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On teaching assistant-task assignment problem: A case study ☆

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ABSTRACT

Teaching assistants (TAs), together with the senior academic staff, are the centerpiece of university education. TAs are primarily graduate students and they undertake many of the academic and administrative tasks. These tasks are assigned at the beginning of each semester and the objective is to make fair assignments so that the loads are distributed evenly in accordance with requests of the professors and assistants. In this study, a goal programming (GP) model is developed for task assignment of the TAs in an industrial engineering department. While the rules that must be strictly met (e.g., assigning every task to an assistant) are formulated as hard constraints, fair distribution of the loads are modeled as soft constraints. Penalties for deviation from the soft constraints are determined by the Analytic Hierarchy Process (AHP). The proposed GP model avoids assigning the same TA to the same task in several consecutive academic years, i.e., sticking of a task to a TA. We show that the proposed formulation generates better schedules than the previously used ad hoc method with a much less effort.

1. Introduction

Due to the increase in the number of universities, there has been a growing need for academic staff in Turkey since the beginning of 2000s. While there were 79 universities in 2005, this number increased to 168 by the end of 2012 with the establishment of new state and private universities. These recently established institutions employ their academic staff from the PhD graduates of old and prominent universities of Turkey like Boğaziçi University, METU (Middle East Technical University), ITU (Istanbul Technical University), etc. In order to encourage graduate education, the government increased the amount of scholarships granted by TÜBİTAK (The Scientific and Technological Research Council of Turkey) and YÖK (The Council of Higher Education). As a result, the number of PhD students increased substantially, in particular in the prominent universities cited above.

Boğaziçi University Industrial Engineering Department (BUIE) was founded in 1973 and has served as the top industrial engineering department in Turkey for the last 40 years. The effects of recent changes in higher education policies are also observed in BUIE. For example, in 2005, there were 4 PhD students among 23 Teaching Assistants (TAs). In 2010, the number of PhD students increased to 11 among 19 TAs. In BUIE, task assignments are manually prepared at the beginning of the semesters (fall, spring, summer) under the supervision of a senior TA and a professor. Previously, when the number of TAs that are MSc students (MSc-TAs) were high, the only issue with the assignments was to distribute tasks evenly. The TAs do not provide strong preferences on the tasks since they leave the department after 2 years on average: they focus on completing their master as soon as possible rather than assisting a specific course. However, as the number of TAs that are PhD students (PhD-TAs) increase, the preferences of the TAs become more significant: their focus now includes assisting specific courses due to their areas of interest, or to review some of the courses before qualification exam. Therefore, it becomes harder to generate an assignment on which everybody agrees with. In general, three issues arise with the current assignment process. First, there is always a number of TAs who are unsatisfied with the resulting assignments. Secondly, the total assignment process takes about 40 man-hours, most of which is spent by the senior assistant. The tedious assignment of "sticky" tasks, which are carried out by the same TA for several years, is the last issue. These tasks are either the most favorite or the most undesirable. Therefore, the sticky tasks bother either the responsible TA or the remaining TAs.

In this paper, we present a goal programming (GP) model for the task assignment problem of the TAs in BUIE that addresses

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the above issues. The resulting formulation yields better schedules in a reasonable amount of time. The mathematical model that we provide can be easily generalized for the use of any university with small modifications since the structure is similar in most universities.

The rest of the paper is organized as follows. The related literature is given in Section 2. Section 3 presents the current situation and gives the problem definition in detail. In Section 4, we propose the GP model. Section 5 provides the results and demonstrates the benefits of our model. We provide concluding remarks and future research avenues in Section 6.

2. Literature review

The studies on TA-task assignment problem is scarce and all of those handle the problem as a Constraint Satisfaction Problem (CSP). In their CSP formulation, Gaubius et al. (2002) define courses as variables, available TAs as variable domains and the assignment rules as constraints. Their approach is implemented to a real world problem where the degree of satisfaction is evaluated as follows: the formulation maximizes the number of assigned courses. If two schedules have the same number of assigned courses, then the schedule, which satisfies TA preferences better, is preferred. In fact, their problem is not a formal CSP, since some of the courses could be left unassigned in the final assignment. Furthermore, it is an over-constrained problem where the constraints are unary, binary or non-binary and maximizing the number of satisfied constraints is not an issue in their problem. They solve the problem by using a systematic search technique based on the depth-first backtrack search (BT). Zou and Choueiry (2003) utilize an efficient Multi-Agent (MA) search to solve the same problem and compare its performance with the BT (Gaubius et al., 2002) and a Local Search (LS). According to their findings, although MA finds a solution for all solvable problems while others can not, other methods outperform MA in the number of assigned courses for over-constrained problems. Lim et al. (2004) develop a web-based interactive system to manage the same TA-task assignment problem in a more automated way. The system can collect and process data (e.g. class schedules, TA preferences, department manager preferences) by using the BT, MA and LS methods. They implement this system successfully in the Department of Computer Science and Engineering of University of Nebraska–Lincoln.

Although interest is not so much in TA-task assignment problem, there exists an extensive literature on the related faculty–course assignment problem. These studies deviate widely due to the point of view of the decision makers and the scope of the scheduling. We are interested in the models which seek efficient faculty–course assignments by considering teaching target load levels and preferences in the perspective of faculty members. Therefore, in this section we focus more on the studies for preference based faculty–course assignment models rather than the well-known university timetabling problem.

As a pioneer work, Dyer and Mulvey (1976) propose a GP model to maximize the total preference level in faculty–course assignment problem. They provide a model with network structure and support it by an information system for detailed scheduling and short range planning. Another network-based decision support system is developed by Dinkel, Mote, and Venkataramanan (1989). Besides the faculty preferences for courses, the classroom and time slot preferences are also considered in their formulation. Schniederjans and Kim (1987) formulate a GP model which aims to minimize deviations from (i) the required number of faculty staff to teach all courses, (ii) faculty teaching load, and (iii) teaching preferences. Later, this model is improved by Badri (1996) with a two-stage model, which determines course–faculty assignments in the first stage and uses these assignments for course–faculty–time slot assignments in the second stage. Their study takes into account departmental planning preferences rather than faculty course preferences. A following study of Badri, Davis, Davis, and Hollingsworth (1998) further extends the previous one by considering the faculty–course preferences simultaneously with course–time and classroom assignments in a GP approach.

On the other hand, Daskalaki, Birbas, and Housos (2004) propose a different integer programming formulation that considers teaching preferences in the objective function. Their model uses multi-dimensional variables that enable determination of assignments between the set of triplets (course, teacher, group of students) and the set of pairs (period, day). Furthermore, Ismayilova, Sağir, and Gasimov (2007) study a multi-objective model which simultaneously maximizes the instructors' total preferences on faculty–course–time slot assignments and the administration's total preferences on instructor–course and course–time slot assignments. Additionally, total deviation from the instructors' load limit is minimized. This study is an extension of the work by Özdemir and Gasimov (2004), in which a nonlinear multi-objective faculty–course assignment model is presented. In both studies, the priorities are determined by Analytic Hierarchy Process (AHP) and Analytical Network Process (ANP), and exact solution methodologies are proposed for the solution of the models. Al-Husain, Hasan, and Al-Qaheri (2011) analyze the faculty–course–time–classroom assignment problem by decomposing it into three stages: faculty–course assignment in the first stage, time assignment in the second stage and classroom assignment at the last. In all stages an integer GP model is solved to obtain an optimal assignment, then it is transferred to the next stage to act as an input parameter.

In particular, for the large sized problems (containing faculty–course–time and/or classroom assignments) metaheuristics are frequently used. Gunawan, Ng, and Ong (2008) present a mathematical model to minimize the deviation of faculty workloads in a university. In their model, each course section can be assigned to more than one teacher, which makes the problem harder. They apply a genetic algorithm (GA) on two real data sets and obtain better results than the ones obtained by manual allocation. The GA results are improved by the use of the simulated annealing and tabu search methods in a following work of Gunawan and Ng (2011). GA is also applied by other authors to maximize the willingness of faculty assignments to courses in Wang (2002) or to minimize the conflicts in teaching hours and discontinuity of course timetable in Wang (2003). Most recently, faculty–course–classroom assignment problem has been tackled simultaneously and efficiently by the particle swarm optimization based algorithms proposed by Shiau (2011) and Tassopoulos and Beligiannis (2012).

Although course–faculty assignment problem has some similarities with TA-task assignment problem, they are very different in several aspects. Structure and hourly loads of the tasks vary substantially in TA-task assignment problem, while these are more alike in course–faculty assignment problem. In addition, TAs are categorized into PhD and MSc student groups for each of which the academic and administrative load requirements differ as well. Beyond any doubt, these facts lead up to a different assignment problem with distinct features. Thus the TA-task assignment problem should be elaborated by an independent study in more detail as it is provided by this work.

Our paper has the following contributions. First, we introduce the notion of sticky tasks which have a conflicting objective with the model introduced by Lim et al. (2004). In their model, courses are more likely assigned to the TAs who are more experienced whereas jobs are not allowed to be assigned to a TA more than 2 years in our model. Second, we let the TAs to express their preferences about their colleagues as well. The model does not