Optimize Delivery Routing with Roaming Delivery Location

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Overview

Location + **Time Window** = **Customization**

Traditional routing problems only focus on which locations to deliver, but fail to incorporate time window. In this project we revisited the routing problem with **roaming delivery locations**.

Data & Formulation

The data has customer information: customer **demands**, location **coordinates**, a **time window** for each location;
It also has **general side information**: total number of customers, locations, available vehicles, and capacity for each vehicle.

```
0  0   0 [0,720]
1  75  1 [0,111]    2 [129,304]  3 [322,373]  4 [382,618]  5 [628,720]
2  52  6 [0,4]      7 [14,217]   8 [246,391]  9 [399,448]  10 [468,720]
3  51  11 [0,720]
4  29  12 [0,9]     13 [22,31]   14 [55,607]  15 [621,720]
5  47  16 [0,43]    17 [49,335]  18 [344,352] 19 [355,720]
```

Why do we care?

Customers are usually active at different locations during specific time windows on one day, and are therefore not able to receive packages directly at a fixed location all day long. For companies that would like to add more personalizations, it is important for them to give customers the option to choose the time and location they would like the goods to be handed.

Formulation with selected important constraints:

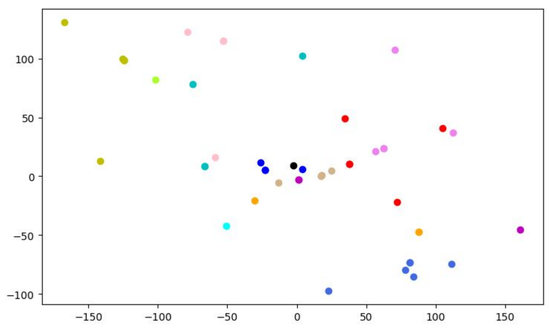
- Each customer c is visited by the vehicle v during his stay at a certain location,
- The time vehicle v leaves the previous customer plus the transportation time from the previous customer to the next customer should be within the time window of the next customer.
- The amount of customers visited by a vehicle should satisfy the capacity constraints of this vehicle.

$$\sum_{i\in V_c} a_i^c \sum_{\substack{j\in V \\ i\neq j}} x_{i,j,k} \leq \tau_{c,k} \leq \sum_{i\in V_c} b_i^c \sum_{\substack{j\in V \\ i\neq j}} x_{i,j,k} \qquad \forall k \in Z, c \in C, c \neq 1 \qquad (3)$$

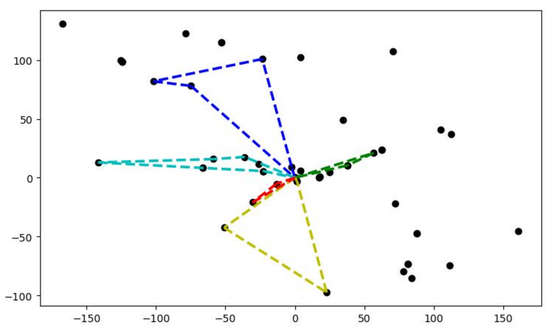
$$\tau_{c,k} + \sum_{i\in V_c}\sum_{j\in V_{c'}} t_{i,j} x_{i,j,k} \leq \tau_{c',k} + T\{1 - \sum_{i\in V_c}\sum_{j\in V_{c'}} x_{i,j,k}\} \quad \forall c \in C, \quad \forall k \in Z, c' \in C, c' \neq c \qquad (4)$$

$$y_z^c + Q\{1 - \sum_{i\in V_c}\sum_{j\in V_{c'}} x_{i,j}\} \geq d_{c'} + y_z^{c'} \qquad \forall c \in C, \quad \forall c' \in C, c' \neq c, \quad \forall z \in Z \qquad (5)$$

Result & Impact



15 Customers
50 Locations
4 Vehicles



Cost improvement:
We reduce the cost by **59.92%** compared to the ***worst*** case, **26.60%** compared to the ***average*** case cost.

Business Impact:
Employing our model not only **saves costs**, but also **adds personalization** for customers, which may generate additional revenue

Future Work:

1. We'll try multiple instances to enlarge the project scope
2. We'll relax assumption that customer locations can't be overlapped

Augustin, L., Simon, T., Frédéric, F., "Vehicle Routing Problem with Roaming Delivery Locations and Stochastic Travel Times (VRPRDL-S)", Transportation Research Procedia, vol. 30, pp 167-177, 201