Multi-Objective Aspects of the Examination Timetabling Competition Track
(Abstract)

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1 Introduction

The examination timetabling problem has been extensively studied since Carter produced a collection of real instances [1] (for a recent survey see [2]). This year, a significant extension to the set of realistic instances has been provided by the examination timetabling track [3] of the 2007 International Timetabling Competition[2]. The exam track instances are much more realistic than the Carter ones in that they include a variety of soft constraints designed to give timetables that match the requirements of the various individual parties. The associated penalties for violations naturally give rise to a multi-objective optimisation problem. Although, exam timetabling has been previously treated as multi-objective [4, 5], the much richer structure of the new formulation [3] brings new opportunities and difficulties, and these form the topic of this abstract.

For the purposes of keeping the competition manageable, the instances were presented as single-objective problems by means of giving weights for the various penalties. However, the purpose of this paper is to also encourage treatment of the instances as multi-objective problems. Also, although the weights expressing the trade-off between penalties are motivated by experience, they are still partially ad hoc, and so the effects of changing them is worthy of study.

2 Multi-Objective Aspects

The formulation [3] has 7 separate penalty costs in the objective function:

1. C^{2R}: "2-in-a-Row." For students having two events in consecutive periods of a day.
2. C^{2D}: "2-in-a-Day." For students having two events on the same day.
3. C^{2D}: "Period-Spread." For students having events within a period range specified a "period spread parameter."

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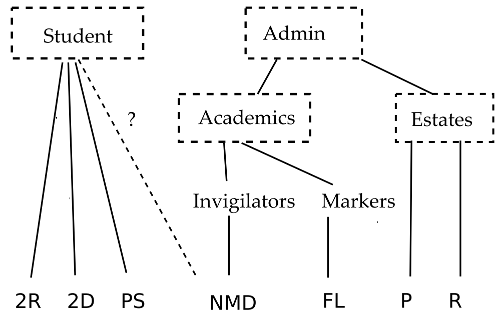


Figure 1: Hierarchy of stakeholders associated with the seven base objectives.

4. C^{NMD}: "No-Mixed-Durations." For exams in a room and period being of more than one time duration.
5. C^{FL}: "Front-Load." For putting large exams at the end of the exam session.
6. C^{P}: "Period." For using deprecated time periods.
7. C^{R}: "Room." For using deprecated rooms.

The single-objective version of the competition is simply given by a linear sum using fixed weights $w^{2R}, \ldots, w^{R}$ for each of the penalty terms.

This naturally gives a seven dimensional multi-objective problem, however, such high-dimensional problems are particularly difficult to solve and interpret. A standard response to this is to group together the objectives. Generally, the groups of objectives should represent the compromises between the various interested parties or "stakeholders". Here we give some candidates for such grouping, and that we believe make a reasonable representation of the key stakeholders. The initial grouping is based on four stakeholders:

- **Students**: the desire of student s is for a good individual timetable with good spread of exams, is represented by $w^{2R}C_s^{2R} + w^{2D}C_s^{2D} + w^{PS}C_s^{PS}$.
- **Invigilators**: their work is made harder when the exams have different durations, and so is associated with C^{NMD} (Though, arguably mixed duration exams also cause disturbance to students, and so should also be included in the Students interests.)
- **Markers**: exam markers want more time to mark exams with many students, and so are matched by the front load penalty C^{FL}.
- **Estates**: the management controls when rooms or periods are deprecated, and so is associated with C^{P} and C^{R}

The resulting four objective problem is possibly still too complex, hence, we further group together these stakeholders, giving the hierarchy of Figure 1. The simplest form is to reduce to just students, and "the rest" which we collectively refer to as "admin". We believe this gives a reasonable way to explore the trade-off between the preferences of the students for well-spread out exams, and the preferences judged by the institution to be needed for smooth running of the exam session.

Our aggregation of objectives differs significantly from the work of [4]; for example, many of its soft constraints are hard constraints here. We are closer to that of Romero [5] who splits into stakeholders: (central) administration, departments and students.

C(Stud)	C(Admin)	W(Stud)	W(Admin)	Gap
8	245	10000	1	4.1
32	85	3	1	53.8
38	55	2	1	6.2
43	45	1	1	0
122	15	1	2	42.8
225	5	1	10000	99

Table 1: Results on the small instance, giving the cost pairs resulting from a variety of weight pairs. The "gap" is the final gap reported by CPLEX on the linearized version – indicating the gap between upper and lower bounds.

Given the "(student,admin)" split then within each group the relative weights of the relevant objectives are given by the initial fixed weights:

$$C^{stud} = w^{2R}C^{2R} + w^{2D}C^{2D} + w^{PS}C^{PS} \quad (1)$$

$$C^{admin} = w^{NMD}C^{NMD} + w^{FL}C^{FL} + C^{P} + C^{R} \quad (2)$$

However, we should then minimise C^{stud}, C^{admin} in the bi-objective Pareto sense. Or, with the standard weighted sums approach, introduce new weights (w_{stud}, w_{admin}) and minimise

$$w_{stud}C^{stud} + w_{admin}C^{admin} \quad (3)$$

Notice this is equivalent to a rescaling of all the individual weights, and since the weights are part of the data rather than hard-coded into the formulation, it follows we do not require a modification to any single objective solver.

3 Initial Explorations

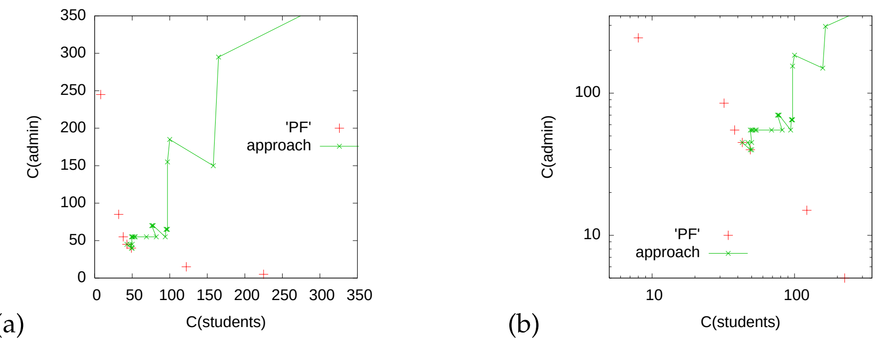
As a preliminary exploration of this bi-objective formulation, we created an integer program very similar to that used to specify the examination track [3], and used it with CPLEX to solve the linearisations. However, the use of a complete solver and unoptimized formulation meant it was not capable of solving the full instances. Hence, we created a new small instance: we took instance "set4" and truncated it by hand; the truncation was random and ad hoc so we cannot claim full realism for the resulting instance, but use it to illustrate possible behaviour.

Using CPLEX we produced the results of Table 3. (Runtimes were up to a week!; but will hopefully be vastly improved).[3]

The resulting (approximate) Pareto Front is illustrated in Figure 2. Reassuringly, it seems to be a standard trade-off. Of course, a challenge for solvers is to produce such data much more quickly.

The 'approach' curves in Figure 2 are the progress on one run of the IP solver on the case $w_{stud} = w_{admin} = 1$ towards the eventual optimal solution. As might be expected for a systematic solver, it seems to work equally hard on both objectives: it would be interesting to see the equivalent progress for other solvers.

[3]Observe that the case with weights $(1, 1)$ was solved to optimality. and so we will make the instance available for testing meta-heuristic solvers which otherwise cannot measure how close they get to optimality.



(a) (b)

Figure 2: The approximation, 'PF', to the Pareto Front obtained using various linear sums. Also, one particular path of 'approach' by the IP solver towards the Pareto Front, corresponding to the case of $w_{stud} = w_{admin} = 1$. (a) Linear axes, and (b) log-scale axes.

4 Conclusion

We give a reasonable way to group together the seven objectives of the examination timetabling track into those corresponding to the stakeholders. For the 2-d case, this just corresponds to considering the trade-off between the interests of students and administration. Future work should include improvement of the IP solver, or other exact methods so that we can aim to eventually fully solve the problems. Also, to investigate whether the trade-off curves for the real instances are similar to those presented here for a small semi-artificial instance.

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