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Integer programming formulations for exam hall allocation

(Topic presentation)

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Background

- During exam weeks, a large number of students must be assigned to seats in exam halls
- Poor allocation increases cost (hall reservations, exam supervisors)
- Currently, the allocation is done manually → opportunity for optimization

Objectives

- Develop an integer programming (IP) model for exam hall allocation
- Implement the IP formulation using Python and a suitable optimization solver
- Assign each student in a course to some exam hall while minimizing hall reservation and supervision costs
- Test the implementation on anonymized datasets from past exam weeks

Constraints

- Core constraint:
  - Seat capacity of each exam hall
- Additional constraints:
  - Students in the same exam must not be split across too many halls
  - Maintain spacing between students taking the same exam
  - Reserve buffer capacity for unexpected students

Scope

- Focus on the exam hall allocation problem (not scheduling exam times)
- Starting with just the core constraints

Tools

- Python and PyOptInterface package for writing the model
- Gurobi as the underlying solver
- Pandas for reading and preprocessing Excel files

Data sources

- Anonymized student registeration data from mathematics exams (periods 1 & 2, 2024) in Excel format
- Hall capacities, layout data (seats in each row) and pricing in Excel format

Data overview

Table 1: Overview of mathematics exam registration data for periods 1 and 2 in 2024

Period 1										
Date	14.10.2024	14.10.2024	15.10.2024	16.10.2024	17.10.2024					**Total**
Time	9:00-12:00	13:00-16:00	16:30-19:30	16:30-19:30	9:00-12:00					
Total registrations	322	609	633	1139	621					**3324**
Unique course codes	5	2	2	5	3					**17**
Period 2										
Date	02.12.2024	03.12.2024	03.12.2024	05.12.2024	09.12.2024	10.12.2024	11.12.2024	12.12.2024	12.12.2024	**Total**
Time	9:00-12:00	9:00-12:00	16:30-19:30	9:00-12:00	9:00-12:00	9:00-12:00	9:00-12:00	9:00-12:00	16:30-19:30	
Total registrations	984	100	1180	938	292	208	288	406	149	**4545**
Unique course codes	7	3	5	7	7	2	2	5	2	**40**

Bin packing problem

The problem is related to the bin packing problem where items (here student groups) must be packed into bins (exam halls)

Let:

- $y_i \in \{0, 1\}$ be 1 if bin i is used, 0 otherwise
- $x_{ij} \in \{0, 1\}$ be 1 if item j is assigned to bin i, 0 otherwise

Given:

- n items, each with weight w_j
- n bins, each with capacity c

$$\text{minimize} \quad \sum_{i=1}^{n} y_i$$

$$\text{subject to} \quad \sum_{j=1}^{n} w_j x_{ij} \leq c y_i \qquad \forall i = 1, \ldots, n \quad \text{(bin capacity constraint)}$$

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad \forall j = 1, \ldots, n \quad \text{(each item assigned to exactly one bin)}$$

(Martello and Toth, 1990)

Schedule

- 13/06/2025 Topic presentation
- 06-07/2025 Literature review, formulating the problem, building the model
- 07-08/2025 Writing the thesis
- 08/2025 Thesis presentation

References

- Martello, S. and Toth, P. (1990). *Bin-packing problem*. In: *Knapsack problems: Algorithms and computer implementations*.