15.093 Project: Schedule Optimization

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1 Introduction and Practical Implications

In the domain of operations research and management science, scheduling optimization stands as a cornerstone problem, pivotal in enhancing efficiency and productivity across various industries. Scheduling, at its core, is the process of assigning resources to tasks over time, ensuring that certain constraints are met and specific objectives are achieved. Doing scheduling manually is inefficient, time-consuming, or even infeasible. The complexity of scheduling arises from the multiplicity of variables and constraints that must be considered, such as time, resource availability, working hour legislation, and task dependencies. We will begin by considering the basic problem described in section 2 and extend our model as described in section 5.

2 Basic Problem Formulation

Let $p = 1, \cdots, n$ be the person index and $s = 1, \cdots, m$ be the index for a shift. The decision variable for the scheduling problem is $x_{ps} \in \{0, 1\}$ which is 1 if person p is scheduled to work shift s and 0 otherwise. In addition, we have the parameters as described in table 1 and the model formulation in 2.1. With the current formulation, this is a binary integer optimization problem which we will use Gurobi to solve.

$$
\begin{aligned}
\min \quad & \sum_{s=1}^{m}\sum_{p=1}^{n} x_{ps} L_s S_p \\
s.t. \quad & \sum_{p=1}^{n} x_{ps} \geq D_s, \forall s \\
& \sum_{s=1}^{m} x_{ps} L_s \geq R_p(1-\epsilon), \forall p \\
& \sum_{s=1}^{m} x_{ps} L_s \leq R_p(1+\epsilon), \forall p \\
& x_{ps} \in \{0,1\}
\end{aligned} \tag{2.1}
$$

Parameter	Description
$D_s \in \mathbb{Z}^m$	Number of workers required to work shift s
$L_s \in \mathbb{Z}^m$	The length of shift s in hours
$S_p \in \mathbb{R}^n$	Hourly salary for person p
$R_p \in \mathbb{Z}^n$:	Number of hours person p is contracted to work in a given time period
ϵ	Percentage of accepted deviation from FTE rate, organization policy

Table 1: Parameters for the Scheduling Problem

3 Data

At present time, no real-world data has been acquired so the plan is to generate data. It should be relatively easy to generate data that that mimic real-world scheduling scenarios in this case.

4 Expected results

We anticipate needing to fine-tune the model's parameters, such as epsilon, to maintain feasibility. We also expect the FTE rate constraints to give us some insight into whether a work-force is over or under staffed. We are also curious to see if there are any trends in the scheduling. We expect the results to give some insight into what constraints are limiting, especially as we add several constraints in the next steps.

5 Next Steps

Our current formulation emphasizes simplicity and control. As the project evolves, we aim to include more real-world nuances: 1) Availability of workers, 2) multiple shifts a day, 3) overlapping shifts, 4) time-based rather than shift based, 5) fairness considerations (consistency, equity), 6) roles (shifts require different skills which different workers possess), 7) holidays, unique periods etc., 8) breaks, and 9) out-sourcing or hiring.