# A Review on innovative Metaheuristic approaches for complex vehicle routing and delivery challenges.

## Modelling, Simulation and Optimisation (H9MSO)

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***Abstract* - The literature review focuses on evaluating the utilization of metaheuristic technique to address the vehicle routing issue with time windows. Several studies have tackled these complex optimization problems using various methodologies, including mixed-integer programming, adaptive large neighbourhood search algorithms and simulated annealing. A common thread throughout the reviewed papers is the aim to devise efficient solutions for real-world scenarios.**

**The use of simulated metaheuristic methods to solve challenging optimisation problems has made significant strides during the past three decades. Key findings show that while exact methods, including mixed-integer programming with solvers like GUROBI, provide the best results for small-scale problems, the use of metaheuristic techniques is essential for dealing with bigger datasets. Complex pharmaceutical routing issues have been successfully solved using simulated annealing and adaptive large neighbourhood search, exceeding conventional methods in terms of computing effectiveness and solution quality. These metaheuristic approaches successfully negotiate an additional layer of complexity brought on by the incorporation of pickup and delivery factors as well as time frame restrictions. This review, which covers advances over three decades, not only demonstrates the development of supply chain optimisation but also provides an essential resource for researchers who are navigating the complex confluence of logistics.**

***Keywords —Metaheuristic, delivery, simulation, vehicle, optimisation, technique.***

## I. INTRODUCTION

In today's rapidly evolving landscape of logistics and management of the supply chain, the efficient routing and delivery of goods have become paramount challenges for businesses seeking to enhance their operational effectiveness and customer satisfaction. The design of logistics networks involves several choices, including deciding on depot locations, planning routes from those depots to customers, and allocating routes to vehicles. These choices frequently involve many objectives and interdependencies. The major consideration in the decision-making process is the overall cost of the system. Satisfaction of customer also shows the effectiveness of the system's service. The length of time the customer waits can be one of the factors [2]. To solve challenging optimization issues, a class of algorithms known as metaheuristic techniques takes inspiration from how nature solves problems. Metaheuristic approaches offer a flexible toolkit capable of navigating complex solution spaces with agility and efficiency, unlike the standard precise algorithms, which might struggle with the computational demands of large-scale and dynamic scenarios. Due to their adaptability, they can handle a wide range of difficulties, including complex scenarios like vehicle routing with varying vehicle types, unresolved demands, and dynamic time windows.

There are several papers presented on dealing with vehicle routing and delivery challenges using metaheuristic approach. Over the past 30 years, significant advancements have been gained by using simulated metaheuristic techniques to address difficult optimization problems.. While specific approaches, such as mixed-integer programming are frequently carried out using reliable solvers like GUROBI, excel in producing the best results for smaller issues, the use of metaheuristic methods has proven crucial for tackling larger and more complicated datasets. The success in resolving challenging pharmaceutical routing problems, in which simulated annealing and adaptive large neighborhood search have outperformed conventional approaches in terms of computational effectiveness and solution quality, is particularly noteworthy[4]. The integration of innovations and research findings from the past three decades is not only a historical marker to the development of supply chain optimization, but also a valuable tool

for academics navigating the complex intersection of logistics. People trying to understand the complexities of logistical difficulties in the real world might benefit greatly from the depth and range of insights gained through this review. This investigation establishes the framework for changing how optimization is approached, understood, and successfully applied in a constantly developing global setting by combining the capabilities of metaheuristic techniques with the requirements for modern supply chain complexity.

## II. Literature Review

The paper [1] focuses on developing a simulated annealing metaheuristic technique for the vehicle routing issues with time window. The two distinct neighborhood architectures are used, Christofides and Beasley's k-node interchange method and Osman's Z-interchange mechanism. As a base for enhancing the metaheuristic approach, It provides insight into how a tabu list can improve the annealing process by enabling short-term memory. Large-scale real-world problems and test problems from the literature are used in the computations, and the findings demonstrate that the metaheuristics produce solutions that are comparable to previously published results. The key findings enhance the field of vehicle routing problem with time windows by proposing simulated annealing metaheuristics and assessing their effectiveness for several problem-solving situations. The metaheuristic technique may be improved with the use of different neighborhood structures and the improvement of the annealing process using a tabu list. the limitations of the papers include the lack of comparison with other existing metaheuristic approaches and the need for further evaluation on a wider range of problem instances. The developed simulated annealing metaheuristics can be used to solve practical issues like bank deliveries, postal deliveries, and school bus routing that require vehicle routing with time window restrictions.

Paper [2] introduced a novel metaheuristic methodology for addressing challenges in issues with delivery and pickup including time windows. The method uses a tabu-embedded simulated annealing technique to restart the search from the best solution after a number of unsuccessful iterations. In order to prevent recurrent patterns in the search process, this is complemented by an effective metaheuristic strategy built on a K-restarts annealing procedure integrated with a tabu-list mechanism. Additionally, using Solomon's benchmark datasets for the issue in vehicle routing with time frames, the study constructed 56 instances with 100 consumers each. The proposed approach was discovered to be the ground-breaking solution for solving complicated multiple-vehicle pickup and delivery problems with time windows problems containing distinct distribution characteristics through computer experiments on these six freshly constructed heterogeneous datasets. Notably, the developed algorithm exhibits adaptability for addressing broader extensions of pickup and delivery problems with time windows.

To reduce overall costs and customer waiting times, the paper [3] addresses the Location-Routing Problem (LRP) with simultaneous pickup and delivery. The suggested approach creates a nonlinear multi-objective integrated programming model for the issue and employs a tabu search-based heuristic algorithm to discover high-quality solutions. Additionally, the trade-off between two objective functions and the pursuit of Pareto ideal solutions are discussed. The suggested heuristic approach for the problem expands on an existing algorithm with a single cost objective. Both the location and the vehicle routing portions of the process are involved. The computational results are evaluated in terms of both CPU time and solution quality . The optimal objective function of cost and waiting time are recorded. The optimal cost and waiting time functions of an objective are noted. By considering optimal solutions, which are created using computing software, the average and greatest percentage gaps of the heuristic solutions are determined. It has been observed that the test problems can be resolved in acceptable CPU times regarding the computational burden. the experiment's findings says that the overall cost rises noticeably as client demand for pickup or delivery rises. Results show that parameters have distinct effects on waiting time and cost. Additionally the study observed that if the customer's time window becomes more constrained, the overall number of cases and waiting times will rise. The proposed approach can be applied in integrated logistic systems where decisions on depot location and vehicle routing need to be made simultaneously. It helps minimize total cost and customer waiting time.

The paper [4] explore the vehicle routing problem with time windows (VRPTW) in relation to the network architecture of Turkey's pharmaceutical supply chain. It focusses on identifying routes which are the most approachable using the vehicles available and restrictions like road length and time. To reduce the overall route cost while still meeting certain requirements, it suggests a mixed-integer programming (MIP) approach based on VRPTW. Metaheuristic techniques like simulated annealing (SA) and adaptive large neighborhood search (ALNS) algorithms are suggested for big issue sizes. Evaluation and comparison of the metaheuristic algorithms' efficiency with the GUROBI solver is conducted. The GUROBI solver is limited to one to three hours or fails to find a solution within this time frame, whereas the metaheuristic algorithms produce the optimal solution in lesser than a minute. According to the research, the metaheuristic algorithms (SA and ALNS) handle larger problems much more quickly than the exact methods used with the GUROBI solver. It provides potential solutions for larger instances of the pharmaceutical supply chain network design problems. the limitations include the reliance on real datasets, which may not capture all possible scenarios, and the need for further evaluation and comparison with other metaheuristic algorithms to assess their performance comprehensively. Decision-makers in the pharmaceutical business can use the suggested metaheuristic algorithms (SA and ALNS) to optimize the vehicle scheduling issues with time intervals and enhance their network architecture. The papers' conclusions can be utilized as a starting point for creating workable pharmaceutical supply chain management strategies while considering limitations like time windows and road length. The work may also serve as a springboard for further investigation into the use of metaheuristic algorithms for other real-world routing issues and an examination of their efficacy in various contexts and industries.

## III. CONCLUSION

In conclusion, the literature review presents a comprehensive overview of the application of metaheuristic techniques to tackle the complex challenges posed by the vehicle scheduling issues with intervals. Over the past three decades, researchers have strived to develop efficient solutions for real-world scenarios in supply chain optimization. While methodologies like mixed-integer programming and solvers like GUROBI provide the best results for modest-sized issues, it is clear that the use of metaheuristic techniques is essential when dealing with larger datasets and complex optimisation challenges. Simulated annealing and adaptive large neighbourhood search outperform traditional methods in terms of computing effectiveness and solution quality, as demonstrated by the successful resolution of challenging pharmaceutical routing problems. These metaheuristic methods have risen to the challenge of addressing additional layers of complexity brought about by considerations such as pickup and delivery factors and time frame constraints. The reviewed studies collectively illuminate the evolution of supply chain optimization over the past thirty years, illustrating how metaheuristic techniques have played a crucial part in navigating the multifaceted realm of logistics. By analysing the insights gained from these studies, this review not only contributes to our understanding of supply chain optimization advancements but also serves as a vital resource for researchers venturing into the intricate intersection of logistics. The ongoing development and innovation in the field of metaheuristic techniques promises to further strengthen our capacity to provide effective and efficient solutions for challenging real-world scenarios.

## IV. REFERENCES


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