Planning in Education: Some Challenging Scheduling Problems

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Education and research are often indicated as primary means to achieve sustainability. A rapidly updating and increasing knowledge together with the political decision of increasing the number of students finishing a high level education call for a continuous attention at educational programmes and pedagogical organization. On the other hand, the delegation of managerial tasks to educational institutions brings new attention on a parsimonious usage of resources. The interdisciplinarity of programmes and the flexibility, personalization and multiplication of curricula pose significant organizational challenges to the administrations. In this context, automatic planning and OR techniques are of crucial importance for the economical performance and for the operation of activities.

A list of planning tasks that arise in education can be organized by time horizon. On the long term horizon, there is the definition of curricula and study programmes at universities or the decisions of employments of teachers at secondary schools. On the middle term, there is the course timetable organized by quarters or semesters, team creations (aka student sectioning) and instructors assignments. Finally, on the short term one can envision management of disruptions in course timetables or more ad-hoc tasks, such as the assignment of students to project groups. In all these cases resources such as teachers, rooms and time periods are limited and the criteria are load balancing, amenability of the schedule as well as a social and individual fairness.

Basic integer programming and constraint programming models are in some of these tasks enough. At our department, they are used for scheduling a restricted set of courses, the elective ones, after compulsory courses have been fixed. They are also used for the assignment of students to projects according to preferences and for team creation. In other cases, dedicated algorithms can be useful, like algorithms for stable marriage [4] in instructors assignments. Rather than computational difficulties the main issues that arise in these cases are linked with modeling individual fairness.

In other cases, stochastic local search methods and metaheuristics are necessary because of the intrinsic computational difficulty of the problems. In [3] we approached the problem of scheduling courses in the teaching terms in such a way that course prerequisites are satisfied and working load in the term is balanced. The problem we faced was a generalization of a previous cases easily solved in the literature by constraint programming. However, it is still a simplification of the real needs experienced at out institution, where also the possibility that the same course is attended in different years by different curricula, or alternative durations and credits have to be taken into account. We showed that integer programming and quadratic programming are outperformed in terms of upper bounds by a local search in a composite neighborhood guided by a simulated annealing strategy.

Another case that requires local search methods is the scheduling of courses at the Faculty of Science of our university [5]. The peculiarity of the formulation of this problem, with respect to more classical examples like the problem of the International Timetabling Competition [2, 1], is that the schedule is not fixed thorough the weeks that compose the term (in our case quarters) but may change. This characteristic is desirable for flexibility and pedagogical reasons.

We studied alternative approaches for the application of local search methods to solve four real life instances relative to the academic year 2010. A first approach starts by solving a kernel problem consisting of only one worst-case week. This week is then repeated throughout the quarter and adjustments applied to take into account different week requirements. Another approach addresses the problem globally, considering a solution representation that includes all seven weeks of the quarter and seeks for schedules rewarding regularities among the weeks. For both approaches two different solution representations are considered: a complete solution that has all lectures placed but is not guaranteed to be feasible (w.r.t. the hard constraints) and a partial solution that is always feasible but may not have all lectures assigned. In all four combinations a two phase solver was tested: first only hard constraints are addressed by a solver that uses minimum conflict heuristic with tabu search; then soft constraints violations are minimized by simulated annealing.

Preliminary results indicate that the best strategy is the global approach with partial solution representation. But the four real life instances are not solved to feasibility yet.

References

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