Development & Implementation of a Matching Algorithm for Student-Project Allocation

Project defence presentation

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Introduction

- Importance of allocating students to projects effectively
- Manual allocation challenges: time-consuming, error-prone
- Motivation for automation and optimization

Agenda

- Background: Gale-Shapley algorithm & challenges
- Student Project Allocation (SPA) algorithm
- Mathematical model & optimization
- Implementation & web interface
- Results & performance evaluation
- Discussion & comparison
- Conclusion & future work

Background: Gale-Shapley algorithm

- Stable marriage problem foundation
- One-to-one matching explained
- Proposal and acceptance concept
- Limitations in many-to-one context (projects with multiple students)

Challenges with Gale-Shapley

- Difficulty handling many-to-one allocations
- Instability risks when quotas > 1
- Computational complexity with grouping students
- Need for a more flexible approach

SPA algorithm overview

- Purpose-built many-to-one stable matching algorithm
- Supports student project preferences & project quotas
- Produces stable matchings respecting constraints

Proposed Solution : MILP

- **Research paper :** “Handling preferences in student-project allocation” The university of Southern Denmark - 2017

- We model the allocation problem as a **Mixed Integer Linear Program**.

How the algorithm works

Step 1: Input Data Preparation

- Collect inputs:
    - **Students:** Each student provides a ranked list of preferred projects.
    - **Projects:** Each project has a minimum and maximum capacity.

How the algorithm works

Step 2: Define Decision Variables

- For each student s and each project p in their preference list:
    - **x_s,p = 1** if student s is assigned to project p, otherwise 0.
- For each project p:
    - **y_p = 1** if project p is active (has at least one student), otherwise 0.
- **z:** represents **the worst rank** (maximum dissatisfaction) across all student assignments.

How the algorithm works

Step3 : Minimize the Worst Rank (z)

- The algorithm adds a variable z to represent the worst rank assigned to any student.
- Then it adds a constraint for every student:
- → If student i is assigned project j, and j is their rank r_ij, then r_ij ⩽ z.
- This forces **z** to be at least as bad as the worst rank used, and the solver will try to **make z as small as possible.**
- This way, **the optimization** is focused on **fairness**: making sure no student gets a really bad project.

How the algorithm works

Step 4: Solve & Extract Solution

The MILP solver searches for values of x[i][j] (assignments) that:

- Respect all constraints (1 project per student, capacity limits)
- Ensure that if a student gets a project, its rank $\leqslant$ z
- And minimize z (so all assigned ranks are as good as possible)

Results overview

MILP Solution (Automated):

Rank Distribution

- **Rank 1:** 61 students
- **Rank 2:** 7 students
- **Rank 3:** 4 students

Manual Allocation:

Rank Distribution

- **Rank 1:** 59 students
- **Rank 2:** 8 students
- **Rank 3:** 4 students
- **1 student left unmatched** (assigned to a non-preferred project)

Results overview

- 72 students allocated successfully
- 84.7% received first choice, 9.7% second, 5.6% third
- Zero unmatched students
- ~92% overall satisfaction

Another Proposed Solution : (Based on Gale Shapley algorithm)

- **Research paper :** “Two Algorithms for the Student-Project Allocation Problem” by Abraham et al. (2004).
- Constraints:
  - Each project has a capacity.
  - Lecturers (implicitly via project preferences) have ranked preferences.
  - Students can express preferences over a limited set of projects.

Implementation

- Inputs:
  - students.csv: student preferences
  - projects.csv: project quotas and preferences
- Results and Output
  - Output Matching printed and saved as CSV
  - Summary Statistics:
    - Number of students who got 1st/2nd/3rd choice
    - Number of unmatched students

How the Algorithm Works

- Step 1: Initialization
  - All students are unmatched
  - All projects are empty
  - Each student has a list of preferred projects
  - Each project has a quota
- Step 2: Student Proposes
  - Pick any unmatched student with remaining preferences
  - The student proposes to their top remaining project

How the Algorithm Works

- Step 3: Tentative Assignment
  - The project tentatively accepts the student
  - If it exceeds its quota, it rejects the least preferred among all assigned students (according to the project’s ranking)
- Step 4: Update Lists
  - The rejected student becomes unmatched again
  - Any student worse than the worst accepted is removed from the project’s preference list

How the Algorithm Works

- Step 5: Repeat
  - Keep iterating until there are no unmatched students with available preferences

- The result is a stable matching:
  - No unmatched student and project would rather be with each other than with their current match

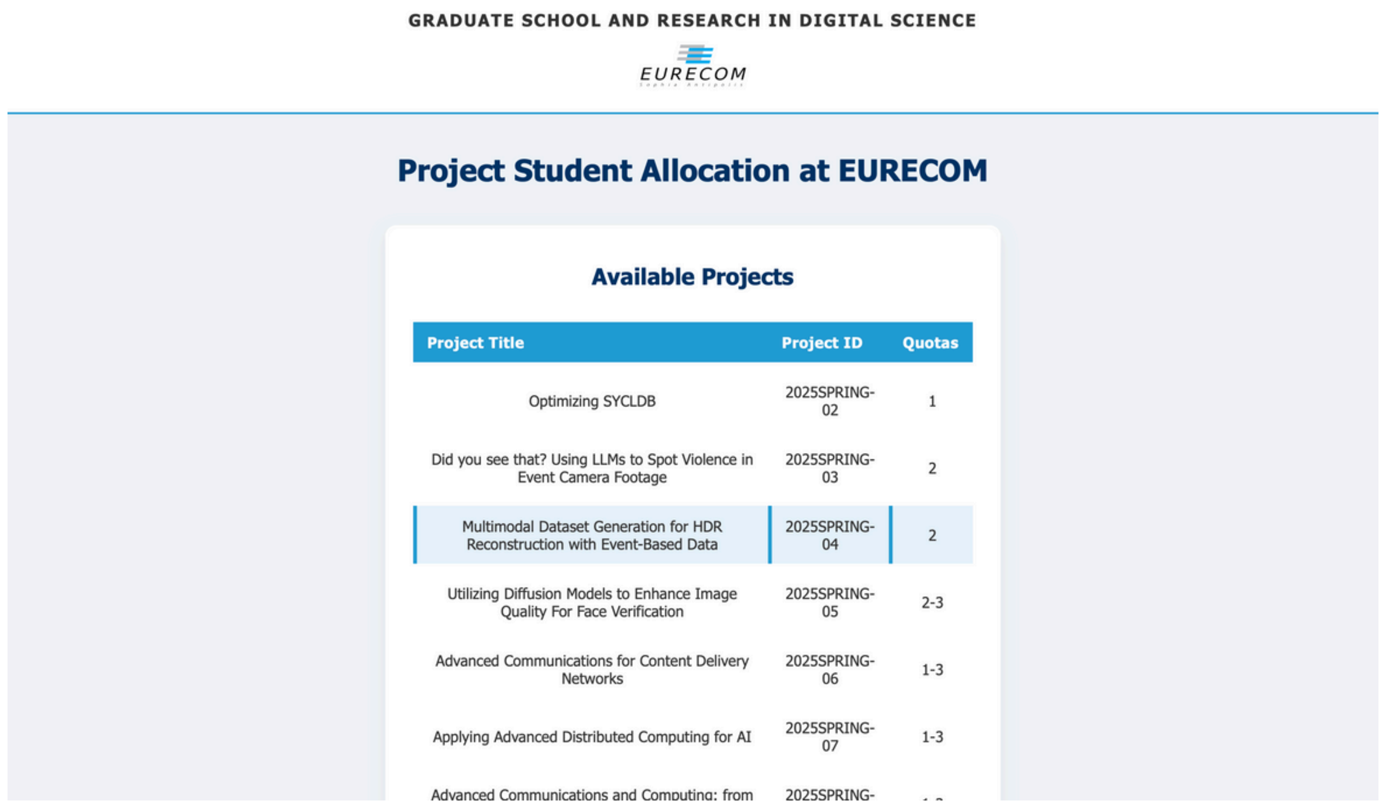
Results overview

- Total students: 72
- Matched students: 68
- Unmatched students: 4
- Students who got their 1st choice: 56
- Students who got their 2nd choice: 7
- Students who got their 3rd choice: 5

Implementation overview

- Dual web interface: Students & Administrators
- Students rank projects; admins run algorithm and export results
- Backend algorithm deployment and Excel output

Student web interface



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Project Student Allocation at EURECOM

Available Projects

Project Title	Project ID	Quotas
Optimizing SYCLDB	2025SPRING-02	1
Did you see that? Using LLMs to Spot Violence in Event Camera Footage	2025SPRING-03	2
Multimodal Dataset Generation for HDR Reconstruction with Event-Based Data	2025SPRING-04	2
Utilizing Diffusion Models to Enhance Image Quality For Face Verification	2025SPRING-05	2-3
Advanced Communications for Content Delivery Networks	2025SPRING-06	1-3
Applying Advanced Distributed Computing for AI	2025SPRING-07	1-3
Advanced Communications and Computing: from	2025SPRING-	

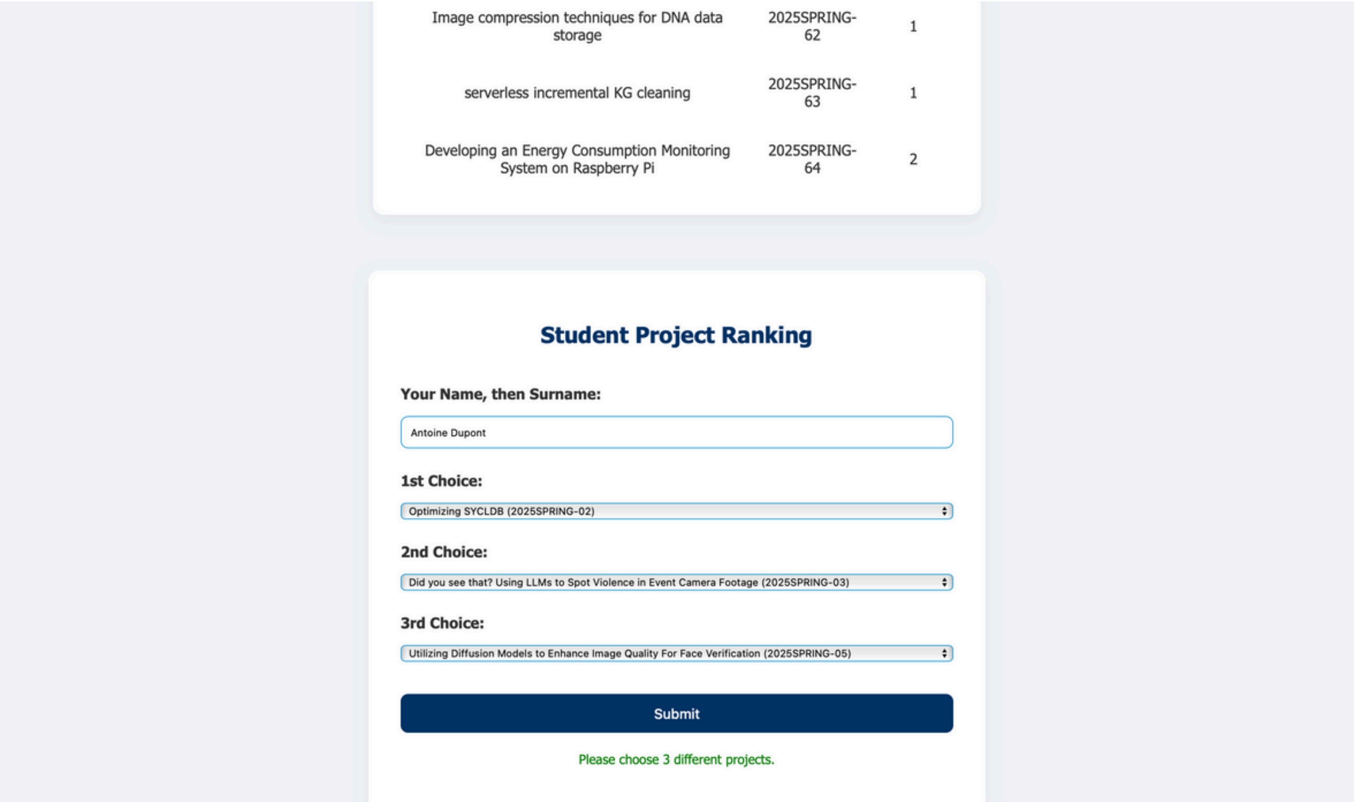


Image compression techniques for DNA data storage	2025SPRING-62	1
serverless incremental KG cleaning	2025SPRING-63	1
Developing an Energy Consumption Monitoring System on Raspberry Pi	2025SPRING-64	2

Student Project Ranking

Your Name, then Surname:

Antoine Dupont

1st Choice:

Optimizing SYCLDB (2025SPRING-02)

2nd Choice:

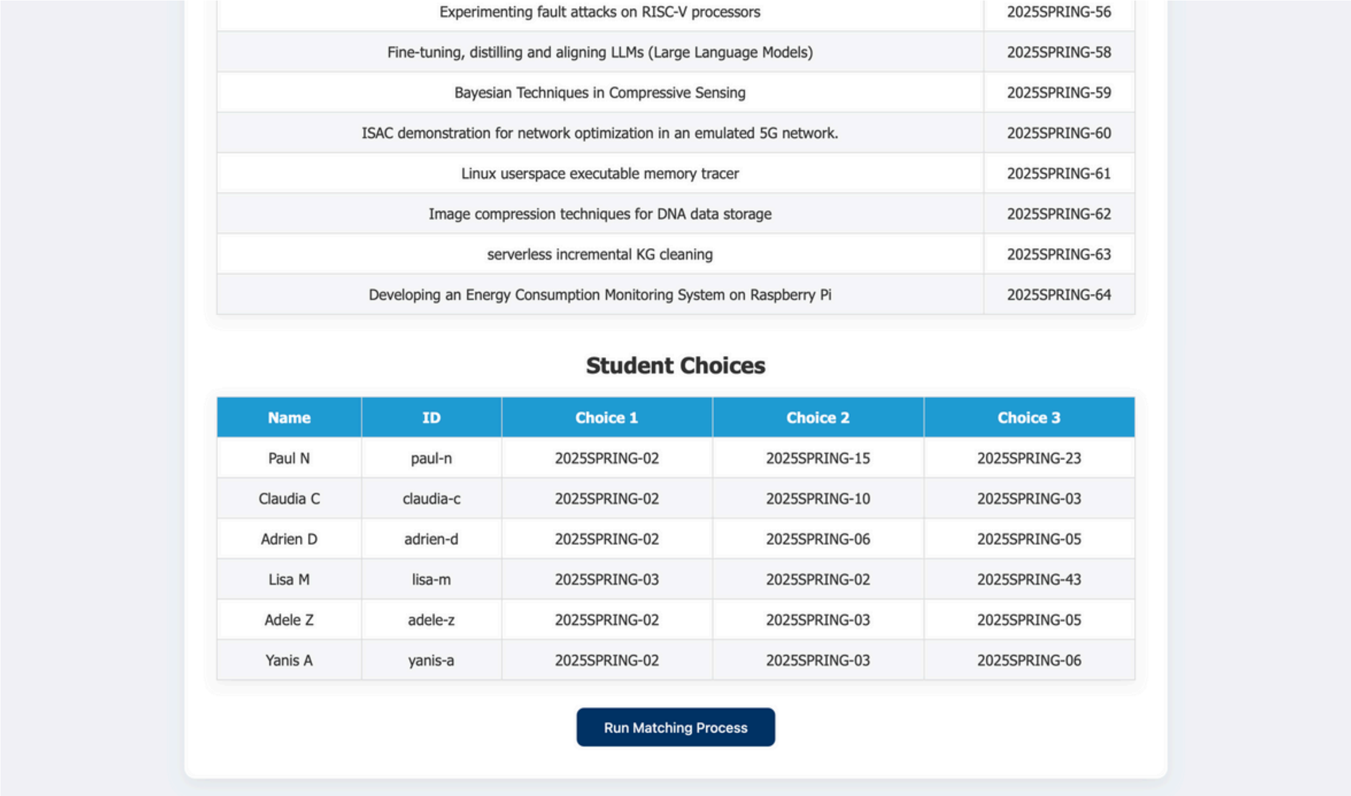
Did you see that? Using LLMs to Spot Violence in Event Camera Footage (2025SPRING-03)

3rd Choice:

Utilizing Diffusion Models to Enhance Image Quality For Face Verification (2025SPRING-05)

Please choose 3 different projects.

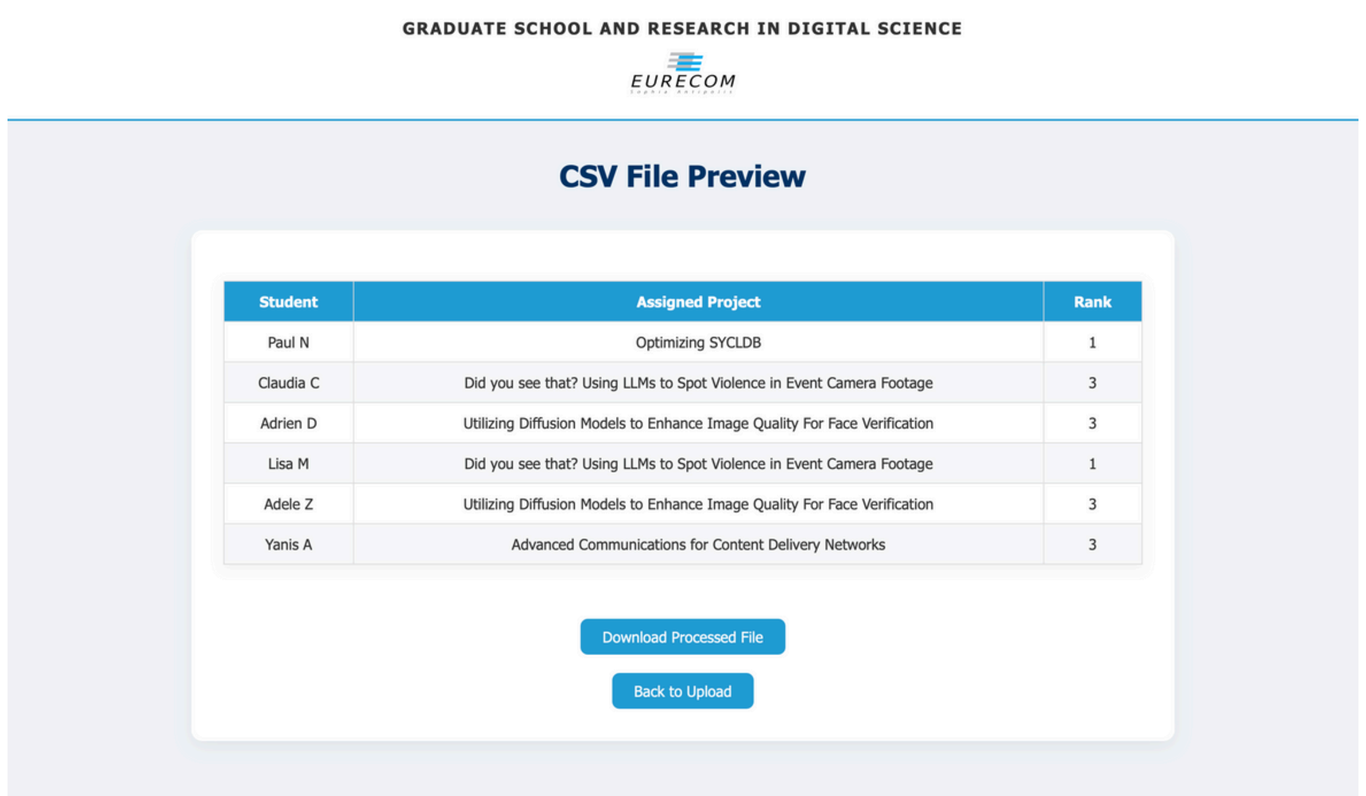
Admin web interface



Experimenting fault attacks on RISC-V processors	2025SPRING-56
Fine-tuning, distilling and aligning LLMs (Large Language Models)	2025SPRING-58
Bayesian Techniques in Compressive Sensing	2025SPRING-59
ISAC demonstration for network optimization in an emulated 5G network.	2025SPRING-60
Linux userspace executable memory tracer	2025SPRING-61
Image compression techniques for DNA data storage	2025SPRING-62
serverless incremental KG cleaning	2025SPRING-63
Developing an Energy Consumption Monitoring System on Raspberry Pi	2025SPRING-64

Student Choices

Name	ID	Choice 1	Choice 2	Choice 3
Paul N	paul-n	2025SPRING-02	2025SPRING-15	2025SPRING-23
Claudia C	claudia-c	2025SPRING-02	2025SPRING-10	2025SPRING-03
Adrien D	adrien-d	2025SPRING-02	2025SPRING-06	2025SPRING-05
Lisa M	lisa-m	2025SPRING-03	2025SPRING-02	2025SPRING-43
Adele Z	adele-z	2025SPRING-02	2025SPRING-03	2025SPRING-05
Yanis A	yanis-a	2025SPRING-02	2025SPRING-03	2025SPRING-06



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CSV File Preview

Student	Assigned Project	Rank
Paul N	Optimizing SYCLDB	1
Claudia C	Did you see that? Using LLMs to Spot Violence in Event Camera Footage	3
Adrien D	Utilizing Diffusion Models to Enhance Image Quality For Face Verification	3
Lisa M	Did you see that? Using LLMs to Spot Violence in Event Camera Footage	1
Adele Z	Utilizing Diffusion Models to Enhance Image Quality For Face Verification	3
Yanis A	Advanced Communications for Content Delivery Networks	3

Class Timetabling

Problem Statement:

- Allocate school courses to rooms and timeslots.
- Avoid conflicts (room or teacher overlap).
- Respect teacher preferences and room capacities.
- satisfaction, and minimal constraint violations.

Class Timetabling

Input Data:

- **Courses:** Name, teacher, number of students, duration (short/long).
- **Rooms:** Name, type (classroom or amphitheater), capacity.
- **Timeslots:** Combinations of day and time (e.g., Monday AM), excluding unavailable periods.
- **Teacher Constraints:** Availability and preferences.

Goal:

- Generate valid and optimized timetables with no conflicts, high satisfaction, and minimal constraint violations.

How the algorithm works

Step 1: Initialization

- Generate a random set of possible timetables (solutions).

Step 2: Evaluation

- Score each timetable based on:
  - Hard constraints: No conflicts (room/teacher), room capacity respected.
  - Soft constraints: Teacher preferences, availability.

Step 3: Selection

- Keep the best-scoring solutions.

How the algorithm works

Step 4: Crossover & Mutation

- Crossover: Combine two good timetables.
- Mutation: Small changes to improve diversity.

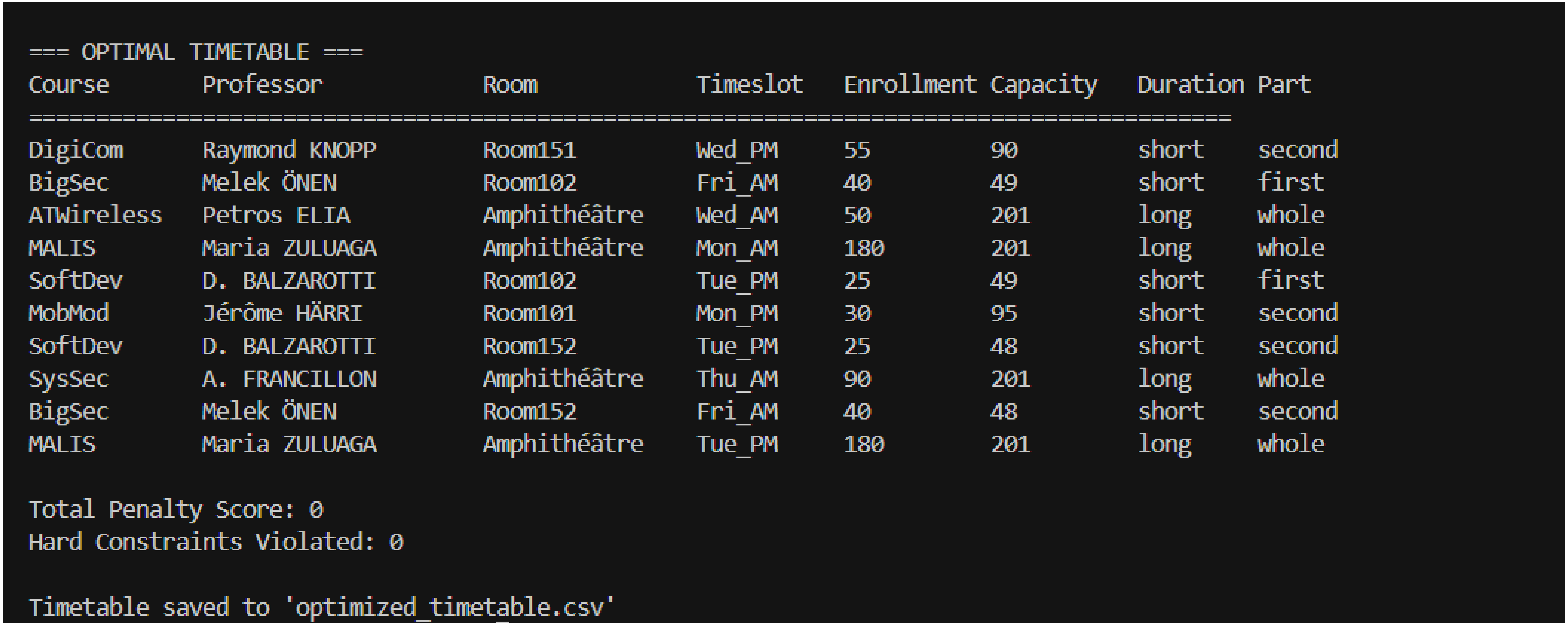
Step 5: Local Optimization

- Slightly adjust good solutions to fix small issues (e.g., better time or room).

Final Output:

- A valid timetable: conflict-free, fair, and preference-aware.

Results Overview



```
=== OPTIMAL TIMETABLE ===
Course       Professor            Room            Timeslot   Enrollment Capacity   Duration Part
==========================================================================================
DigiCom      Raymond KNOPP        Room151         Wed_PM     55         90         short    second
BigSec       Melek ÖNEN           Room102         Fri_AM     40         49         short    first
ATWireless   Petros ELIA          Amphithéâtre    Wed_AM     50         201        long     whole
MALIS        Maria ZULUAGA        Amphithéâtre    Mon_AM     180        201        long     whole
SoftDev      D. BALZAROTTI        Room102         Tue_PM     25         49         short    first
MobMod       Jérôme HÄRRI         Room101         Mon_PM     30         95         short    second
SoftDev      D. BALZAROTTI        Room152         Tue_PM     25         48         short    second
SysSec       A. FRANCILLON        Amphithéâtre    Thu_AM     90         201        long     whole
BigSec       Melek ÖNEN           Room152         Fri_AM     40         48         short    second
MALIS        Maria ZULUAGA        Amphithéâtre    Tue_PM     180        201        long     whole

Total Penalty Score: 0
Hard Constraints Violated: 0

Timetable saved to 'optimized_timetable.csv'
```

Conclusion & future work

- Summary of achievements
- Potential enhancements