A MultiAgent Architecture for Distributed Course Timetabling

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We consider the timetabling problem for a set of university departments (or schools, or faculties) that have to schedule the lectures for their curricula in a given term. Each department prepares its own schedule according to its own rules, constraints, and objectives, without taking into account the schedule of the other departments.

In general, a department is not willing to share its information with other departments. Therefore we assume that all input data including constraints, priorities, preferences, and in some cases even the resources used are private for each department, and thus unknown to the others. In addition, each department is free to use whichever solution algorithm it wishes, and it can be either manual or automatic.

On the other hand, whenever resources are usable for more departments, e.g., they are located in the same building or site, the departments could benefit from sharing and/or exchanging their resources. This is due to the fact that the resource endowment for each term is not always optimally suited to the needs of the departments, but rather based on political and historical matters.

In our university, the Faculty of Engineering uses an automatic solver described in [1] that schedules the courses in a quite satisfactory way (the underlying decision problem is NP-complete). Unfortunately though, it is not able to negotiate automatically with the other departments that are located in the same campus. At present, the negotiation takes place verbally among the deans of the departments, the administrative staffs, and/or the operators of the timetabling system (i.e., ourselves). It requires good "diplomatic skills", it is quite time consuming, and in general not effective enough.

Differently from similar proposals in the timetabling area (see, e.g. [4]), in our context there are no global objectives to be satisfied. Therefore, all departments negotiate for their own selfish interest, although they have a moral impulse to be helpful with the other departments, whenever possible without loss.

Due to privacy of information, different objectives, and selfish behavior, it is clear that the use of a single centralized timetabling system is not a viable option within this framework. Therefore, we propose an automatic scheduling system based on a *multiagent* architecture. More specifically, each department has three cooperating agents:

Solver: this agent generates the solution to the timetabling problem for the department. To this regard, there are many proposals in the literature, based on different search techniques (see, e.g., [5]), that can be profitably adopted. However, in our framework the search strategy of the individual Solver must be adapted so as to take into account the deliberation of potential tradings [2]. For example, if Solver "sees" a solution requiring an extra room that improves significantly to the current best, it might want to store this solution and subsequently try to find the missing room by negotiation.

Negotiator: this agent is able to communicate with other Negotiators and exchanges resources with them (see, e.g., [3]). To this regard, we define a marketplace where resources can be traded by the agents, and we include an artificial currency that Negotiators use to sell and buy resources.

Manager: this agent stores and updates the information necessary to the other two agents to make their decisions correctly. For example, Manager maintains an estimate of the market prices for both possessed and needed resources (see, e.g., [6]). These prices are used by Negotiator to make bids, and by Solver to evaluate whether a given solution is interesting, based on the estimated cost of the missing resources and the return for resources that can be sold.

We assume that each department is given an initial amount of money, and it can spend it as long as its budget is above zero. An important point of our setting is that money maintains its value also over subsequent teaching terms. Therefore, an agent can be willing to sell its resources not only to buy other resources, but also to accumulate money to spend later. This mechanism, that already exists in the current verbal negotiation (in a less formal way, though), allows a department to save money for future harder instances (i.e., more dense terms), and also creates more room for negotiations and exchanges.

Our work is still ongoing and we are working on a proposal of a general architecture for the system, to define the tasks and the functionalities of each of the three agents, and to reconcile the notion of money to the objective functions of the problem.

At present, our efforts are mostly focused on Solver, and we are developing a version that is based on local search. Our local search algorithms exploit different cost functions that take into account expenses and gains related to possible sell and buy operations. The algorithms rely also on information coming from Manager about the probability of finding certain resources and the expected prices for them.

We are also working on an experimental analysis of the system in a specific setting. In this analysis, we are evaluating the overall performance of the system, based on a small number of parameters that control the behavior of the agents.

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