Personnel scheduling

Challenging combinatorial optimisation problems with a personnel scheduling component

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Abstract Personnel scheduling can become a particularly difficult optimisation problem due to human factors. And yet: people working in healthcare, transportation and other round the clock service regimes perform their duties based on a schedule that was often manually constructed. The unrewarding manual scheduling task deserves more attention from the timetabling community so as to support computation of fair and good quality results. The present abstract touches upon a set of particular characteristics of personnel rostering problems for which, for the time being, only very scattered models and algorithms exist.

Besides being hard to solve, personnel scheduling never occurs as an isolated problem in real life. The interconnectedness of personnel scheduling and other vertical decision levels of the organisation constitutes the second focus of this extended abstract. Not only is it difficult to produce an acceptable solution to a personnel rostering problem, it is also cumbersome to detect possible infeasibilities or conflicting constraints, caused by decisions at a higher level than the scheduling level. Part of the contribution is dedicated to mutual parameters at the manpower, staffing and rostering level.

Next to the vertical influences, personnel scheduling cannot be ignored as an optimisation problem that is influenced by other optimisation problems in an organisation, e.g. patient admission scheduling, operating theatre scheduling and personnel scheduling cannot really be solved independently. Another interesting set of problems consists of strongly intertwined personnel rostering and other problems, such as vehicle routing and rostering combined in the home care scheduling problem.

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Each separate decision level includes challenging research questions and opportunities. Large margins for improvement exist when crossing the borders of decision levels or optimisation problems interfering with personnel scheduling.

Keywords Personnel scheduling · automated rostering · decision levels

1 Introduction

Personnel scheduling is a relevant logistic problem in healthcare, transportation and the service industry [10]. It covers a wide range of optimisation problems [4], most of them dealing with tasks or shifts that need to be covered by a team of people over a given planning horizon. Manual planners as well as scientists optimising schedules generally agree that personnel scheduling is a difficult problem to solve. Some characteristics, including personnel's skills, round the clock work, large sets of contractual and individual constraints contribute to the hardness of the problem.

The academic side of personnel scheduling reveals a rather well-established combinatorial optimisation problem, while only little supporting theory is available. The actual problem definitions and constraints differ considerably among academic papers [7], which has led to a very large variety of models and algorithms, e.g. [2,3,8,12,15,16,19,20].

Personnel scheduling offers plenty of challenges to the timetabling community, both in terms of theory and application development.

2 Manual versus automated scheduling

Despite many years of excellent advancements in personnel scheduling research, only little results have made it to practical decision support systems [13]. This is rather unfortunate for organisations spending a large budget on human resources and, in particular, for the planners who are responsible for generating weekly or monthly rosters without advanced software systems.

Many explanations can be given for the lack of effective decision support. Addressing the shortcomings probably requires multi-disciplinary approaches, rather than faster or better optimisation algorithms. The main research challenges include:

- precisely capturig the actual coverage needs, the actual meaning of required skills and experience, time definitions, etc. Manual planners are inclined to controlling out every possible detail of the scheduling problem. How much detail should be contained in the model for automated decision support?
- correctly interpreting the complex hard and soft constraints. Working time regulations that have been interpreted in contradictory ways within one single organisation are very common indeed. How should they be modelled in an automated system?

- capturing information on the perceived importance of constraints and objectives. The implicit ranking of constraints and objectives differs surprisingly often from the official ranking. This may lead to unwanted situations in which the personnel prefers a low quality schedule over a high quality one because of a different quality perception. Should the implicit ranking be ignored? If not, how can it be determined?
- accurately modelling the human factors [17]. The planner's expertise concerning fairness among members of staff, the actual skill level of people, the private life of individuals, the personal preferences and concerns, etc. cannot be ignored. This implicit information is again very hard to capture.
- developing mechanisms for dealing with unpredictable issues. The need for quick rescheduling in case of unexpected staff shortage has been studied, e.g. [18]. Which other urgent decision or optimisation problems cannot be ignored in the context of automated decision support?
- implement state of the art personnel scheduling approaches within central software systems of the organisation, if such systems exist at all. How should the new approach be implemented, integrated and maintained?

3 Personnel scheduling and other decision levels

3.1 Vertical decision levels

Personnel scheduling is subject to constraints set at other decision levels. One of the most restrictive constraints is determined by the estimated workload per hour, shift, day and department. It is quite common that the corresponding coverage constraints are unsatisfiable, given the available people, their contracts and the set of regulations. Eventual schedules executed in practice are indeed not always feasible.

Without going into methodologies for accurately determining the workload, the estimations cannot be made independently from assumptions on the available members of staff per department. The number of personnel is one issue but their contracts and skills are at least as important.

The individual members of personnel have been assigned to each department at the staffing level. These decisions should ideally be influenced by the potential subsequent schedule quality. Unfortunately, there exists no analytical relationship between the personnel composition and the schedule quality, not even when the workload is precisely known. One possible decision aid is to compute personnel schedules for varying compositions of personnel. The outcome may help to select particular contract and skill mixes for staffing each department.

The management should be concerned about manpower planning, which is a long term organisation wide decision to be made. Besides determining how many people the organisation should hire at a certain point in time, it should also consider which skill and age mix is required and which mechanisms, e.g. recruitment, training, dismissal, are necessary to attain this staff composition

in a certain period in time. Including future scheduling concerns into manpower planning is an interesting research direction, which should lead to improved long-term schedule qualities.

3.2 Horizontal decision levels

Some optimisation problems are solved by people responsible for completely different structural parts of an organisation, without any hierarchical dependency. Nurse rostering, operating theatre scheduling [5] and patient admission scheduling [6,9], for example, are three demanding optimisation problems in hospitals. A good solution for one of the thee problems strongly constrains the other two problems. Some interaction among the three planners would definitely help a hospital to increase its service level and personnel satisfaction at the same time.

Besides the previous challenge at the operational level, departmental personnel scheduling cannot always be dealt with in an isolated manner. Departmental planners try hard to improve the quality of their own schedule. They sometimes need to do that by temporarily transferring a member of staff from one department to another, while having only subjective information about workload differences. This interesting negotiation process can be automatised in an objective manner [14], which opens up many perspectives for better decision support.

A different issue arises when personnel scheduling is strongly interwoven with other combinatorial optimisation problems, in such a way that the problems cannot be solved independently at all. Problems like this are called 'structured problems'. Home care scheduling [1,11] is one example of a problem that requires nurse rostering and vehicle routing to be solved at the same time. A good quality home care schedule should optimise service to the patients while also optimising individual nurses schedules and minimising driving time or distance. One possible way to address the problem could be to develop one single model and a general purpose heuristic to generate a solution. It may be better, however, to take advantage of the existing knowledge on nurse rostering and vehicle routing and include some aspects in a dedicated approach.

Task scheduling is another example of a structured personnel scheduling problem, common in the retail, production and health care sector. Shift scheduling is too course grained to produce satisfactory solutions to the task scheduling problem, but the tasks need to be composed such that good quality shift schedules are obtained for the personnel.

The connection with other problems makes it obviously harder to arrive at acceptable solutions. Nevertheless, it is interesting to have sufficient supply of new personnel scheduling problems for the timetabling community to keep improving existing optimisation approaches and developing completely new ones.

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