A Heuristic Based Class-Faculty Assigning Model with the Capabilities of Increasing Teaching Quality and Sharing Resources Effectively

Chin-Ming Hsu\textsuperscript{1} and Hui-Mei Chao\textsuperscript{2}

\textsuperscript{1} Department of Information Technology, Kao Yuan University, Taiwan, R.O.C.
\textsuperscript{2} Department of Electronic Engineering, Kao Yuan University, Taiwan, R.O.C.
\texttt{chinming.hsu@cc.kyu.edu.tw and huimei.chao@cc.kyu.edu.tw}

Abstract

This paper proposes a class-faculty assigning model to increase teaching quality and share resources effectively. To increase teaching quality, both faculty and classes are classified into different groups based on teachers’ specialties and courses’ attributes. The classified data are processed by a heuristic driven process and two fitness functions. To share resources effectively, the allocating rules for using the classrooms and laboratories are formulated based on the attributes of courses and availabilities of the resources. From the experimental results, there are about 90\% of 168 courses assigned to the specific professional teacher. The minimum and maximum average satisfaction for all teachers is 0.9 and 0.95, respectively, where the lowest score is 0.7 and the highest score is 1. These results show that the difference of each teacher’s satisfaction is small; the courses can be assigned to a specific professional teacher; and teachers’ expectations on specific teaching subjects can be satisfied as nearly as possible.

Keywords: Class-faculty assignment, heuristic driven process, and teaching quality.

1. Introduction

A class-faculty assigning problem is generally concerned with assigning classes to appropriate faculty members, proper classrooms, and available time-slots [1]. Solving this assigning problem is an important administrative task because it has to be performed in an individual department of a university every semester. In Taiwan, this task is specifically complicate and difficult because of existing multi-educational systems, including four-year undergraduate program, four-year night-class college program, graduate school program, and two-year college program in an academic department. In addition, each educational system handles different class assigning tasks and each professional teacher has different preferences on the specific teaching courses. Therefore, inappropriate class-faculty assignment may bring some unwilling consequences, such as decreasing teaching quality, lessening faculty expectations on preferred teaching courses, and deteriorating harmonious atmosphere in a department. Hence, finding an effective and efficient approach for assigning appropriate courses to university faculty is an important issue that must be solved.

At Electronic Engineering (EE) department of Kao Yuan University (KYU), the class-faculty assignment usually needs to assign about 200 teaching courses to 40 full-time teachers every semester. Commonly, assigning these numerous courses to every teacher relies on human labors and is influenced by four factors: (1) the course catalog structure changes with the student demands for specific courses every semester; (2) the limited facility, laboratory, and classroom resources affect the effectiveness of allocating available resources; (3) the faculty specialties and personal preferences influence the teaching quality and an individual’s satisfaction; and (4) the organizational policies related to the limitations of the teaching loads (such as the minimal and maximal teaching hours for night and day classes) and the fixed timetable would increase the difficulties of the assigning task. Consequently, the generated class-faculty schedules have the disadvantages of time consuming, inefficient utilization of facility and human resources, biased class-faculty assignments, and dissatisfaction among faculty members.

In order to increase the overall performance of the educational system, a heuristic based class-faculty assigning model with the considerations of teachers’ specialties and preferences, course catalog structure, and all organizational constraints and requirements is proposed in this paper. This study refers to the model proposed by Al-Yakoob and Sherali [1] in which the time-slots for classes are initially assumed to be given. The proposed model allows students to choose the elective courses and teachers to get on the Web Site to key in their preferred teaching courses. The developed
heuristic driven process with iterative mutation applies two fitness functions to achieve teachers’ satisfaction and support the fairness of the class-faculty assignment. The teaching quality can be ensured by assigning the classes to the appropriate professional teacher. In the following, Section II reviews some related studies. Section III describes the proposed class-faculty assigning model. The experimental results and the conclusions are shown in Section IV and Section V.

2. Technology background

In this paper, class-faculty assigning problem can be viewed as employee scheduling problem which assigns employees to qualified required works where employees are faculty members and qualified required works are specific professional classes [1]. Generally, the employee scheduling problem builds the works and time-slot assignments in one stage. The researches [2-5] are the examples for assigning the schedule and placing the employees to works simultaneously. Lapiere and Ruiz [2] applied Tabu search meta-heuristic technology on solving hospital supply systems located in Montreal, Canada. The approach mainly emphasizes on making scheduling decisions such as when each employee should work and what task should he do, etc. However, it needs more work on evaluating its performance efficiency by testing its practical value. Alvarez-Valdes, etc. [3] proposed a heuristic algorithm to solve the glass factory scheduling problem for incoming customer order. Although this model can provide tight due dates and can perform a complete mid-term plan, it is lack of flexibility on adapting other customer order, such as rescheduling remaining jobs. Sherali, etc. [4] and Seckiner [5] are two studies related to balance workload among workers. The study proposed by Sherali, etc. utilizes a quantitative approach to find out the optimal schedule on set-up task assignment for multi-objective program. The study proposed by Seckiner uses a simulated annealing approach to solve job rotation problem.

Class scheduling and timetabling problems have been widely addressed in the literatures [6-10] in which the literatures [6-8] built the schedule and place the teachers to classes simultaneously; the literatures [9-10] solved the class-faculty assignment in two stages. Hsiung and Chang [6] proposed a genetic algorithm based courses assignment with the consideration of faculty preferences, which has the disadvantage of repeating starting searching point for the proposed genetic algorithm. Beligiannis, etc. [7] applied the mathematical model to solve course and time-slot assignment without considering teachers’ preferences. Head and Shaban [8] formulated a heuristic approach for course-student timetabling, which is the student-oriented scheduling model. For solving class-faculty assignment through a two-stage process, Badri [9] made class-faculty assignments in the first stage and made class-faculty time-slot assignments in the second stage, which seeks to maximize faculty course preferences. Alvarez-Valdes, etc [10] developed a set of heuristic algorithms with Tabu search to solve the problem for building the timetable in planning the third year in which the student would choose different professional orientation (Business Management, Financial Management, Accounting, etc.). These two researches have the advantage of presenting a complicated model as a more comprehensive model by simplifying one problem into two sub-problems.

As described above, there is no universal model that fully considers all the aspects for solving the class-faculty assigning problem because each individual problem has its specific nature. The authors have proposed a two-stage approach for the academic class scheduling and time tabling problem at EE department of KYU. Stage I is concerned with designing an efficient class timetable that provides flexible class and time offering patterns [11]. The references [12-14] are the examples related to this issue. Stage II, the present paper, is concerned with assigning faculty members to different classes aiming at increasing teaching quality and sharing resources effectively.

3. Research design and methods

Figure 1 shows the block diagram of the class-faculty assigning system. The system consists of three inputs, a faculty course assigning process, and outputs. The inputs include faculty inventory, faculty preferences, and course inventory. The class-faculty assigning process takes the inputs through the heuristic driven process coupled with two fitness functions to generate the expected class/course/faculty assigning outputs. Each part of the system is described in detail as follows.

3.1. Inputs

As shown in Figure 1, the inputs of the class-faculty assigning system include faculty inventory, faculty preferences, and course inventory. The faculty inventory is the list of all full-time teachers in the department; the faculty preferences are the teachers preferred teaching courses and time slots; and the course inventory is the list of all requirements and elective courses extracted from the class/course catalog. In this study, every faculty has to choose seven different courses and seven half days, at least, via the website. Table 1 shows the data structure of the faculty inventory. As shown in Table 1, the teachers are classified into four groups (including computer engineering, system control, navigation electricity, and semiconductor) and five levels (including instructor, assistant professor, associate professor, full professor, and teacher with administration work) based on their
specialties and positions. Table 2 gives the data structure of the faculty keyed in preferred teaching courses, which lists his/her keyed in classes, the course titles, and teaching hours. Table 3 illustrates the data structure of the course inventory. In Table 3, all courses are indexed and classified into five groups (including the fields of navigation electricity, system control, computer engineering, semiconductor, and general courses) based on their attributes.

Table 2. The data structure of the faculty keyed in preferred teaching courses

<table>
<thead>
<tr>
<th>Teacher’s Name</th>
<th>Class/Course Title/Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Wang</td>
<td>4EE21/Electronic Lab./3</td>
</tr>
<tr>
<td>Jim Hsu</td>
<td>2EE11/Electronic Lab./3</td>
</tr>
<tr>
<td>A.O. Brown</td>
<td>4EE32/PLD Lab/4</td>
</tr>
<tr>
<td></td>
<td>4EE41/Microcontroller/3</td>
</tr>
</tbody>
</table>

3.2. Class-faculty assigning process

The class-faculty assigning process utilizes the heuristic method coupled with two fitness functions to optimize the class-faculty assignment outputs, which includes three steps: organizing heuristic data, designing fitness functions, and iterative mutation.

Step 1: Organizing heuristic data

Organizing heuristic data means representing all necessary data sets and constraints as useful information in order to find an optimal solution. In this section, all courses, including required and elective courses, are numbered from 1 to \( n \) and all teachers are numbered from 1 to \( k \) where \( n \) and \( k \) are the maximum index number of courses and teachers, respectively. The definitions of the data sets and system constraints used throughout in this section are given as follows.

The data sets are:

1. \( \text{TGroup}[i][j]=k \): The teacher numbered \( k \) is classified into the index number \( j \) of the \( i \)th group.
2. \( \text{TPosition}[k]=m \): The position of the teacher numbered \( k \) is \( m \).
3. \( \text{TPref}[k]=n \): The preferred teaching course chosen by the teacher \( k \) is the course number \( n \).
4. \( \text{TOK}[i][j]=1 \): The teacher indexed number \( j \) of the \( i \)th group has completed the courses assignment.
5. \( \text{CGroup}[i][j]=n \): The course numbered \( n \) is classified into the index number \( j \) of the \( i \)th group.
6. \( \text{CPref}[i][j]=k \): The course indexed number \( j \) of the \( i \)th group is chosen by the teacher numbered \( k \).
7. \( \text{TAssign}[k][\text{p}]=n \): The course numbered \( n \) is assigned to the teacher numbered \( k \), where \( p=1...5 \), the index number of the assigned teaching course.
8. \( \text{MutOP}[k]=n \): The course number \( n \) is assigned to the teacher \( k \) and labeled as an mutation operator.

The system constraints are:

1. Any subject is assigned to the teacher who is the only one choice that subject.
2. If a subject is chosen by more than two teachers, the first priority of assigning teaching courses is the advisor of the class, the second priority is the teacher with the specific professional of the subject based on the data sets listed in the TGroup and CGroup.
3. A teacher has to be assigned at least two different subjects except for the teacher also working at administration department; all teachers must have no more than three different subjects.

Step 2: Designing fitness functions
The fitness function is designed by satisfying different specific constraints and meeting the different needs to evaluate the degree of faculty satisfaction for their courses assignment. Under the constraints described above, two fitness functions, the satisfaction and the average satisfaction of the faculty, are given as follows.

The satisfaction of the teacher numbered \( k \) is defined as

\[
S_k = \frac{TM_k}{p_k} > 0.6
\]

where \( TM_k \) is the total number of the satisfaction matched for the teacher numbered \( k \); \( p_k \) is the total number of the assigned teaching courses to the teacher numbered \( k \).

The average satisfaction of all the faculty is defined as

\[
TS = \frac{\sum_{k} S_k}{K} > 0.8
\]

Step 3: Iterative mutation

An iterative mutation begins at the mutation operator marked in the array of MutOP. The objective of this process is to increase the algorithm’s effectiveness while searching another solution and gain better output optimization for the assigning task. Following shows the iterative mutation procedures.

For each MutOP do

For each TAssign do

Process1. Select another specific professional teacher

Process2. Assign the course to this teacher, if the selected teacher is allowed to assign a course, \( TM_k = TM_k + 1 \), otherwise, go to Process 1.

Process3. Update new state of TAssign of this teacher.

End TAssign

End MutOP

3.3. Outputs

Table 4 gives the data structure of the system output. From Table 4, the outputs of the class-faculty assigning system contain each faculty’s teaching courses, corresponding teaching hours, and their satisfaction matched.

4. Experimental results

The class-faculty assigning system is simulated in C programming codes with using MS SQL server as backend database. The proposed method has been tested by EE department of KYU, Taiwan, spring semester, 2008. The proposed approach allows teachers to get on the Web Site to key in at least 7 different courses of their preferred teaching courses. From Table 5, because Prof. Wang is classified into the computer group, he can only choose the courses either in the field of computer group or in the group of general courses. Table 6 lists Prof. Wang’s assigned courses and whether the assigned courses are matched to his satisfaction. From Table 5, Prof. Wang’s assigned courses are all satisfied in his keyed in preferred teaching courses.

In this study, the faculty’s satisfaction is modeled as the value of 0-1. From the experimental results, the difference of each teacher’s satisfaction is small, where the lowest score is 0.7; the highest score is 1; the minimum and maximum average satisfaction scores for all teachers is 0.9 and 0.95, respectively. Moreover, there are 90% of 168 courses assigned to the specific professional teacher. Therefore, the proposed approach can support good enough faculty satisfaction and the fairness of the course assignment.

Table 4. The data structure of the system outputs

<table>
<thead>
<tr>
<th>Teacher Group</th>
<th>Teacher’s Name</th>
<th>Cls./Cour. Title</th>
<th>H/Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navi. Ele.</td>
<td>David Wang</td>
<td>4EE21/Elec. Lab./3</td>
<td>3/Y</td>
</tr>
<tr>
<td>Syst. Con.</td>
<td>Jim Hsu</td>
<td>2EE11/Elec. Lab./3</td>
<td>3/Y</td>
</tr>
<tr>
<td>Comp. Eng.</td>
<td>A.Brown</td>
<td>4EE31/PLD Lab/4</td>
<td>4/Y</td>
</tr>
<tr>
<td>Semi.</td>
<td></td>
<td>4EE32/PLD Lab/4</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Prof. Wang’s keyed in 7 different courses of his preferred teaching courses

<table>
<thead>
<tr>
<th>Teacher’s Name</th>
<th>Class/Course Title</th>
<th>Teaching Hours</th>
<th>H/Sat</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Wang</td>
<td>4EE21/Elec. Lab/3</td>
<td>3/Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2EE11/Elec. Lab/3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE31/PLD Lab/4</td>
<td>4/Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE32/PLD Lab/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE41/Microcontroller/3</td>
<td>3/Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE42/Microcontroller/3</td>
<td>4/Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE43/Microcontroller/3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Prof. Wang’s assigned courses and the satisfaction matched

<table>
<thead>
<tr>
<th>Name</th>
<th>Class/Course Title</th>
<th>Teaching Hours</th>
<th>Satis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Wang</td>
<td>4EE31/PLD Lab/4</td>
<td>3/Y</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>4EE32/PLD Lab/4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE41/Microcontroller/3</td>
<td>3/Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4EE42/Microcontroller/3</td>
<td>4/Y</td>
<td></td>
</tr>
</tbody>
</table>

5. Conclusions and future works

In order to increase the overall performance of the department-based educational system, a heuristic based class-faculty assigning model with the considerations of teachers’ specialties and preferences, course catalog
structure, and all organizational constraints and requirements is proposed in this paper. The proposed approach provides three advantages: (1) By allowing teachers keyed in their preferred teaching courses through the Web Site, this ensures that the courses can be assigned to a specific professional teacher and teachers’ expectations on specific teaching subjects can be satisfied as nearly as possible, therefore teaching quality is guaranteed. (2) By formulating the rules for using the classrooms and laboratories based on the attributes of courses and availabilities of the resources, this ensures that resources can be effectively shared. (3) The developed heuristic driven process with iterative mutation applies two fitness functions to achieve teachers’ satisfaction and support the fairness of the class-faculty assignment. In addition, the proposed method puts the advisor of the class into the first priority of assigning courses. This would increase the chances for teacher involving students learning.

This research can be extended to solve the academic based class-faculty assigning problem in order to increase the overall performance of the university’s educational system.

6. References


