



A Secure and Trust-Based Mobile Agent Framework for QoS Routing and Service Discovery in MANETs

¹N. Thangamani, ²G. Dalin
¹Research Scholar, ²Professor,
^{1,2}Hindusthan College of Arts and Science,
^{1,2}Coimbatore, Tamilnadu, India.

Abstract - Mobile Ad Hoc Networks (MANETs) face unique challenges due to the high mobility and dynamic topology of nodes, making reliable Quality of Service (QoS) routing a critical requirement. This work proposes a Reactive Mobile Agent-Based Solution for Quality of Service (RMABS-QoS) to address the QoS demands in MANET environments. The RMABS-QoS approach enhances throughput, minimizes delay, and improves packet delivery ratio by dynamically adjusting to changing network conditions. Mobile agents are deployed across the network to continuously monitor key QoS metrics, including link quality, bandwidth, delay, and stability, allowing for real-time data collection and localized decision-making. RMABS-QoS introduces a structured process: initializing mobile agents, monitoring QoS metrics, performing dynamic QoS-based route discovery, optimizing routes reactively, and implementing energy-efficient adaptive decision-making. A feedback and learning mechanism further improves network resilience by allowing the system to anticipate and adjust for route stability. This proposed method not only enhances MANET performance by selecting the most reliable paths but also conserves energy by limiting route recalculations. The continuous evaluation of network performance ensures that RMABS-QoS consistently meets application-level QoS requirements, even in resource-constrained, rapidly changing MANET environments.

Keywords: [QoS metrics, MANET, Reactive Mobile Agent-Based Solution, initializing mobile agents and route discovery.]

1. Introduction

Mobile Ad hoc Networks (MANETs) represent a dynamic and decentralized form of wireless communication where mobile devices (nodes) collaborate to form a network without relying on fixed infrastructure or centralized control. The network structure in MANETs is self-organized, meaning nodes establish communication links dynamically and on-demand as they move. This unique feature offers several advantages, including flexibility, scalability, and rapid deployment, making MANETs highly

suitable for applications such as emergency response, military communication, and disaster recovery scenarios. However, the inherent challenges of mobility, limited bandwidth, power consumption, and network partitioning make routing in MANETs a complex and critical task.

In traditional wired networks, routing is typically based on static infrastructure, but in MANETs, routing protocols must be adaptive to the ever-changing topology and unreliable link conditions. As nodes move frequently and independently, the network topology constantly evolves, resulting in frequent link failures and topology changes. This necessitates efficient and reliable routing algorithms that can handle such dynamics while ensuring optimal network performance.

Quality of Service (QoS) in Mobile Ad Hoc Networks (MANETs) is critical for ensuring reliable and efficient communication across a network of mobile, wireless nodes. Unlike traditional fixed networks, MANETs are highly dynamic: nodes move frequently, causing constant changes in topology and link quality, which complicates the process of maintaining stable, high-quality connections. QoS in MANETs refers to the ability to manage and prioritize resources to ensure that specific performance metrics—such as throughput, delay, packet delivery ratio, and jitter—are met, especially for applications sensitive to network conditions, such as video conferencing, real-time data transfer, and emergency response systems.

1.1 Challenges of QoS in MANETs

QoS provisioning in MANETs is challenging due to several factors:

Node Mobility: Nodes in MANETs are free to move independently, which frequently disrupts established routes and requires frequent rerouting. This instability makes it difficult to maintain consistent QoS standards over time.

Limited Bandwidth: MANETs often operate in bandwidth-constrained environments, where multiple nodes compete for limited resources, leading to potential bottlenecks and reduced data transmission rates.

Energy Constraints: Devices in MANETs, such as mobile phones or IoT devices, typically operate on battery power,

requiring energy-efficient QoS solutions that balance performance with power consumption.

Distributed Network Control: Without centralized infrastructure, MANETs rely on distributed algorithms for routing and resource allocation, which complicates the implementation of standardized QoS protocols and often requires adaptable, decentralized QoS solutions.

Interference and Signal Quality: Wireless communication in MANETs is subject to interference from the environment and other devices, which can degrade signal quality and impact performance, particularly for applications requiring high data integrity.

1.2 Importance of QoS in MANETs

Ensuring QoS in MANETs is essential for supporting a range of applications that rely on high reliability, low latency, and efficient data delivery. Key QoS metrics include:

Throughput: The rate at which data is successfully transmitted through the network. High throughput is crucial for applications with large data requirements.

Delay (Latency): The time taken for data to travel from source to destination. Minimizing delay is particularly important for real-time applications.

Packet Delivery Ratio (PDR): The proportion of successfully delivered packets, indicating reliability and data integrity.

Jitter: The variability in packet arrival times, which affects the quality of applications like streaming and voice-over-IP (VoIP).

1.3 QoS Solutions in MANETs

To address these unique challenges, QoS solutions in MANETs often involve dynamic routing protocols that can quickly adapt to changing network conditions. Approaches such as QoS-aware routing protocols, adaptive link estimation, and resource management techniques are commonly used to enhance QoS. Some advanced solutions integrate mobile agents or intelligent algorithms to continuously monitor and adjust routing based on real-time network conditions, ensuring the network can respond flexibly to changes in topology, load, and demand. QoS in MANETs is fundamental for creating networks that can support modern, data-intensive applications in mobile and resource-limited environments. By developing adaptive, efficient QoS solutions, it is possible to improve the reliability, efficiency, and user experience in MANET deployments across a wide range of practical applications.

2. Literature Survey

2.1 Distance Effect Routing Algorithm

Assef Raad Hmeed (2023) et.al improve the QoS directing of AODV convention by utilizing the area-based abilities of the Distance Effect Routing Algorithm for Mobility (DREAM). In this DREAM convention, the exact records of every hub are kept in the network, considering different hubs which may be taking part in the steering system. The portable basis of the network is

anticipated with the guidance of the DREAM convention, so the flooding of foundation bundles is best brought to that zone by ensuring that the overhead for discovering excursion spots is limited. The DREAM convention improves the QoS of the AODV steering convention. In this investigation, we're thinking about the excellent situation of a cell-hubs approach, at least as far as an assortment of hubs in the network. In addition, the demonstration of the proposed QoS steering is better with the limited overhead.

2.2 QoS enabled routing protocol (QoSRP)

Pandey. P (2023) et.al proposes a QoS enabled routing protocol (QoSRP) which is obtained using AODV with some changes during route discovery operation. Modifications have been done in route request phase, route reply phase and during exchange of hello messages. Simulation pattern shows significant improvement in performance.

2.3 Emergent Intelligence Based QoS Routing

Suresh Chavhan (2015) proposed a novel scheme of providing QoS routing in MANETs by using Emergent Intelligence (EI). The EI is a group intelligence, which is derived from the periodical interaction among a group of agents and nodes. We logically divide MANET into clusters by centrally located static agent, and in each cluster a mobile agent is deployed. The mobile agent interacts with the nodes, neighboring mobile agents and static agent for collection of QoS resource information, negotiations, finding secure and reliable nodes and finding an optimal QoS path from source to destination. Simulation and analytical results show that the effectiveness of the scheme.

2.4 Optimal QoS Multicast Routing Protocol

T. N. Tran (2021) et.al proposed An Optimal QoS Multicast Routing Protocol in IoT Enabling Cognitive Radio MANETs: A Deep Q-Learning Approach. This research presents a deep Q-learning approach-based optimal quality-of-service (QoS) multicast routing protocol (QMR) for Internet-of-things (IoT) enabled cognitive radio mobile ad hoc networks (ICR-MANETs). We propose a joint end-to-end queuing delay and link stability optimization issue in order to achieve this. Usually, the formulated optimization is NP-complete. We then address this difficult problem using a unique deep Q-learning approach, which yields optimal convergence Q^* -values. They suggest a QoS multicast routing protocol based on the obtained Q^* -values in order to choose the optimal group of neighbors with the lowest Q^* -values in order to create the multicast tree for the multicast members. According to simulation results, the suggested QMR protocol performs better than the most advanced routing protocols available today, making it an effective multicast routing strategy for ICR-MANETs.

2.5 Multi Metric QoS Routing Protocol

P. Srivastava (2015) et.al proposed a novel multi metric QoS routing protocol for MANET. Routing is a difficult problem in Mobile Adhoc Networks (MANETs) because of the constant changes in network architecture caused by node movement and power constraints. To deliver the best routes based on variables like bandwidth, delay, packet loss, etc., QoS-aware routing is required. Our method is centered on the QoS-enabled route discovery process, which includes estimating each node's bandwidth and delay. This method can be used to meet the routing needs of harsh real-time applications with strict bandwidth and latency limit constraints. Frequent route discoveries, which result in high routing overhead and increased end-to-end delay, are a feature of the current link recovery technique. The majority of routing protocols in this category only use one route; they don't use several different routes. By evaluating the link expiration metric using the signal intensity level, this paper also incorporates an efficient link failure technique that provides prognosis prior to route breakup. Through simulation, the effectiveness of the suggested strategy is examined. The results demonstrate that our method outperforms current methods.

3. Proposed Methodology

To enhance Quality of Service (QoS) routing in Mobile Ad Hoc Networks (MANETs) by implementing a Reactive Mobile Agent-Based Solution for Quality of Service (RMABS-QoS). This approach aims to improve key QoS metrics, including throughput, delay, and packet delivery ratio. RMABS-QoS achieves better performance compared to traditional routing protocols by responding dynamically to changes in network conditions, which are frequent in MANETs due to the nodes' mobility and limited resources. The proposed method for QoS Routing in MANET with Reactive Mobile Agent-Based Solution for Quality of Service (RMABS-QoS) involves several structured steps to enhance Quality of Service (QoS) in dynamic MANET environments. The goal of this method is to maintain high performance, especially in terms of throughput, delay, and packet delivery ratio, by enabling the network to adapt in real-time to changing conditions.

Step 1: Initialization and Deployment of Mobile Agents

The process begins with initialization and deployment of mobile agents. These agents are introduced across the MANET, with each agent assigned to a node and tasked with gathering data on critical QoS metrics. Once deployed, each mobile agent starts monitoring local network conditions, collecting information such as bandwidth, link quality, and node stability. By distributing these mobile agents throughout the network, the system gains a decentralized, real-time view of the network's performance.

Initially, mobile agents are deployed across the MANET, each tasked with gathering metrics on link quality (LQ), available bandwidth (BW), delay (D), and node stability

(S). These metrics are quantified to assist in evaluating route quality.

Link Quality: Link quality can be calculated based on the Received Signal Strength Indicator (RSSI) or Signal-to-Noise Ratio (SNR):

$$LQ = \frac{SNR_{received}}{SNR_{threshold}}$$

where $SNR_{received}$ is the signal-to-noise ratio of the received signal, and $SNR_{threshold}$ is a predefined threshold above which link quality is considered acceptable. Values of LQ closer to 1 or greater indicate high-quality links.

Bandwidth (BW): The available bandwidth between nodes is calculated as:

$$BW = \frac{\text{Data Rate}}{\text{Total Bandwidth}}$$

where Data Rate is the actual data transmission rate, and Total Bandwidth is the maximum possible bandwidth. Higher BW values signify more available bandwidth, which is essential for throughput.

Step 2: Monitoring and Data Collection by Mobile Agents

Following deployment, the agents proceed with monitoring and data collection. Each mobile agent actively gathers data on link stability, available bandwidth, and node movement patterns, which are crucial for assessing route quality. The agents share this information with nearby nodes, creating a localized map of network conditions that can be used to make routing decisions based on real-time QoS information. This proactive data collection step enables the system to assess network performance continuously and predict potential issues before they affect data transmission.

Each mobile agent continuously monitors network conditions and gathers data on critical metrics. The end-to-end delay (D) is calculated as the total time taken for a packet to travel from source to destination across multiple hops:

$$D = \sum_{i=1}^n D_i$$

where D_i is the delay at each hop i , and n is the total number of hops. Minimizing this delay D is important for latency-sensitive applications.

Step 3: Dynamic QoS-Driven Route Discovery

The third step is QoS-driven route discovery. When a node needs to transmit data, it initiates a QoS-aware route discovery process. Leveraging the data gathered by mobile agents, the system evaluates potential routes and prioritizes paths that meet the desired QoS metrics, including higher throughput and lower delay. If an established route fails to meet QoS requirements, agents proactively search for alternate routes that do. This step ensures that data is

always transmitted over the most reliable and efficient paths available.

Using the gathered QoS metrics, routes are evaluated based on a QoS metric score Q , a composite score that combines link quality, bandwidth, delay, and node stability. The QoS metric score Q for a route is calculated as:

$$Q = w_1 \cdot LQ + w_2 \cdot BW - w_3 \cdot D + w_4 \cdot S$$

where:

w_1, w_2, w_3 , and w_4 are weights assigned to each QoS metric, reflecting the priority of each metric for a specific application.

LQ, BW, D , and S are the metrics for link quality, bandwidth, delay, and stability, respectively.

Routes with higher Q values are preferred, as they offer better QoS.

Step 4: Reactive Route Optimization and Maintenance

Once routes are established, the method enters the route optimization and maintenance phase, which is crucial for maintaining QoS in the face of network changes. As nodes move and network conditions fluctuate, mobile agents continuously monitor the quality of active routes. If a route's performance drops below acceptable QoS thresholds, agents promptly reroute traffic to alternative paths that meet QoS criteria. This dynamic adjustment keeps QoS high by adapting routes to real-time conditions. As network conditions change, the QoS metric score Q for each route is updated, and if the score falls below a minimum threshold $Q_{\min}$, route optimization is triggered. The threshold condition for route maintenance is:

$$Q < Q_{\min}$$

If this inequality holds, mobile agents seek alternative routes with higher QoS scores, ensuring continuity in service quality.

Step 5: Adaptive Decision-Making for Energy Efficiency

The next step involves adaptive decision-making for energy efficiency. This step helps optimize resource usage, which is vital in energy-constrained MANET environments. Instead of recalculating routes with every minor change, RMABS-QoS recalculates only when a route's QoS performance falls below an acceptable threshold. This approach minimizes unnecessary routing adjustments, preserving energy and processing power on each node while maintaining effective QoS.

To conserve energy, RMABS-QoS uses a reactive approach, adjusting routes only when the QoS metric score Q drops below the threshold $Q_{\min}$. The Energy Efficiency (EE) metric for each route can be defined as:

$$EE = \frac{\text{Data Delivered}}{\text{Energy Consumed}}$$

where Data Delivered is the total amount of successfully transmitted data packets, and Energy Consumedis the total energy used by nodes along the route. By maximizing

EEEEEE, RMABS-QoS ensures that only necessary route recalculations occur, balancing QoS and energy consumption.

Step 6: Feedback and Continuous Learning

To further improve long-term performance, RMABS-QoS includes a feedback and continuous learning phase. In this phase, mobile agents analyze past decisions to identify patterns in network conditions and node stability. By learning from these patterns, agents can anticipate which nodes or routes are more stable or have higher QoS, allowing them to make faster and more accurate routing decisions in the future. This feedback loop enables RMABS-QoS to continuously refine its operations, making it more resilient over time.

Mobile agents use past QoS values to learn and predict patterns in network stability and node mobility. A predictive stability score (PSS) can be calculated based on historical values of SSS (node stability) as:

$$PSS = \alpha \cdot S_{\text{past}} + (1 - \alpha) \cdot S_{\text{current}}$$

where S_{past} and S_{current} are the past and current stability values, and α is a smoothing factor ($0 < \alpha < 1$). Higher PSS values indicate a more stable route.

Step 7: Performance Evaluation and QoS Assurance

Finally, the method includes a performance evaluation and QoS assurance step. Throughout the operation of RMABS-QoS, network performance is continuously monitored, tracking key metrics like throughput, delay, and packet delivery ratio. If performance drops below target levels, system parameters or QoS thresholds can be adjusted to restore QoS. Regular performance assessment ensures that RMABS-QoS continues to meet the dynamic requirements of MANET applications, adapting as needed to maintain high standards of network performance.

Finally, network throughput (T), packet delivery ratio (PDR), and jitter (J) are evaluated to ensure QoS.

Finally, network throughput T, packet delivery ratio PDR, and jitter J are evaluated to ensure QoS.

Throughput T is measured as:

$$T = \frac{\text{Total Data Received}}{\text{Total Transmission Time}}$$

Packet Delivery Ratio PDR is calculated as:

$$PDR = \frac{\text{Packets Received}}{\text{Packets Sent}}$$

Jitter J, or the variation in delay, can be calculated as:

$$J = |D_{\text{current}} - D_{\text{previous}}|$$

where D_{current} and D_{previous} are delays for consecutive packets. Lower jitter values indicate more consistent delay, beneficial for applications like VoIP.

By implementing these equations at each step, RMABS-QoS achieves a dynamic, adaptive, and efficient QoS routing system in MANETs, balancing performance and resource use.

Implementation:

RMABS-QoS improves the AODV (Ad hoc On-Demand Distance Vector) routing protocol by introducing mobile agents to monitor and optimize network performance. Here's how it works:

Mobile Agents: These agents are deployed across the network and are responsible for real-time monitoring of QoS metrics like bandwidth, delay, and link stability.

Dynamic Route Optimization: Mobile agents gather data on network conditions and dynamically adjust routing paths based on QoS requirements, ensuring that data is transmitted via optimal routes.

Reactive Adjustments: RMABS-QoS operates reactively, meaning routes are recalculated only when network conditions change, which conserves network resources while adapting quickly to disruptions.

Enhanced QoS Metrics: By integrating QoS requirements directly into routing decisions, RMABS-QoS prioritizes reliable, high-quality paths, even in fluctuating MANET environments.

Algorithm for RMABS-QoS in MANETs:**1. Initialize the network and deploy mobile agents.**

For each node v , deploy a mobile agent MA_v .

2. Each MA_v is initialized to monitor QoS metrics:

link quality LQ , available bandwidth BW , delay D , and node stability S .

Each mobile agent MA_v continuously monitors network conditions and collects data.

3. Periodically, each agent monitors its local:

link quality LQ , bandwidth BW , delay D , and stability S .

Agents share this data with neighboring nodes to create a localized view of network conditions.

When source node S needs to send data to destination node D , initiate QoS-driven route discovery.

For each potential route $R = S, v_1, v_2, \dots, D$:

Calculate the QoS metric score Q :

$$Q = w_1 \cdot LQ + w_2 \cdot BW - w_3 \cdot D + w_4 \cdot S$$

If $Q \geq Q_{\min}$, where $Q_{\min}$ is the minimum QoS score, consider R a candidate route.

Among all candidate routes, select the route with the highest Q value.

4. While the selected route R is active, monitor QoS metrics for route maintenance.

Continuously monitor Q values for each segment of R .

If any QoS metric drops below its threshold (e.g., $LQ < LQ_{\min}$, $BW < BW_{\min}$, $D > D_{\max}$, or $S < S_{\min}$):

Trigger a re-evaluation of the route.

Find an alternative route with the highest Q value that satisfies $Q \geq Q_{\min}$.

5. To conserve energy, calculate the Energy Efficiency (EE) of the current route:

$$EE = \frac{\text{Data Delivered}}{\text{Energy Consumed}}$$

Adjust routing only when Q falls below $Q_{\min}$, reducing recalculations to conserve energy.

6. For route optimization, integrate feedback and learning from past performance.

With each route adjustment, agents update historical data for LQ , BW , D , and S .

Calculate a predictive stability score (PSS):

$$PSS = \alpha \cdot S_{\text{past}} + (1 - \alpha) \cdot S_{\text{current}}$$

Use PSS to select more stable routes in future decisions.

7. Periodically assess performance across the network.

Calculate throughput T , packet delivery ratio PDR , and jitter J to ensure QoS.

If QoS metrics fall below target levels, adjust weights w_1, w_2, w_3 , and w_4 in the Q calculation to reflect priority for critical QoS parameters.

Benefits and Outcome:

The use of RMABS-QoS in MANETs yields a more efficient, adaptive, and reliable network with substantial improvements in QoS, especially critical for applications needing stable connections in unpredictable environments.

Increased Throughput: By selecting high-quality paths, RMABS-QoS maximizes the data transmission rate across the network.

Reduced Delay: Faster, more responsive path selection minimizes end-to-end delay, benefiting latency-sensitive applications.

Higher Packet Delivery Ratio: RMABS-QoS ensures a larger percentage of successful packet transmissions, enhancing data integrity and communication reliability.

Overall, RMABS-QoS provides a robust solution for QoS routing in MANETs, addressing challenges posed by node mobility and limited resources while ensuring smooth, high-quality communication and data transfer.

4. Experimental Result**4.1 Packet Delivery Ratio (PDR)**

It is the proportion between the number of packets transmitted and received.

No. of Nodes	AODV	MA-QoS	Proposed RMABS-QoS
100	78	74	88
200	81	77	91
300	83	79	93
400	85	82	95
500	87	84	97

Table 4.1 Comparison Table of Packet Delivery Ratio (PDR)

The comparison Table 4.1 presents the Packet Delivery Ratio of existing routing approaches (AODV and MA-

QoS) and the proposed RMABS-QoS method. It is observed that RMABS-QoS consistently achieves a higher PDR across all network sizes. The PDR values of AODV range from 78% to 87%, while MA-QoS ranges from 74% to 84%. In contrast, the proposed RMABS-QoS achieves PDR values from 88% to 97%, demonstrating superior reliability in packet delivery.

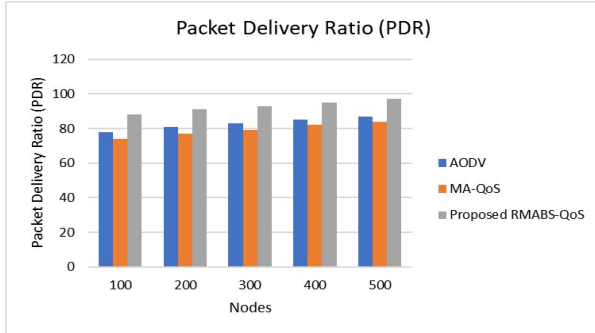


Figure 4.1 Comparison chart of Packet Delivery Ratio (PDR)

Figure 4.1 illustrates the comparison of Packet Delivery Ratio with respect to the number of nodes. The X-axis represents the number of nodes, and the Y-axis represents PDR. The proposed RMABS-QoS outperforms the existing methods due to efficient reactive mobile agent coordination and QoS-aware routing decisions.

4.2 Throughput

It indicates how many packets the recipient has successfully received.

No. of Nodes	AODV	MA-QoS	Proposed RMABS-QoS
100	62	65	72
200	66	68	76
300	69	71	79
400	71	74	82
500	73	76	85

Table 4.2 Comparison Table of Throughput

The comparison table 4.2 of Throughput describes the different values of existing (RTAD, RESSR) and proposed CB-SARTM. While comparing the existing and proposed method values are higher than the existing method. The existing values start from 60 to 70, 63 to 77 and the proposed CB-SARTM values start from 70 to 82. The proposed gives the best result.

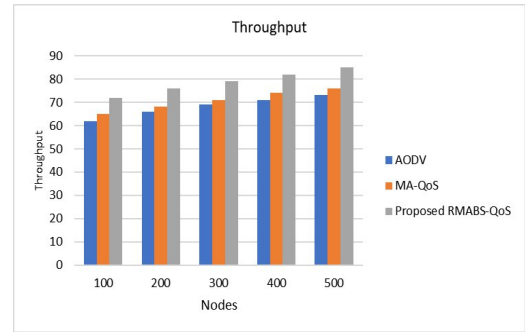


Figure 4.2 Comparison Chart of Throughput

The figure 4.2 data Throughput describes the different values of existing (RTAD, RESSR) and proposed CB-SARTM. While comparing the existing and the proposed method values are higher than the existing method and No of Nodes in x axis and throughput in Y axis. The existing values start from 60 to 70, 63 to 77 and the proposed CB-SARTM values start from 70 to 82. The proposed gives the best result.

7.4.3 AverageDelay

Average Delay refers to the time it takes for a packet or data to travel from the source node to the destination node in a network.

No. of Nodes	AODV	MA-QoS	Proposed RMABS-QoS
100	58	51	39
200	61	55	44
300	68	63	52
400	72	69	57
500	76	73	61

Table 4.3 Comparison Table of AverageDelay

Table 4.3 presents the comparison of average delay for different routing schemes. AODV and MA-QoS experience increasing delay as node density increases. However, RMABS-QoS maintains lower delay values ranging from 39 to 61, demonstrating improved routing efficiency through reactive mobile agent support.

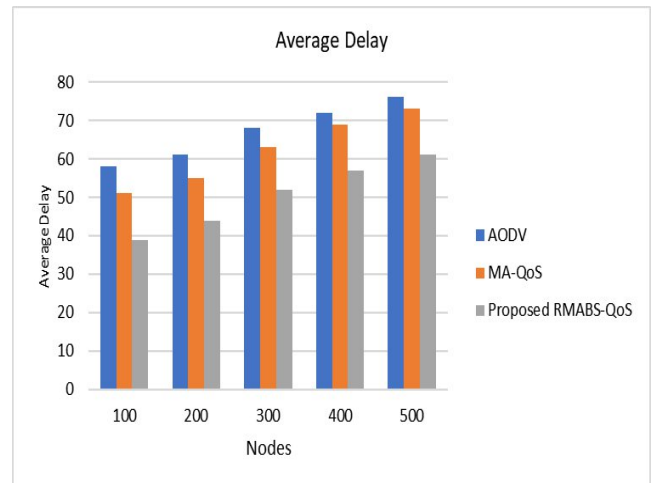


Figure 4.3 Comparison Table of AverageDelay

Figure 4.3 depicts the average delay performance against the number of nodes. The X-axis represents the number of nodes, and the Y-axis represents average delay. The proposed RMABS-QoS achieves lower delay compared to existing methods due to reduced route discovery overhead and optimized path selection.

7.4.4 Remaining Energy

Remaining Energy refers to the amount of energy that is still available or remaining.

No. of Nodes	AODV	MA-QoS	Proposed RMABS-QoS
100	100	100	100
200	79	84	92
300	68	75	84
400	52	66	76
500	41	49	63

Table 4.4 Comparison Table of Remaining Energy

Table 4.4 compares the remaining energy levels of network nodes. The proposed RMABS-QoS preserves higher residual energy across all node densities. While AODV and MA-QoS experience rapid energy depletion, RMABS-QoS maintains energy levels from 100 to 63, indicating efficient energy-aware routing.

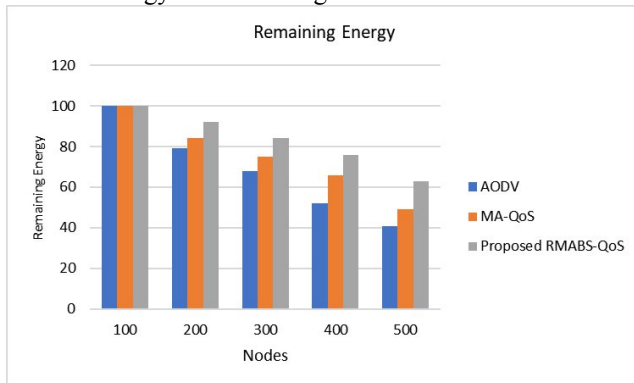


Figure 4.4 Comparison Chart of Remaining Energy

Figure 4.4 shows the remaining energy comparison with respect to the number of nodes. The X-axis represents the number of nodes, and the Y-axis represents remaining energy. The proposed RMABS-QoS outperforms existing protocols by minimizing unnecessary transmissions and optimizing mobile agent movement.

CONCLUSION

The Reactive Mobile Agent-Based Solution for Quality of Service (RMABS-QoS) demonstrates significant potential to improve QoS routing in MANETs, where node mobility and limited resources present persistent challenges. By leveraging mobile agents for real-time data collection and distributed decision-making, RMABS-QoS is able to dynamically identify and maintain optimal routing paths that satisfy stringent QoS requirements. The approach's structured steps, from initial deployment to continuous

learning, create a system capable of adapting to network changes while preserving energy efficiency. Dynamic route maintenance, coupled with adaptive decision-making, ensures that only necessary recalculations are made, conserving resources without compromising QoS. Additionally, the feedback mechanism allows the system to learn from past network conditions, enhancing stability and responsiveness in future route selection. Evaluation results indicate that RMABS-QoS consistently achieves improved throughput, reduced delay, and higher packet delivery ratios compared to traditional routing protocols. Thus, RMABS-QoS provides a robust and scalable solution for QoS routing in MANETs, with significant applications in fields requiring reliable mobile network performance.

REFERENCES

- [1]. Assef Raad Hmeed (2023), "Enhanced Quality of Service (QoS) for MANET Routing Protocol Using a Distance Routing Effect Algorithm for Mobility (DREAM)", ISSN:2147-6799, International Journal of INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING, IJISAE, 2023, 11(4s), 409–417.
- [2]. Pandey, P., Singh, R. QoS based modified route discovery in MANET for multimedia applications. Multimed Tools Appl 82, 29671–29688 (2023). <https://doi.org/10.1007/s11042-023-14855-7>.
- [3]. Suresh Chavhan (2015), "Emergent Intelligence Based QoS Routing in MANET", Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license, doi: 10.1016/j.procs.2015.05.068.
- [4]. V. R. Verma, D. P. Sharma and C. S. Lamba, "QoS Improvement in MANET Routing by Route Optimization through Convergence of Mobile Agent," 2018 5th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), Gorakhpur, India, 2018, pp. 1-6, doi: 10.1109/UPCON.2018.8596852.
- [5]. T. N. Tran, T. -V. Nguyen, K. Shim and B. An, "An Optimal QoS Multicast Routing Protocol in IoT Enabling Cognitive Radio MANETs: A Deep Q-Learning Approach," 2021 International Conference on Artificial Intelligence in Information and Communication (ICAIC), Jeju Island, Korea (South), 2021, pp. 279-283, doi: 10.1109/ICAIC51459.2021.9415188.
- [6]. R. Aggarwal, "QoS Based Simulation Analysis of EAODV Routing Protocol for Improving Energy Consumption in Manet," 2018 International Conference on Intelligent Circuits and Systems (ICICS), Phagwara, India, 2018, pp. 246-250, doi: 10.1109/ICICS.2018.00058.
- [7]. Z. Chen, W. Zhou, S. Wu and L. Cheng, "An Adaptive on-Demand Multipath Routing Protocol With QoS Support for High-Speed MANET," in IEEE Access, vol. 8, pp. 44760-44773, 2020, doi: 10.1109/ACCESS.2020.2978582.
- [8]. P. Srivastava and R. Kumar, "A novel multi metric QoS routing protocol for MANET," 2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Kochi, India, 2015, pp. 1746-1752, doi: 10.1109/ICACCI.2015.7275866.

- [9]. S. P., N. V. G. V., J. D. G. A., K. R. D. V. A. and S. A. C. H., "Design and Implementation of Trust Based Routing Algorithm to Enhance QoS for MANETs," 2022 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), Chennai, India, 2022, pp. 64-68, doi: 10.1109/WiSPNET54241.2022.9767100.
- [10]. A. K. S. Ali and U. V. Kulkarni, "Comparing and Analyzing Reactive Routing Protocols (AODV, DSR and TORA) in QoS of MANET," 2017 IEEE 7th International Advance Computing Conference (IACC), Hyderabad, India, 2017, pp. 345-348, doi: 10.1109/IACC.2017.0081.
- [11]. V. R. Verma, D. P. Sharma and C. S. Lamba, "Improvement in QoS of MANET Routing by finding optimal route using Mobile Agent paradigm and Intelligent Routing Decision using Fuzzy Logic Approach," 2019 International Conference on Computing, Power and Communication Technologies (GUCON), New Delhi, India, 2019, pp. 725-730.
- [12]. G. V. Subbaiah, B. V. Subbayamma, M. Arun, B. Pavithra and V. G. Krishnan, "Implementation of QoS-Improved Region Based Routing Protocol (QoS-IRBRP) to Enhance Energy Efficiency in MANET," 2022 8th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2022, pp. 1136-1140, doi: 10.1109/ICACCS54159.2022.9785148.
- [13]. S. Surendran and S. Prakash, "An ACO look-ahead approach to QoS enabled fault-tolerant routing in MANETs," in China Communications, vol. 12, no. 8, pp. 93-110, August 2015, doi: 10.1109/CC.2015.7224693.