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An appointment scheduling policy for healthcare systems with multiple servers, non-flexible uptake time and pre-determined services levels

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One of the critical steps in patient care path is diagnosis. The demand for advance imaging tests, such as CT, MRI and PET, increased dramatically in the past 15 years. Since imaging equipment is relatively expensive, in order to fit the demand, the imaging resources must be managed effectively. In most healthcare systems, where examination length is uncertain (stochastic), the goal of the appointment scheduling is to balance between resource utilization and patient waiting times.

In some imaging scans, such as PET, a radiopharmaceutical (radioactive substance) is injected to the patients in order to perform the diagnosis. In these systems, the time between the substance injection and the scan is non-flexible (for example, due to the substance short half-life duration). This constraint makes the patient appointment scheduling more challenging. On the one hand, there is a predetermined time required between the injection of the radiopharmaceutical and the scan – the uptake time (time that it takes to the substance injected to be absorbed into the body). However, on the other hand, if at the end of the expected uptake time one of the scanners is not available, the quality of the scan is jeopardized. Of course, the availability of the scanners is a consequence of appointments and durations of prior scans.

This work aims to extend a previous work by considering multiple scanners that serve patients in parallel. The aim of this work is to develop a method for determining a patient appointment scheduling in a system with non-flexible uptake time in order to minimize the end of day and increase resource utilization while keeping minimal pre-determined service levels.

To this end, we consider the following setting: a given sequence of patients is to be scheduled on several scanner machines; the durations of scans are normally distributed with various expectations and variances; a minimal probability for each appointment to start on time is required (service level).

The first step is to formulate the problem using a stochastic programming formulation. We then formulate the equivalent deterministic problem, based on simulated data, as a mixed-integer linear programming. To overcome the dimensionality limitations, we also develop a simulation-based sequential model. We conduct some experimental runs and compare to current practice as well as to previous results on one machine in order to get insights on how to manage efficiently appointments in the environment with several parallel machines.