Work Smarter Not Harder

Optimal Scheduling for Quality Control Labs

Authors:
Michal Laskowski, Shannan Liu

Faculty Advisor:
Prof. Nikolaos Trichakis

Pfizer Mentors:
Caroline Daugherty, Abigail Garrett

6x
faster than current scheduling procedures

18%
decrease in the number of tests/reviews conducted

$1.6M
saved in analyst working hours per year

1. Problem Statement

Background

Quality Control Labs are **essential** to ensuring **safe** and **effective medication**

Objective

Develop a **personalized weekly schedule** for analysts working in labs

2. Project Scope

Lab #1

 # analysts:
15
 # samples:
~250 per week

Lab #2

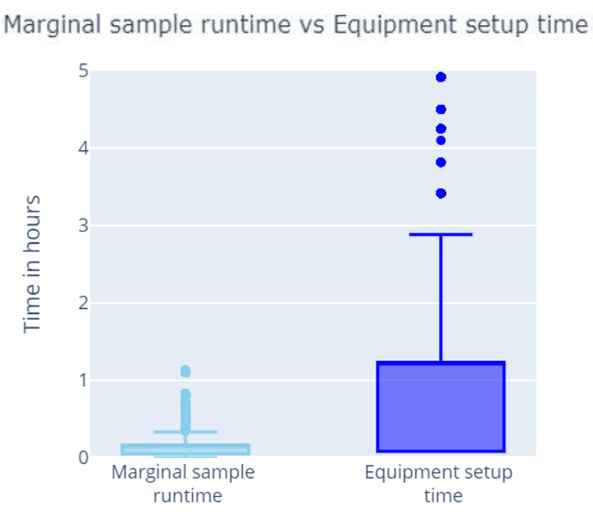
 # analysts:
28
 # samples:
~1 250 per week

3. Exploratory Data Analysis

Data

- **Demand** for quality control testing
- **Lab capabilities** e.g., # analysts
- **Testing** and **regulatory requirements**
- **Expected test/review time** per analysis

Grouping Samples is Critical



4. Current Approach

Lab-specific, heuristic scheduling, which requires **multiple manual procedures**

Limitations

Time consuming

Not optimal

5. Challenges

Lab-specific data format

Combining **scheduling and assignment** problems

6. Optimization

Decisions

- **When** a sample is **pulled** out of storage
- **Who tests** a sample and **when**
- **Who reviews** a sample and **when**

Objective

$$\min_{y,u,d,o,w} \underbrace{\alpha\Big(\sum_{a\in A}\sum_{g\in G}\sum_{t\in T}\sum_{j\in J} c^0_{g,j} y^j_{a,g,t} + \sum_{a\in A}\sum_{s\in S}\sum_{r\in R}\sum_{g\in G}\sum_{t\in T}\sum_{j\in J} c^1_{g,j} u^j_{a,s,r,g,t}\Big)}_{\text{Total estimated testing time}} +$$

$$\underbrace{+\,24(1-\alpha)\sum_{s\in S}\sum_{t\in T}(p_{s,1,t} - d_{s,1,t})}_{\text{Total cycle time}} + \underbrace{\sum_{t\in T}\sum_{a\in A}\lambda_1 o_{a,t}}_{\text{Penalty for overtime}} + \underbrace{\sum_{s\in S}\sum_{g\in G}\lambda_2 * \sum_{a\in A}(1 - w^{j_{end}}_{a,s,1,g,t_{end}})}_{\text{Penalty for late tests}}$$

Key decision variables

- $w^j_{a,s,r,g,t}$: binary, if process j is performed by analyst a on sample s of type r *by* time t
- $u^j_{a,s,r,g,t}$: binary, if process j is performed by analyst a on sample s of type r *at* time t
- $y^j_{a,g,t}$: integer, number of times a process j is performed by analyst a on a sample from group g *at* time t
- $o_{a,t}$: continuous, overtime of analyst a on day t
- $d_{s,r,t}$: binary, time t *by* which the final process for a specific sample s of type r is initiated

Key parameters

- c^0_g: sample setup cost of group g
- c^1_g: sample run time of group g
- $p_{s,r,t}$: 1 on and after the scheduled arrival date for each sample s of type r, and 0 otherwise
- λ_1: penalty for 1h of overtime
- λ_2: penalty for one sample not fully tested
- j_{end}: final process
- t_{end}: final day of optimization horizon

Constraints

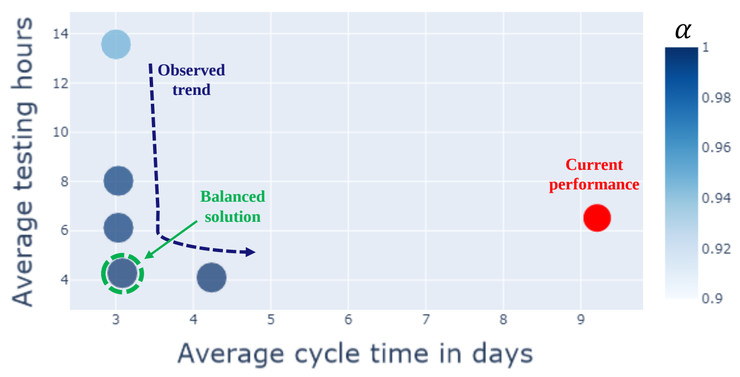
- Multiple **regulatory requirements**
- Various **lab testing conditions**

Robustified Against

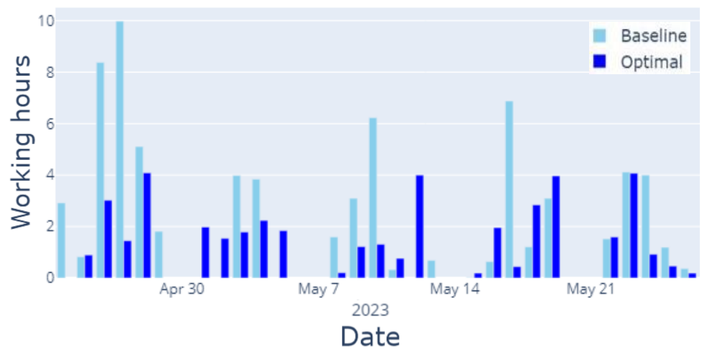
Potential longer test and **review times**

7. Results

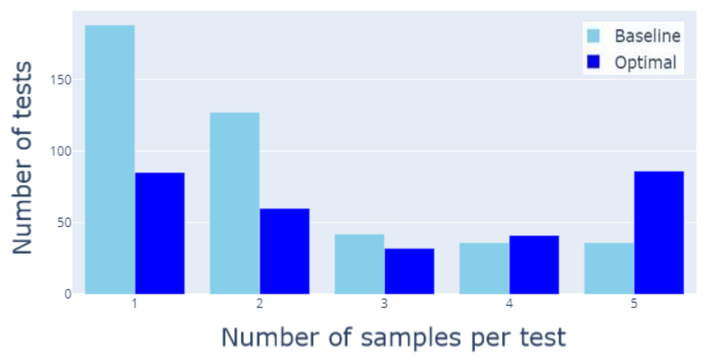
Trade-off: Testing Time vs Cycle Time



Analyst's Average Daily Working Hours

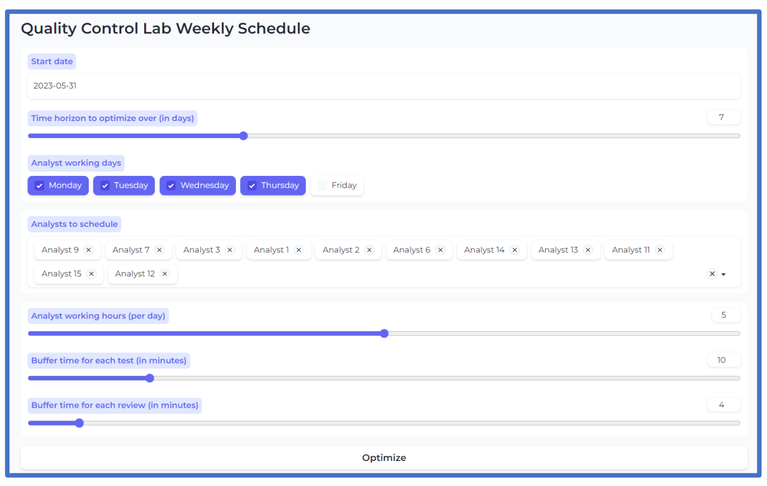


Samples per Test

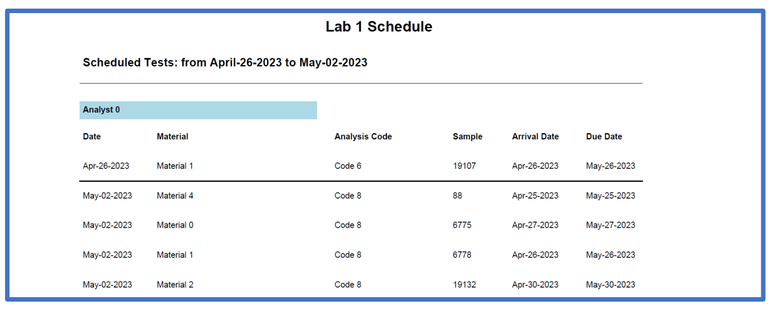


8. Scheduling Tool

User Interface



Personalized Weekly Schedule



Lab 1 Schedule

Scheduled Tests: from April-26-2023 to May-02-2023

Analyst 0

Date	Material	Analysis Code	Sample	Arrival Date	Due Date
Apr-26-2023	Material 1	Code 6	19107	Apr-26-2023	May-26-2023
May-02-2023	Material 4	Code 8	88	Apr-25-2023	May-25-2023
May-02-2023	Material 0	Code 8	6775	Apr-27-2023	May-27-2023
May-02-2023	Material 1	Code 8	6778	Apr-26-2023	May-26-2023
May-02-2023	Material 2	Code 8	19132	Apr-30-2023	May-30-2023

9. Future Work

- Extend the **number of** collaborating **labs**
- Perform a **sensitivity analysis for key components** of the process e.g., maximum testing size