Problem setting (variant of CVRP)

Given a map $G = (L, E)$ with a set of locations L, a set of bookings $b_i \in \mathcal{B}$ and an unlimited set of vechicle $v_j \in \mathcal{V}$. Each location has a set of bookings to be delivered to. Each booking b_i associate with its seats s_i and locations $l_i \in \mathcal{L}$. Each vechicle has its own operation fee f_j and capacity c_j. The goal is to select a subset of vechicles, each associates with a path p_j covering a subset of locations $L(p_j) \subset \mathcal{L}$ and for each vechicle, select a subset of clients to be delivered by. The vehicles take its clients to their destinations with minimum cost.

Remarks

- If we have very good CVRP IP solver, we could consider use this formalization to solve the problem.
- A postprocess is necessary. In classical CVRP, the demand (in our setting, demand of location is the total seats to be delivered to the location) is seperable. But in our case, seats in one booking is not seperable.

counterpart in codebase

booking $\leftrightarrow$ booking
location $\leftrightarrow$ hotels (or hotel areas)
trip $\leftrightarrow$ trip
vehicle $\leftrightarrow$ vehicle

Annotations

Constants:

G :$G = (L, E)$. A graph showing the location and route of the cus

L :A collection of locations represeting hotels. The location that r

E :Set of direct pathes connecting each hotel $e_{ij} = (i, j)$.

V :$V = \{1, 2, \ldots, |J|\}$. Set of vehicles.

s_i :$s_i \geq 0$. Seats of booking i, i.e. number of customers w.r.t booki

c_j :vehicle's capacity (Not all vehicles have the same maximum ca

d_{ij} :Travel distance between location i and j (distance between i a

f_j :fee to operate vehicle to manage trip j. Fees could be determin

Variables:

y_j^T :$y_j^T = \begin{cases} 1 & \text{if trip } j \text{ is selected} \\ 0 & \text{otherwise} \end{cases}$

$x_{ii'}^j$:A decision variable that indicates whether the vehicle j has tal

$x_{ii'}^j = \begin{cases} 1 & \text{taken} \\ 0 & \text{otherwise} \end{cases}$

Formalization (LP)

The goal is to minimize cost:

$$\min \sum_{k \in K} \sum_{(i,i') \in E} (\alpha \cdot f_j + \beta \cdot d_{ii'} \cdot x_{ii'}^j) \cdot y_j$$

While satisfies:

$$\sum_{j \in V} x_{ii'}^j \geq 1 \qquad \forall i \in L \backslash \{0\} \tag{1}$$

$$\sum_{i \in L, i \neq i'} x_{ii'}^j - \sum_{i \in L} x_{i'i}^j = 0 \qquad \forall i, i' \in L, \quad \forall j \in V \tag{2}$$

$$\sum_{i \in L} \sum_{i' \in L \backslash \{0\}, i \neq i'} s_i x_{ii'}^j \leq c_j \qquad \forall j \in V \tag{3}$$

$$\sum_{j \in V} \sum_{(i,i') \in S, i \neq i'} x_{ii'}^j \leq |S| - 1 \quad S \subseteq L \backslash \{0\} \tag{4}$$

$$x_{ii'}^j \leq y_j \qquad \forall i, i' \in L, \quad \forall j \in V \tag{5}$$

$$y_j, x_{ii'}^j \in [0, 1] \qquad \forall j \in V, \quad \forall (i, i') \in E \tag{6}$$

(1) Each hotel should be vistied at least once
(2) Constraint which means “the number of vehicles coming in and out of a location is the same”
(3) Constraint which means “the delivery capacity of each vehicle should not exceed the vehicle's maximum capacity”
(4) Constraint for “removal of subtours”
α and β are weights to manually control.

CVRP formalization
CVRP another formalization