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# Utilizing Ant Colony Optimization and Intelligent Water Drop for Solving Multi Depot Vehicle Routing Problem

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# Utilizing Ant Colony Optimization and Intelligent Water Drop for Solving Multi Depot Vehicle Routing Problem

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**Abstract**. Multi-depot vehicle routing problem (MDVRP) is a real-world variant of the vehicle routing problem (VRP). MDVRP falls under NP-hard problem where trouble in identifying the routes for the vehicles from multiple depots to the customers and then, returning to the similar depot. The challenging task in solving MDVRP is to identify optimal routes for the fleet of vehicles located at the depots to transport customers' demand efficiently. In this paper, two metaheuristic methods have been tested for MDVRP which are Ant Colony Optimization (ACO) and Intelligent Water Drop (IWD). The proposed algorithms are validated using six MDVRP Cordeau's data sets which are P01, P03, P07, P10, P15 and P21 with 50, 75, 100, 249, 160 and 360 customers, respectively. Thus, the results using the proposed algorithm solving MDVRP, five out of six problem data sets showed that IWD is more capable and efficient compared to ACO algorithm.

## 1. Introduction

Nowadays, the logistic distribution planning has emerged as a critical research constraint for supply chain management. The aim of the management is to get an efficient distribution planning due to increased consumers' demand. An efficient distribution of goods is very important because it holds massive impact on cost and customer satisfaction [1]. The challenging strategy in logistic distribution planning is the optimization of the delivery of products from suppliers to customers by fulfilling all the obstacles. The problem of the strategy known as Vehicle Routing Problems (VRP). This research focused on MDVRP which is more complex than VRP because consists of more than one depot [2].

## 2. Related works

There are many research articles discussed on traditional MDVRP problems that deals with metaheuristic algorithms. One of the recent metaheuristic method in solving MDVRP is an improved ant colony optimization algorithm (ACO) [3] which dealt with multi-depot green vehicle routing problem with multi- objectives. The algorithm is improved by using the innovative approach in pheromone update. While [4] introduced a new hybrid technique of intelligent water drop (IWD) and simulated annealing (SA) to solve MDVRP. [4] have successfully proved that the hybrid algorithm is a good alternative in solving the MDVRP constraints. Nevertheless, [5] have solved MDVRP by conducting allocation of new depot using *k*-means clustering algorithm as the first step and followed by routing using Clarke & Wright algorithm. The results from the [5] is compared with ACO and other metaheuristic algorithms. [5] also proved that Clarke & Wright algorithm is better than ACO algorithm.

## 3. Multi Depot Vehicle Routing Problem

One of the variant of VRP problems is MDVRP problems. The difference between VRP and MDVRP is VRP involved only one depot while MDVRP involves more than one depots which make the problem more complicated. The main goal of MDVRP is reducing the total expenditures and total distance of routes. The important elements in MDVRP are customers, depots and vehicles. In MDVRP, there are few constraints [6] involved which are:

(a) Every customer must be served only once.
(b) Every customer begins and ends at the similar depot.
(c) Vehicle must not exceed the vehicles' capacity.
(d) Every vehicle should back to its depot after visiting the allocated customers.

Figure 1 illustrates MDVRP with three depots and 15 customers.

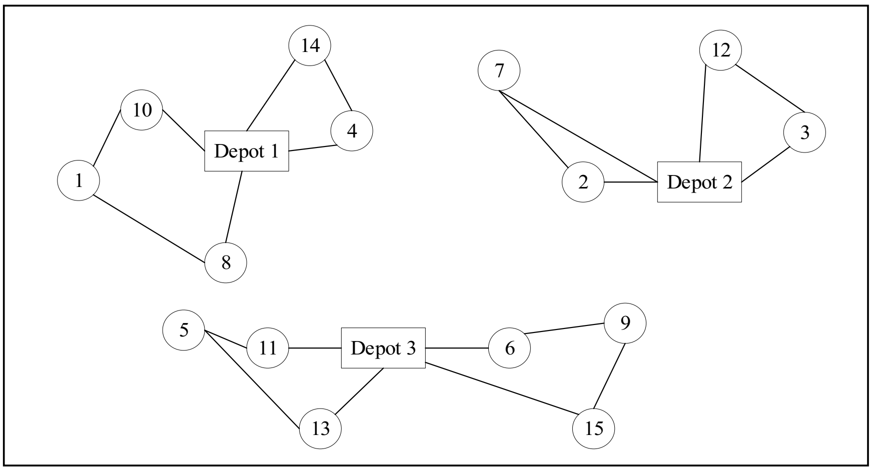


**Figure 1**. MDVRP with three depots and 15 customers

## 4. Intelligent Water Drop

In order to solve the combinatorial optimization issues, intelligent water drop (IWD) is used in recent research [7]. The concept of IWD is from natural rivers where the water flow through a path from one place to another. One of the important parameter in this algorithm is velocity. Some amount of soil will be carried along by water drops that flow from one place to another. The soil will dislocate from fast parts of the path to slow parts of the river. The soils will be removed in the slower beds of the river [8]. In MDVRP cases, each water droplets act as the vehicles. Each water drop begin from the depot chooses the next accessible customer from the unavailable list, and updates the weight of the demand carried by the vehicle. When the vehicle loads or if all customers were visited lesser than the weight of the water droplets, the water droplets will return to the depots. Thus, all the vehicles have successfully completed the routes. Figure 2 shows the IWD algorithm. While Table 1 shows the parameter values of IWD used in this research.

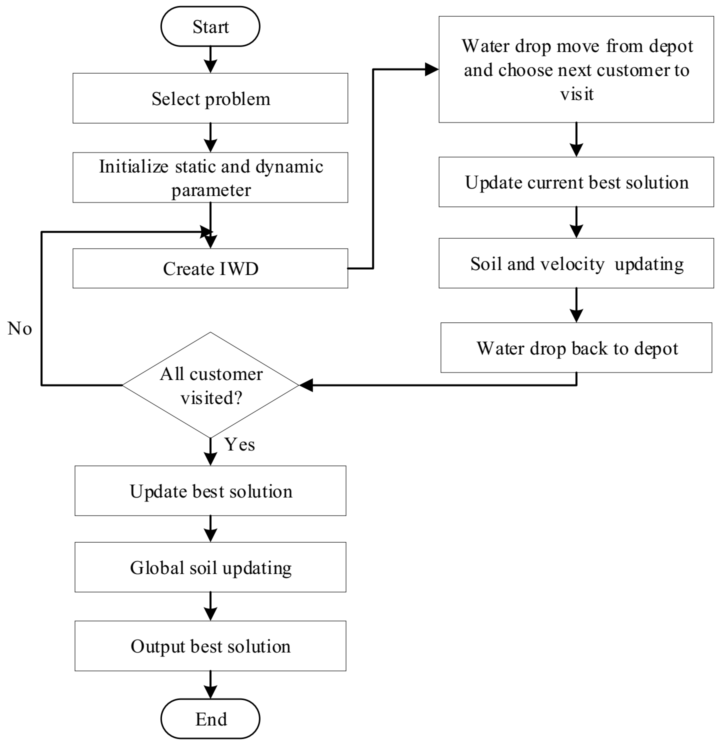


**Figure 2**. Flowchart of IWD

**Table 1**. Parameter values of IWD

| Parameter | Values |
|---|---|
| Maximum number of iterations | 100 |
| Initial temperature for SA | 150 |
| Temperature decrease rate | 0.95 |
| Number of iterations at each step | 1 |
| Initial value of soil | 1000 |
| Initial value of velocity | 100 |
| Soil updating parameters | 0.9 |
| Global soil updating parameters | 0.8, -1.5 |

## 5. Ant Colony Optimization

[9] introduced ant colony optimization (ACO) which resembles the food-seeking behaviors of ant colonies in nature [10]. The elements in ant colonies are as follow, depot as the nest, customers as the food and ants similar to vehicles [10]. Each ant moves at random from the nest to food source. The pheromone trails discover the shortest paths and deposited on the path. More pheromone on path shows more probability of the path being followed. Figure 3 shows the flowchart of ACO algorithms. While Table 2 shows the parameter values of ACO used for this research.

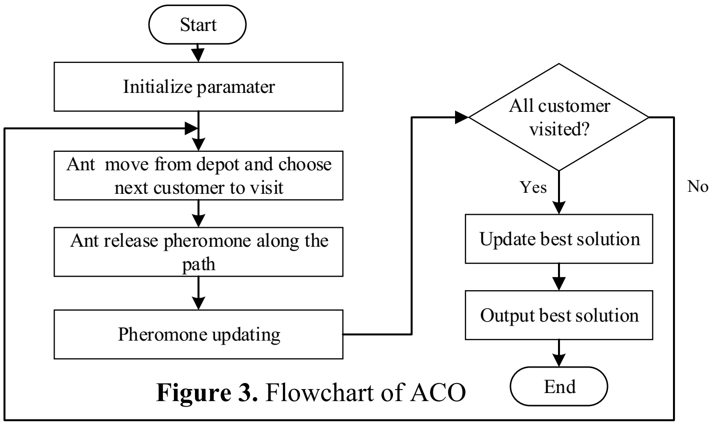


**Figure 3.** Flowchart of ACO

**Table 2**. Parameter values of ACO

| Parameter | Values |
|---|---|
| Iterations (maximum) | 100 |
| Population size | 10 |
| Pheromone exponential weight | 1 |
| Evaporation rate | 0.05 |
| Heuristic exponential weight | 1 |

## 6. Experimental results

This research used six samples of Cordeau's benchmark data sets taken from [11]. Table 3 shows the results of two algorithms on six MDVRP data sets which are P01, P03, P07, P10, P15 and P21 which has 50, 75, 100, 249, 160 and 360 number of customers, respectively. Table 3 presents the average results over 10 runs for every 100 iterations. Based on the computational results in Table 3, five out of six data sets showed that IWD algorithm has better solution quality compared to ACO algorithm. Also, it can be seen that IWD algorithm give better solution in dealing with large number of customers.

**Table 3**. Obtained computational results for IWD and ACO algorithms

| Data sets | No. of customers | No. of depots | No. of vehicles | Algorithms | |
|---|---|---|---|---|---|
| | | | | **IWD** | **ACO** |
| P01 | 50 | 4 | 4 | **1122.032** | 1589.481 |
| P03 | 75 | 5 | 3 | 1517.804 | **1405.275** |
| P07 | 100 | 4 | 4 | **1921.735** | 2420.839 |
| P10 | 249 | 4 | 8 | **14708.57** | 15360.12 |
| P15 | 160 | 4 | 5 | **10243.75** | 10349.7 |
| P21 | 360 | 9 | 5 | **19864.82** | 24881.71 |

## 7. Conclusion

This article has presented utilization of ACO and IWD in solving multi depot vehicle routing problem (MDVRP). The effectiveness of both algorithms is tested using six Cordeaus' data sets which are P01, P03, P07, P10, P15 and P21. From the experimental results in this research, proven that IWD algorithm is more effective in finding optimal solutions compared to ACO algorithm. For future work, this research suggested to improve IWD algorithm to obtain more feasible solution in vehicle routing problems especially for MDVRP variant.

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