Journal of
Mobile Computing, Communications & Mobile Networks

ISSN: 2349-901X
Volume 12, Issue 3, 2025
September–December
DOI (Journal): 10.37591/JoMCCMN

https://journals.stmjournals.com/jomccmn

Review JoMCCMN

Adaptive Routing Protocol to Optimize the Quality of Service of MANET Using Neural Network

Awadhesh Kumar Rai[1],*, Akhilesh A. Waoo[2]

Abstract

A MANET is a group of mobile nodes that create a temporary network without relying on centralized administration or standard supporting devices, often functioning as a conventional network. These dynamic environments present significant challenges for traditional routing and switching protocols, particularly in delivering Quality of Service (QoS) benchmarks such as bandwidth, latency, packet delivery ratio, and robustness. This study proposes an Adaptive Routing Protocol (ARP) leveraging Neural Network (NN) techniques to enhance QoS in MANETs. The framework incorporates a feed-forward neural network trained on network-specific parameters such as node density, signal strength, mobility patterns, and historical performance metrics. The NN is a decision-making engine that dynamically adjusts routing paths and switching criteria based on real-time network conditions, optimizing data transmission efficiency. Simulations conducted using standard QoS metrics demonstrate that the proposed ARSP significantly outperforms existing protocols like AODV, DSR, and OLSR in terms of latency reduction, increased packet delivery ratios, and improved overall network throughput. The NN's ability to learn and adapt to changing network conditions provides a flexible solution that can be applied to different MANET scenarios. This research underscores the potential of machine learning techniques, especially neural networks, in addressing the complex routing challenges in MANETs while ensuring optimal quality of service for diverse applications.

Keywords: Adaptive routing protocol, DDPG, MANET, neural network, quality of service

INTRODUCTION

A mobile ad hoc network (MANET) is composed of independent nodes that communicate with each other through radio signals. It is a distributed wireless network where signals are broadcast. Unlike traditional networks, MANETs do not require fixed infrastructure. The nodes in a MANET are mobile, meaning they can move freely from one location to another. Communication is established through routing methods, which are needed for nodes that are at a distance from each other. However, within each other's radio range, nodes can communicate directly. MANETs operate within a frequency range of 30 MHz to 5 GHz and are self-forming, peer-to-peer networks, making them highly flexible and dynamic. MANETs are commonly used in applications such as disaster recovery, healthcare, rescue operations, defence, robotics, and environmental monitoring. The nodes in a MANET are wirelessly transportable and are interconnected in a self-configuring, automatic setup that includes healing capabilities without the need for a specified infrastructure. Nodes are free to move. They can change the network topology. Every node forwards traffic to other nodes within the network. Every

***Author for Correspondence**
Awadhesh Kumar Rai
E-mail: awadheshrai.lko@gmail.com

[1]Assistant Professor, Department of Computer Science and Engineering, Amicable Knowledge Solution University, Satna, Madhya Pradesh, India
[2]Professor (Dean), Department of Computer Science and Engineering, Amicable Knowledge Solution University, Satna, Madhya Pradesh, India

Received Date: May 15, 2025
Accepted Date: September 03, 2025
Published Date: September 29, 2025

Citation: Awadhesh Kumar Rai, Akhilesh A. Waoo. Adaptive Routing Protocol to Optimize the Quality of Service of MANET Using Neural Network. Journal of Mobile Computing, Communications & Mobile Networks. 2025; 12(3): 1–9p.

node acts as the router. The most efficient route to the destination in MANETs with constrained node resources, utilizing conventional single-path routing methods, is determined by the ad hoc on-demand distance vector and dynamic source routing protocols [1]. However, if a node is deficient in resources or experiences overload, the shortest path may not consistently be the most optimal or stable. Traffic congestion at the junction can adversely affect QoS performance. Consequently, several routing protocols integrate supplementary node parameters, like available bandwidth, residual energy, and network stability, into their path selection algorithms. The Quality of Service (QoS) AODV protocol is intended to construct QoS pathways within a Mobile Ad Hoc Network (MANET). Quality of Service (QoS)-aware protocols in Mobile Ad Hoc Networks (MANETs) are crucial for determining optimal pathways between source and destination nodes, taking into account QoS criteria such as link stability and available bandwidth. EQ-AODV uses Q-learning to get global table state information from local communications, taking into account the sensor's residual energy and the kind of packet to be transmitted while determining the routing path. Multipath routing protocols are designed to enhance communication quality in MANETs by providing multiple paths and backup routes for data transmission [2]. These protocols improve fault tolerance, load balancing, and overall communication reliability by enabling quick path switching in case of node failures or network disruptions.

Additionally, multipath routing protocols access node resources, such as available bandwidth, idle queue duration, and battery levels, to select the most appropriate path for data transmission. In modern MANETs, path selection goes beyond evaluating node resources alone. For instance, the Energy and QoS-supported AODV (EQ-AODV) protocol considers both the remaining energy of sensors and the type of data packet being transmitted when selecting a routing path. Similarly, the QoS-aware AODV protocol prioritizes available bandwidth and link stability (Figure 1).

MANET ROUTING PROTOCOLS

Proactive (or table-driven) and reactive (on-demand) are the two primary categories into which ad hoc routing protocols are typically classified. In a Mobile Ad Hoc Network (MANET), proactive protocols necessitate that nodes maintain routes to all prospective destinations. This guarantees that the route is instantaneously accessible and can be implemented when a packet requires forwarding. In contrast, reactive protocols adopt a more conservative approach, in which routes are identified only when they are required. Until the destination is required to receive data packets, a node does not maintain a route to that destination. Proactive protocols provide the benefit of minimal latency when a route is required, as the route can be immediately retrieved from the routing table. On the other hand, they may be inefficient in terms of network utilization, as they require a constant stream of bandwidth to maintain the routing information. Conversely, reactive protocols mitigate this challenge by identifying routes solely when they are required, thereby utilizing less bandwidth [3].

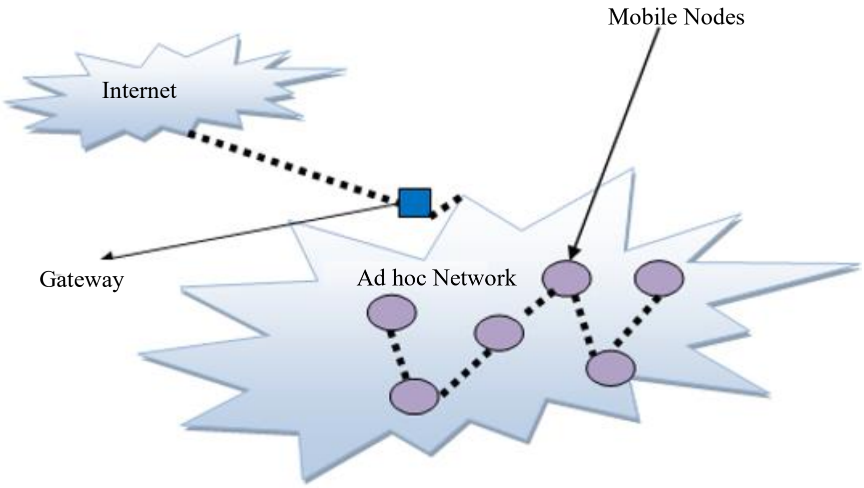

Figure 1. Mobile Ad-Hoc network.

Nevertheless, this method may lead to substantial delays in the discovery of the route before the actual communication commences. Proactive routing approaches involve protocols such as the Destination-Sequenced Distance-Vector Protocol (DSDV) and the Wireless Routing Protocol (WRP). DSDV is a proactive distance vector protocol where nodes periodically send updates and maintain routing tables with sequence numbers to differentiate fresh routes. This approach reduces network traffic by using full dumps and incremental updates while ensuring route stability through a "settling time" for optimization. WRP, on the other hand, is a table-based protocol that uses four tables: Distance, Routing, Link-cost, and MRL, to send update messages that notify neighbours about link changes. WRP also prevents routing loops by verifying the consistency of routing information, facilitating faster convergence after link failures [4]. Reactive routing approaches include protocols such as Dynamic Source Routing (DSR), Ad Hoc On-Demand Distance Vector Protocol (AODV), and Temporally Ordered Routing Algorithm (TORA). DSR is an on-demand protocol where nodes maintain route caches, operating in two phases: route discovery, which involves broadcasting route requests, and route maintenance, which handles errors and link failures through error packets. AODV combines features of DSR and DSDV, focusing on on-demand route discovery while minimizing broadcasts and using sequence numbers to ensure routes remain up-to-date and loop-free [5]. It also uses link failure notifications for route maintenance. TORA, a distributed and loop-free protocol, adjusts routing based on topological changes using link reversal and a "height" metric. TORA supports multiple routes, minimizes the impact of failures, and functions both proactively for maintenance and reactively for route creation. Each protocol addresses different challenges in dynamic ad hoc networks, offering a balance of efficiency, stability, and responsiveness to varying network conditions [6].

Hybrid routing protocols, like the Zone Routing Protocol (ZRP), combine proactive and reactive systems. ZRP limits proactive routing to a node's local neighbourhood (routing zone) and uses reactive methods for network-wide searches. Nodes maintain local routes using the Intra Zone Routing Protocol (IARP) and discover routes to distant destinations through the Inter Zone Routing Protocol (IERP), which minimizes flooding with a broadcasting mechanism. This hybrid approach optimizes route discovery, reduces network overhead, and allows multiple route replies, enabling the selection of the best route based on quality metrics [5].

Salient Features of MANET Routing Protocols

Routing protocols in MANETs must possess certain key characteristics to overcome routing challenges. These include a high degree of decentralization and localization. The protocol must accommodate frequent topological changes caused by node mobility and should not rely on rigid or unchangeable routes. Routes must be established quickly, and each node in the network should be responsible for maintaining information about the local network topology. Additionally, the protocol should be capable of delivering services with reasonably high quality [4].

Quality of Service (QoS) Parameters in MANET

- *Bandwidth:* The amount of data that can be transmitted over the network in a given period.
- *Latency:* The delay in packet transmission.
- *Jitter:* The variation in time between when a signal is sent and when it's received over a network connection.
- *Packet Loss:* The percentage of lost packets due to congestion, interference, etc.

QoS Requirements for Different Applications

Real-time applications (like video streaming) require lower latency and minimal jitter, while data applications are more tolerant of delays.

Neural Network with MANET

A neural network is a computational model inspired by the human brain, made up of interconnected units called neurons. These neurons process input data, perform mathematical operations, and produce outputs to carry out tasks like classification, regression, and reinforcement learning. Neural networks are organized in layers: input, hidden, and output, where hidden layers perform key computations to extract patterns. Learning in neural networks involves adjusting weights and biases during training to minimize prediction error, using optimization algorithms like Stochastic Gradient Descent, Adam, or RMSprop. Two key processes in neural networks are forward propagation, where data flows through the network to produce an output, and backward propagation, where the network learns by updating weights based on errors. Activation functions like ReLU, Sigmoid, and Tanh determine the output of each neuron. Different types of neural networks are designed for specific tasks: Feed-Forward Neural Networks (FNNs) for general prediction tasks, Recurrent Neural Networks (RNNs) for sequential data like text and speech, Generative Adversarial Networks (GANs) for creating synthetic data, and Transformers for natural language processing using attention mechanisms. Neural networks are widely applied in areas such as image and speech recognition, natural language processing (NLP), sentiment analysis, and machine translation, showcasing their ability to model complex, data-driven problems [7]. Among autonomous vehicles, self-driven cars interpret their surroundings based on neural networks for their real-time decisions regarding driving. Neural networks have, in fact, also seen applications in game playing, the learning of strategies, both in chess and other computer games. In traffic prediction, neural networks can predict traffic patterns and congestion to optimize routing. In congestion control, they predict network congestion levels and adjust routing paths accordingly to avoid bottlenecks and ensure better quality of service (QoS). In addition, in energy-efficient routing, neural networks can optimize the paths based on the energy levels of nodes, thereby prolonging the network's lifespan, especially in mobile and battery-powered networks such as Mobile Ad Hoc Networks (MANETs). In MANETs, neural networks are used to develop adaptive routing protocols. These protocols use historical network data to predict the best routing paths and dynamically adjust routing decisions. Such protocols include neural network-based AODV, which is a hybrid approach where neural networks predict optimal routes to minimize delay and packet loss. Fuzzy Neural Network Routing (FNNR) is another example, combining fuzzy logic with neural networks to make decisions based on multiple parameters, such as delay, bandwidth, and energy [8]. Neural networks combined with adaptive routing in MANETs require learning in a dynamic environment with topology change, traffic change, and mobility of nodes. Learning can be either through a supervised or reinforcement process by training on a labelled data set or interaction with the environment. For neural network training, real-time data related to node location, traffic load, link status, and battery power are crucial. Once trained, the neural network can make dynamic decisions regarding route selection, packet forwarding, and protocol switching. In addition, feedback loops can be used to adjust routing strategies based on the observed network performance for improved QoS [9]. Neural networks, however, have some challenges in the application of MANETs. One of the main issues is the need for large, high-quality datasets for training, which can be difficult to obtain in dynamic environments like MANETs. Additionally, the computational complexity of neural networks can be a barrier, particularly for mobile devices with limited processing capabilities [10]. As the size of the network grows, the complexity of the neural network model and the data required for training can also increase, leading to performance bottlenecks. Finally, neural networks may not always generalize well to different network conditions. Networks trained in one environment may struggle to adapt to new conditions, requiring frequent retraining to maintain optimal performance.

OBJECTIVES

This research aims to enhance routing efficiency in high-mobility mobile ad hoc networks by employing Deep Deterministic Policy Gradient (DDPG) and neural network-based prediction models to proactively select stable routes based on path stability and node density. It further supports context-aware QoS decision-making while minimizing control overhead and routing latency through predictive mechanisms.

LITERATURE SURVEY

Mobile Ad Hoc Networks (MANETs) are self-configuring wireless networks characterized by node mobility and frequent topology changes. Ensuring Quality of Service (QoS) in such networks is a significant challenge due to variable link quality, limited bandwidth, and energy constraints. Traditional routing protocols such as AODV and DSR, though efficient in route discovery, often fail to maintain QoS under high mobility scenarios. To address this, several QoS-aware routing protocols have been proposed, incorporating metrics like delay, throughput, and jitter [11]. However, these protocols are often static and do not adapt effectively to dynamic network conditions. Recently, the application of machine learning techniques, particularly neural networks, has shown promise in enhancing routing adaptability. Neural networks, with their ability to learn and predict from data, have been employed to estimate link stability and predict optimal paths [12].

Hande and Sadiwala proposed an ANN-based routing protocol for MANETs to optimize energy consumption and improve Quality of Service [7]. Unlike traditional static routing methods, their approach uses real-time network data to adaptively select efficient paths, resulting in reduced energy usage, extended network lifetime, and enhanced performance. The study highlights the potential of neural networks in dynamic network environments and suggests future exploration into deep learning models for further improvements.

Jesús-Azabal *et al*. developed a software-based tool to evaluate the Quality of Service (QoS) of opportunistic MANET routing algorithms on real devices [12]. Their findings revealed that simulation results often overestimate performance compared to real-world tests, emphasizing the need for physical evaluations in protocol development. This study highlights the value of practical, device-level testing in improving routing reliability and accuracy in MANETs.

Baumgartner *et al*. proposed resilient enhancements to MANET routing protocols by integrating blockchain and deep neural networks [4]. Their approach improves routing reliability by intelligently selecting stable paths, leading to better throughput, lower latency, and higher packet delivery. The study demonstrates that combining AI and decentralized technologies strengthens MANET performance in dynamic and hostile environments.

Ali *et al*. introduce a classifier-driven deep learning clustering approach aimed at improving data collection in MANETs [13]. The method utilizes deep learning techniques to classify and cluster nodes, optimizing data collection processes. The approach demonstrates enhanced efficiency in data gathering within MANETs, contributing to the development of more effective data collection strategies in mobile ad hoc networks.

Safari introduces a cross-layer framework designed to enhance routing decisions in Mobile Ad Hoc Networks (MANETs) by considering Quality of Service (QoS) parameters at multiple layers of the network stack [6]. The framework probably integrates information from the physical, data link, and network layers to make more informed routing decisions, aiming to improve metrics such as throughput, delay, and packet delivery ratio. By adapting to the dynamic nature of MANETs, the proposed framework likely seeks to optimize network performance and resource utilization.

Chen *et al*. introduce an adaptive on-demand multipath routing protocol that supports Quality of Service (QoS) in high-speed MANETs [3]. The protocol dynamically selects multiple paths based on real-time network conditions, ensuring reliable data transmission and minimizing latency, which is crucial for applications requiring high throughput and low delay.

Shah *et al*. present an adaptive routing protocol that employs a genetic algorithm to optimize path selection in MANETs [9]. The protocol evolves routing paths based on fitness functions, considering parameters like energy consumption and link stability, leading to improved network efficiency and extended node lifetime.

Bai *et al*. propose a deep reinforcement learning-based routing algorithm that adapts to network dynamics [8]. Simulation results demonstrate that the algorithm balances energy consumption and node load, achieving over 10% improvement in remaining energy and reducing packet loss by at least 10%, while maintaining high QoS performance.

Ahmed and Al-Asadi integrate blockchain technology into the OLSP to enhance security and efficiency in video packet transmission over MANETs [14]. The proposed framework reduces validation time and overhead, addressing challenges related to node validation and computational complexities in ad-hoc networks.

Danilchenko *et al*. explore the application of deep learning techniques to enhance routing decisions in MANETs [10]. The proposed methods aim to improve routing efficiency and adaptability in dynamic network environments.

Vargheese *et al*. propose an improved multi-path routing protocol to enhance QoS in MANETs [2]. The approach aims to optimize routing paths, thereby improving network performance and reliability.

Shanthini *et al.* introduce a cluster routing-based group adaptive mechanism to enhance node mobility in MANETs [11]. The proposed method aims to improve network stability and performance by adapting to node mobility.

Oyelakin offer a concise analysis of routing and security challenges in MANETs, dividing solutions into routing protocols and security mechanisms [15]. It outlines the progression of traditional routing methods and introduces recent innovations like QoS-aware and energy-efficient protocols. The paper also discusses common security threats such as black hole and wormhole attacks, along with proposed defences. Emerging trends like blockchain, machine learning, and IoT integration are highlighted, pointing to a future of smarter and more adaptive MANET solutions.

Bhatia *et al*. focus on integrating Mobile Ad Hoc Networks (MANETs) into Networked Control Systems (NCS), specifically using the AODV (Ad hoc On-demand Distance Vector) routing protocol [1]. The authors explore how the dynamic nature of MANETs can support distributed control systems in environments lacking fixed infrastructure, such as military or disaster response scenarios.

Affandi *et al*. evaluate and compare the performance of three prominent routing protocols in MANETs: DSDV (Destination-Sequenced Distance Vector), DSR (Dynamic Source Routing), and ZRP (Zone Routing Protocol) [5]. The primary focus is on analysing their behaviour under different mobility and network conditions.

DISCUSSION

The reviewed literature reveals a diverse range of methodologies aimed at enhancing the performance, reliability, and adaptability of routing protocols in Mobile Ad Hoc Networks (MANETs). A prevailing theme across many of the studies is the integration of intelligent and adaptive technologies notably, artificial intelligence (AI), deep learning, and reinforcement learning. For instance, Hande and Sadiwala [7], and Bai *et al*. [8] demonstrate how AI-based approaches, particularly neural networks and reinforcement learning, can significantly optimize energy consumption, route stability, and Quality of Service (QoS).

Blockchain integration emerges as another promising direction, notably in the works of Baumgartner *et al*. [4] and Ahmed and Al-Asadi [14]. These studies show that blockchain can enhance data security, route validation, and trust in decentralized, infrastructure-less environments. However, the complexity and computational overhead introduced by blockchain still require further optimization for practical MANET deployment.

From a QoS perspective, studies such as Safari and Chen *et al*. provide insights into cross-layer designs and location-aware enhancements that cater to the dynamic and unpredictable nature of

MANETs [6, 3]. These approaches effectively reduce latency and packet loss while adapting to high mobility scenarios, which is essential for real-time and critical applications.

The importance of empirical validation is underscored by Jesús-Azabal *et al*. and Affandi *et al*., who argue that simulation-based studies may not accurately reflect real-world conditions [12, 5]. This highlights a gap between theoretical development and practical deployment, pointing to the necessity for real-device testing and evaluation.

Furthermore, survey papers such as those by Oyelakin provide comprehensive overviews of existing challenges and solutions, offering valuable frameworks for future protocol development [15]. Notably, they emphasize the growing relevance of security threats, including black hole and wormhole attacks, and advocate for a tighter integration of security mechanisms into routing protocols.

Finally, mobility and clustering approaches presented by Shanthini *et al*. and Ali *et al*. demonstrate alternative paradigms where routing decisions are optimized based on group behaviour or node roles, which is particularly beneficial in highly dynamic networks like disaster zones or military operations [11, 13].

Findings

The reviewed literature highlights a wide array of innovative approaches designed to improve the efficiency, reliability, and adaptability of routing protocols in Mobile Ad Hoc Networks (MANETs). A key trend is the integration of intelligent technologies such as artificial intelligence, deep learning, and reinforcement learning to enhance energy efficiency, route stability, and Quality of Service. Blockchain is also being explored to strengthen security and trust, though its practical deployment is limited by computational demands. Several studies focus on optimizing QoS through cross-layer and mobility-aware designs, while others emphasize the importance of real-world testing over simulations. Additionally, survey-based works provide valuable overviews of routing challenges and emerging solutions, including security threats. Overall, the literature points toward a future where MANETs are increasingly adaptive, intelligent, and secure, especially in dynamic or critical environments.

Here, Table 1 presents a comparative table of the research papers provided, organized by key attributes to help analyse similarities and differences across methodologies, technologies, goals, and outcomes.

EXPECTED OUTCOMES

If neural networks are integrated into adaptive routing protocols for Mobile Ad Hoc Networks (MANETs), they can effectively enhance network performance, reliability, and efficiency is to improve routing efficiency, stability, and QoS within mobile ad hoc networks (MANETs). By utilizing Deep Deterministic Policy Gradient (DDPG) and reinforcement learning, the protocol will dynamically adjust routing decisions in real-time, enhancing path stability and reducing packet loss, particularly in high-mobility environments.

Neural networks will be employed to predict path stability and link expiration, allowing the protocol to avoid unreliable routes and maintain a more stable network. Additionally, the system will prioritize routing based on the specific QoS requirements of different applications, such as voice and video, which will optimize network performance for a variety of services. Predictive mechanisms will reduce the frequency of route discovery events, thereby minimizing control overhead and routing latency, and enhancing overall network scalability. Ultimately, the research aims to create a more efficient, reliable, and context-aware MANET, which will improve the user experience by reducing latency, boosting stability, and optimizing resource usage.

Table 1. Summary of studies included in the review.

Authors (Year)	Technology/Method	Objective	Key Contribution	Unique Aspect
Hande and Sadiwala (2024) [7]	ANN-based routing	Energy efficiency and QoS	Real-time adaptive routing	Suggests future use of deep learning
Jesús-Azabal *et al*. (2024) [12]	Real-device QoS evaluation tool	Test routing protocols on real hardware	Exposes overestimation by simulations	Focus on practical testing
Baumgartner *et al.* (2024) [4]	Blockchain + DNN	Resilient, reliable routing	Improves throughput, latency	Combines AI with decentralized tech
Ali *et al.* (2023) [13]	Deep learning clustering	Optimize data collection	Node classification and clustering	Focus on efficient data gathering
Safari (2023) [6]	Cross-layer framework	QoS-aware routing	Uses multi-layer data for routing	Cross-layer integration
Chen *et al*. [3]	Multipath adaptive routing	High-speed QoS	Selects paths dynamically	Suited for high-throughput needs
Shah *et al*. [9]	Genetic algorithm	Optimize path selection	Fitness function-based routing	Uses evolutionary approach
Bai *et al*. (2024) [8]	Deep RL routing	Balance energy and load	Improves energy use, reduces loss	Quantitative improvements shown
Danilchenko *et al*. (2023) [10]	Deep learning	Enhance routing adaptability	Applies DL to dynamic networks	Focused on dynamic routing adaptation
Vargheese *et al*. (2023) [2]	Improved multipath	Enhance QoS	Optimizes routing paths	Emphasis on path optimization
Shanthini *et al*. (2023) [11]	Cluster adaptive routing	Handle node mobility	Group adaptive mechanism	Mobility adaptation
Oyelakin (2023) [15]	Survey + analysis	Routing and security	Discusses threats and trends	Focus on IoT, ML, blockchain
Bhatia *et al*. (2022) [1]	AODV in NCS	MANETs in control systems	Applies to infrastructure-less settings	NCS integration focus
Affandi *et al*. (2023) [5]	Protocol comparison	Performance benchmarking	Compares DSDV, DSR, ZRP	Empirical evaluation of protocols

CONCLUSION

It proposes a framework for enhancing the performance of Mobile Ad Hoc Networks (MANETs) by addressing key challenges such as high mobility, path instability, and diverse application requirements. The protocol optimizes routing decisions in real-time by utilizing Deep Deterministic Policy Gradient (DDPG) and reinforcement learning, improving path stability and minimizing disruptions caused by node mobility and topology changes. The integration of neural network-based prediction models enables the proactive identification of stable paths, reducing the likelihood of link expiration and ensuring a more reliable network. Furthermore, the research introduces a context-aware QoS decision-making mechanism, which adapts routing strategies based on the specific requirements of various applications, ensuring optimal resource allocation for services like voice, video, and data. This adaptability results in a significant improvement in overall network performance. Additionally, by incorporating predictive mechanisms, the reliance on frequent route discoveries is reduced, thereby decreasing control overhead and routing latency, leading to enhanced scalability and efficiency. Ultimately, this research contributes to the development of more intelligent, efficient, and reliable MANETs, capable of meeting the evolving demands of mobile, dynamic communication environments while optimizing QoS across diverse applications. The outcomes of this study have the potential to significantly enhance user experience and network performance in scenarios with limited bandwidth, high mobility, and varying QoS requirements.

REFERENCES

1. Bhatia A, Kumar A, Jain A, Kumar A, Verma C, Illes Z, Aschilean I, Raboaca MS. Networked control system with MANET communication and AODV routing. Heliyon. 2022 Nov 1; 8(11): e11678.
2. Vargheese M, Bhatia S, Basheer S, Dadheech P. Improved Multi-Path Routing for QoS on MANET. Comput Syst Sci Eng. 2023 Jun 1; 45(3): 2521–2536.
3. Chen Z, Zhou W, Wu S, Cheng L. An adaptive on-demand multipath routing protocol with QoS support for high-speed MANET. IEEE Access. 2020 Mar 5; 8: 44760–73.
4. Baumgartner M, Papaj J, Kurkina N, Dobos L, Cizmar A. Resilient enhancements of routing protocols in MANET. Peer-to-Peer Netw Appl. 2024 Sep; 17(5): 3200–21.
5. Affandi FF, Mahiddin NA, Hashim AD. MANET performance evaluation for DSDV, DSR and ZRP. Int J Adv Technol Eng Explor. 2023 Feb 1; 10(99): 244–256.
6. Safari F, Kunze H, Ernst J, Gillis D. A novel cross-layer adaptive fuzzy-based ad hoc on-demand distance vector routing protocol for MANETs. IEEE Access. 2023 May 18; 11: 50805–22.
7. Hande JY, Sadiwala R. Optimization of energy consumption and routing in MANET using Artificial Neural Network. J Integr Sci Technol. 2024; 12(1): 718.
8. Bai J, Sun J, Wang Z, Zhao X, Wen A, Zhang C, Zhang J. An adaptive intelligent routing algorithm based on deep reinforcement learning. Comput Commun. 2024 Feb 15; 216: 195–208.
9. Shah N, El-Ocla H, Shah P. Adaptive routing protocol in mobile ad-hoc networks using genetic algorithm. IEEE Access. 2022 Dec 21; 10: 132949–64.
10. Danilchenko K, Azoulay R, Reches S, Haddad Y. Deep Learning for MANET routing. IEEE Trans Mach Learn Commun Netw. 2023 Oct 12; 1: 412–24.
11. Shanthini J, Punitha P, Karthik S. Improvisation of Node Mobility Using Cluster Routing-based Group Adaptive in MANET. Comput Syst Sci Eng. 2023 Mar 1; 44(3): 2619–2636.
12. Jesús-Azabal M, García-Alonso J, Galán-Jiménez J. Evaluating the quality of service of Opportunistic Mobile Ad Hoc Network routing algorithms on real devices: A software-driven approach. Ad Hoc Netw. 2024 Oct 1; 163: 103591.
13. Ali AA, Hussein MK, Subhi MA. A classifier-driven deep learning clustering approach to enhance data collection in MANETs. Mesop J CyberSecur. 2024 Sep 26; 4(3): 36–45.
14. Ahmed HA, Al-Asadi HA. An optimized link state routing protocol with a blockchain framework for efficient video-packet transmission and security over mobile ad-hoc networks. J Sens Actuator Netw. 2024 Mar 11; 13(2): 22.
15. Oyelakin AM. Approaches for solving routing and security issues in mobile Ad-Hoc Networks (MANETS): A Review. Journal of Information Technology and Computing. 2023 Dec 30; 4(2): 20–30.

