and in some cases technically it is impossible or need times, wireless networks as without structure or Ad-Hoc is used.

On the other hand in these wireless networks because of electromagnetic waves are very short-range, acoustic waves are used for communication between sensors so we called such networks as underwater acoustic sensor networks. Sensor network without a central access point for the environment are able to exchange information. The problem discussed here is to review the challenges and make improvements to the process of routing in such networks to enhance their important parameters. Since the networks are often mobile and three-dimensional networks, as inherent routing for them are more complex from other Ad-Hoc networks. Next, we discuss about network goals and their corresponding challenges.

II. CHALENGES AND AIMS

According to specific features of underwater sensor networks such as electromagnetic attenuation, intrinsic propagation delay, acoustic channel system and not accessibility [7]. so we can say two general problems:

A. Traffic and Low Bandwidth challenges. Sharing of bandwidth in all times and frequencies in these networks causes many challenges because of inter node contention is in medium access control (MAC) sub-layer. Therefore in dense mode or high traffic systems, the collision exists, generally. In fact reason of it refers to this subject that network graph has too nodes or path is very long for packet forwarding [8]. Of course this problem in reality causes delay increasing in communication links but simulation shows that PDR is fixed or in the other word has no decreasing. Finally these events cause low performance for general traffic (see appendix).

B. Energy consumption and network life time. In the whole of wireless sensor networks, battery limitation is a main problem. This problem in underwater networks often is in the worst condition of itself because of no accessibility to any energy resource such as wired power supply or sun light. If energy level of each node being zero, consequently that node will be died. When number of died nodes in network is extreme, so two phenomena will be happen. First, died nodes as sensor cannot cover its main duty and second, these nodes cannot help to network traffic as router.

Therefore we can say link reliability is depending on energy consumption and in fact this statement is valid that traffic is depending on energy consumption.

III. DISTRIBUTED ROUTING

In this section, we present vector-based forwarding (VBF) protocol in details [5] .

A. Overview of VBF. In sensor networks, energy constraint is a crucial factor since sensor nodes usually run on battery, and it is impossible or difficult to recharge them in most application scenarios. In underwater sensor networks, in addition to energy saving, the routing algorithms should be able to handle node mobility in an efficient way. Vector-Based Forwarding (VBF) protocol meets these requirements successfully. We assume that each node in VBF knows its position information, which is provided by some location algorithms. If there is no such localization service available, a sensor node can still estimate its relative position to the forwarding node by measuring its distance to the forwarder and the angle of arrival (AOA) and strength of the signal by being armed with some hardware device. This assumption is justified by the fact that acoustic directional antennae are of much smaller size than RF directional antennae due to the extremely small wavelength of sound. Moreover, underwater sensor nodes are usually larger than land-based sensors, and they have room for such devices. In this work, we assume that the position information can be calculated by measuring the AOA and strength of the signal. In VBF, each packet carries the positions of the sender, the target, and the forwarder (i.e., the node which transmits this packet). The forwarding path is specified by the routing vector from the sender to the target. Upon receiving a packet, a node computes its relative position to the forwarder. Recursively, all the nodes receiving the packet compute their positions. If a node determines that it is sufficiently close to the routing vector (e.g., less than a predefined distance threshold), it puts its own computed position in the packet and continues forwarding the packet; otherwise, it simply discards the packet. In this way, all the packet forwarders in the sensor network form a "routing pipe": the sensor nodes in this pipe are eligible for packet forwarding, and those which are not close to the routing vector (i.e., the axis of the pipe) do not forward. Fig. 1 illustrates the basic idea of VBE In the figure, node S_1 is the source, and node S_2 is the sink. The routing vector is specified by $\overrightarrow{S_1S_2}$. Data packets are forwarded from S_1 to S_2. Forwarders along the routing vector form a routing pipe with a pre-controlled radius (i.e., the distance threshold, denoted by W in this paper). As we can see, like all other source routing protocols, VBF requires no state information at each node. Therefore, it is scalable to the size of the network. Moreover, in VBF, only the nodes along the forwarding path (specified by the routing vector) are involved in packet routing, thus saving the energy of the network.

B. The Basic VBF Protocol. VBF is a source routing protocol where each packet carries simple routing information. In a packet, there are three position fields, SP, TP, and FP, that is, the coordinates of the sender, the target, and the forwarder. In order to handle node mobility, each packet contains a RANGE field. When a packet reaches the area specified by its TP, this packet is flooded in an area controlled by the RANGE field. The forwarding path is specified by the routing vector from the sender to the target. Each packet also has a RADIUS field, which is a predefined threshold used by sensor nodes to determine if they are close enough to the routing vector and eligible for packet forwarding .

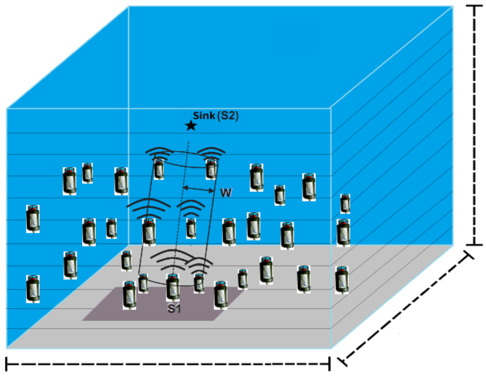


Fig. 1. VBF for UWSNs.

Sink-Initiated Query. There are two types of queries. One is location-dependent query. In this case, the sink is interested in some specific area and knows the location of the area. The other type is location independent query, when the sink wants to know some specific type of data regardless of its location. For example, the sink wants to know if there exist abnormal high temperatures in the network. Both of these two types of queries can be routed effectively by VBP. For location dependent queries, the sink is interested in some specific area; so it issues an INTEREST query packet, which carries the coordinates of the sink and the target in the sink-based coordinate system. Each node which receives this packet calculates its own position and the distance to the routing vector. If the distance is less than RADIUS (i.e., the distance threshold), then this node updates the FP field of the packet and forwards it; otherwise, it discards this packet. For location-independent queries, the INTEREST packet may carry some invalid positions for the target. Upon receiving such packets, a node first checks if it has the data which the sink is interested in. If so, the node computes its position in the sink-based coordinate system, generates data packets, and sends back to the sink. Otherwise, it updates the FP field of the packet and further forwards it.

Source-Initiated Query. In some application scenarios, the source can initiate the query process. VBF also supports such source-initiated query. If a source senses some events and wants to inform the sink, it first broadcasts a DATA-READY packet. Upon receiving such packets, each node computes its own position in the source-based coordinate system, updates the FP field, and forwards the packet . Once the sink receives this packet, it calculates its position in the source-based coordinate system and transforms the position of the source into its own coordinate system. Then the sink can decide if it is interested in such data. So, if it may send out an INTEREST packet to the area where the source resides .

Handling Source Mobility. Since the source node keeps moving, its location calculated based on the old INTEREST packet might not be accurate any more. If no measure is taken to correct the source location, the actual forwarding path might get far away from the expected one; that is, the destination of the data forwarding path most probably misses the sink. We propose the following sink-assisted approach to solve this problem.

IV. Proposed Method: Spherical Divisions in Source Routing

Simulation results in previous works show that in dense networks that have too large number of nodes in limited volume, packet delivery ratio (PDR) is in the highest order and if density has a large amount of increasing where this amount must be greater than saturation value, then PDR is equal to 100% [4] and after occurrence of saturation, PDR has maximal constant value of itself. So this idea is logical that in some high density applications we can put an extra limitation on routing and however PDR holds its maximum value. It is observable that high constrained policies con decrease PDR value. In the other word we can say that limitation can reduce saturation point of network but finally saturation occurs.

Keeping of PDR in 100% is often simultaneous with energy consumption decreasing but the goal of this paper is not energy analysis and we intend to introduction a limitation for link delay improvement. If we divide underwater 3-D space to co-central spherical regions as radiuses deference of two consecutive spheres is less than acoustic radius range, consequently network graph after applying of periodical deletion of consecutive regions will be connected but this issue save energy of nodes that are in deleted regions (energy transmission mode) and also deletion of this nodes causes forwarding path will be shorter than before and therefore delay decreases.

According to past statements, it is explicit that in higher densities, we can delete more regions via keeping of previous PDR. These concepts mean this deletions although reduce value of saturation point but yet saturation is occurring. Therefore in Fig. 2 the radius length of color regions is depending on two variables: first, density of network and second, radius range of acoustic modems (R_r). Yellow regions show forbidden nodes that are excluded from routing process and green regions show included nodes.

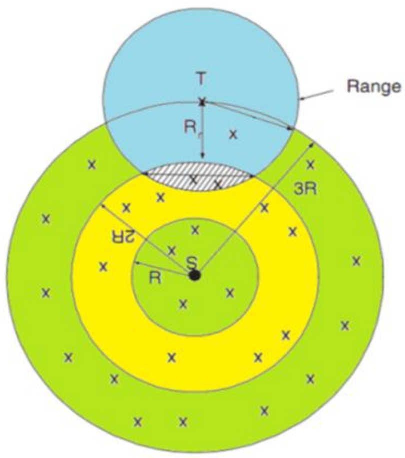


Fig. 2. Spherical Regions.

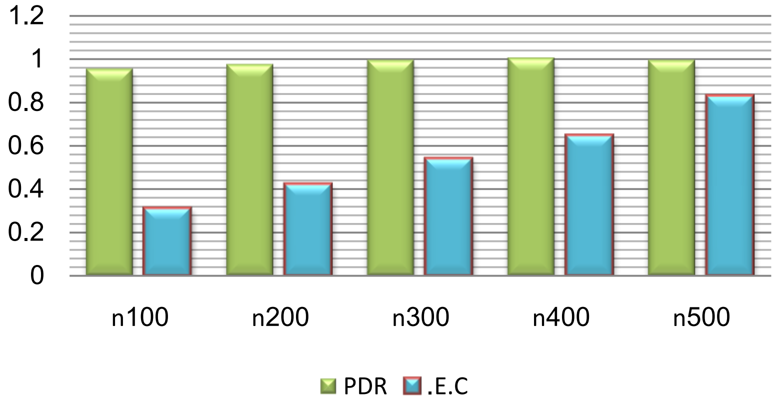
V. Performance Evaluation

In order to network performance evaluation, we can use NS-2 software [6] and for creation of underwater model Aqua-sim is used. Underwater space has dimensions in sizes of $100^m \times 100^m \times 100^m$. Mobility of nodes is Omni-directional from kind of Random Walk. Speed of nodes is selected between 1 to 5 m/s, randomly. Primary positions of nodes except sender and sink node (unique receiver named sink) are random in 3-D space [9]. Other simulation circumstances are according to UDP (Transport layer), CBR (Application layer) and Underwater MAC/Broadcast (MAC sub-layer) [1-2]. Metrics that used in evaluation is normalized energy consumption (*E.C.*) and average end to end delay ($\overline{Delay}$) with PDR studying. Main network variable is density or number of nodes (*NN*), equivalently in constant volume. For simulation 30% from depth radius is deleted (under suitable condition for graph connectivity and delay enhancement). Nodes that were included in routing because of they were in routing pipe of VBF, and now are excluded. Other simulation conditions are fixed as; 1 packet per second for sending interval, 100 sec. for simulation time, 20m and 15m length for routing pipe radius (*W*) and radius range, respectively. Fig. 3.a shows PDR and E.C. values for original VBF and Fig. 3.b shows them for Enhanced VBF (E-VBF) ender 30% deletion of depth in spherical divided regions deletion (also named depth zoning). Fig. 4 compares delay of VBF and E-VBF for various densities. These results prove spherical division is influent on delay enhancement.

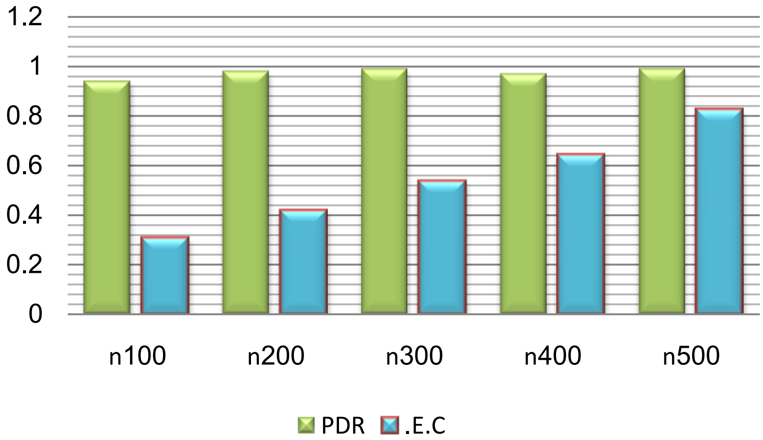
VI. CONCLUSION

Modern telecommunication networks indicate that wireless networks have become today's most important communication networks. Networks that are commensurate with the challenges of new approaches have to be developed and applied. Network engineering problems is the most complex engineering problems hence it would be difficult dealing with such complex issues that have numerous variables and the behavior of the system are less well-known.

One of the best ways for enhancing of network performance issues is innovative solutions and heuristic. Proving innovative solutions are not possible, except with the simulation. What is studied in this paper is to improve the routing of an underwater sensor network in dense applications. The general idea that is represented in this article beyond VBF routing protocol also can be used in other protocols [3]. Spherical divisions and forbidden regions is unique for each sender and so far is only for source routing.



(a)



(b)

Fig. 3. Performance of VBF (a) and E-VBF (b).

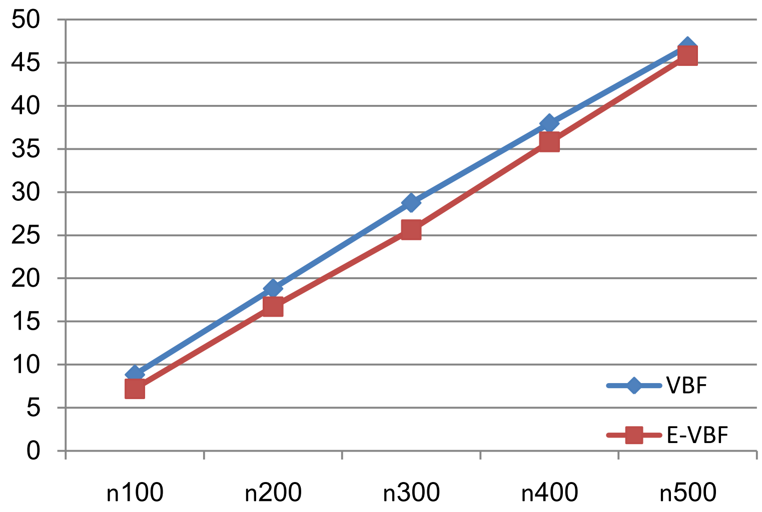


Fig. 4. Delay Comparison Results (Second) vs. NN.

REFERENCES

[1] Xie P, Cui J-H, Lao L., "VBF: vector-based forwarding protocol for underwater sensor networks". Networking technologies, services and protocols performance of computer and communication networks, mobile and wireless communications systems. Springer, 2006, pp. 1216–21.

[2] Yan H, Shi ZJ, Cui J-H., "DBR: depth-based routing for underwater sensor networks", the 7th international IFIP-TC6 networking conference on adhoc and sensor networks, Singapore: Springer-Verlag; 2008.

[3] Muhammad Ayaz, Imran Baig, Azween Abdullah, Ibrahima Faye, "A survey on routing techniques in underwater wireless sensor networks", Journal of Network and Computer Applications 34, 2011, pp. 1908–1927.

[4] Nicolas Nicolaouy, Andrew See, Peng Xie, Jun-Hong Cui, Dario Maggiorini, "Improving the Robustness of Location-Based Routing for Underwater Sensor Networks", IEEE Conference, 2007, pp. 1-6.

[5] Peng X, et al., "Efficient vector-based forwarding for underwater sensor networks", Hindawi Publishing Corporation, 2010.

[6] Xie. Peng et al., "Aqua-Sim: an NS-2 based simulator for underwater sensor networks". In: Proceedings of the OCEANS2009, MTS/IEEE Biloxi marine technology for our future: global and local challenges, 2009.

[7] J. G. Proakis, J. A. Rice, E. M. Sozer, M. Stojanovic, "Shallow water acoustic networks", IEEE Communications Magazine, vol. 39, no. 11, pp. 114–119, 2001.

[8] D. Niculescu and B. Nath, "Trajectory based forwarding and its applications", in Proceedings of the 9th Annual International Conference on Mobile Computing and Networking (MOBICOM'03), San Diego, Calif, USA, September 2003.

[9] D. Pompili, T. Melodia, "Three-dimenisional routing in underwater acoustic sensor networks", in Proceedings of the 2nd ACM International Workshop on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks (WASUN'05), pp. 214–221, Montreal, Calif, USA, October 2005.

APPENDIX

In this paper, in definition of PDR, the packets that are incorrect not have impact and PDR is only based on correct packets. Generally, network traffic depends on two indices as PDR and delay of queuing. $\overline{Delay}$ is sum of propagation delay and queuing delay that propagation delay is constant for all conditions and so has not any impact in comparison and in fact must be independent from traffic but for simplicity in simulation we not consider it because of it is low value according to dimensions of 3-D space for simulation. If PDR has approximate static condition thus traffic only depends on delay.

$$Traffic \propto f(\overline{Delay}, PDR)\ {}^{bit}\!/_{\sec} \quad If\ PDR\ is\ fixed \Rightarrow Traffic \propto f(\overline{Delay})$$

$$Traffic \approx \frac{Packet\ Size \times Number\ of\ Arrival\ Packets}{Total\ Time\ for\ Arrival\ of\ All\ Packets + Silence\ Times}$$

$$PDR \approx \frac{Number\ of\ Arrival\ Packets}{Number\ of\ Sent\ Packets} \in [0,1]$$

$$Total\ Delay_{for\ each\ arrival\ packet} \equiv TDE$$

$$\overline{Delay} \approx \frac{1}{M}\sum_i TDE_i \quad where \sum i = M$$

$$\Rightarrow Total\ Time\ for\ Arrival\ of\ All\ Packets \approx \sum_i TDE_i \approx M \times \overline{Delay}$$

