Nurse scheduling and patient assignment

Defining the problem

I wanted to implement a new strategy for the original problem with 2 different layers - 2 substep:

1. scheduling nurses and
2. patient assignment to nurses in order to optimize the initial solution.

First layer:

Some basic constraints and assumptions:

- Each day is divided into 3 separate shifts of 8 hours (s1,s2,s3).
- There are a number of required nurses for each of them(5,4,3).
- A nurse is off on a specific day if no shift is assigned or if the nurse has requested a day off
- A nurse will have just a shift in a day
- A nurse who works on the 3rd shift will take the next day off.
- Max numbers of night shift for each nurse is at most ONE per week

Second layer:

After we schedule the nurses per shift, we will try to assign the patients to them.

The same constraints from initial solution are kept:

- Each patient is treated by exactly one nurse
- A nurse can not work more than 8 hours per day
- A patient from a shift is treated by the nurses assigned to that shift

Model

The first objective was to **minimize** the numbers of scheduled nurses by satisfying all constraints and the second to **maximize** the number of assigned patients.

The implementation is based on linear programming with pulp python package to find the solution of this constrained optimization problem.

In the both cases, we will use a binary variable for example:

var_n_s = 1, if the nurse will work on shift s, 0 otherwise

var_p_n = 1, if the patient p is treated by the nurse n, 0 otherwise

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The number of nurses required for each shift is:
[5 4 3 5 4 3 5 4 3 5 4 3 5 4 3 5 4 3 5 4 3]

In matrix form:
   M Tu  W Th  F Sa Su
0  5  5  5  5  5  5  5
1  4  4  4  4  4  4  4
2  3  3  3  3  3  3  3
```

	M_s1	M_s2	M_s3	Tu_s1	Tu_s2	Tu_s3	W_s1	W_s2	W_s3	Th_s1	Th_s2	Th_s3	F_s1	F_s2	F_s3	Sa_s1	Sa_s2	Sa_s3	Su_s1	Su_s2	Su_s3
nurse0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0
nurse1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
nurse2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
nurse3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
nurse4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
nurse5	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1
nurse6	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
nurse7	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
nurse8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
nurse9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
nurse10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
nurse11	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
nurse12	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
nurse13	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
nurse14	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
nurse15	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
nurse16	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
nurse17	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
nurse18	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
nurse19	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
nurse20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nurse21	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
nurse22	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nurse23	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
nurse24	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
nurse25	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
nurse26	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
nurse27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
nurse28	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
nurse29	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nurse30	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
nurse31	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
nurse32	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0

	0	1	2	3	4
0	0	1	0	0	0
1	0	1	0	0	0
2	1	0	0	0	0
3	1	0	0	0	0
4	1	0	0	0	0
5	0	0	0	0	1
6	0	0	1	0	0
7	0	0	0	0	1
8	0	0	1	0	0
9	0	0	0	1	0
10	0	1	0	0	0
11	0	0	0	0	1
12	0	1	0	0	0
13	0	0	0	1	0
14	1	0	0	0	0
15	0	0	0	0	1
16	0	0	0	1	0
17	0	0	1	0	0
18	0	0	0	1	0
19	0	0	0	0	1
20	0	0	0	1	0