A mathematical formulation for constructing feasible solutions for the Post Enrollment Course Timetabling Problem

Angelos Dimitsas[1]
Christos Valouxis[2]
Vasileios Nastos[1]
Christos Gogos[1]

[1]Dept. of Informatics & Telecommunications, University of Ioannina, Arta, Greece

[2]Dept. of Electrical & Computer Engineering, University of Patras, Rio, Greece

7th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference - 2022

The Post Enrollment Problem 1/3

Room	Capacity
1	10
2	10
3	10

Room	Features
1	F2
2	F1,F2
3	F3

Student	Events
1	EV1, EV2, EV4
2	EV1, EV2
3	EV3, EV4

Event	Features
1	F2
2	F3
3	F3
4	-

GOAL: Create a schedule in 2 timeslots.

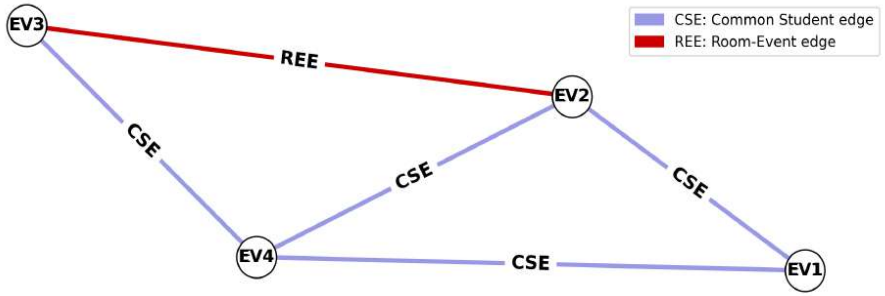
The Post Enrollment Problem 2/3 - Suitable event-rooms

- A room is suitable for an event if:
  - A room's feature set satisfies the event's feature requirements
  - The number of students participating in that event is less or equal than the room's capacity.

Event	Suitable rooms
1	R1, R2
2	R3
3	R3
4	R1, R2, R3

The Post Enrollment Problem 3/3 - Event Conflicts

- Nodes of the graph represent events.
- An edge between the nodes exists if:
  - Two events have at least one common student.
  - Both events should be placed only at the same room.



Hard Constraints

- No student is allowed to attend more than one event in the same timeslot.
- Each event should be scheduled in a timeslot.
- A room must be suitable for an event.
- Events may have specific timeslot requirements.
- Precedence relations between events might exist.

Soft Constraints

A single penalty point is imposed for each of these violations.

1. A student attends an event at the last timeslot of a day.
2. A student attends three events in a row in the same day.
3. A student attends only one event during a day.

Identical Students

- Two students are considered identical if they attend exactly the same set of events.
- Identical students can be aggregated in the objective function.

Student	Events
1	EV2
2	EV1,EV2
3	EV3
4	EV2

Instances

ITC 2002 Instances

- 20 Instances.
- No precedence relations between the events.
- No timeslot restrictions.
- 45 available timeslots(5 days, 9 periods per day)

ITC 2007 Instances

- 24 Instances.
- Precedence relations between the events.
- Timeslot restrictions.
- 45 available timeslots(5 days, 9 periods per day)

ITC - 2002 Instances

Instance	Events	Rooms	Features	Students	Conflict Density
o01.tim	400	10	10	200	0.2025
o02.tim	400	10	10	200	0.2075
o03.tim	400	10	10	200	0.2342
o04.tim	400	10	5	300	0.2257
o05.tim	350	10	10	300	0.3100
o06.tim	350	10	5	300	0.2599
o07.tim	350	10	5	350	0.2060
o08.tim	400	10	5	250	0.1696
o09.tim	440	11	6	220	0.1705
o10.tim	400	10	5	200	0.2006
o11.tim	400	10	6	220	0.2045
o12.tim	400	10	5	200	0.2039
o13.tim	400	10	6	250	0.2079
o14.tim	350	10	5	350	0.2454
o15.tim	350	10	10	300	0.2469
o16.tim	440	11	6	220	0.1802
o17.tim	350	10	10	300	0.3084
o18.tim	400	10	10	200	0.2099
o19.tim	400	10	5	300	0.2017
o20.tim	350	10	5	300	0.2458

ITC - 2007 Instances

Instance	Events	Rooms	Features	Students	Conflict Density	Precedence	Timeslot restrictions
i01.tim	400	10	10	500	0.3409	40	7863
i02.tim	400	10	10	500	0.3735	36	7724
i03.tim	200	20	10	1000	0.4724	20	3893
i04.tim	200	20	10	1000	0.5173	20	3867
i05.tim	400	20	20	300	0.3074	120	7830
i06.tim	400	20	20	300	0.3021	119	7843
i07.tim	200	20	20	500	0.5310	20	5428
i08.tim	200	20	20	500	0.5149	21	5566
i09.tim	400	10	20	500	0.3400	41	7833
i10.tim	400	10	20	500	0.3834	40	7813
i11.tim	200	10	10	1000	0.4980	21	3936
i12.tim	200	10	10	1000	0.5813	20	3866
i13.tim	400	20	10	300	0.3227	116	7699
i14.tim	400	20	10	300	0.3201	118	7824
i15.tim	200	10	20	500	0.5339	21	5525
i16.tim	200	10	20	500	0.4536	19	5486
i17.tim	100	10	10	500	0.6986	11	1927
i18.tim	200	10	10	500	0.6480	20	3866
i19.tim	300	10	10	1000	0.4698	31	5891
i20.tim	400	10	10	1000	0.2780	40	7863
i21.tim	500	20	20	300	0.2316	147	9518
i22.tim	600	20	20	500	0.2609	176	11702
i23.tim	400	20	30	1000	0.4390	41	3869
i24.tim	400	20	30	1000	0.3111	197	7897

Mathematical Integer Programming Formulation - Definitions

$\mathbb{E}$	Set of all events
$\mathbb{R}$	Set of all rooms
$\mathbb{C}$	Set of conflicting events
$\mathbb{P}$	Set of pairs of events having precedence relation
$\mathbb{T}$	Set of timeslots
$\mathbb{R}_e$	Set of rooms that can host event e
$\mathbb{T}_e$	Set of timeslots that event e can occur

Mathematical Integer Programming Formulation 1/2

$$x_{etr} = \begin{cases} 1 & \text{if } e \text{ is scheduled on } t \text{ and } r \\ 0 & \text{otherwise} \end{cases}$$

$$\forall e \in \mathbb{E}, \forall t \in \mathbb{T}_e, \forall r \in \mathbb{R}_e \quad (1)$$

Mathematical Integer Programming Formulation 2/2

$$\text{Subject to} \sum_{t \in \mathbb{T}_e} \sum_{r \in \mathbb{R}_e} x_{etr} = 1 \quad \forall e \in \mathbb{E} \tag{2}$$

$$\sum_{e \in \mathbb{E}, r \in \mathbb{R}_e} x_{etr} \leq 1 \quad \forall r \in \mathbb{R}, \quad \forall t \in \mathbb{T} \tag{3}$$

$$\sum_{r \in \mathbb{R}_{e_1}} x_{e_1 tr} + \sum_{r \in \mathbb{R}_{e_2}} x_{e_2 tr} \leq 1 \quad \forall (e_1, e_2) \in \mathbb{C}, \quad \forall t \in \mathbb{T} \tag{4}$$

$$\sum_{t \in \mathbb{T}_{e_1}} \sum_{r \in \mathbb{R}_{e_1}} t * x_{e_1 tr} + 1 \leq \sum_{t \in \mathbb{T}_{e_2}} \sum_{r \in \mathbb{R}_{e_2}} t * x_{e_2 tr} \quad \forall (e_1, e_2) \in \mathbb{P} \tag{5}$$

ITC 2002 - Results for feasible solutions

- Solutions for 20/20 instances.
- Solution time set to 600 seconds.

Instance	Solution time (sec)
o01.tim	112
o02.tim	96
o03.tim	174
o04.tim	133
o05.tim	89
o06.tim	151
o07.tim	83
o08.tim	99
o09.tim	115
o10.tim	146
o11.tim	95
o12.tim	81
o13.tim	104
o14.tim	106
o15.tim	87
o16.tim	134
o17.tim	72
o18.tim	80
o19.tim	154
o20.tim	133

ITC 2007 - Results for feasible solutions

- Solutions for 18/24 instances.
- Solution time set to 600 seconds.

Instance	Solution time (sec)
i01.tim	442
i02.tim	N/A
i03.tim	33
i04.tim	46
i05.tim	112
i06.tim	90
i07.tim	20
i08.tim	13
i09.tim	N/A
i10.tim	N/A
i11.tim	26
i12.tim	86
i13.tim	400
i14.tim	50
i15.tim	16
i16.tim	11
i17.tim	9
i18.tim	50
i19.tim	N/A
i20.tim	70
i21.tim	161
i22.tim	N/A
i23.tim	N/A
i24.tim	43

Conclusions

- Identification of identical students.
- Identification of event-room eligibility.
- Extend the conflict concept based on room features.
- Propose a mathematical formulation for the Post Enrollment Course Time problem.
- Generate feasible initial solutions for the majority of the instances in reasonable time.

The End

Questions? Comments?