Abstract

1 Introduction

Hospital departments provide crucial services to a great deal of people all over the world. The demand created by patients and other consumers of a hospital vastly exceeds the available supply. As such, it is crucial that a hospital department allocates its resources, such as the availability of clinicians, optimally, to provide the best possible service for its patients. In particular, in order for various hospital departments to function efficiently it is necessary for clinicians to have carefully allocated on-call schedules that simultaneously ensure sufficient resources are provided to their patients while not overworking clinicians to prevent costly mistakes. It is common practice for on-call schedules to be created manually, although this method is prone to errors. Namely, when there is a large number of clinicians in a single department, or the constraints that need to be satisfied by the department are very complex, a manual method is unlikely to provide an optimal schedule. Moreover, such methods are likely to overlook certain constraints that must be maintained to have an operational department. For these reasons, it is important to develop automated methods that are able to find optimal schedules that satisfy the given constraints.

Automated methods for tackling optimization problems related to scheduling have been studied extensively and applied in many industries, including transportation [??], manufacturing [??], [...]. Of special interest to our work are the approaches to tackle the nurse scheduling problem. In this problem, the goal is to find an optimal assignment of nurses to shifts that satisfies all of the hard constraints, such as hospital regulations, and as many soft constraints as possible, which may include nurse preferences. A wide variety of approaches, including exact and heuristic approaches, have been used to solve the nurse scheduling problem: integer linear programming [??], network flows [??], genetic algorithms [??], simulated annealing [??], and artificial intelligence [??]. An extensive literature review of these and other methods is presented by [??]. We will briefly summarize the main ideas of some of these approaches.

[...] Many of these approaches were designed to satisfy the requirements of a specific hospital department which causes a large number of variables and constraints to be incorporated into the problem formulation. While this allows for finding precise schedules that satisfy the needs of the department and the preferences of the nurses and clinicians, it makes it very difficult to adapt a particular approach to other departments in the same hospital or other hospitals. Moreover, the large number of variables and constraints also leads to computational complexity issues, especially when using exact methods for finding the solution. In this paper, we will tackle a version of the nurse scheduling problem arising from a case study of two on-call divisions of St. Michael's Hospital in Toronto,

ON. Our goal is to present a simple formulation for the problem that has been developed and tested at the hospital after switching from a manual approach to scheduling, as well as analyze the performance of integer linear programming in solving difficult instances of the problem and compare the results with those of the manual approach. We hope that the formulation we present is adaptable, at least as a basic framework, for solving similar problems in other departments.

[...]

2 Problem

Clinicians at the Infectious Diseases (ID) and HIV departments of St. Michael's Hospital are scheduled throughout the year to receive patients during on-call hours. Each clinician is typically scheduled for a full week or a full weekend of on-call service. To prevent under- and over-working of clinicians, they each have a minimum and maximum number of weeks that they are required to work. Moreover, during holidays weekends, the work-load for on-call service increases drastically, and it is important to distribute these weekends equally. At the same time, clinicians often request to not be put on service during certain days or weeks, and the generated schedule should attempt to respect those requests as best as possible. Other considerations also need to be taken into account, such as making sure someone is available for on-call service at any time of the year, and preventing multiple back-to-back assignments for a single clinician. It is clear that ensuring all of these conditions are met manually, especially with an increasing number of clinicians, is a difficult task and can lead to mismanagement of the schedule. Therefore, in this paper we attempt to develop an efficient algorithm that can generate a satisfying schedule, while optimizing clinician and patient contentment.

In order to develop an algorithm, we need to formalize the variables and constraints of the problem mathematically. Table [??] presents the sets and indices that are used in the definition of the constraints. [...]

[...]

3 Methods

4 Results

5 Simulations

6 Discussion