**Review of Literature and Existing Research**

Vehicular Ad Hoc Networks (VANETs) are integral to modern intelligent transportation systems, enabling seamless communication between vehicles, infrastructure, and pedestrians. However, challenges such as Non-Line-of-Sight (NLOS) node localization, efficient routing, and emergency message dissemination necessitate advanced optimization techniques. Metaheuristic algorithms, particularly Ant Colony Optimization (ACO) and Simulated Annealing (SA), have demonstrated significant improvements in VANET performance. The work in [1] introduced a hybrid Spotted Hyena Optimization (SHO) and SA-based approach, enhancing NLOS node localization and warning message dissemination. Similarly, an Adaptive ACO with Node Clustering (AACO-NC) technique [2] has been proposed to optimize routing efficiency by dynamically adjusting pheromone evaporation and clustering mechanisms, leading to enhanced data transmission in high-mobility scenarios. Hybrid metaheuristic approaches have been explored to overcome computational limitations and ensure real-time adaptability in dynamic network conditions.

Hybrid optimization strategies further refine VANET performance by balancing exploration and exploitation. Research in [3] developed an ACO-SA hybrid model for scheduling problems, demonstrating its effectiveness in optimizing Automated Guided Vehicle (AGV) scheduling under constrained environments. Additionally, ACO-based clustering frameworks such as CACONET [9] have improved scalability and robustness in VANET routing by dynamically adjusting cluster formations based on network conditions. Bio-inspired algorithms, including Gray Wolf Optimization (GWO) [12] and the Raccoon Optimization Algorithm (ROA) [10], have been employed to refine localization accuracy, ensuring reliable emergency communication. Techniques such as the Hybrid Invasive Weed Optimization and Squirrel Search Algorithm (HIWO-SSA) [21] and the Harris Hawk Optimization Algorithm (HHOA) [22] have been proposed to improve NLOS localization accuracy and message dissemination efficiency in VANETs. Additionally, hybrid approaches are being explored to balance computational efficiency and real-time performance in highly dynamic vehicular environments.

Further advancements in hybrid algorithms have integrated multiple metaheuristic techniques for solving network and scheduling problems. The ACO-SA hybrid algorithm [24] has been successfully applied for route optimization, while a combination of SA and ACO [25] has been leveraged for scheduling problems, improving resource allocation. Other hybrid approaches, such as the Ant Colony Optimization-Simulated Annealing Algorithm [26], have been used in workshop scheduling problems with limited buffer capacity. Additionally, studies in [28] and [29] highlight the effectiveness of ACO and SA in solving network routing challenges, further emphasizing the role of metaheuristic techniques in improving VANET performance. Moreover, blockchain-based authentication models have been introduced to enhance VANET security, ensuring secure and reliable vehicular communication.

Emerging technologies, particularly 5G-enabled cooperative localization, have further enhanced VANET efficiency. Studies in [18] and [19] investigated cooperative localization mechanisms leveraging 5G networks, achieving improved vehicle positioning accuracy and reduced latency through advanced beamforming techniques and real-time data aggregation. Additionally, V2X Sidelink Localization [20] presents an infrastructure-independent method for precise vehicular tracking, reducing dependency on traditional GPS-based methods that suffer from signal degradation in urban environments. However, the integration of these technologies into VANETs presents challenges such as interoperability, real-time adaptability, and data security concerns. While these advancements have improved VANET performance, addressing computational efficiency and adaptive routing mechanisms remains essential for seamless and scalable intelligent transportation solutions.