DARTMOUTH ENGINEERING

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Optimizing Routes to Deliver Packages

Introduction

The transportation of goods has become an essential task in today's world. People require sending packages, documents, and other important items from one place to another regularly, and thus rely on courier services. Most customers expect to receive their packages within one to two days, making the courier service industry a crucial tool for businesses. To meet customer expectations, courier services spend huge amounts on fuel, equipment, maintenance, and wages. Time is money, and finding the most efficient route to deliver packages can significantly reduce the time it takes to make these deliveries, leading to better mileage, reduced fuel usage, decreased carbon emissions, improved asset utilization, and increased customer service.

Let's consider an average driver making around 120 deliveries per day. The number of different possible routes that the driver could travel is vast, with 120! routes equal to 6.68 x 10^198 combinations. So, how can we find the most optimal route among these combinations that minimizes the total expense while meeting customer demands?

This question can be divided into three sub-questions:

1. There might be several delivery centers in a city, so which delivery center is responsible for a particular package?

2. The packages arrived at the delivery center, there might be huge number of packages that several trucks might be required to deliver these packages. So, how to split the routes most effectively between these trucks if more than one truck is being used?

3. Once the packages are in the truck and if there are a set of addresses where the packages are to be delivered, what is an efficient order to visit them?

Responsibility for a particular package:

There may be several delivery centers in a city, so which delivery center is responsible for a particular package? This solution to this question is relatively straightforward. Each delivery center can be made responsible for a particular set of zip codes, and the package belonging to a particular zip code can be routed to its corresponding delivery center.

Splitting routes between trucks:

If there are a large number of packages, several trucks might be required to deliver them. How can we split the routes most effectively between these trucks if more than one truck is being used? The coverage area of the delivery center and the number of packages and trucks available for delivery

are the two factors that need to be considered. A single truck may not always be sufficient to make deliveries. If two packages need to be delivered to the same apartment, it is more efficient to have both packages on the same truck instead of two different trucks. This is known as the Vehicle Routing Problem and an optimal solution to this problem would result in the improvements discussed earlier.

Efficient order to visit addresses:

Once the packages are in the truck, the truck needs to visit a set of addresses to deliver the packages. What is the most efficient order to visit these addresses? The driver needs to go through the addresses, and there are different routes that can be taken. If the driver visits a building, delivers a package, then goes around and returns to the same building for a different package, this is not an efficient route. This is known as the Travelling Salesman Problem.

Vehicle Routing Problem

The Vehicle Routing Problem (VRP) is a well-known combinatorial optimization and integer programming problem. It involves a single depot, a set of customers, multiple vehicles, and the objective to minimize the total cost while servicing every customer. Each vehicle starts and ends the travel at the depot. The objective of the VRP is to find a solution that minimizes the total vehicle number required and minimizes the length of the total traveled path. The VRP was first formulated by Dantzig and Ramser in 1959.

Travelling Salesman Problem

The Travelling Salesman Problem (TSP) asks the question: Given a list of nodes and the distances between each pair of nodes, what is the shortest possible route that visits each node exactly once and returns to the origin node? The TSP is an NP-hard problem in combinatorial optimization, important in operations research and theoretical computer science.

Conclusion

In conclusion, the courier service industry plays a crucial role in ensuring the timely delivery of packages and documents to customers. With the increasing demand for efficient and fast delivery services, the industry is facing challenges such as minimizing expenses, reducing travel time and improving asset utilization. These challenges can be addressed through the use of mathematical optimization problems such as the Vehicle Routing Problem (VRP) and the Travelling Salesman Problem (TSP). By applying the solutions of these problems, the courier service industry can improve its operations, reduce costs, and provide better customer service.

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