The impact of problem characteristics on the robustness of a personnel schedule: An empirical investigation

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1 Introduction

Personnel scheduling is an important aspect in every organization. The goal is to meet the customer demands as much as possible while offering an attractive roster to employees [1]. The latter is usually determined from an employee's point of view [2]. The first objective is, however, less clear. Meeting the customer demands as much as possible indicates that the organization should be able to cope with unexpected events at the time of execution, due to variability in supply and demand. Both these objectives have to be met while minimizing the total cost for the organization.

Different circumstances may arise that make it impossible for organizations to sustain their preferred service level, i.e., meeting customer demands. Examples are machine breakdowns, employee absence, etc. These disruptions force organizations to intervene. Possible interventions can include the use of reserve employees, overtime, consciously not meeting customer demand, and assignment of employees who were scheduled to have a day off [3]. Note that changes to the personnel roster can lead to violations of personnel preferences and to significant differences between planned and actual costs. As a consequence, robustness becomes more and more important.

In this paper, we examine a proactive scheduling approach, where we try to construct a predictive robust schedule to deal with uncertainty. We evaluate different parameters and their respective impact on the robustness of personnel schedules. Their impact will be studied under different circumstances, which will be simulated using discrete event simulation.

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2 Problem Description

In our research, we consider the tactical phase of personnel planning, where a personnel roster is constructed for the next month. We assume that, in this phase, all input is known and deterministic. Given the estimated daily shift requirements, individual personnel schedules are constructed for the different employees. However, on the operational level, every organization is subject to different forms of uncertainty, leading to the importance of robust personnel scheduling during the tactical phase (cfr. section 1). [4] use three categories of uncertainty in their classification, which are uncertainty of demand, uncertainty of arrival, and uncertainty of capacity.

In this paper, we study a general personnel task scheduling problem. The personnel information, task characteristics, objectives, and constraints are general and common in literature [5,6]. In our test design, we construct personnel rosters for up to 20 employees and a planning period of 28 days. We consider a set of constraints consisting of those constraints that occur frequently in literature [6] and that can be classified into coverage constraints, time related constraints, and work regulations [5]. The coverage constraints will consist of minimum and preferred requirements and, for the time related constraints, we define minima and maxima, in accordance with [7].

3 Methodology

The tactical personnel schedule is constructed using a branch-and-price procedure, programmed in C++. These resulting schedules are then tested using discrete event simulation. In this operational phase we simulate variability in supply and demand using different stochastic distributions. Next, we evaluate the outcome and, if necessary, recourse actions will be taken, based on a re-optimization of the model using integer programming optimization [8].

4 Computational Experiments

The experiments consist of two phases. In the first phase, the above-mentioned uncertainty classes are considered separately. In the second phase, the integration and interaction of these classes are handled. Within these two phases, the problem will evolve from rather easy (e.g., no employee preferences) to complex (e.g., employee preferences). The impact of different parameters on the robustness is examined in each phase. One of these parameters is the competence level of employees. This parameter determines whether it is possible to downgrade, and thus to achieve a higher flexibility in rescheduling, or not. Furthermore, changes in the constraint set and the constraint parameter values are tested. It is, for example, possible to change the minimum and maximum required number of consecutive working days or to include penalties for not meeting the preferred requirements instead of the minimum requirements.

In both phases, we test the robustness by checking what happens if certain changes occur [9]. As indicated above, a simulation procedure randomly generates disruptions and the impact of these disruptions, on a robust and deterministic schedule, is compared [4]. This comparison enables the evaluation of the impact of different parameters/performance indicators on the robustness of personnel schedules.

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