MALAYSIAN JOURNAL OF COMPUTING AND APPLIED MATHEMATICS (2024) 7 (2) 16-26

DOI: *https://doi.org/10.37231/myjcam.2024.7.2.125*

Article: Received 19.07.2024; Accepted 13.09.2024; Published 30.09.2024

EVALUATION OF RESIDUAL ENERGY IN MANET USING AODV AND DSR

Abdul Fattah Sharifuddin, Raja Hasyifah Raja Bongsu

Faculty Information and Computing, University Sultan Zainal Abidin Campus Besut, Malaysia
fattahsharifuddin@gmail.com

Abstract: Efficient communication in Mobile Ad-Hoc Networks (MANETs) is crucial, given their decentralized nature and reliance on battery-powered devices, where energy efficiency directly impacts network longevity. The study evaluates the residual energy in MANETs by means of two reactive routing strategies: Dynamic Source Routing (DSR) and Ad-hoc On-demand Distance Vector (AODV). By use of an energy model measuring transmission, reception, idle, and sleep energy consumption, the aim is to find which protocol preserves greater residual energy under different mobility scenarios. Using both protocols in Network Simulator 2.35 (NS-2.35), we simulated settings with node counts of 50, 100, 150, and 200, evaluating mobility speed and energy consumption at 2 m/s and 4 m/s. Energy consumption was calculated from power consumption across node operations. Key measures examined are residual energy, end-to-end delay, throughput, and packet delivery ratio (PDR). Particularly under high mobility and node density, results reveal that AODV generally exceeds DSR in energy efficiency, reduced end-to-end delay, and higher throughput. These results provide useful information for choosing routing techniques to maximize performance and energy consumption in MANETs, hence extending network lifetime and operational effectiveness.

Keywords: MANET, Routing Protocol, Residual Energy, AODV, DSR.

1. INTRODUCTION

Effective interaction depends on communication networks, particularly in contexts calling for speedy coordination and information exchange. When conventional infrastructure is absent, like in disaster recovery, Mobile Ad-Hoc Networks (MANETs) are especially valuable. In these situations, rescue teams rely on MANETs to interact outside of known systems [8]. Because MANETs operate in a dynamic, decentralized way, managing energy use effectively is crucial to keep the network running and extend device life [13]. In highly mobile environments like rescue operations, it's important to use a mobility model that reflects real-world movement patterns. The Random Walk Mobility Model does this well by simulating the kind of unpredictable movements typical of rescue teams, which helps with realistic assessments of network stability and performance [9].

Furthermore crucial for the operation of MANETs are routing protocols. Evaluated two reactive protocols: Ad Hoc On Demand Distance Vector (AODV) and Dynamic Source Routing (DSR). By just putting up paths only when needed, reactive systems like this conserve energy instead of always maintaining paths [5]. While DSR stores the whole route at the source before transmitting data, AODV creates routes on demand [6]. Energy use is a key concern in MANETs, especially in resource-limited settings like rescue operations where frequent link breaks and network splits can drain power [2]. Network Simulator 2.35 (NS-2.35) is used to compare how AODV and DSR perform in terms of energy efficiency, simulating random movement with the Random Walk Mobility Model [9]. Tests across various node densities and speeds look at energy left, delay, throughput, and packet delivery ratio (PDR) for each protocol. Results suggest that AODV generally uses energy more efficiently, with lower delays and higher throughput in high-mobility scenarios, while DSR may be better suited to lower-mobility situations. These results suggest consistent, energy-efficient MANET use in important environments [10][12], hence guiding protocol choice.

2. RELATED WORKS

A. Energy-Efficient Routing Protocols

Authors of [1] presented the Ad hoc On-demand Multipath Distance Vector Fitness Function (AOMDV-FFn). This protocol minimizes energy consumption by means of a genetic algorithm considering residual energy, distance, and congestion, therefore optimizing packet delivery rates. Using the same criteria, a comparable method (AOMDV-GA) is suggested for best path choosing. Both systems fit really nicely with our aim to improve energy economy. Examining node energy dynamics, authors in [5] create a routing approach with an emphasis on energy efficiency hoping to lower energy usage per routing transaction. This emphasis is particularly relevant to the study because effective energy management is crucial in dynamic environments. Furthermore, [6] suggests an AODV-based method to distribute node tasks. This approach helps to distribute resources equally, so preserving energy all over the network. Our suggested routing systems could benefit from this workload management concept.

B. Improves Current Protocols

By including dynamic jitter in the Route Request (RREQ) procedure, the authors in [4] enhance the DSR and AODV protocols. This improvement enables the identification of paths with less jitter and greater residual energy, therefore strengthening the resilience of the protocols. These revelations will help us to maximize current systems for improved performance under different environments. In [3], authors investigate the coupling of routing protocols with clustering methods. This work manages energy in dynamic environments by combining the Low Energy Adaptive Clustering Hierarchical (LEACH) protocol with AOMDV. By using several AOMDV paths, we can solve problems including dead and mobile nodes, thereby implying that clustering could improve our method.

C. Impact of Mobility Models

Routing efficiency depends much on mobility patterns. Various mobility models are investigated in [8] disaster situations; the Disaster Area (DA) model is discovered to be the most realistic for simulating rescue team movements. This helps us to properly assess routing strategies by supporting our emphasis on reasonable mobility models. Authors study in [9] how different movement patterns influence procedures such as AODV, OLSR, and GRP. They discover that OLSR performs particularly well in dynamic contexts, which emphasizes the requirement of flexible protocols in our proposed study. Their study of performance indicators, including end-to-end delay and data drop rate, will direct our evaluation standards.

D. Analysis of Energy Consumption

At last, [10] investigates the energy usage of several systems. In high-mobility situations, DSDV exhibits the lowest total energy consumption, although it has higher energy costs per packet. DSR is shown to use the least energy per packet; AODV strikes a compromise between energy use and throughput.

3. METHODOLOGY

3.1 RESEARCH METHODOLOGY

Like with Fig 1, the methodology for this research consists of several main stages. The basis of the research is first the identification of the problem statement on energy usage in MANETs. After that, the design and development stage is started to find a suitable design, such as an adequate energy model. This stage is absolutely essential for matching the design with the aims of research. Simulations are then run with the

NS-2.35 tool to generate a MANET environment and apply the AODV and DSR routing systems. At last, performance is assessed with an eye on end-to-end delay, network lifetime, and residual energy. The iterative nature, this evaluation stage guarantees the accuracy of NS-2.35 simulation findings. The study's energy model formulas are a perfect fit since they provide a comprehensive picture of how energy is utilized in MANETs by accounting for all significant energy use factors, including transmission, reception, idle time, and sleep. By taking into consideration the power required for various tasks and their duration, they replicate the behavior of nodes in real-world situations. The formulas are appropriate for the dynamic nature of MANETs since they also adjust well to varying mobility speeds and node density.

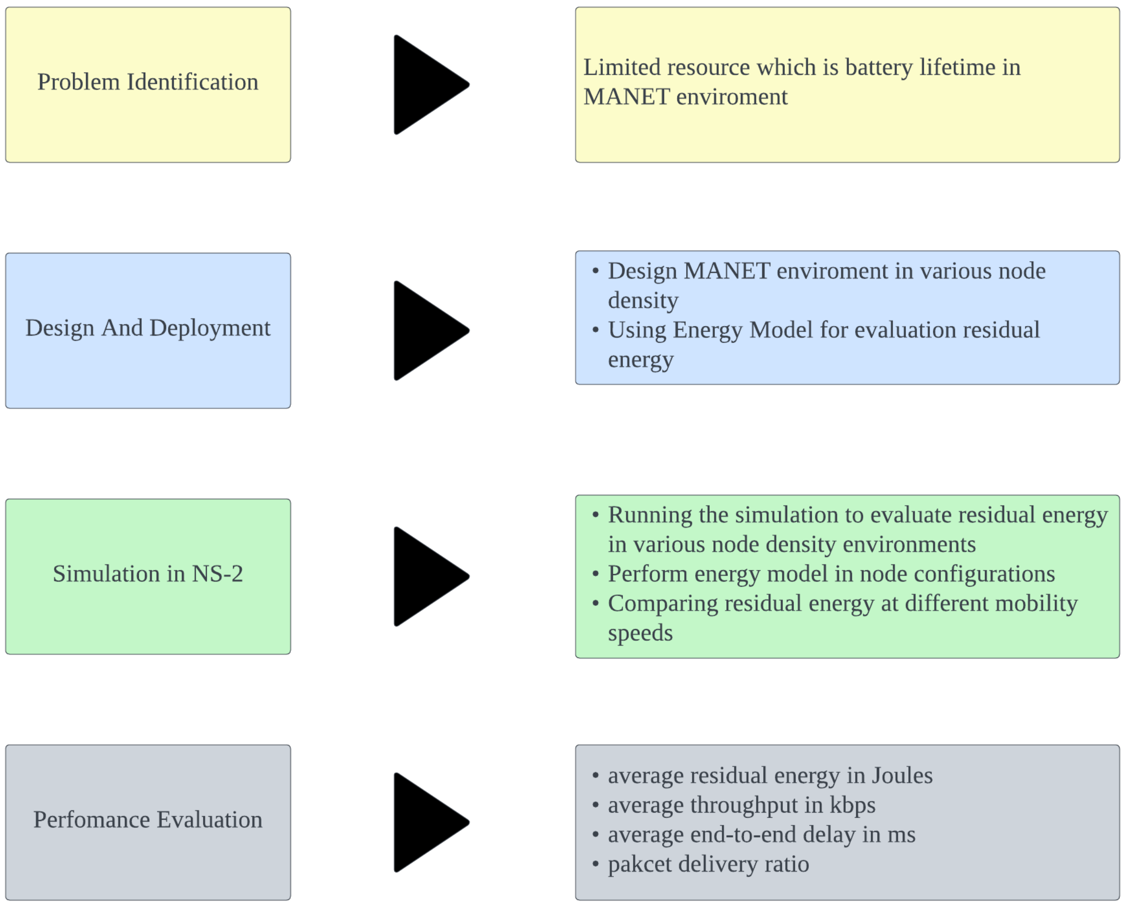

Figure 1. Research Methodology

3.2 PROJECT FRAMEWORK

Theoretically, the project's framework, shown in Fig. 2 outlines how Ubuntu OS might simulate nodes in NS-2.35. With assigned source and destination nodes, every node will reflect the network environment for MANET. Two reactive routing techniques, AODV and DSR, will be applied along with an energy model to evaluate energy consumption within this MANET. Three main metrics are residual energy, network longevity, and end-to-end delay, which will be the main emphasis of the performance evaluation.

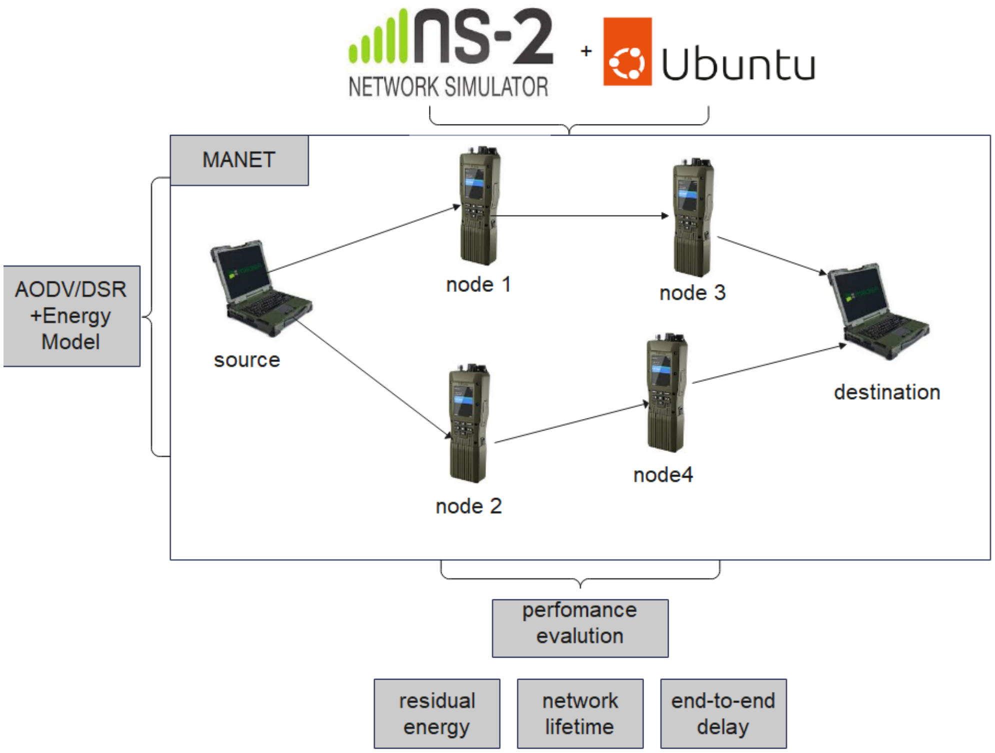

Figure 2. Project Framework

4. EVALUATION RESIDUAL ENERGY USING ENERGY MODEL

4.1 Type of mode in Energy Model

Two main modes underlie the energy model in Mobile Ad-hoc Networks (MANET) are active and power-saving. Active mode is the operational state in which nodes are completely functional, able to both data packet transmission and reception. This mode guarantees nodes for continuous communication and network connectivity are ready. The power-saving mode covers sleep as well as idle. In idle mode, a low-power state node remains vigilant to network activities while not actively transmitting or receiving data. This mode lets nodes quickly switch to active mode as needed, conserving energy while yet being sensitive to possible communication requirements. Nodes in idle mode immediately enter sleep mode, the lowest energy level, should they remain inactive for too long. Nodes in sleep mode disable most functionalities, thereby consuming less energy and being ready to be awakened when needed. Figure 3 clarifies the way power saving operates in an energy model.

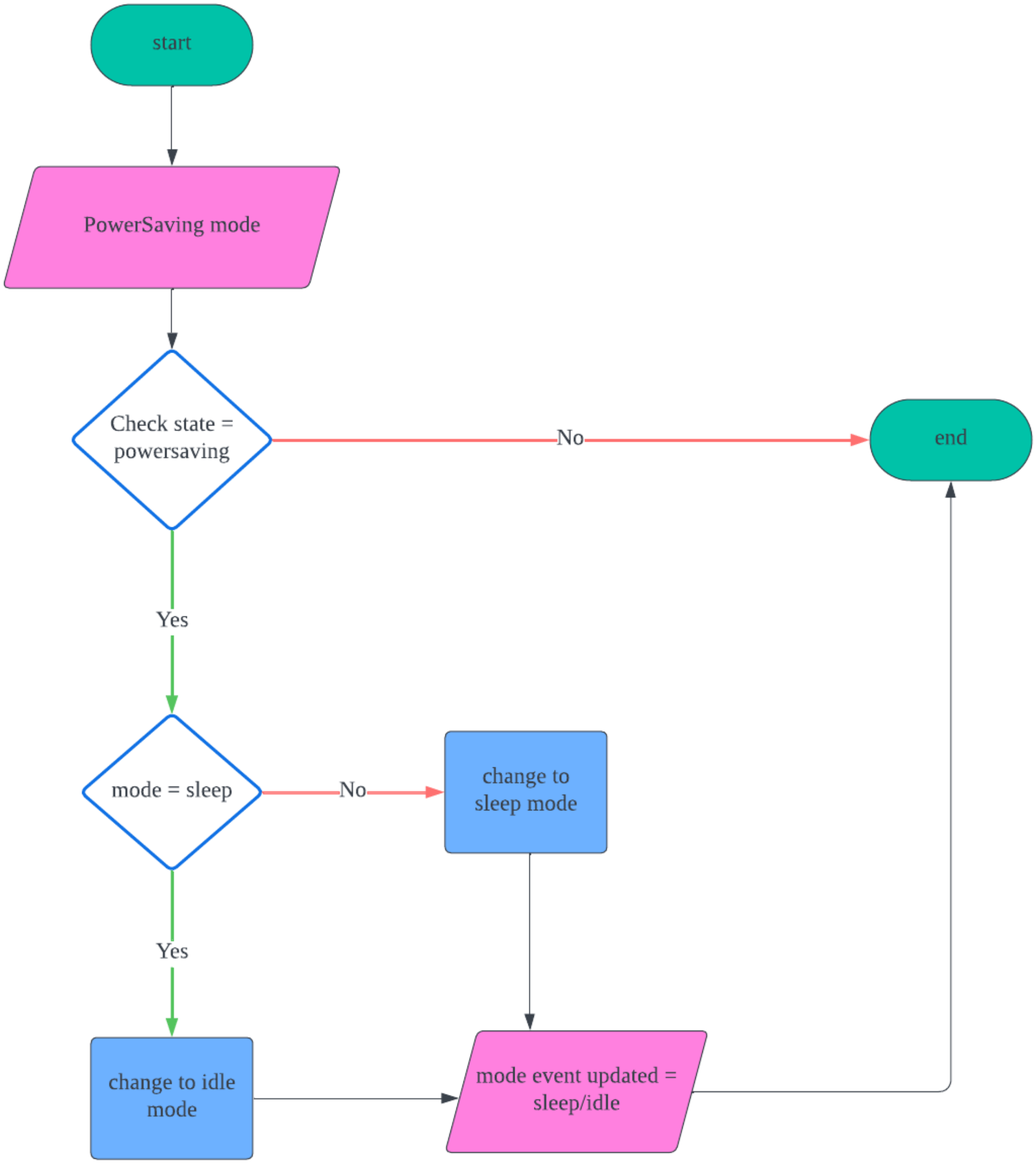

Figure 3. Power Saving Mode Flowchart

In active mode, if the routing time does not exceed the predefined parameter, active mode maintains the idle mode, allowing nodes to transmit or receive packets. Active mode changes to power-saving mode to improve efficiency, though, should the maximum routing time be achieved and the nodes not be used for communication. This change reduces the time nodes spend in active states when they are unlikely to interact, therefore conserving energy. Figure 4 clarified the active will acting in the energy model.

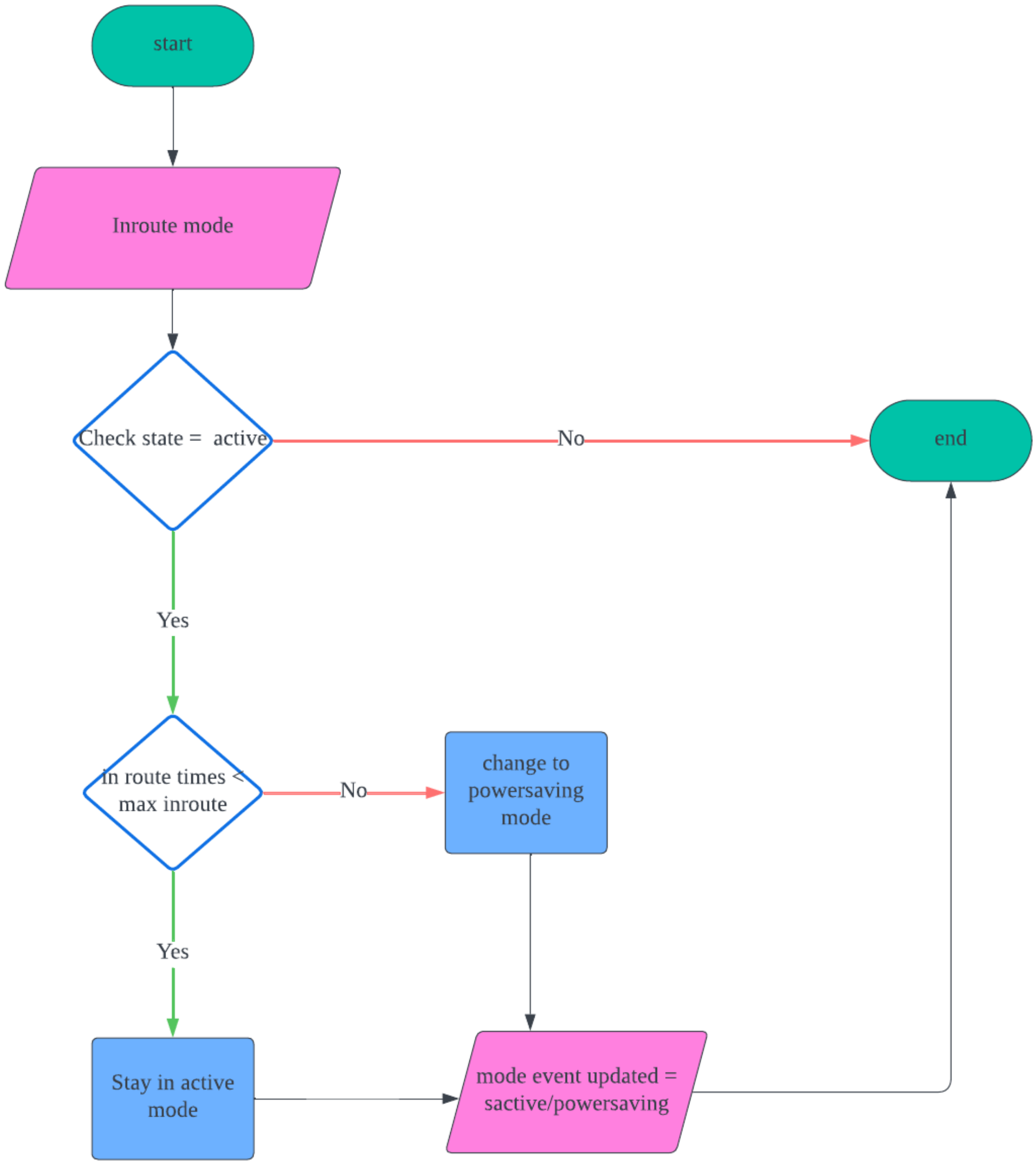

Figure 4. Active Mode Flowchart

4.1.1 Calculation in Energy Model

Transmission Energy Consumption

$$Teng = Ptx \times txtime$$

This formula calculates the energy consumed Teng during the transmission of data. Ptx is the power required for transmission, and $txtime$ is the duration for which the transmission occurs.

Reception Energy Consumption

$$Reng = Prcv \times rcvtime$$

This formula calculates the energy consumed $Reng$ during the reception of data. $Prcv$ is the power required for reception, and $rcvtime$ is the duration for which the reception occurs.

Idle Energy Consumption

$$Ieng = Pidle \times idletime$$

This formula calculates the energy consumed $Ieng$ during the idle state. $Pidle$ is the power required for idling, and $idletime$ is the duration for which the node remains idle.

Sleep Energy Consumption

$$Seng = Psleep \times sleeptime$$

This formula calculates the energy consumed $Seng$ during the sleep state. $Psleep$ is the power required for sleeping, and $sleeptime$ is the duration for which the node remains in the sleep state.

4.2 Mobility Model

The Random Walk Mobility Model is utilized to simulate and study node mobility dynamics. In this model, each node moves in a randomly chosen direction for a specified period before selecting a new direction and speed. For instance, nodes may move at 2 meters per second (m/s) to represent lower-density scenarios where nodes are spread out and move slower to conserve energy. On the other hand, speeds of 4 m/s replicate higher-density situations whereby nodes are closer together and migrate faster to fit changing network requirements.

5. SIMULATION SETUP

This work makes use of the Table 1 settings. Designed to assess residual energy across various settings, the number of nodes ranges—50, 100, 150, and 200 nodes specifically. Standardized at 1000 m x 1000 m, the MANET environment's simulation area helps to enable effective evaluation of packet transmission performance. Using Constant Bit Rate (CBR) transmission, every packet, which is 512 bytes, is broadcast. Watts are the unit of measurement for initial energy levels kept in every node and connected to sent/received packets. Variations in mobility speed are used to replicate reasonable node movement dynamics, therefore influencing network performance measures in certain contexts.

Table 1: Simulation parameters

Parameter	**Value**
Topology	Random
Simulation tool	NS-2.35
Number of nodes	50,100,150,200
Channel	Channel/WirelessChannel
Routing protocol	AODV,DSR
Area of simulation	1000 m x 1000 m
Simulation time	300 seconds
Radio propagation-model	TwoRayGround
Interface queue-type	DropTail/PriQueue/CMUPriQueue
Mobility speed	2 m/s,4 m/s

Packet size	512 bytes
Intial energy	200 Joules
Transmission power	1.0 Watt
Reception power	1.0 Watt
Sleep power	0.001 Watt
Idle power	0.6 Watt
Traffic type	CBR
Perfomance Metrics	Average residual energy, Average End-to-End Delay, Average Throughput, Packet delivery Ratio

6. RESULT AND DISCCUSSION

Across changing node densities (50, 100, 150, and 200 nodes), the average residual energy for AODV and DSR routing protocols is shown in Fig. 5 at two mobility speeds (2ms and 4ms). AODV at 2 ms displays the maximum residual energy at a lower node density of 50 nodes, therefore showing better energy efficiency at this speed. AODV at 4 ms starts to show better when the node density rises to 100 nodes. AODV at 4 ms still keeps more residual energy at 150 nodes, thereby sustaining its effective performance. At last, at 200 nodes, AODV at 4 ms stays the most efficient; DSR at 4 ms also improves but still lags behind. Generally speaking, the 4 ms speed is more effective as the number of nodes rises since AODV at 2 ms is more efficient at lower densities while AODV at 4 ms is more efficient at larger densities.

At mobility speeds of 2 ms and 4 ms across diverse node densities (50, 100, 150, and 200 nodes), the Fig. 6 shows the average end-to-end delay for AODV and DSR routing protocols. AODV at 4 ms has the lowest delay at a 50-node density, so it is the most efficient. Although AODV at 4 ms offers somewhat better results, overall AODV at both speeds performs better when node density rises to 100 and 150 nodes. DSR performs worse. AODV at 4 ms maintains the lowest delay at the largest density of 200 nodes, therefore greatly outperforming DSR, which shows the highest delay here. AODV is a more efficient protocol than DSR overall in terms of end-to-end delay across different node densities, especially at 4 ms. This is consistent with studies showing that under more mobility and bigger network sizes, AODV usually exhibits greater efficiency and performance measures.

Across changing node densities (50, 100, 150, and 200 nodes), the average throughput for AODV and DSR routing protocols is shown in Fig. 7 at two mobility speeds (2 ms and 4 ms). Around 45 kbps, AODV at all node densities consistently shows higher and more constant throughput than DSR, which lags somewhat behind, especially around 4 ms. DSR 4ms exhibits the lowest density-based throughput overall. AODV's effective route discovery and maintenance systems help to explain its constant performance since they lower overhead and increase data transmission efficiency. Thus, AODV is usually more effective in preserving higher throughput across diverse node densities and mobility speeds, supporting its superiority over DSR in this criterion.

At two mobility speeds (2 ms and 4 ms) across different node densities (50, 100, 150, and 200 nodes), the Fig. 8 shows the Packet Distribution Ratio (PDR) for AODV and DSR routing protocols. AODV at both 2 ms and 4 ms as well as DSR at 2 ms reliably maintain a PDR close to 1 at all node densities, therefore suggesting almost all packets are successfully delivered. Starting with a lower PDR at 50 nodes, DSR at 4 ms improves and matches other designs at larger node density. AODV exhibits far superior consistency in preserving a high PDR over all densities and speeds overall. This implies, in particular under different node density and mobility situations, AODV is usually more dependable in delivering packets efficiently than DSR.

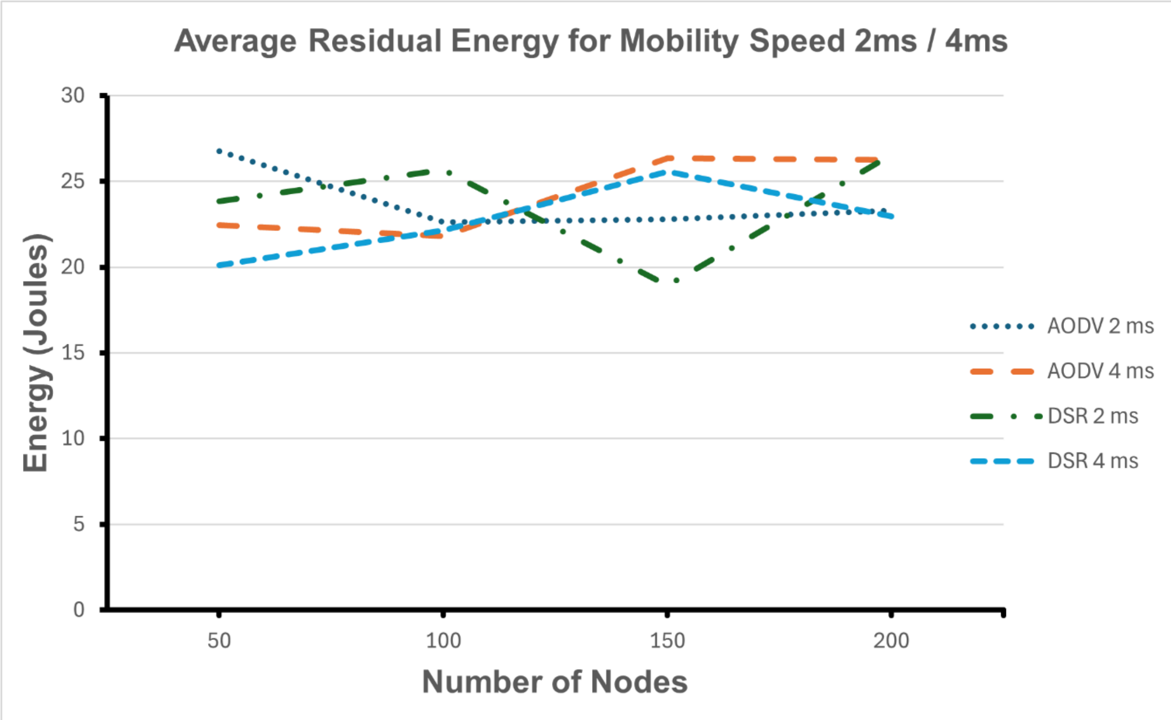

Figure 5. Graph for average residual energy

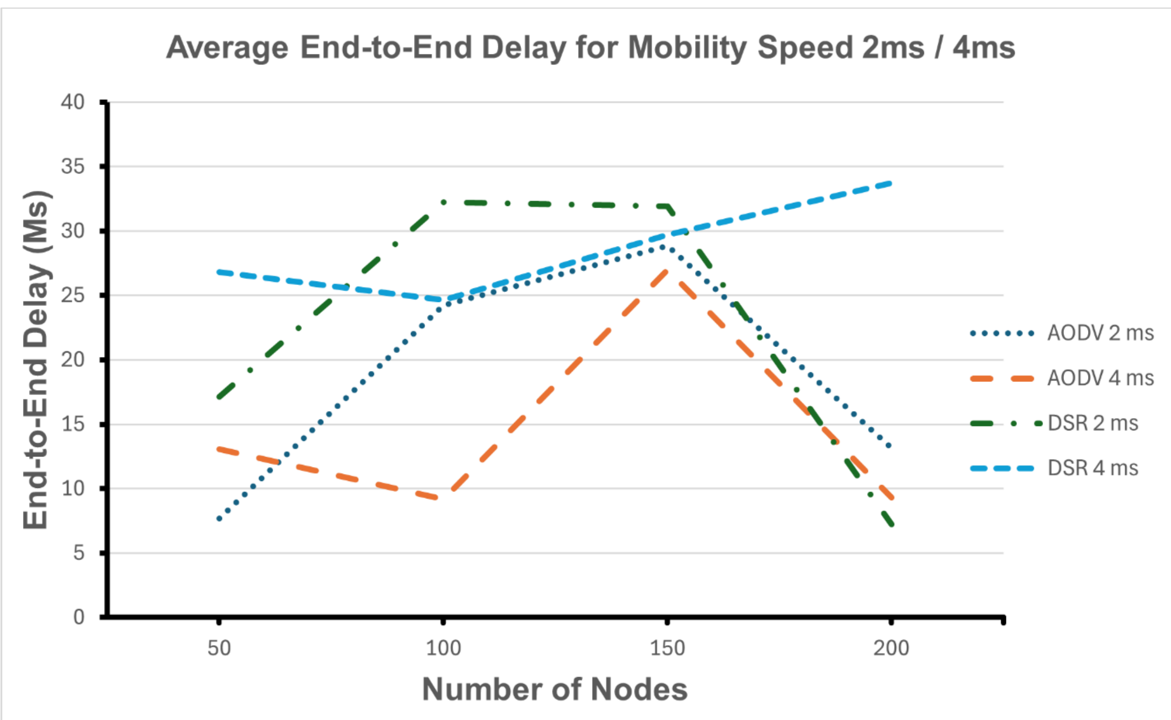

Figure 6. Graph for average end-to-end delay

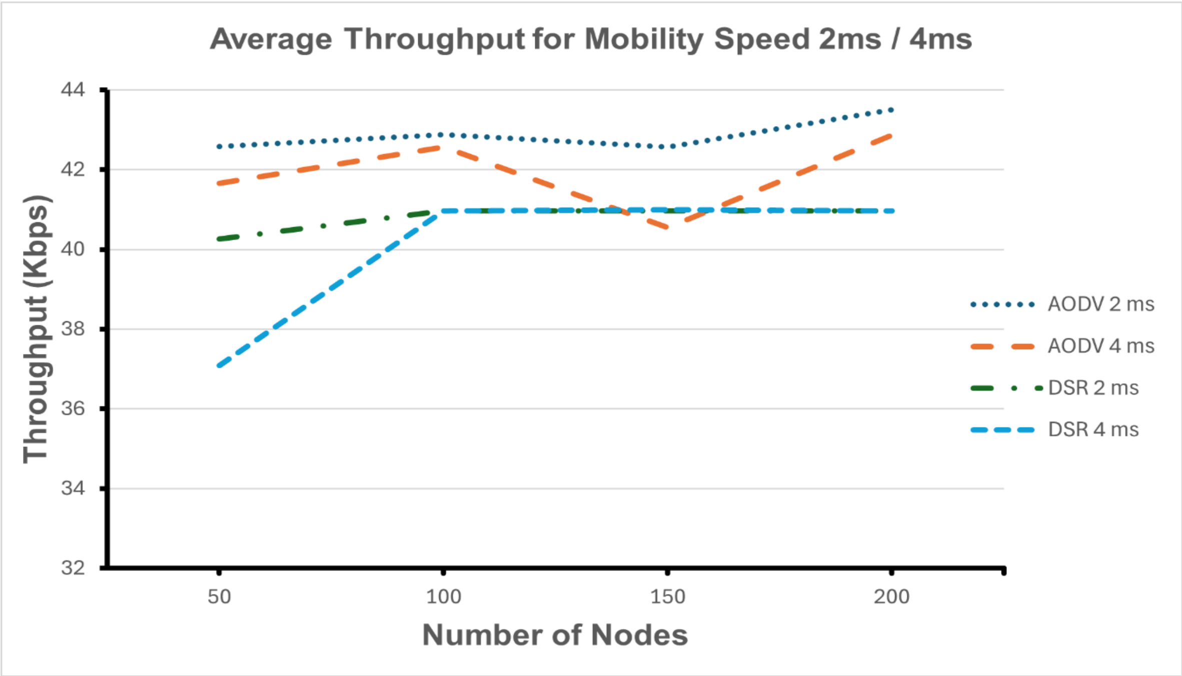

Figure 7. Graph for throughput

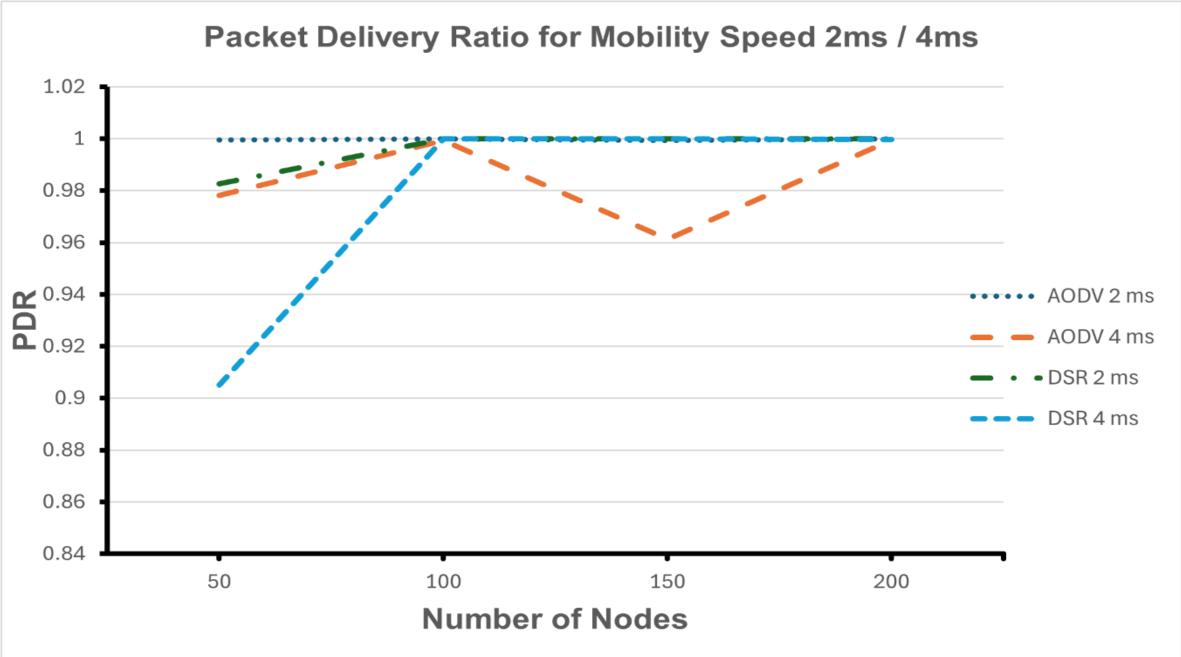

Figure 8. Graph packet delivery ratio

7. CONCLUSION

AODV generally performs better than DSR, according to an analysis of several performance metrics, including residual energy, end-to-end delay, throughput, and packet delivery ratio (PDR), for AODV and

DSR routing protocols at different mobility speeds (2ms and 4ms) and node densities of 50, 100, 150, and 200 nodes. Over a range of node densities and mobility speeds, AODV shows better energy efficiency, routinely the lowest end-to-end delay, and faster throughput. It also preserves a high and consistent PDR, so signaling consistent packet delivery. Common in mobile ad-hoc networks (MANET), dynamic and high-density environments are especially where AODV excels. Frequent topological changes and route breaks arising from high mobility in MANET are common; AODV's effective route discovery and maintenance systems help to reduce these problems, hence lowering energy consumption and improving general network performance. DSR's reliance on route caches and source routing, on the other hand, raises overhead and energy consumption, thereby reducing efficiency under high mobility scenarios. These results highlight the need of choosing suitable routing protocols to maximize performance and energy economy in MANET.

REFERENCES

[1] Bhardwaj and H. El-Ocla, "Multipath Routing Protocol Using Genetic Algorithm in Mobile Ad Hoc Networks," in IEEE Access, vol. 8, pp. 177534-177548, 2020, doi: 10.1109/ACCESS.2020.3027043.

[2] K. B. Rinku, M. P. Manish and B. P. Megha, "Energy efficient routing in mobile Ad-hoc network," 2017 Third International Conference on Sensing, Signal Processing and Security (ICSSS), Chennai, India, 2017, pp. 48-53, doi: 10.1109/SSPS.2017.8071563.

[3] B. Rana and D. Rana, "Energy efficient load balancing with clustering approach in MANET," 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, India, 2017, pp. 2019-2024, doi: 10.1109/ICECDS.2017.8389803.

[4] P. Vyas, M. Tipkari and S. Pathania, "Energy efficient path selection in MANET," 2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), Kerala, India, 2017, pp. 1-6, doi: 10.1109/ICICICT1.2017.8342525.

[5] S. M. Benakappa and G. M. Sushmitha, "E-E-AODV: An efficient approach for energy conservation in MANETs," 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, India, 2018, pp. 909-916, doi: 10.1109/ICISC.2018.8398932.

[6] M. B. Patel and M. M. Patel, "Energy Efficient Routing Using Residual Energy and Stability in Mobile Ad-Hoc Network," 2018 International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 2018, pp. 857-861, doi: 10.1109/ICIRCA.2018.8597298.

[7] Issariyakul, T., & Hossain, E. (2009). Introduction to Network Simulator NS2. In Introduction to Network Simulator NS2. Springer US. https://doi.org/10.1007/978-0-387-71760-9

[8] Mahiddin, Nor Aida & Mohd Affandi, Fatin Fazain & Mohamad, Zarina. (2021). A review on mobility models in disaster area scenario. International Journal of Advanced Technology and Engineering Exploration. 8. 848-873. 10.19101/IJATEE.2021.874084.

[9] Abdullah, Ako & Ozen, Emre & Bayramoglu, Husnu. (2019). Investigating the Impact of Mobility Models on MANET Routing Protocols. International Journal of Advanced Computer Science and Applications. 10. 25-35. 10.14569/IJACSA.2019.0100204.

[10] Kumar, Ashish & Rafiq, M. & Bansal, Kamal. (2012). Performance Evaluation of Energy Consumption in MANET. International Journal of Computer Applications. 42. 7-12. 10.5120/5662-7692.

[11] Papanna, N., Reddy, A., & Seetha, M. (2019). EELAM: Energy efficient lifetime aware multicast route selection for mobile ad hoc networks. *Applied Computing and Informatics*. https://doi.org/10.1016/J.ACI.2017.12.003.

[12] Tilwari, V., Dimyati, K., Hindia, M., Fattouh, A., & Amiri, I. (2019). Mobility, Residual Energy, and Link Quality Aware Multipath Routing in MANETs with Q-learning Algorithm. *Applied Sciences*. https://doi.org/10.3390/APP9081582.

[13] Fatima, L., Mahin, S., & Taranum, F. (2019). Efficient strategies to reduce power consumption in MANETs. *PeerJ Computer Science*, 5. https://doi.org/10.7717/peerj-cs.228..

[14] Kandari, S., & Pandey, M. (2015). Evaluation of energy consumption by nodes of MANET. *2015 National Conference on Recent Advances in Electronics & Computer Engineering (RAECE)*, 32-35. https://doi.org/10.1109/RAECE.2015.7510221.

[15] Mustafa, M., Rasheed, M., & Salih, O. (2020). Low energy consumption in Manet network. *Periodicals of Engineering and Natural Sciences (PEN)*, 8, 904-915. https://doi.org/10.21533/PEN.V8I2.1336.