

Physician Scheduling in a Gynaecology Department

MSc Dissertation

Developing Mathematical Models in Healthcare

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Outline

- 1 Introduction
- 2 Problem Description
- 3 Mixed Integer Linear Program
- 4 Local Search Framework
- 5 Results

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Figure 1 : University of Twente, Enschede

Introduction



(a)



(b)

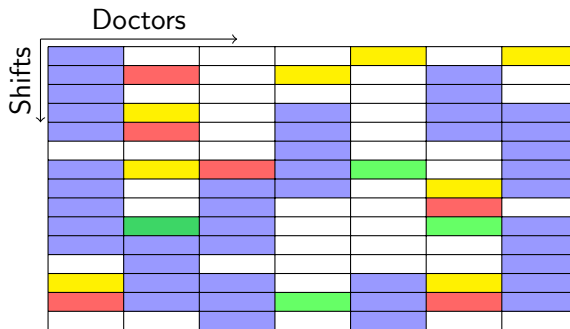
Figure 2 : Jeroen Bosch Ziekenhuis

- Personnel scheduling problem found in the Gynaecology Department in Jeroen Bosch Hospital, 's-Hertogenbosch
- Problem of timetabling doctors: specifying both what shifts they work, but also what task they will be doing in that shift
- Currently done by hand, taking 2-3 days to schedule the next 6 weeks

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Introduction



- Both essential and desired properties that a schedule must meet
 - Relating to individual doctors work patterns e.g. days off, contracted hours, 'fair' proportion of undesirable tasks etc...
 - Relating to overall scheduling of task e.g. adequate clinics scheduled each month, always two doctors on-call etc...

Similar Problems

- Nurse Rostering Problem
- (Master) Physician Scheduling Problem
- Employee Timetabling Problem

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Introduction

- General linear program formulation:

$$\begin{aligned} \text{Min} \quad & \mathbf{c}^T \mathbf{x} \\ \text{s.t.} \quad & \mathbf{Ax} \geq \mathbf{b} \\ & \mathbf{x} \geq \mathbf{0} \end{aligned}$$

- Decision variable:

$$x_{i,j,s,t} = \begin{cases} 1 & \text{if doctor } i \text{ does task } t \text{ on shift } s \text{ on day } j \\ 0 & \text{otherwise} \end{cases}$$

- Can easily express problem in terms 'hard' and 'soft' constraints; for example:

$$\sum_{t \in T} x_{i,j,s,t} \leq 1 \quad \forall i \in I, j \in J, s \in S$$

To ensure a doctor can only be assigned to one task per shift

Objective Function

Weighted sum of soft constraint violations, for example:

- Under-scheduling of tasks weekly
- Under and over scheduling of each doctor with respect to contract:
- Instances when a doctor has 'holes' in schedule
- Tasks being unfairly distributed among doctors

Solution Progress

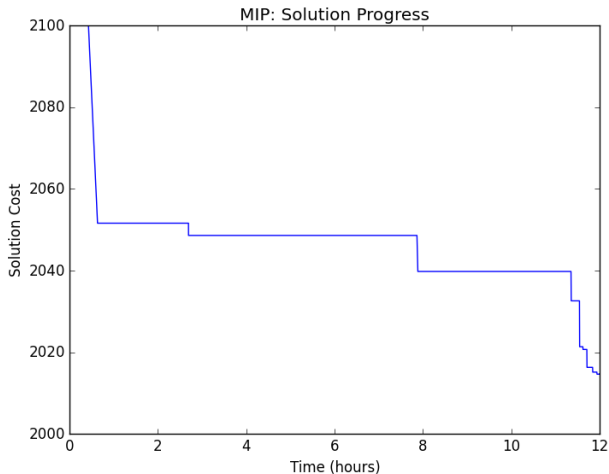


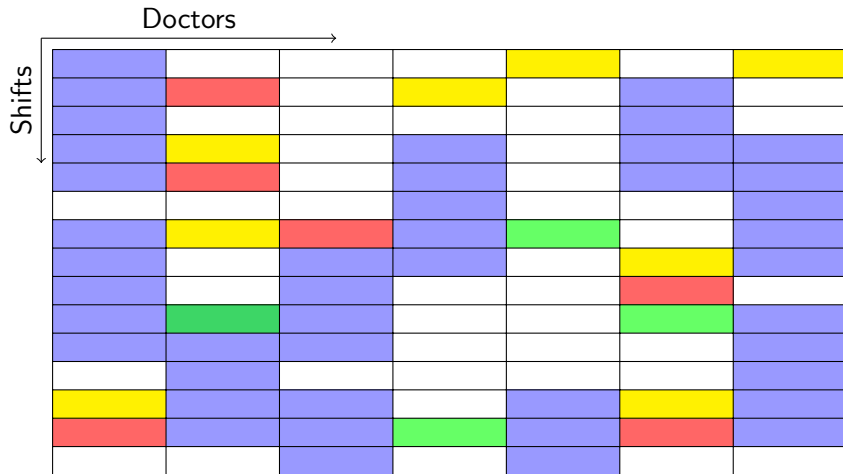
Figure 3 : 8 Week Planning Horizon: Solution Progress

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- Starting from some initial solution, repeatedly attempt to improve solution through some small change
- Move operators:
 - Schedule task
 - Delete scheduled task
 - Swap 2 shift assignments in a week
 - Change doctor performing a on-call sequence
 - Swap between doctors performing on-call tasks

Move Operators



Simulated Annealing

- Local search likely to get stuck in 'local optimum'
- Simulated annealing aims to overcome this by probabilistic acceptance of worsening moves
 - At beginning of search, high probability of accepting worsening moves
 - Probability decreases as search continues

- Mixed Integer Linear Program implemented in AIMMS 4.6 and solved using CPLEX 12.6
- Repeated Local Search and Simulated Annealing where implemented in Python programming language
 - Repeated Local Search ran multiple search processes simultaneously over multiple CPU cores

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Table 1 : Results Summary

Case	4 Week			8 Week			12 Week		
	MIP	SA	RLS	MIP	SA	RLS	MIP	SA	RLS
0	1386	1476	1490	2203	2393	2380	114411	3393	3365
1	1336	1376	1441	2136	2249	2401	2938	3493	3273
2	1322	1483	1501	2123	2486	2454	110421	3351	3458
3	1358	1525	1489	2383	2502	2512	105894	3508	3411

- In almost all cases the MIP was the best performer
- Local search algorithms could be improved through the use of 'faster' programming language
- Quantification of solutions is subjective; is beneficial to give decision maker a choice of 'good solutions': something local search algorithms can do well

Benefits and Applicability

- Man-hours saved through use of scheduling tool
- Potential for greatly improved schedule quality
- Scheduling tools generally are specific to problems

Thanks for listening!

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www.github.com/slunenenglish/Presentations