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 either on the design of teams or on the creation of daily plans (see e.g. [3]). However, recent studies 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, when balancing the workload among resources is required (see e.g. [5]). 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 planned. 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 health care, where the number of beneficiaries is increasing. Optimizing the distribution of the resources is an opportunity to reduce the costs and the frenetic working pace, while still providing high-quality services (see e.g. [5]).

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 is a suitable way to take more complexity into account. By decoupling the decisions depending on the temporal horizon they impact, more realistic workforce planning and scheduling problems should become solvable. As the problem comes from industry, we focus here 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 ([2], [6]).

In the context of a mobile workforce, whose 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 on which day. All the required tasks must be scheduled and a trade-off must be ensured between the clients' and the company's interests : the frequent tasks must be distributed over the horizon according to the 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 heuristic that iterates between two phases, a lot-sizing and a routing ones, to solve a production routing problem. Each iteration solves the lot-sizing

problem to decide which vehicle will deliver which client on which day, then the routing problem according to the plan that has been obtained. Depending on the quality of the routes drawn at this second step, some metrics are raised as a feedback to improve the lot-sizing plan at the following iteration.

We adapted 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 solved by an integer programming model, then the routes are drawn 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).

We compared the results obtained with our algorithm for real-size instances to the results of DecisionBrain's actual algorithms and of a one-shot integer programming model which estimates the distances while solving the tactical plan problem. It appears that our adapted iterative method allows performing the required tasks with a good respect of the required frequencies. Varying the value of the penalties induced by non-respecting the frequency constraints, we can observe the trade-off that the method creates between the respect of the frequencies 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 drawing the routes. In particular, more complexity can be handled while getting solutions faster than when directly determining the daily routes.

By varying the values of some parameters in the iterative approach, different solutions can be determined and thus Pareto optimal solutions. Planners could then interact with the approach by selecting one of several solutions and improving them. The problem could also be extended to consider different skills for the employees and to balance the workload between the employees and on the planning horizon. Another relevant perspective consists in 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).

We also plan to compare this iterative approach with two other approaches that consider travel distances when optimizing the tactical plan. Our goal is to find the best way to embed scheduling and routing considerations in workforce planning and scheduling problems.

Références

[1] Nabil Absi, Claudia Archetti, Stéphane Dauzère-Pérès, and Dominique Feillet. A two-phase iterative heuristic approach for the production routing problem. *Transportation Science*, 49(4) :784–795, 2014.

[2] Young-Jin An, Yeong-Dae Kim, BongJoo Jeong, and Seung-Dae Kim. Scheduling healthcare services in a home healthcare system. *Journal of the Operational Research Society*, 63(11) :1589–1599, 2012.

[3] J Arturo Castillo-Salazar, Dario Landa-Silva, and Rong Qu. Workforce scheduling and routing problems : literature survey and computational study. *Annals of Operations Research*, 239(1) :39–67, 2016.

[4] Stéphane Dauzère-Pérès and Jean-Bernard Lasserre. Integration of lotsizing and scheduling decisions in a job-shop. *European Journal of Operational Research*, 75(2) :413–426, 1994.

[5] Nico Dellaert and Jully Jeunet. A variable neighborhood search algorithm for the surgery tactical planning problem. *Computers and Operations Research*, 84 :216 – 225, 2017.

[6] Wooseung Jang, Huay Lim, Thomas Crowe, Gail Raskin, and Thomas Perkins. The missouri lottery optimizes its scheduling and routing to improve efficiency and balance. *Interfaces*, 36 :302–313, 08 2006.