

# A Comparative Study of Quality of Service (QoS) Metrics in Reactive Routing Protocols DSR and AODV in Manet Check for



Abstract: This study is based on the analysis of specific Quality of Service (QoS) metrics. The acquisition of these metrics was achieved by modifying the code in the C++ language within the NS-3 network simulation software. The choice of the Random Way Point mobility model contributed to the generation of metrics, which were subsequently used in the evaluation and comparison of two selected protocols, DSR and AODV. These evaluations focused on critical parameters, including throughput, Delay, and Jitter. To conduct meaningful comparisons, three different scenarios were designed, each characterised by variations in the number of nodes used. This approach enabled a comprehensive assessment of the protocols' effectiveness in various MANET network configurations. Ultimately, the selection of the most accurate protocols was based on a detailed analysis of metrics in various MANET scenarios. This process provided a deeper understanding of how DSR and AODV perform in specific environments, enabling the identification of more effective protocols according to the particular demands of each scenario.

Keywords: Ad-Hoc, AODV, Delay, DSR, Routing, Jitter, MANET, Metrics, Mobility, Nodes, Ns3, QoS, Random Waypoint, Networks, Throughput.

# I. INTRODUCTION

Over time, as technology has developed, wireless networks have become integral elements in the technology used daily. With this development, along with the evolution of mobile devices, the implementation of network mobility has become imperative. This does not mean mobility among connected devices, but instead creating a whole network that can operate independently of a network management device. Ad-hoc networks emerge to fulfil this mobility need by

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creating technology that can set up networks anywhere without an existing infrastructure. It also results in the creation of new routing protocols for these types of networks, taking into account potential problems such as protocol efficiency and the time required for packet delivery. To determine the proper protocol for this type of network, this project aims to compare some Quality-of-Service metrics of two reactive routing protocols in MANET to identify which one is the best option in scenarios with different node densities. To achieve this, the tool used will be the NS-3 software for simulations in the proposed scenarios and to compare protocols.

Simulations will begin by analysing the behaviour of two routing protocols in MANET with varying node densities. Random Waypoint will be the mobility model used to simulate random movement within a specific area, as if it were a group of people moving around. Then, it will be possible to calculate and retrieve the data to compare the routing protocols, finding out the best one for the proposed scenario.

## II. MANET

MANET (Mobile Ad-Hoc Network) is a network in which all nodes, in this case, mobile devices, work together. MANET does not need a static topology, fixed structure or intermediate devices such as a router, switch or access point [1].

Mobile devices have autonomy and mobility, broadening the scope of action of MANET, which enables them to operate using the TCP/IP model structure with peer-to-peer transmission. A MANET transmits based on adjacent neighbouring nodes sending messages in flooding mode to their neighbours within the covered area. Likewise, if the destination node is not nearby, each node will repeat the flooding process with its neighbouring nodes until it reaches the destination node.



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Figure 1 illustrates the operation of a typical MANET. Figure 1(a) shows the network that will be analysed, where node A is the source and node F the destination. Figure 1(b) shows the route discovery process starting with the recognition of node A and its neighbours. As none of the adjacent nodes is the destination node F, Figure 1(c) shows nodes B and C being closer to the destination node F, so Figure 1(d) shows the route and message sent from node A to F using node C as an intermediary [2].

As MANET operates differently from conventional networks, protocols with specialised functions for these types of networks are necessary to achieve optimal performance.

## **A. Manet Applications**

There are different scenarios where MANET can be helpful.

- Education

MANET can be applied in the education field. For example, when setting up groups to work together or on dynamic tasks, the teacher is considered a supernode supervising students' work.

- Emergency protocols

MANET would be of great help in cases of catastrophes such as earthquakes and floods. If the telecommunication system were affected, MANET would develop a backup while the infrastructure is repaired.

- Search and rescue operations

MANET could be helpful during search and rescue operations, as it is essential to disseminate updated information about the search progress in areas with limited or no communication infrastructure. MANET could prevent losing communication with the rescue team.

- Event-based temporary scenarios

In meetings, conferences, shopping malls and other places where information needs to be shared or to support communication among devices within a place, MANET could be a great solution. It's easy to deploy and simple to dismantle after the event.

# - Sensors

MANET could also aid in the use of sensors in daily life.

Homes have sensors installed in various equipment, such as smoke detectors and electronics, that send regular status reports. Another area of interest could be BAN (Body Area Network) devices for continuous monitoring of vital signs. MANET would facilitate the transmission of information to remote patient supervisors regarding the health status of their patients.

## III. AODV

This protocol is based on DSDV and DSR. It features characteristics that allow nodes to find and maintain routes to their destinations. AODV is a reactive protocol, so routes are set only when needed. It uses distance vectors and distance measure in hops. It supports unicast and broadcast, as explained in RFC 3561.

Packets sent by AODV do not know the network where they are operating, as they only know the source-to-destination route. This protocol does not maintain a route for each node; instead, it works on demand, discovering new routes as needed.

Retrieval Number: 100.1/ijese.C256012030224 DOI: 10.35940/ijese.C2560.12030224 Journal Website: www.ijese.org The AODV protocol enables each node to create routing tables, allowing packets to be routed without requiring the explicit loading of routes. All routes included in AODV have a sequence number to be identified and a timer or lifetime to help the protocol determine new and old information to prevent loops and transmission in outdated routes [3].

The AODV protocol enables route maintenance through HELLO messages, which inform the network of any failures or changes that occur within it. If a node disconnects from its neighbour, it is because it has not received the HELLO message. In the AODV protocol, it is assumed that the first route discovered is the shortest, but it won't always be the case, as sometimes it ends up choosing a longer route[4].

## IV. DSR

The DSR protocol was presented in 1994 by Johnson and Maltz as a solution for routing in MANET. It is a reactive routing protocol with two phases: on-demand route discovery and route maintenance. The request packets used in the discovery process are stored in the message header. When this packet reaches a node with the destination information or the destination node itself, a message is sent to the source node including all the information gathered from the nodes connecting the info, so the packets have the whole route information [5]. The DSR protocol can make routing changes quickly when nodes move frequently and requires minimal overhead when nodes are stationary. Each node using DSR has a routing table or route cache to identify the route towards the destination node. If there is no existing route, it will be discovered through a process known as Route Discovery. During this process, packets are kept in a buffer, either waiting or ready to be discarded [6].

## V. SIMULATION

To assess the network behaviour in this work, three proposed scenarios are used with 25, 50, and 100 nodes. The simulation area would cover 500 x 500 meters in Loja city, taking into account that it is a bustling area and considering a random mobility model for people. Its length extends from Azuay St. to 10 de Agosto St., and its width spans from 18 de Noviembre St. to 24 de Mayo St.









AODV and DSR are the routing protocols simulated in this work to determine which one exhibits better characteristics in various scenarios and with different node densities. This work aims to study and compare the Quality-of-Service metrics in each protocol, so choosing which metrics to use is essential. The selected metrics are:

- Throughput

Throughput is one of the metrics chosen because it is relevant to observing the effective rate of received data in each scenario, considering that one of the most critical factors within the network is the effective data reception rate.

- Delay

Analyzing delay will provide information about the average time it takes each packet to be received by a node. This parameter would be of great help to determine which protocol and scenario have the fastest transmission and reception.

- Jitter

The average jitter would help determine the average delay variation in each packet. This is important because it will indicate which protocol has the most consistent delay variation in the network. It could also help predict the arrival time of a packet within that network.

- Metric gathering

To gather metrics in this work, calculations will be made within the source code used, as some of the tools applied to NS3 are not recommended for this type of protocol. It is not possible to recognize flows, especially in the DSR protocol. Likewise, Python Viz is the chosen visual method, as it allows for better monitoring of flows. Through these calculations, it will be possible to obtain the three QoS metrics mentioned above: Throughput, Delay and Jitter. To calculate the Throughput, the amount of data is converted into bytes and then divided by the simulation time, yielding the result in kilobits per second (kbps).  $Th = \frac{bytes \cdot \varepsilon}{T_{e} \cdot 1000} Equation 1$ 

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Where:

Bytes: Total of Bytes in each packet

**TS**= Simulation time

To obtain the delay, the times of arrival of each packet are received first. Then, the difference between the current time and the time of arrival of the previous packet reception is calculated. The formula is the following:

 $Dly = T_A - T_P$  Equation 2

Where:

**TA:** Current time of simulation or reception

TP = Previous time of simulation or reception

The Jitter is obtained from the delay data by calculating the difference between the current delay and the previous delay. Then, this amount minus the previous Jitter is divided by 16 to reduce noise, as per RFC 3393.

$$Jitt = \frac{[(Dly_A - Dly_P) - Jitt_P]}{16} \quad Equation 3$$

Where: Jitt = Jitter DlyA = Current packet delay DlyP: Previous packet delay JittP = Previous packet jitter

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## VI. DATA ANALYSIS

## Scenario 1: MANET with 25 Nodes

The first simulation scenario will utilise the parameters specified in Table 3, and the QoS metrics mentioned above will be calculated.

# Table 1: Parameters in the First Simulation Scenario

Parameters	Quantity	
Number of nodes	25	
Area [m]	500x500	
Mobility model	Random Waypoint	
Simulation duration time [s]	100	
Maximum node speed [m/s]	20	
Pause [s]	0.5	
Routing	AODV, DSR	

Source: Author

All data in the chart will be applied to both protocols. As shown in Figure 3, both protocols will have a route discovery phase.



Fig. 3: Route Discovery Phase in First Scenario

Source: Author

Here we have the packet delivery phase as shown in Fig. 4



Fig. 4: Packet Delivery Phase in the First Scenario

Source: Author

The route discovery phase and the delivery packet phase, as shown in Figs. 3 and 4 are present in both protocols, differing only after the route discovery phase.



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In AODV, routes are maintained through the constant Hello broadcast messages; however, DSR only broadcasts during the route discovery phase, as it retains route information by saving routing data in the packet header.

Regarding the packet delivery phase, each protocol works differently, obtaining the following general data on the QoS metrics mentioned when describing the methodology.

Based on these metrics, the comparison is made one by one.

## - Throughput

According to the data gathered from simulating a 25-node network, it is considered that the most effective protocol in that scenario will be the one with the highest throughput. Fig. 5 shows that DSR tends to yield higher throughput results in most of the assessed nodes in the 25-node scenario, indicating that DSR can receive data more effectively than AODV.



Fig. 5: Throughput Results for Each Protocol in the First Scenario

## Source: Author

- Delay

Fig. 6 shows that the delay numbers in the AODV protocol are higher than those in DSR, indicating that DSR has a greater effectiveness in transmitting and receiving packets, as evidenced by the lower average delay numbers. It means sending and receiving packets in DSR is faster than in AODV.



Fig. 6: Delay Results for Each Protocol in the First Scenario

#### Source: Author - Jitter

When measuring Jitter, the lower the better, as it represents a variation in delay. The best protocol is the one with a more constant delay. Fig. 7 shows that the DSR protocol is superior, as it has a lower average jitter.

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Fig. 7: Jitter Results for Each Protocol in the First Scenario

#### Source: Author

## Scenario 2: MANET with 50 nodes

The following parameters are set during the simulation in the second scenario.

Parameters	Quantity	
Number of nodes	50	
Area [m]	500x500	
Mobility model	Random Waypoint	
Simulation duration time [s]	100	
Maximum node speed [m/s]	20	
Pause [s]	0.5	
Routing	AODV, DSR	

#### Source: Author

Figure 8 shows the route discovery phase of the network.



Fig. 8: Route Discovery Phase in the Second Scenario

Source: Author Figure 9 shows the packet delivery phase in the second



Fig. 9: Packet Delivery Phase in the Second Scenario Source: Author





# Throughput

Figure 10 shows that throughput results for the AODV protocol tend to be higher than those for DSR in all cases. Then, the difference in a 25-node scenario implies that DSR is behind in effective delivery, and the AODV protocol stands out in this area with a higher number of nodes.



Fig. 10: Throughput for Each Protocol in the Second Scenario

# Source: Author

- Delay

Figure 11 shows that, regarding average delay results, the AODV protocol yields higher results than the DSR protocol, which aligns with the previous scenario, indicating that DSR is more effective in terms of packet delivery speed in this scenario.



# Fig. 11: Delay Results for Each Protocol in the Second Scenario Source: Author

- Jitter

Figure 12 shows that, in several cases, Jitter results are lower in the DSR protocol than in the AODV protocol, so DSR once again stands out with more consistent delay results.



Fig. 12: Jitter Results for Each Protocol in the Second Scenario Source: Author Scenario 3: MANET with 100 Nodes

Retrieval Number: 100.1/ijese.C256012030224 DOI: <u>10.35940/ijese.C2560.12030224</u> Journal Website: <u>www.ijese.org</u> The third scenario is presented in Table 7, with the following parameters:

Table 3: Parameters in the Third Simulation Scenario

Parameters	Quantity	
Number of nodes	100	
Area [m]	500x500	
Mobility model	Random Waypoint	
Simulation time [s]	100	
Maximum node speed [m/s]	20	
Pause [s]	0.5	
Routing	AODV, DSR	

Source: Author

Figure 13 illustrates the route discovery phase in a 100-node scenario.



**Fig. 13: Route Discovery Phase in the Third Scenario** Source: Author

Figure 14 shows the packet delivery phase in the current scenario



Fig. 14: Packet Delivery in the Third Scenario

Source: Author

- Throughput

In this scenario, Figure 15 shows that the throughput of the AODV protocol tends to be better than that of the DSR protocol. All in all, there are two scenarios where AODV outperforms DSR on this particular metric, indicating that AODV achieves a better effective packet reception with more nodes.





Fig. 15: Throughput Results for Each Protocol in the Third Scenario

## Source: Author

## - Delay

The second metric analysed in this scenario is shown in Fig. 16. Delay results tend to be lower using the DSR protocol, as well as in the previous scenarios.



# Fig. 16: Delay Results for Each Protocol in the Third Scenario

# Source: Author

- Jitter

Finally, Figure 17 shows that when analysing jitter, DSR yields lower delay results, indicating that jitter is more stable in DSR than in AODV.



Fig. 17. Jitter Results for Each Protocol in the Third Scenario Source: Author

# VII. CONCLUSIONS

- The NS-3 simulation software, together with applicable tools like PythonViz and the ability to integrate calculations within C++ and Python, facilitates the simulation of multiple scenarios in Ad-Hoc networks. It opens up a wide range of possibilities for running tests, such as those in routing protocols.
- The Random Waypoint mobility model is a simple yet valuable tool for testing routing protocols in MANET,

Retrieval Number: 100.1/ijese.C256012030224 DOI: <u>10.35940/ijese.C2560.12030224</u> Journal Website: <u>www.ijese.org</u> where nodes represent people moving at different speeds within a predetermined area.

- In a scenario with a higher number of nodes, throughput results in the simulated areas are more efficient in AODV than in DSR. At the same time, DSR tend to be more efficient in a scenario with fewer nodes. This happens because the longer the distance a DSR packet covers, the bigger its header is, as it stores routes and routing information. This differs from AODV, as it maintains a separate routing table within each node, allowing packets to be smaller and carry primarily data.
- Delay results in the DSR protocol are more efficient in scenarios with 25, 50 and 100 nodes, so it could be concluded that this protocol is suitable for scenarios with a lower delay in packet delivery.
- The simulated jitter tends to be lower in DSR than in AODV, regardless of the increase in node density, concluding that delay results in a network with a DSR protocol are more stable than in AODV. It means delivery times work better in DSR than in AODV.

# **DECLARATION STATEMENT**

Authors are required to include a declaration of accountability in the article, including review-type articles, that stipulates the involvement of each author. The level of detail differs; some subjects yield articles that consist of isolated efforts that can be easily detailed, while other areas function as group efforts at all stages. It should be after the conclusion and before the references.

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