Iterated Tabu Search for Curriculum-Based Course Timetabling

Zhipeng Lü and Jin-Kao Hao

LERIA, Université d'Angers, Angers Cedex 01, France
lu@info.univ-angers.fr, hao@info.univ-angers.fr

We present a two-step solution algorithm for the curriculum-based course timetabling. The first step is to construct a feasible initial timetable which satisfies all the four hard constraints. When a feasible initial assignment is reached, the second step is aimed to reduce the number of soft constraint violations without breaking any hard constraint. To this end, we propose an iterated tabu search algorithm.

For the first step, starting from an empty timetable, our initial feasible solution is generated using a constructive greedy heuristic. At each time, one appropriate lecture of a course is selected and assigned to a period and a room. In the course selection procedure, we attempt to select those courses based on the idea of *least period availability* while for the period assignment, lectures of courses are scheduled at the period with the least influence to the period availability of other courses. Notice that soft constraints are also considered in this procedure.

In TS, we introduce two distinct neighborhood structures: one is swapping two lectures or moving one lecture to a free position (i.e., *SimpleSwap*), the second is defined by single or double Kempe chain interchanges concerning two distinct periods (i.e.,*KempeSwap*)[1]. In the move of *KempeSwap*, room assignments after swapping the periods of lectures are solved using an exact bipartite matching algorithm. Moreover, a special technique is employed to reduce the neighborhood size of *KempeSwap*. TS is implemented by combining these two neighborhoods in a token-ring way[2].

Tabu tenure is dynamically and automatically tuned according to the current solution quality f and the frequency of moves involved $freq(x)$[3], i.e. $TT(x) = f + \alpha \cdot freq(x)$. The aspiration criterion accepts a tabu move if it improves the best known results. TS stops when the best solution cannot be improved within a given number of steps and we call this number the *depth of TS*.

When it is impossible to improve the best solution using tabu search, a perturbation procedure is employed to perturb the local minimum solution obtained by TS. Perturbations are implemented by randomly and sequentially running a certain number of *SimpleSwap* or *KempeSwap* moves, each of which involves at least one of the first k highly-penalized lectures. For acceptance criterion in perturbation, we use a strong exploitation technique, i.e., only better solutions are accepted.

The *depth of TS* and *perturbation strength* are adaptively adjusted according to the historical search records. That is to say, when the local minimum obtained by TS is promising, the *depth of TS* is increased to allow more intensive search, while *perturbation strength* is strengthened so as to diversify the search if the best solution has not been improved within a given number of TS procedures.

References

1. Chiarandini, M., Birattari, M., Socha, K. and Rossi-Doria, O. An effective hybrid algorithm for university course timetabling. *Journal of Scheduling*, **9** (2006) 403–432.
2. Di Gaspero, L. and Schaerf, A. Neighborhood portfolio approach for local search applied to timetabling problems. *Journal of Mathematical Modeling and Algorithms*, **5(1)**: (2006) 65–89.
3. Michel Vasquez and Jin-Kao Hao A "logic-constrained" knapsack formulation and a Tabu algorithm for the daily photograph scheduling of an earth observation satellite. *Computational Optimization and Applications*, **20(2)**: (2001) 137–157.