UNIVERSITY COURSE SCHEDULING PROBLEM

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Abstract

The University Course Scheduling Problem (UCSP) involves generating automated timetables under resource constraints, an essential yet complex task in academic institutions. This project addresses the UCSP by proposing a scalarized multi-objective mixed-integer programming model that incorporates both faculty-related and student-related constraints. Our goal is to optimize the course timetable by maximizing teacher satisfaction and minimizing student attendance days. By aligning courses with teachers' preferred timeslots, we aim to enhance teacher satisfaction. At the same time, reducing the number of days students need to attend classes makes the schedule more efficient and convenient for them. This balance ensures a smooth and effective timetable that meets both faculty and student needs.

I. Introduction

Timetabling is a real-life optimization problem that involves scheduling events within fixed timeslots and resources, aiming to satisfy both hard and soft constraints while achieving the necessary objectives. In the University Course Scheduling Problem (UCSP), hard constraints typically include ensuring that each instructor teaches one class at a time, and students attend only one class during a given timeslot. These must be strictly adhered to in any feasible solution. Soft constraints, such as instructors' preferences for specific days or timeslots, are more flexible and aim to enhance the overall satisfaction of the stakeholders.

Timetabling problems have diverse applications in various domains, including employee scheduling, transportation systems, educational institutions, sports activities, and industrial operations. In the context of educational institutions, course scheduling is crucial for effective use of resources, teacher satisfaction, and minimizing student workload.

Several studies have previously tackled the UCSP, with many focusing primarily on assigning courses to teachers and considering only the teacher's preference list. However, in our approach, we extend the problem by also addressing the reduction of student academic load while still considering the preferences of teachers. Unlike previous works, we do not assign theoretical classes and laboratory sessions to instructors; instead, we use pre-assigned data as input. This approach aims to strike a balance between teacher satisfaction and student workload, optimizing the timetable with respect to both objectives.

II. PROBLEM DESCRIPTION

The goal of our project is to efficiently distribute courses across a week while adhering to various constraints and optimizing specific objectives. The problem involves scheduling courses in such a way that they are assigned to appropriate rooms, timeslots, and days without conflicts.

A. Objectives

The objectives of the scheduling process are:

1. Maximizing teacher satisfaction: By aligning course schedules with teachers' preferred timeslots, we aim to maximize the sum of teacher preferences.
2. Minimizing Student Attendance Days: Reducing the number of days each year of students must attend classes to make the schedule more efficient for them.

This scheduling problem involves balancing multiple constraints and objectives to produce a feasible and optimal timetable that satisfies the needs of teachers, students, and resources.

B. Constraints

Our approach considers the following basic constraints:

1. Each course must be assigned to a specific room, timeslot, and day.
2. No two courses can be scheduled in the same room during the same timeslot.
3. Courses for the same year of students must not clash in time.
4. Rooms with specific features must be allocated only to courses that require those features.

C. Notations

1) Sets:

D	Set of working days available for scheduling.
P	Set of periods (timeslots) available each day.
R	Set of rooms available for conducting classes.
T	Set of teachers available for course delivery.
C	Set of courses to be scheduled.
F	Set of Characteristics such as lab equipment, audio-visual aids, etc., required by certain courses.

2) Parameters:

W_c	Timeslots required for each course c.
$YEAR(C)$	It indicates the academic year to which course c belongs.
$RF_{f,r}$	Binary variable indicating whether room r has feature f. $RF_{f,r} = 1$ if room r has feature f, otherwise $RF_{f,r} = 0$.
$CF_{f,c}$	Binary variable indicating whether course c requires feature f. $CF_{f,c} = 1$ if course c requires feature f, otherwise $CF_{f,c} = 0$.
$Pref_{t,d,p}$	Preferred timeslots for teacher t.
$TC_{t,c}$	Binary variable indicating whether teacher t is eligible to teach course c. $TC_{t,c} = 1$ if teacher t can teach course c, otherwise $TC_{t,c} = 0$.

3) Decision Variables:

$x_{c,r,d,p}$	Binary variable; equals 1 if course c is scheduled in room r on day d during period p, otherwise equals 0.
$RC_{c,r}$	Binary variable; equals 1 if course c is assigned to room r, otherwise equals 0.
$Y1_d, Y2_d$	Binary variables; equals 1 if students of years 1, or 2 respectively have classes on the day d, otherwise equals 0.
$Y3_d, Y4_d$	Binary variables; equals 1 if students of years 3, or 4 respectively have classes on the day d, otherwise equals 0.

III. PROBLEM FORMULATION

A. Formulation

Maximizing

$$\sum_{c\in C}\sum_{r\in R}\sum_{d\in D}\sum_{p\in P}\sum_{t\in T} x_{c,r,d,p} \cdot TC_{c,t} \cdot Pref_{t,d,p} - 10 \cdot \sum_{d\in D}(Y1_d + Y2_d + Y3_d + Y4_d) \tag{1}$$

Subject to:

$$\sum_{c\in C} x_{c,r,d,p} \leq 1 \quad \forall r \in R, \forall d \in D, \forall p \in P \tag{2}$$

$$\sum_{r\in R}\sum_{c\in C} x_{c,r,d,p} \leq 1 \quad where, YEAR(C) = 1, \forall d \in D, \forall p \in P \tag{3}$$

$$\sum_{r\in R}\sum_{c\in C} x_{c,r,d,p} \leq 1 \quad where, YEAR(C) = 2, \forall d \in D, \forall p \in P \tag{4}$$

$$\sum_{r\in R}\sum_{c\in C} x_{c,r,d,p} \leq 1 \quad where, YEAR(C) = 3, \forall d \in D, \forall p \in P \tag{5}$$

$$\sum_{r\in R}\sum_{c\in C} x_{c,r,d,p} \leq 1 \quad where, YEAR(C) = 4, \forall d \in D, \forall p \in P \tag{6}$$

$$\sum_{r\in R} x_{c,r,d,p} \leq 1 \quad \forall c \in C, \forall d \in D, \forall p \in P \tag{7}$$

$$\sum_{f\in F}\sum_{p\in P}\sum_{d\in D} x_{c,r,d,p} \cdot CF_{f,c} \leq \sum_{f\in F}\sum_{p\in P}\sum_{d\in D} x_{c,r,d,p} \cdot RF_{f,r} \quad \forall c \in C \tag{8}$$

$$\sum_{d\in D}\sum_{p\in P}\sum_{r\in R} x_{c,r,d,p} = W_c \quad \forall c \in C \tag{9}$$

$$\sum_{d\in D}\sum_{p\in P} x_{c,r,d,p} = W_c \cdot RC_{c,r} \quad \forall c \in C, \forall r \in R \tag{10}$$

$$\sum_{f\in F} RC_{c,r} \cdot CF_{f,c} \leq \sum_{f\in F} RC_{c,r} \cdot RF_{f,r} \quad \forall c \in C, \forall r \in R \tag{11}$$

$$\sum_{r\in R} RC_{c,r} \leq 1 \quad \forall c \in C \tag{12}$$

$$\sum_{r\in R}\sum_{p\in P}\sum_{c\in C} x_{c,r,d,p} \leq 9 \cdot Y1_d \quad whereYEAR(C) = 1 \quad \forall d \in D \tag{13}$$

$$\sum_{r\in R}\sum_{p\in P}\sum_{c\in C} x_{c,r,d,p} \leq 9 \cdot Y2_d \quad where,YEAR(C) = 2 \quad \forall d \in D \tag{14}$$

$$\sum_{r\in R}\sum_{p\in P}\sum_{c\in C} x_{c,r,d,p} \leq 9 \cdot Y3_d \quad where,YEAR(C) = 3 \quad \forall d \in D \tag{15}$$

$$\sum_{r\in R}\sum_{p\in P}\sum_{c\in C} x_{c,r,d,p} \leq 9 \cdot Y4_d \quad where,YEAR(C) = 4 \quad \forall d \in D \tag{16}$$

B. Constraint Specifications:

Constraint 2 ensures that at most one course is scheduled in a given room r during a specific day d and period p. It prevents room conflicts by ensuring no two courses overlap in the same room at the same time. Constrain 3,4,5,6 make sure that students of the same year (e.g., first-year, second-year) do not have overlapping courses during the same timeslot across different rooms. Constraint 7 guarantees that a single course c is assigned to only one room r in a specific timeslot d,p. Constraint 8 ensures that a course c requiring a particular feature f (e.g., lab equipment, projector) is assigned only to rooms r that have those features available. Constraint 9 ensures that course c is scheduled exactly for its required number of timeslots W_c throughout the week. Tenth constraint makes sure that course c is scheduled only in room r that are compatible, as defined by $RC_{c,r}$. Constraint 11 ensures that the feature requirements $CF_{f,c}$ of a course c are met by the assigned rooms r with the corresponding features $RF_{f,r}$. Constraint 12 ensures that a course c is not scheduled in more than one room r during the scheduling period. Constraints 13,14,15,16 limit the total number of periods students of a particular year need to attend classes each day. Y(D) is a binary variable indicating whether students of year Y need to attend classes on day d.

IV. REFERENCES

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