

## **TRANSSHIPMENT DEMAND IN VEHICLE ROUTING PROBLEM USING GENETIC ALGORITHM**

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**ABSTRACT** – The Transshipment Demand in Vehicle Routing Problem (VRPTD) is a problem that involves transferring items between retailers due to shortages at retail stores and availability at another retail store. Strategically transferring items between retailers minimizes lost sales by ensuring item availability which leads to increasing customer satisfaction. In this study, the VRPTD considered real world scenarios involving valuable bulk items. The objective is to minimize the transportation cost while efficiently meeting customer demand by finding the best delivery routes that fulfill both regular and transshipment demand. A metaheuristic method, Genetic Algorithm (GA) was proposed for the problem. Three main genetic operators employed are Stochastic Universal Sampling (SUS) is used for selection, a modified Edge Recombination Operator (ERO) as the crossover operator and two different swap strategies in mutation operator. The control parameters: population size and maximum generation were determined through a small-scale experiment. GA was run for 10 independent runs, and the results obtained were compared with previous literature. The best sequence found has slightly higher distance with a running time of less than 3 minutes. In conclusion, this study successfully developed GA for solving VRPTD with near-optimal solutions with difference of not more than 10% when compared to the previous literature.

**Keywords:** Vehicle Routing Problem, transshipment demand, Genetic Algorithm

### **1. INTRODUCTION**

The Vehicle Routing Problem (VRP) is a problem that involves finding an optimal design of routes traveled by a fleet of vehicles to serve a set of customers (Toth & Vigo, 2014). This study focuses on one of the VRP variants, which is VRPTD. As VRP itself is NP-hard, thus VRPTD falls in the same category. The VRPTD is a complex optimization problem in network distribution for retailers. The objective of VRPTD is to minimize the distance traveled by the delivery vehicles while meeting the regular and transshipment demand requirements. For retail companies dealing with seasonal and limited-edition items, transshipment demand ensures that retailers fulfill orders from other retailers to prevent lost profits due to delayed deliveries. Additionally, optimizing delivery routes considering transshipment demands enables the implementation of same-day delivery services, leading to enhanced customer satisfaction and loyalty.

This study used benchmark dataset that mimics a real-world problem. The undirected network graph consists of 20 nodes, with one depot and 19 retailers. Two homogeneous vehicles are available at depot to deliver items from depot to the retailers. At the same time, will visit pickup customers to pick up items for delivery to the delivery customer. To ensure feasibility, pickup customer must be visited before the delivery customer. The dataset and mathematical formulation for the VRP with Transshipment Demand (VRPTD) are adapted from Leelertkij et al. (2021).

### **2. METHODOLOGY**

This study proposed a metaheuristic method, Genetic Algorithm (GA), which known for its the ability to find near-optimal solutions for NP-hard problems. GA employs evolutionary processes such as selection, crossover, and mutation as the operators to converge towards a near-optimal solution. The GA was coded in MATLAB Software R2022a version. The SUS is employed in the selection operator, and a modified Edge Recombination Operator in the crossover operator. The modification is done to ensure that transshipment demands are fulfilled. The mutation operator implemented is swap. Note that previous literature implemented Threshold Accepting and Neighborhood Search to solve VRPTD.

### **3. RESULTS AND DISCUSSION**

As metaheuristic found near-optimal solution, hence the GA was executed independently 10 runs and the average results were recorded. Small-scale experiments were done with various combinations of population size and maximum number of generations. From the experiment, it is decided that population size and maximum number of generations was set at 300.

GA achieved feasible results in an average time of 209.11 seconds, which is slightly longer than 3 minutes. Out of the 10 runs the minimum running time is 175.77 seconds, the longest time is 245.27 seconds. The GA was able to find the best sequence with the best distance optimality range of less than 10%, when compared to the findings of Leelertkij et al. (2021). On average, GA performed well for VRPTD with standard deviation not more than 25, which showed the ability of GA in finding consistent solutions.

### **4. NOVELTY OF RESEARCH / PRODUCT**

This study proposes the use of Genetic Algorithm (GA) to solve the VRPTD. This study introduced the designed of the GA to adapt transshipment demands, specifically, SUS for selection operator, ERO for crossover and two type of swap strategies for mutation. The developed GA successfully achieved feasible shortest distance. By applying this approach, the study offers valuable insights into efficiently solving complex real-world distribution problems.

### **5. CONCLUSION**

In this study, the Transshipment Demand with Vehicle Routing Problem (VRPTD) was solved by Genetic Algorithm (GA). The performance of the GA was tested using a benchmark dataset. The GA successfully obtained optimal delivery route sequences to fulfill regular and transshipment demands within the same routes using two homogeneous vehicles. The total distance for the best sequence was slightly higher of 48.95 units compare to the literature. The approach proved and achieved near-optimal solutions within a 10% optimality range. Future research directions for VRPTD include incorporating delivery time windows to address real-worlds constraints. Additionally, exploring the transshipment facilities, where retailers can be served directly or indirectly through selected facilities can provide further insights.

### **REFERENCES**

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