CIVIL-557

Decision Aid Methodologies In Transportation

Lab VIII: Balancing Bike Sharing Systems

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Overview

- Bike sharing system
- Introduction to the exercise: balancing bike-sharing systems

Bike Sharing Systems

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Bike sharing systems

- Types of systems:
  - With docks vs dock-less
  - Station-based vs free-floating
  - Bikes and/or e-bikes

- Usually a subscription to the systems guarantees free rides up to x minutes, then a per-minute charge is applied.

- Smartphone apps can allow users to verify real-time availability at pick-up station (and occupancy at drop-off station).

Bike sharing systems

- Examples:
  - Paris
  - London
  - Lausanne

- More and more popular all over the world, but it does not always go as planned…
  - https://www.brand-e.biz/innovation/dockless-bikes-are-taking-pretty-heavy-flak
  - http://www.copenhagenize.com/2015/02/watching-copenhagen-bike-share-die.html

Bike sharing systems and Operations Research

Some problems that can be solved by using OR techniques:

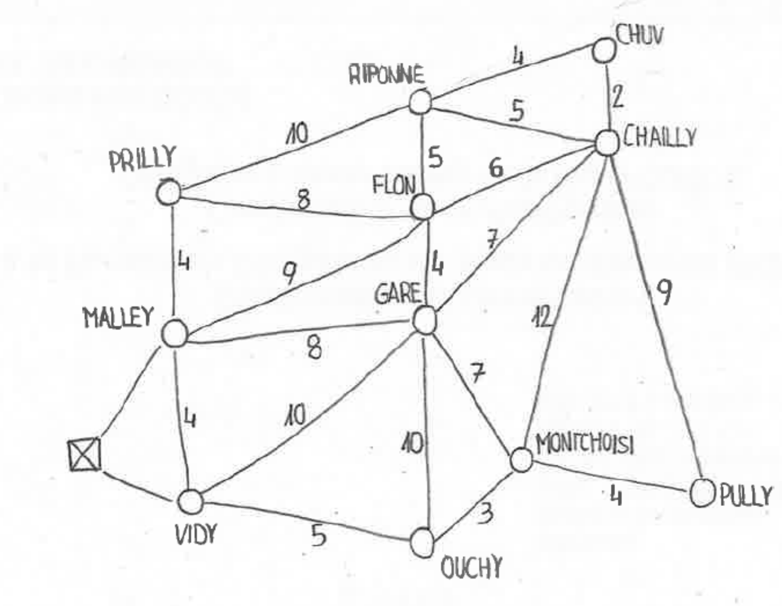
- Network design:
  - Input: number of bicycles, number of stations, spatial distribution of the expected demand, ...
  - Output: best locations where to places stations
- Pricing:
  - Input: supply of bicycles, demand forecasts, customer utility (e.g. willingness-to-pay), ...
  - Output: optimal fares and subscription fees
- **Balancing**:
  - Input: network, availability at stations at a given time, demand forecasts, number of vehicles used to relocate bicycles and their capacity, ...
  - Output: route of vehicles and number of bicycles to be picked up or dropped off at each station

Exercise:
Balancing bike-sharing systems

Our case study

- A new bike sharing scheme in Lausanne with 11 stations and 100 bicycles

- The demand matrix is not symmetric:
  - o Morning commute will be mostly directed from residential areas to workplaces. In the afternoon the opposite will happen.
  - o Some users might only use the bicycles to travel downhill...



- We want to find the best way (i.e. minimizing the operation costs) to move bicycles at the end of each period while satisfying all the given constraints.

Model

Objective function:

- Minimize the total daily operational costs.

Constraints:

- After each time period (P = 4: p1 = 7:00-11:00, p2 = 11:00-15:00, p3 = 15:00-19:00, p4 = 19:00-07:00), the company must reposition the bicycles in order to satisfy the demand for the next period at all stations.
- After repositioning, there must be at least 3 bicycles available at all stations.
- After the last time period, the repositioning should lead back to the initial configuration.

Exercise questions

- 2 parts:

1. Pure network flow formulation
   - Write the model and implement it in OPL.
   - Look at the results and answer the questions.

2. Routing formulation (the routing constraints are already implemented)
   - Complete the model (can you re-use the code implemented in part 1?) and implement it in OPL.
   - Look at the results and answer the questions.
   - Try to change the vehicle capacity (increase it and decrease it) and look at how the optimal solution changes.

Assignment #7

- Send a zip file which contains your code and a document with the answers to the questions.
- Submit to stefano.bortolomiol(at)epfl.ch by 8 pm next Monday.
- Group/individual work