Solving diverse real-life rostering problems with generic models and algorithms

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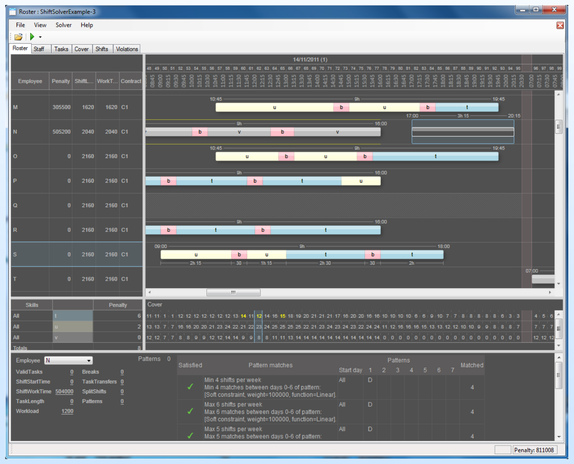
Overview

Staff scheduling problems vary significantly between organisations. The problems have a common problem structure but the constraints, objectives and dimensions are often very different. Our research focusses on developing general models, algorithms and heuristics which can be applied to a wide range of real-life rostering problems found in healthcare and retail environments.

Scheduling problems with variable shift start times and lengths

In this version of the problem the shift start times and durations are not pre-defined. Shifts can start at any time of the day and can be of any length. Other features of the model include:

- Cover - Staff demand is given per activity, per user defined interval, e.g. every 15 mins (also optionally per skill)
- Activities - Staff can change activity during a shift
- Breaks - Break requirements vary by shift start time and shift length.
- Split shifts - Staff can be assigned more than one shift on a single day
- Constraints - Shift start/end times, shift durations, total work time, shift patterns, activity lengths etc.



Methodology

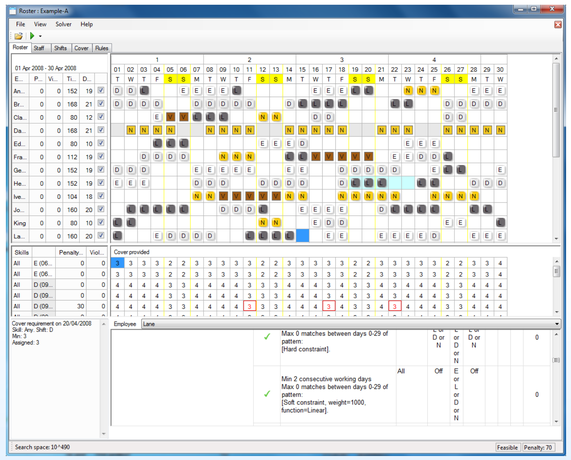
The algorithm must be able to handle all the model requirements as well as large variations in instance size. For example up to 1000 employees and long planning horizons. Heuristic approaches scale well with very large instances and computational time and resource requirements. Heuristics used are based on:

- Search neighbourhoods - Adding, removing, moving, re-sizing shifts and activity stretches
- Search re-start mechanisms - Partial solution un-assignment, constraint relaxation/weight adjusting

Scheduling problems with pre-defined shift types

In this version of the problem a set of shift types is provided as an input. Shifts must be assigned to staff subject to constraints and objectives. Model features include:

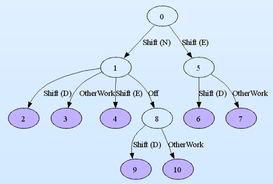
- Location based shifts
- Employees requesting to work together/separately
- Rules defined using arithmetic, relational, equality and boolean operators, constants, control statements (if, then, else), functions (e.g. abs, ceil, floor, round) and variables
- Pattern matching/regular expression constraints

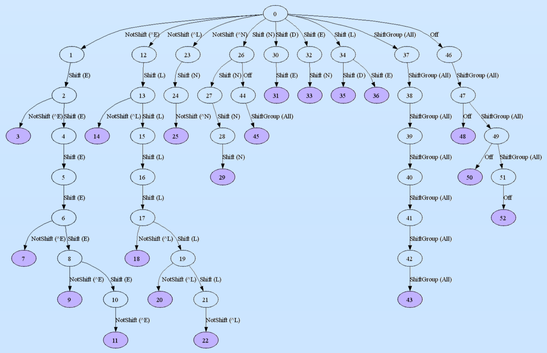


Pattern matching constraints

Most constraints on employees' schedules can be modelled using a pattern matching/regular expression constraint.

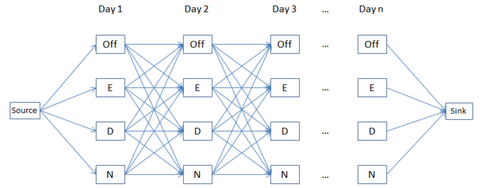
The pattern matching functions are implemented using graph structures for fast and efficient performance.





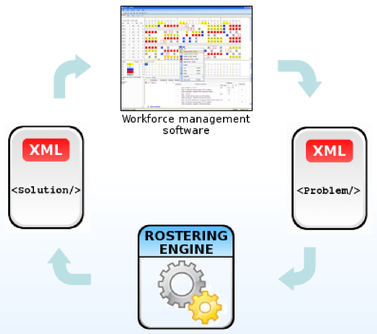
Dynamic Programming

Simplifying the model to a small number of generic constraints allows us to develop a single dynamic programming algorithm for generating optimal schedules for employees. This algorithm was used to solve pricing problems in column generation and branch and price methods and also used as a heuristic/neighbourhood in a very large-scale neighbourhood search.



Interface

The problem models and solutions are encoded in platform independent XML format. This allows the algorithms to interface with and be incorporated into existing workforce management software products.



Impact

Staff Roster Solutions is a spin-out company formed by the University of Nottingham to commercially license and develop staff scheduling technologies. The research presented here has fed into the company's products which have been licensed to customers in Europe and North America. The technologies are used daily to schedule employees in the healthcare and retail sectors.