# ”The Examination Timetabling Problem Project report ”

Profs. R. Rizzi, R. Zanotti

Discrete Optimization and Decision Making - 2022/2023

Mahsa Sedaghatinia / VR481427

August 2023

# Contents

# 1 Introduction

The exam scheduling problem (ETP) is an optimization problem that includes creating a well-organized plan for a group of exams and students with the goal of reducing exam conflicts and ensuring fairness in the allocation of exam imposes among the students. In order to meet schedule criteria and resource constraints, the best possible arrangement of exam time slots must be found.

# 2 Project definition

Let us consider a set E of exams, to be scheduled during an examination period at the end of the semester, and a set S of students. Each student is enrolled in a non-empty subset of exams. The examination period is divided into T ordered time-slots. Given two exams $e1, e2 \in E$, let $n_{e1,e2}$ be the number of students enrolled in both. Two exams $e1, e2 \in E$ are called conflicting if they have at least one student enrolled in both, i.e., if ne1,e2 ¿ 0. Rules and regulations impose that conflicting exams cannot take place in the same time-slot. Moreover, to promote the creation of timetables more sustainable for the students, a penalty is assigned for each pair of conflicting exams scheduled up to a distance of 5 time-slots. More precisely, given two exams $e1, e2 \in E$ scheduled at distance $i$ of time-slots, with $1 \leq i \leq 5$, the relative penalty is $2(5 - i) \cdot \frac{n_{e1,e2}}{|S|}$.

The ETP aims at assigning exams to time-slots ensuring that:

- each exam is scheduled exactly once during the examination period;
- two conflicting exams are not scheduled in the same time-slot;
- the total penalty resulting from the created timetable is minimized.

## 2.1 Advanced Model

### 2.1.1 Equity Measures

In addition to the traditional objective of minimizing the total penalty, there are a number of other equity measures that can be considered when creating a timetable. Some of these measures include:

- Maximum distance: This measure is the maximum number of time-slots between any two conflicting exams. A timetable with a high maximum distance is more equitable for students, as it means that they will have more time between exams.
- Number of students with back-to-back exams: This measure is the number of students who have two conflicting exams scheduled in consecutive time-slots. A timetable with a low number of students with back-to-back exams is more equitable for students, as it means that they will have more time to rest between exams.

#### 2.1.2 Additional restrictions

- At most 3 consecutive time slots can have conflicting exams
- If two consecutive time slots contain conflicting exams, then no conflicting exam can be scheduled in the next 3 time slots.
- Include a bonus profit each time no conflicting exams are scheduled for 6 consecutive time slots.
- Change the constraints that impose that no conflicting exams can be scheduled in the same time slot. Instead, impose that at most 3 conflicting pairs can be scheduled in the same time slot.

## 3 Methodology

Firstly, In order to implement and solve this optimization problem with regard to satisfying the objective function (minimizing the penalty here) and meeting the required and defined criteria and constraints, I have formulate this problem as a Linear programming problem, Then I have used Python and Gurobi optimizer in implementation step. My project includes the implementation of the basic code, one advanced equity measure (Maximum distance) and also additional restrictions. Finally I have run all the 11 instances and got feasible solution for some. The results of different instances for all project versions are provided as follows.

## 4 Results

The results of this optimization model are assessed by evaluating the "Penalty" value achieved for a given instance, the lower the penalty is the better the exams are scheduled, Also a timetable of scheduled exams is printed for every instance in the output of the code (details in the screenshots folder). Below there is a table of achieved penalties for different versions of the project for all 11 instances:

| instances | basic model | advanced model |
|---|---|---|
| instance 01 | 187.702 | 186.216 |
| instance 02 | 53.095 | 52.049 |
| instance 03 | 59.575 | 53.20 |
| instance 04 | 12.988 | 12.745 |
| instance 05 | 27.211 | 33.738 |
| instance 06 | No feasible solution | No feasible solution |
| instance 07 | 18.902 | 18.902 |
| instance 08 | 45.175 | 45.345 |
| instance 09 | 22.009 | 21.599 |
| instance 10 | No feasible solution | No feasible solution |
| instance 11 | No feasible solution | No feasible solution |

Table 1: Penalty values of the instances

We can see that adding the equity measure of maximum distance decreases slightly the penalty value for instances 01, 02, 03, 04 and 09, increases slightly the penalty for instances 05 and 08 and for instance 07 the penalty value is the same. for the larger instances (06, 10 and 11) No feasible solution was found in both models.