REMS Scheduling Optimization

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Motivation

- **Problem:** Rice University Emergency Medical Services (REMS) must efficiently schedule emergency medical shifts for student volunteers across 60 available shifts per month (2 shifts per day over 30 days) while balancing student preferences, availability, and adequate coverage requirements. This is done by a manager who manually create schedule based on the information from google forms, which is time-consuming and not accurate.
- **Solution:** We propose developing an optimized scheduling algorithm that automatically generates shift assignments based on student preferences, availability constraints, and coverage requirements, ensuring equitable distribution while minimizing scheduling conflicts and administrative overhead

Please select **at least 6 shifts.**

AT LEAST ONE MUST BE A SHIFT BE **a Friday 8am, Friday 8pm, Saturday 8am, or Saturday 8pm**

	1
Sat, Mar 1, 8AM	☐
Sat, Mar 1, 8PM	☐
Sun, Mar 2, 8AM	☐
Sun, Mar 2, 8PM	☐
Mon, Mar 3, 8AM	☐
Mon, Mar 3, 8PM	☐
Tue, Mar 4, 8AM	☐
Tue, Mar 4, 8PM	☐
Wed, Mar 5, 8AM	☐
Wed, Mar 5, 8PM	☐

Figure 1: Availability google forms

[Wed, Jan 1, 8A	[Wed, Jan 1, 8P	[Thu, Jan 2, 8AI	[Thu, Jan 2, 8PI	[Fri, Jan 3, 8AM	[Fri, Jan 3, 8PM	[Sat, Jan 4, 8AI	[Sat, Jan 4, 8PI	[Sun, Jan 5, 8AI	[Sun, Jan 5, 8PI	[Mon, Jan 6, 8A	[Mon, Jan 6, 8
4	5	2	4	2	3	2	0	0	0	0	
☑	☑	☐	☑	☐	☐	☑	☐	☐	☐	☐	☐
☑	☑	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐
DC4	DC1		DC3			DC2					
Observer1	Observer1		DC4								
	1		1		1						
1	1	1		1	1						
1			1	1		1					
	1	1	1								
1	1		1		1	1					
1	1										

Figure 2: Google sheets with availabilities

Formulation and Implementation

Constants

n - number of people

d - number of shifts ($2 \times$ number of days in the month)

t_j - $\begin{cases} 1 & \text{is night shift} \\ -1 & \text{is day shift} \end{cases}$

h_j - is shift j a high demand shift (Thursday, Friday, Saturday nights) (binary)

a_{ij} - is person i available at shift j

o_i - is person i a member of duty crew (non-observer)

c_i - is person i off campus

Formulation and Implementation

Decision Variables

x_{ij} - is person i assigned to shift j

b_j - penalty for if shift j has less than three people

m_i - penalty for if person i has less than 2 shifts

Objective Components

under utilization $= \sum_{i=1}^{n} m_i$

under staffed $= \sum_{j=1}^{d} h_j b_j + .2 \sum_{j=1}^{d} (1 - h_j) b_j$

shift imbalance $= \sum_{i=1}^{n} (\sum_{j=1}^{d} t_j x_{ij})^2$

Formulation and Implementation

$$\min \ 5 \cdot \text{under utilization} + 10 \cdot \text{under staffed} + \text{shift imbalance}$$

$$x_{ij} \leq a_{ij}$$

Assign to shift when available

$$b_j + \sum_{i=1}^{n} o_i x_{ij} = 2 \quad \forall j \in [d]$$

2 non observers

$$b_j + \sum_{i=1}^{n} x_{ij} \leq 3 \quad \forall j \in [d]$$

3 people per shift

$$m_i + \sum_{j=1}^{d} x_{ij} = 2 \quad \forall i \in [n]$$

no one is assigned more than 2 shifts

$$\sum_{i=1}^{n} c_i x_{ij} \leq 2 \quad \forall j \in [d]$$

no one than 2 OC

$$x_{ij} \in \{0, 1\}$$

Impact

- Scalability Beyond REMS (Chaus, Rec center, student-run clubs requiring event staffing, academic departments coordinating TA coverage, athletic teams managing practice schedules, campus security assigning patrol shifts)
- Key Learnings:
  - Balancing optimization with flexibility: Pure optimization doesn't always account for human factors like preferred shift partners
  - Modularity: Created a reusable framework for constraint-based scheduling problems
  - Trade off between simplicity of formulation and solve time: ultimately chose Quadratic Binary Programming because of small problem size