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Multi-Objective Node Disjoint Routing Protocol Using Whale Optimization Algorithm

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Abstract

Objective: The objective of this work is to find any node-disjoint pathways that fulfill the multi-objective optimization problem that improves packet delivery ratio, path lifetime, End to End delay and Network lifetime. The optimum path is identified by creating many node-disjoint paths between source and destination. Node-disjoint path selection is made to decrease interference and improve Packet Delivery Ratio efficiency (PDR).

Methods: A whale optimization algorithm (WOA) is used in this work to identify the best-secured routing path in the MANET.

Findings: The suggested system consumes less energy and has a more extended network lifetime than the existing Dynamic Source Routing (DSR) and Energy Efficient Power-Aware Routing Protocol (EPAR). End-to-end latency, path lifetime, packet delivery ratio, and network lifetime are all used to analyze the efficiency of the suggested work. The packet delivery ratio, network lifetime and path lifetime are increased and delay decreased in the proposed work. The delay of the proposed work is 2.8% less than DSR and 3.29% less than EPAR. The packet delivery ratio of the proposed work is 15.9% higher than DSR and 10.08% higher than EPAR. The network lifetime of the proposed work is 43.89% higher than DSR and 16.22% higher than EPAR.
Novelty: Multi-Objective Node Disjoint Routing Protocol with Whale Optimization Algorithm is utilized to find the optimal route and it can reduce transmission delay caused by link failure and distributes high traffic load into multiple paths in the MANET.

Keywords: MANET, Dynamic Source Routing Protocol (DSR), Energy consumption, Energy Efficient Power-Aware Routing Protocol (EPAR), Whale Optimization Algorithm (WOA).

1. Introduction

According to afinding [1], node-disjoint multipath routing is not energy efficient due to the increased number of hops and energy utilization. According to the researcher, longer alternative routes are less advantageous, as they are more likely to break early. Loop development in data packets commonly disrupts the path of a multi-node joint, resulting in the connection failing. Keeping the number of hops to a minimum is vital to enhance the number of shared links with neighbors and keep the battery from running out of energy too quickly. From a multi-objective function, a single optimum route model has been created. According to research, sensors' power consumption may be lowered through intelligent utilization of multi-hop communications and routing protocols. While cluster-based multi-hop protocols have been shown to reduce sensor power usage, they are prone to power balance and data conflict [2]. Time is a critical aspect of how messages are handled between nodes in the network. They introduced the Time Delay-Based Multipath Routing (TMR) protocol in [3], which efficiently determines an optimum route for packet delivery to the target vehicle with the slightest delay. There is a chance of route recovery delay and overhead during routing. There may also be complications due to the link and node's shorter lifespan. To avoid errors caused by frequent disconnections and node failures, the transmission line with the least mobility and the highest residual energy is chosen [4]. The use of good clustering and routing strategies can assist in extending the life of a network. Clustering and routing procedures are NP-hard problems that evolutionary algorithms (EAs) can tackle. [5] utilized hybrid EAs to develop an energy-efficient clustering technique for MANETs entitled EECSRP. The EECSRP strategy groups nodes and selects more energy-efficient and effective data transmission channels.

The Whale Optimization Algorithm (WOA) has increasingly attracted the scientific community's attention as an excellent solution for various optimization problems. [6] presented the WOA's fundamental principles and binary version and a penalty strategy for dealing with optimization constraints. Then, three examples of WOA in wireless network resource allocation were presented: power distribution for secure throughput maximization, power distribution for energy-and-spectral efficiency tradeoffs in wireless interference networks, and mobile edge computing offloading. The required stability region must be provided via an energy-efficient dynamic routing system while extending the network's lifespan. This SN uses a low-overhead passive clustering technique to pick cluster heads (CHs).The clustering approach relies on particle swarm optimization's (PSO) passive clustering. The energy competent dynamic source routing protocol (EC-DSR) is utilized in the WSN to avoid delayed output. CSO (chicken swarm optimization), wherein the optimum cluster path is estimated using distance and residual energy as limitations [7]. A fitness function improves pathways based on power consumption in individual nodes in a genetic algorithm (GA)-based Ad

Hoc On-Demand Multipath Distance Vector routing protocol (GA-AOMDV). This protocol improves network performance by enhancing throughput, roundtrip time, packet delivery ratio, and energy usage [8]. To enhance the lifespan of a WSN, and routing protocols must always preserve energy. The Improved Animal Migration Optimization (IAMO) approach delivers energy-efficient clustering. The improved ant colony optimization (IACO) technique was utilized to determine the routing path to the destination [9]. To address the optimal offloading approach of computational offloading in mobile edge computing, the Multi-Objective Whale Optimization Algorithm (MOWOA) is provided [10].To enhance the microarray data classification accuracy, to accelerate the convergence speed of classifier, and Modified Whale Optimization Algorithm (MWOA), refine the best balance among local exploitation and global exploration, a Search space enhanced Modified Whale Optimization Algorithm (SMWOA) is proposed [11].

Meta-heuristic algorithms are increasingly commonly utilized to identify the best possible solution to complicated problems. The Whale Algorithm effectively uses three directed operators and a set of random variables to enable these operators to replicate humpback whale hunting tactics. The primary goal of this study is to resolve route lifetime difficulties while transferring data from source to destination. In recent years, no strategies have adequately tackled the route lifetime consideration difficulties between the source and destination. Congestion and packet loss occur if the route lifespan is not considered. The suggested solution addresses this issue by utilizing the Met heuristic method known as Whale Optimization. Node-disjoint route is used in the proposed approach to eliminate the connection failure. The contributions of the work are.

- The Multi-objective Node-disjoint Multipath Routing protocol is proposed to identify several node-disjoint paths that solve the multi-objective optimization challenge in end-to-end latency reduction, path lifetime improvement, and network lifetime improvement.
- To identify the optimum path, many node-disjoint paths are created between source and destination.
- Using node-disjoint path selection to decrease interference and improve Packet Delivery Ratio efficiency (PDR).

The flow of our proposed work is represented in figure1.

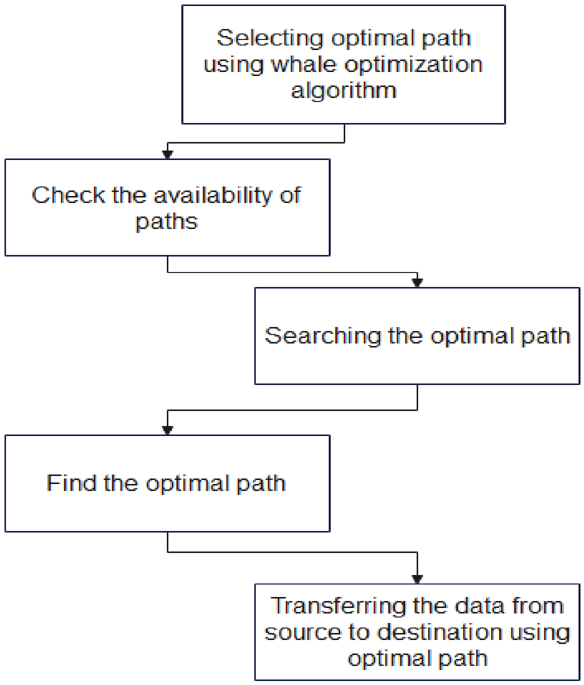

Figure 1: Flow of the work

2. METHODOLOGY

2.1 Finding the optimal path using whale optimization

The parameters $'\Upsilon_1$ and $'\Upsilon_2$ are weights, and a normalization coefficient is introduced and derived by taking the average of $\frac{'\Upsilon_1 \text{ and} '\Upsilon_2}{2}$ to normalize the three separate parameters. The best value for f(x) is determined by the weight value chosen. Total path lifetime (ms) in the path between source and destination is denoted by P(x), the total hop. The word 1 is the product of the highest amount of energy utilized in a single hop (h) and h(x). The product of the highest used energy usage for a traffic load (t) is t (x).

$$f(x) = \min\left('\Upsilon_1 '\Upsilon_2 \frac{p(x)}{\alpha} + (1 - '\Upsilon_1)'\Upsilon_2 h(x) + (1 - '\Upsilon_2)t(x)\right) \qquad (1)$$

$$0 \le '\Upsilon_1, '\Upsilon_2 \le 1$$

The proposed study incorporates a multi-objective function-based routing system to enhance the performance. The multi-objective concept enhances the network's lifespan by prolonging the path life span. A limitation period for receiving the RREQ (Route Request) is established to minimize delays in identifying the node-disjoint path at the destinations. RREQ messages arriving at the destination are deleted without processing when the time restriction has been exceeded. A path maintenance approach is developed to avoid network segmentation that starts discovering pathways when the route cache is complete, with one alternative path.

2.2 Finding the Energy Consumption computation for paths

This part considered the path energy consumption to obtain the optimal path efficiently. Energy Consumption (ec). First, as described in Equation, we calculate energy usage in a connection involving two nodes, J and I ($ec_{I,J}$) in equation 2.

$$ec_{IJ} = ec_I + ec_J \quad (2)$$

The total energy usage by a route between a source and a destination is calculated for all the n -1 connections indicated as (e(x)), as shown in Equation (3). The number of nodes in the route is denoted by (n).

$$e(x) = \sum_{n=1}^{n-1} ec_t(n) \quad (3)$$

2.2.1 Encircling Path

Many data transmission channels are identified when creating node-disjoint routes that fulfill the objective function given in Equation (1) for reliable transfer. When the time limits lapses, the destination sends an RREP to the source node to check for node-dis jointness in the collected paths. The destination transfers all node-disjoint paths to the source point as route responses. The source node obtains the RREP from the target destination based on the ID. The source discards the RREPs collected from the intermediate nodes.

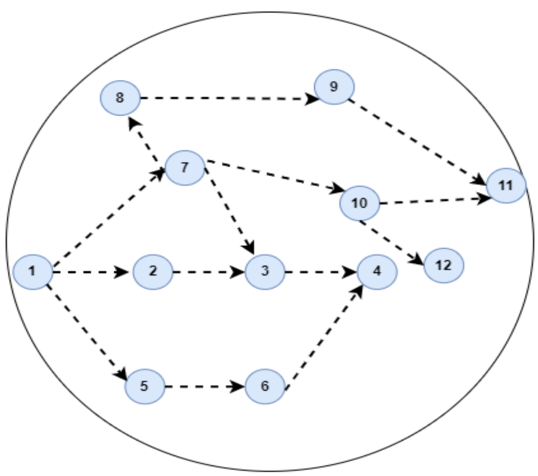

Figure 2: Number of Paths

2.2.2 Search for paths

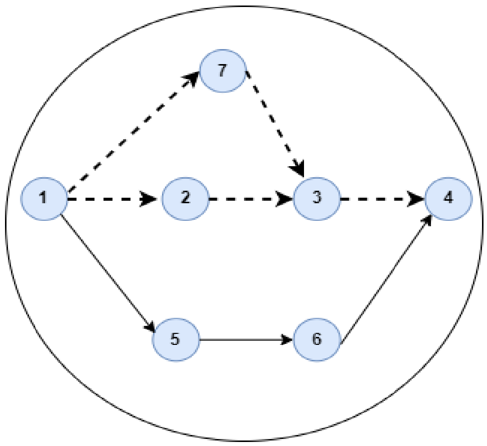

Figure 3: List of optimal paths

The source in Figure 3 is node 1, whereas the destination is node 7. Three different paths can reach nodes 1 and 7. The number of pathways determines the size of the node-disjoint matrix; hence the matrix is 3* 3. By comparing the existing routes, the element of the node-disjoint matrix 3* 3 is made. To create the first-row items, the first path is analyzed with the other two paths; to produce the second-row elements, the second path is compared to the third and first tracks; and to make the third-row components, the third path is compared to the first and second paths. The matrix is built as given in Equations below for each of the three previously specified pathways.

$$nd_{I*J}[111213212223313233] = nd_{I*J}[011100000] \quad (3)$$

2.2.3 Hunting Paths

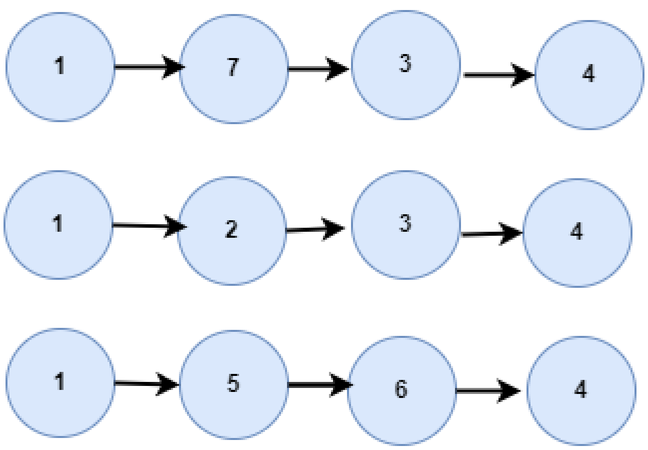

Figure 4 a) Optimal Paths

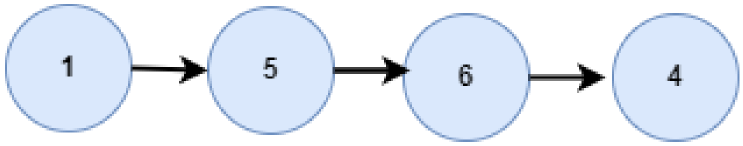

Figure 4 b) Hunting Paths

Consequently, to transport data between the source and destination, Path 3 (node 1node 5 node 6 node 4) is used. The goal is to minimize the number of nodes by eliminating node sharing along the supplied path. Node sharing should create fewer path breakdowns, and node lifespan should be increased. The route response is transmitted back to the source node when the destination node predicts node-disjoint pathways. According to the objective function provided in Equation (1), the source node then picks alternate paths. The value of the objective function is used to sort the many pathways that were generated. At any given time, three pathways are utilized for data delivery. New route discovery is initiated if the number of gathered pathways is fewer than three or no node-disjoint paths are detected. The key benefit of adopting node-disjoint path selection is that it prevents the node from failing to owe to excessive traffic while transferring data.

3. Result and Discussion

The goal of this study's evaluation was to figure out how much better the proposed method might make things. The suggested work is compared to EPAR and found to be more efficient in the following parameters.

- Packet delivery ratio
- Path lifetime
- End to End delay
- Network lifetime

3.1 End to End delay

End-to-end delay states the time it takes a packet to travel from its source to its destination across a network. Figure 1 compares the suggested work's end-to-end delay with that of previous work. With increasing movement speed, the end-to-end latency of all algorithms increases. The proposed method's increment ratio is smaller than the other two algorithms, indicating that movement speed does not affect this approach.

Figure 1 shows that when compared to DSR and EPAR, the proposed work has a shorter end-to-end latency from source to destination. For MONDUWO, EPAR, and DSR, the end-to-end delay is 35.8, 36.2, and 37 seconds, respectively. Because it finds the node-disjoint path at the destination, it avoids delays.

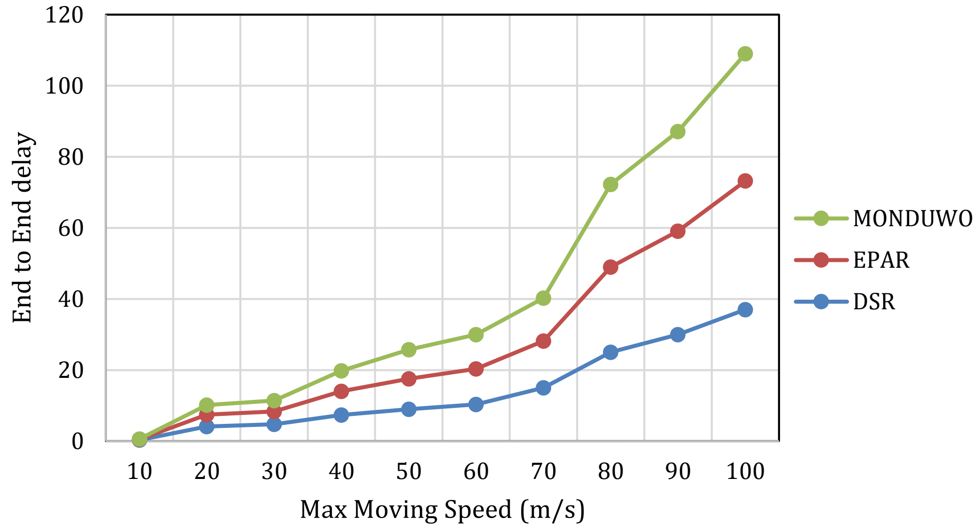

Figure 1: End to end delay

3.2 Packet Delivery Ratio

The packet delivery ratio (PDR) refers to the proportion of total packets transferred from source to destination in a network. Figure 2 compares the proposed algorithm's packet delivery ratio to existing methods. MONDUWO chooses the most reliable node-disjoint pathways that fulfill the data transmission mathematical model. As a result, route breakage due to node failure is extremely unlikely. It has been discovered that the planned MONDUWO has a higher PDR and EPAR than DSR [1]. The PDR increases as the number of nodes increases. The optimal path between sources to destination is selected since there are more nodes. It also increases the number of possible backup channels and the length of time they may be used or path lifespan.

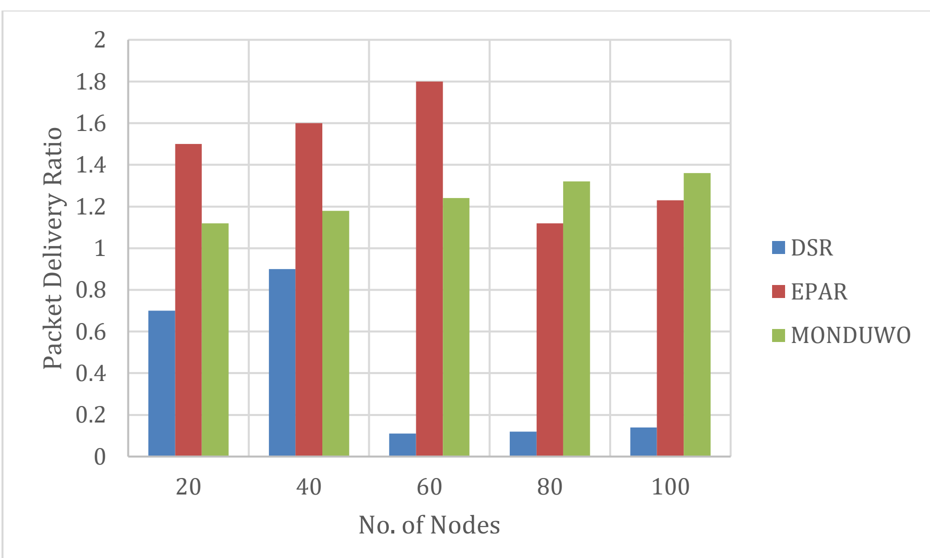

Figure 2: Packet Delivery Ratio

Some of the links on EPAR and DSR may be used by more than one shortest path, resulting in increased traffic on those lines. Congestion may arise, leading to additional delay for data packets sent via these networks and a drop in PDR.

3.3 Path Lifetime

The time passed between the initiation of data flow in a specific path and identifying some of the path's nodes as dead is called path lifetime. The MONDUWO, which is projected, has a longer route lifespan than the others. Because a multi-objective function is employed to choose the path, data transfer will be prohibited for the node with the highest energy usage and the most prolonged traffic delay. High traffic loads induce both packet loss and unnecessary energy use.

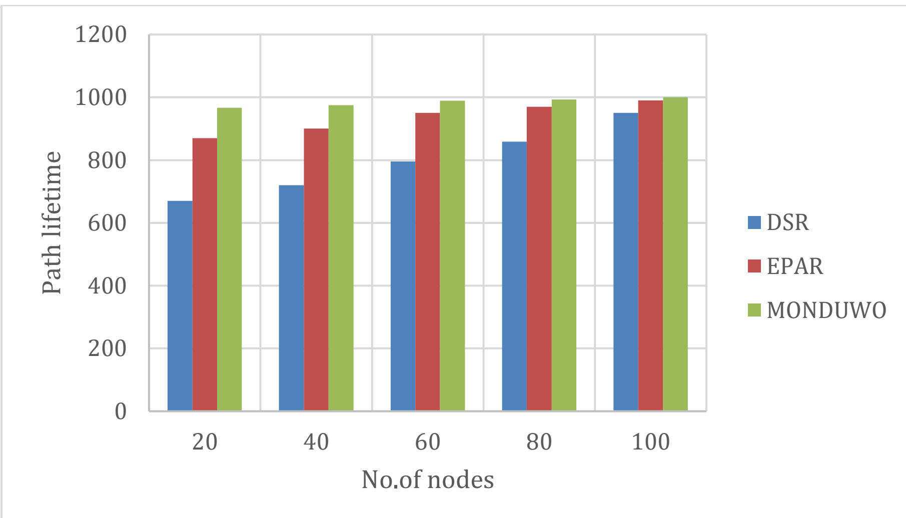

Figure 3: Path lifetime

The route lifetimes of DSR [1], EPAR, and MONDUWO are compared in Figure 3. The time between the start of the path setup and when all of the nodes in the path are alive is measured here. The graph clearly shows that as the number of nodes grows, the lifespan grows as well. The performance of MONDUWO is superior to that of the basic DSR and EPAR because the suggested work took into account the energy consumption of the path to choose the most efficient approach.

3.4 Network lifetime

The time it takes for the first node in a network to run out of energy is the network's lifetime. Figure 4 shows the DSR, EPAR, and MONDUWO network lifespan values in second vs the number of mobile nodes. The network lifetimes of DSR, EPAR, and MONDUWO are compared in Figure 4. The network lifespan of the DSR, EPAR, and MONDUWO grows as the number of network nodes increases.

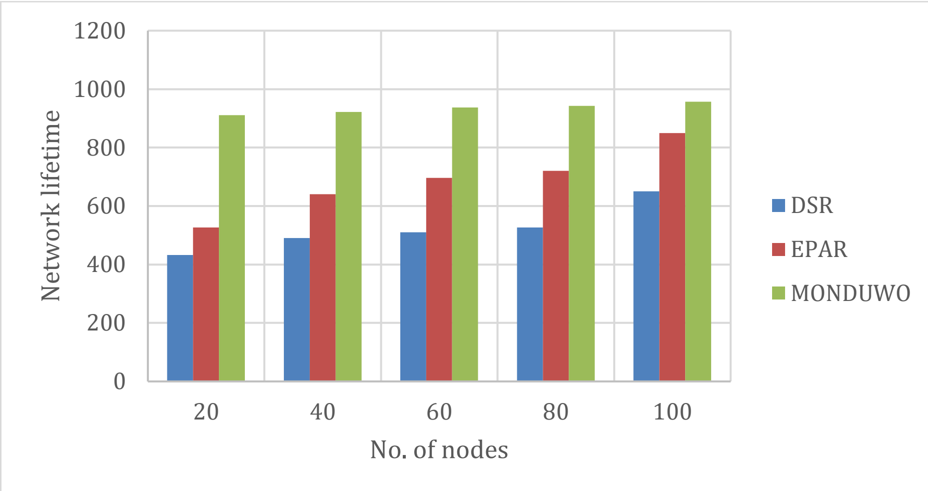

Figure 4: Network lifetime

If a more significant number of nodes are placed in the network region, the energy usage of each node is reduced, extending the network's lifetime. According to this research, the suggested method has a longer network lifespan than previous techniques, even as nodes grow.

4. CONCLUSION

This paper proposes the whale optimization technique for developing an optimum MANET routing protocol. The primary goal of MONDUWO is to transport data effectively between source and destination while also extending the network lifetime. The proposed protocol makes energy-aware decisions to lower the sensor network's overall energy usage. Node-disjoint path selection was used to avoid route failure due to numerous pathways sharing nodes. A performance-enhancing multi-objective function-based routing system is included in the proposed study. The suggested technique was compared to alternative routing protocols in terms of end-to-end delay, network lifespan, packet delivery ratio, and path lifetime. The proposed method outperforms the other routing protocols. The delay of the proposed work is 2.8% less than DSR and 3.29% less than EPAR. The packet delivery ratio of the proposed work is 15.9% higher than DSR and 10.08% higher than EPAR. The network lifetime of the proposed work is 43.89% higher than DSR and16.22% higher than EPAR.

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