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An Iterative Approach for the Mobile Workforce Tactical Scheduling Problem with Frequency Constraints

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1 Introduction

Workforce planning and scheduling problems mainly focus on designing teams or on creating daily plans. However, recent studies have highlighted that management aspects should not be left out, and that models should better consider the complexity of real-life objectives and constraints, see e.g. the reviews [3], [5] and [7]. Those reviews raise a need for a broader view when building the daily schedules of employees, for example when different resources are required to perform some tasks. This, for instance, is the case for surgery operations, where balancing the workload among resources is required (for instance the amount of work or the type of the tasks assigned) and resources must be coordinated (see e.g. [6]). Scheduling the tasks to perform in bidding order, or depending on their deadline, is no longer enough to ensure that the resulting plan is optimal, or that every required task is performed on time. In such cases, studying personnel scheduling problems on a longer horizon than several days becomes mandatory. This need is reinforced in some contexts such as healthcare, where the number of beneficiaries is continuously increasing. Optimizing the distribution of the resources is there an opportunity to reduce the costs and the frenetic working pace, while still providing high-quality services (see e.g. [6]).

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In the light of the above, we believe that studying an optimization problem at the tactical level to plan the tasks to be performed by a team of employees on several weeks helps to handle more complexity and to find even better solutions. By decoupling the decisions depending on the temporal horizon they impact, more realistic workforce planning and scheduling problems should become solvable.

In our problem, which comes from industry, we focus on the scheduling of tasks with frequency constraints for a mobile workforce. Scheduling and routing optimization problems under frequency constraints have not been studied much in the literature, and usually with restrictions since the assignment of the tasks to the employees is generally given as an input (see [2] and [8]).

In the context of a mobile workforce, where employees travel from one client to the next to perform cleaning tasks, we call our problem the *Mobile Workforce Tactical Scheduling Problem with Frequency Constraints*. The goal is to determine a plan on several weeks which defines who will perform which task in which day. All the required tasks must be scheduled and a trade-off must be ensured between the clients' and the company's interests. Tasks must be distributed over the horizon according to frequency constraints and the total working cost must be minimized. As the workforce is mobile, the tactical plan is the basis on which the daily routes of the employees are optimized at the operational level. The tactical plan has thus to take traveling distances into account to be consistent. To ensure this consistency, we adapt the two-phase iterative heuristics of [4] for the integrated production planning and scheduling problem and of [1] for the production routing problem.

2 Solution Approach and Results

Absi et al. [1] developed a two-stage heuristic, that iterates between a lot-sizing phase and a routing phase, to solve a production routing problem. The lot-sizing phase decides which vehicle will deliver which client in which day, and the routing phase optimizes the routes in each day. Depending on the quality of the routes determined in this second phase, some metrics are raised as a feedback to improve the lot-sizing plan in the following iteration.

We propose to adapt this iterative method by replacing the lot-sizing phase by the construction of the tactical plan with frequent tasks and each vehicle by an employee of the team. The tactical plan is optimized by solving an integer programming model with a standard solver. The routes are determined for each employee and each day by an assignment heuristic and improved by local search when needed. The routing heuristics were developed by DecisionBrain (www.decisionbrain.com).

Our industrial instances include up to 30 employees and 2100 tasks to perform each month. In order to decrease the size of those instances and be able to plan on several months, we propose to pre-process the data in a clustering step. Using a gaussian mixture model, we determine groups of employees that are assumed to be equivalent and use these groups in the heuristic. Furthermore, this approach improves the construction of the operational routes, since several routes can simultaneously be designed and improved in one cluster.

We compare the results obtained with our algorithm for real-size instances to the results of the current DecisionBrain's algorithms and of a one-shot integer programming model, which estimates the distances while solving the tactical problem. It appears that our iterative method allows the required tasks to be performed with a good respect of the required frequencies. By varying the value of the penalties induced by not respecting the frequency constraints, we can observe the trade-off between the satisfaction of the frequency constraints and the cost resulting from subcontracting and traveling.

3 Conclusion and Perspectives

Scheduling tasks on a horizon of several weeks before optimizing the daily routes allows more complex constraints to be taken into account. We showed here the interest of scheduling tasks with frequency constraints on a longer horizon before optimizing routes. In particular, more complexity can be handled while getting solutions faster than when directly optimizing the daily routes.

By varying the values of some parameters in the iterative approach, different solutions can be determined and thus Pareto optimal solutions. Depending on the definition of the quality of the routes, the tactical plan can find the best distribution of the tasks to satisfy frequency constraints while taking the constraints of operational routes into account. Planners could then interact with the approach by selecting one of several solutions and improving them. More constraints could also be added in the tactical plan, such as dependencies between tasks, assignment of the tasks to a specific employee or day, different skills for employees and workload balancing between the employees and over the planning horizon.

By solving the problem in two phases, our goal is to find the best way to embed scheduling and routing considerations in workforce planning and scheduling problems. As far as future research is concerned, our main perspective involves studying the robustness of the plan regarding small perturbations (e.g. duration of a task or delay of an employee) or the ease of re-building the plan when major disruptions occur (e.g. the absence of an employee).

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