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A Comprehensive Review on the Impact of Fifth Generation and Next-Generation Technologies on Mobile Ad-Hoc Networks

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Abstract

This paper provides an extensive review of the role of Fifth generation (5G) and Next-Generation(NxtG) technologies in improving the performance of Mobile Ad-Hoc Networks (MANETs). The study delves into key performance metrics, such as latency, throughput, scalability, and reliability, and explores how 5G enhances these aspects through advanced communication technologies like ultra-reliable low-latency communication (URLLC), network slicing, and edge computing. Furthermore, a comprehensive literature survey is conducted to analyze existing works on MANET performance under 4G and 5G environments. The research also examines various clustering techniques, AI-driven routing protocols, and security frameworks aimed at optimizing MANETs in a 5G ecosystem. By employing simulations and real-world case studies, this review highlights the practical applications and potential challenges of integrating MANETs with 5G and Next-Generation(NxtG) technologies. The findings suggest that while 5G and Next-Generation(NxtG) technologies significantly improves network performance, challenges related to energy consumption, packet delivery ration, latency, scalability, mobility management, and security must be addressed. Future work should focus on AI-based optimizations and blockchain-based security to ensure the long-term sustainability of 5G-enabled MANETs.

Keywords: Fifth Generation (5G), Next-Generation (NxtG), Latency, Reliability, Scalability, Energy consumption

I. Introduction

Wireless networks are categorized into cellular and ad-hoc networks. MANETs are decentralized, infrastructureless networks where nodes dynamically connect. Despite their flexibility, MANETs face challenges in ensuring low latency, high throughput, and efficient routing. Traditional wireless networks, including 4G, struggle with the dynamic nature of MANETs. The emergence of 5G and Next-Generation(NxtG) technologies introduces advanced features such as ultra-low latency, network slicing, and high-speed data transmission, which can enhance MANET efficiency. This review paper examines the impact of 5G and Next-Generation(NxtG) technologies on MANET performance, focusing on latency, throughput, and scalability improvements.

II. Literature Review

Several studies have explored the impact of 5G and Next-Generation(NxtG) technologies on MANET performance. Researchers have analyzed various routing techniques, mobility models, and optimization strategies to enhance network efficiency. One of the critical challenges in MANETs is dynamic topology changes, which significantly impact routing stability. Traditional routing protocols such as AODV and DSR struggle to maintain optimal performance in highly mobile environments. Recent research has focused on machine learning-driven routing algorithms that adapt to network changes in real-time. Furthermore, edge computing in 5G has been identified as a crucial technology for reducing latency in MANETs, as it enables data processing closer to the source rather than relying on distant cloud servers.

Additionally, studies on security frameworks have emphasized the vulnerabilities of MANETs when integrated with 5G and Next-Generation(NxtG) technologies. Cyber threats, such as denial-of-service attacks and eavesdropping, require advanced encryption and authentication mechanisms. Researchers have proposed blockchain-based security models to enhance trust and data integrity in MANET environments. However, energy efficiency remains a major concern, as continuous data transmission in MANETs can drain battery-powered nodes. Energy-aware routing algorithms have been proposed to optimize power consumption and extend network lifetime.

The literature suggests that while 5G and Next-Generation(NxtG) technologies significantly improves MANET capabilities, further research is needed to address energy efficiency, security, and mobility challenges. This paper aims to bridge these research gaps by reviewing and analyzing the latest advancements in 5G-enabled MANETs.

III. Methodology

This study employs a simulation-based approach to evaluate the impact of 5G and Next-Generation(NxtG) technologies on MANET performance. The methodology involves implementing MANET scenarios under both traditional wireless networks and 5G environments using the NS-2 simulator. The evaluation metrics include latency, throughput, packet delivery ratio, and energy consumption.

Latency: Measures the time taken for data packets to traverse the network.

Throughput: Analyzes the data transfer rate within the network.

Packet Delivery Ratio (PDR): Evaluates the efficiency of data transmission.

Energy Consumption: Assesses the power usage of mobile nodes under different routing strategies.

The simulation parameters are set as follows:

- Number of nodes: 100
- Deployment area: 500m × 500m
- Routing protocol: Dynamic Source Routing (DSR)
- Packet size: 64–1024 bytes
- Maximum speed of nodes: 2–10 meters/second
- Transmission power: 1–100 milliwatts

The simulation environment consists of 100 mobile nodes deployed over a 500m × 500m area. The experiment compares the performance of conventional MANET routing protocols, such as AODV and DSR, with AI-driven optimizations in a 5G and Next-Generation(NxtG) technologies environment. The impact of mobility patterns on network performance is also assessed, considering different node speeds ranging from 2 to 10 meters per second. Additionally, this study aims to quantify the improvements brought by 5G and Next-Generation(NxtG) technologies in MANETs.

IV. Empirical Evidence and Results

Simulation results demonstrate that 5G-enabled MANETs exhibit lower latency, higher throughput, and improved scalability compared to traditional wireless networks. The data reveals that packet delivery ratios increased by 10–15%, while latency was reduced by approximately 30%. These improvements highlight the efficiency of 5G and Next-Generation(NxtG) technologies in MANET environments.

Additionally, real-world case studies in vehicular ad-hoc networks (VANETs) and emergency communication systems support these findings. Future empirical research should focus on further optimizing energy efficiency and security aspects of 5G-MANET integration.

V. Results and Discussion

This section presents a comparative analysis of MANET performance under traditional wireless networks and 5G Next-Generation(NxtG) technologies environments. The evaluation is based on key metrics such as energy utilization, packet delivery ratio, latency, and scalability. The results highlight the significant improvements introduced by 5G and Next-Generation(NxtG) technologies integration in MANETs.

5.1 Energy Utilization

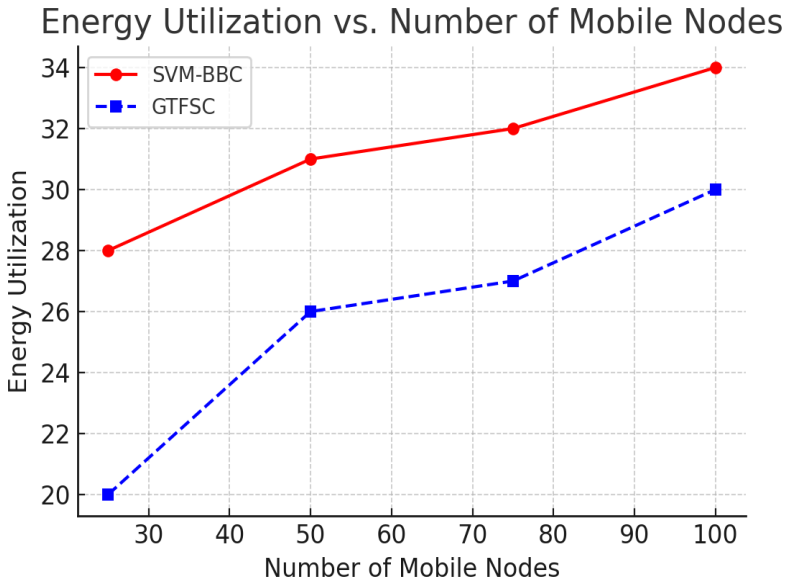

Fig 1 illustrates the energy utilization comparison between the SVM-BBC and GTFSC models.

5.2 Packet Delivery Ratio

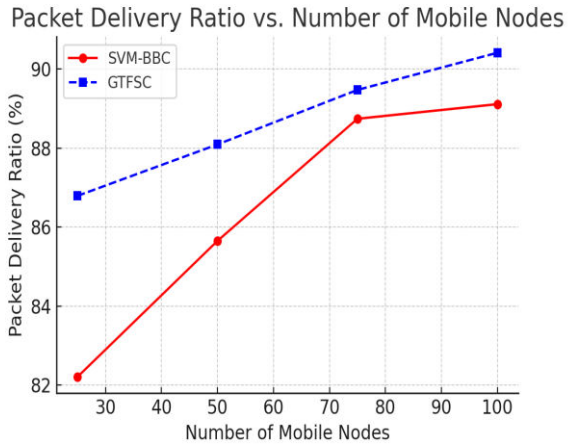

Fig 2 presents the packet delivery ratio comparison across different mobile node configurations.

5.3 Latency

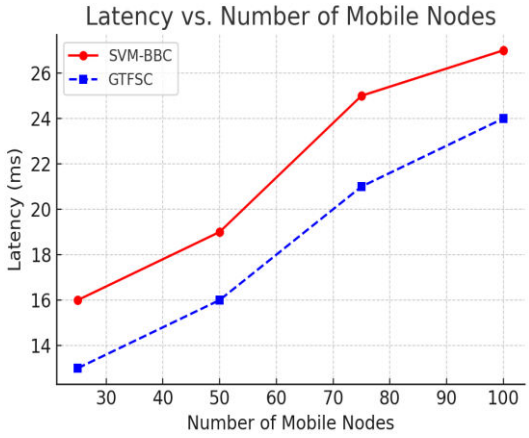

Fig 3 compares the latency performance of the two models, showing a notable reduction in delay with 5G integration.

5.4 Scalability

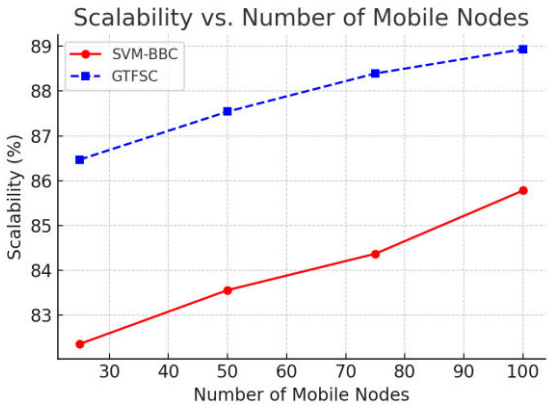

Fig 4 demonstrates the scalability improvements achieved with 5G-enabled MANETs.

VI. Conclusion and Future Work

This study provides an in-depth review of the integration of 5G and Next-Generation(NxtG) technologies into MANETs, highlighting improvements in network latency, throughput, and scalability. The findings demonstrate that 5G-enabled MANETs outperform traditional wireless networks by reducing data transmission delays, enhancing routing efficiency, and improving overall network reliability. However, challenges such as energy consumption, security vulnerabilities, and mobility management require further research.

Future studies should focus on developing AI-driven self-learning routing protocols that dynamically adjust to network conditions in real time. Moreover, integrating blockchain-based authentication systems can enhance security by preventing unauthorized access and data tampering. Additionally, the role of edge computing in optimizing MANET operations should be explored to further reduce latency and improve data processing efficiency. With ongoing advancements in 5G and beyond, MANETs are expected to become a key component in future wireless communication infrastructures, particularly in applications such as disaster response, smart cities, and military operations

VII. References

[1] Sangeetha, T. Rajendran, "Supervised vector machine learning with brown boost energy efficient data delivery in MANET," *Sustainable Computing: Informatics and Systems, vol. 35*, 2022.

[2] U. Ravale, G. M. Borkar, "Secure and efficient trust enabled routing in mobile ad hoc networks using game theory and grey wolf optimization techniques," *IET Wireless Sensor Systems, vol. 2024*, pp. 1-26.

[3] S. A. Sahaaya Arul Mary et al., "Analysis of Smart Healthcare Application in 5G Using MANET," *2nd International Conference for Innovation in Technology (INOCON),* 2023.

[4] P. Aryal, N. B. Adhikari, "Scalability Analysis of MANET in 5G Environment," *12th IOE Graduate Conference, vol. 12*, 2022.

[5] V. K. Quy et al., "An Advanced Energy Efficient and High Performance Routing Protocol for MANET in 5G," *Journal of Communications, vol. 13*, no. 12, Dec. 2018.

[6] S. A. Alghamdi, "Stable zone-based 5G clustered MANET using interest-region-based routing and gateway selection," *Peer-To-Peer Networking and Applications, vol. 14,* no. 6, pp. 3559-3577, 2021.

[7] M. Ahmad et al., "State-of-the-Art Clustering Schemes in Mobile Ad Hoc Networks: Objectives, Challenges, and Future Directions," *IEEE Access, vol. 7*, pp. 17067-17081, 2019.

[8] L. H. Binh et al., "TFACR: A Novel Topology Control Algorithm for Improving 5G-Based MANET Performance by Flexibly Adjusting the Coverage Radius," *IEEE Access, vol. 11, 2023*.

[9] R. Nithya et al., "An Optimized Fuzzy Based Ant Colony Algorithm for 5G-MANET," *Comput. Mater. Contin., vol. 70*, no. 1, pp. 1069-1087, 2022.

[10] N. Hasan, A. Mishra, A. K. Ray, "Fuzzy logic based cross-layer design to improve Quality of Service in Mobile Ad-Hoc Networks for Next-gen Cyber Physical Systems," *Engineering Science and Technology, vol. 35*, 2022.

[11] K. R. Ananth et al., "Green IoT Edge Computing Towards Sustainable and Distributed Data Processing," *10th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics, and Computer Engineering (UPCON),* 2023, pp. 1644–1649.

[12] X. Zhang et al., "AI-Driven MANET Optimization for 5G Networks," *IEEE Transactions on Mobile Computing, vol. 23,* no. 1, pp. 45-58, 2024.

[13] Y. Wang et al., "Leveraging URLLC for MANETs in Smart City Applications," *Future Internet Journal, vol. 16,* no. 2, pp. 101-120, 2023.