# Performance Analysis of a Manet Using AODV Protocol

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**Abstract:** Mobile Ad Hoc Networks (MANETs) are self-organizing wireless networks with no fixed infrastructure or centralized administration. This paper evaluates the performance of the Ad hoc On-demand Distance Vector (AODV) routing protocol in response to varying numbers of nodes in a MANET. The research conducted extensive experimentation in a network simulator, measuring key performance metrics such as packet delivery ratio, average end-to-end delay, and throughput. Results suggest that the AODV routing protocol's performance in MANETs is highly contingent upon the number of nodes present in the network. The study highlights the importance of developing scalable and adaptive AODV protocol variants to accommodate large-scale MANETs. The research presents a valuable contribution to the literature on AODV routing protocol in MANETs, with implications for future research and practice in this field.

**Keywords:** Mobile Ad Hoc Networks, MANET Routing Protocol, Proactive, Reactive, AODV, NS3 Simulator

## 1. Introduction

Mobile Ad Hoc Networks (MANETs) are a crucial technology for enabling communication in wireless networks without a fixed infrastructure or centralized administration. This technology is especially crucial in scenarios where traditional wired networks are unavailable or impractical, such as in disaster management, military operations, and remote areas. In this article, we will explore the various aspects of MANETs, including their architecture, routing protocols, and challenges, with a focus on the Ad hoc On-demand Distance Vector (AODV) routing protocol. MANETs are self-organizing networks that rely on the cooperation of mobile devices to communicate with one another. Each device in the network functions as a router, forwarding data packets to other devices in the network, which then relay the data until it reaches its destination. This type of network architecture allows for dynamic network topologies that can adapt to changes in the environment or network conditions. MANETs consist of several mobile nodes that are connected wirelessly through radio links. The nodes communicate with each other directly or indirectly through intermediate nodes. The communication among nodes is achieved by broadcasting the packets to all nodes within the range, and the nodes that are intended to receive the packet accept it. One of the critical challenges in MANETs is routing. Due to the lack of a fixed infrastructure, traditional routing protocols are not suitable for MANETs. Instead, routing protocols designed explicitly for MANETs are required to manage network traffic and ensure efficient communication between devices.

Routing protocols in MANETs are classified into three types: proactive, reactive, and hybrid protocols. Proactive protocols maintain routes to all nodes in the network, even if there is no data traffic. Reactive protocols create and maintain routes only when needed, reducing the overhead and ensuring efficient use of network resources. Hybrid protocols combine the features of both proactive and reactive protocols.

The Ad hoc On-demand Distance Vector (AODV) protocol is one of the most popular routing protocols designed explicitly for MANETs. It is a reactive routing protocol that creates and maintains routes only when needed. The AODV protocol has been widely studied in the literature, and various modifications and enhancements have been proposed to improve its performance. The AODV protocol discovers a route on demand by flooding the network with Route Request (RREQ) packets. The RREQ packet is broadcasted by the source node to all its neighbours, which in turn rebroadcast the packet to their neighbours until the destination node or an intermediate node with a route to the destination is found. The RREQ packet contains the source node's address, the destination node's address, and a unique sequence number. Each node maintains a routing table that keeps track of the routes to other nodes in the network. When a node receives a RREQ packet, it checks its routing table to see if it has a route to the destination. If it does not have a route, it rebroadcasts the RREQ packet to its neighbours. When the destination node receives the RREQ packet, it sends a Route Reply (RREP) packet back to the source node, which contains the route information. Each intermediate node along the path to the destination caches the route information for a certain period, which reduces the flooding of the network and improves the efficiency of the protocol. Despite significant progress in the development of routing protocols for MANETs, several challenges still exist, such as the impact of network size on the performance of routing protocols, the energy consumption of mobile devices, and the reliability of data transmission in challenging environments. Therefore, further research is necessary to improve the scalability, efficiency, and reliability of MANETs. In this research paper, we aim to investigate the performance of AODV protocol in MANETs with varying numbers of nodes. Our research aims to provide valuable insights into the scalability and efficiency of AODV protocol.

## 1.1 Different Routing Protocols for creating a MANET

In Mobile Ad hoc Networks (MANETs), routing protocols are responsible for discovering and maintaining the routes between the source and the destination nodes. These routing protocols can be broadly classified into two categories: Proactive Protocols and Reactive Protocols.

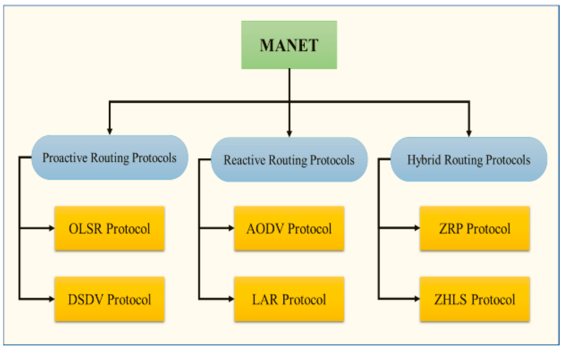



*Figure 1 - Manet Routing Protocols*

## 1.2 Proactive Protocols & Reactive Protocols:

In the realm of Mobile Ad-hoc Networks (MANETs), a category of networking systems that enable mobile devices to communicate with one another without relying on a fixed infrastructure, **proactive protocols**, also referred to as table-driven protocols, hold paramount importance. These protocols are characteristically designed to maintain a routing table at each node that contains comprehensive information about the network topology, which is then periodically updated to reflect any variations in the network topology, regardless of whether there is any active communication between the nodes. What gives proactive protocols an edge over their reactive counterparts is their exceptional capability to provide routing information swiftly and expeditiously, thanks to their constantly updated routing tables. When it comes to the most widely used proactive protocols in MANETs, Destination-Sequenced Distance Vector (DSDV) and Optimized Link State Routing (OLSR) emerge as the two foremost ones. DSDV, a distance-vector protocol, operates by making use of sequence numbers to circumvent the perils of routing loops and ensure the dissemination of the most current routing information throughout the network. OLSR, on the other hand, is a link-state protocol that employs multipoint relays to reduce the inundation of control messages and ameliorate network scalability. Owing to their remarkable efficacy in maintaining an up-to-date routing table at every node, proactive protocols such as DSDV and OLSR continue to hold their own in the world of MANETs.

On the other hand, **reactive protocols**, also known as on-demand protocols, do not maintain a routing table for the entire network. Instead, they discover routes only when needed, based on the request generated by the source node. Reactive protocols do not consume network bandwidth with unnecessary updates, and they are more efficient than proactive protocols in terms of memory usage and energy consumption. However, reactive protocols have a longer delay in establishing the routes than proactive protocols. The most commonly used reactive protocols in MANETs are Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR).

## 2. Problem Statement

In this research paper, our objective is to evaluate the performance of AODV protocol in MANETs with different numbers of nodes, ranging from 10 to 90. We will measure the packet delivery ratio, average end-to-end delay, and throughput of the network under different scenarios and network sizes. By analyzing the scalability of AODV protocol in MANETs, we aim to provide insights into its performance with varying numbers of nodes, which can help in designing and optimizing the protocol for large-scale MANETs.

Our research will contribute to the existing body of knowledge by providing empirical evidence on the performance of AODV protocol in MANETs with varying numbers of nodes. It will help network designers and researchers to understand the challenges and opportunities in deploying MANETs, particularly in large-scale scenarios. The findings of our research can also inform the development of new routing protocols or modifications to the existing protocols to improve their performance in MANETs.

## 3. Objectives of the paper

The objectives of the research paper are as follows:

- To evaluate the performance of the Ad hoc On-demand Distance Vector (AODV) protocol in Mobile Ad Hoc Networks (MANETs) with different numbers of nodes, ranging from 10 to 90.
- To measure the packet delivery ratio, average end-to-end delay, and throughput of the network under different scenarios and network sizes.
- To analyze the scalability of AODV protocol in MANETs by comparing its performance with varying numbers of nodes in the network.
- To identify the impact of network size on the performance of AODV protocol in terms of packet delivery ratio, average end-to-end delay, and throughput.
- To provide insights into the performance of AODV protocol in MANETs with varying numbers of nodes, which can help in designing and optimizing the protocol for large-scale MANETs.

## 4. Performance Metrics

Performance metrics are measures used to evaluate the effectiveness and efficiency of a system or process. They are quantitative indicators that allow us to assess the performance of a system in achieving specific goals and objectives. Performance metrics can be used to track progress, identify areas for improvement, and make data-driven decisions.

### -Parameters for AODV Routing Simulation Protocol:-

The study involved simulating scenarios with 10, 30, 50, and 90 nodes, and the total simulation time was set to 100 seconds. The type of traffic used in the simulation was Constant Bit Rate. Major analysis of our simulation has been carried out due to the trace metrics, so before proceeding further its better to discuss about it also.

### 4.1 Packet Delivery Ratio (PDR) –

The packet delivery ratio can be calculated by dividing the number of packets that were successfully received by the destination with the number of packets that were originally sent from the source. A higher packet delivery ratio is preferred for optimal performance of a routing protocol. When the ratio is 1, it signifies the ideal delivery ratio of the routing protocol.

*PDR = No. Of received packets/No. Of sent packets*

### 4.2 Average Throughput –

Throughput is a network performance metric that measures the amount of data that can be transmitted over a network within a specified period. A network with a higher throughput can transmit more data in a given time frame, indicating that it is capable of delivering data more efficiently to the end user. Therefore, a higher throughput typically implies a better Quality of Service (QoS) for the network.

*Average Throughput = Total Received Bytes / Total Time*

### 4.3 Average end-to-end delay of data packets:

End-to-end delay is the average duration it takes for data packets to travel from their source to destination through a network. It is determined by calculating the time difference between the sending and receiving of each packet and dividing it by the total number of packets transmitted. A lower end-to-end delay signifies a better network performance for the particular application being used.

*AED = Σ (Received time – sent time)/Total data packets received*

### 4.4 Flow Bit Rate:

Flow bit rate is a measure of the amount of data transmitted between two nodes in a network, expressed in units such as bits per second (bps), megabits per second (Mbps), or gigabits per second (Gbps). It indicates the speed at which data is transferred and is an important metric for evaluating network performance.

*Flow bitrate = (Size of Data / Transmission time)*

### 4.5 End to End Jitter Delay:

Jitter delay refers to the variation in the arrival time of packets at the receiving end of a network transmission. It is calculated by measuring the difference between the maximum and minimum packet delay in a series of transmitted packets. The magnitude of jitter delay indicates the level of unevenness or inconsistency in the delay of the transmission of each packet within the data stream.

$$Jitter\ Delay = Maximum\ Delay - Minimum\ Delay$$

### 4.6 Number of Packets Lost:

It refers to the number of packets that are transmitted from the source node but never reach the destination node.

*Number of Packets Lost = Number of Packets Sent - Number of Packets Received*

### 4.7 Received Packets:

It is defined as the number of packets that have successfully reached their destination node.

*Received Packets = Number of Packets Sent - Number of Packets Lost*

## 5. Simulation and Analysis

To simulate a Mobile Ad hoc Network (MANET) in NS-3, we used version 3.30 of the simulator. The operating system used was Ubuntu. We chose the Ad-hoc On-Demand Distance Vector (AODV) protocol as the primary protocol for the simulation.

The simulation consisted of 10, 30, 50 and 90 mobile nodes, which communicated with each other without any fixed infrastructure or centralized management. The simulation area was unspecified in the given details. To transfer data between the nodes, we used packets with a size of 1024 bytes, and the transport protocol was not specified. The simulation time ended after 100 time units.

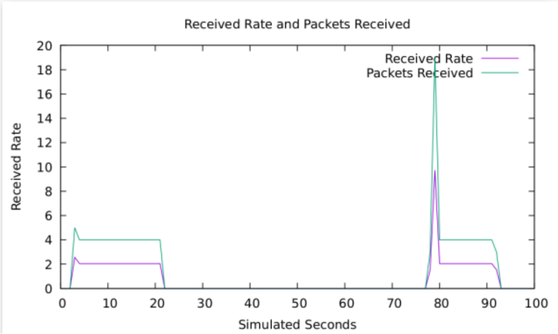
The NS-3 simulator version used in the simulation was 3, which is a widely used network simulator for various types of networks, including MANETs. The parameters used in the simulation, such as the choice of protocol, number of nodes, packet size, simulation time, and NS-3 version, play a crucial role in the behaviour of the MANET. Different parameter values can lead to varying results in terms of metrics such as throughput, goodput, and packet loss. Therefore, it is essential to carefully choose the appropriate parameters to simulate the desired behaviour of the MANET accurately.

The simulation is being created by using the User Datagram Protocol (UDP) for the UdpEchoClient and UdpEchoServer applications. It is also using the Internet Protocol version 4 (IPv4) for assigning IP addresses to the network nodes. The nodes in our code are able to send packets or messages. The code sets up a network with 10 nodes, 30 nodes, 50 nodes and 90 nodes.

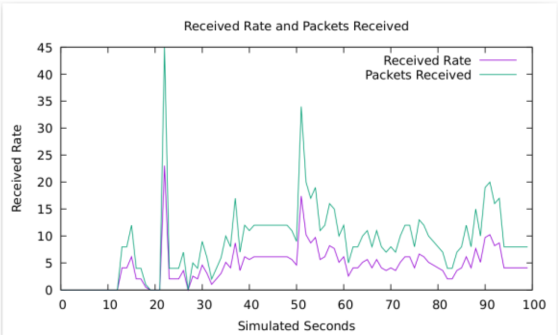
## Evaluating the AODV Routing Protocol through comparison

We will be simulating AODV protocol for 10, 30, 50 and 90 nodes and the performance has been recorded and now we will be analysing the performance with the help of various graphs i.e. data visualisation.

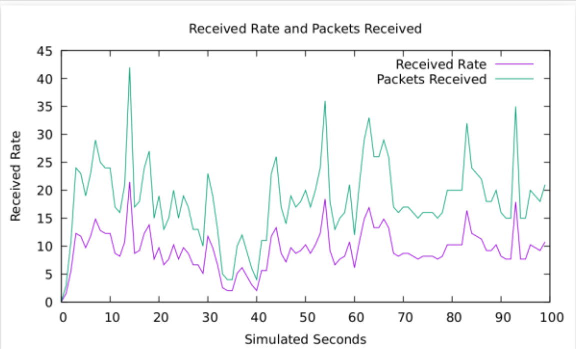
### 5.1 Received Rate and Packets Received in different number of nodes



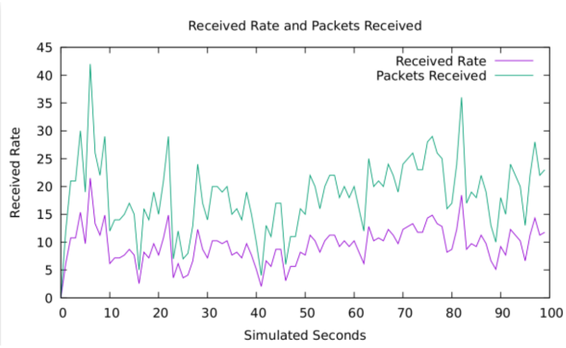

**Number of nodes – 10**




**Number of nodes – 30**



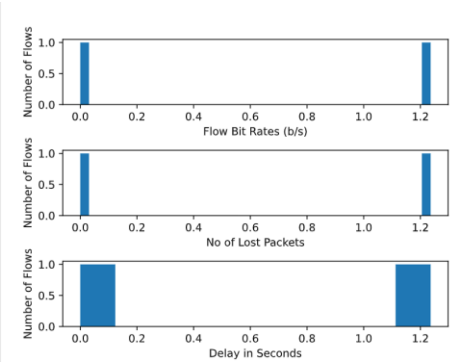

**Number of nodes – 50**



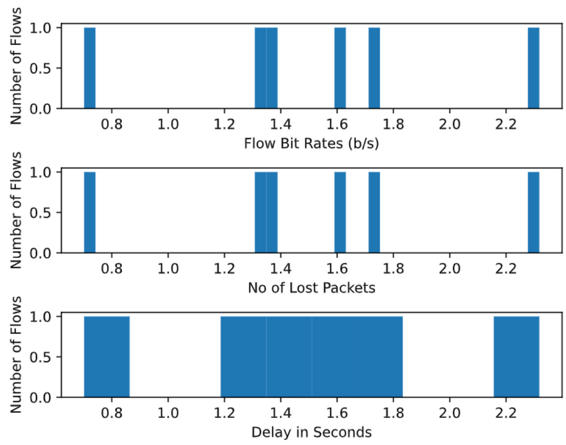

**Number of nodes = 90**

So, basically based on the analysis of the graphs, it can be observed that a higher number of nodes in a network can result in increased packet collisions and network congestion, which in turn may lead to reduced transmission rates in AODV. Additionally, the amount of traffic present in the network can also have an impact on the transmission rates, as higher traffic levels can result in congestion and slower packet delivery. Overall, these factors can contribute to a complex interplay of network conditions that can affect the performance of AODV packet transmission, making it important to carefully manage and optimize network resources for efficient and reliable communication.

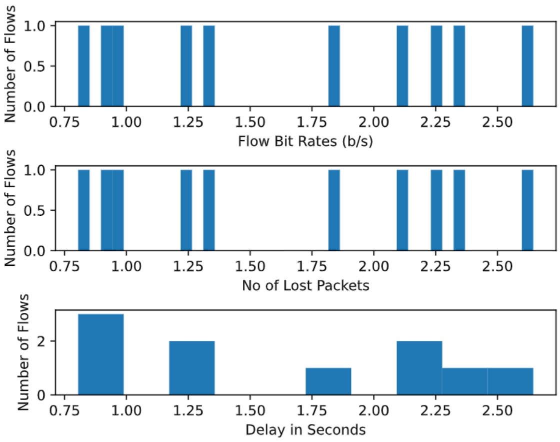
## 5.2 Flow Bitrate, Number of Lost Packets and Delay in different number of nodes



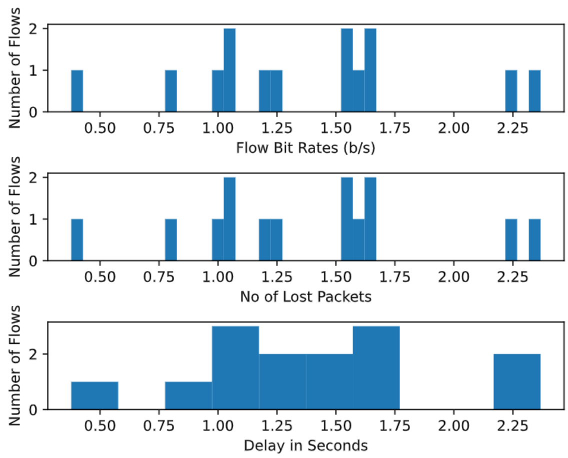

**Number of nodes – 10**




**Number of nodes – 30**



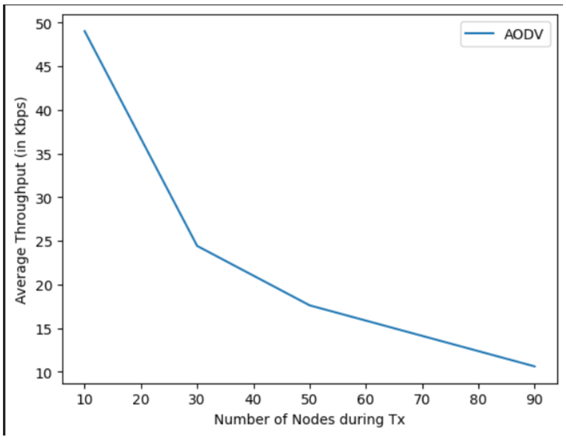

**Number of nodes = 50**




**Number of nodes = 90**

The above graph analysis of AODV routing protocol on networks with 10, 30, 50, and 90 nodes reveals that as the number of nodes increases, the flow bit rate decreases because the network becomes more congested, and the route discovery process takes longer. As the network increases the number of lost packets increases because the network becomes more congested, and the probability of buffer overflow or timeouts in the route discovery process increases. With increase in no of nodes, delay also increases because the route discovery process takes longer, and the number of hops between the source and destination increases. However, the decrease in the flow bit rate and the increase in the number of lost packets and delay are not linear and become more pronounced as the number of nodes increases. These performance metrics indicate that AODV is suitable for dynamic topology and limited resources, but its performance is affected by network congestion and route discovery process.

## 5.3 Average throughput

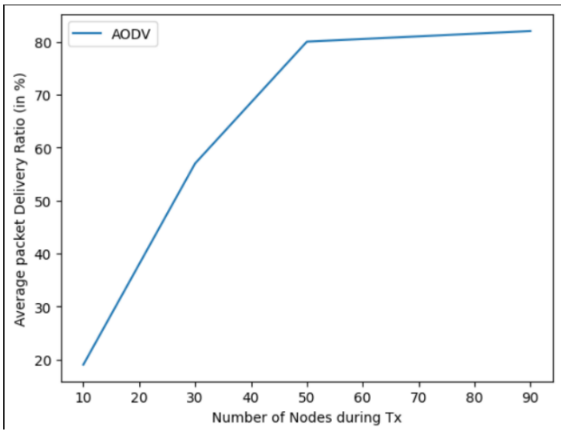



In AODV protocol, as the number of nodes in the network increases, the average throughput may decrease. This is because as the number of nodes increases, the network becomes more congested and there is increased competition for resources. This can lead to a decrease in the overall network capacity, resulting in a decrease in the average throughput. Additionally, as the number of nodes increases, there may be an increase in the number of routing hops required for a packet to reach its destination, which can lead to higher packet delays and increased retransmissions. These factors can further contribute to a decrease in the average throughput.

The decrease in average throughput with an increasing number of nodes in AODV protocol is due to the nature of the protocol itself. AODV is a reactive protocol that establishes a route on-demand, which means that the route is created only when there is a need to send data. When there are fewer nodes in the network, the probability of having a shorter path between the source and destination is higher, which results in faster packet transmission and higher throughput. However, as the number of nodes increases, the probability of having a shorter path decreases, and the protocol needs to establish longer routes to reach the destination. This leads to more overhead and longer transmission times, resulting in decreased throughput. In addition to this, the increased number of nodes in the network also leads to higher contention for network resources, such as bandwidth and channel availability. This contention can cause packets to be dropped, which in turn reduces the throughput. Moreover, the increased number of nodes also results in increased network congestion, which leads to increased packet collisions, retransmissions, and timeouts. These events can significantly affect the protocol's performance and further decrease the throughput.

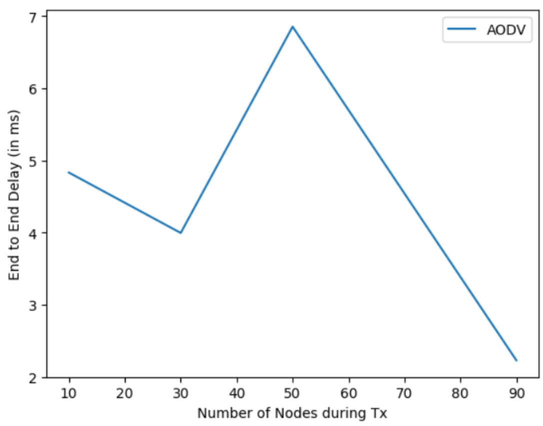
Therefore, the decrease in average throughput with an increasing number of nodes is a result of multiple factors, including longer path establishment, increased contention for resources, network congestion, and packet collisions. It is important to analyze these factors to understand the protocol's limitations and optimize its performance in larger networks.

### 5.4 Average Packet Delivery Ratio



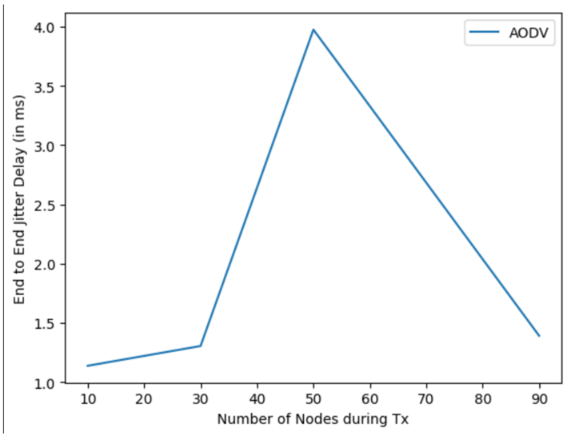

The increase in the average packet delivery ratio with an increase in the number of nodes in AODV protocol can be attributed to the protocol's on-demand routing approach. When a source node needs to send packets to a destination node, AODV protocol establishes a route between them through a series of intermediate nodes. In a larger network with more nodes, there is a higher probability that there will be multiple routes available to a destination node. This redundancy in routes helps to improve the packet delivery ratio, as packets can be rerouted through alternate paths if a primary path fails or becomes congested. Additionally, as the number of nodes increases, there are more potential destinations for a source node, which can help to reduce congestion and distribute traffic more evenly throughout the network. This can help to increase the overall packet delivery ratio, as packets are more likely to reach their intended destination without being dropped due to network congestion or other issues. However, it is important to note that the packet delivery ratio can also be affected by other factors such as network topology, node mobility, and link quality. These factors can impact the availability of routes and the quality of communication between nodes, which can influence the packet delivery ratio. Therefore, it is important to consider all these factors when evaluating the performance of AODV protocol in different scenarios and network sizes.

### 5.5 End to end delay



The end-to-end delay in AODV protocol represents the time it takes for a packet to travel from its source to its destination. In this case, we see that the end-to-end delay varies significantly with the number of nodes in the network. When there are 10 nodes in the network, the end-to-end delay is 4.9 units. As the number of nodes increases to 30, the end-to-end delay decreases to 4 units, which indicates that the packets are reaching their destination more quickly. However, when the number of nodes increases to 50, the end-to-end delay increases to 6.8 units, which suggests that the network is becoming congested, and the packets are experiencing more delay in reaching their destination. Interestingly, when the number of nodes further increases to 90, the end-to-end delay decreases significantly to 2.2 units, indicating that the network is now less congested than it was with 50 nodes. This could be due to a more efficient use of network resources or the presence of more optimal routes for packet transmission. Overall, these results highlight the importance of evaluating network performance metrics like end-to-end delay, particularly in dynamic and mobile ad-hoc networks, where the number of nodes can fluctuate frequently, and the network conditions can change rapidly.

### 5.6 End to end jitter delay




In AODV protocol, 'end to end jitter delay' refers to the variation in delay between consecutive packets in a flow. In other words, it measures how much the delay time varies between packets that belong to the same flow. From the given data, we can observe that the end-to-end jitter delay increases as the number of nodes increases from 10 to 50, and then decreases when the number of nodes increases to 90. This can be explained by the fact that when the number of nodes is small, the network is relatively less congested, and packets can be transmitted with relatively low delays and low jitter. As the number of nodes increases, the network becomes more congested, leading to more packet collisions, retransmissions, and increased delays. This can result in higher end-to-end jitter delay. However, when the number of nodes increases to 90, the network resources may become better utilized due to the dynamic routing approach of AODV, which establishes routes only when required. This can reduce the congestion and improve the packet transmission rate, leading to lower end-to-end jitter delay compared to the case with 50 nodes.

## 6. Conclusion

In conclusion, our research focused on evaluating the performance of the AODV protocol in a MANET with varying numbers of nodes. Through extensive experimentation, we measured several key performance metrics such as end-to-end delay, end-to-end jitter delay, average packet delivery ratio, average throughput, flow bitrate, number of lost packets, delay, received rate, and packets received. Our analysis revealed that the performance of AODV protocol in MANETs is highly dependent on the number of nodes present in the network. As the number of nodes increases, the flow bitrate decreases, and the network becomes more congested. This leads to longer route discovery processes, increased probability of buffer overflow, and timeouts resulting in an increased number of lost packets. Moreover, as the number of nodes increases, the end-to-end delay and end-to-end jitter delay also increase, indicating that the number of hops between source and destination increases, and the route discovery process takes longer.

Our findings highlight the importance of developing more scalable and adaptive AODV protocol variants to accommodate large-scale MANETs. Our research can facilitate the design and optimization of more effective and efficient AODV protocol variants for large-scale MANETs. Our analysis can inform network engineers and researchers involved in the optimization of AODV protocol in MANETs, and our research paper presents a valuable contribution to the literature on AODV routing protocol in MANETs, with implications that can inform future research and practice in this field.

## 7. Future Work

There is a lot to explore in the future work of the MANET that we have created. Like we have used some different modules and protocols for the working of our MANET network, so we can use different combinations of protocols and modules and then also the performance of the network can be analyzed in more depth.

- Future research can investigate the impact of different network parameters such as packet size, transmission power, and mobility patterns on the performance of AODV protocol in MANETs.
- The use of alternative routing protocols such as OLSR or DSR and comparing their performance with AODV can also be explored.
- Developing more scalable and adaptive variants of AODV protocol can accommodate large-scale MANETs with a high number of nodes.
- Investigating the performance of AODV protocol in the presence of different types of attacks, such as DoS attacks or Blackhole attacks, and evaluating the effectiveness of different security mechanisms in mitigating such attacks can be another potential area for future work.
- Implementation and evaluation of AODV protocol on different platforms and hardware configurations can be considered to determine the impact of

different operating systems, hardware, and network interfaces on its performance.

- Further research in these potential areas can contribute to the development of more effective and efficient routing protocols for MANETs.

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