Modelling Issues in Nurse Rostering

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Abstract The real world nurse rostering problem requires numerous extensions to the nurse rostering models reported in the literature. In this work, we present some issues in nurse rostering model and illustrate them with specific examples. The extensions to our previous model [1] are inspired by the cases collected during collaboration with an industrial partner (GPS Time Security NV).

De Causmaecker and Vanden Berghe have categorised the nurse rostering problems regarding to the personnel environment, work characteristics, and optimisation objectives [2,3]. The skill type is an element of the personnel environment in this categorisation. Although there are several categories regarding the treatment of skill types, we report the most complicated one in this abstract. In some wards, employees can have multiple skill types and different levels of experience for each skill type. Consider a senior regular nurse who is a trainee as a head nurse. She has two skill types: regular and head nurse, but different levels of experience for each of them: senior and trainee. In this type of problems, the minimum level of experience is also given in the coverage constraints.

Domain. Domain is a new modelling element used in the definition of constraints. The composition of a domain object is as follows:

- Date set
  - Handling of the date set: individual or complete
- Shift type set

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– Skill type set

Absence request as a block. In the following examples, different domain objects are used as parameters in the absence and assignment requests of the nurses. Consider a nurse who plans a ski vacation over a period of five days with a fixed starting day. This vacation request will be considered granted, if and only if all the days in the date set are granted. Hence, the date set is handled as a single block.

Absence request on individual days. Another example is a nurse who wants to help redecorating her house. This vacation request can be granted partially. The more days are granted, the better it is for the nurse. Hence, the dates in the set are handled individually.

Absence request on a specific shift types set. A common example encountered in Belgian hospitals is a nurse who wants to take care of her children on Wednesday afternoons, because Wednesday afternoons are school free in Belgium. In this case, the date set consists of the Wednesdays in the planning period, and the shift type set consists of the afternoon, evening, and probably also the night shifts.

Assignment request for a specific skill types set. There are also cases in which a nurse is a senior caregiver but a trainee as a regular nurse. She wants to work as a regular nurse as much as possible to gain experience in this skill type. In this case, the *skill type set* of the domain element consists of "regular nurse".

Individual bank holidays. The utilisation of domains is not limited to the employee requests. Some institutions allow their nurses to define their own bank holidays. There are two advantages of this practice. First, the shortage of the available nurses during the public holidays is reduced, because not all nurses take leave at the same time. Second, nurses can select their own holidays based on their religion and nationality. Instead of defining a global *holidays worked counter* that applies to the whole ward, counters with domains that represent the holidays of the individuals are defined to address this practice.

Constraint period exceeding the planning period. The *holidays worked counter* poses another challenge. The period of this constraint, a year, exceeds the planning period. A typical planning period of four weeks is shorter than a year. The holidays before and after the current planning period need to be taken into account as well. The threshold values of the constraint need to be adjusted using the following formula. Let h be the number of assignments on bank holidays before the current planning period. Let r be the number of remaining holidays after the current planning period.

$$min' = min - h - r \tag{1}$$

$$max' = max - h \tag{2}$$

In academic models, the planning period is usually considered to be isolated. The real world practice, however, requires the consideration of assignments in the previous planning periods, as well as the structure of the upcoming planning periods. The *holidays worked counter* is an example of this requirement. The continuity between the

planning periods is studied in greater detail by Glass and Knight [4]. They carried out their studies on the Nottingham benchmarks, a collection of nurse rostering problem instances from different countries [5].

Collaboration. The collaboration constraint restricts the composition of the nurses that work together. The parameters of the collaboration constraint are as follows:

- Employee set
- Domain
- Threshold
- Weight

The employee set needs to consist of at least two employees that have to work together or not. The collaboration can be defined regarding any domain element. The threshold value determines the nature of the collaboration. If the maximum threshold value is set to zero, this means that a collaboration among the nurses in the employee set is not desired. A positive minimum threshold is needed in order to express a requirement of nurses working together.

Training. The objective of the training constraint is to increase the level of experience of the trainees. Usually, seniors of a skill type are engaged to supervise the work of trainees of the same skill type. This supervision is considered as training. The training constraint can occur in different ways in real world practice. Here is a common example: a senior can train up to five trainees at the same time. There must be sufficient numbers of seniors assigned for the trainees that are assigned to the same domain. The parameters and the formula of the training constraint are as follows:

- Preceding level of experience (t)
- Succeeding level of experience (s)
- Ratio (r)
- Domain
- Weight

$$\lceil r \cdot t \rceil \leq s \tag{3}$$

In this work, we report extensions to the nurse rostering model in order to address the real world problems. The publication of an XSD of the extended model, real world data files with the extended features and experimentation on the data files constitute the future work. The nurse rostering problem is dynamic in its nature and all the time provides the industry professionals with new challenges. The models need to be in continuous redevelopment to address the upcoming challenges.

References

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