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AUTOMATIZATION OF UNIVERSITY TIMETABLING PROBLEMS

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Abstract

This article is running a formalization of the basic elements of the problem of scheduling training sessions for universities. Analyzing "hard" and "soft" constraints.

We are developing computing Information model for scheduling problem of the university. Describing the table components, their structure and linked relations as well as describing the general scheme of solving the problem

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Introduction

In operations research, real world problems are often solved by analyzing and modeling them so that they can be solved by some sort of mathematical program or heuristic. These problems can be anything. From an optimization of a plant, a schedule for a job shop, a transportation routing problem, or even a university timetable. The programs used to solve these problems can range from integer, mixed-integer, or constraint programming to simulation, and also heuristics such as tabu search and other local search techniques. In order to model a problem or put a problem into a language that a program can solve, the problem definition must be formulated . This step of formulating the problem called scheduling problems for the university . University course scheduling can be considered as an instance of what so called timetabling problem, which appears to be a tedious job in every academic institute once or twice a year. This problem involves the scheduling of classes, students, teachers and rooms at a fixed number of time slots, in a way that satisfies a set of hard constraints and minimize the cost of a set of soft constraints. This problem is considered to be of more complexity, and this implies that there is no

known polynomial time algorithm that can guarantee finding the best solution . Traditionally, the problem is solved manually by trial and hit method, where a valid solution is not guaranteed. Even if a valid solution is found, it is likely to miss far better solutions. These uncertainties have motivated scientific studies of the problem to develop automated solution techniques for it. In this work, the university scheduling problem will be handled; this includes the process of assigning a set of (classrooms and laboratories, research and manufacturing equipment, computer and projection equipment, teachers) into account a set of hard and soft constraints. An example of hard constraints: no person can be in more than one place at a time. Another example is that the total resources allocated to a timeslot must be less than or equal to the resources that are available in that timeslot.

Soft constraints, on the other hand, are advisable to plan a lecture at the beginning of the working day and not to alternate them with studies of other species.

In these circumstances, the current task is to improve the efficiency of the university through the development and implementation of methods, models and software for making rational scheduling of various processes [1,2,3].

Definition of the problem

In the base of mathematical model of the subject area "Schedule" the concept of "process" is the considered the most significant which is a set of interrelated resources and activities that are linked to a specific time interval.

Let’s perform the formalization of the concepts "resource", "time interval", "activity" and "schedule" within the subject area.

As a resource we consider the university classroom sets where j is a multi-index:

$j = (j_b, j_a, j_c, j_t)$ taking into account the audience belonging to an educational building, its number, its type (for example, lecture-room, computer lab, electronics lab, etc.) and its capacity (for example, the audience for 25, 50 or 100 people) [1].

For concept formalization of time interval, there are two approaches in the task of period for scheduling. At the first approach the "natural" period of the curriculum - a semester is taken as a period, at the second is one educational week or two in succession going weeks (first and second, etc.). The second approach ("a week's time-table") is simpler in realization, more clear to the participants of educational process(teachers and students) due to the rhythm of a week's time-table . The elementary temporal interval of sets according to folded tradition is called a "pair", and the totality of all temporal intervals in the span of time corresponding to the period of scheduling formation makes up the great number of $\boldsymbol{T} = \{t_i\}$, that is used in the process of scheduling [1,2].

Applying to scheduling formation the concept activity is characterized by three objects, that we will name a teaching unit:

$$u_p = \{g_k, d_q, p_l\}$$

Where: g_k is a group of learners , d_q - the studied discipline and p_l is a teacher . The totality of all educational units of higher learning institution forms for the examined period of scheduling sets $\boldsymbol{U} = \{u_p\}$.The above mentioned formalization of such concepts as a resource, a temporal interval and an activity allows to examine a time-table (schedule) as some unambiguous reflection of s from sets $\boldsymbol{U}$. in a set (work is Cartesian) $\boldsymbol{T} \times \boldsymbol{A}$:

$$s: \boldsymbol{U} \rightarrow \boldsymbol{T} \times \boldsymbol{A} \in \boldsymbol{S} .$$

Constraints

Obviously, not every reflection from S can be considered as a time-table because of its possible physical realization that is determined by the set of "hard" constraints. In turn, the time-table quality serving as a criterion during the selection of the "best" time-table from the sets of possible is related to the degree of "soft" constraints satisfaction.

We consider the list of main "hard" limitations as follows:

1)The condition of audiences availability. It is assumed that every audience has the chart of availability forbidding its use in certain temporal intervals. It means that some columns of F matrix must be canceled beforehand (or filled by values "n/a"). As the limitation can be named static due to its implementation providing the decision of scheduling task and is resulted in the simple narrowing of decision area searching.

2) The condition of teachers availability assumes that a teacher can have the "chart of presence" meaning that in certain temporal intervals he is out of higher learning institution and cannot

participate in educational process. There is also a static limitation and its implementation is taken to priori placing of several values "n/a" in the lines of F matrix corresponding to the set of a teacher.

3) The condition of two educational units' compatibility u_i *and* u_j meaning that in the set temporal interval (pair) every student and every teacher can participate only in one elementary process. The verification of this limitation is taken to the calculation of $u_i \cap u_j$ crossing if it is empty, then teaching units of u_i *and* u_j are compatible. We should notice that this constraint is dynamic, as it needs to be checked up only in the process of decision making. However, for corresponding calculations reduction is boole of $\boldsymbol{BU}$ matrix can be formed beforehand.
4) The condition of educational units and audiences compatibility, that supposes the existence of possible audiences list for every teaching unit. The admission can be related both to the capacity of audience and it specialization (a stream lecture cannot be conducted in a laboratory, laboratory employment on mechanics cannot be conducted in chemical laboratory etc.). Static constraints and their implementation are also taken to a priori placing of several of values "n/a" in lines of$\boldsymbol{F}$ matrices.
5) The condition of "attainability": two audiences appointed in a time-table in contiguous temporal intervals can appear "unattainable" in relation to a teacher or students if distance between corresponding educational corps is great (dynamic constraint).

Along with "hard" constraints it is accepted to also examine "soft" constraints of $\boldsymbol{R}_m$, that can be broken and on the whole the degree of violation of totality of such constraints can characterize the time-table "quality".

We consider some of "soft" constraints as follows:

1) The amount of the lessons during the day conducted by a teacher, must not exceed a set value W_p. The verification of this constraint can be executed effectively enough taking into account that indexes of p for u_p and i t_i are multi indexes (i.e. there is a teacher index of l in the index of p , and in the index i containing the number of the day of the week of d).
2) The amount of lessons during the day, on which a student must be present, must not exceed a set value W_s. The verification of this constraint is produced with the use of the above mentioned boole matrix of $\boldsymbol{BG}$.
3) The lessons planned to a teacher on a concrete day must be located in contiguous temporal intervals (without " break ").

   Accordingly, the amount of such " break " can serve as the measure of time-table quality.

4) The lessons planned to students on a concrete day also must be located in contiguous temporal intervals (without " break "), and the amount of " break" influence on the estimation of time-table quality.
5) The absence of "transitions" is desirable between educational corps during the day both for teachers and students (accordingly, the amount of transitions serves as the measure of time-table quality).

It is possible to suppose that the brought list of "soft" limitations is not exhaustive and can be broaden.

With the use of the formalization described above it is possible to offer the next chart of scheduling task decision:

1) The preparation of basic data: the forming of U, T *and* A sets. It is rather routine process, however because of large dimensions of these quantities and the presence of them some structural peculiarities in (that is expressed by the use of multi indexes), their realization must lean against the careful working of corresponding structures of data (informative model) and envisage the use of "friendly" interface users.

2) The forming of the initial state of sets S by the treatment of "hard" constraints array.

3) The generation of " null " approaching – a possible curriculum of $s \in S$ satisfying "hard" limitations and the estimation of its "quality" by the folding of vectorial criterion in which private criteria are the measures of the violation degree estimation of "soft" constraints.

4) The organization of iteration process improvement of current time-table by the use of some known methods of discrete optimization [1,2].

Computer Informative Model (CIM)

Taking into account the large volume of set of model parameters, the presence of difficult logical and quantitative dependences between them, and also the possibility of decision task receipt of acceptable quality and in reasonable terms only by means of a computer, a necessary step is the creation of computer informative task model of scheduling. Under the computer informative model (CIM) the set of sizes (data), containing all necessary information about the investigated objects and processes, and also relations (connections) between them, is implied, logically and physically organized as the database (DB) kept in the memory of a computer and being under a management of control system databases (CSDB).

The realization of this step will allow not only to provide the comfortable form of data grant to programmatic application realizing the surplus of possible variants of time-table and the searching among them the best one, but also creates an "informative platform" for the realization of necessary functions for the use of the data kept in the CIM different categories of users. In the most general view central part CIM can be presented by the figure no [1]:

We've done a short review of the known methods that is necessary as a subject sphere within the framework of the Time-table formation for Institutions of higher learning. Among the methods of decision of scheduling task, it is possible to distinguish the following methods: the method of annealing imitation, the algorithm of count coloration, the imitation programming, the linear programming, and the genetic algorithms in whole [1,2,3,4].

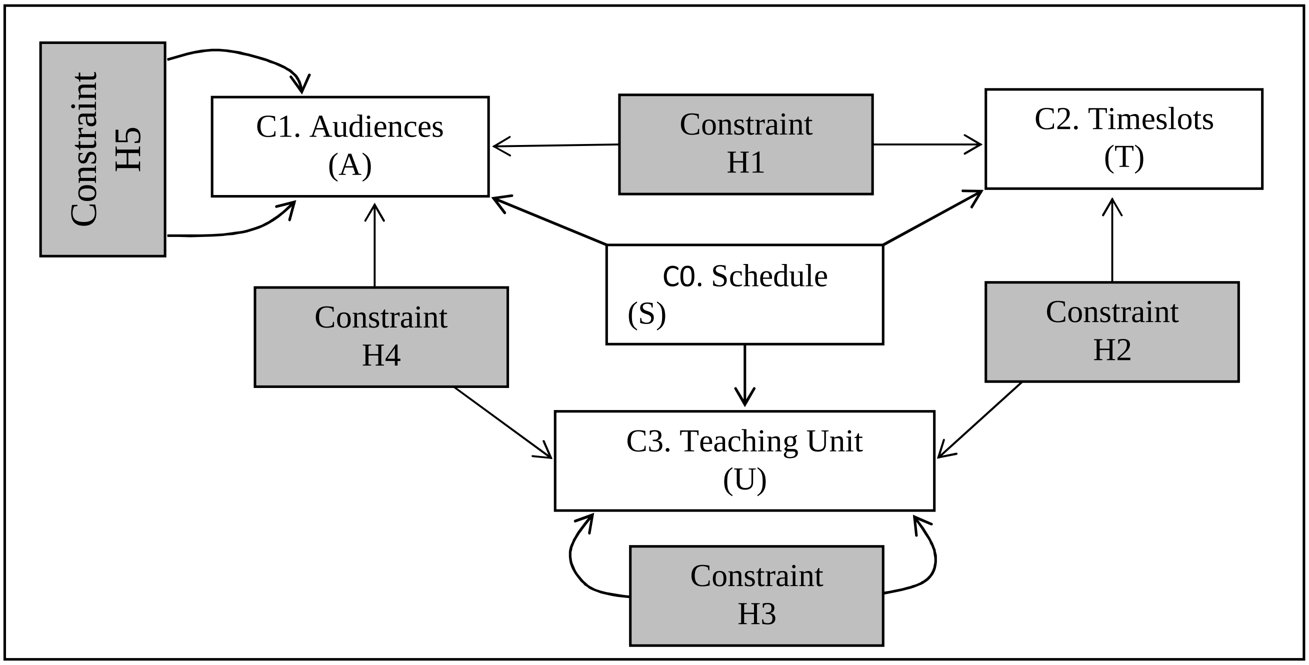

Fig. 1. Relations between the central table and the constraints

Conclusion and future work

In this research a new methodology for solving university course scheduling is proposed and implemented using real data set from the South Russia State Technical University. We have reduced the soft cost without affecting the hard cost by using multi-objective optimization.

As a future work, it would be a good idea to enhance the algorithm by trying other methods and evolutionary techniques. Also, to consider more soft constraints to better satisfy the willingness of the students and teachers, better.

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