ABSTRACT

Goods distribution is one of the core activities in a logistics system that demands high efficiency, both in terms of travel distance and the optimal utilization of vehicle capacity. In practice, logistics companies often face challenges in designing distribution route systems that are not only cost-effective but also capable of balancing vehicle workload efficiently. A classic problem that frequently arises is how to construct an optimal combination of delivery routes so that vehicles can visit all customers, fulfill both delivery and pickup demands, and remain within the allowed weight and volume capacity limits.

This study specifically addresses that problem in the real-world context of a logistics company, PT XYZ, using the approach of the Vehicle Routing Problem with Simultaneous Pickup and Delivery with Cargo Loading (VRPSPD-CL). This problem falls into the category of complex combinatorial optimization (NP-hard), considering the large number of variables and constraints that must be evaluated simultaneously. VRPSPD-CL is developed to generate vehicle routes that not only deliver goods to customers but also pick up goods from other customers, while optimizing total travel distance and maximizing cargo space utilization.

To solve this optimization model, the Genetic Algorithm (GA) is employed as the solution-searching technique. GA is selected for its ability to explore the solution space broadly and efficiently through a simulated evolution process and to find near-optimal solutions within a reasonable computational time. The solution process begins with population initialization, generating random combinations of vehicle routes. This is followed by evaluating a fitness function based on total travel distance and vehicle capacity utilization. Then, the best individuals are selected, crossed over, and mutated to form a new generation of improved solutions. This process is repeated for several generations until the most optimal solution is found.

The developed model also explicitly considers operational constraints of the vehicles, including the maximum weight (kg) and volume (m^3) that can be carried in a single route, as well as the sequence of pickup and delivery services that must not cause overload during the journey. The model is tested using real daily delivery data from PT XYZ for the period of November 4–16, 2024. Each day *includes a number of customers to be served, with varying demands for both delivery and pickup. The optimization results show a significant reduction in the total travel distance compared to the existing condition. In addition, the average utilization of vehicle load capacity also increases, both in terms of weight and volume, indicating improved truck usage efficiency. Further evaluation is conducted by comparing the optimized results with actual field conditions, including the number of vehicles used, the routing patterns formed, and cargo space efficiency. A sensitivity analysis is also performed on the maximum number of vehicles used per day to assess how flexible the model is in dealing with limited fleet availability. The results demonstrate that through an efficient customer cargo merging strategy and route allocation based on the shortest distance, the model can still maintain high performance even when the number of vehicles is restricted.*

Overall, this research proves that the VRPSPD-CL method based on a Genetic Algorithm can be effectively applied to design an efficient goods distribution system that is adaptive to changing operational conditions. The developed model not only produces optimal solutions in terms of cost and travel distance but also provides flexibility in responding to simultaneous delivery and pickup demands.

Keywords: ***Logistics Distribution, VRPSPD-CL, Genetic Algorithm, Cargo Capacity.***