Theoretical study of MANET network single- and multiple-path routing

K.Ashokkumar[1], M.Shylu[2], P.Dinesh kumar[3]

Assistant Professor, Information Technology, Excel Engineering College, Namakkal[1]
Assistant Professor, Master of Computer Applications, Excel Engineering College, Namakkal[2]
Assistant Professor, Information Technology, K.S.Rangasamy College of Technology, Tiruchengode, Namakkal[3]

Abstract

The networking industry has taken an interest in mobile ad-hoc networks (MANETs) due to their desirable features, which include multi-hop routing, self-configuration, self-healing, self-managing, reliability, and scalability. Even in cases where nodes are static, the dynamic nature of connection quality makes routing over wireless mobile networks a crucial concern. The requirement for an effective routing system that determines a route based on specific performance measures connected to the link quality is a major difficulty in MANETs. Finding a good path between the source and destination pairs is typically the focus of the routing problem in MANETs. This indicates that a high throughput routing protocol has to be developed. Investigation is necessary to determine how single-path and multipath routing protocols affect MANET performance. This paper introduces a performance comparison utilising network simulator version 2 (NS-2) of popular routing protocols, including AODV, AOMDV, and OLSR, in terms of throughput, packet delivery, routing overhead, and end-to-end delay.

Keywords: *mobile ad-hoc, MANET, multi-hop routing, routing protocols, AOMDV.*

Introduction

The New World Order (NWO) is based on Information and Communication Technologies (ICT). Wireless networks have exhibited crucial growth and development to address real-world challenges since their inception until 5th Generation (5G). Everyday, we come across a wide variety of wireless networks, such as Bluetooth, wireless local area networks (WLAN), fourth-generation (4G) mobile networks, etc. A primary factor contributing to the availability of several wireless technologies is the research and development (RD) conducted in this field. A review of the literature reveals the existence of a number of ad-hoc networks, including the Mobile Ad-hoc Network (MANET) and the Vehicular Ad-hoc Network (VANET). While the majority of ad-hoc networks have similar traits and difficulties, there are some key differences as well.

[1] Our main goal in this paper is to investigate route selection interventions for mobile ad hoc networks based on topology. Protocols that use one or more paths are the main topic of this research. [2] A type of no infrastructure-based wireless network known as a mobile ad-hoc network (MANET) is made up of nodes that have the freedom to roam about and conduct decentralised operations. [3] The self-configuration and autonomy of nodes are the main components of the decentralised nature. An administrator is not required to configure MANETs because to its self-configuration (also called auto-configuration) capability. [4] These characteristics set MANET apart from conventional infrastructure-based wireless networks.

Owing to its distinct characteristics, MANETs have been used for a variety of purposes, including online commerce, mobile surgery, and video streaming. [8] However, because MANET is inexpensive to build, it might be used in emergency relief situations. According to a survey of the literature, the routing protocol being used is critical to enhancing the MANET's scalability and quality of service. [9] In recent years, a number of ad-hoc routing protocols have been developed to send data over a single path. On the other hand, an additional form of data transmission expands upon the notion of multiple paths. [10] These technologies make it possible to create many paths for information transfer between a source and a destination. [11] In any case, a variety of performance indicators, or metrics, are used to determine the best path, including hop count, distance travelled from the source to the destination, remaining energy, etc.

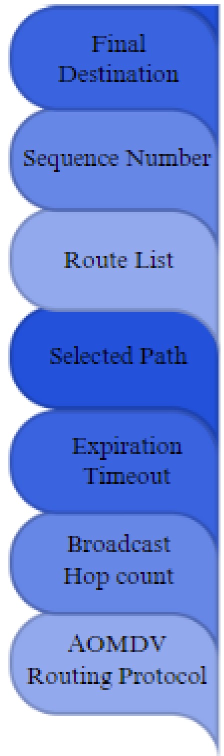

Figure 1: AOMDV protocol.

The remainder of this essay is structured as follows: [12] An overview of routing protocols will be provided in the second section of this study. The literature review, which is presented in Section III, summarises the major conclusions of earlier studies conducted in this field and discusses their shortcomings in relation to MANET.

Officially, Relay Routed-DSR is used to efficiently manage data packets. [13] This innovative routing technique uses a broadcasting method to gather data from neighbouring nodes. Redundant pathways are found during the flooding process, which raises network overhead. [14] The Preemptive-DSR (PDSR) protocol is a costly and slow mechanism that anticipates connection failures. [15] P-DSR establishes a threshold and sends warning signals to source nodes due to low signal strength. The most popular multi-path routing technique is the recently developed ad-hoc On-Demand Multipath Distance Vector (AOMDV) routing protocol. The novel routing technique depends on a low hop count and prevents connection loss.

In order to send data packets and save energy in nodes, multiple AODV and Fibonacci multi-path load balancing are taken into consideration. [16] But many common network attacks, such wormholes, black holes, and grey holes, are made possible by AODV routing weaknesses. These attacks can quickly obtain data packets and establish rogue nodes within the network. AOMDV protocol routing study is shown in Fig 1. Attackers increase the amount of misleading information in the network by sending data packets continuously, which has a direct impact on the dynamics of the system. By raising node energy levels, context-aware routing offers a fresh approach that will support the security of channel links. Route monitoring is facilitated via adaptive routing decisions.

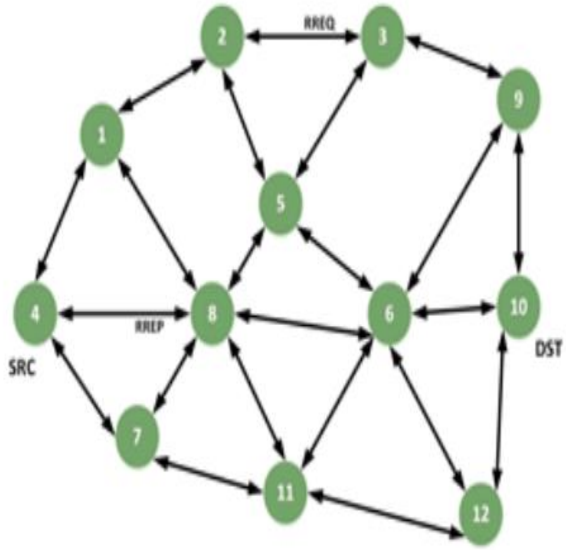

Figure 2: AODV routing protocol.

Mobility aware Termite computes the concept of meta-heuristics, which enhance local monitoring in mobile ad hoc networks. Consequently, extended ad hoc networks exhibit exponential improvement when utilising GPS-based knowledge predictive-OLSR to determine the precise position. Authors of a recent study created an ad-hoc routing system to save energy on each node. In mobile ad hoc networks, routing strategies can be single- or multi-path. It is advised to use single-path routing when sending all data packets via the path. Nevertheless, certain noteworthy issues with single-path routing have been discovered, such as a slower route discovery time and an increase in end-to-end delay. These factors explain why single-path routing is unable to complete tasks in all situations. Multiple routes are chosen from source to destination by multi-path routing protocols. Certain measures, like latency, bandwidth, and throughput, have improved when compared to a single-path. In AODV and AOMDV data analysis, response surface optimisation determines the ideal response time in the end. Figure 2 illustrates the AODV routing idea in action. Two phases are typically taken while transmitting an AODV message from one node to another: (i) path investigation and (ii) route repair. Message data is available in four formats for route discovery and maintenance: hello packet, reply, request, and error. Routing protocols with many paths offer various benefits. The end-to-end latency of multi-path routing protocols is generally lower. When comparing these protocols to single-path routing techniques, the latter use network bandwidth more effectively.

Materials and Methods

View of manet routing protocols

Routing is the process by which nodes choose the most efficient way or route to send packets to their destination. A device or node must route a packet if it is received and the target destination is not the one for which it was intended. In ad hoc networks, every intermediary node must use a routing table lookup to determine the best route for each packet. The routing table is filled in by routing protocols. In MANETs, routing protocols are crucial, particularly when nodes are mobile and the network's dynamics are subject to run-time changes. Routing interventions are classified into many groups in the literature according on how they construct, maintain, and work with the routing table. Fig. 2 presents the taxonomy of routing protocols. An overview of several protocols that share common functionality is presented in Figure 2.

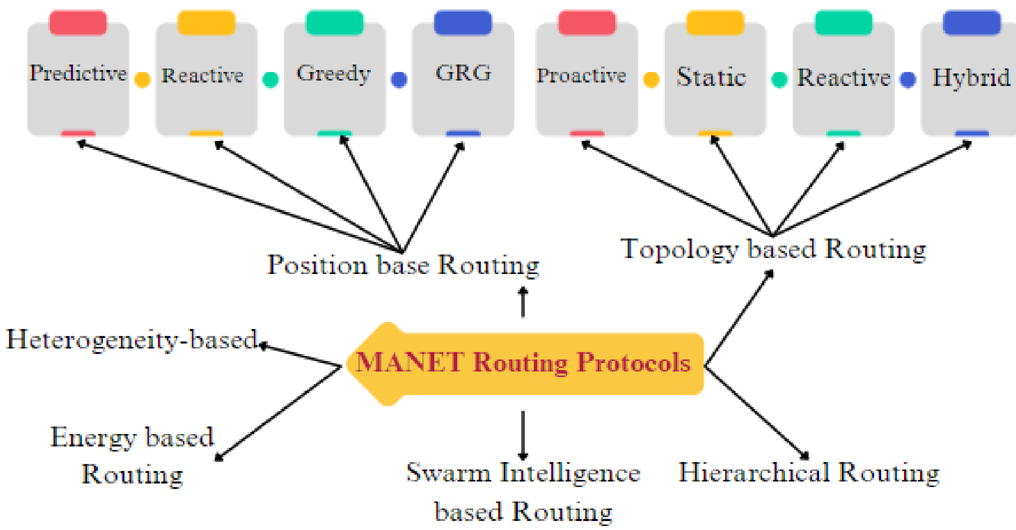

Figure 3: Moile ad-hoc networks - Protocol hierarchy.

Routing Protocols Based on Heterogeneity

In various cases, such as MANET, VANET, etc., different kinds of wireless mobile networks must collaborate because these networks have different dynamics. As a result, as illustrated in Fig. 3, academics have suggested various routing strategies that can be used in comparable circumstances.

Routing Protocols Based on Swarm Intelligence

Routing algorithms based on swarm intelligence are typically influenced by the biological behaviours of various animals, birds, insects, etc. As a result, another name for them is the bioinspired routing technique. Numerous bio-inspired or swarm-intelligence based routing systems, such as the BeeAdhoc routing protocol and the Ant Colony Optimisation (ACO) algorithm, have been proposed in previous research studies. In certain situations, these routing strategies have yielded exceptional outcomes.

Protocols for Hierarchical Routing

Those who belong to this category typically create clusters. "Nodes reside in close proximity" is the definition of a cluster. A procedure leads to the formation of a cluster. The setup phase, which is the process of forming clusters, involves all nodes in the vicinity. Elections are used to choose a cluster leader during the setup phase.

Routing Protocols Based on Topology

Routing tables are constructed using network topology information via topology-based routing strategies. The most common application for this type of routing strategy is in ad hoc networks. The following categories apply to topology-based protocols: proactive, reactive, hybrid routing, and static. Because static routing table building techniques are static, they are not used or recommended for usage in mobile ad hoc networks.

Proactive Routing Protocols

At the beginning of operation, every proactive routing protocol builds an entire routing table beforehand. The goal of this table is to create and keep open a path to each target node in the network or topology.

Similar to the Lower Energy Adaptive Clustering Hierarchy (LEACH) protocol, all devices/nodes that speak any proactive routing protocol begin exchanging network information at the beginning. This phase is sometimes referred to as setup. Nodes exchange routing messages during setup, determining which is the best next hop for each destination. Every time there is a topology change, nodes exchange the entire routing table, which uses a lot of network traffic and compute power from the nodes.

Optimized Link State Routing (OLSR)

Conventional distance vector-based routing alternatives are not at all like link state routing techniques. Link state routing protocol notifies neighbours of their link's status and cost. Another LS routing scheme that adheres to the same philosophy is OLSR. The routing protocol used by OLSR is multi-path. OLSR doesn't release any content. Every hello message is periodically shared solely with the neighbours. They only share topological change notifications (TCNs) with their neighbours in the event of a topology change. Additionally, OLSR chooses Multipoint Relay (MPR) nodes from its neighbours in order to minimise routing communication. Sending these communications to other neighbours or peers is another duty of MPR. This method reduces network bandwidth by a significant amount.

Reactive Routing Protocol

Reactive routing approaches begin the route lookup or discovery process as soon as a node receives a request, in contrast to proactive ones. They are called reactive for this reason. Unlike proactive routing protocols, there is no setup process, and routes are not maintained for every target. They are known as "on-demand routing protocols" because of this. The node only saves a route for a specific target in the routing table for a restricted period of time after it is found. A route entry is deleted from the table when a predetermined amount of time has passed and no further packets are received for the target node. Reactive protocols have the advantage of producing less routing burden and having scalable network sizes, which allow them to be applied in large typologies. Unpredictable delays might occur in reactive processes.

Adhoc On-Demand Distance Vector (AODV)

Reactive routing protocols like DSDV and DSR are combined into AODV. It exhibits what is referred to as "hope-by-hop nature," or adaptive activity with each hop. The DSR protocol is where the AODV's hop-by-hop feature originated. It makes use of the DSDV protocol's periodic exchange of messages method. To establish a routing path, it first starts the route discovery process. It attempts to choose the path with the fewest hops. This feature minimises network congestion and drastically lowers overhead. It sends update messages to established links to keep them current.

Ad-hoc On-Demand Multipath Distance Vector (AOMDV)

Multi-path routing protocols include AOMDV. For the target node, multi-path routing protocols find and maintain numerous pathways. Maintaining several paths is intended to prevent or minimise frequent route finding. AODV reactive routing protocol is the foundation of AOMDV.

Routing protocols hybrid: The best characteristics of both groups—proactive and reactive—are selected by hybrid approaches. Reactive proactive techniques' overheads and constraints are reduced by these measures. A hybrid routing technique called the Zone Routing Protocol (ZRP) divides the region into several "zones". Proactive routing aids in the selection of intra-zone paths, whereas reactive interventions are used to create inter-zone paths.

The study given in this paper employs a simulation approach with settings set up for the task to be completed successfully. The study, taken as a whole, emphasises how crucial network simulator 2 (NS-2) is to carrying out the simulation. A popular open-source discrete event simulator in research is called NS-2. The Object-Oriented Tool Command Language (OTCL) is utilised by the front system, which generates simulation topologies, while the C++ programming language powers the NS-2 core engine. The most recent version of NS-2, 2.35, was employed. It produces two different kinds of trace files: simulation traces and nam traces. Data analysis is another use for the simulation trace file. On the other hand, the network animator can be fed the Nam trace file. Using NS-2 for simulation is seen in Fig. 5. The images have been produced and the trace file has been analysed using MATLAB and formulas using the MATLAB programming language. For our investigation, we developed three distinct testbeds or scenarios. The fundamental simulation parameters are the same for all three situations. The number of nodes in each of the three testbeds, however, is the primary distinction.

Ten simulation iterations were carried out for every scenario. This is a repetitive exercise designed to minimise statistical abnormalities or disparities in the outcome. As a result, the simulation is run through 30 rounds or iterations in total during this investigation. The length of the simulation plays a crucial part in understanding how any given phenomenon behaves. The majority of researchers employed a short time span, according to literature. As a result, the simulation was run in the submitted article for up to 4 minutes, or 240 seconds, under varying network loads. Another important component of the study is the coverage region, sometimes referred to as the simulation area. Built a vast coverage area that allows nodes to move freely and easily in order to accommodate hundreds of nodes. In our investigation, the network space was set up as 1500 × 1500 m for each scenario. Node mobility has a significant impact on a network's performance. In the study presented, we employed the Random Way Point (RWP) mobility model. The most popular movement pattern is RWP. Nodes' velocity, or speed, is also very important. Every node in our topology has a maximum velocity of 20 $m.s^{-1}$. We incorporated single and multiple path routing techniques, like we covered in Section I.

The adoption of AODV, AOMDV, and OLSR routing protocols was recommended in this paper. Additionally, as was already noted, the simulation was run ten times with a different number of nodes in each run. Table III provides a summary of the pertinent topological design and parameters, though.

Results and Discussion

These somewhat intriguing evaluation results may be related to important MANET network criteria, as the following paragraph explains. We looked at four distinct parameters, to evaluate the efficiency and performance of each routing protocol.

- Network Throughput.
- End to End Delay (E2E delay).
- Normalized Routing Load (NRL) / Routing Overhead(RO).
- Packet Delivery Ratio (PDR).

Parameters of the network

Throughput: A protocol's throughput is a measure of its efficiency. While low throughput suggests limited network activity, higher performance rates signify ideal outcomes. In technical terms, throughput is defined as the number of efficiently transferred frames, packets, or bytes per unit of time. Equation 1 is used to calculate throughput.

Due to this limitation, programmers have to memorize thefield's name as per its position in the trace file. To overcome

$$\text{Throughput} = \frac{\Sigma \text{ received packets size}}{\text{Time}} \quad (1)$$

NS-2, the issue at hand, has given rise to a new wireless trace format. The new wireless trace format was used in the current work. Compared to the previous wireless trace format, the new one has a number of advantages. In the new format, each field has an associated type field with an E2E delay: End-to-end latency is a crucial measure for network assessment. End-to-end delay is the amount of time a packet takes to get to its destination. In actuality, this entails deducting from the starting time determined by Eq. 2 the amount of time a data packet receives upon reaching its destination.

$$D_{avg} = Tr_{avg} - Ts_{avg} \quad (2)$$

NRL: Routing overhead, also known as normalised routing load, is seen as an overhead. "Ratio of network control packets to all delivered packets" is its definition [50]. The simulation's NRL/RO is shown in Fig. 9 and may be calculated using Eq. 3 for path routing protocols and throughput. We determined the cumulative standard deviation throughput for each of the three testbeds, which is shown in table IV. The standard deviation calculates the degree of departure from the mean values.

TABLE IV: Standard deviation analysis of routing protocols.

NO. of Nodes	*AODV*	*AOMDV*	*OLSR*
100	93.089	86.752	70.4
200	94.788	88.318	50.1
300	93.911	89.81	40.2
Average	93.929	88.293	53.566
Standard Deviation (SD)	1.693	2.248	22.570

Results analysis and discussion

Network throughput: As the number of nodes drops, it is clear from Fig. 6 that the OLSR routing protocol's network performance begins to decline. This could be as a result of the Multi-Point Relays (MPR) being chosen by the OLSR routing protocol to forward control messages. It had to choose many relays in the architecture as node density increased, which ended up being the source of the lower throughput. Additionally, the precise numbers demonstrate that AODV and AOMDV are less susceptible to variations in the node count.

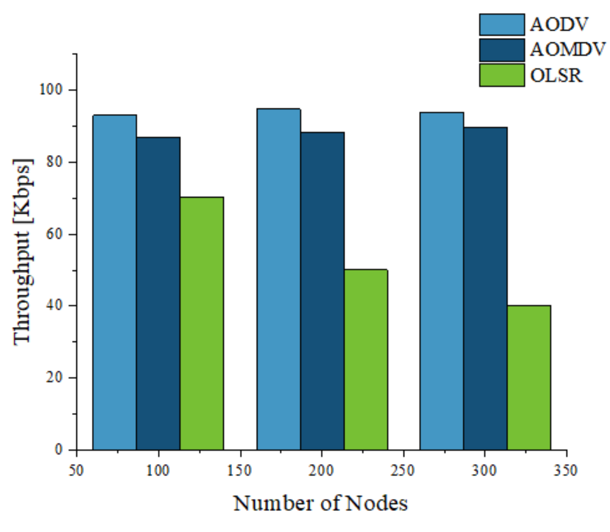

Figure 6: Network throughput based variety nodes number.

Owing to the throughput's great significance, the study that was presented proposed an additional technique—the standard deviation—to confirm the veracity of findings pertaining to routing protocols' throughput. The standard deviation analysis of single and multiOLSR is displayed in Table IV. It implies that altering the number of nodes in comparison to AODV will have an impact on the throughput of the AOMDV protocol. The OLSR, on the other hand, has the lowest standard deviation. It implies that changing the number of nodes will have a significant impact on its throughput. It is therefore not advised to utilise it in extensive, intricate typologies. The standard deviation of routing protocols is displayed in Fig. 7.

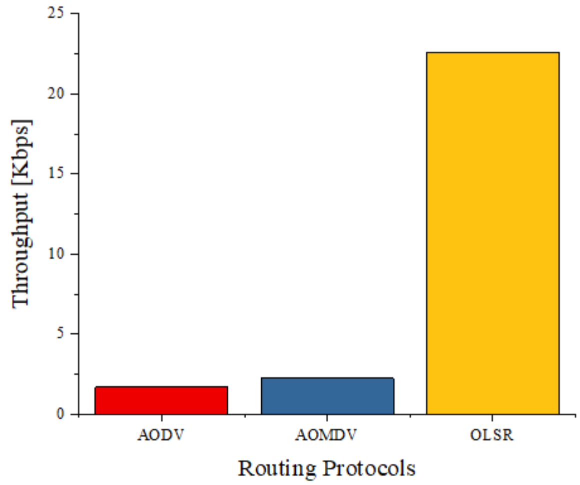

Figure 7: Network throughput based on the standard deviation.

E2E latency: Fig. 8 illustrates how the OLSR protocol's end-to-end delay significantly rises with node density, rendering it less effective in intricate and large-scale topologies. Furthermore, a significant decrease in latency is noted for the AOMDV routing system. We found that AODV and AOMDV delays are initially greater than OLSR. They significantly improve as the number of nodes rises.

RL: Fig. 9 demonstrates that reactive routing protocols, such as AODV, have remarkably reduced routing overhead when compared to the other two research-studied approaches, OLSR and AOMDV. Instead, the routing overheads of OLSR and AOMDV are nearly identical.

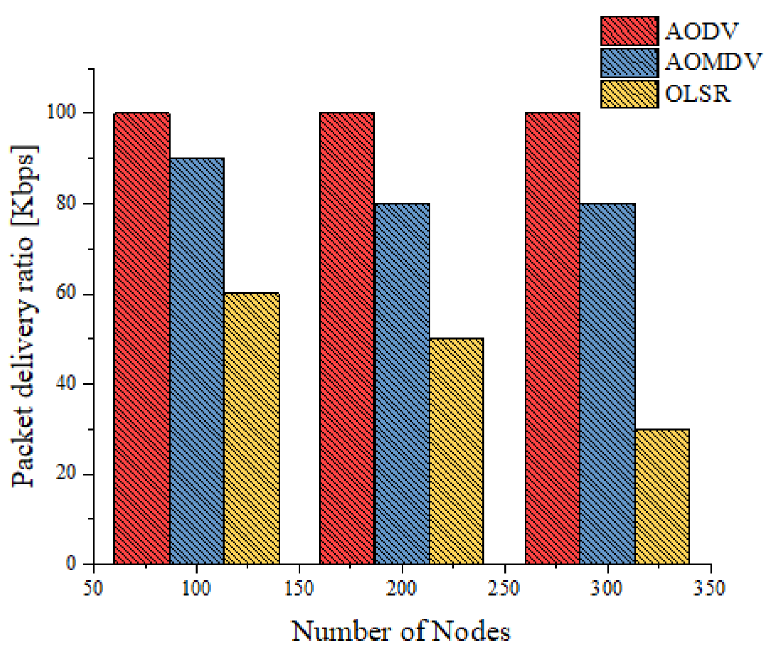

Figure 8: E2E delay of routing protocols.

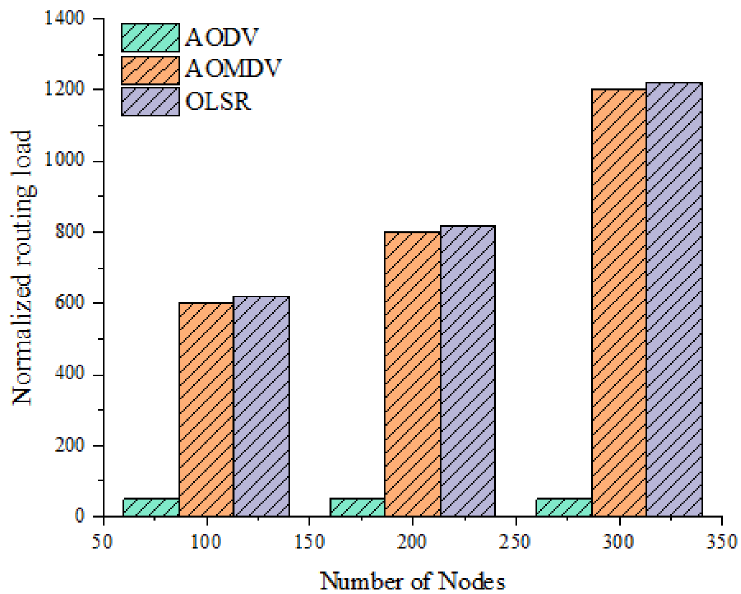

Figure 9: NRL of routing protocols.

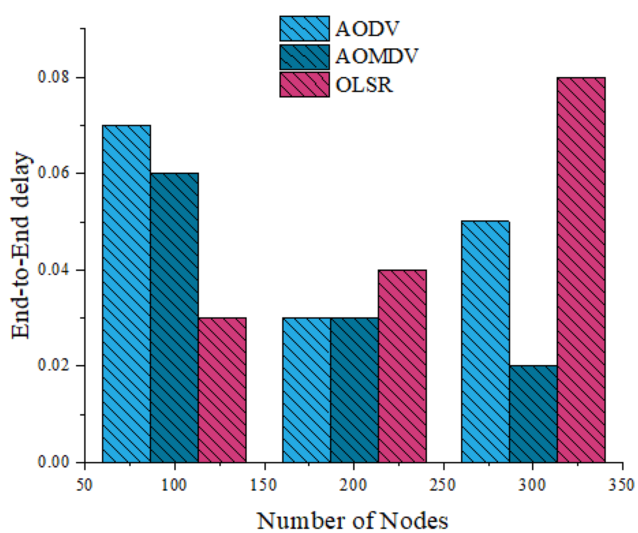

Figure 10: PDR of routing protocols.

PDR: OLSR has the lowest delivery ratio when compared to AOMDV and AODV, according to the packet delivery ratio graph. Furthermore, an additional pattern that may be examined is the result of a growing number of nodes. Figure 10 illustrates that AODV remains unaffected when the network's node count grows. AOMDV and OLSR are impacted, though. The PDR can be shown in Figure 10.

Conclusion

The simulation findings show that, in contrast to the AODV and AOMDV protocols, the OLSR protocol's throughput is significantly impacted by variations in node density. Compared to the multipath protocols used in this study, the single-path AODV routing protocol shows superior network throughput in terms of throughput. In this study, the impact of node density on network performance has also been examined. This study has demonstrated that the OLSR procedure displays a considerable increase in node density. That suggests that the OLSR protocol is not a good fit for networks with a high density of users. The study's future work proposes additional research on the dynamic behaviour of the AODV routing protocol, which may result in changes to the protocol's routing mechanism to address link quality instability.

Abbreviation

MANET	- Mobile Ad Hoc Network
RRER	- Route Error
RREP	- Route Reply
RREQ	- Route Request
TC	- Topology Control

Competing interests

The authors declare that they have no competing interests.

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Ethics approval and consent to participate

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Authors' contribution

Author A supports to find materials and results part in this manuscript. Author B helps to develop literature part.

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References

AL-Hasani, B., and B. Waheed. (2022). "Comparative Study and Performance Investigation of MANET Routing Protocols." *International Journal of Nonlinear*. https://ijnaa.semnan.ac.ir/article_6677.html.

Alameri, Ibrahim Ahmed, and Jitka Komarkova. (2020). "A Multi-Parameter Comparative Study of MANET Routing Protocols." In *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–6. IEEE.

Alameri, Ibrahim, Štěpán Hubálovský, and Jitka Komarkova. (2021). "Evaluation of Impact of Mobility, Network Size and Time on Performance of Adaptive Routing Protocols." In *2021 International Conference on Information and Digital Technologies (IDT)*, 245–53. IEEE.

Alameri, Ibrahim, Jitka Komarkova, and Mustafa K. Ramadhan. (2021). "Conceptual Analysis of Single and Multiple Path Routing in MANET Network." In *2021 International Conference on Information and Digital Technologies (IDT)*, 235–44. IEEE.

Alamsyah, Eko Setijadi, I. Ketut Eddy Purnama, and Mauridhi Hery Pumomo. (2018). "Performance Comparative of AODV, AOMDV and DSDV Routing Protocols in MANET Using NS2." In *2018 International Seminar on Application for Technology of Information and Communication*, 286–89. IEEE.

Ching, T. W., and A. H. M. Aman. (2021). "Performance Evaluation of AODV Routing Protocol in MANET Using NS-3 Simulator." *2021 3rd*. https://ieeexplore.ieee.org/abstract/document/9392519/.

Haglan, Hussein M., Salama A. Mostafa, Noor Zuraidin Mohd Safar, Aida Mustapha, Mohd Zainuri Saringatb, Hosam Alhakami, and Wajdi Alhakami. (2021). "Analyzing the Impact of the Number of Nodes on the Performance of the Routing Protocols in Manet Environment." *Bulletin of Electrical Engineering and Informatics* 10 (1): 434–40.

Hashim, Al-Aiz, Mujahed Mohammed Farhan, and Sabri Alshybani. (2019). "Performance Evaluation of OLSR and AODV Routing Protocols over Mobile Ad-Hoc Networks." In *2019 First International Conference of Intelligent Computing and Engineering (ICOICE)*, 1–8. IEEE.

Kullayappa Naik, K. C., Ch Balaswamy, and P. Ramana Reddy. (2019). "Performance Analysis of OLSR Protocol for MANETs under Realistic Mobility Model." In *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, 1–5. IEEE.

Kurniawan, Ashadi, Prima Kristalina, and Moch Zen Samsono Hadi. (2020). "Performance Analysis of Routing Protocols AODV, OLSR and DSDV on MANET Using NS3." In *2020 International Electronics Symposium (IES)*, 199–206. IEEE.

Nisar, Kashif, Ibrahim A. Lawal, Usman Ismail Abdulmalik, Abubakar Aminu Mu'azu, B. S. Chowdhry, Sohrab Khan, and Shuaib Memon. (2020). "QoS Analysis of the MANET Routing Protocols with Respect to Delay, Throughput, & Network Load: Challenges and Open Issues." In *2020 IEEE 14th International Conference on Application of Information and Communication Technologies (AICT)*, 1–8. IEEE.

Rampurkar, K., N. Lavande, and S. Shilgire. (2017). "Study of Routing Overhead and Its Protocols." *International Journal of*. https://hal.science/hal-01484883/.

Sahu, P. K., B. Acharya, and N. Panda. (2018). "QoS Based Performance Analysis of AODV and DSR Routing Protocols in MANET." *2018 2nd International*. https://ieeexplore.ieee.org/abstract/document/8588915/.

Saudi, N. A. M., M. A. Arshad, A. G. Buja, and A. F. A. Fadzil. (2019). "Mobile Ad-Hoc Network (MANET) Routing Protocols: A Performance Assessment." *Proceedings of the London Mathematical Society. Third Series*. https://link.springer.com/chapter/10.1007/978-981-13-7279-7_7.

Yadav, S., and T. Firdaus. (2019). "Congestion Aware Routing in AODV Based Mobile Ad-Hoc Network (MANET)." *2019 International Conference on*. https://ieeexplore.ieee.org/abstract/document/8940474/.

Zarzoor, Ahmed R. (2021). "Enhancing Dynamic Source Routing (DSR) Protocol Performance Based on Link Quality Metrics." In *2021 International Seminar on Application for Technology of Information and Communication (iSemantic)*, 17–21. IEEE.