EMERGENCY ROOM SCHEDULING FEATURING OPTIMIZATION OF INTRA-HOSPITAL ROUTING

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1 Introduction

Hospitalized patients typically have to undergo several treatments and examinations before their actual surgery. In order to get to their appointments they are escorted by designated medical staff (porters). Porters accompany patients from their ward to the corresponding hospital unit(s) and escort them back afterwards. In order to minimize the patients' inconvenience those appointments (including the surgery) should be scheduled tightly such that the resulting cycle time is minimized. Capacities of porters, operating theaters and examination rooms should be managed efficiently and the resulting schedules need to be feasible in terms of the capacities available.

In this talk we will present a novel mixed-integer problem (MIP) formulation for an interesting combinatorial optimization problem combining the above-mentioned features from scheduling and routing, while minimizing client (i.e. patient)-centered objectives such as their perceived inconvenience. Computational results indicate a substantial advantage of the synchronized approach over the decoupled decision process.

2 Literature

The embedded scheduling problem can formally be modeled in terms of a combinatorial optimization problem (see [1] and [2]). The subproblem corresponding to the routing aspect shares some commonalities with classical Pickup and Delivery Problems (PDPs) (see [3]) and Dial-a-Ride Problems (DARPs) (see [4] and [5]). More recently these problems have been applied

for intra-hospital routing (see [6] and [7]). More recent papers take into account the underlying routing problem explicitly and solve the combined problem simultaneously (see [8] and [9]).

3 Solution Procedure

Traditionally the underlying subproblems are solved *sequentially*. The scheduling problem is solved first. Next, dependent on the result of the scheduling problem the routing problem is going to be solved. This however may result in *suboptimal* solutions. The reason therefore is twofold. One needs to keep in mind during the scheduling process the focus lies on finding schedules that are feasible from the resources (i.e. rooms) point of view. Both the patients and porters perspective are ignored. The first issue may lead to solutions which turn out to be unfavorable from the patients' point of view, as the resulting cycle times might become too long. The latter aspect may result in infeasible solutions, as due to the limited availability of porters patients may be delivered too late to their appointments, especially when the time buffer between consecutive appointments is short.

We are going to show however that it is crucial to solve the resulting problem *simultaneously* in order to obtain high-quality solutions. The usage of exact methods for solving the MIP at hand in a reasonable amount of time is limited to very small-sized problem instances only. Hence we will present a hybrid metaheuristic which has been developed and applied successfully for solving real-world sized instances. The methods itself is inspired by concepts coming from Variable Neighborhood Search (VNS). It iteratively solves the underlying subproblems in both a metaheuristic - and if applicable - exact fashion. The embedded components are able to exchange information, and hence to guide the solution process of their counterpart, which in turn allows obtaining high-quality solutions in a reasonable amount of runtime. The guidance has been implemented in terms of a feedback loop where we try to influence the scheduling of appointments based on information that has been gathered during the previous routing process. A graphical representation of the two proposed approaches in depicted in Figure 1a and 1b respectively.

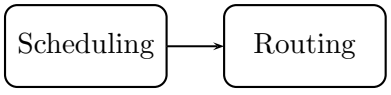

Figure 1a: Sequential Approach

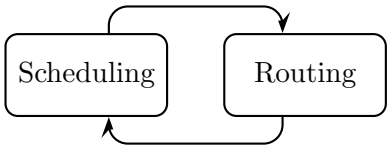

Figure 1b: Simultaneous Approach

Our experiments show that the solution quality obtained can be improved substantially when considering routing and scheduling aspects simultaneously.

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