AN APPROACH FOR PARALLEL DATA ROUTING IN OBSTRUCTED WIRELESS SENSOR NETWORK

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Abstract— Data routing in an obstructed environment puts several conflicting constraints for WSN. In this paper, we proposed a novel approach to design an energy efficient routing protocol in order to guide the message traversing through an efficient path and prevent the message routed towards any obstructed zone. Our proposed Distributed Obstacle Zone Avoidance Routing is capable of both serial and parallel message transmissions from multiple sources to multiple destinations. Experimental results represent the improved performance of our proposed algorithm compared to other existing routing algorithms.

Keywords- Wireless Sensor Network, Obstacle Zone, Shortest Routing Path, Parallel Message Transmission

I. INTRODUCTION

A distributed Wireless Sensor Network can be built by scattering a large number of tiny devices to monitor inaccessible geographical regions [7]. The applications of WSNs is found in various fields like in military surveillance, environmental monitoring and health monitoring and many more [1][8][15].The regions of sensor deployment could be in populated with different types of obstacles[6] like hills, valleys, trees, walls, houses, cars, etc. The presence of such obstacles may block signals in certain parts of the network which in turn leads to costly routing due to the increment of route length. It also reduces average network life time. Routing protocol which do not consider the presence of obstacles are prone to poor performance with respect to throughput and latency[6].Hence, the information of obstacles in the deployment region of wireless sensor network is essential for developing efficient routing protocol.

There are very limited works those have been proposed for routing in an obstructed WSN environment. Some works are found in literature that focused routing in an obstructed environment. In [3], the authors proposed Greedy Perimeter Stateless Routing (GPSR), which employed the concept of a combination of greedy forwarding approach and face routing in order to decrease the length of the route. Like GFG, GPSR primarily builds faces for the corresponding wireless sensor network. In GPSR, each forwarding sensor node selects its neighbor nearest to the destination sensor node as the next sensor node to which packet will be forwarded. In [4], the authors employed the concept of voronoi diagrams in order to

actively set up the forbidden zone and the border sensor nodes of forbidden zones resist the message entering into the obstructed zone and guide the packets through the efficient routes. In [5], Chang et al. proposed a weight-based routing algorithm in which the information of obstacle is maintained and sensor nodes, which are located near the obstacles, are aware of the presence of the obstacles thereby preventing the forwarding packets coming into the concave zone formed by the obstacles. The drawback of the algorithm is the repeated usage of the shortest path that leads to drainage of energy of the sensor nodes rapidly and energy optimization is an essential tool for routing in WSN [7][12]. Existing routing protocols have shown their simulation results considering only a single source node and a single destination node at a particular time. In addition, not much work is done, to the best of our knowledge for parallel data transmission in an obstructed environment.

The proposed routing algorithm has following characteristics.

- Determination of an approximate rectangular prohibitive zone due to the presence of an obstacle
- Data transmission through the best possible shortest routing path avoiding obstacles
- The shortest path is determined based on an weighted average of two objective functions
- Consideration of the remaining energy of sensor nodes[9] to select nodes in the routing path
- Implementation of parallel message transmission from multiple sources to multiple destinations with contention removal

The rest of the paper is organized into following sections. Section II represents our proposed method named as Distributed Obstacle Zone Avoidance Routing (DOZAR). Section III will be employed for the simulation results with comparative studies with the other existing algorithms. Finally, Section IV concludes the paper with possible future directive.

II. PROPOSED DOZAR ALGORITHM

This section deals with the our proposed algorithm DOZAR for obstacle avoidance routing in a WSN where all randomly deployed sensors have their unique identification number and follow the principle of TDMA [11][13] to implement a collision free

parallel routing. The location of sensors is assumed to be known [15].Instead of taking the actual shape of the obstacle into account, our proposed algorithm DOZAR considers the rectangular obstacle zones which contain single or multiple obstacles.

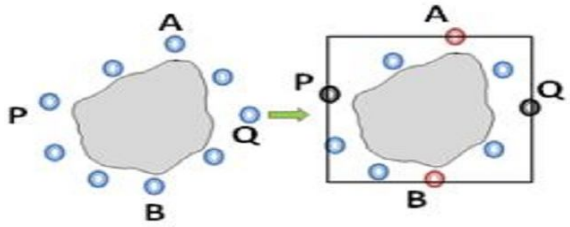


Figure 1: Obstacle Zone Formation

Fig. 1 depicts the location of boundary sensors of an obstacle [4][14][10].Referring to Fig. B, P,A and Q are the boundary sensors using farthest on the obstacle zone. These four sensors are detected from the pool of sensors surrounding the obstacle, guided by the RSSI among them [10].Once the farthest apart sensors are identified, a virtual rectangular boundary is realized to decide upon the presence of obstacle. Hence Sensor nodes B, P, A and Q together create the rectangular boundary and provide the location of this obstacle zone to their neighbor nodes so that they are aware of their neighbors in obstacle zone and identify the proper neighbor sensor to forward the message.

In our proposed algorithm DOZAR, we considered two significant factors in order to design routing protocol i.e. Effective Distance of next hop with respect to the location of the destination sensor node and Remaining residual energy of the sensor node. If any sensor node in the routing path finds the presence of destination sensor node within its coverage zone, then it sends the desired message to the destination. Otherwise the sensor node determines the position of the next sensor node to which the message will be forwarded according to the following steps.

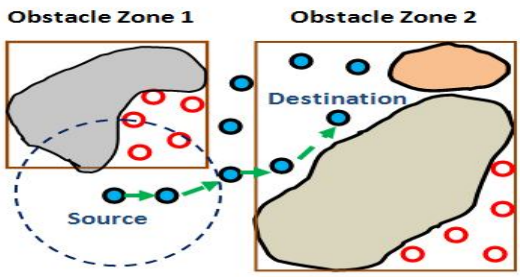


Figure 1: Destination in an obstacle zone

When a sensor node has a message to be forwarded, at first it selects a neighbor sensor node or a group of neighbor sensor nodes which are nearest to the destination sensor. The sender node selects its neighbors located within any obstacle zone if and only if the destination is located within any obstacle zone(as depicted in Fig. 2) or there is no neighbor (nearest to the destination) outside of any obstacle zone.

The concept of obstacle zone provides a shortest and energy efficient way to prevent the message routed through sensor nodes located inside the obstacle zone containing a single or multiple closely placed obstacles thereby reducing the chances of the message encountering an obstructed area (including the chances of deadlock causing packet loss and also a significant message delay) and ensuring the successful delivery of the message to the desired destination.(Fig. 3) Hence the concept of rectangular obstacle zones instead of taking each obstacle's boundary individually as in other obstacle avoidance routing protocols [4] indicates the shortest route in most of the situations. The location information of the rectangular obstacle zones are known to all sensor nodes.

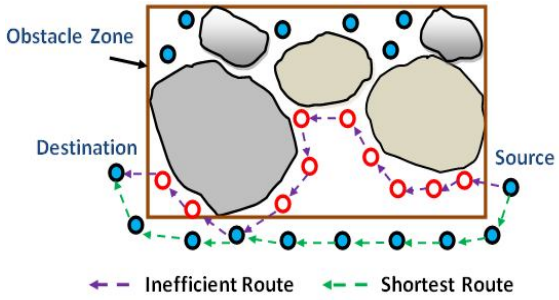


Figure 2: Obstacle Zone with multiple obstacles

We have considered Euclidian Distance (E_D) along with perpendicular distance(P_D) (the perpendicular distance of the neighbor sensor from the straight line created by source point and destination point) in order to select the next hop for transmitting the message. Each sensor node calculates the effective distance D of its those neighbor sensor nodes selected in the previous phase using equation number (1)

$$D = \lambda E_D + (1 - \lambda) P_D \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

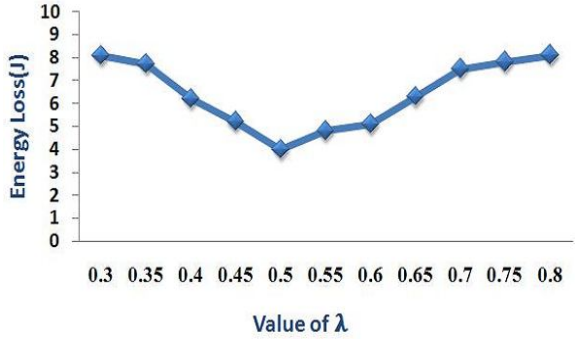


Figure 4: Determination of the value of λ

The value of **λ** varies from 0 to 1.Fig. 4 shows the minimum energy consumption for the value of **λ** at 0.5.Hence in this paper we have considered the value of **λ** as 0.5. After the determining the effective distance D for each of selected neighbor, sender sensor calculates the weight factor (W) of such neighbor sensors as the ratio of effective distance (D) and remaining energy (E) of the sensor node.

After the completion of the process of determining weight factor, source sensor finds the

neighbor S_1 having minimum weight factor W_1 and time-slot number for transmission T_1 among selected neighbor sensor nodes, and also identifies neighbor S_2 which has weight factor W_2 and the nearest time slot number T_2 of transmission to the timeslot number of sending the message. After the completion of such selection, each sensor follows the algorithm mentioned below to send the message based on the priority between energy and time.

Algorithm: Finding the appropriate neighbor sensor to which the message will be forwarded

1. IF ($S_1 \neq S_2$) THEN
2. IF (($|W_1 - W_2|/W_1$) > ($|(T_1-T_2)/T_1|$)) THEN
3. Send the message to S_1
4. ELSE
5. Send the message to S_2
6. END IF
7. END IF

III. SIMULATION RESULTS

This section deals with the performance evaluation of DOZAR In order to compare the performance of DOZAR with the other existing obstacle avoidance routing protocols with respect to different measurable metrics.

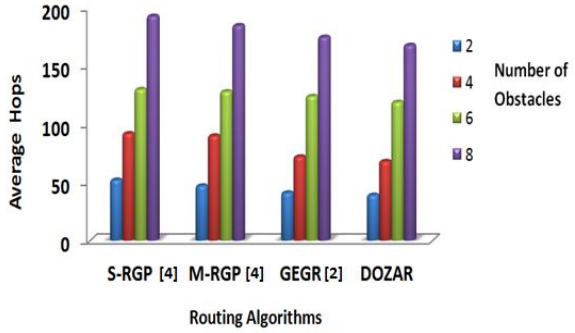


Figure 5: Average Hop-Count in Routing Algorithms

Fig. 5 expresses the enhanced performance of DOZAR comparing other routing algorithms based on the average hop count respectively. The concept of effective distance and obstacle zone reduces the number of average hops in DOZAR.

Table 1: Comparison based on the average remaining energy of sensors

Time Unit	S-RGP[4]	GEGR[2]	EBRP[7]	DOZAR
0	1.5	1.5	1.5	1.5
20	1.45	1.46	1.48	1.48
40	1.41	1.42	1.45	1.46
60	1.38	1.4	1.42	1.42
80	1.34	1.36	1.39	1.4
100	1.3	1.31	1.36	1.37

Table 1 shows the superior performance of DOZAR comparing other existing obstacle avoidance routing protocols in terms of based on of the average remaining energy (based on the energy model [16]) of the sensor nodes after the different time intervals.

Fig. 6 shows the superiority of DOZAR over GEGR [2]
in terms of packet delivery ratio (PDR) which is the ratio of the number of packets delivered to base station and the number of packets transmitted by all deployed sensor nodes as the reaching time of DOZAR in less number of sensor nodes comparing that of GEGR.

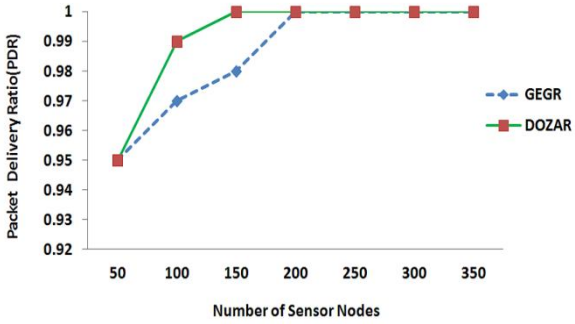


Figure 6: Packet Delivery Ratio in GEGR and DOZAR

Fig. 7 indicates the improved result of parallel transmission over serial transmission based on the delay and the number of live nodes after the transmission of different number of messages. As the parallel data routing reduces the chances of repetitive usage of the same routing path to a great extent, the number of live nodes in parallel data routing are high than that of in serial data routing.

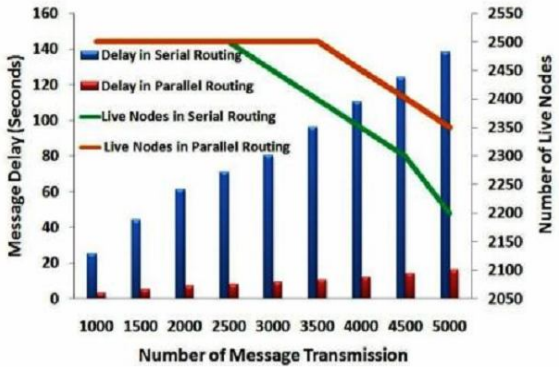


Figure 7: Comparison between Serial and Parallel Transmission

Throughput of DOZAR is calculated using the ratio of total number of packets received by the destinations nodes to the total execution time of this network. Throughput of WSN is an important metric for identifying the efficiency of the network along with the time incurred for message delivery specially in the presence of different shaped real obstacles.

Table 2 exposes the comparison based on throughput between serial data transmission and parallel data transmission using DOZAR. Zigbee sensor devices with transmission frequency 2.5 MHz are used to perform hardware experiments. In a serial data transmission, two such sensor devices are used among which one is source and another is sink node.

In case of parallel transmission, two sources and two sink nodes are used for performing our experiment taking the concept of multiple sources and multiple destinations into account. Source and sink sensor devices are placed randomly in opposite directions of the different obstacles mentioned in Table 2 both for serial and parallel transmission. Maximum 250 kbps data rate is supported by the Zigbee sensor devices used in our experiment.

Table 2: Comparison between serial transmission and parallel transmission

Types of Obstacles	Throughput per second	
	Serial Transmission	Parallel Transmission
Pillars of papers	3	3.3
Building Walls	2.5	2.7
Running Pedestal Fan(220volt AC,50Hz)	3.5	3.9
Running Offset Printing Machine (440 volt AC,50Hz)	1.5	1.65

The improvement in throughput of the network is also shown in case of parallel data transmission by Table 2.

CONCLUSIONS AND FUTURE WORK

DOZAR can provide the shortest and energy efficient routing path in most of the cases and also ensure the successful delivery of the messages as well as the enhancement of the functional lifetime of the sensor nodes. In this paper, we have also employed the parallel message transmission of messages from multiple sources to multiple destinations. Simulation results explore the improved performance of our proposed algorithm over the performance of the other existing algorithms. In future, our work may be extended to reduce the control overheads and develop more efficient routing protocol for simultaneous message transmission considering the other real world simulation parameters like the loss or jitter in a signal or delay bandwidth product determination of routing links along with multipath fading.

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