
**When referring to data from these test instances in publications,
please use the following references:**

M. Moz, M. Pato, A genetic algorithm approach to a nurse rostering problem. *Computers & Operations Research*, 34 (2007), pp. 667–691.

M. Pato, M. Moz. Solving a bi-objective nurse rostering problem by using a utopic Pareto genetic heuristic. *Journal of Heuristics*, 14 (2008), pp. 359–374.

This document is divided in two main parts: the **nurse rostering problem definition** described in the above referred papers, and the **test set description**.

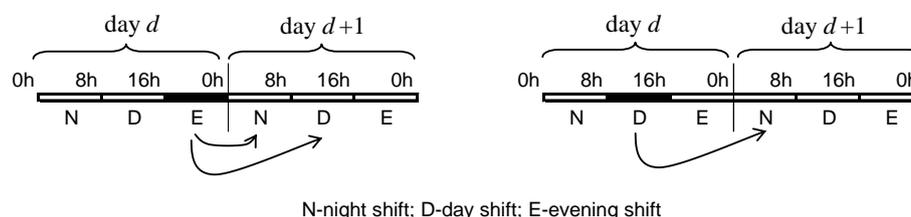
Problem definition

The **nurse rostering problem** occurs when one or more nurses cannot work shifts that were previously assigned to her. If no pool of reserve nurses exists to replace those absent, then the current roster must be rebuilt from the first day of absences (day d). This new roster must comply with the same rules as the current one - labour rules, institutional constraints, and satisfy as much as possible the preferences of nurses for certain sequences of shifts/days-off (the so-called patterns). Moreover the new roster must be as similar as possible to the current one. For hospital units that work around the clock nurse work is divided into three fixed starting time eight-hour shifts: Night (N), Day (D) and Evening (E) shift.

These conditions may be summarised by the following constraints:

Hard constraints

- (0) the minimum number of nurses required to work in each shift must be met;
- (i) each day each nurse must work an eight-hour shift or get a day-off;
- (ii) some nurses have a weekly workload of 35 hours, while others have 42 or 30 hours;
- (iii) nurses must rest at least 16 hours between two consecutive shifts; consequently some shift sequences are not feasible: work on an evening shift should not be followed by work on a night shift or a day shift; work on a morning shift should not be followed by work on a night shift. This Figure highlights infeasible sequences:



- (iv) nurses must enjoy a minimum number of days' leave in every seven day sequence, depending on their weekly workload (2 days-off for those with a 35 hour week or less, and 1 day-off for a 42 hour week);
- (v) nurses who should not be working on certain shifts and/or on certain days should not be assigned to those shifts and/or to those days;
- (vi) absent nurses must not be assigned to shifts on the days they are absent.

Note: For hard constraint (v), in `File_of_Nurses`, for each nurse, there is a value in the item “type of pattern”. In file `Type_of_pattern` the correspondence of this value to the sequence of shifts of the respective pattern is given. When the pattern is “fixed” the nurses should not be assigned to shifts that are not in the pattern.

Soft constraints:

- (i) some nurses should not work on the night shift on consecutive days;
- (ii) nurses should be assigned a pre-determined number of work tasks during the rostering period (from the first day of absences, day d , to the end of the rostering period, day 28), in keeping with the respective weekly workload;
- (iii) the preferences of nurses for some sequences of tasks should be met (in the rostering context, nurses prefer not to alter the previously assigned work tasks).

Objective(s)

In *C&OR*, 34 (2007), the objective of the problem is to find a new feasible roster as similar as possible to the current one, that is, one yielding a minimum number of shift swaps in the nurses previously assigned (soft iii).

[Note that soft (i) and soft (ii) have not been taken into consideration in this uni-objective optimization, as solutions for the rostering problem that minimise dissimilarity with the current roster will tend to contemplate those constraints when satisfied by the current roster].

In *JofH*, 14 (2008), rostering consists in determining a roster which satisfies the hard constraints plus (soft i), guided by the two scheduling objectives:

- (objective 1) to obtain a minimum gap between the number of scheduled duties and the number of duties each nurse should perform during the period (soft ii);
- (objective 2) to minimise dissimilarity to the previously announced roster for the same period (soft iii).

[Note 1: in this paper (soft i) is dealt as hard constraint.

Note 2: the number of duties each nurse should perform during the period referred in objective 1 is saved in the file `File_of_Nurses`, in item `total shifts per period`.]

Test set description

- **two sets of instances in the following folders:**
 - 19_nurses unit
 - 32_nurses unit;
- **in each folder there are two sub-folders named “Data” and “Instances”.**
 - “Data” contains the files:
 - **Current roster;**
 - **N. nurses per shift;**
 - **File_of_Nurses;**
 - **Type_of_pattern.**
 - “Instances” contains the files of the instances for rostering tested in the papers above referred.

Description of the "Data" files contents

- File Current roster

1st line: month of the year (if 0 then February with 29 days);
2nd line: number of nurses of the unit;
each remaining line: nurse number followed by the nurse schedule for 28 days;
(N stands for night shift; M for morning shift; T for evening shift; F for day-off)

File N. nurses per shift

1st line: the twenty eight days;
2nd line: minimum number of nurses required to work on the night (N) shift;
3rd line: minimum number of nurses required to work on the morning (M) shift;
4th line: minimum number of nurses required to work on the evening (T) shift;

File File of Nurses contains, for each nurse

```
name: XXXXX
number: X      last shifts:          F N F M T F N
pattern: Y      penalty: 0 credit days-off: 0
total shifts per period: WW type of pattern: Z n.hours per week: XX
```

[name: the name of the nurse; number: the number of the nurse; last shifts: the shifts the nurse worked in the last seven days of the previous planning period; pattern: the position in the nurses' pattern of the shift assigned in the last day of the previous planning period; penalty and credit days-off are not taken into account, that is why they are equal to zero; total shifts per period: the contractual workload of the nurse for the planning period; type of pattern: a value that corresponds to the sequence of shifts the nurse prefer the most; n.hours per week: nurse weekly workload]

File Type of pattern contains

the patterns in use and respective numbers.

Description of the "Instances" files contents

There are 32 instances in the 19-nurses unit folder and 36 in the 32-nurses unit folder;

The names of the files are related to the dimension of the rostering period and the hospital unit. The first number in the name indicates the particular week of the 28-day rostering period where the first day of absences falls (group I – fourth week, group II – third week and so on). For the 32-nurses unit, an additional group of larger instances, group V.

The files of the instances for rostering are organized in the following way:

- Number of an absent nurse
- First day of the first block of absences

- Last day of the first block of absences

IF an “s” follows, then this nurse has another block of absences and again

- First day of another block of absences
- Last day of another block of absences

IF an “n” follows, then this nurse has no more absences;

IF another “n” follows this, there are no more absences;

IF another “s” appears , another nurse has absences and again

- Number of the absent nurse
- First day of another block of absences
- Last day of another block of absences

Examples:

1) Instance I4_19

2
25
25
n
n

Meaning that nurse 2 will be absent on the February 25th (“n” = this nurse has no more absences; “n” = no other nurse will be absent).

2) Instance I2_19

12
1
2
n
s
17
29
2
n
n

Meaning that nurse 12 will be absent on the 1st and 2nd of March (“n” = this nurse has no more absences; “s” = other nurse will be absent); nurse 17 will be absent from the February 29th to March 2nd (“n” = this nurse has no more absences; “n” = no other nurse will be absent).

3) Instance III5_19

9
11

18
s
22
27
n
s
3
16
22
s
25
25
n
s
14
16
18
n
n

Meaning that nurse 9 will be absent from the 11th to the 18th of February (“s” = this nurse has more absences) from day 22 to 27 (“n” = this nurse has no more absences; “s”= other nurse will be absent); nurse 3 will be absent from the 16th to the 22nd (“s” = this nurse has more absences) and on the 25th (“n” = this nurse has no more absences; “s” = other nurse will be absent); nurse 14 will be absent from the 16th to the 18th (“n” = this nurse has no more absences; “n” = no other nurse will be absent).