VAUCOURT Tom

TD4 Report

Pediatrician scheduling at British Columbia Women's hospital

Question 1

We model this problem using the two suggested primary (or natural) decision variables. The hard constraints are:

- Every shift is covered by exactly one doctor (constraint **Ha** in the CPLEX model, corresponding to the hard constraint **a** in the formulation of the problem)
- Every doctor covers exactly the number of shifts requested **(Hb)**
- No back-to-back shifts for any doctor **(Hc)**
- No back-to-back night shifts for any doctor **(Hd)**
- No more than 2 shifts per doctor per weekend **(He)**
- No working on shifts requested off **(Hf)**
- Every week is covered by exactly one POW **(Hg)**
- The POW must cover at least Tuesday day, Thursday day and Saturday night **(Hh)**
- No doctor can be POW more than once per cycle **(Hi)**
- No doctor can be POW if he has no POW requirement left **(Hj)**

The secondary decision variables, corresponding to the soft constraints, are the following:

- **nightS2A**[1..26][Doc] : a positive integer tracking the number of night shifts 2 nights apart worked by each doctor (avoid night shifts two apart). There are 26 such pairs of night shifts two apart.
- **consWE**[1..3][Doc] : a positive integer tracking the number of consecutive weekend worked by each doctor (avoid consecutive weekends). There are 3 such pairs of consecutive weekends.
- **nightS3W**[1..4][Doc] : a positive integer tracking the number of night shifts worked each week by each doctor (avoid scheduling anyone to work 3 night shifts in a week). We consider 4 weeks in this model.
- **equityPOS**[Doc] : a positive integer tracking the number of supplementary day shifts for each doctor (aim for a 50-50 split between day and night shifts).

- **equityNEG**[Doc] : a positive integer tracking the number of supplementary night shifts for each doctor (aim for a 50-50 split between day and night shifts).

Then, the soft constraints were labelled in a similar way **(Sa, Sb, Sc and Sd)**.

Finally, the **objective function** simply seeks to minimize the sum of all 5 of the decision variables associated to the 4 soft constraints **(see lines 49 to 51 in mod1.mod).**

To easily appreciate the solution, we'll enhance the provided excel file to be able to check the correctness of the model we implemented. This feature is implemented in the **Solution_check** sheet of the excel file provided in this zip file.

For every soft constraint, I used excel formulas to calculate the so-called "dummy decision variables" (in the yellow cells). This allows for the total sum of penalties to be automatically calculated from the input of the x and y decision variables in the corresponding tables (E12:S67 for x and E73:S76 for y).

Then, I used the *SheetWrite* function in CPLEX to write the solution to the corresponding tables in the excel file **(see lines 16 to 17 in data1.dat)**.

This allows us to quickly check:

- if the hard constraints are respected
- the deviation from the ideal value for each soft constraint
- the sum of all deviations.

Please note I added conditional formatting (red text) to the helper cells above the dummy decision variables to quickly find the deviations in the solution.

The xlsx file has to be located in the project folder (as provided in the zip file) for the code to work.

Question 2

Let's run the model for the first time: we can see that the solution provided features a total sum of penalties of 7, making it equally desirable to the solution provided in the problem formulation (total sum of 7). It is, however, not the exact same solution.

Let's see for which soft constraint and doctor the deviations are :

- Doctor 2 works on two consecutive weekends (weekend 1 and weekend 2) **(Sa)**
- Doctors 6, 10 and 12 work one more day shift than night shifts, whereas Doctors 5, 8 and 15 work one more night shift than day shifts **(Sd)**.

Sd is the soft constraint which contributes to the total sum of penalties the most with a value of 6. This is the one we should work on; a first idea could be to increase the coefficient of the corresponding decision variable in the objective function. However, it should be noted that the penalty of this soft constraint can't be reduced. Indeed, the 6 doctors which work an unequal number of day and night shifts are required to work an odd number of shifts. Consequently, they'll always work at least one more day shift than night shifts or vice versa. This soft constraint is therefore solved in an ideal way.

The remaining soft constraint **(Sa)** can't seem to be reduced. I used a coefficient of 100 for the corresponding decision variable, but to no effect.

Question 3

If Meg gave me a rank-ordering of the relative importance of the different soft constraints, I could increase the coefficient of the decision variables corresponding to the most important soft constraints in the objective function. Consequently, the model will prioritize minimizing the value of these decision variables.

Question 4

If the shifts requested off by doctors made it impossible to find a solution, we would have to modify the model to find a feasible solution.

The hard constraint corresponding to this issue **(Hf)** would have to be turned into a soft constraint. Similarly to the other existing soft constraints, we would then calculate the deviation from the ideal situation (which is no doctor working on shifts requested off). Since this constraint remains important to Meg and the doctors, we would have to assign it a large coefficient in the objective function, relative to the coefficients of the other soft constraints.

Doctors would have to decide whether they prioritize not working on the days they requested off, or rather respecting one of the other soft constraints. If they prefer not to work on the days they requested off, but don't mind breaking another soft constraint, the coefficient of the decision variable associated with not working on days requested off would have to be the largest of all.