

A Case-Study about Shift Work Management at a Hospital Emergency Department with Genetic Algorithms

Alberto Gómez
Professor University of
Oviedo
Edificio de Energía
Campus de Viesques
34985182106, 33203
agomezg@uniovi.es

David de la Fuente
Professor University of
Oviedo
Edificio de Energía
Campus de Viesques
34985182147, 33203
david@uniovi.es

Javier Puente
Professor University of
Oviedo
Edificio de Energía
Campus de Viesques
34985181996, 33203
jpunte@uniovi.es

Jose Parreno
Professor University of
Oviedo
Edificio de Energía
Campus de Viesques
34985182106, 33203
parreno@uniovi.es

ABSTRACT

Organising shifts, or work rosters, is a problem that affects a large number of businesses where staff are subject to some kind of work rotation or other. Researchers in the fields of Operations Research and Artificial Intelligence have devised several systems in an attempt to optimise the problem. This paper focuses on the problem of medial staff shift rotation at a hospital emergency department, and attempts to establish a method to automate its management by applying genetic algorithms. It also analyses one of the duty rosters that came out of the proposed solution.

Categories and Subject Descriptors

I.2.8 Problem Solving, Control Methods, and Search.- *Heuristic methods*

General Terms: Algorithms, Management.

Keywords: Timetabling; Rostering; Genetic Algorithms; Health Services; medical staff.

1. INTRODUCTION

The aim of rotation schemes is to decide the order work should be done in to achieve the aims and comply with the policies laid down by an organisation. Although there is abundant literature on the subject [6], there is nevertheless no all-encompassing solution for every single problem, as each case has its own unique constraints and characteristics.

Devising a work timetable, or roster, begins with a number of objectives, or resources, and a set of processes to be applied in order to make optimal use of these resources. Depending on the type of problem at hand, the order each of the processes is applied may be crucial to solving the problem, as would be the case, for example, in an educational setting where each student has to have a set number of classes per subject per week. In an example of this sort, the student would be the object and the hours of class would be the process, and time-tabling of the subjects would not be relevant.

Yet despite such drawbacks, there have been a plethora of applications of heuristic techniques, and different variants of these

problems can be found in the literature. From Brusco et al. [2], how apply heuristic techniques to optimise shifts, or duty rosters - in the airline industry- Burke et al.[3] how also apply Tabu Search in this field, several researchers have tried to solve the problem of rostering in an efficient mode. Bechtold et al. [1], among others, provide a good reviews and compariones of the different heuristic methods that have been applied in this field.

Genetic Algorithms (GA) were first employed to address the problem of time-tabling to organise the lecture timetable at an Italian university. They have since helped to provide further breakthroughs in the field, the most importants of them being documented in [4].

2. THE DISTRIBUTION OF SHIFTS IN A HOSPITAL EMERGENCY DEPARTMENT

Establishing duty rosters, or work calendars, for the medical staff of a hospital emergency department does not fit into a general behavioural pattern because of the heterogeneity of such a unit's structure [6]. This heterogeneity is due to many factors, such as the extent or range of the services offered (which depends on the category of the hospital, and therefore on the hospital's catchment area), the work mode (shifts, on call, or a combination of both), the type of staff contract (full time or part-time staff member, etc.), and the kind of work that is undertaken (general emergencies, outpatient service, mobile intensive Care Units, emergency care with other departments), and other factors.

The general characteristics of the service are as follows.

- a) There is a medical staff of 16 people (permanent contracts; this number of staff was obtained based on the work of Graff and Radford [5]), and an indeterminate number of temporary staff who work shifts and/or are on call when permanent staff are unable to do these duties because of certain constraints that apply.
- b) Department staff work in different modes depending on whether the day is a working day or a holiday. Saturdays, Sundays, local, regional and national holidays, Christmas Eve and New Year's Eve are all classed as holidays, when work is organised as a twenty-four hour on-call period (starting at 10 a.m.). The remaining work days are organised into shifts, either in the morning (from 8 a.m. to 3 p.m.), afternoons (from 3 p.m. to 10 p.m.) or nights (from 10 p.m. to 8 a.m.). Additionally, every working day somebody must also be on call for 24 hours (from 8 a.m.) – called the 'stand-by duty' – to look after and supervise

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patients who are under 24 hour observation (maximum) before either being discharged or hospitalised.

3. CONSTRAINTS

The constraints imposed on the shift management system can be divided into two different types: ‘hard’ constraints, which must necessarily be complied with, and ‘soft’ constraints, which need not be catered for, although any solution which does manage to include them will be better considered for having done so.

The hard constraints are the following:

- A minimum number of staff should be assigned to each shift. As a general rule for working days, four members of staff will be assigned to the morning and afternoon shifts, two will be assigned to the night shift and one person will be on 24-hour stand-by call. On Saturdays, Sundays and holidays, the department will work in on-call mode, whereby four members of staff will generally work for an uninterrupted 24-hour period.
- Whenever the on-call work mode is being worked at least two of the 16 members of staff should be on call
- Any member of staff who is on 24-hour stand-by call during a working day, on call over a holiday period or who works a night shift will not work the following day.
- Constraints imposed by periods of illness and holidays should be catered for.

The soft constraints are as follows:

- Each member of staff should be on call three times a month (one of them a 24- hour standby call during a working day)
- All members of staff should, if possible, work the same number of Saturdays and Sundays per month.
- Staff should be on the same shift for a whole week.
- The same order of shifts from one week to the next, based on a morning, afternoon and evening pattern should be maintained if possible.
- The 24-hour standby shifts on working days should be linked to the night shift.
- The day before being on call it is preferable to work the morning rather than the afternoon shift.
- The number of different types of shift should be shared out amongst staff as fairly and as equally as possible.
- Temporary staff will be resourced as little as possible.
- Temporary staff will only be on call during holidays and for the 24-hour stand-by working day shift.

An in-depth analysis of these constraints clearly shows how difficult it is to find a solution to this time-tabling problem. Remember too that the time-tabling is on a monthly basis, and that the work load should be fairly shared out amongst all the staff. This means that any shift roster system should include a ‘memory’ to include the yearly subtotals of shifts worked by each member of staff. Given these difficulties, a weighting was applied to each of these softer constraints, and a ranking of the relative importance of each factor to the solution was established.

4. RESULTS AND DISCUSSION

The table 1 shows one of the solutions we found with us algorithm.

Table 1: The first solution (M = morning, T = afternoon, N = night, G = on call , B = 24-hour call)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
OP1	M	M	M	M	G	B	N	N	N	T	T	T	T	T	T	N	N	B	G	M	M	M	M										
OP2	T	T	T	T	G	N	B	N	G	M	M	M	M	M	N	N	B	G	T	T	T	T											
OP3	B	N			T	T	T	T	T	N	B	N	M	M	M	M	M	G	T	T	T												
OP4	M	M	M	M	G	T	T	T	T	M	G	M	M	B	N	N																	
OP5	N	N	B		M	M	M	M	M	G	T																						
OP6	T	T	T	T	G	N	N	N		M	M	M	M	G	T	T	T	T	T														
OP7	N	N	B		M	M	M	M	M	T	T	T	T	N	N	B	N	G	T	T	T												
OP8	M	M	M	M		N	B	N	G	M	M	M	M	T	T	T	T	G	N	N													
OP9	B	N			T	T	T	T	T	G	N	N	B	M	N	B	M	M	M	M	M	G	M	M	M								
OP10														T	T	T	G	M	M	M	M												
OP11	T	T	T	T	G	M	M	M	M	B	N	N		N	N		N	N	G	T	T	T											
OP12	M	M	M	M		T	T	T	T	G	M	N		G	T	T	T	T	T	T													
OP13	N	N	N	G	M	M	M	M	M	G	T	T	T	M	B	N																	
OP14	T	T	T	T	G	N	N	N	B	M	G	N																					
OP15																																	
OP16	N	N	N			B	N	N		M	M	M	M	G	T	T	T	T															
TR1					G					G				G																			
TR2					G					G				G																			
TR3														G																			
TR4															B																		
TR5																																	
TR6																																	

5. CONCLUSIONS

In this job, a problem of difficult treatment by exact mathematical methods is approach. This problem consists of a hourly distribution for de medical staff at the Emergency Department in a Hospital. The complexity of the problem resides in the high number of constraints. So that heuristic methods, as Genetic Algorithms, were used in order to solve it. The use of this technique allows the treatment of different kind of constraints. Thus, it can be required that some constraints (hard ones) always fulfil the conditions, and other constraints (the soft ones) have a high degree of accomplishment with the conditions. In order to simplify the full accomplishment of the hard constraints, the use of a vector coding is proposed, which makes difficult the generation of solutions that do not fulfil the hard constraints, obtaining solutions adapted to the relative importance imposed to soft constraints, as well as the fact of providing solutions of practical application.

6. REFERENCES

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