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Research on Underwater Wireless Acoustic Communication Routing Protocol

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Abstract: Due to the limitation of the communication range of sensor nodes, underwater nodes must transmit data to the water surface through routing mechanism. Therefore, the design of routing algorithm is related to the performance of the network, and the research of routing algorithm is necessary. However, underwater nodes are vulnerable to ocean turbulence and biological factors. The underwater environment is dynamic and complex, which greatly affects the acoustic channel, making the improvement of routing protocol a challenge. These factors lead to problems in underwater acoustic communication network, such as empty nodes, packet delivery rate, energy consumption, delay and other problems, and in the dynamic and complex seawater environment, the performance of acoustic network will be further reduced. This paper introduces some main routing algorithms, such as hollow node awareness algorithm, layer-based routing protocol; Opportunistic routing algorithm; Double-hop routing protocol, etc. These routing algorithms can solve some problems. Simulation shows that they have certain advantages in packet delivery rate, delay, network lifetime, etc.

Keywords: Void node, Opportunistic routing, Two-hop, Underwater wireless acoustic communication.

1. Introduction

The area of the Shanghai Ocean of the earth accounts for about 70%. Such a vast area contains rich mineral, biological and other natural resources, which will produce huge economic benefits every year [1]. However, the ocean is divided into shallow sea and deep sea according to its depth. At present, humans only use and explore the shallow sea, while only a small part of the deep sea area has been explored, most of which are in an unknown state. Therefore, the applications and technologies that can be applied underwater have attracted the attention of marine exploration workers and scientists. Underwater wireless acoustic network is a wireless sensor network composed of several nodes, which is composed of underwater sensors, relay nodes, and water collection nodes. It can replace people in underwater exploration and all-weather monitoring. Now, underwater wireless acoustic network has been applied in military, marine survey, drilling platform, natural disaster prevention and other aspects.

Underwater wireless acoustic network is a wireless sensor self-organized underwater network, as shown in Figure 1 [2] is the entire transmission process of the acoustic network: the acoustic nodes deployed underwater are responsible for collecting and monitoring underwater data, converting physical signals into electrical signals for processing data, and converting electrical signals into acoustic signals through the acoustic channel to send to the relay node; The relay node in the water transmits the data to the sink on the water through multi-hop transmission. The sink converts the acoustic signal into electrical signal and transmits it to the base station on the land through radio frequency wave.

The organizational structure of this paper is as follows: Section 2 introduces the routing protocol to solve the problem of empty nodes, Section 3 introduces the routing protocol based on opportunity mechanism, Section 4 introduces the routing protocol based on double hop, and finally summarizes some existing problems and future research directions of underwater acoustic communication.

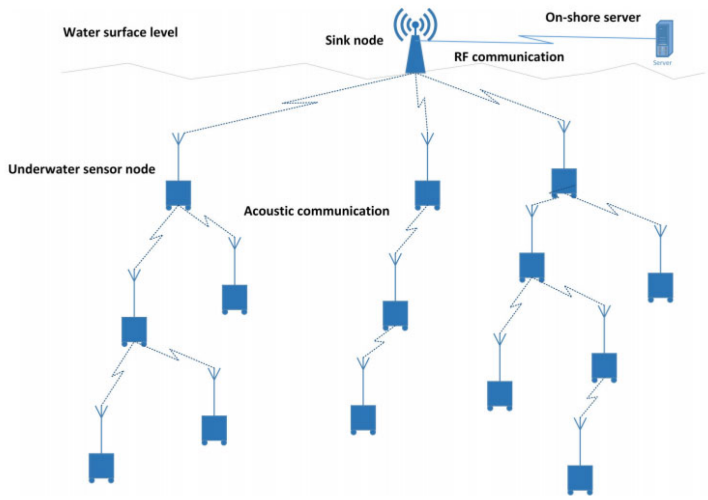

Figure 1. Structure diagram of underwater wireless acoustic communication

2. Algorithm for Solving the Problem of Void Nodes

2.1. An Energy-Efficient Routing Void Repair Method Based on an Autonomous Underwater Vehicle for UWSNs.

This paper is an energy-saving routing algorithm that uses underwater autonomous vehicles to repair holes. In order to solve the routing hole problem caused by node failure during data transmission, the algorithm design includes the hole node detection mechanism and data transmission mechanism. The purpose of the empty node detection phase is to detect empty nodes and trap nodes. The time strategy is used to detect empty nodes. The empty nodes broadcast message packets downward to identify trap nodes, so that the AUV can determine the navigation path, as shown in Figure 2. In the data transmission stage, the AUV starts the network, and the AUV track determines the navigation area according to the specific location of the hole node and the trap node, which can enable the AUV to efficiently solve the routing hole problem. The schematic diagram of this phase is shown in Figure 3: nodes in the AUV motion range directly send data to the AUV; Nodes outside the range of motion determine the transmission path to the sink through the opportunistic routing mechanism. According to the simulation results, the algorithm can significantly solve the hole problem, improve the problem of data transmission, and improve the packet delivery rate [3].

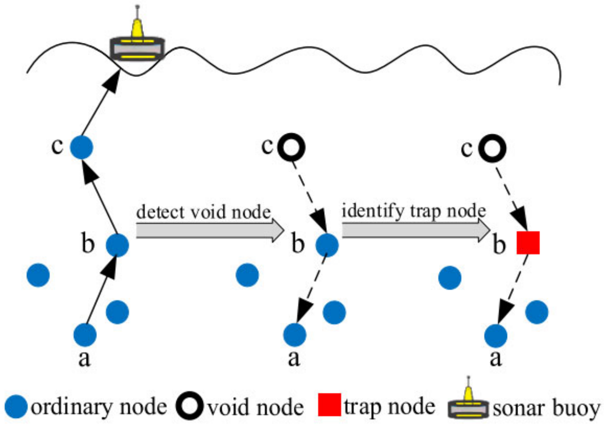

Figure 2. Cavity detection mechanism

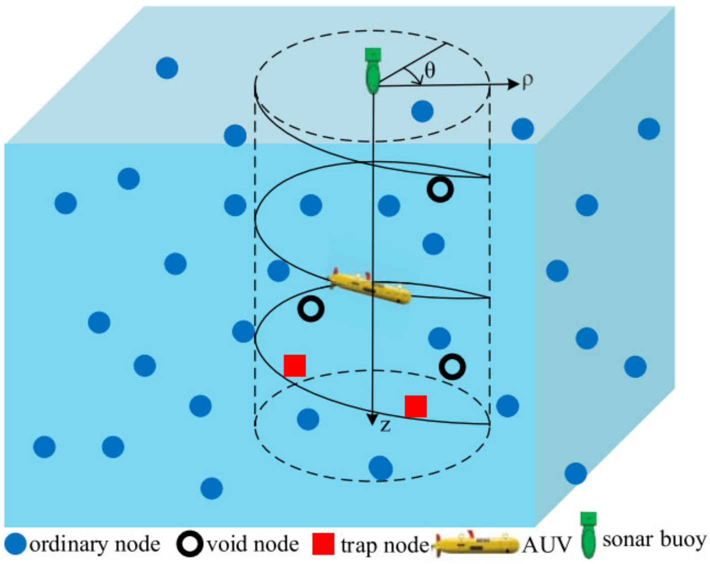

Figure 3. AUV motion track

2.2. LEER: Layer-Based Energy-Efficient Routing Protocol for Underwater Sensor Networks

The algorithm is a multi-forwarding routing protocol. Sink nodes can receive multiple copies of the same packet from different paths. In order to improve the packet delivery rate, layer-based routing design is adopted. It is divided into two stages: the first stage is the initialization stage. Each node is layered. There are sink nodes that periodically broadcast hello packets downward. The nodes that can reach one hop are set as the first layer, and then broadcast downward from the nodes in the first layer. The number of layers increases gradually until all nodes are layered; The second stage is the data forwarding stage. The nodes at the lower level can only forward data to the nodes with the lower number of layers, and the nodes at the same layer or above the layer do not participate in the forwarding. In this way, data is transmitted to the water surface hop by hop. This not only reduces redundant forwarding and energy consumption, but also avoids data loss caused by data transmission to empty nodes, as shown in Figure 4. In the performance demonstration, the packet delivery rate and energy consumption of the algorithm are significantly improved [4].

3. Opportunity Routing Algorithm

3.1. EECOR: An Energy-Efficient Cooperative Opportunistic Routing Protocol for Underwater Acoustic Sensor Networks.

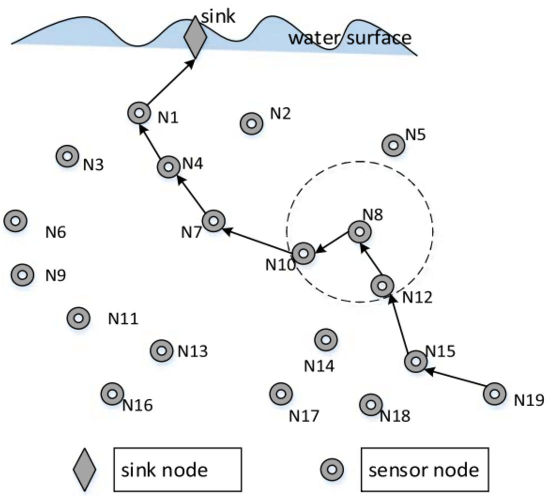

Figure 4. Schematic diagram of data forwarding

This algorithm is an efficient cooperative routing protocol using opportunistic routing mechanism, which mainly solves the problem of energy consumption. It considers the impact of energy consumption ratio and packet delivery probability on routing, and uses fuzzy logic to select the best relay node to forward data. Fuzzy logic is to output a group of data through a specific mapping function according to a group or groups of inputs. The algorithm takes the energy consumption ratio and packet transmission probability as the input, and the output is the probability of becoming the best relay node. Map the energy consumption ratio and packet delivery probability to low, medium, high and small, medium and large respectively, so there will be 9 combinations. As shown in Figure 5, the node with the largest energy consumption ratio and packet delivery probability has the highest priority to become the best relay node. In addition, the monitoring mechanism is also used to suppress redundant forwarding, that is, when the forwarding node is selected to transmit data, the packets received by other nodes will be discarded, otherwise, the packets will be forwarded by the node with the second priority. Simulation comparison shows that the algorithm has great advantages in packet delivery rate and energy consumption [5].

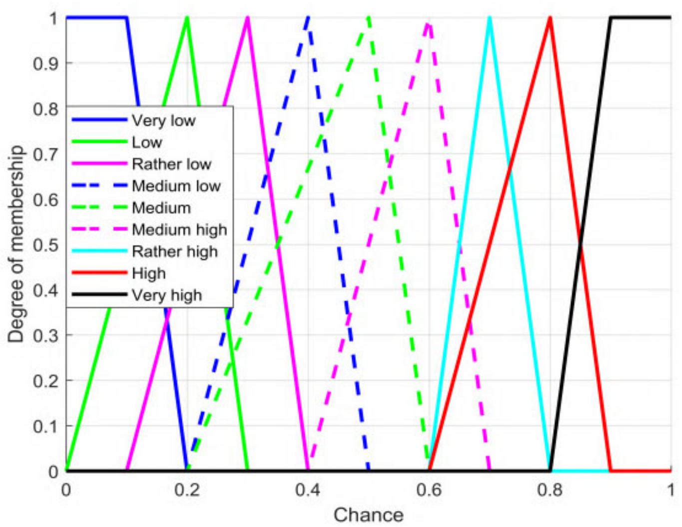

Figure 5. Relay node priority

3.2. A Directional Transmission based Opportunistic Routing in Underwater Acoustic Sensor Networks

The underwater directional sensor can concentrate power in a fixed direction, increase transmission distance and reduce energy consumption. Therefore, this paper proposes a opportunistic routing protocol based on directed transmission. The network structure of the node is shown in Figure 6. It is equipped with a beam sensor with switching function to achieve full coverage of the positive 12-sided body, and can independently send data to any surface. Therefore, the forwarding area is a conical area centered on the sensor with an opening of 60 degrees. Only nodes in the forwarding area can participate in forwarding data. In order to suppress data redundancy and reduce energy consumption, it uses opportunistic routing mechanism to prioritize nodes in the forwarding area. Each node confirms the forwarding order according to the priority order. The node with high priority has priority in forwarding. At the same time, the node with low priority will discard the packets forwarded by the node with high priority, otherwise it will participate in forwarding together with the node with high priority. The method of combining opportunistic routing and directional transmission is adopted to improve the reliability and timeliness of data transmission and reduce energy consumption. Simulation results show that the algorithm is superior to other routing protocols in packet delivery rate, average end-to-end delay and energy consumption[6].

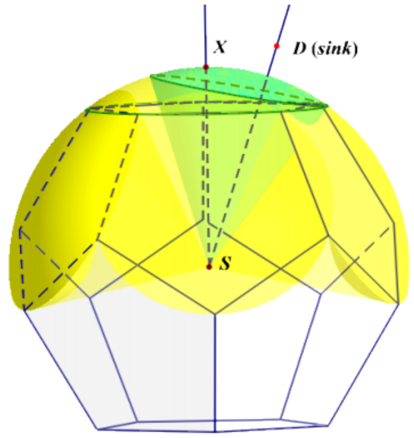

Figure 6. Forwarding zone

4. Two-hop Routing Protocol

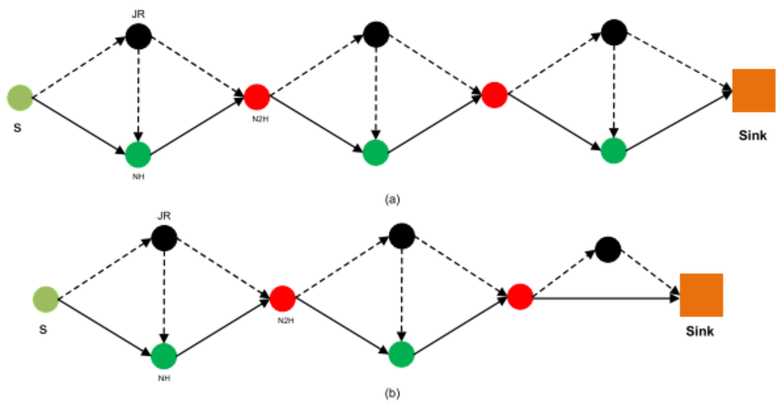

Figure 7. Schematic diagram of two-hop cooperative routing process

4.1. Channel-Aware Energy-Efficient Two-Hop Cooperative Routing Protocol for Underwater Acoustic Sensor Networks

This paper is a dual-hop cooperative energy-saving routing protocol based on channel awareness, which realizes dual-hop transmission through one-hop node as a relay. As shown in Figure 7, two routing protocols are proposed. One is the two-hop cooperative energy-saving routing protocol. The process of the two-hop cooperative routing protocol is that in a data transmission, the source node sends data to a two-hop node through a one-hop node, during which a relay node communicates jointly. The protocol will select the three best nodes independently to minimize the energy consumption of a two-hop transmission, and then the two-hop node will send data as the source node until the data is transmitted to the sink. The other is an efficient dual-hop routing protocol based on channel awareness: it selects the appropriate relay according to the neighbor information received by the sensor, extracts the signal-to-noise ratio information from the reply message packet, and the node with the largest signal-to-noise ratio acts as the best relay node, so that the maximum channel capacity can be obtained. At the same time, it also takes into account the factors such as residual energy and distance to save energy consumption. The simulation results show that the protocol has a great improvement in energy consumption, network throughput and end-to-end delay [7].

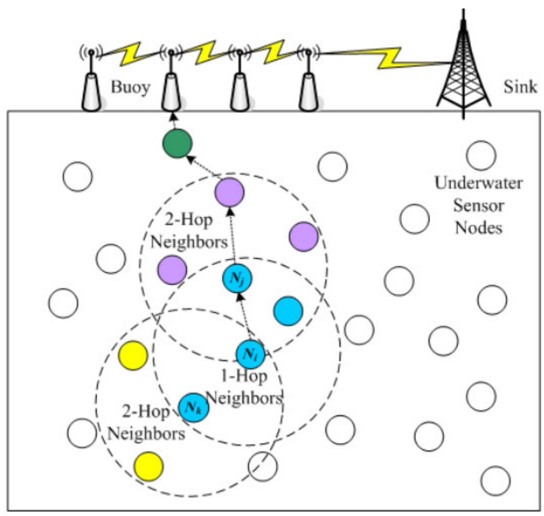

Figure 8. Two-hop routing structure diagram

4.2. Energy-efficient Depth based Probabilistic Routing within 2-Hop Neighborhood for Underwater Sensor Networks.

Based on the traditional depth-based routing protocol, this paper proposes an energy-efficient dual-hop routing protocol, which considers not only the depth of nodes, but also the remaining energy and the number of forwarding nodes. This algorithm extends the traditional DBR algorithm that only considers one hop node to consider two hops at the same time. The appropriate forwarding node is determined by the depth information of the two hop nodes. At the same time, a probability forwarding mechanism is introduced, that is, a probability function is set, which is related to the residual energy and depth of the node. When the residual energy of the node is high and the depth is small, the probability of participating in the forwarding is high, If the probability of a two-hop node is higher than that of the other two-hop nodes, select the two-hop node to forward the data until the packet is forwarded to the sink, as shown in Figure 8. Through performance comparison, it is found that the algorithm has obvious advantages in data transmission rate, energy consumption and other aspects [8].

5. Conclusion

At present, compared with other underwater wireless networks, underwater wireless acoustic communication has the advantages of transmission distance and energy consumption.It has great advantages, and its application scope and research degree are also the most extensive, but there are still many problems, and there is still a long way to go from civil popularization. Many routing algorithms have been improved in terms of energy consumption, delay, packet delivery rate, etc., but due to the limitation of acoustic characteristics, only part of the problem can be solved. In addition, due to the requirement of clarity in the era of big data, the amount of data continues to increase, and the acoustic channel is difficult to meet the large data transmission rate. The research prospect of underwater wireless acoustic communication still has broad space.

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