Multi-neighbourhood Simulated Annealing for the Capacitated University Examination Timetabling Problem (ITC-2007)

David Van Bulck[1][0000−0002−1222−4541], Dries Goossens[1,2][0000−0003−0224−3412] and Andrea Schaerf[3][0000−0001−6965−0536]

[1] Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000 Ghent, Belgium
{david.vanbulck,dries.goossens}@ugent.be
[2] FlandersMake@UGent – core lab CVAMO
[3] Polytechnic Department of Engineering and Architecture, University of Udine, via delle Scienze 206, 33100 Udine, Italy, andrea.schaerf@uniud.it

Keywords: Examination Timetabling · Simulated Annealing · ITC-2007-ETT

1 Introduction and problem description

Many variations of the Examination Timetabling Problem (ETT) exist, each with their own resources, constraints, and objectives. In this extended abstract, we consider the ETT in the classical version as proposed for the Second International Timetabling Competition (ITC-2007). This variant consists of allocating each exam to a single period (time slot) and room, allowing exams to share a room. Some of the hard constraints are for instance that no two conflicting exams (i.e. exams with at least one student in common) are assigned to the same period, or that the capacity of the rooms is at least the number of students allocated to the exams assigned to that room in a given period. The main soft constraints are to spread the students' exams as much as possible over time, while avoiding that exams with a different length are scheduled together in the same room. The assignment of exams to periods thus has some similarities with graph colouring, whereas the assignment of exams to rooms resembles a packing problem, given that a room can be shared among exams. For the sake of brevity, we do not report the full problem description here, but instead we refer to [10].

2 Solution method

Following the spirit of the work by Bellio et al. [2] for the uncapacitated ETT, we developed a multi-neighbourhood Simulated Annealing (SA) algorithm. The choice for SA is motivated by the fact that SA has already proven to be very effective for this [1, 9] and a number of other timetabling problems (see, e.g., [3, 6]). Our search space is composed by an array of pairs that assigns to each exam a period and a room, and also includes solutions that may violate hard

Table 1. Considered neighbourhoods

`Move(e,p,r)`	Move exam `e` to period `p` and room `r`.
`Swap(e1,e2)`	Swap the period and room assigned to exams `e1` and `e2`.
`Kick(e1,e2,p,r)`	Move exam `e1` to the period and room assigned to `e2`. Move exam `e2` to period `p` and room `r`.

constraints such as conflicts or room capacities. These violations are included in the cost function, along with the soft constraints, but with a suitably larger weight.

The portfolio of neighbourhoods that we already implemented is given in Table 1. These neighbourhoods were originally proposed for the uncapacitated version to the ITC-2007 problem by Bellio et al. [2], and were adapted to deal with the assignment of rooms which is not considered in the uncapacitated problem.

3 Preliminary experimental results

Preliminary results can be found in Table 2, which compares the best found solutions over 30 runs with some of the best results found by algorithms previously published in the literature. Runtimes are set approximately according to ITC-2007 specifications. Although the development and the experimentation with our algorithm is still ongoing, at present we reach results quite comparable with the state-of-the-art approaches albeit still inferior to the best known. Final results will be discussed at the conference.

Table 2. Preliminary results. Best available solutions are from https://opthub.uniud.it

No.	Best available	[4]	[5]	[8]	[1]	Us
1	3488	3691	3787	4128	3752	3579
2	380	385	402	380	385	385
3	7041	7359	7378	7769	8175	7975
4	11806	11329	13278	13103	13681	14106
5	2327	2482	2491	2513	2544	2539
6	25145	25265	25461	25330	25560	25265
7	3424	3608	3589	3537	3522	3513
8	7356	6818	6701	7087	7505	7405
9	904	902	997	913	941	935
10	12878	12900	13013	13053	13582	13288
11	22465	22875	22959	24369	26114	24921
12	5095	5107	5234	5095	5153	5423

4 Future work

The present work is an initial step toward a more comprehensive final goal. First of all, we will develop other, more elaborate, neighbourhood relations, specifically designed for this problem. Secondly, we plan to investigate SA variants (see [7]) , alternative metaheuristics, and hybrid techniques. Finally, we aim at performing an instance space analysis and a corresponding algorithm selection procedure for this problem.

Regarding the first point, we are currently developing a *Kempe chain* neighbourhood, such that possible conflicts generated by a movement are repaired. In detail, in order to repair any new conflict introduced by moving exam `e` to period `p` and room `r`, the move `KempeChain(e,p,r)`, reassigns all exams in `p` in conflict with `e` to the period originally assigned to `e` and to the cheapest room (greedily determined), and so on until there are no newly introduced conflicts (see also [2]).

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