Chosen: **Genetic Algorithm (GA)**

The metaheuristic algorithm chosen was genetic algorithm (GA) to solve the given problem of capacitated vehicle routing problem.

* This is because GA is a good method to **explore wide ranges of potential solutions** by introducing crossovers and mutations to ensure **variety and diversity** in searching for the most optimal route.
* GA also can maintain a population of solutions rather than a single solution, which helps in avoiding local optima and **promotes the exploration of the solution space**. This helps the current problem to find the global optimum instead through a winder range of solutions to be considered.

**Implementation:**

The implementation outline of the GA used follows the step of:

1. **Creating a sample population**.
   * A random sample population will be created to simulate the random paths in which the vehicles will take to deliver goods to customers
   * The constraints of the capacity for each vehicle will be followed by trimming the routes until it is below the load capacity of the vehicle.
2. **Calculating fitness of the individuals in the population**.
   * The fitness of each individual will be calculated based on a fitness function.
   * The fitness function will calculate the efficiency of goods delivered by the vehicle using the formula:
   * Therefore, individuals with **lower fitness score** are actually considered **better** as it has **lower cost per goods delivered**.
3. **Performing tournament selection on the population**.
   * Tournament selection will be carried out where a random number of individuals will be selected to compete against each other where the individual with the lowest fitness score will be selected for crossover in the next step.
   * More tournaments will be carried out until there are a required number of individuals selected.
4. **Performing crossover on the selected individuals to produce child solutions**.
   * Crossovers will be carried out to obtain back the initial population size.
   * It is done between two selected individuals where child1 will follow initial route of parent1 until it encounters a customer which parent2 also has within its route.
   * Then, child1 will follow the route of parent2 from that customer onwards.
   * Any routes that end up being too short or too long will be adjusted back to satisfy the capacity constraints of the vehicles.
5. **Applying mutation to a small number of child solutions**.
   * Inversion mutation will be applied to some children from the crossovers to introduce diversity to the solutions to allow a wider search of possible solutions.
   * The mutation is determined by the mutation probability, not by the number of children.
6. **Repeat steps 2 to 5 for the desired generations to evolve**.
   * The evolution of repeats until the desired number of generations have been carried out.
7. **Comparing fitness between each vehicles’ best route**.
   * The best route from both vehicle A and B will be compared to identify which type of vehicle will be used to deliver the goods in the end.
8. **Repeat steps 1 to 7 after each delivery cycle**.
   * After the best route is determined, the customers on that route will be removed and another population will be created and evolved to choose the best route for the remaining customers
   * This process repeats until all the goods have been delivered to the customers.

**Results:**

The result of evolving the population of solutions using genetic algorithm is:

A diagram of a triangle with green lines and dots

Description automatically generated

Red square = Depot; Blue dots = Customers

Green lines = route by vehicle A; Blue lines = route by vehicle B

From the diagram, all goods were delivered using vehicle A.

Furthermore, multiple runs have been carried out and vehicle A has been chosen to deliver the goods most of the time as well, showing that **vehicle A is more cost effective** for delivering the goods based on its capacity as well.