Multi-objective laboratory: Knapsack Problem & Group project

Léa Ricard

Transport and Mobility Laboratory
School of Architecture, Civil and Environmental Engineering
École Polytechnique Fédérale de Lausanne

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Knapsack Problem (KP)

Problem definition:

- A decision-maker must choose from a set of non-divisible objects (e.g., projects, tasks).
- Decision variables: $x_i = 1$ if item i is in the knapsack, 0 otherwise.
- Each object $i \in \{0, ..., n\}$ has a weight w_i.
- $w^T x \leqslant W$ where W is the maximum weight allowed, e.g. 100kg

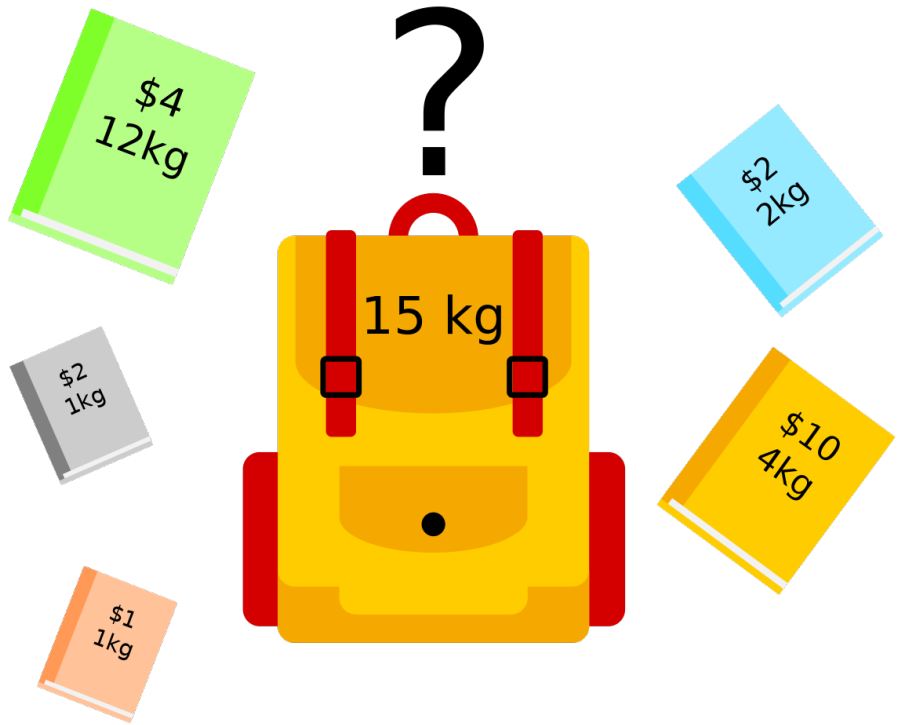
Objectives

- Maximizing the utility: $\max f_1(x) = \sum_{i=1}^{n} u_i x_i$
- Minimizing the cost: $\min f_2(x) = \sum_{i=1}^{n} c_i x_i$

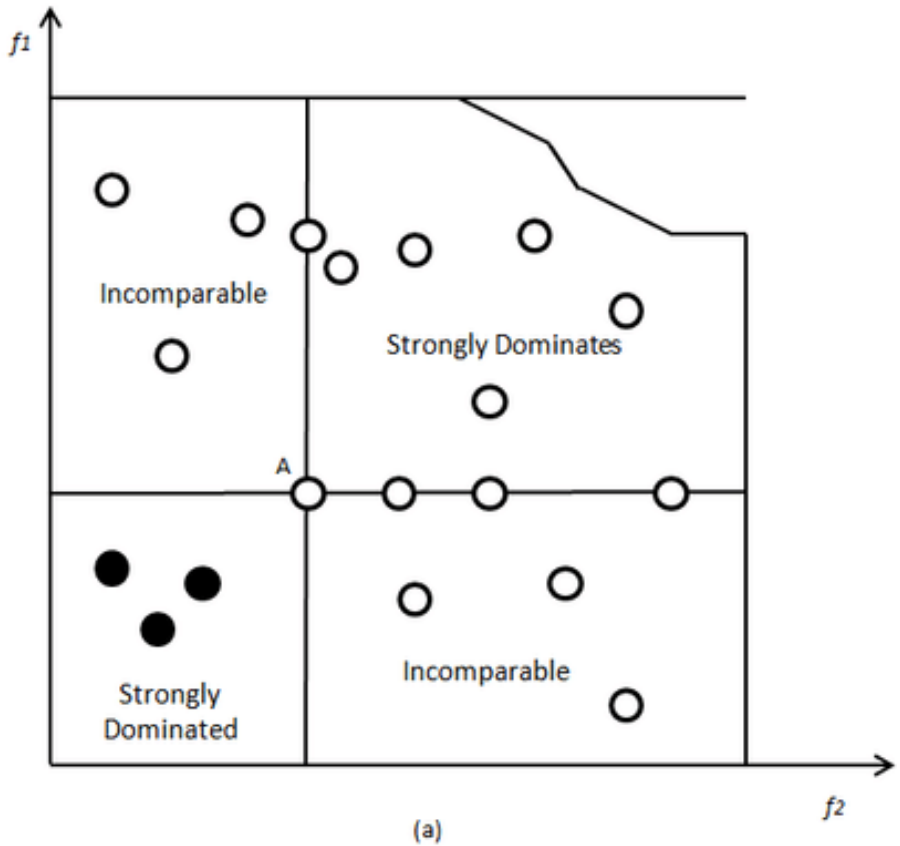
Knapsack Problem (KP)

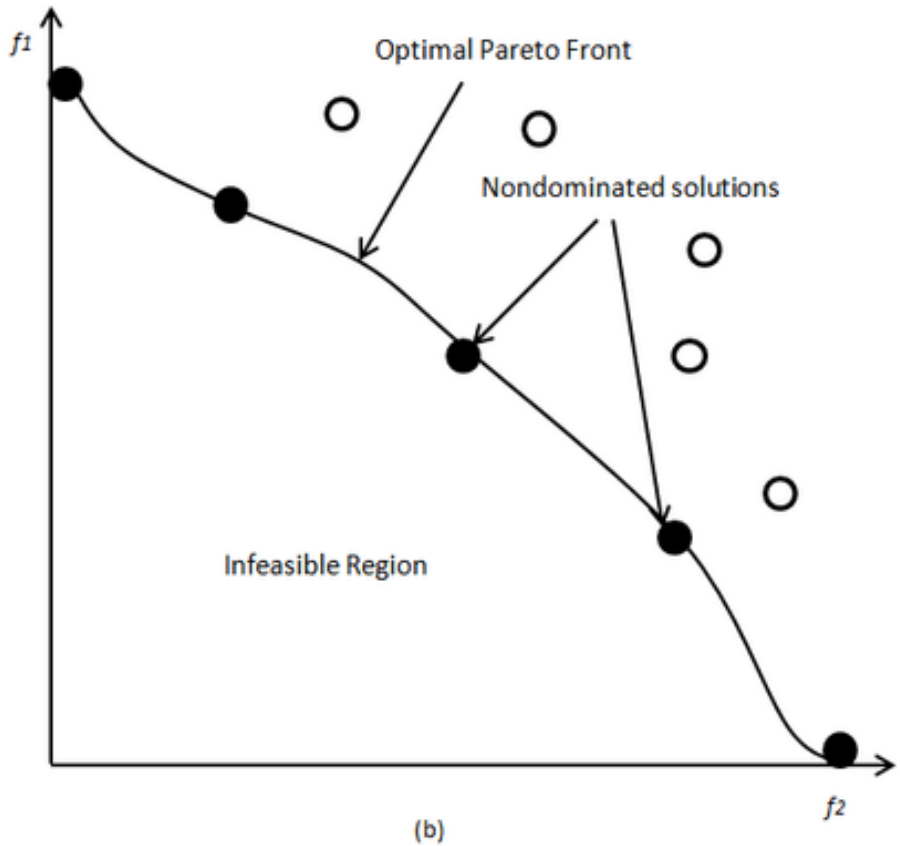
Application

- Cutting raw materials;
- Asset optimization (portfolio);
- Cloud computing;
- Etc.



Dominance and Pareto frontier



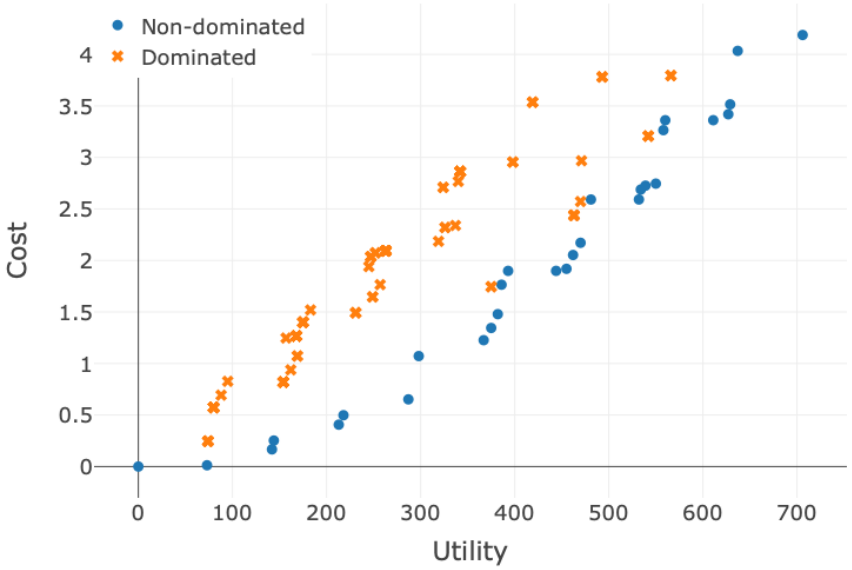


Important

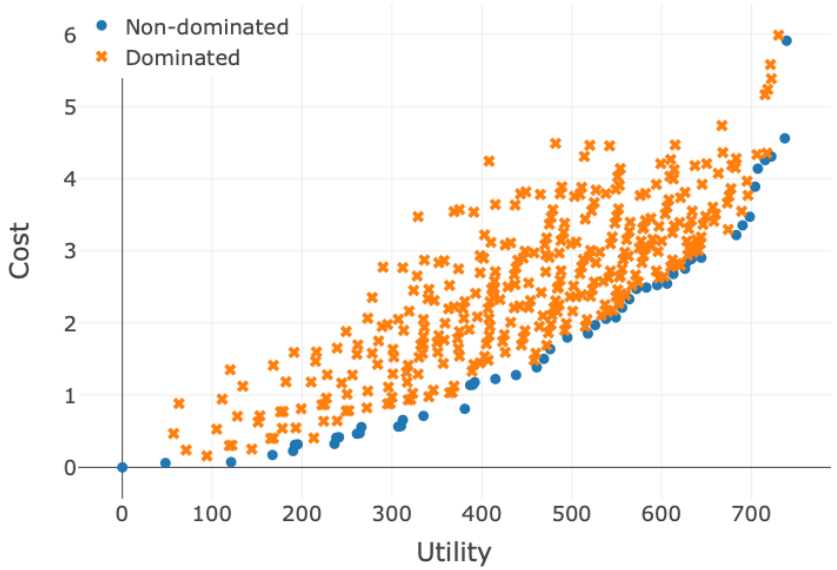
Be careful, because in our case, one objective is minimized, while the other is maximized! An easy trick is to multiply either objective by -1.

My results

For an instance with 20 items.



(a) Local search heuristic



(b) Full enumeration

Project overview

Aim:

- Full application of a **simulation-based optimization** example.
- Apply the methods you learned to solve a real-world problem.
- The main purpose is to identify the **optimal** system configuration.

Objectives:

- **Simulation:** develop a discrete events simulation and appropriately evaluate the performance in two different scenarios.
- **Optimization:** define and solve an optimization problem to obtain the optimal solution for the system.

Case study

Simulation:

- Develop a discrete events simulation.
- Identify the appropriate statistical indices.
- Correctly use simulation techniques to generate results.
- Correctly analyze the simulation results.
- Consider the efficiency and precision of simulation.

Optimization:

- Identify the decision variables.
- Define the objective function(s).
- Design an optimization algorithm to solve the problem.
- Identify many meaningful and goods solutions.

Keep in mind

Optimization project

- Expand the discrete-event simulation.
- Embed the discrete-event simulation in the optimization algorithm.

Keep in mind

Tips

- Start by defining the **objective function(s)** you want to minimize/maximize.
- Consider how you would **evaluate** the objective functions with the simulated data.
- Start with **simple** constrained optimization.
- Explore different objective functions, for example:
  - Maximize or minimize the mean value of X (e.g., revenue, capacity, or time).
  - Minimize the variance of X across multiple dimensions.

Keep in mind

Attention!

- Computational time

Support

- Email to `cloe.cortesbalcells@epfl.ch` and `pavel.illinov@epfl.ch` for the simulation part
- Email to `lea.ricard@epfl.ch` for the optimization part

Presentation of the project

- **30 May 2024**, MED01418.
- Make sure that the first presentation will start at 9:15 on time.
- Make sure that each student of the group presents approximately the same time during the final presentation.
- 25 minutes presentation and 10 minutes Q&A.
- You should include both simulation and optimization parts.

Group	**Time**	**Review**
Group 1 - Train service	9:15-9:50	Group 2
Group 2 - Online movie	9:50-10:25	Group 3
15 minutes break		
Group 3 - Drone delivery	10:40-11:15	Group 4
Group 4 - Vaccination	11:15-11:50	Group 1

Project submission

- Submit by e-mail to `cloe.cortesbalcells@epfl.ch`, `pavel.illinov@epfl.ch`, and `lea.ricard@epfl.ch`.
  1. **PDF file** for the presentation,
  2. **Jupyter notebook** for the project,
  3. **Jupyter notebooks** for the labs (one notebook per group and lab).
- Deadline: **29.05.2024 at 17:00**.
- Subject: "OptSim24 project: Group X"
- File: make one zip file "Group$X$.zip".