Robust Surgical Case Scheduling problem with sterilizing activities constraints : a relax and fix approach

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1 Introduction

Surgery plays a huge role in the finances of hospitals as it is considered as one of the main sources of income and counts for more than 40% of the total costs (labor, facilities and equipment costs). Due to this big role, many researchers studied the OR planning and scheduling problems [4]. In this work we extend the work presented in [1], where we study a real Surgical Case Scheduling (SCS) problem from the University Hospital of Angers (UHA). The main objective is to minimize the operating costs when scheduling elective surgeries to operating rooms while taking into account the uncertainties on their duration and the activities of the sterilizing unit. To the best of our knowledge, the research that has been done on this particular problem is very limited. 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 multiple blocks and a sterilizing unit which provides its services to all the other blocks. In this work, we focus only on the activities of the Orthopedic Surgery Block (OSB) and the Sterilizing Unit (SU).

There are between 10 to 14 surgeons at the OSB, they share 3 operating rooms. The first 2 rooms are open 5 days a week from 8:15 to 17:00, while the third room is open only 4 days a week from 8:15 to 14:30. The sharing of the rooms is guided by a planning that indicates which surgeon can use which room at which day. Each month, a list of surgeries has to be performed by each surgeon : some of these surgeries (ambulatory surgeries) must be completed before 15:00 in order for the patient to go home at the end of the day, while the rest of the surgeries can be scheduled anytime during the opening hours of the rooms. For each surgery, an estimated duration and a list of the required surgical instruments are known in advance. These surgical instruments are organized in small boxes called kits and are available in limited quantities. At the end of each surgery, the kits that were used must be pre-disinfected by keeping them submerged in water for 30 minutes. After that, these kits are sent to the SU for sterilization. Since the SU works with all the blocks of the UHA, they have different pickup and delivery times of kits for each block. In the case of the OSB, these times are given in Table 1. At the SU, the sterilization process takes in average around 4h30 from the moment a kit arrives to the SU till it is ready for delivery. During this time, the kits pass a multi-step process of washing and cleaning.

Pick-up	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

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 causes delays to other kits from other blocks, hence, it 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

We propose 2 robust mathematical formulations to tackle the problem. One based on the formulation presented by [3] and the second is a redundancy based technique. Both models use the fact that each day can be split into four periods. This division is obtained from the key hours in the pick-up and delivery times of the SU, and the opening and closing hours of the ORs. The multiple objectives are taken into account by using a lexicographic method.

We used 10 real instances provided to us by UHA. Each instance represents the activity of the OSB during one month with varying number of surgeries between 164 and 220. We used CPlex 12.6.1 to solve the model and a time limit of 3600 seconds was set. Both our models outperformed the solutions of the UHA in every criteria, with the first model providing the best results. The only downside is that the first model requires a lot of computational time to find good solutions. For this, we proposed a relax and fix method, where only a part of the decision variables are considered as integers at each iteration while the rest are relaxed. When testing, this method still gave us better results than the second model and the actual solutions of the OSB, while using 64% less time to achieve these results than the first model without the relax and fix method.

4 Conclusions and perspectives

This work focuses on a real surgical case scheduling including sterilization activity constraints, and three objective functions. We propose 2 robust MILP formulations which are solved in a lexicographic fashion. Our results significantly improve those operationally implemented.

Still in line with the needs of the UHA, the next step is to implement the relax and fix method with the first model in the dynamic version of the problem where patients arrive over time. This research was partly funded by Angers Loire Metropole (ALM).

Références

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