First International Nurse Rostering Competition 2010

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Introduction

In hospitals much effort is spent producing rosters which are workable and of a high quality for their nurses. Though the Nurse Rostering Problem is known to be a difficult combinatorial optimisation problem of practical relevance, it has received ample attention mainly in recent years.

Building on the success of the two timetabling competitions, ITC2002 and ITC2007 [1], the First International Nurse Rostering Competition (INRC2010) aims to further develop interest in the general area of rostering and timetabling while providing researchers with models of the problems faced which incorporate an increased number of real world constraints.

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A first important goal of INRC2010 is to generate new approaches to the associated problems by attracting users from all areas of research. As with many cases in the past, significant advancements have been made in research areas by attracting multi-disciplinary approaches and comparing them on a common ground.

The second important goal is to close the gap which currently exists between research and practice within this important area of operational research. Although for the sake of the competitive element, we do not include all aspects of the 'real world' problem, we do build on the recent developments to introduce significantly more depth and complexity.

A third goal of INRC2010 is to further stimulate debate within the widening rostering and timetabling research community.

The competition is composed of three tracks; called, after the Olympic disciplines, *1. Sprint*, *2. Middle Distance*, and *3. Long Distance*. The tracks differ from each other based on the maximum running times and on the size of the proposed instances, whereas the problem formulation considered is the same throughout the competition. These tracks represent distinct solution settings in practice. Track 1 (Sprint) requires a solution in a few seconds, and it is meant for interactive use. Track 2 (Middle Distance) requires the solution in a few minutes and simulates the practical situation in which the problem has to be solved a few times in a solving session. Track 3 (Long Distance) grants the solver a few hours of running time and is related to overnight solving. The algorithm features are often tuned to the available running time so that the three tracks represent different challenges to the participants. For each track there are three sets of instances. The Early instances are released immediately after the competition launch. The Late instances will be made available two weeks prior to the end of the Competition on 15 April 2010. A number of instances will be kept aside in order to test the best performing algorithms. These are the Hidden datasets and will be released to the community at a later stage once the competition ends.

Below, we provide information about the Nurse Rostering Problem considered in the competition. The competition rules, a precise problem description, and more info about the data formats can be found at the site of the competition[2] and in a technical reports describing the competition[3].

1 The Nurse Rostering Problem

The nurse rostering problem involves assigning shifts to nurses taking several constraints into account. As usual, we consider two levels of constraints:

- **hard constraints**: constraints that must be satisfied
- **soft constraints**: the sets of constraints that should be to satisfied but for which we expect that it will not be possible to satisfy them all

For example, the demand, i.e. the number of shifts to be covered per day, is a hard constraint. Personal preferences of nurses, work regulations, legal issues, ... provide the soft constraints.

A feasible solution is one in which all hard constraints are satisfied. The quality of the solution is measured in terms of soft constraint violations.

First a more detailed description of the problem is given. Second, we elaborate on the hard and soft constraints and the evaluation of the solution.

1.1 Problem Description

The problem consist of the following:

- a roster is made for a number of days for one ward in a hospital
- shift types: a shift type represents a time frame for which a nurse with a certain skill is required. E.g. between 08h30 and 16h30 a head nurse needs to be present.
- for each day and each shift type, the number of required nurses is provided
- the set of contracts representing the work regulations of the nurses. Each nurse works according to exactly one contract. A contract provides the following information:
  - maximum number of assignments:
    the maximum number of shifts that can be assigned to the nurse
  - minimum number of assignments:
    the minimum number of shift that must be assigned to the nurse
  - maximum number of consecutive working days:
    the maximum number of consecutive days on which a shift can be assigned to a nurse
  - minimum number of consecutive working days:
    the minimum number of consecutive days on which a shift must be assigned to a nurse
  - maximum number of consecutive free days:
    the maximum number of consecutive days on which a nurse has no shift assigned
  - minimum number of consecutive free days:
    the minimum number of consecutive days on which a nurse has no shift assigned
  - maximum number of consecutive working weekends
  - maximum number of working weekends in four weeks
  - the number of days off after a series of night shifts
  - unwanted shift patterns:
    e.g. a nurse does not want to work the following shifts in a row: L-E-L (late-evening-late)
- the nurses of the ward
- the nurses' requests:
  - day on/off requests: a nurse can request (not) to work on a certain day
  - shift on/off requests: a nurse can request (not) to work a particular shift type on a certain day

1.2 Constrains and Evaluation Function

We identify both soft and hard constraints. Note that our decision on which constraints are hard and which are soft is rather arbitrary. In practice many different combinations will be found. Furthermore, wards may assign different weights to certain soft constraints in an attempt to produce solutions that are more appropriate for their particular needs.

There are two hard constraints:

- all demanded shift types must be assigned to a nurse;
- a nurse can only work one shift type per day, i.e. no two shift types can be assigned to the same nurse on a day.

A feasible solution is a solution that does not violate any of those two constraints. All other constrains are soft. A formal description of the constraints can be found in the technical report[3]. We provide a solution evaluator at the site[2].

References

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2. INRC2010 website: `http://www.kuleuven-kortrijk.be/nrpcompetition`
3. CODES/Technical Report/2010/1 `https://www.kuleuven-kortrijk.be/CODeS/`