An Adaptive Large Neighborhood Search for an Appointment Scheduling Problem in Health Care

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1 Content

The appointment scheduling problem is one of the most studied problems in the context of health care services. The scheduling decisions in hospitals are one of the most important tasks performed by the planners, these decisions will impact the resource utilization (rooms, doctors, nurses, etc) and the service quality. Our study is in collaboration with the Assistance Publique - Hôpitaux de Paris (APHP) unit and is focused on the outpatients department of hospitals, where the patients have their appointments in a given day and leave the place in the same day, unlike the inpatients who need to spend some days in the hospital.

The current procedure in the hospital is divided in two main decisions : the day-patient schedule, where the planner determines the visit day of each patient ; and the daily schedule, where the hour and resources required for each appointment is defined. This study is focused on the daily schedule only. The set of patients is known in advance as well as the Clinic Pathway (CP, see [3]) of each patient. The CP represents the set of care activities that the patient must attend in order to diagnose and/or treat a disease. Each activity requires resources like materials, rooms, or human resources. The objective of the problem is to schedule all activities of the day in order to minimize the total waiting time of the patients.

Some recent literature review can be found in appointment scheduling problems in health care [1] and [5]. In most studies, only one type of resource or only one activity are considered. The problem is similar to the *resource constrained multi-project scheduling problem (RCMPSP)* that is a generalization of the single project version proposed in [2].

2 Problem description

The problem is defined by three sets of parameters (P, A, R), where P is the set of patients in a given day that must be treated and/or diagnosed, A is the set of activities that the hospital can perform, and R is the set of all available resources in the hospital.

Each patient $p \in P$ has a time window $[a_p, b_p]$ which represents her/his preference of availability, and the CP that she/he must follow. The CP is defined by a set of activities $i \in \Lambda_p \subset A$, an associated set Π_p that are the precedences between activities within the CP, and for some pairs of activities $(i, j) \in \Pi_p$ a minimum and maximum time lag is defined. Note that some activities can have no precedence with others activities in a CP.

Each activity $a \in A$ is defined by a vector $\hat{n}_a = \{n_a^1, n_a^2, \ldots, n_a^T\}$ where every element represents a requirement of different types of resources, and the estimated treatment (or consultation) time t_a. Finally, every resource $r \in R$ is defined by its type $t \in T$, and a time window that represents its availability $[\alpha_r, \beta_r]$.

The decision variables are the time schedule of each activity and their assignment to the resources. The goal is to find a schedule of all activities respecting all the constraints (preferences of patients, resource availabilities, time lags between activities, precedence constraints, cumulative resources, etc.). The objective function is to minimize the total waiting time of all patients, and the over utilization of the resources.

3 Solution method

First, we formulate the problem as a mixed integer linear programming and use CPLEX solver to solve it. Since only small instances can be solved with the solver due the complexity of the problem, we propose an Adaptive Large Neighborhood Search (ALNS[4]) metaheuristic. The initial solution follows an active scheduling generation, which means that every activity is scheduled as soon as possible and without generating infeasibilities. In this procedure, the assigned activities cannot be rescheduled. The destructive operators consists in removing all activities of several patients from the schedule by using some selection rules like random rule or biggest waiting time rule. The repairing operators aim to reschedule all activities that have been removed, using a best insertion procedure and several priority rules. The selection of destroy and repair operators is based on an adaptive score adjustment procedure.

The test instances was generated assuming that all the patient can be served in a given day and the results obtained with the MILP formulation and the ALNS algorithm will be presented and discussed at the conference.

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