Workforce Planning Optimization: Satisfying Company Requirements and Employee Wishes

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Abstract: This paper describes an industrial application that helps schedule employees in a call center. The schedules are optimized for a week and aim to plan the activities of 30 to 200 employees, considering 2 to 5 different activities. The goal is to assign activities to employees in order to cover the demand, by minimizing understaffing and overstaffing. A rule formalism has also been defined to cater to each company's specific needs. Furthermore, the employees' preferences and wishes are considered when creating schedules to improve the quality of work life and retain employees. This highly combinatorial optimization problem involving complex business constraints has been efficiently modeled using Hexaly. The solver optimized this problem with optimality guarantees for medium-sized instances within 30 seconds of running time. Based on this optimization problem, an industrial web application for workforce planning has been developed.

Keywords: workforce planning, combinatorial problem, coverage, scheduling, industrial problem

1. INTRODUCTION

Optimizing workforce planning is a major challenge for organizations. It enables them to meet their staffing needs while respecting the HR constraints and rules specific to each organization. Besides, in order to improve the quality of life at work and to build employee loyalty, planners want to take into account the wishes and desires of their employees when creating schedules. This problem has been studied extensively in the literature.

This paper presents an industrial application of staff scheduling in a call center, as studied by Benoist et al. The business context imposes numerous operational constraints that differ from the classical problems discussed in the literature. In particular, some specific business rules make it difficult to obtain schedules that satisfy all constraints. In order to best satisfy the planners, a system for penalizing constraints in order of priority has been implemented. This optimization problem is modeled and solved using Hexaly, a mathematical optimization solver based on various operational research techniques combining heuristics and exact methods (Gardi et al.).

2. WORKFORCE PLANNING OPTIMIZATION

2.1 Problem description

Consider a call center where you want to optimize the schedule of all employees. Each employee is characterized by an hourly contract to be respected. This contract is defined per week with a number of days and hours to work in the week, a list of days that can be worked, and a minimum and maximum number of hours that can be worked per day. We also consider a set of activities to be performed. Each activity has a minimum and a maximum duration. Each employee has a skill level for each activity to determine whether or not they can perform it.

For a given week, we define a demand per activity, per day, and per 30-minute period. This demand determines the number of people needed to perform the activity at a given time. For example, in the call center in question, 10 employees are needed on Mondays from 10:00 to 10:30 to perform the activity "Answering the phone".

A session is characterized by a day, a start time, and an end time. Sessions are defined according to the minimum and maximum duration of the activity and the opening hours of the site. For example, if an activity has a minimum duration of 1.5 hours and a maximum duration of 2 hours, and the site is open from 9 a.m. to 6 p.m., the sessions created will be: 9 am - 10:30 am; 9 am - 11 am; 9:30 am - 11 am; 9:30 am - 11:30 am; 9:30 am - 11:30 am; etc. until 4 pm - 5:30 pm; 4 pm - 6 pm; 4:30 pm - 6 pm.

2.2 Modeling with Hexaly

This combinatorial optimization problem was efficiently modeled using Hexaly. Boolean decision variables x_{ij}^{k} determine whether employee i performs activity j during session k. The constraints are as follows:

- Respecting HR constraints and site opening hours.
- Respecting incompatibilities between sessions and agents: non-overlapping of two sessions.
- Respecting skills per activity,
- Considering agent absences,
- etc.

Demand satisfaction is not modeled as a constraint but as two penalty objectives:

1. The first aims to minimize the sum of understaffing, i.e., the periods during which not enough agents are mobilized. The goal is to achieve sufficient coverage for each activity.
2. The second is to minimize the sum of oversizing, so as not to mobilize employees unnecessarily.

The objectives are treated in lexicographic order, i.e., they are sorted in order of priority, and the second objective can only be improved if it does not degrade the first. This modeling approach's advantage is that it ensures a solution that is feasible in practice, even if not all requirements are covered.

Conventional multi-objective optimization methods often rely on weighted sum formulations to balance competing objectives, which can lead to trade-offs that do not align with practical scheduling priorities. In contrast, the proposed approach structures objectives hierarchically, ensuring that high-priority constraints are satisfied before considering secondary criteria. This method provides a more interpretable optimization framework, allowing planners to better understand and adjust scheduling decisions based on operational requirements.

3. COMPANY RULES AND EMPLOYEE WISHES: A TRADEOFF BETWEEN GENERICITY AND EFFICIENCY

A key challenge in workforce scheduling is the need to balance company-imposed constraints with employee preferences. Unlike classical scheduling models that primarily focus on demand fulfillment and contractual constraints, this work introduces a structured framework for integrating complex business rules and individual preferences into the optimization process.

3.1. Company rules

To ensure flexibility across different business contexts, the rule formulation is designed to be both generic and adaptable. Rules are classified into four main categories: duration-based rules, hour-based rules, sequencing constraints, and equity constraints. This framework enables the flexible encoding of constraints such as "Each employee may perform Activity A for a maximum of 3 hours per day", "Employees on a 35-hour contract may only perform activities A and B at least 2 hours apart", or "The number of hours of ‘Phone’ activity must be distributed equitably among employees over the week."

Each rule is defined in the web application using a structured format:

- Rule description, including a name and a priority level.
- Employee conditions, specifying which groups, contracts, or skills the rule applies to.
- Activity filters, determining which activities or activity groups are affected.
- Rule-specific logic, defining trigger conditions and the consequences of non-compliance.

In the optimization model, these rules are incorporated as soft constraints, where non-compliance incurs a penalty. The objective function minimizes the total penalty. A common metric is used to quantify violations—typically the number of time periods (e.g., 30-minute slots) over which the rule is not satisfied. If we take the example "Each employee may perform Activity A for a maximum of 3 hours per day", then if an employee performs Activity A for 5 hours, the associated rule penalty is 4 (5h - 3h = 2h = 4 x 30min). The real-world constraints can vary, and the presentation will show concrete examples of rules the optimization model handles.

We can also apply different priorities to each rule: the first objective aims at respecting the rules of priority 1, and the second at those of lower priority. These objectives are added after the requirements coverage goals. This formulation ensures that higher-priority rules are enforced before lower-priority ones, producing feasible schedules that align with operational policies while allowing some degree of flexibility when necessary.

3.2. Employee wishes

Beyond business constraints, the model also integrates employee preferences, which are categorized into three types: work hours preferences (e.g., preferred start and end times), synchronization constraints (e.g., aligning work periods with colleagues), and activity preferences (e.g., requesting to avoid or prioritize certain tasks). Rather than requiring manual adjustments by planners, these preferences are embedded directly into the optimization process as additional penalty-based objectives. This approach systematically accounts for individual constraints while maintaining the overall feasibility of the schedule. This approach enhances scheduling efficiency and improves workforce engagement by proactively addressing individual preferences, reducing the need for post-optimization modifications.

The proposed methodology provides a structured way to formalize and integrate heterogeneous constraints within an optimization framework. The rule-based penalty system, combined with lexicographic prioritization, allows the model to handle complex scheduling requirements efficiently while maintaining interpretability. This contributes to the broader field of workforce scheduling by demonstrating an approach that can be generalized across different industries without requiring extensive manual adjustments.

4. COMPUTATIONAL RESULTS

The scheduling problems addressed in this study are optimized over a one-week horizon, determining work schedules for 30 to 200 employees across 2 to 5 different activities. From a computational perspective, the approach efficiently handles large-scale instances, solving models with up to 50,000 binary decision variables within 30 seconds. Additionally, the rule-based formalism allows for adaptability across different industries beyond call centers, as constraints and priorities can be adjusted to reflect specific operational requirements. This flexibility makes the methodology applicable to a range of workforce scheduling contexts.

5. CONCLUSION

This study contributes to the field of workforce optimization by proposing an industrially viable approach that integrates complex real-world constraints into an optimization model. While classical staff scheduling models primarily focus on satisfying demand and adhering to contract constraints, our approach extends these models by introducing a flexible penalty-based system for handling hierarchical constraints. This allows for a structured prioritization of rules, making the optimization process more adaptable to business-specific requirements.

This work also bridges the gap between academic optimization models and practical industrial applications by embedding the solver in a web-based scheduling tool used in production. The seamless integration of mathematical optimization with user-friendly scheduling tools highlights the importance of operational research in decision-support systems and human-in-the-loop decision-making.

Call center planners currently use this application in daily production, significantly reducing the time they need to create weekly schedules. The application will be demonstrated during the talk, focusing on the rules and wishes formalism presented in this paper.

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