Chapter 4

Scheduling Amazon Delivery Trucks

E-commerce companies like Amazon face complex logistical challenges in delivering customer orders efficiently. One such challenge is planning the routes for their delivery trucks to optimize factors like total distance traveled, number of trucks needed, and ability to meet promised delivery windows. In this project, we will build a simplified model of the Amazon delivery truck scheduling problem. The goal is to develop routing algorithms that minimize the total distance traveled by the trucks while respecting constraints like customers who have paid for next-day "Amazon Prime" delivery. This project is inspired by the exercises in Chapter 8 of *Projects for Scientific Programming in C++ and Other Languages* by Victor Eijkhout.

Problem Definition

We make the following simplifying assumptions:

- The delivery area is a 2D plane. Customer locations are specified by x, y coordinates.
- All trucks start and end at a central depot at coordinates (0,0).
- Each customer has a deadline specifying the last day their delivery can take place.
- "Amazon Prime" customers must receive their delivery the next day.
- For non-Prime customers, deliveries can be spread over multiple days.
- Deliveries cannot be split—each customer receives their full delivery in one truck visit.

With these assumptions, the problem is to schedule a given set of customer deliveries over multiple days and trucks to minimize the total distance traveled.

C++ Programming Aspects

This project will involve:

- **Object-Oriented Design**: Using C++ classes to represent delivery requests, truck routes, and delivery schedules.
- **Algorithm Implementation**: Coding algorithms for route optimization and delivery scheduling.
- **Data Structures**: Using appropriate C++ data structures for managing delivery data and route information.
- **Performance Optimization**: Techniques for efficient data processing and algorithm optimization in C++.
- **File I/O**: Handling input/output operations for loading delivery data and saving scheduling results.

Methods

We will implement the following components:

- **Address** class representing a customer delivery location.
- **DeliveryRequest** class representing a customer order with location and deadline.
- **Route** class representing a truck route as a sequence of addresses.
- **Schedule** class representing a multi-day plan of truck routes.

Key algorithms will include:

- Constructing single-truck delivery routes with a greedy nearest-neighbor heuristic.
- Improving routes by reversing route segments (Lin-Kernighan heuristic).
- Scheduling Prime vs. non-Prime deliveries optimally over multiple days and trucks.

We will test the algorithms on randomized delivery data. The main evaluation metric will be the total route distance for fulfilling a given set of deliveries under Prime vs. non-Prime constraints.

Team Collaboration and Task Partitioning

Tasks may be divided into:

- **Algorithm Development**: Building and optimizing routing algorithms.
- **Class Implementation**: Coding the primary classes in C++.
- **Data Management**: Handling input data and results.
- **Testing and Validation**: Running simulations and validating results.
- **Documentation and Reporting**: Preparing comprehensive documentation and reports.

Applications

This project will provide hands-on experience with common vehicle routing problems and algorithms. The code can serve as a starting point for more realistic scheduling models that consider factors like truck capacity, delivery time windows, traffic, and driver breaks.

With additional data on costs and delivery priorities, the model could be extended to optimize objectives beyond distance, such as minimizing fuel costs or maximizing on-time deliveries.

Conclusion

Vehicle routing is a rich problem domain that combines optimization, algorithms, and logistical constraints. This project will explore core techniques for efficient delivery scheduling in a simplified model relevant to e-commerce companies. The methods can be expanded in many directions to tackle real-world transportation challenges.