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

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1 Introduction

In the context of a mobile workforce, whose employees travel from one client to the next to perform cleaning tasks, we define 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 tasks must be scheduled and distributed over the horizon according to the frequency constraints and the total working cost must be minimized.

The previous research on workforce planning and scheduling problems mainly focused either on the design of teams or on the creation of daily plans. However, recent studies raise a need for models that more accurately represent the application contexts while more easily generalizing to various constraints. Such requirements urge for personnel scheduling problems to be studied on a longer horizon than several days. This need is reinforced in some contexts such as healthcare, 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. [4], [5]).

In the light of the above, we reintegrate workforce scheduling and routing as the operational decision level of the workforce rostering framework, as introduced by Begur et al. [2] or Ernst et al. [4]. Within such a process, we introduce an optimization problem at the tactical level to plan the tasks to be performed by a team of employees on several weeks. This enables to take more complexity into account. 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 pre-assignment restrictions (see e.g. [6]).

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 [3] for the integrated production planning and scheduling problem and of [1] for the production routing problem.

2 Solution Approach and Numerical Results

To solve the MWTSP-FC, we adapted the iterative heuristic of Absi et al. [1] that iterates between a Planning Module and a Routing Module. The first module determines the tactical plan, assigning frequent tasks to days and employees of the team. It is solved by a mixed integer linear programming model. The second module optimizes the routes for each employee and each day using an assignment heuristic developed by DecisionBrain (www.decisionbrain.com). Quality metrics of the routes provided by the Routing Module are used to improve the tactical plan of the Planning Module in the next iteration.

We assessed our iterative approach (IA) on real-size instances from different application contexts. The resulting plans offer very good trades-off between service costs and quality in less than two hours of computational times. As shown in Table 1, the plans are highly improved compared to the ones obtained using a straightforward sequential approach (SA). In Table 1, Columns JDR, F and TT are indicators that translate the costs computed in the objective function. Further computational experiments demonstrate that various business constraints (e.g. appointments to time or assignments to an employee, multi-skill) can be added without significantly increasing the computational times.

Instance			**JDR (%)**		**F (%)**		**TT**		**Z***		**CT (sec.)**	
♯	E	T	SA	IA	SA	IA	SA	IA	SA	IA	SA	IA
1	2	224	96.6	**100**	**0**	**0**	1h 6min	0h 52min	4,910,392	**2,069**	223	105
2	5	410	96.62	**100**	**0**	**0**	1h 42min	1h 38min	9,805,405	**9,847**	244	748
3	10	861	93.49	**100**	**0**	**0**	2h 23min	1h 31min	36,432,571	**18,203**	336	2,394
4	18	1,683	93.93	**98.56**	**0**	**0**	2h 38min	1h 48min	63,282,088	**15,037,999**	652	1,950
5	26	1,918	98.4	**100**	**0**	**0**	4h 49min	1h 8min	24,591,940	**35,496**	782	6,089

TAB. 1 – Some results obtained on industrial instances. E : Number of Employees ; T : Number of tasks ; JDR : % of total job duration realized ; F : % of work orders breaking frequency constraints ; TT : Average daily employee travel time ; Z^* : Best objective function ; CT : Computational time.

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 determining the daily routes.

Our current research aims at ensuring an effective transfer of the decisions from the tactical level to the operational level. Indeed, because of operational constraints or unexpected events, some tactical decisions may be reconsidered when optimizing the employee routes on a day-to-day basis. Such decisions should be made in line with the tactical plan. Another relevant perspective is to study the robustness of the tactical plan to small perturbations (e.g. duration of a task or delay of an employee) or the ease of rebuilding the plan in the event of major disruptions (e.g. the absence of an employee).

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