Ethics Mini-Project 2: Linear Programs

Version 2: We corrected a typo in shift numbering (it's now always 1,2,3).

Due Date: This assignment is due at 11:59 PM Friday February 26 (Seattle time, i.e. GMT-8).
You will submit as a PDF to gradescope.

Algorithms have effects in the real-world. Linear Programs (and some of their relatives like integer programs) are widely used in businesses for automating decision making. But no application in the real world is perfect. In this project you'll think about impacts of using linear programs in the real world.

The goal of this exercise is for you to consider the effects of running algorithms in the real-world. This assignment is a mix of technical tasks and non-technical ones. The technical aspects can be "right" or "wrong", but the non-technical aspects are unlikely to be simply "right" or "wrong" – we won't have to **agree** with the non-technical aspects of your analysis to consider them a good analysis. Our evaluation will be based on how well they connect to the technical aspects, as well as the depth of reasoning demonstrated.

Collaboration Policy

You are to conduct your own thinking and analysis for this assignment. While you may get feedback form other students on your writing, you cannot just use the results of another student's work.

1. Reading

Read the excerpt of Cathy O'Neal's *Weapons of Math Destruction* linked on Canvas. Specifically, read through the section break (the three dots) on page 130 of the pdf here. You may read the rest if you wish, but it is not required.

2. A Model

One way to model scheduling as an integer program would be as follows:

Let $x_{i,j,k}$ be the variable representing assigning empoyee i to shift j on day k.

- Employees are numbered $1, \ldots, n$.
- Shifts are numbered 1 (the opening shift), 2 (late morning through afternoon), and 3 (the closing shift).
- Days are numbered $1, \ldots, 7$ (Monday through Sunday).

Our LP is:
min $\sum x_{i,j,k}$

Subject to:

(every worker works between 3 and 6 shifts)
$3 \leq \sum_{j,k} x_{1,j,k} \leq 6$
$3 \leq \sum_{j,k} x_{2,j,k} \leq 6$
...
$3 \leq \sum_{j,k} x_{n,j,k} \leq 6$

(every morning shift has at least 4 employees)
$\sum_i x_{i,1,1} \geq 4$
$\sum_i x_{i,1,2} \geq 4$
...
$\sum_i x_{i,1,7} \geq 4$

(and every other shift has at least 3 employees)
$\sum_i x_{i,2,1} \geq 3$
$\sum_i x_{i,2,2} \geq 3$
$\vdots$
$\sum_i x_{i,3,7} \geq 3$

(integrality constraint – in an LP this would be $0 \leq x_{i,j,k} \leq 1$)
$x_{i,j,k} \in \{0,1\}$ for all i, j, k.

(a) Suppose you wish to enforce that "clopening" is not allowed. I.e. no one can be on a close shift on one day and on an opening shift the next. Describe constraint(s) and/or variable(s) to add to the linear program to ensure that no one will be assigned such a shift.

(b) Think of at least one other policy that workers might want (in the style of "no one will be assigned a clopen shift") that can be efficiently encoded[1] in the linear program. State the policy (in 1-2 sentences) and describe the constraint(s) and/or variable(s) to add to the linear program to ensure that policy will be enforced.

(c) Think of at least two policies that workers might want that **cannot** be efficiently encoded in the linear program. State the policies (in 1-2 sentences each) and briefly (1-3 sentences each) explain your intuition for why those policies would be difficult/impossible to efficiently encode.

3. Changing a Schedule

The basic LP in the last section is a very simple model – O'Neal's book considers software that take into account lots of additional information (very recent customer demand, for example), and makes changes to schedules days or even hours in advance.

Suppose you made a schedule for this week, but Monday night you want to make changes to Tuesday. You've already announced choices $x_{i,j,k}$ set to $0, 1$ for whether worker i is working shift j tomorrow, and you wish to make an altered schedule $y_{i,j,k}$ for the rest of the week, where the number of required employees for some shifts has been altered.

You've already added the constraints on the $y_{i,j,k}$ to encode all restrictions you have (including changing the shifts needed)

Describe a possible objective function which would be linear, but would help you minimize the number of changes between the original schedule and the new schedule.[2] Describe what it does in 1-2 sentences.

4. What about the law

O'Neal argues at the end of the section we read that activities like the last section of this assignment are fundamentally insufficient – that as software becomes more powerful businesses will exploit it in a way that harms workers unless they are regulated. She specifically mentions draft legislation that would require schedules be posted at least two weeks in advance to prevent that harm.

You (optionally) may read this news story about the draft legislation or read the most recent draft.

Would you support legislation of this type? Describe why or why not. In your argument give at least one **technical** reason (e.g. a statement about algorithms, software, or linear programming), and mark it with an asterisk so we can find it. Your overall argument (which can include both technical and non-technical aspects) should be at least 6 sentences, but can be longer if you wish.

[1]By "efficiently encoded" we mean adding at most a polynomial number of variables and/or constraints.
[2]Your objective function does not necessarily have to exactly minimize the number of changes between the x's and y's. You might decide to prioritize some workers or penalize cancelling someone's shift differently than adding a new shift.