A TABU SEARCH PROCEDURE FOR COURSE TIMETABLING AT A TUNISIAN UNIVERSITY

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1. Introduction

Constructing a good solution to the real case timetabling problem is not an easy task. To find an initial feasible solution of the course timetabling problem for the Faculty of Economics and Management Sciences of Sfax, the authors have already developed a heuristic procedure which starts by assigning lectures to time slots. The strategy of starting by scheduling lectures first is explained by the fact that the lectures are very difficult to reschedule since it concerns a large number of students (several groups). Constructing a schedule for lectures from a virgin timetable allows us to place the lectures in the most suitable time slots. This procedure is called Lecture Timetabling Heuristic (LTH) and developed by Dammak et al. (to appear 2009) consists of assigning big sections first to classrooms with closest size. It proceeds by scheduling the first period of lectures with two time slots then those with single period and finally terminates by assigning the second period of lectures with two time slots. The main objective of this heuristic is to minimize the number of empty seats in each classroom by assigning student sections to classrooms having close capacity. It also tries to prevent having two or more consecutive lectures.

The second heuristic, presented in another paper, (Dammak et al. 2008), called Course Timetabling Heuristic (CTH) is embedded with LTH in a global heuristic called Timetabling Heuristic Approach (THA) that combine both heuristics to get a feasible solution to course timetabling problem. The procedure CTH is applied after obtaining the final solution of LTH.

It concerns the scheduling of tutorials in the remaining time slots of professors, students and classrooms left by the LTH. In this paper we extend the formulation to include both the lectures and the tutorials. This generalization induces an increased number of hard and soft constraints.

The following hard constraints are considered in our model:

1. All course activities (lectures and tutorials) included in the curriculum of each section must be taught.
2. No professor can teach more than one activity in any time slot.
3. No classroom can be used for more than one activity in any time slot.
4. No group can be taught more than one activity in any time slot.
5. No sub-section can take two lectures in two consecutive time slots.
6. Two lectures or two tutorials of the same course cannot be taught to the same sub-section during the same day.
7. No professor can teach three activities in three consecutive time slots.
8. No group can have successive activities in the third and fourth periods of Monday, Tuesday, Thursday or Friday.
9. No professor can teach successive activities in the third and fourth periods of
2. Monday, Tuesday, Thursday, or Friday.

In this paper, we start by the solution generated by the THA and adapt the tabu search procedure in order to ameliorate the quality of the solution via a suitable objective function constructed in the light of three criteria: the number of holes, the number of isolated lessons and the number of professor preferences violations.

3. Tabu search technique

Tabu search is a metaheuristic developed by Glover (1986) and independently by Hansen (1986), has proved to be very efficient to solve many combinatorial problems and especially educational timetabling problems. The method was developed to overcome the previous local search methods that lead to local optima like hill climbing and descent methods. The originality of the procedure is the use of short-term memory in order to prevent the return to inverse moves (cycling) and long term memory in order to diversify and intensify the search space. According to Brucker (1995), “tabu search is an intelligent search technique that uses a memory function in order to avoid being trapped at a local minimum and hierarchically canalizes one or more local search procedures in order to search quickly the local optimality”. For a detailed description of the tabu search procedure with applications, we refer the reader to the three good surveys: de Werra and Hertz (1989), Hertz and de Werra (1990) and Glover et al. (1993).

This procedure has demonstrated its ability to solve large and difficult combinatorial optimization problems (see Ferland et al. 2001, Gendreau et al. 1994 and Legües et al. 2007) and has performed well especially in educational timetabling containing both course and exam timetabling.

Tabu search is an iterative procedure starting from a feasible solution constructed with any constructive heuristic. At each iteration, a neighbourhood of the current solution is generated using some simple moves. The best solution in the neighbourhood replaces the current solution, even if it deteriorates the value of the objective function. In order to prevent cycling (returning to solutions already visited), the procedure use a short-term memory denoted tabu list including the most recent moves used to generate the sequence of current solutions. At each iteration, the move used to generate the new current solution is added to the list and the oldest element of the list is removed from this list (if the list is full). The size of the tabu list has to be moderately large enough to prevent cycling, but also small enough to avoid eliminating too many potentially good solutions.

The solution generated using tabu move is generally eliminated from the neighbourhood. But a solution generated with a tabu move may improve the value of the best solution generated so far. Such a solution is said to satisfy the aspiration criterion, and it is included in the neighbourhood.

Diversification strategies can be used to search more extensively the feasible domain. A commonly used diversification strategy consists in generating a new initial solution to reinitialize the search, relying on historical information stored in long term tabu list.

4. Application to course timetabling

In our solution, we can operate several moves to fill a hole (free inter-meetings) or eliminate an isolated lesson (a single activity in one half day); each type of the following moves generates an independent neighbor:

- Fill a hole by an isolated tutorial,
- Isolated tutorial can be moved to either isolated lecture or tutorial consecutively,
- Isolated tutorial can be moved to two consecutive activities (lecture or tutorial),
- Two consecutive tutorials can be used to fill two holes,

- Three consecutive activities are relieved by moving the first or the third tutorial to an isolated activity.
- Two holes can be eliminated by one hole containing two tutorials.

Our strategy consists of sequencing all classes and locates the frequency of holes in each group timetable; also we look for the occurrence of isolated lessons especially tutorials to be moved into holes. We work on the half days and assume that only tutorials can be moved and used to correct both holes and isolated sessions. The procedure applies the different already prescribed moves for all classes and chooses the best one which yields the best value of the objective function. The moves already applied are coded by their activity, the initial time slot, and the last time slot which are assigned to each tabu list TL_{ijg} of each group as a short term memory in order to prevent the inverse move. We choose a tabu list with a medium size containing 10 moves and it is managed by the rule first in first out. The neighbourhood solution is therefore any timetable generated through the application of any of the six prescribed moves. The question that can be asked concerns the feasibility of the solution when we operate any type of move, how to verify at each iteration that the neighbourhood solution is feasible? The procedure used to check the feasibility of the move consists of verifying the availability of the teacher and a convenient classroom (having enough seats to hold the group). For any group, if the concerned teacher and/or a suitable classroom are not available, then no move is applied. After each modification to any group, professor, classroom and group availability should be updated. We say that we obtain a neighbourhood solution of any current solution only if we try to apply the moves to timetables of all groups.

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