User project scheduling and allocating : Design, modelling and solving

Yinuo Li[1,3], Jin-Kao Hao[1,2], Rachid Naitali[3]

[1] LERIA, Université d'Angers, 2 Boulevard Lavoisier, 49045 Angers Cedex 01, France
[2] Institut Universitaire de France, 1 rue Descartes, 75231 Paris Cedex 05, France
[3] GePI Conseil, Grand Maine - Allée du Grand Launay, 49000 Angers, France

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1 Introduction

In this work, we study a real-world problem, the user project scheduling and allocating problem of the social and medico-social sector.

In France, the social and medico-social sector is experiencing a fast evolution due to the continuing growth of older and disabled population. These people are looked after in more than 34,000 structures of different types offering 1.4 million places (French SAH Ministry, 2012). In addition to the daily care, the French law No.2002-2 ensures the right of users to participate in the conception and the implementation of the his/her personalized project.

However, the implementation of this policy in these structures is not progressing well because there still exist many difficulties in the design and implementation of user projects. Indeed, the deciders of these structures have to consider various aspects such as user's will, budget, activity scheduling, resource availability, assignment, etc. Moreover, these structures are typically faced with a lack of decision support tools to help them consider and organize those dimensions.

This work deals with the main issue of elaborating thoughtful and feasible users' projects, which aims to improve the efficiency of projects implementation for the whole structure. We formulate this user project planning problem by identifying its constraints and objectives. We also study solution methods based on integer linear programming (ILP) and neighborhood search heuristics and show preliminary results on simulated realistic test instances.

2 Problem statement

User project planning belongs to the large class of scheduling problems which arise in many real-world applications such as transport scheduling [2], educational timetabling [3], nurse rostering [4], etc. This kind of problem is often characterized by a set of constraints (which can be further divided as hard constraints and soft constraints in some cases [1]) as well as some optimization objectives. The problem studied in this work is described in this way.

A personalized user project is a planning of several activities during a period. To introduce the main constraints and objectives of the problem, we state :

- A set U of users, each being characterized by his/her budget, availability and preferences for each activity.
- A set A of activities, each being characterized by its price, duration, capacity, availability and features required.
- A set R of resources, each being characterized by its availability and features.
- A set T of timeslots, during which users, activities and resources are to be scheduled. Usually we take 5 working days per week and 8 timeslots per working day, that means, for a project of 3 months, there are 12*5*8 = 480 timeslots.

To establish a feasible user project, a number of hard constraints must be satisfied :

— *User availability.* User cannot be scheduled when he/she is not available and cannot participate in two activities at the same time.
— *Activity availability.* An activity cannot be scheduled when it is not available.
— *Resource availability.* A resource cannot be scheduled when it is not available and cannot be used by two activities at the same time.
— *Budget constraints.* The cost of user's project cannot exceed his/her budget.
— *Activity Capacity.* For each activity starting at a given timeslot, the number of users attending this activity cannot be greater than the capacity of this activity .
— *Feature constraints.* An activity cannot be scheduled when there are not enough resources to use.
— *Preference.* User must indicate a preference for each chosen activity.

To keep our model compact, we assume that there are no relation between activities and a user can only participate in an activity at most once during the given period.

We identify the following objectives to be optimized :

— *Suitability.* Maximize the satisfaction in terms of the preferences of activities of the users.
— *Minimum resources.* Minimize the use of resources to save resources for the structure.
— *Minimum cost.* Minimize the cost of the plan to save expenses for the users.

Based on the above description, we have elaborated a mathematical formulation of the problem, which is however omitted here due to page limit.

3 Solution methods and results

To solve the problem, we propose an ILP model and run a general ILP tool (CPLEX) on the model. Given that the problem is complex and highly constrained, we also experiment a heuristic approach based on multiple neighborhood search with various search operators to explore the constraints of the problem. We present computational results on a set of simulated test instances of different sizes and tunable characteristics to fit as much as possible real situations. These instances were based on real scenarios identified according to more than 200 responses received from different structures answering to a large-scale survey sent to these structures. Finally, we draw conclusions and identify future research perspectives.

Références

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