Surgical Case Scheduling with sterilizing activity constraints

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1 Introduction

Surgery has been recognized as a main source of income for hospitals, and counts for around 40% of hospital costs (facilities and personnel costs). Given the big financial role of the operating theater, many researchers have tackled OR planning and scheduling problems ([1]). In this paper, we focus on the particular surgical case scheduling problem of the University Hospital of Angers (UHA). The problem consists in scheduling elective surgeries to operating rooms with the objective of minimizing the operating costs while taking into account the activities of the sterilizing unit. To the best of our knowledge there are very few literature and research on such particular problem. For instance in [2] the authors study an operating room scheduling problem including medical devices sterilization but with the objective of reducing the number of medical devices needed to respect a planning.

2 Problem description

The UHA includes several blocks and a sterilizing unit which centralizes all the sterilizing activities. In this study, we focus only on the activities of the Orthopedic Surgery Block (OSB) and the Sterilizing Unit (SU).

The OSB is composed of 3 operating rooms, with different opening hours : room 1 and 2 are open 5 days a week from 8:15 to 17:00, and room 3 is open only 4 days a week from 8:15 to 14:30. Between 10 and 14 surgeons share these rooms according to a planning indicating the days when they operate, and the list of rooms that each surgeon can use each day. Each surgeon has to perform a list of surgeries on an horizon of one month : some of them can be scheduled anytime during the opening hours of the rooms, whereas others (ambulatory surgeries) have to be completed before 15:00 to allow the patient to go home at the end of the day. Each of these surgeries is characterized by an estimated duration time and requires a list of surgical instruments which are organized in small boxes called kits. These kits are available in limited quantities. After each surgery, the used kits are kept into water for 30 minutes for pre-disinfection. Then they are collected at the predefined periods given in table 1 and sent to the SU for sterilization.

Collect	06:50	11:30	14:30	16:00	17:30
Delivery	06:50	-	14:30	-	17:30

TAB. 1 – Pick-up and delivery times at the OSB

At the SU, the sterilization process is being performed in several steps : the instruments are first cleaned by automatic washers, then reassigned in their corresponding kit before being processed through sterilization machines. Finally, the kits are kept at the SU to cool off before being returned to the block. On average, when a kit arrives at the SU, the whole sterilization process takes around 4h30.

Due to the duration of the sterilization process, a kit picked-up at 6:50, 11:30 or 14:30 on a given day will not be available until 08:15 the next day for another surgery ; and a kit collected at 16:00 or 17:30 will not be available until 14:30 the next day. Nevertheless, a kit picked-up at 16:00 can exceptionally be treated as urgency throughout the whole process in the SU in order to be used from 8:15 the next morning, but this situation has to be avoided as much as possible.

According to the UHA, the first objective is to schedule all the surgeries in order to minimize the total overtime of the staff members of the OSB. The second objective consists in minimizing the number of used rooms, and finally the third objective is to keep the total number of kits urgently processed as low as possible.

3 Mathematical formulation and computational results

In order to model this problem, we propose a mathematical formulation based on the decomposition of the day in four periods (period 1 from 8:15 to 14:00, period 2 from 14:00 to 14:30, period 3 from 14:30 to 15:30 and period 4 from 15:30 to 17:00) and using binary variables x_{itr}^{bf} equal to 1 if operation i begins at period b and finishes at period f on day t in room r, and 0 otherwise. The multiple objectives are taken into account by using a lexicographic method.

To test and validate our model, we used a 10 instances testbed provided by the UHA. Each instance corresponds to the activity of the OSB during one month. The number of surgeries in these instances varies from 164 to 220. We used CPlex 12.6.1 to solve the model and a time limit of 3600 seconds was set. Compared to the real planning of the UHA, our solutions use fewer rooms in 6 instances out of 10, and the total overtime and urgent kits are significantly lower in all instances.

4 Conclusions and perspectives

This work focuses on a real surgical case scheduling including sterilization activity constraints, and three objective functions. We propose an MILP formulation which is solved in a lexicographic fashion. Our solutions provide competitive results in terms of used rooms, and significantly improve those operationally implemented in terms of overtime and urgent kits at the SU.

Still in line with the needs of the UHA, the next step is to jointly address the surgical case scheduling problem and the surgeons' planning problem (list of the days where they operate).

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Références

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