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Void aware Opportunistic Routing Protocol using Fuzzy Logic Relay System for Underwater Wireless Sensor Networks

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***Abstract:** In research community, UWSN has been evolving immensely due to the innovation of wireless sensor technology. UWSN is a sensor network formed by underwater sensor nodes with sensing, processing, storage and underwater wireless communication capabilities for different underwater applications. A fuzzy logic void aware opportunistic routing (FLVAOR) protocol has been proposed to overcome void area problems and high energy consumption of a sensor node. A void node is detected using monitor centre sensor node and forwards the data packets to the surface sink node by means of energy constraints in sensor devices to enhance the network performance. FLVAOR is scheduling the packets transmission towards the surface sink by taking the account of holding timer which is designed for the forwarder relay set and to elect the best relay path in order to enhance the performance metrics of energy expenditure, packet delivery ratio and end to end delay.*
***Keywords:** fuzzy logic, holding timer, forwarder relay set.*

I. INTRODUCTION

UWSN consists of sensor nodes equipped with acoustic modems and a sink node equipped with both acoustic and radio modems. Due to restrictions on the use of radio waves, acoustic transmission is most commonly used in the underwater environment. Generally, acoustic waves are used for underwater communication. These challenges lead to high energy consumption of network nodes, and low reliability of received data. Each sensor node in the monitoring area reports relevant data to the surface sink with the aid of multi-hop routing through the acoustic links. The data from the surface sink are offloaded to the monitoring centre via radio communications for further offline processing. Required data are collected by the underwater sensors and directed towards the sink on the surface node. The 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.Extensive research has focused on localization and node deployment algorithms in UW-ASNs, the majority of which aim at achieving high network connectivity and coverage, minimizing the number of sensor nodes and their energy consumption, or improving data delivery ratio.

In [1] survey that while avoiding void regions in the network, proper holding time calculation, and bit error rate BER minimization. Forwarder selection technique resulted in high delivery ratio (DR) even in sparse network conditions., In [2], discussed about the different features of void communications in the terrestrial and underwater environments and mentioned the unique challenges of designing void-handling techniques in UWSNs. [3], when the node is in a communication void region, GEDAR 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.In [4], analysed about routing strategy that leads to an even energy depletion among all sensors in the network and consequently an improved network lifespan number of levels. [5] Proposed Hydraulic pressure-based anycast routing that allows time critical sensor data to be reported to son-buoys at sea level using acoustic multi-hopping was investigated. Because acoustic transmissions are power hungry, the research goal was to minimize the number of packet transmissions in underwater sensor deployments. [6] The direction of data flows in data collection scenarios with depth-based routing and find that the packets are forwarded from deep nodes to shallow nodes and the direction aims to the sink nodes. The directional packet transmissions may lead to load imbalance in UASNs. [8] Analysed the impacts of node deployment strategies on localization performance in UW-ASN. [14] investigated various communication channels involved in underwater acoustics, where the impacts of random access compressed sensing over fading and noisy communication channels has been analysed.

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II. PROPOSED METHOD

To solve the energy consumption challenge of the acoustic signal propagation, the FLVAOR protocol utilizes an opportunistic routing concept to enhance communications reliability. By taking advantage of the broadcast nature of wireless communications, the source node locally selects the forwarding relay nodes based on depth information from the embedded depth sensor and the link quality between the source node and each neighbour node. In the FLVAOR protocol, consider the multi sink node for collecting the packets from the underwater sensor nodes. To establish a routing path, the source node needs the depth information of the sensor nodes and their current residual energy. Therefore, the sink node periodically broadcasts a beacon message to the sensor nodes and the beacon message is augmented with the depth information and the residual energy of the sensor nodes. The source node first determines a forwarding set, and then, the fuzzy logic-based relay selection scheme is used to select the best relay from the neighbour relay set and to broadcast the packet for the selected relay. Moreover, the relay nodes can retransmit the packet to the next-hop destination if the selected relay node fails to transmit. After receiving the packet from the source node, the selected relay will forward the packet to the next-hop destination. If the selected relay fails to transmit the packet to the next-hop destination, the second-best relay will be selected by the source node to forward the packet to the next-hop destination, and the packet-forwarding mechanisms will continue until the packets finally reach the surface sink. The forwarding relay nodes with different fitness factor values will have different holding times, even for the same packet. To reduce the number of hops along the forwarding path to the surface sink, this protocol tries to select the neighbour relay node based on considering maximum packet advancement towards the surface sink along with high energy. It also tries to prevent other neighbouring relay nodes from forwarding the same packet, in order to reduce energy consumption. The packet forwarding process will repeat until the packets finally reach the surface sink.

A. Relay Selection Method

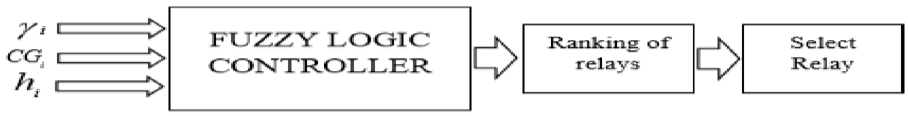

Fig.1 Relay Selection Method

In the proposed FLVAOR protocol, Fig.1 represents the relay selection method is proposed to select the best relay from the forwarding relay set. The fuzzy logic control performs the membership function by considering the three input variables are energy consumption, packet delivery ratio and holding time, into appropriate linguistic values, which are needed in the fuzzy inference system (FIS) and defuzzify the values in order to select the best relay node to forward the data packets to the surface sink.

B.Flowchart of forwarding relay set

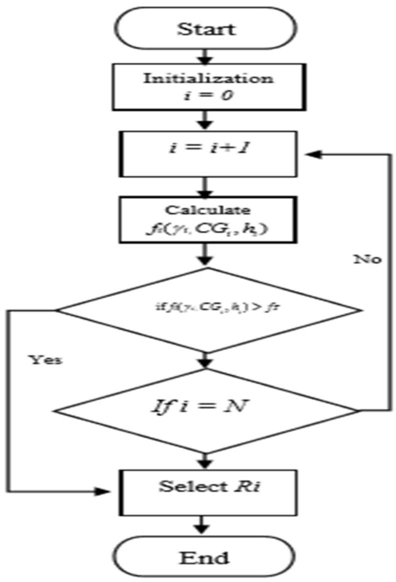

Fig.2 Flowchart of the forwarding relay set

1) *Step 1:* source node sends the data to all the nodes
2) *Step 2:* Fuzzify the input variables
3) *Step 3:* Apply the fuzzy operators
4) *Step 4:* Apply implication method
5) *Step 5:* Aggregate all output of the implication
6) *Step 6:* Defuzzify the aggregated output by the CoG method
7) *Step 7:* Return The source node selects the best relay
8) *Step 9:* surface sink receives the packet
9) *Step 10:* end

III. SIMULATION RESULTS

A. Simulation Parameters

The proposed algorithm is simulated for the project is done by using Aquasim –NS2. For simulation, 42 nodes are created in the underwater wireless sensor network. Multi-level sink nodes are present in this scenario as shown in table 1. The monitor center node gathers information about all the sensor nodes deployed in the Then, the nodes start to calculate the energy of it nodes. Energy for each node will be calculated.

Table.1 Simulation Parameters

Parameters	Value
Simulation area	600x350
Number of nodes	42
Sink nodes	4
Energy of node	2J
Packet size	888 bytes
Initial energy of sensor node	0.5J

*B. **Deployment of Sensor Nodes***

The fig.3 represents the random deployment of sensor nodes under acoustic channel in underwater wireless sensor network. The area of the network is 600*350 km. The monitor centre is used to gather information about the source node and the surface sink nodes.

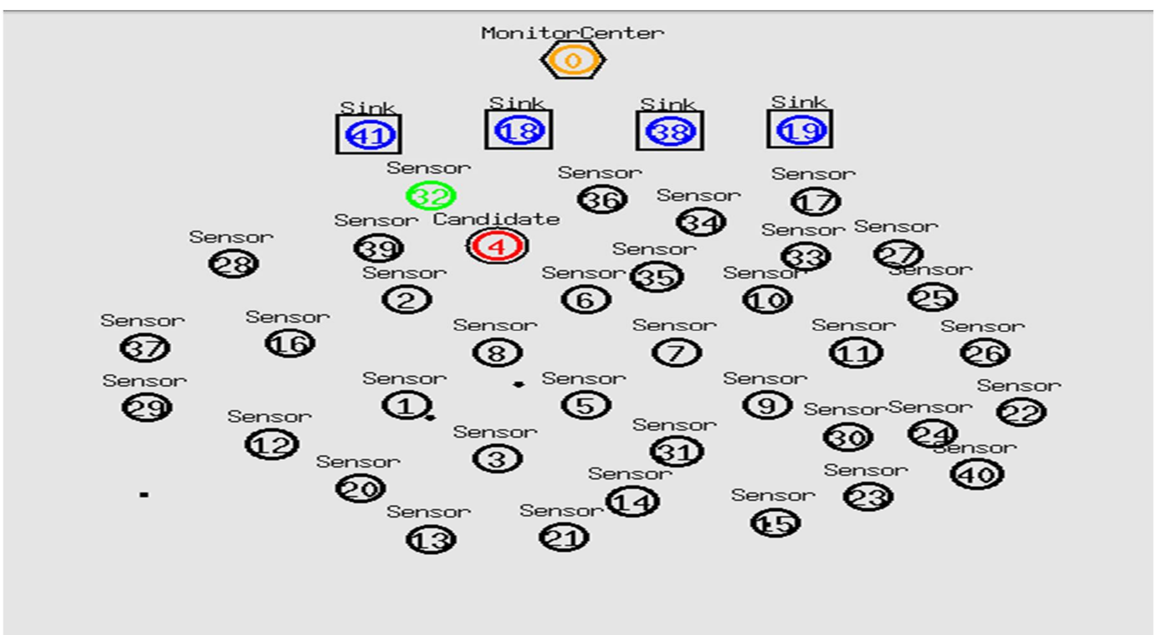

Fig. 3. Deployment of nodes

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C. Graphical Representation

It is necessary to check the network life time, energy consumption, end to end delay. A comparison is made with the existing system. The energy consumption may be defined as designing and analyzing a mathematical representation of a UWSN to study the effect of changing the system parameters. Fig. 4 shows the graph for energy consumption.

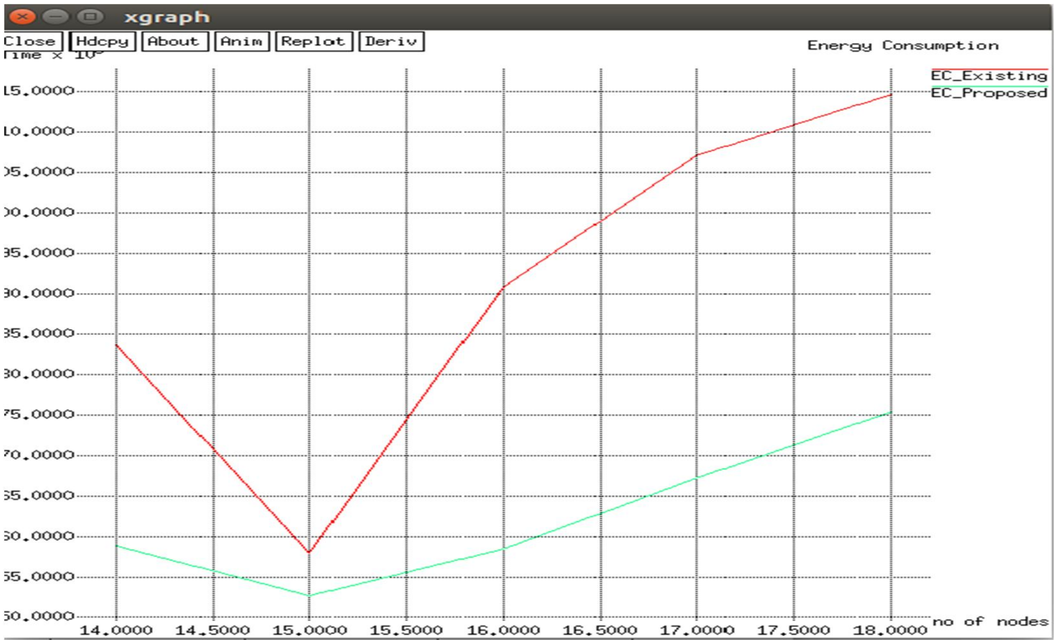

Fig. 4. Energy Consumption

The Fig. 5 shows the graph for network lifetime. One of the most used definitions of network lifetime is the time at which the first network node runs out of energy to send a packet, because to lose a node could mean that the network could lose some functionalities. It is possible to use a different definition, in which some nodes could die or run out of battery power, whenever other network nodes could be used to capture desired information or to route information messages to their destination.

Fig. 5 Network Lifetime

The Fig. 6 shows the graph for end to end delay. End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination. It is a common term in IP network monitoring, and differs from round-trip time (RTT) in that only path in the one direction from source to destination is measured.

Fig. 6. End to End Delay

IV. CONCLUSION

In UWSN, high energy consumption is the key challenge to improve the lifetime of the network by consuming less amount of energy. in order to overcome this problem , FLVAOR protocol is proposed to forward the data packets be selecting the best relay node by implementing fuzzy logic rules to forward the data packets by scheduling the time to the forwarder node to route the packets to the surface sink nodes and bypass void nodes at minimum deviation. The simulation results are carried out in Aqua sim based Ns2 tools is used to evaluate the performance metrics for the proposed method. FLVAOR protocol is enhanced in terms of end-to-end delay, energy consumption and network lifetime by comparing with existing method.

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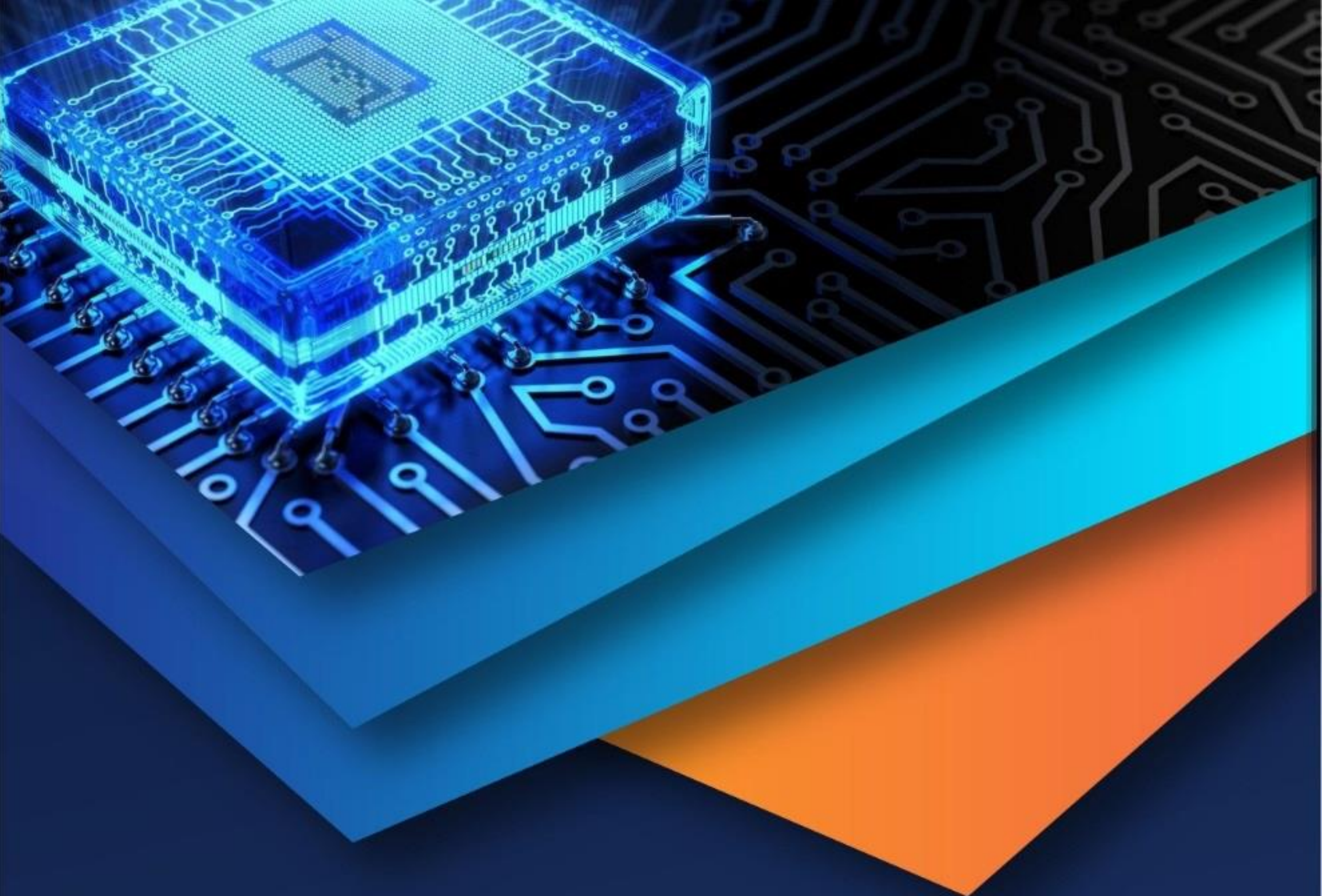

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