Input data

- nurses $n \in \{1, \ldots, N\}$, days $d \in \{1, \ldots, D\}$, shifts $s \in \{1, \ldots, S\}$
- week numbers $w \in \{0, \ldots, W\}, W = \lfloor D/7 \rfloor - 1$
- nurses demand per day and shift - $demand_{d,s} \in \mathbb{N}$
- workhours lower and upper limit per nurse - $maxhours_n \in \mathbb{N}$
- vacation requests - $VR \subset N \times D$
- preferred companions - $PC \subset N \times N$
- unpreferred companions - $UC \subset N \times N$
- preferred slots - $PS \subset N \times D \times S$
- unpreferred slots - $US \subset N \times D \times S$

Optimization variables: schedule for each nurse, day and shift

$$schedule_{n,d,s} \in \{0, 1\}$$

and interactions of nurses (weekends 2)

$$interaction_{n,n',d,s} \in \{0, 1\}$$

and "worked in given weekend" indicators

$$\texttt{weekend}_{n,s} \in \{0, 1\}, \texttt{min\_weekends\_worked}, \texttt{max\_weekends\_worked}$$

and "fraction of contract fulfilled" proportions, as well as lower and upper bound for those

$$\alpha_{min}, \ \alpha_{max}$$

Reward function

$$
\begin{aligned}
&\lambda_{PC} \cdot \sum_{(n,n') \in PC} \sum_{d,s} interaction_{n,n',d,s} \\
&-\lambda_{UC} \cdot \sum_{(n,n') \in UC} \sum_{d,s} interaction_{n,n',d,s} \\
&+\lambda_{PS} \cdot \sum_{(n,d,s) \in PS} schedule_{n,d,s} \\
&-\lambda_{US} \cdot \sum_{(n,d,s) \in US} schedule_{n,d,s} \\
&-\lambda_{\mathrm{WHS}}(\alpha_{max} - \alpha_{min}) \quad \text{(prefer equal work to max work hours ratio)} \\
&-\lambda_{\mathrm{W}}(\texttt{max\_weekends\_worked} - \texttt{min\_weekends\_worked}) \quad \text{(prefer equal busy weekends distribution)}
\end{aligned}
$$

Constraints

$$\forall_{d,s} \;\sum_n schedule_{n,d,s} = demand_{d,s} \quad \text{(demand is met)}$$

$$\forall_n \;\frac{24}{S}\sum_{d,s} schedule_{n,d,s} \leq maxhours_n \quad \text{(workhours limits are not exceeded)}$$

$$\forall_{n,d} \;\sum_s schedule_{n,d,s} \leq 1 \quad \text{(max 1 shift per day)}$$

$$\forall_{n,w} \;\sum_{d=7w+1}^{\min(7(w+1),D)} schedule_{n,d,S} \leq 6 \quad \text{(max 6 night shifts per week)}$$

$$\forall_{n,d} \; schedule_{n,d,S} + schedule_{n,d+1,1} \leq 1 \quad \text{(can't continue past midnight)}$$

$$\forall_{(n,d)\in VR} \; \forall_s \; schedule_{n,d,s} = 0 \quad \text{(vacations are respected)}$$

$$\forall_{n,n',d,s} \; interaction_{n,n',d,s} \leq schedule_{n,d,s} \quad \text{(interactions 1)}$$

$$\forall_{n,n',d,s} \; interaction_{n,n',d,s} \leq schedule_{n',d,s} \quad \text{(interactions 2)}$$

$$\forall_{n,n',d,s} \; interaction_{n,n',d,s} \geq schedule_{n,d,s} + schedule_{n',d,s} - 1 \quad \text{(interactions 3)}$$

$$\forall_{n,w} \; weekend_{n,w} \geq \frac{1}{S}\sum_s (schedule_{n,7w+6,s} + schedule_{n,7w+7,s}) \quad \text{(weekends 1)}$$

$$\forall_{n,w} \; weekend_{n,w} \leq \sum_s (schedule_{n,7w+6,s} + schedule_{n,7w+7,s}) \quad \text{(weekends 2)}$$

$$\forall_n \; \texttt{min\_weekends\_worked} \leq \sum_n \texttt{weekend}_{n,s} \leq \texttt{max\_weekends\_worked} \quad \text{(min/max weekends worked are computed)}$$

$$\forall_n \; \alpha_{min} \leq \frac{\frac{24}{S}\sum_{d,s} schedule_{n,d,s}}{workhours_n} \leq \alpha_{max} \quad \text{(alphas with bounds)}$$