Sevannette Tours

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Outline

- Problem Overview
  - Objective
  - Constraints
- Problem Formulation
- Information Required
- Discussion

Problem Overview - Objective

- Sevannette Tours is a tour guide company that services 4 hotels in Montreal.
- 27 potential locations in 18 regions.
- Rather than planning set tour destinations, the clients are given a checklist of their top destinations to fill out prior to boarding.
- Our goal is to create personalized tours that satisfy the greatest number of customer.
  - A satisfied client has been defined as a customer who visits at least 4 of their preferred locations.

Problem Overview - Constraints

- Fleet:

Vehicle Type	Quantity Available	Maximum Capacity	Minimum # of Passengers	Fuel Cost ($ /Tour)	Parking Cost ($)
Van	8	8	6	80	12
Mini-Bus	5	20	14	130	15
Bus	3	30	24	200	25

- Restrictions:
  - Vans cannot be used for night tours.

Problem Overview - Constraints

- Guides

Guide	Quantity	With / Without License	Pay With/ Without License
Anglophone	15	11	$22/h
		4	$13/h
Francophone	10	0	$13/h

- Restrictions:
  - Each vehicle must have a driver (Anglophone).
  - Quebec law: each vehicle must have a French guide.
  - One guide must be allocated for every 10 passengers.

Problem Overview - Constraints

- Tour requirements:
  - Must generate $400 profit per day.
  - Must visit 2 regions per tour.
  - At least one of the regions that we visit must have a restaurant.
  - Tours must be approximately 4 hours.

- Income:
  - Day: $45 /tour
  - Night: $35 /tour

Problem Formulation - Variables

Variables:

$vehicle_{i,l,t} \in \{0,1\}$

$i \in \{1,...,16\}$ Type of vehicle

$l \in \{1,...,27\}$ Locations

$t \in \{1,2\}$ Day or night

$i \in \{1,2,3\}$ ⟶  Buses

$i \in \{4,...,8\}$ ⟶  Mini buses

$i \in \{9,...,16\}$ ⟶  Van

Problem Formulation - Variables

$tourist_{j,i,t} \in \{0,1\} \quad j \in \{1,...,508\}$ Potential satisfied customer.

Customer j goes in a vehicle i in a time t

$y_{j,i,t} \in \{0,1\}$ satisfied customer.

Customer j goes on a vehicle i during a time of the day t

$region_{n,i,t} \in \{0,1\} \quad n \in \{1,...,18\}$ set of locations

$inuse_{i,t} \in \{0,1\}$ vehicle in use during day or night

Problem Formulation - Objective

$$z = \max \sum_{i=1}^{508} \sum_{l=1}^{27} \sum_{t=1}^{2} y_{i,l,t}$$

Maximize the number of satisfied customers.

Given that a tourist j wants to visit a location l, denoted as $choice_{l,j}$, it is possible to establish how a customer can be satisfied.

Choices $\rightarrow$ input data

Problem Formulation - Constraints

$$\sum_{l=1}^{27} choice_{l,j} \cdot vehicle_{i,l,t} \geq 4 \cdot y_{i,l,t} \qquad \forall j,i,t$$

$$\sum_{i=1}^{16}\sum_{t=1}^{2} tourist_{j,i,t} = 1 \qquad \forall j$$

$$tourist_{j,i,t} \geq y_{j,i,t} \qquad \forall j,i,t$$

First constraint → turn the ***y*** variable on

Second constraint →each tourist must be allocated to a vehicle only once

Third constraint → the tourist can only be happy at most once (upper-bounded by the 2nd constraint).

Problem Formulation - Constraints

$$\sum_{l=1}^{27} vehicle_{i,l,t} \geq inuse_{i,t} \qquad \forall i,t$$

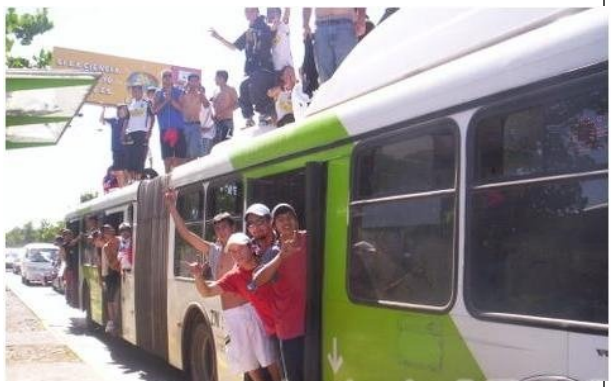
$$\sum_{l=1}^{27} vehicle_{i,l,t} \leq 27 \cdot inuse_{i,t} \qquad \forall i,t$$

These constraints state that if we decide to use a vehicle, it will set the inuse variable to 1. Otherwise, the inuse will be 0.

Problem Formulation - Constraints

$$\sum_{j=1}^{508} tourist_{j,i,t} \leq MaxCapacity_i \cdot inuse_{i,t} \qquad \forall i,t$$

$$\sum_{j=1}^{508} tourist_{j,i,t} \geq MinCapacity_i \cdot inuse_{i,t} \qquad \forall i,t$$



The above equations allocate tourists to vehicles.

If *inuse* for a vehicle is 1, then we must meet the minimum capacity requirements, while remaining under the maximum capacity requirements.

If *inuse* is 0, then 0 tourists can be assigned to that vehicle.

Problem Formulation – Assigning Guides

- Let $guide_{k,i,t}$ be a binary variable that represents whether or not the guide k is assigned to the vehicle i at time t (day/night).

11 Anglophone guides with driver's license (k from 1 to 11)

4 Anglophone guides without driver's license (k from 12 to 15)

10 Francophone guides without driver's license (k from 16 to 25)

Problem Formulation – Assigning Guides

- At least one guide with driver license per vehicle

$$\sum_{k=1}^{11} \boldsymbol{guide}_{k,i,t} \geq \boldsymbol{inuse}_{i,t} \qquad \forall \boldsymbol{i},\boldsymbol{t}$$

$$\sum_{k=1}^{11} \boldsymbol{guide}_{k,i,t} \leq 11 \cdot \boldsymbol{inuse}_{i,t}$$

- At least one francophone guide per vehicle

$$\sum_{k=16}^{25} \boldsymbol{guide}_{k,i,t} \geq \boldsymbol{inuse}_{i,t} \qquad \forall \boldsymbol{i},\boldsymbol{t}$$

$$\sum_{k=16}^{25} \boldsymbol{guide}_{k,i,t} \leq 10 \cdot \boldsymbol{inuse}_{i,t}$$

Problem Formulation – Assigning Guides

- If the vehicle is a bus, an additional guide is needed:

$$\sum_{k=12}^{15} \boldsymbol{guide}_{k,i,t} \geq \boldsymbol{inuse}_{i,t}$$

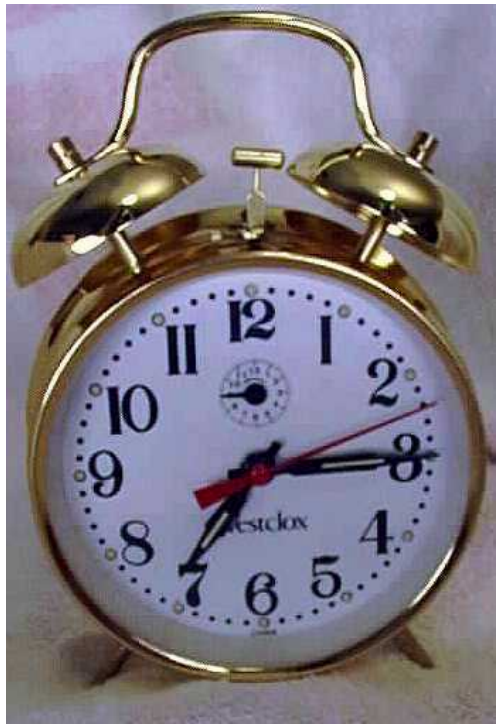
$$\sum_{k=12}^{15} \boldsymbol{guide}_{k,i,t} \leq 1 \qquad \forall \boldsymbol{i} \in \{1,2,3\}, \boldsymbol{t}$$

Problem Formulation – Tour Time Constraint

- The tour cannot exceed 4 hours

$$\sum_{l=1}^{27} \boldsymbol{time}_l \cdot \boldsymbol{vehicle}_{i,l,t} \leq 4 \cdot 60$$

$$\forall \boldsymbol{i}, \boldsymbol{t}$$



Problem Formulation – Visiting Regions

- Let $\boldsymbol{region}_{n,i,t}$ be a binary variable that represents whether or not a region n is visited by a vehicle i at time t (day/night).

- Each region contains at least one touristic place. We have 18 regions and 27 locations.

Region	Location
n=1	l=$l_{1.intial}$
	:
	l=$l_{1.final}$
n=n	l=$l_{n.intial}$
	:
	l=$l_{n.final}$
n=18	l=$l_{18.intial}$
	:
	l=$l_{18.final}$

Problem Formulation – Visiting Regions

$$\sum_{l=l(n.initial)}^{l(n.final)} vehicle_{i,l,t} \leq 27 \cdot region_{n,i,t}$$

$$\forall i,n,t$$

- At least two regions have to be visited in each tour

$$\sum_{n=1}^{18} region_{n,i,t} \geq 2 \cdot inuse_{i,t} \qquad \forall i,t$$

Problem Formulation – Visiting Regions

- If the vehicle *i* is not used at time *t* any region can be visited by that vehicle

$$\sum_{n=1}^{18} region_{n,i,t} \leq 18 \cdot inuse_{i,t} \qquad \forall i,t$$

- At least one region with restaurant must be visited in each tour

$$region_{2,i,t} + region_{6,i,t} + region_{13,i,t} + region_{16,i,t} + region_{17,i,t} \geq inuse_{i,t}$$

$$\forall i,t$$

Problem Formulation - Profits

$$Income = \sum_{j=1}^{508}\sum_{i=1}^{16}\left(45 \cdot tourist_{i,j,1} + 35 \cdot tourist_{i,j,2}\right)$$

$$Fuel = \sum_{i=1}^{16}\sum_{t=1}^{2} FuelCost_i \cdot inuse_{i,t}$$

$$Parking = \sum_{i=1}^{16}\sum_{l=1}^{27}\sum_{t=1}^{2} ParkingCost_{i,l} vehicle_{i,l,t}$$

$$Employee = \sum_{i=1}^{16}\sum_{t=1}^{2}\sum_{k=1}^{11} 22 \cdot 4 \cdot guide_{k,i,t} + \sum_{i=1}^{16}\sum_{t=1}^{2}\sum_{k=12}^{25} 13 \cdot 4 \cdot guide_{k,i,t}$$

$$Income - Fuel - Parking - Employee \geq 400$$

Information Required

- List of the expected customers for the day/night tours.
- Choices of locations to visit for each customer.
- Preference of time (i.e. only day or night, or client is indifferent what time to go on a tour).

Discussion