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

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Abstract*: This study is based on the analysis of specific Quality of Service (QoS) metrics. The acquisition of these metrics was carried out by modifying codes in C++ language within the Ns3 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 such as Throughput, Delay, and Jitter. To conduct meaningful comparisons, three different scenarios were designed, each characterized by the variation in the number of nodes used. This approach allowed for a comprehensive assessment of the protocols' effectiveness in different 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 and as technology develops, wireless networks have become key elements on technology used on a daily basis. With this development together with the evolution of mobile devices, the implementation of network mobility has become imperative. This does not mean mobility among connected devices but to create a whole network able to operate regardless of the existence of a network managing device. Ad-Hoc networks appear in order to fulfill this mobility need creating technology able to set up networks anywhere without an existing infrastructure. It also brings as a result the creation of new routing protocols for these types of networks, taking into account possible problems such as protocol efficiency and the amount of time taken during packet delivery. To determine the right protocol for this type of networks, 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 density. To achieve this, the tool used will be the NS-3 software for simulations in the proposed scenarios and to compare protocols.

Simulations will start off by analyzing the behavior of two routing protocols in MANET with different node density. Random Waypoint will be the mobility model used to simulate random movement within a specific area as if it were people. 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.

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II. MANET

MANET (Mobile Ad-Hoc Network) are networks in which all nodes, mobile devices in this case, work together. MANET does not need a static topology, fixed structure or intermediate devices such as a router, switch or access point [1][10][11].

Mobile devices have autonomy and mobility broadening the scope of action of MANET so they operate using the structure of the model TCP/IP with peer-to-peer transmission. MANET transmits based on adjacent neighboring nodes sending messages in flooding mode to their neighbors in the covered area. Likewise, if the destination node is not near, each node will repeat the flooding process to their neighboring nodes until they reach the destination node.

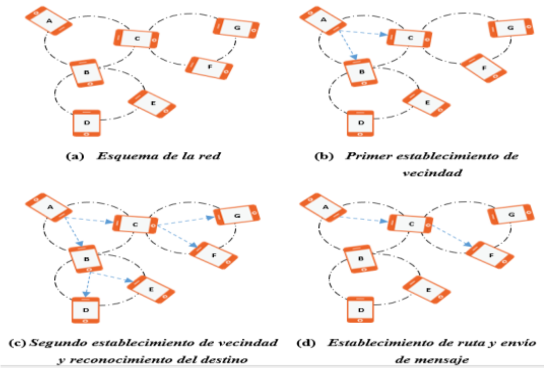

Fig. 1: MANET´s Operation Mode
Source: Autor

Figure 1 shows how a normal MANET operates. Figure 1(a) shows the network that will be analyzed 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 neighbors. 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 specialized functions for these types of networks are needed in order to achieve the best performance.

A. Manet Applications

There are different scenarios where MANET can be helpful.

- Education

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

- Emergency protocols

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

- Search and rescue operations

MANET could help during search and rescue operations as it is important to release updated information about the search progress in places with little 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 help with sensors used in daily life.

Homes have sensors installed in different equipment such as smoke detectors and electronics sending recurrent status reports. Another area of interest could be BAN (Body area network) devices for permanent monitoring of vital signs. MANET would help sending information to people supervising remotely the health status of the patients.

III. AODV

This protocol is based on DSDV and DSR. It features characteristics allowing nodes to find and keep routes to destination. 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 and it is 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 keep each node route but works only on-demand discovering new routes as needed.

The AODV protocol has the ability to create routing charts in each node so packets do not need to load routes. All routes included in AODV have a sequence number to be identified and a timer or lifetime to help the protocol determining new and old information to prevent bucles and transmission in outdated routes [3].

The AODV protocol makes it possible to work on route maintenance through HELLO messages informing any network failure so if a node disconnects from its neighbor, it is because it has not received that 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 information so the packets have the whole route information [5]. The DSR protocol can make routing changes quickly when the nodes move frequently and needs little overload when the nodes are moving less. Each node using DSR has a routing chart 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][7][8][9].

V. SIMULATION

To assess the network behaviour in this work there are 3 proposed scenarios using 25, 50 and 100 nodes. The simulation area would cover 500 x 500 meters in Loja city taking into account it is a very busy area and considering a random mobility model for people. Its length reaches from Azuay St. to 10 de Agosto St. and its width goes from 18 de Noviembre St. to 24 de Mayo St.

Fig. 2: Simulation Area in Loja City

Source: Google Maps

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AODV and DSR are the routing protocols simulated in this work to find out which one has better characteristics in different scenarios and with different node density. The aim of this work is to study and compare the Quality-of-Service metrics in each protocol so choosing which metrics to use is important. The selected metrics are:

- Throughput

Throughput is one of the metrics chosen as it is relevant to observe the effective rate of received data in each scenario taking into account that one of the most important 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 as it would be able to show which protocol has the steadiest delay variation in the network. It could also help predicting 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 visual method chosen as it allows to monitor flows in a better way. Through these calculations it will be possible to obtain the three QoS metrics mentioned above: Throughput, Delay and Jitter. To get the Throughput, the amount of data will be converted into bytes and divided by the simulation time getting the result in kbps.

$$Th = \frac{bytes*8}{T_s*1000} \quad \textit{Equation 1}$$

Where:
bytes= Total of Bytes in each packet
TS= Simulation time

To obtain the delay, the times of arrival of each packet are obtained 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:

$$Dly = T_A - T_P \quad \textit{Equation 2}$$

Where:
TA= Current time of simulation or reception
TP = Previous time of simulation or reception

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

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

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

VI. DATA ANALYSIS

Scenario 1: MANET with 25 Nodes

The first simulation scenario will use 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.

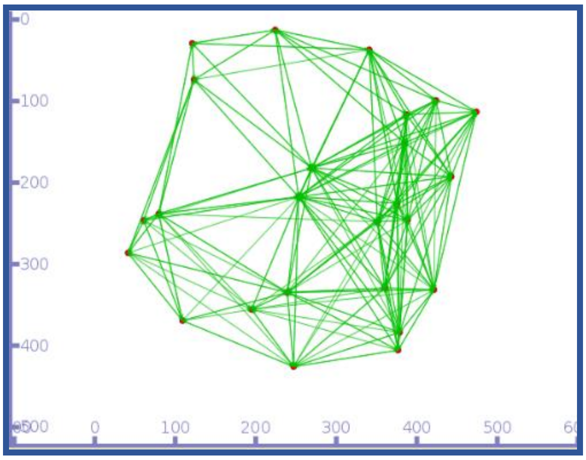

Fig. 3: Route Discovery Phase in First Scenario

Source: Author

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

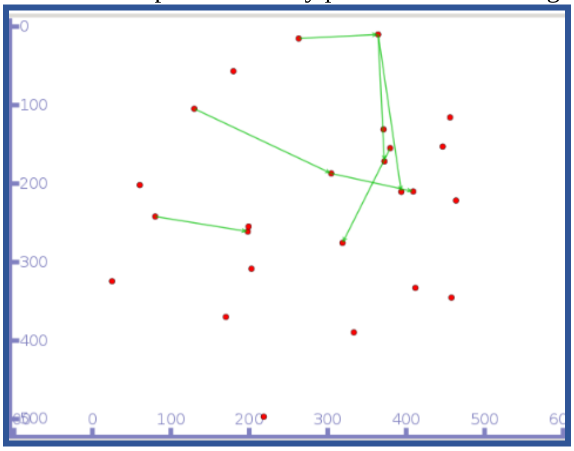

Fig. 4: Packet Delivery Phase in the First Scenario

Source: Author

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

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In AODV routes are kept due to the Hello broadcast messages that are constantly sent; however, DSR only broadcasts during the route discovery phase as it keeps the route information by saving routing data in the header of the packet sent.

Regarding the packet delivery phase, each protocol works differently obtaining the following general data of 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 in the simulation of 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 have higher throughput results in most of the assessed nodes in that 25 node scenario so we could say DSR is able to receive in an effective way more data than AODV.

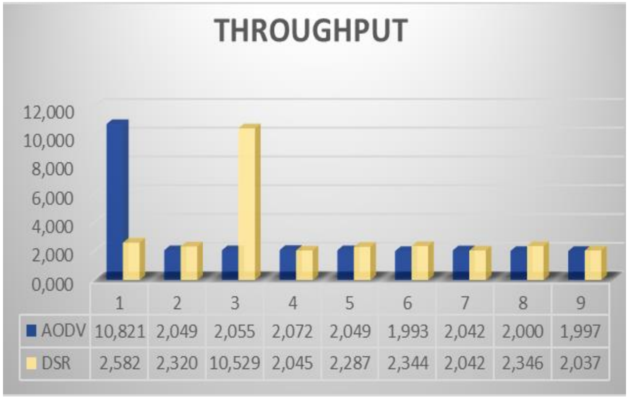

Fig. 5: Throughput Results for Each Protocol in the First Scenario

Source: Author

- Delay

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

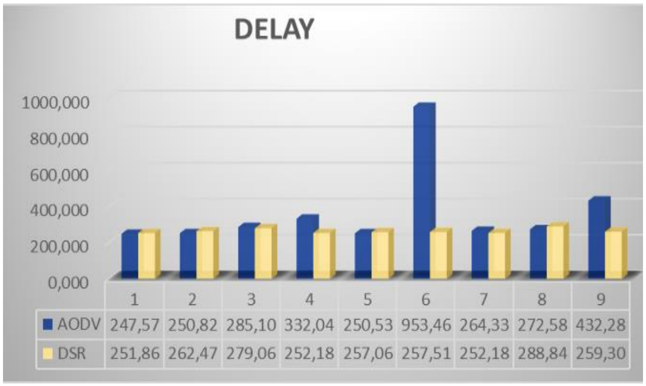

Fig. 6: Delay Results for Each Protocol in the First Scenario

Source: Author

- Jitter

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

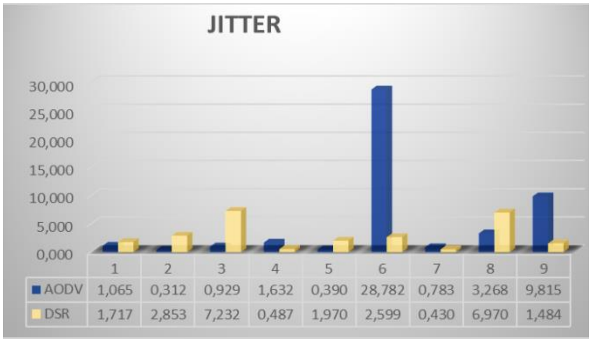

Fig. 7: Jitter Results for Each Protocol in the First Scenario

Source: Author

Scenario 2: MANET with 50 nodes

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

Table 2: Parameters in the Second Simulation 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.

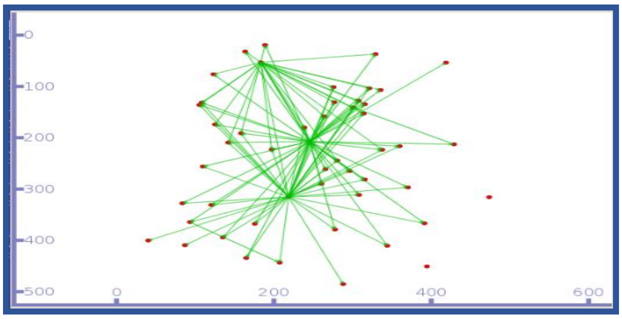

Fig. 8: Route Discovery Phase in the Second Scenario

Source: Author

Figure 9 shows the packet delivery phase in the second scenario.

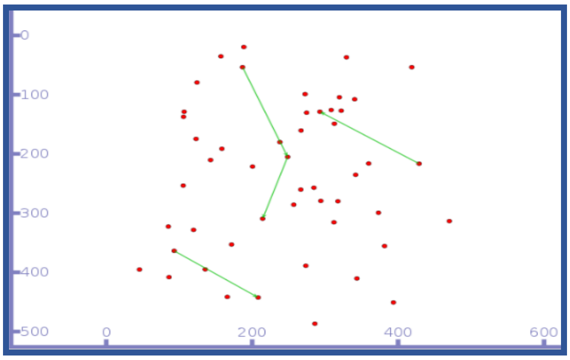

Fig. 9: Packet Delivery Phase in the Second Scenario

Source: Author

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- Throughput

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

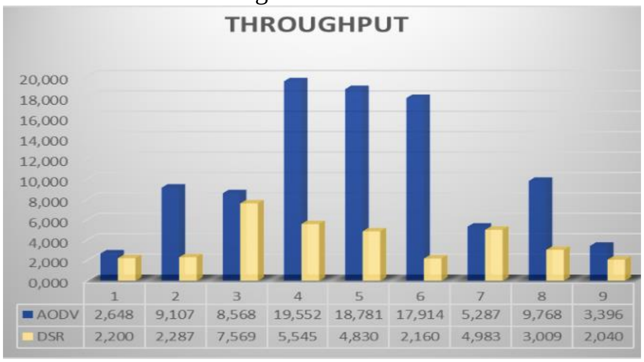

Fig. 10: Throughput for Each Protocol in the Second Scenario

Source: Author

- Delay

Figure 11 shows that regarding average delay results, the AODV protocol presents higher results than the DSR protocol, so it matches the previous scenario showing that DSR is more effective regarding 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 once again DSR stands out having more consistent delay results.

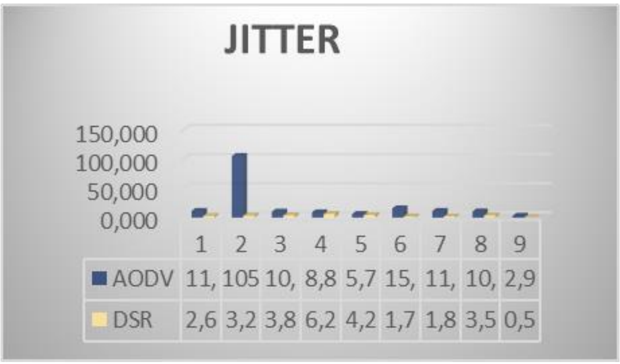

Fig. 12: Jitter Results for Each Protocol in the Second Scenario

Source: Author

Scenario 3: MANET with 100 Nodes

The third scenario presents in table 7 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 shows the route discovery phase in a 100 node scenario.

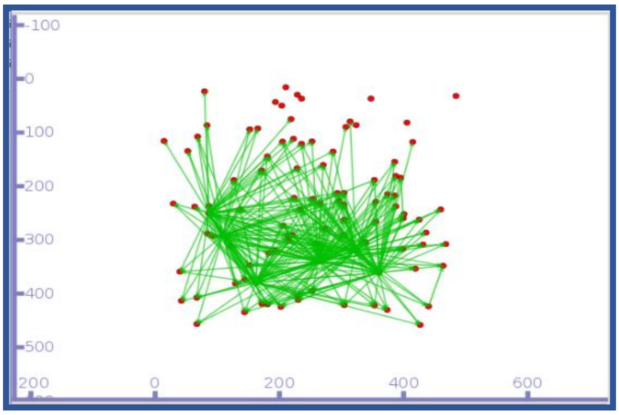

Fig. 13: Route Discovery Phase in the Third Scenario

Source: Author

Figure 14 shows the packet delivery phase in the current scenario

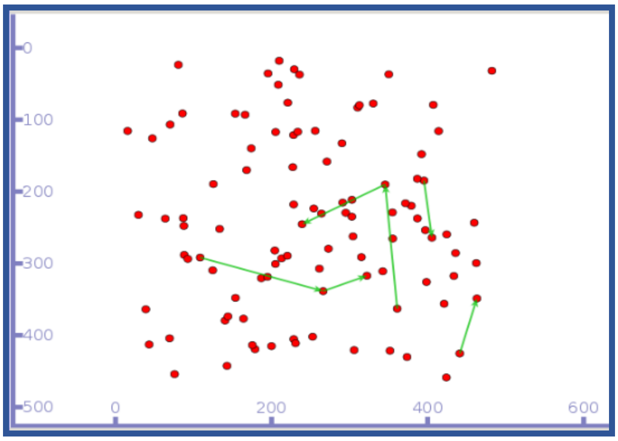

Fig. 14: Packet Delivery in the Third Scenario

Source: Author

- Throughput

In this last scenario, figure 15 shows that the throughput in the AODV protocol tends to be better than the DSR protocol. All in all, there are two scenarios where AODV is better than DSR on this particular metrics, meaning that there is a better effective packet reception in AODV with more nodes.

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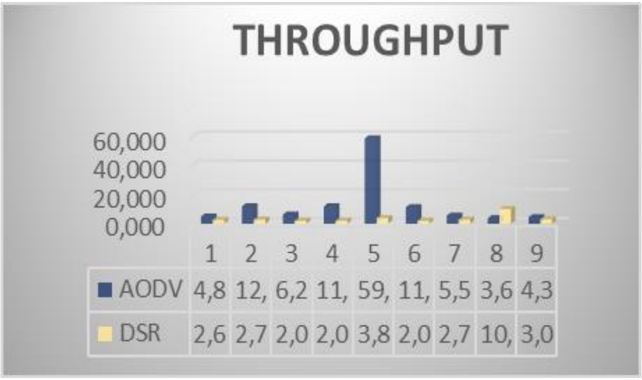

Fig. 15: Throughput Results for Each Protocol in the Third Scenario

Source: Author

- Delay

The second metrics analyzed 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 when analyzing jitter that DSR has lower delay results, so jitter is more stable in DSR than in AODV.

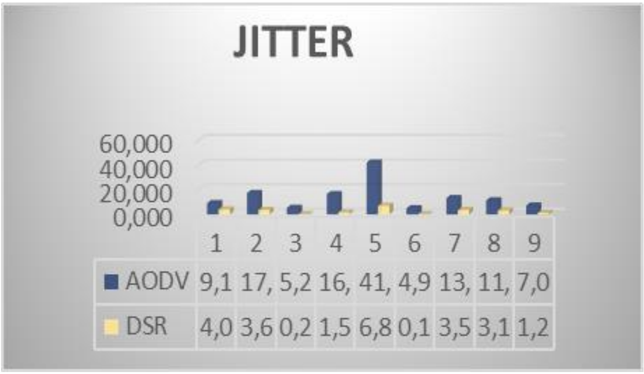

Fig. 17. Jitter Results for Each Protocol in the Third Scenario

Source: Author

VII. CONCLUSIONS

- The NS-3 simulation software together with applicable tools like PythonViz and the possibility to add up calculations within C++ and Python help the simulation of several scenarios in Ad-Hoc networks. It opens up a wide range of possibilities to run tests such as in routing protocols.
- The Random Waypoint mobility model is a simple and useful tool when testing routing protocols in MANET to represent people moving as nodes in a predetermined area at different speeds.
- In a scenario with a higher number of nodes, throughput results in the simulated areas are more efficient in AODV than in DSR, while DSR tend to be more efficient in a scenario with less nodes. This happens because the longer the distance a DSR packet covers, the bigger its header as it stores routes and routing information. This differs from AODV as it keeps each routing table within each node allowing packets to be smaller carrying mostly 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 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, counting 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 are easily voiced in detail, while other areas function as group efforts at all stages. It should be after the conclusion and before the references.

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Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. G. O. Young, "Synthetic structure of industrial plastics (Book style with paper title and editor)," in *Plastics*, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.
3. H. Poor, *An Introduction to Signal Detection and Estimation*. New York: Springer-Verlag, 1985, ch. 4.
4. B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.
5. E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," *IEEE Trans. Antennas Propagat.*, to be published.
6. J. Wang, "Fundamentals of erbium-doped fiber amplifiers arrays (Periodical style—Submitted for publication)," *IEEE J. Quantum Electron.*, submitted for publication.
7. Ganesh, Dr. E. N. (2022). Analysis of Fracture and Toughness of a Denture Base with Polyvinyl Fibers. In International Journal of Advanced Pharmaceutical Sciences and Research (Vol. 2, Issue 2, pp. 1–4). https://doi.org/10.54105/ijapsr.c4004.022222
8. Prabhanjan, N., Pawar, P., Tipraj, Alok, G., & Md. Asif. (2020). Strengthening Properties of Concrete with Partial Replacement of Sand by GBFS. In International Journal of Innovative Technology and Exploring Engineering (Vol. 9, Issue 4, pp. 1746–1751).

https://doi.org/10.35940/ijitee.d1670.029420
9. Patidar, C. P., Katara, Y., & Sharma, Dr. M. (2020). Hybrid News Recommendation System using TF-IDF and Similarity Weight Index. In International Journal of Soft Computing and Engineering (Vol. 10, Issue 3, pp. 5–9). https://doi.org/10.35940/ijsce.c3471.1110320
10. Razak, R. R. A., Sanusi, Z. A., Yusoff, A. N. M., & Isa, N. A. M. (2020). Spirituality and Quality of Life Among University Students During Covid-19 Pandemic. In International Journal of Management and Humanities (Vol. 5, Issue 2, pp. 4–9). https://doi.org/10.35940/ijmh.b1142.105220
11. Said, J. M., Ismail, M. H., & Abidin, N. A. Z. (2019). Additive Manufacturing of 316L Stainless Steel. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 8, Issue 4, pp. 6825–6829). https://doi.org/10.35940/ijrte.d5199.118419

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Diego A. Sánchez C is a distinguished Electronics and Telecommunications Engineer, holding a degree from the Universidad Nacional de Loja, Ecuador, specializing in the Department of Electronics and Telecommunications. With a solid academic background, Diego has showcased exceptional commitment to research and technological development. Focusing on Electronics and Telecommunications, Diego has made significant contributions to innovative projects within his field. His ability to tackle complex technical challenges and devise efficient solutions has been instrumental in advancing science and technology in his specialized area. In addition to his academic achievements, Diego A. Sánchez C has actively participated in conferences and seminars, establishing himself as an influential professional in the field of electronic engineering and telecommunications. His dedication to research and his adeptness at applying theoretical concepts in practical settings distinguish him as a promising leader in his field.

John J. Tucker Yepez is an accomplished engineer with a specialization in communication networks and switching systems, having earned his degree from the State University of Belgorod in Russia. Further enhancing his expertise, he holds a Master's degree in International Sciences and Diplomacy from Ecuador. Currently serving as a dedicated researcher at the Universidad Nacional de Loja in the Department of Telecommunications, John brings a wealth of knowledge and experience to his academic and professional pursuits. With a focus on communication networks and switching systems, John J. Tucker Yepez has demonstrated a profound understanding of the intricate dynamics within these domains. His academic journey, marked by an international perspective gained through his master's program, has equipped him with a holistic approach to addressing challenges in the rapidly evolving field of telecommunications

Gabriela C. Durán Tapia is a distinguished architect and holds a Master's degree in Architecture and New Urbanism. With a decade-long commitment to both academic and professional arenas, she has significantly contributed to the fields of urban and architectural design. Her expertise extends to teaching and private sector engagements, showcasing a multifaceted career. In her academic role, Gabriela has dedicated ten years to teaching, where she imparts her knowledge and passion for architecture and urbanism to aspiring professionals. Her pedagogical approach incorporates contemporary trends and innovative practices, nurturing the next generation of architects. With a Master's in Architecture and New Urbanism, Gabriela brings a comprehensive and forward-thinking perspective to her projects, contributing to the evolution of urban landscapes. Her blend of academic excellence and practical experience positions her as a dynamic force in shaping the future of architectural and urban design.

Heydi M. Roa López Heydi M. Roa López is a dedicated professional affiliated with the Escuela Superior Politécnica del Litoral (ESPOL). She is an integral part of the Faculty of Natural Sciences and Mathematics, located at the Campus Gustavo Galindo, km 30.5 Vía Perimetral, Guayaquil, Ecuador. Heydi's academic and professional contributions have left a notable impact on the university's scientific community. Within the academic realm, Heydi engages in the exploration of natural sciences and mathematics, showcasing her commitment to advancing knowledge in these crucial disciplines. Her presence at ESPOL underscores her dedication to the pursuit of excellence in education and research. As a member of the ESPOL community, Heydi M. Roa López actively contributes to the university's academic environment, fostering a culture of learning, innovation, and intellectual curiosity