Master 1 MIAGE **2024-2025**

Authors: Cyril KONE & Loïc Nassara
Groupe 1 - TP A

TP3 Report : The optimal parking problem

This report presents the process of modeling and solving a parking optimization problem using linear programming. Using the PuLP library, we were able to find an optimal solution while respecting specific constraints.
Mr. Edmonds' parking problem is to optimize the occupancy of Dantzig Street to accommodate his guests' cars at a party. With 15 cars and varying lengths, the goal is to minimize the space occupied while respecting certain parking constraints.

Question 1: Propose a linear model of Mr. Edmonds' problem.

Decision Variables
Xi is a binary variable that indicates whether car iii is parked on the left side (1) or on the right side (0).

Objective Function
The aim is to minimize the total length occupied by cars .
Let Z = min (max (Lleft, Lright))
Let lambda_i the length
Minimize Z= sum (lambda_i * Xi +lambda_i * (1-Xi))

Contraints
Total length of cars parked on the left
Lleft= sum lambda_i * Xi
Total length of cars parked on the right
Lright = sum lambda_i * (1-Xi) with i= 1,2,...,15

```
# Variables: X = 1 if car i is on the left side, 0 if on the right side
    X_i = [LpVariable(f'X_i{i}', cat=LpBinary) for i in
range(len(t_lambda))]
    # Longueur totale du côté gauche (Lleft)
    Lleft = lpSum(t_lambda[i] * X_i[i] for i in range(len(t_lambda)))
    # Longueur totale du côté droite (Lright)
    Lright = lpSum(t_lambda[i] * (1-X_i[i]) for i in
range(len(t_lambda)))
```

Question 2: Transform if necessary your model into canonical form.
The objective function was rewritten in maximization form:
Z'=-Z=-Lleft-Lright

Question 3: Implement it in Python using PuLP, then solve it. What is the solution?
After running the code, the results were as follows:
Status: (Indicates whether an optimal solution has been found).
Total occupied length: (Shows the minimized length).
Car layout: (Shows where each car is parked).
We get 27.1 as a solution.
Also, the length of the car on the left is 27.1
The length of the car on the right is 27.0

```
Z: 27.1
----------------------------------------
La longueur de la voiture sur le coté gauche: 27.1
La longueur de la voiture sur le coté droit: 27.0
```

Question 4.1: the sum of cars' length parked on the left side should be less than 20 meters;

```
Lleft = lpSum(t_lambda[i] * X_i[i] for i in range(len(t_lambda)))
prob += Lleft <= 20
```

We get:

```
   La longueur de la voiture sur le coté gauche: 20.0
   La longueur de la voiture sur le coté droit: 34.1
```

Question 4.2: cars are allowed to occupy more or equal to 16m on no more than one of the street sides;
We have:

```
# Longueur totale du côté gauche (Lleft)
    Lleft = lpSum(t_lambda[i] * X_i[i] for i in range(len(t_lambda)))
    # Longueur totale du côté droite (Lright)
    Lright = lpSum(t_lambda[i] * (1-X_i[i]) for i in
range(len(t_lambda)))
```

```
 prob += Lleft >= 16, "Plus de 16m sur le coté gauche"
```

```
prob += Lright <= 16, "Moins de 16m sur le coté droit ou égale"
prob += Lleft + Lright >= 16
```

We get:

```
------------------------------------
La longueur de la voiture sur le coté gauche: 38.1
La longueur de la voiture sur le coté droit: 16.0
```

Question 4.3: cars longer than 4 meters should be parked on left side;

```
for i in range(len(t_lambda)):
        if t_lambda[i] > 4:
            prob += X_i[i] == 1
```

We get:

```
----------------------------------------
La longueur de la voiture sur le coté gauche: 27.200000000000003
La longueur de la voiture sur le coté droit: 26.900000000000002
```

Question 4.4: if the length of the left side is larger than 10 meters, the length of the right side should be smaller than 13 meters.

```
M = 1000  # Big contraite M
    Y = LpVariable("Y", cat=LpBinary)
    prob += Lleft <= 10 + M * Y, "10m comme limite à gauche"
    prob += Lright <= 13 + M * (1 - Y), "13m comme limite à droite"
    return prob, X_i
```

We get:

```
----------------------------------------
La longueur de la voiture sur le coté gauche: 41.1
La longueur de la voiture sur le coté droit: 13.0
```

Source code: https://github.com/Largaton1/Optimization.git