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Opportunistic Void Avoidance Routing for Underwater Sensor Networks

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ABSTRACT

Opportunistic void avoidance routing (OVAR) protocol has been proposed for UWSNs. It is an any cast, geographic and opportunistic routing protocol. OVAR switches to the recovery mode procedure which is based on topology control through the depth adjustment of the void nodes, instead of the traditional approaches using control messages to discover and maintain routing paths along void regions. Increasing attention has recently been devoted to underwater sensor networks (UWSNs) because of their capabilities in the ocean monitoring and resource discovery. UWSNs are faced with different challenges, the most notable of which is perhaps how to efficiently deliver packets taking into account all of the constraints of the available acoustic communication channel. The opportunistic routing provides a reliable solution with the aid of intermediate nodes' collaboration to relay a packet toward the destination. In this paper, we propose a new routing protocol, called opportunistic void avoidance routing (OVAR), to address the void problem and also the energy-reliability trade-off in the forwarding set selection. OVAR takes advantage of distributed beaconing, constructs the adjacency graph at each hop and selects a forwarding set that holds the best trade-off between reliability and energy efficiency. The unique features of OVAR in selecting the candidate nodes in the vicinity of each other leads to the resolution of the hidden node problem. OVAR is also able to select the forwarding set in any direction from the sender, which increases its flexibility to bypass any kind of void area with the minimum deviation from the optimal path. The results of our extensive simulation study show that OVAR outperforms other protocols in terms of the packet delivery ratio, energy consumption, end-to-end delay, hop count and traversed distance.

Keywords : OVAR, UWSN, USN, AHH-VBF, VAPR, WSN, RCF, RGP, GPS

I. INTRODUCTION

Underwater sensor networks consist of number of underwater sensor nodes or just called sensor nodes which are equipped with acoustic transceivers that enable them to communicate with each other to perform collaborative sensing tasks over a given area from shallow water and seabed. USNs have many potential applications in ocean monitoring, such as current flow, oil pollution, seismic and tsunamis monitoring, to supply the high spatiotemporal resolution capability. Nowadays, resource discovery in the underwater environment has become one of the important goals to reduce dependency on land resources. However, it is a difficult and costly task to monitor and discover the underwater environment. Underwater sensor networks (UWSNs) have recently attracted much attention due to their significantly ability in ocean monitoring and resource discovery. Due to restrictions on the use of radio waves, acoustic transmission is most commonly used in the underwater environment. Required data are collected by the underwater sensors and directed towards the sink on the surface. Afterwards, the sink can transmit collected information to the monitoring centre via satellite for further analysis, as shown in Figure1. Some unique features of UWSNs make data forwarding in this environment a challenging task. This includes node movement, low available bandwidth, slow propagation speed, high deployment cost and a lossy environment. It also should be mentioned that the Global Positioning

System (GPS) cannot be used in an underwater environment as a localization system because of the quick attenuation of its waves in water. Furthermore, nodes cannot be aware of their positions by pre-configuration, because they are not stationary due to the water current. Nevertheless, the depth of each node in the water can be estimated through an embedded pressure gauge. Then, depth information can be used during the data forwarding procedure. The presence of void areas, a high bit error rate and energy conservation are perhaps the most challenging issues from the perspective of routing protocols in UWSNs. A void communication area is a three-dimensional region between underwater nodes that lacks any nodes inside (similar to holes). The void area can prevent communication between some of the nodes in the network. There are various reasons for the presence of void areas, such as sparse topology, temporary obstacles, unreliable nodes or links, etc. In most cases, the lack of employing enough sensor nodes, due to their high cost, while covering a large monitoring area might lead to sparse deployment of the sensors and, consequently, the creation of some void area. Moreover, the relocation of underwater sensor nodes by the water current can potentially create a void area. On the other hand, the adverse characteristics of the underwater channel can cause a high bit error, resulting from high attenuation, channel fading, noise, Doppler spread, etc. The communication channel quality varies at different ocean depths under varying pressure, temperature and salinity. The limited bandwidth of acoustic transmission also reduces the efficiency of communication between underwater nodes. Generally, nodes are considered connected to each other if the transferred signal between them can be decoded without any error. In terms of energy consumption, there are also some restrictions due to the difficulties of replacing or recharging batteries, which are the main energy supply for the nodes, in the adverse and often deep underwater environment. In addition, underwater sensors consume more energy than terrestrial sensors because they use acoustic communication. Thus, employing an efficient routing protocol is quite essential to prolong the whole network lifetime. Opportunistic routing is a promising scheme in sensor networks because of its remarkable ability to increase transmission reliability and network throughput. In this way, packet forwarding is enhanced by taking advantage of simultaneous packet reception of neighboring nodes of a forwarding node and their collaboration to forward the packet. However, applying a terrestrial opportunistic routing protocol in UWSNs without considering its specific features is not possible in most cases. In the underwater environment, forwarding set selection without a hidden terminal and prioritizing them are affected by features like a high error bit rate, energy consumption, node movement and slow propagation speed. Furthermore, some terrestrial opportunistic protocols are GPS-based, which make them inappropriate for the GPS-denied underwater environment. The redundant packet transmission issue is one of the influential factors on the opportunistic routing performance. When a group of candidate nodes are selected to collaboratively forward a packet while placed out range of each other, they cannot notice the transmission of any packet by other candidates. Thus, each forwarding node sets its forwarding timer and forwards the packet separately, resulting in more collisions and energy consumption. If the forwarding nodes are selected within the transmission range of each other (without any hidden node), this increases the chance of hearing the packet transmission by other higher priority candidate nodes, although there is no absolute guarantee, because of other factors, like shadow zone occurrence. Nevertheless, some underwater routing protocols (e.g., Adaptive Hop-by-Hop Vector-Based Forwarding (AHH-VBF), HydroCast, Void-Aware Pressure Routing (VAPR) take advantage of a group of forwarding nodes in the vicinity of each other with a timer-based coordination to eliminate the duplicated packet problem in the routing layer. It should be noticed that the hidden terminal problem still may exist in the other layers of the network, which is out of the scope of this work. In this paper, we propose a new opportunistic void avoidance routing (OVAR) protocol in order to increase the throughput and reliability in the sparse and lossy underwater environment while imposing less overhead in comparison to those protocols using high cost localization to obtain their geographic coordinates in this environment. Furthermore, unlike the stateful protocols, which require global topology information, OVAR only depends on the information provided by one-hop neighboring nodes. Each forwarding node selects its forwarding set with the aid of information obtained from the distributed beaconing mechanism initiated from the sink node. OVAR is able to bypass void areas before being stuck in a void node and simultaneously selects a group of candidate nodes with the highest advancement towards the sink. The forwarding set is selected in such a way that its members can hear each other and suppress duplicate transmissions, which leads to a decrease in energy consumption and congestion. In order to prevent energy wasting in a high-density forwarding set, the number of receiving nodes can be appropriately adjusted.

II. LITERATURE REVIEW

1. A New Approach of Opportunistic Routing for Bypassing Void Region in WSNs

Wireless sensor networks (WSNs) are widely applied in many different fields in which routing protocol is one of the key technologies. In geographic routing, a sensor node exploits a path depending only on the location information of neighbor nodes. Routing protocol based on geographic information is more efficient. When transmitting packets, the void problem occurring cannot be predicted in advance. Thus, how to improve greedy forwarding in geographic routing with void avoidance becomes an important issue. This paper proposed an enhanced bypassing void routing protocol based on virtual coordinate mapping (EBVR-VCM) to solve the routing void problem. Based on optimal path to reach the destination, relay node is moved to the optimal position that can shorten the average routing path length and decrease the transmission delay. Reducing routing distance can be more economical and efficient to forward packets to improve the current geographical void problem in wireless sensor network, and to enhance the performance of network routing. With wireless network technology's advancement, varieties of applications are there. Among that wireless sensor network is the popular research area in recent years. As the wireless sensor network node move at any time and the topology fast change feature, nodes often have void problem. When node transports packet, the void problem occurring cannot be predicted in advance. This will produce packet losing, resending, rerouting, additional transmission cost and electric power output. Thus, how to improve wireless network technology's geographic routing method is more important. Due to its high expansibility and low influence by network size, geographic routing has wide application in large scale WSNs. For example, plenty of nodes equipped with geophones are distributed uniformly on the ground and have the ability to get their own locations by global positioning system (GPS) or localization algorithms in seismic exploration, where geographic routing has potential to serve as routing protocol. However, if a routing void called local minimum is encountered resulting from the random distribution of sensor nodes, the greedy algorithm in geographic routing will fail, and ultimately data transmission also fails in such situation. To solve routing void problem, an enhanced bypassing void routing protocol based on virtual coordinate mapping (EBVR-VCM) is proposed in this paper. The protocol not only maps the routing void of edge node coordinate to a void in the center of the cavity so as to cover a virtual circle in the network, but also creates the virtual coordinate of the edge node. Therefore the edge node with a virtual coordinate can be selected as a relay node. For the void area on the network, a circular virtual structure can effectively bypass routing void. Compared with the traditional protocols, the proposed protocol selects the relay node by greedy algorithm. Based on the transmission range of source node and destination node, this paper finds the shortest path to reach the destination. So greedy forwarding place relay nodes in this optimal path to transmit the packet to destination. Thus the communication delays and the overhead are reduced. Also the energy consumption is significantly reduced compared to other methods. Through establishing the virtual location, it is independent of the destination node. There is no need to rebuild the virtual location information even if the destination node changes. In authors proposed Ring constraint forwarding (RCF). It establishes a multi-ring region around a routing void, in which relay nodes are selected to avoid routing void and balance energy consumption. In authors proposed route-guiding protocols (RGP) for resisting obstacles in wireless sensor networks. Relay nodes are selected according to the geographic location relationship between the destination node and the routing void in order to prevent failing of greedy algorithm. These algorithms above have low complexity, but high overhead of control packet and time delay result in high energy consumption and inefficient transmission. Beyond that, routing void problem still exists around those established regions, and that no further scheme is proposed to solve this problem.

2. Active Opportunistic Routing In Underwater Sensor Networks

Acoustic communication is considered as the ideal communication and is used in aqua applications.

Acoustic transmission, innate to the aquatic environment and used in underwater sensor networks (UWSNs), presents its own challenges in the terms of energy consumption, long propagation delay, and available bandwidth. These challenges are difficult to directly adapt in the underwater sensor networks which have been already proved in the terrestrial networks. End-to-end delay is the main element for delay sensitive underwater sensor networks. In this work, the idea of opportunistic based routing is applied for maximizing the performance of the network while meeting the end to end delay requirements for delay sensitive UWSN applications. For implementing the idea, a new metric called End to End Latency is introduced. To effectively solve the delay problem two step heuristic algorithms is applied, which is composed of forwarding set determination and packet forwarding prioritization.

The proposed scheme involves that any packet which cannot meet its deadline is dropped. The result of the performance shows that the scheme performs better than other existing works in terms of energy costs and network good put. Opportunistic routing is a function of the relay prioritization and so it is necessary to arrange relay priorities to maximize this metric. There are a couple of challenges for designing and implementing packet forwarding effectively. First, background traffic fluctuations can severely affect the end-to-end inference accuracy of router properties. Second, probe traffic of a relatively large packet bursts are neither independent nor strong correlated. Most existing inference methods have to assume certain independence (i.e., i.i.d. processes) or strong correlation models for inference (e.g., back-to-back probe packets). However, a good mathematical model is needed to determine whether the loss rates difference between two packet types is the consequence of a random effect or being treated really differently. Third, more than two packet types are to be measured at the same time, so simply determining whether they are treated differently is not enough. To overcome these challenges, the mechanism takes the following three steps to infer priority based packet forwarding inference. First, it sends a relatively large amount of traffic to temporarily saturate the bottleneck traffic class capacity, which gives better resistance against background traffic fluctuations. Second, a robust nonparametric method is applied based on the ranks instead of pure loss rates. Thirdly, a rank-based metric is assigned to each packet type and hierarchical clustering method is used to group them when there are more than two packet types. If there is more than one forwarder with the same minimum metric, time is high. Nodes in the forwarding set must hear nearby nodes in order to prevent packet duplication. Therefore, finding a forwarding set for this optimization problem is a variation of the maximal clique NP-complete problem. This problem is more specifically important in the proposed optimization problem where the end-to-end latency of each node and the propagation delay among the nodes are much smaller than the deadline constraints.

The distance among the forwarders are most important factors in order to avoid the excessive coordination latencies. Each neighboring node of the sender node constructs a cluster in which the nodes must hear each other. Whenever the new node is included in the cluster relay prioritization is performed in the network. The expansion of the cluster proceeds until the cluster exceeds the deadline constraints. Hence, each neighboring node expands its cluster from itself. Finally, the cluster with the best one-hop reliability is selected for the forwarding set of the sender node. Three dimensional underwater networks are used to detect and observe phenomena that cannot be adequately observed by means of ocean bottom sensor nodes, i.e., to perform cooperative sampling of the 3D ocean environment. In three- dimensional underwater networks, sensor nodes float at different depths in order to observe a given phenomenon. One possible solution would be to attach each sensor node to a surface buoy, by means of wires whose length can be regulated so as to adjust the depth of each sensor node.

Existing System:

Vector-Based Forwarding (VBF) protocol, 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. VBF is robust, scalable and energy efficient. It is essentially a location-based routing approach. No state information is required on the sensor nodes and only a small fraction of the nodes are involved in routing. Moreover, in VBF, packets are forwarded along redundant and interleaved paths from a source to a destination, thus VBF is robust against packet loss and node failure. Further, we develop a localized and distributed self-adaptation algorithm to enhance the performance of VBF. The self-adaptation algorithm allows nodes to weigh the benefit of forwarding packets and thus reduce energy consumption by discarding low benefit packets. Void-Aware Pressure Routing (VAPR) protocol that uses surface reach ability information to set up each node's next-hop direction toward the surface through which local opportunistic directional forwarding can always be used for data packet delivery even in the presence of voids.

Disadvantages

Communication void region problem.

It is a difficult and costly task to monitor and discover the underwater environment.

GPS does not work in the underwater environment.

Tries to recover them with a time-consuming procedure, leading to higher end-to-end delay

Proposed System

The proposed routing protocol employs the greedy forwarding strategy by means of the position information of the current forwarder node, its neighbours, and the known sonobuoys, to determine the qualified neighbours to continue forwarding the packet towards some sonobuoys. OVAR uses an opportunistic routing algorithm to increase the transmission reliability and also the network throughput while excluding all routes leading to a void area. By taking advantage of the broadcast nature of the acoustic signal, forwarding nodes locally collaborate on packet forwarding with very low overhead. Having a single permanent destination, in the single-sink model, or a number of destinations, in the multi-sink model, is a unique useful feature in developing void-aware routing protocols for UWSNs, which has been perhaps neglected in most routing protocol developments in this field. Using this feature, the process of establishing a void avoidance route for all of the nodes in the network to their destination(s) can be initiated by the sink(s) and cascaded down by intermediate nodes, similar to the route establishment phase of some distance vector routing protocols in wireless ad hoc networks. In order to obtain reach ability information and neighboring nodes' discovery, each node periodically broadcasts a beacon, which includes the hop count information (proximity of nodes to the sink) and also some neighboring information for updating the neighboring tables. The beaconing mechanism has already been implemented and utilized by some MAC protocols for neighboring nodes' discovery. This mechanism can be augmented to support the hop count information required by OVAR without imposing new overhead. It should be noted that OVAR is a soft-state routing protocol. OVAR employs a hop-by-hop forwarding set selection to deliver packets to the sink. Each packet holder uses local information of hop distance and packet advancement to determine its own forwarding set. In addition, the forwarding set should prevent the hidden terminal problem, which is caused by including the nodes that are out of range of each other. In order to manage the energy, the number of collaborative nodes can be adjusted according to the density of the network. Afterwards, in order to priorities the multiple forwarding nodes, each node considers its depth as the second metric to set a relaying timer. The node with the highest priority (lowest depth) transmits the packet earlier, and other low priority nodes can drop the packet after hearing the transmission. This suppression mechanism along with the selecting of a path with a lower hop count leads to more energy savings and a higher delivery ratio. By employing hop-by-hop forwarding set selection, OVAR is highly scalable to be used in large underwater sensor networks. Finally, OVAR automatically excludes all of the routes leading to void areas and, therefore, does not need to switch any high overhead recovery mode for void bypassing.

Advantages

It is compatibles in hard and difficult mobile scenarios of very sparse and very dense networks and for high network traffic loads.

Improves the network performance when compared with existing underwater routing protocols

Improve the data routing in underwater sensor networks

SYSTEM REQUIREMENTS

HARDWARE USED:

Processor	: Pentium III
Processor speed	: 1.5 GHZ
Memory (RAM)	: 256MB
Hard disk	: 40GB

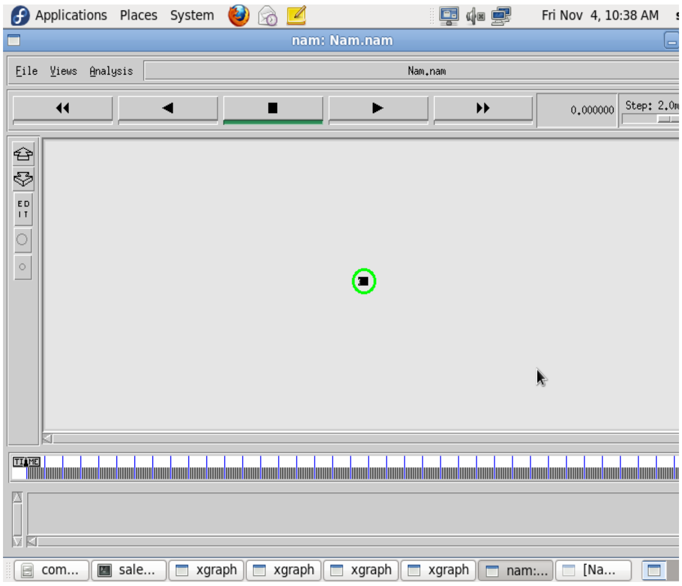
SOFTWARE USED:

Operating System : Linux 8.0(fedora 13)

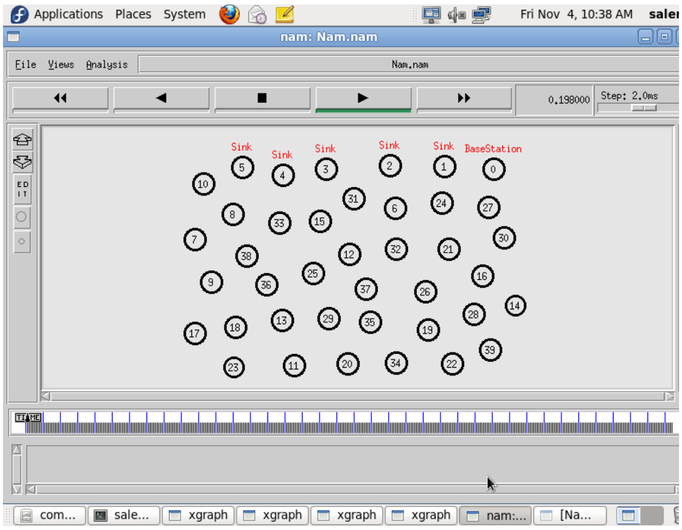
Language : TCL Scripting
Software : ns2.33

III. RESULT

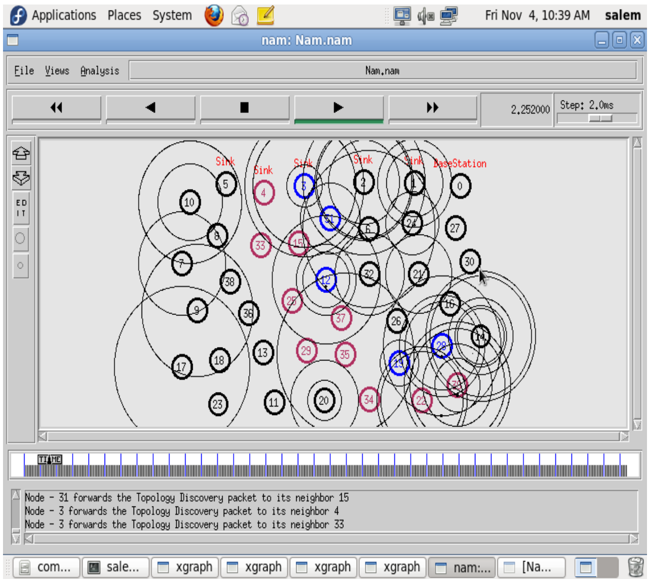
Network Animator:



Deploy the Sensor Nodes:



Forward Topology Discovery Packet to its Neighbor:



IV.CONCLUSION

In this project, we proposed and evaluated the OVAR routing protocol to improve the data routing in underwater sensor networks. OVAR is a simple and scalable geographic routing protocol that uses the position information of the nodes and takes advantage of the broadcast communication medium to greedily and opportunistically forward data packets towards the sea surface sonobuoys. Furthermore, OVAR provides a novel depth adjustment based topology control mechanism used to move void nodes to new depths to overcome the communication void regions. Our simulation results showed that opportunistic routing protocols based on the position location of the nodes are more efficient than pressure routing protocols. Moreover, opportunistic routing proved crucial for the performance of the network besides the number of transmissions required to deliver the packet. The use of node depth adjustment to cope with communication void regions improved significantly the network performance.

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