Mixed integer program for allocating university tutors to course tutorials/workshops.

Liam Timms
liam.timms@uq.edu.au

Sets

I	Set of tutors, i.
S	Set of supertutors, $S \subseteq I$.
W	Set of workshops, w, over all courses.
T	Set of time slots in a day in 24-hour time, e.g. $\{[0800, 1000], [1000, 1200], \ldots, [1600, 1800]\}$.
D	Set of days in a week.
C	Set of courses offered in the semester. $C = \{\text{SCIE1000}, \text{SCIE1100}\}$, or $C = \{\text{SCIE1000}\}$.

Data

Assume that all workshops are 2 hours long, and they begin on the hour (i.e. 8am, 9am, etc.).

P_{iw}	Tutor i's availability to teach workshop w, for $i \in I$, $w \in W$. $P_{iw} \in \{0, 1, A\}$, corresponding to "Unavailable", "If needed", and "Available".
A	Weighting for "Available" status, represents tutors' preferences for specific workshops. $A > 1$ means that "Available" allocations will be preferenced over "If needed" in the objective function.
Exp_i	1 if tutor $i \in I$ is experienced, 0 otherwise.
Conflict_{ij}	1 if tutor i and tutor j cannot tutor together, $i, j \in I$ and, 0 otherwise.
N_w	Number of tutors required for workshop $w \in W$.
M_{ic}	Number of workshops in course $c \in C$ assigned to tutor $i \in I$.
Start_w, End_w	Times when workshop $w \in W$ begins and ends. $[\text{Start}_w, \text{End}_w] \in T$
Day_w	Day of workshop $w \in W$.
DayOne	First day of the week with a workshop.
Overlap_w	The set of workshops that overlap with workshop $w \in W$. These are the workshops that start within an hour of workshop w and are on the same day: $\text{Overlap}_w = \{v \in W \text{ s.t. } \lvert\text{Start}_v - \text{Start}_w\rvert \leq 100 \wedge \text{Day}_v = \text{Day}_w\}$.

Variables

x_{iw} 1 if tutor $i \in I$ is allocated to workshop $w \in W$, 0 otherwise.

Objective

Maximise tutors' preferences for workshop allocations.

$$\max \sum_{i \in I,\, w \in W} P_{iw} x_{iw}$$

Constraints

$$\sum_{i \in I} x_{iw} = N_w, \quad \forall w \in W, \tag{1}$$

$$\sum_{w \in W} x_{iw} = M_{ic}, \quad \forall i \in I,\, c \in C, \tag{2}$$

$$\sum_{i \in I,\, v \in \text{Overlap}_w} x_{iw} \leq 1, \quad \forall i \in I,\, w \in W, \tag{3}$$

$$\sum_{\substack{i \in I \\ |\text{Exp}_i = 1}} x_{iw} \geq 1, \quad \forall w \in W, \tag{4}$$

$$x_{iw} + xjw \leq 1, \quad \forall i, j \in I,\, w \in W, \text{ if } \text{Conflict}_{ij} = 1, \tag{5}$$

$$\sum_{\substack{w \in W, \\ |\text{Day}_w = \text{DayOne}}} x_{iw} \geq 1, \quad \forall i \in S, \tag{6}$$

$$\sum_{i \in S} x_{iw} \leq 1, \quad \forall w \in W, \tag{7}$$

$$x_{iw} \in \{0, 1\}, \quad \forall i \in I,\, w \in W. \tag{8}$$

Constraints 1 ensure that each workshop is staffed with the required number of tutors. Constraints 2 make sure that each tutor is allocated the correct number of workshops. Each tutor can only be in one workshop at a given time on a given day, enforced by Constraints 3. Some tutors are unable to teach together for various reasons, e.g. being in a relationship, personal conflict, etc. These tutors cannot be allocated to the same workshop, shown in Constraints 5.

Tutors are divided into experienced and inexperienced tutors. Constraints 4 ensure that there is at least one experienced tutor in each workshop. Additionally, one or more tutors

are "supertutors" who manage the tutoring team. These supertutors should be allocated to a workshop on the first day of workshops, enforced by Constraints 6, so that they discover any issues with the workshop as soon as possible. However, allocating multiple supertutors to the same workshop is a suboptimal use of resources, as supertutors are among the most experienced tutors. Constraints 7 prevent this from happening.

Finally, Constraints 8 prescribe the domain of the decision variables.