# Final Project

## OR 7310

## Logistics, Warehousing and Scheduling

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# 1.Introduction

## Goal:

- To optimize the existing model of the Distribution Company's Delivery Route with a given sequence of customers, corresponding vehicle rental plans and due times for delivery.
- To find a customizable approach, dealing with different sets of constraints for the company to incorporate a new or to improve the existing model so as to arrive at the best solution in a reasonable computation time.
- To identify the 'Optimality Gap', which is to determine the lower bound for the solution and assess how far this solution is from the optimal one.
- To minimize the total rental and driving cost of the fleet of vehicles.

# 2. Overview

- The Delivery Routing Optimization is one of the hardest problems tackled both in practice and in theory involving the design of a set of minimum-cost vehicle routes, originating and terminating at a central depot, for a fleet of vehicles that services a set of nodes with known demands.
- An important element of many distribution systems is the scheduling and routing of vehicles through a set of nodes representing geographically dispersed customers or cities.
- Each node is serviced exactly once and, furthermore, all nodes must be assigned to vehicles without exceeding vehicle capacities.
- Many problems of interest can be formulated as mathematical programs in which some of the decision variables are constrained to take one of a finite set of values.
- Delivery Routing Problems are essentially shortest path problems for multiple vehicles and/or multiple destinations, subject to a variety of constraints or performance objectives.
- The objective of Delivery Routing is to provide a high level of customer service while keeping the operating and investment costs as low as possible.
- It consists of two sub-problems: the nodes grouping to clusters and finding the best tour for every cluster. Therefore, route is the total number of deliveries made by a single vehicle and tour is their sequence. The solution of these sub-problems results in routes and tours that minimize the total transportation cost.

# 3. Approach

- The given Delivery Routing problem falls under the category of NP-hard problems, denoting that the computational effort required to solve this problem increases exponentially with the increase in problem size.
- An attempt to run the files containing a complete set of 50 and 100 data points was made to comprehend the corresponding results and analyze possibilities to improvise on it.
- This attempt went in vain and led to a failure due to the fact that the computational complexity is high. So, a different technique was required to tackle such problems.
- Initially we divided the nodes and the resources in ascending order in a way to obtain a reduced complexity.
- But later on as we progressed, we understood that the nodal points are distant to one another which could not account for the due times constraint as the package couldn't be delivered on time.

## 3.1 Ideation

- Given a fleet of vehicles available in a depot, a set of customers to be served within their respective prescribed time window, we first divided the given node points into sets of 10 data points to ease the computation in the solver.
- Using ‘KNN-Approach’ to cluster 10 nearest points (without repeating any of the nodes) we incorporated this aggregation for both the 50 and 100 data points using excel solver.
- After clustering them, we formulated a model for each of those 10 data points and ran them in AMPL to find the initial basic feasible solution.

## 3.2 Improvisation

- As we advanced grouping the nodal points into 10 different sets, we observed in some sets the nodes are considerably far off from each other (with that cluster) as they are the leftover nodes after the grouping has been done sequentially.

- To address this issue of larger distances, we implemented node transfer for that particular node-set but placing it into a better node-set into which it can ideally belong to and have lesser distance between each other.

- Finally we were able to solve the nodes again and improvise further on the solution. We also observed that in some groups there may have been more nodes than others due to very close proximities of the nodes within that group.

## 3.3 Limitation

- Ideally, there shouldn't be more than 11 or 12 nodes with the set as it increases the computational complexity in an exponential manner.

- Instead we can further divide it into smaller fragments of node sets, say 5 or 6 in a cluster and continue solving.

## 3.4 Lower Bound

Constraint relaxation was used to find a lower bound but the computational complexity was still high. Then, we did linear relaxation of two different integer variables to solve the problem in polynomial time. We worked on sets of 10 nodes, and we arrived at the lower bound.

# 4. Result

## 4.1 100 Customers

| 100 Nodes | Basic Feasible | Improvised | Lower Bound |
|---|---|---|---|
| Part 1 | 101.5 | 101.5 | 96.7 |
| Part 2 | 83.5 | 83.5 | 81.1 |
| Part 3 | 140.5 | 152 | 142.5 |
| Part 4 | 138.5 | 138.5 | 130.5 |
| Part 5 | 293 | 198 | 189.6 |
| Part 6 | 158.5 | 158.5 | 148.7 |
| Part 7 | 250.5 | 251 | 237.8 |
| Part 8 | 218 | 218 | 212.4 |
| Part 9 | 177 | 250 | 235.2 |
| Part 10 | 293 | 160.5 | 152.5 |
| Sum Cost | $ 1,854 | $ 1,711.5 | $ 1,627 |

| | |
|---|---|
| % Improved from Basic Feasible | **8.33%** |
| % Gap from Lower Bound | **5.19%** |

## 4.2 50 Customers

| 50 Nodes | Basic Feasible | Improvised | Lower Bound |
|---|---|---|---|
| Part 1 | 176 | 213 | 207.4 |
| Part 2 | 137 | 178.5 | 172.1 |
| Part 3 | 235.5 | 256 | 246.3 |
| Part 4 | 237 | 237 | 230.6 |
| Part 5 | 417 | 105 | 93.8 |
| Sum Cost | $ 1,202.5 | $ 989.5 | $ 950.2 |

| | |
|---|---|
| % Improved from Basic Feasible | **21.53%** |
| % Gap from Lower Bound | **4.14%** |

# 5.Future Scope

- For generalized delivery routing we can find a way to optimize using the given data points all at once, which directs us for future research in complex delivery route optimization problems.
- We can suggest vendors and discuss agreements to reduce minimum rental time when involving huge fleets of vehicles for real-life complex scenarios.
- Further node exchanges can be done within the groups and solutions can be improvised further. This would require more computational power due to increase in complexity. To solve this, the data can be divided further.