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Traffic Congestion Minimization and Reliable Data Transmission in Enhanced Fast Forwarding AOMDV (FF-AOMDV) in Mesh-based Multipath Architecture in MANET

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Abstract: Group-oriented services have become a primary focus for MANETs at present. To cater to these services, multipath routing has been adopted. Consequently, there's a growing demand to develop stable and dependable multipath routing protocols for MANETs to enhance packet distribution rates, reduce delays, minimize routing overhead, alleviate traffic congestion, and ensure reliable data transmission. The introduction of multipath routing helps balance data transmission across multiple paths while ensuring energy-efficient and dependable routing. Within MANETs, packet loss commonly results from obstacles, and this challenge can be effectively managed through congestion control mechanisms. The present study presents an approach for multicast routing based on mesh topology, with the goal of establishing dependable multicast pathways connecting the source to the destination. Multicast machine formation is achieved using the route request and route response packets and the multicast routing data stored at each node. To enhance the exploration of multipath routing, alleviate traffic congestion, and boost data transmission performance, the paper recommends the adoption of an FF-AOMDV routing method, which is deployed on MGWO. The proposed method not only improves end-to-end connectivity but also lowers errors. It employs an energy-efficient neighbour node selection method to make multiple paths from the source to the receiver, ultimately identifying a stable path with effective load balancing. The algorithm is simulated and comparison of performance with existing protocols, such as: AOMDV, EE-AOMDV, and MGWO-DSR, across various metrics including PDR, routing overhead, delay, energy utilization, network lifetime, and capacity.

MGWO-FFAOMDV achieves the following performance results:

Packet Delivery Ratio (PDR): 60.8% Routing overhead: 61.8%Delay: 33.6 ms

Energy consumption: 38.8%Network lifetime: 74.8% Throughput: 81.6%

Keywords: *MANET, multi-path routing, Optimization, FF-AOMDV, traffic congestion, data transmission.*

1. Introduction

In recent decades, there has been significant interest in MANETs [1]. MANETs consist of a wireless mobile node or router that can dynamically establish an ad hoc network without relying on existing infrastructure or centralized management. These routers within MANETs have the ability to move freely and self-organize, resulting in continuously changing and unpredictable network topologies. MANETs exhibit characteristics such as multi-hop communication, mobility, diverse device types, limited bandwidth, and finite battery energy resources [2]. These attributes pose a substantial challenge when designing routing protocols for MANETs since routing paths can be disrupted at any moment. Consequently, research has explored mesh-based architectures as a solution. Mesh-based approaches create a network of interconnected paths that connect source and destination nodes, offering improved resilience to link failures and mobility [3].

Congestion is a phenomenon in ad hoc networks where an excessive number of packets overwhelm a section of the network. This situation occurs when the network load surpasses its capacity, resulting in packet losses, degraded bandwidth, and the consumption of time and energy for congestion recovery. Typically, congestion is localized around a single router, affecting the entire coverage area without overloading the mobile nodes themselves [4,5].

As extensions to AODV, several multipath routing protocols have been developed to alleviate the frequent route discovery process inherent in single-path routing. [6]. However, be aware that simply increasing the number of communication sessions does not necessarily improve performance. AOMDV [7] extends the widely employed AODV protocol by identifying a path separated by multiple links between source and destination during the route discovery phase. This is accomplished by enhancing AODV control packets with additional information, like this, a route

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list that contains advertised hops and multiple paths. A limitation of AOMDV, referred to as "route cutoff," This problem occurs when there is a shared intermediate node in a pair of disjoint paths on a link, making it impossible to discover the two reverse paths. To minimize the latency associated with route discovery, the identification of all existing link-disjoint reverse paths becomes a critical consideration [8].

The Grey Wolf Optimizer (GWO) has also shown utility in routing algorithms. For instance, an energy-efficient routing strategy employs an enhanced GWO to select the optimal Cluster Head (CH) for improved routing [9]. This approach selects the CH based on the distance from the destination, resulting in enhanced performance. In this paper, the focus is on multipath routing discovery, congestion reduction, and the enhancement of data transmission performance. A Multi-objective Grey Wolf Optimization (MGWO) based Fast Forwarding FF-AOMDV is proposed.

The contributions of this paper are mentioned below:

- To minimize traffic congestion and reduce energy consumption in MANETs using the MGWO based FF-AOMDV.
- To decrease delay, routing overhead, and improve the PDR.
- To assess the performance of the proposed MGWO-FF-AOMDV, it will be compared with the following existing protocols: AOMDV, EE-AOMDV, and MGWO-DSR.

The remainder of this paper adheres to the following organization: Section -2 conducts a review of pertinent literature. Section-3 provides a comprehensive outline of the proposed methodology. Section-4 is dedicated to the performance analysis. Lastly, in Section-5, we encapsulate the conclusions and chart the course for future directions.

2. Relevant Studies

In [10], pioneering adaptive routing protocols were introduced to address congestion and routing errors in MANETs by employing bypass routing. This protocol incorporates congestion detection based on link and path utilization and capacity, offering improved reliability and throughput while minimizing packet drops and overhead [11].

Additionally, an efficient cross-layer adaptive transmission method is described for congestion control in mobile wireless ad-hoc networks. [11]. Simulation results demonstrated its effectiveness in congestion handling, outperforming existing methods.

In [12], a congestion control and packet recovery model with localized packet recovery, deterministic features, and peer-to-peer recovery capabilities was presented. This model maintains flow rates and improves the Packet Delivery Ratio (PDR), which is particularly beneficial in congested traffic scenarios.

A refined traffic shaping mechanism based on token bucket traffic shaping (TBTS) method within the TCP/IP protocol suite was proposed in [13]. This method performs well in highly congested traffic situations, reducing queuing delays and improving packet delivery rates. The system also addressed various technical challenges, including performance evaluation under variable parameters.

The CC-AODV scheme was introduced in [14] to manage routing conditions. This scheme significantly increased package delivery rates while reducing package drop rates, albeit at the cost of increased package overhead. Further optimization of the predefined counter threshold module is required.

In [15], a Genetic Algorithm (GA) integrated with the AOMDV routing protocol, known as AOMDV-GA, was presented. This integration yielded substantial enhancements in network performance.

The MCLMR strategy for MANETs was showcased in [16]. This approach utilized a multicriteria decision-making technique called the TOPSIS for selecting at the halfway point nodes. Expected send count metrics are used to mitigate control message storms. Detailed simulations show that the proposed MCLMR routing scheme performs better than traditional methods.

In reference [17], an innovative DSR protocol based on MGWO was introduced. The protocol uses energy, latency, lifetime and link quality as objective parameters, effectively addressing energy depletion issues and ensuring reliable multi-path data transmission in MANETs.

In [18], researchers delved into the realm of evolutionary computation techniques to optimize routing, specifically utilizing Grammatical Evolution (GE) to craft intrusion detection programs tailored for the demanding environments of MANETs. The study also emphasized the effectiveness of AOMDV-QoS schemes in meeting Quality of Service requirements, characterized by their ability to achieve low latency and high reliability.

Furthermore, in reference [19], an AODV protocol based on IGWO (Improved Grey Wolf Optimization) was introduced. This protocol fine-tuned AODV parameters to create energy-efficient nodes and establish multiple high-quality routing paths. The simulation results show improved energy utilization, better performance, reduced end-to-end latency and longer network lifetime compared to existing methods.

Packet redundancy increases as multiple copies of the same packet proliferate across the grid, ultimately leading to reduced packet delivery and increased traffic congestion, particularly in highly mobile scenarios. This congestion among nodes translates to a decreased packet delivery ratio and a higher incidence of packet loss. Additionally, node energy consumption rises due to this congestion, thereby diminishing the overall lifespan of the network. To tackle and alleviate these challenges while enhancing data transmission performance, this paper introduces an approach known as MGWO-based FF-AOMDV.

3. Proposed Methodology

MGWO based FF-AOMDV is proposed for reducing traffic congestion and reliable data transmission. The proposed method of Architecture is presented in Figure 1:

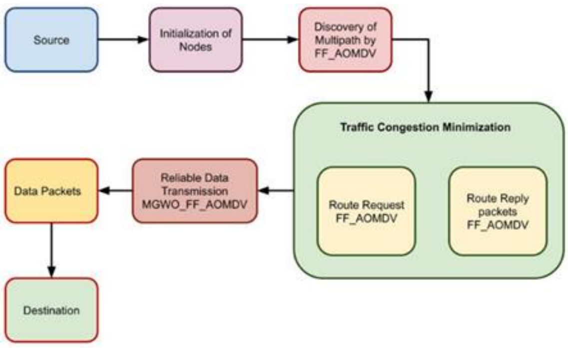


Fig 1: Proposed Architecture

To implement delay-aware routing, FF-AOMDV adapts the route discovery mechanism to incorporate FF-AOMDV, creating a multicast mesh that is simplified if the source node uses RR and RP packets to send data to the receiving nodes. This procedure comprises two distinct phases: the creation of a multicast mesh becomes simpler, when a source node sends data to a receiving node using RR and RP messages. Then, in the response phase, multiple routes to the multicast group are established. Nodes are divided into two groups based on their membership in multicast groups. Group members include all multicast sources and receivers, while non-group members include intermediate nodes that help build a multicast path from sources to receivers. Both group members and non-group members play an important role in managing outages caused by node movement and other disturbances during route maintenance.

FF-AOMDV identifies specific intermediate nodes in the forwarding group to build a robust multicast path. Non-members also have the opportunity to join the group by registering as a member of the group. Recording involves sending request packets by the receiver to neighbouring nodes and receiving request packets from group members or neighbouring forwarding nodes. A non-group member becomes part of the group when it receives an RP packet from a neighbouring group member node.

To implement latency-aware routing, FF-AOMDV employs a route discovery mechanism to incorporate various metrics such as signal strength, queue length, exhaustion rate, and latency. Figure 2 provides insight into route maintenance, illustrating how the route is upheld from source A to destination E. In this scenario, A serves as the source, transmitting the packet to E through nodes B, C, and D. B manages C, C handles D, and D is responsible for the final transmission to E. FF-AOMDV employs an optimization approach with a fitness function, targeting two critical parameters for optimal route selection: route distance and the route's energy level. This optimization aims to enhance data transfer efficiency to the destination, extend the network's lifespan, and conserve energy resources.

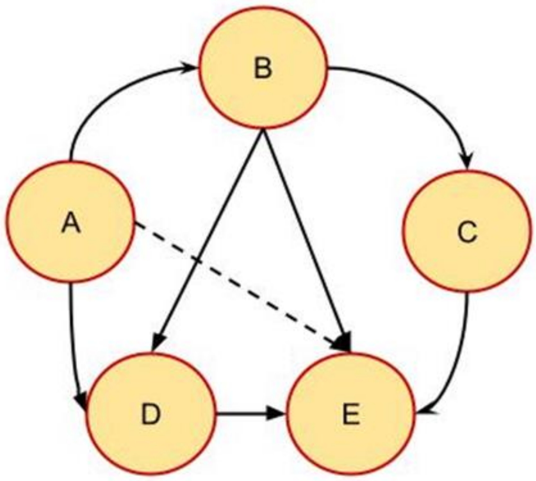


Fig 2: Route maintenance in a mesh architecture

In this phase of the proposed method, the primary objectives are achieving optimal traffic congestion control, enhancing distribution efficiency, and balancing the network load across various paths. To achieve these goals, a comprehensive analysis of traffic patterns and congestion within intermediary paths is employed.

The path response phase from the original AOMDV protocol is employed to evaluate and manage the congestion levels within intermediary paths. During this process, when a route response packet returns from the destination to the source, it collects data about traffic congestion and the traffic load within each intermediary node's buffer. This information is then stored in a designated field within the Route Reply Packet. The congestion levels of the intermediary nodes along the available routes are computed and assessed using the following equations: (1), (2), and (3). This evaluation is carried out for all intermediary nodes until the packet ultimately reaches the source node.

$$C_n(i) = 1 - \left(\frac{Q_u}{Q}\right) \quad (1)$$

$$B_v = \frac{\sum_{i=1}^{n} C_n(i)}{n} \quad (2)$$

$$\partial = \frac{\sum_{i=1}^{n} C_n(i) - \mu}{n} \quad (3)$$

Where $C_n(i)$ is the amount of traffic congestion, B_v represents the average of the total buffer volume, while ∂

represents the extent of congestion fluctuations in the intermediary nodes, and μ signifies the variance in congestion levels. This evaluation helps the source node to determine the best route for the data transfer.

The congestion criterion is crucial for managing network congestion and traffic effectively, ultimately enhancing the quality of service. By relying on congestion analysis to select a node with a lower load volume, network capacity can be optimally utilized, resulting in a more even distribution of load among neighbouring nodes. Additionally, the traffic analysis criterion is instrumental in distributing network traffic, balancing congestion within intermediary nodes, and reducing overall network congestion. Therefore, the congestion levels of different paths can be evaluated using the equations mentioned earlier, with lower averages and rate of change indicating preferable route choices. The efficiency of the paths is also taken into consideration.

The outcome of congestion analysis, along with changes in congestion values and load distribution based on these factors, leads to traffic being routed through the most efficient path selected. Implementing such a mechanism reduces congestion within intermediary paths, resulting in a more balanced and favourable distribution of network load.

The Grey Wolf Optimization (GWO) method is a new approach to swarm intelligence inspired by the social hierarchy and hunting behaviour of grey wolves. GWO is employed to find a set of solutions that strike the best trade-offs between objective functions. The Multi-objective Grey Wolf Optimization (MGWO) extends the GWO by introducing a neighbourhood concept, represented as a circular area around solutions, which can be extended to larger dimensions. This approach, along with the leader selection process, helps maintain diversity in the optimization process, ultimately providing more optimal solutions for the given network.

The circular neighbourhood created by the GWO algorithm resembles a multipath structure, contributing to the efficiency of the algorithm.

Consider X and Y are the random parameters in diverse arbitrary radius of multipath. Number of iterations are reduced by reducing the convergence of the random parameters for optimization. So it is explored as $|X| \geq 1$.

In GWO, the wolves will start to encircle the prey, when the prey is detected and it starts to attack the prey. Likewise, when the multipath routing is established by the FF-AOMDV routing algorithm, the node starts to send data to the receiving node. So, it is needed to reduce the set values of x and it is modelled in advance. The mathematical model for the multipath transmission using GWO is as follows in equations (4), (5) as:

$$\vec{P} = [|\vec{Y}| \cdot |\overrightarrow{S_m(k)|}] - |\vec{S}(k)| \quad (4)$$

$$\overrightarrow{S(k+1)} = \overrightarrow{S_k(m)} + \vec{X} \cdot \vec{P} \quad (5)$$

Where S_m stands for the receiving end node and $\vec{S}(k)$ is the k^{th} position of the transmitting node,

$$\vec{X} = 2\vec{x} \cdot \overrightarrow{a_1} - x \quad (6)$$

$$\vec{Y} = 2 \cdot \overrightarrow{a_2} \quad (7)$$

During the iteration, the coefficient vector $\vec{x}$ ranges from 0 to 2 in incremental steps. The values of a1 and a2 are random numbers from 0 to 1. The computation of distances for multiple mathematical operations is carried out using equations (6) and (7).

Upon completing the distance computation, the final destination node's location is determined. At this stage, the Gray Wolf Optimization (GWO) algorithm comes into play, optimizing the network parameters and identifying the shortest paths. This will select the appropriate value that results in higher throughput. The FF-AOMDV algorithm uses GWO during evaluation to select multipath routes containing nodes with more favourable energy consumption characteristics. While the AOMDV routing protocol enhances power efficiency, GWO plays an important role in extending the network life through multi-path routing.

In the context of MANETs, it is important that all nodes cooperate effectively by sharing information about link quality and available partial routes. GWO-FFAOMDV leverages the GWO algorithm to explore multi-path routes on demand and uses metrics to select the best route. GWO complements FF-AOMDV routing to determine the potential optimal CH.

In this optimal Cluster Head (CH) selection process, the fitness metric taken into consideration is the precision rate. The computation for optimal CH selection solely assesses the cluster group's performance, focusing exclusively on the precision rate, denoted by:

$$OF = MAX(Precision) \quad (8)$$

The precision rate was computed for each cluster generated within the MANET structure, denoted as c1, c2, ..., cn. This fitness evaluation process iterated until the final optimal head selection was determined.

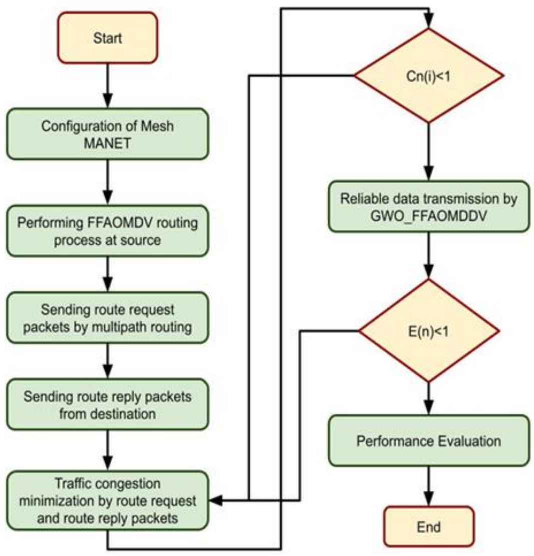
In this research, the objective or fitness function takes into account multiple objectives, including energy, delay, throughput, and lifetime, to identify the best paths. After the route discovery and source encoding stages, the objective parameters are calculated for each path. FF-AOMDV considers these multiple parameters to select a path and efficiently distribute packets to the generated paths.

The main goal of the system is to improve the overall network life cycle and throughput while reducing network latency. The energy consumption of a routing path is determined by estimating the energy used to forward the packet at time t. Given by the following equation (9)

$$E(n) = (2\pi - 1)(E_t + E_r)S$$
(9)

Where, π is the data packet, Et is the energy required to send data packet i, Er is the energy required to receive data packet i, and S represents the distance between the sending node and the destination node.

3.1. Flow Chart



4. Performance Analysis:

The implementation of the MGWO-FFAOMDV model was conducted using the Python tool. The experimental environment featured a PC running Windows 10 Pro, equipped with 8GB RAM, an Intel core i3 processor CPU @1.70GHz, and a 64-bit operating system. MGWO-FFAOMDV underwent a comparative analysis against AOMDV, EE-AOMDV, and MGWO-DSR across various performance metrics, including PDR, routing overhead, delay, energy consumption, network lifetime, and throughput.

4.1. Packet Delivery Ratio (PDR):

PDR quantifies the percentage of packets successfully delivered from the source node to the destination node. It assesses the effectiveness of data delivery to the intended mobile nodes at the destination. The formula for PDR calculation is as follows:

$$PDR = \frac{\sum Number\ of\ packets\ transmitted}{\sum\ a\ number\ of\ packets\ received}$$
(10)

Table 1 represents the comparison of PDR with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Table 1: Comparison of PDR with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO-FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV (Proposed)
100	28	32	38	44
200	42	46	50	52
300	45	51	58	61
400	59	63	69	72
500	62	68	70	75

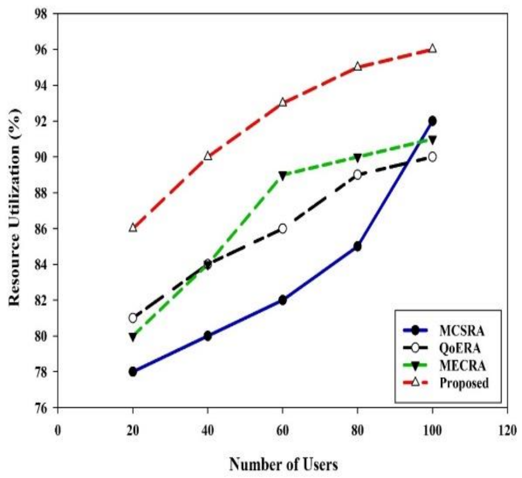


Fig 3: Comparison of PDR

Figure 3 visually compares packet delivery ratios (PDR) to demonstrate the performance of four routing protocols: AOMDV, EE-AOMDV, MGWO-DSR, and the recently introduced MGWO-FFAOMDV. The X-axis corresponds to the number of packets and the Y-axis illustrates the PDR (percent). AOMDV is depicted in dark blue, EE-AOMDV in brown, MGWO-DSR in greenish blue, and MGWO-FFAOMDV in pink. This graphical representation unmistakably highlights that the newly proposed MGWO-FFAOMDV achieves a superior Packet Delivery Ratio (PDR) when compared to the existing systems.

4.2. Routing Overhead:

Routing overhead pertains to the likelihood of establishing a feasible routing and transmission path between two nodes, which may vary in terms of reliability and consistency.

Table 2: Comparison of routing overhead with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV (Proposed)
100	32	35	38	42
200	39	40	45	51
300	42	59	64	68
400	52	65	70	72
500	61	68	72	75

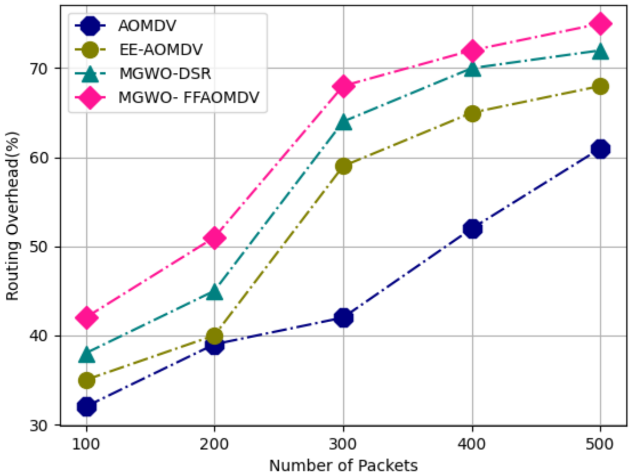


Fig 4: Comparison of Routing Overhead (RO)

In Figure 4, a comparison of RO with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO-FFAOMDV is represented. The X-axis illustrates the number of packets and the Y-axis illustrates the percentage of routing overhead. Dark Blue colour represents AOMDV, EE-AOMDV is represented by brown colour, Greenish blue indicates MGWO-DSR and pink color signifies MGWO-FFAOMDV. From this diagram, the proposed MGWO-FFAOMDV obtains higher routing overhead as compared to the existing system.

4.3. Delay

Delay is calculated by divide the time taken by all packets to reach their destination by the total number of packets sent from the source. This can be expressed with the following formula:

$$\text{Delay} = \frac{T_{received} - T_{sent}}{\sum N_{sent}} \quad (11)$$

where T_{sent} indicates the time when the first packet was sent from the source, while $_{received}$ indicates the time when the last data packet was received at the destination.

Table 3: Comparison of Delay with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO-FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV
100	56	45	35	25
200	59	48	38	28
300	63	52	42	32
400	69	58	48	38
500	76	65	55	45

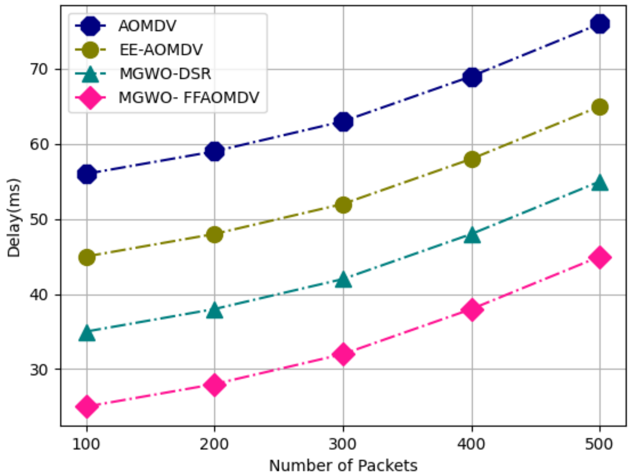


Fig 5: Comparison of Delay (COD)

In Figure 5, a Comparison of the Delay with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV is represented. The X-axis illustrates the number of packets, and the Y-axis illustrates latency in milliseconds. Dark Blue colour represents AOMDV, EE-AOMDV is represented by brown colour, Greenish blue indicates MGWO-DSR and pink color signifies MGWO-FFAOMDV. From this diagram, the proposed MGWO-FFAOMDV obtains higher delay as compared to the existing system.

4.4. Energy Consumption

This represents the cumulative energy consumption of all nodes for transmitting and receiving data during the simulation duration. It calculates the energy used by each node, considering the initial energy levels at the end of each simulation. The energy consumption formula is expressed as:

$$Energy\ consumption = \frac{E_{Total}}{Number\ of\ packets\ successfully\ transmitted} \quad (12)$$

Table 4 represents the comparison of Energy Consumption with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV.

Table 4: Comparison of Energy Consumption with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV
100	46	44	42	35
200	50	49	44	36
300	53	51	49	38
400	55	53	51	41
500	57	54	53	44

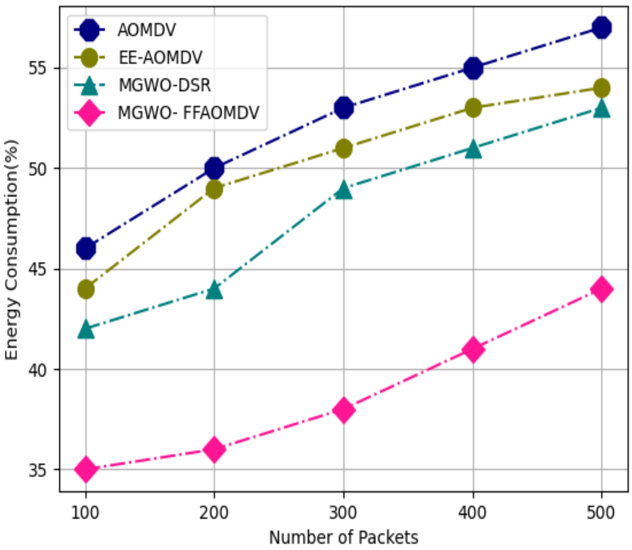


Fig 6: Comparison of Energy Consumption

In Figure 6, we present a comparison of energy consumption, highlighting the performance of existing AOMDV, EE-AOMDV, MGWO-DSR, and the proposed MGWO-FFAOMDV. The X-axis illustrates the number of packets, while the Y-axis illustrates energy consumption as a percentage. AOMDV is depicted in dark blue, EE-AOMDV in brown, MGWO-DSR in greenish blue, and MGWO-FFAOMDV in pink. This diagram clearly illustrates that the proposed MGWO-FFAOMDV exhibits higher energy consumption compared to the existing systems.

4.5. Network Lifetime:

The network lifetime is inversely proportional to energy consumption. As energy consumption improves, the network lifetime shortens. Network lifetime is defined as the duration, during which the network can maintain its desired functionality.

Table 5: Comparison of network lifetime with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV
100	38	45	50	55
200	55	59	63	65
300	65	71	78	81
400	66	79	82	85
500	72	80	85	88

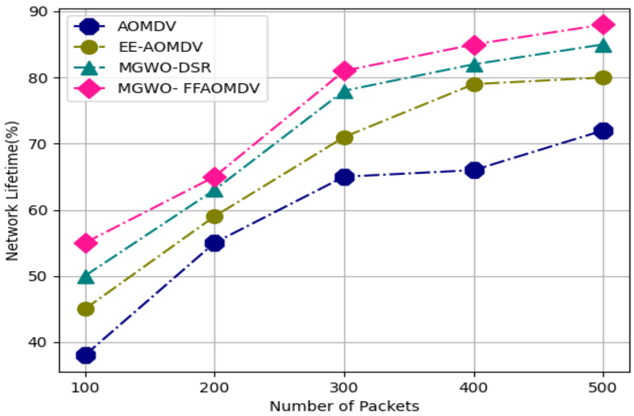


Fig 7: Network Lifetime

In Figure 7, we present a comparison of network lifetime, illustrating the performance of existing AOMDV, EE-AOMDV, MGWO-DSR, and the proposed MGWO-FFAOMDV. The X-axis indicates the number of packets, while the Y-axis indicates the network lifetime as a percentage. AOMDV is represented in dark blue, EE-AOMDV in brown, MGWO-DSR in greenish blue, and MGWO-FFAOMDV in pink. This diagram clearly highlights that the proposed MGWO-FFAOMDV achieves a higher network lifetime compared to the existing system.

4.6. Throughput:

Throughput functions is used as a parameter to evaluate the effectiveness of a routing scheme in the data packet is successfully delivered to the destination node. This is determined by the ratio of packets received by the destination node to the total time it took the source to send these packets. Typically, throughput is quantified in kbps and can be determined using the following formula:

$$Throughput = \frac{(\sum N_{received} \times 8)}{\sum T_{simulation}} \times 1000\ kbps \qquad (13)$$

Where $T_{simulation}$ represents the total simulation time for data packet transmission. $N_{received}$ Refers to the total number of data packets successfully delivered to the destination node.

Table 6: Comparison of throughput with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Number of Packets	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV
100	35	40	45	52
200	44	52	55	61
300	52	63	65	78
400	69	74	79	82
500	72	76	80	85

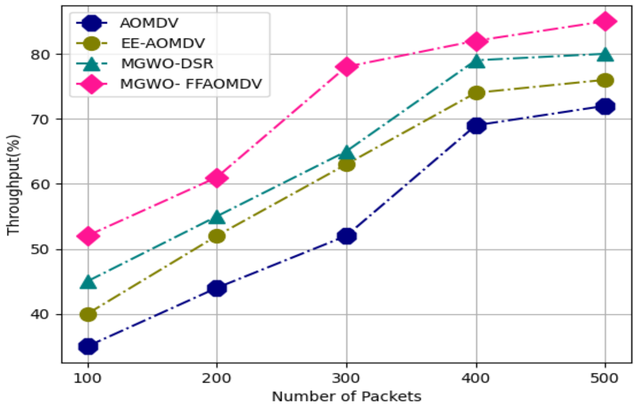


Fig 8. Comparison of throughput

In Figure 8, a Comparison of throughput with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV is represented. X-axis represents the number of packets and Y-axis represents the throughput in percentage. Dark Blue colour represents AOMDV, EE-AOMDV is represented by brown colour, Greenish blue indicates MGWO-DSR and pink color signifies MGWO-FFAOMDV. From this diagram, the proposed MGWO-FFAOMDV obtains higher throughput as compared to the existing system.

4.7. Overall Comparison

Table 7: Overall comparison of various parameters with existing AOMDV, EE-AOMDV, MGWO-DSR and proposed MGWO- FFAOMDV

Parameters	AOMDV	EE-AOMDV	MGWO-DSR	MGWO-FFAOMDV
PDR	47.2	52	57	60.8
Routing Overhead	45.2	53.4	57.8	61.8
Delay	64.6	53.6	43.6	33.6
Energy Consumption	52.2	50.2	47.8	38.8
Network Lifetime	59.2	66.8	71.6	74.8

Based on the table, it is clear that MGWO-FFAOMDV achieved the following noteworthy performance metrics: a 60.8% Packet Delivery Ratio (PDR), 61.8% Routing Overhead, a 33.6 ms Delay, 38.8% Energy Consumption, a 74.8% Network Lifetime, and an 81.6% Throughput.

5. Conclusion

In this research, a Mesh-Based Multicast Routing scheme (MBMRs) was introduced to establish a robust multicast path from source to receiver. By optimizing the multicast routing information stored at each node, a multicast mesh is formed using the Route Request and Route Reply packets. The primary goal was to enhance multi-path routing, alleviate traffic congestion, and boost overall data transmission performance. To achieve this, a novel approach known as a Multi-Objective Gray Wolf Optimization (MGWO) based on FF-AOMDV is proposed. This algorithm not only improved end-to-end connectivity but also reduced errors. Implement a neighbour selection approach that prioritizes efficient energy usage and creates multiple paths from source to destination while maintaining efficient load balancing.

The proposed MGWO-FFAOMDV protocol underwent simulations and comparative evaluations alongside other routing protocols, including AOMDV, EE-AOMDV, and MGWO-DSR. The assessment includes various metrics such as PDR, routing overhead, latency, energy consumption, network lifetime and throughput. In these assessments, MGWO-FFAOMDV consistently outperformed the other protocols, demonstrating significant enhancements across a wide range of performance indicators.

Looking ahead, this methodology holds promise for further development and adaptation to other network types, such as VANET and WSN. Future optimization endeavours may concentrate on reducing overhead and enhancing overall network efficiency.

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