University course timetabling

Project for Problem Solving and Search in Artificial Intelligence

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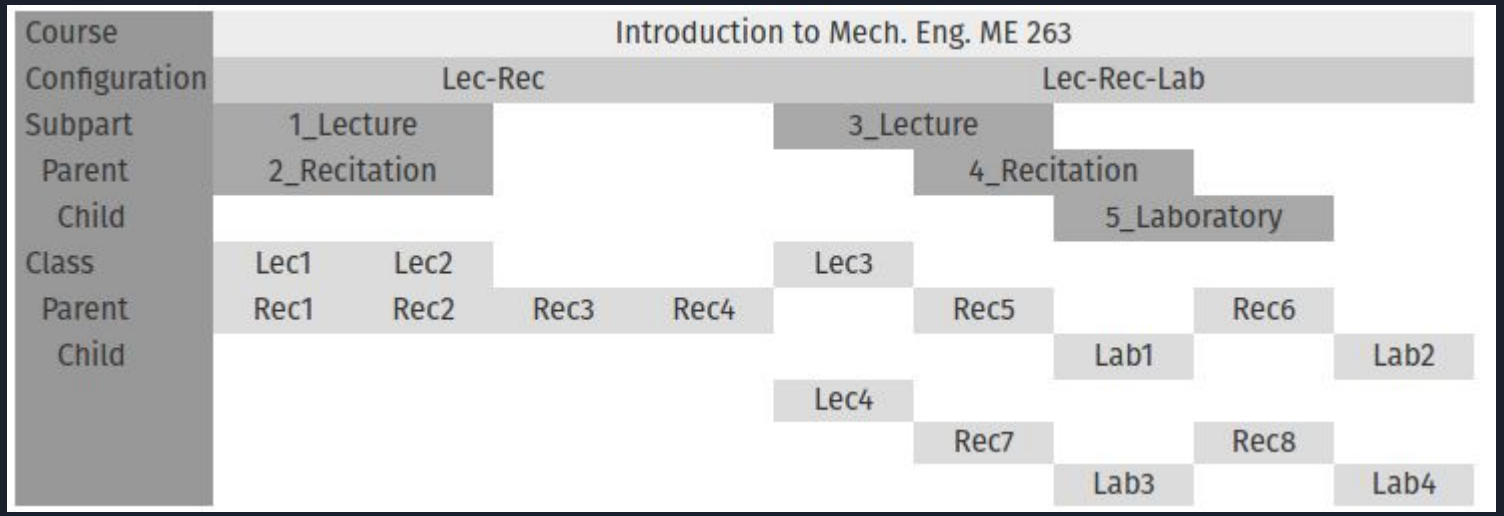
The components of the problem

- Timeline (weeks and days)
- Courses (next slide)
- Students
  - Courses they are interested in
- Rooms
  - Capacity
  - Travel distance between rooms
- Distribution constraints
- Other constraints (e.g. overlapping courses)

Courses



Also stores maximum capacity for each class.

Image from https://www.itc2019.org/format

Distribution constraints

Constraint	Complementary	Time	Days	Weeks	Room	Pairs
SameStart		✓	✗	✗	✗	✓
SameTime	DifferentTime	✓	✗	✗	✗	✓
SameDays	DifferentDays	✗	✓	✗	✗	✓
SameWeeks	DifferentWeeks	✗	✗	✓	✗	✓
SameRoom	DifferentRoom	✗	✗	✗	✓	✓
Overlap	NotOverlap	✓	✓	✓	✗	✓
SameAttendees		✓	✓	✓	✓	✓
Precedence		✓	✓	✓	✗	✓
WorkDay(S)		✓	✓	✓	✗	✓
MinGap(G)		✓	✓	✓	✗	✓
MaxDays(D)		✗	✓	✗	✗	days over **D**
MaxDayLoad(S)		✓	✓	✓	✗	slots over **S**
MaxBreaks(R,S)		✓	✓	✓	✗	breaks over **R**
MaxBlock(M,S)		✓	✓	✓	✗	blocks over **M**

Image from https://www.itc2019.org/format

- Hard constraints vs Soft constraints
- Evaluated in couples: penalty occurs for every pair of classes not satisfying the constraint

Our solution: decision variables

Classes

Days	Weeks	Students	Rooms	Start	Duration	Penalties
Bools	Bools	Bools	Int	Int	Int	1-100
...	...	...	...	...	...	...
...	...	...	...	...	...	...

Subparts

Students
Bools
...
...

Distr. Constr.

Penalties
1-100
...
...

Our solution: input data

Example of our representation:

```
145888  |];
145889
145890  % possible days
145891  classes_days_input = [|true,false,false,false,false,false,false,% class 1
145892  |false,true,false,false,false,false,false,% class 1
145893  |false,false,true,false,false,false,false,% class 1
145894  |false,false,false,true,false,false,false,% class 1
145895  |false,false,false,false,true,false,false,% class 1
145896  |true,false,false,false,false,false,false,% class 1
145897  |false,true,false,false,false,false,false,% class 1
145898  |false,false,true,false,false,false,false,% class 1
145899  |false,false,false,true,false,false,false,% class 1
145900  |false,false,false,false,true,false,false,% class 1
145901  |true,false,false,false,false,false,false,% class 1
145902  |false,true,false,false,false,false,false,% class 1
145903  |false,false,true,false,false,false,false,% class 1
145904  |false,false,false,true,false,false,false,% class 1
145905  |false,false,false,false,true,false,false,% class 1
145906  |true,false,false,false,false,false,false,% class 1
145907  |false,true,false,false,false,false,false,% class 1
145908  |false,false,true,false,false,false,false,% class 1
145909  |false,false,false,true,false,false,false,% class 1
145910  |false,false,false,false,true,false,false,% class 1
```

Auxiliary arrays: idx and cnt

Results

Solver: Chuffed 0.10.3

	Solve Time	Total Time	Result
Tiny dataset (no students)	0.47 s [2]	2.70 [2]	SAT
Tiny dataset	19.9 s [2]	30.1s [2]	SAT
Medium dataset	~4 hours [1]	~4 hours [1]	UNSAT
Real sized dataset	??	??	??

[1] -Ubuntu 18.04.2 LTS; cpu: Intel(R) Core(TM) i7-4720HQ CPU @ 2.60GHz; RAM size: 7865MiB
[2] -Ubuntu 18.04.2 LTS; cpu: Intel(R) Core(TM) i7-4710HQ CPU @ 3.50GHz; RAM size: 7865MiB

- Other solvers did not finish within reasonable time boundaries

Final considerations

Problems within the model:

- Too complex problem representation (Too many decision variables, high dimensionality)
  - Use a different representation (assigned course for every slot of the semester ?)
  - Use boolean decision variable for penalties (smaller research space)
- Constraint optimization required (lack of time)
- Use more MiniZinc's built in function (e.g. row() function)

Lessons learned:

- Test on big instances early
- Model representation is crucial
- Performances heavily dependant on the solvers

Thanks for the attention