CENTER FOR HEALTHCARE ENGINEERING & PATIENT SAFETY
UNIVERSITY OF MICHIGAN

2016 Healthcare Engineering and Patient Safety Symposium

Using Integer Programming to Build Block Schedules for Medical Residents

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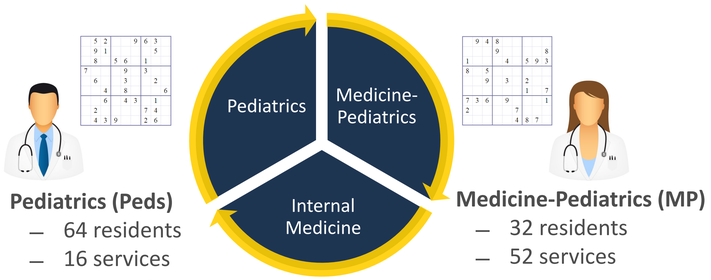
Problem Statement

The University of Michigan Medical School (UMMS) offers postgraduate medical training programs across many disciplines

Ensuring adequate resident education and proper service coverage requires many training programs to integrate schedules



Pediatrics (Peds)
- 64 residents
- 16 services

Medicine-Pediatrics (MP)
- 32 residents
- 52 services

Internal Medicine (IM)
- 136 residents
- 67 services

Coordinating the long-term block schedule – assigning every trainee to services over the year – is a complex challenge

Traditionally, program leadership (chief residents and program directors) constructs the block schedule by hand

The construction process is resource-intensive yet often fails to satisfy the individual & collective needs of stakeholders

Importance of Schedule Quality

Schedule quality impacts

Clinical/administrative workflow

Patient access, quality, safety, satisfaction

Training quality and burnout

Research Objective

Develop a decision support system to enable fast construction of high-quality block schedules while improving measures of quality

Solution Approach

Sets

R: residents
C: resident categories
S: services
M: months

Parameters

$a_{rc} \in \{0,1\}$: whether resident r fits category c

ℓ_{csm}, U_{csm}: lower, upper bounds on staffing of residents fitting category c in service s during month m

λ_{rs}, μ_{rs}: lower, upper bounds on months resident r must spend on service s

Decision Variables

$x_{rsm} \in \{0,1\}$: whether resident r is assigned to service s in month m $\forall\, r \in R, s \in S, m \in M$

Objective Function

$\min 0$

Constraints

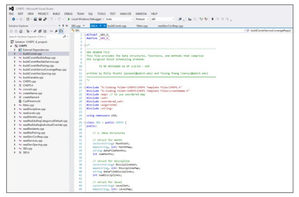
$$\sum_{s \in S} x_{rsm} = 1, \qquad \forall\, r \in R, m \in M$$

$$\lambda_{rs} \le \sum_{m \in M} x_{rsm} \le \mu_{rs}, \qquad \forall\, r \in R, s \in S$$

$$\ell_{csm} \le \sum_{r \in R} a_{rc} x_{rsm} \le U_{csm}, \qquad \forall\, c \in C, s \in S, m \in M$$

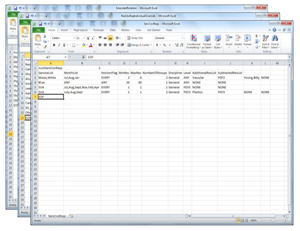
1. Formulate

One model, generalized to satisfy all 3 programs' needs



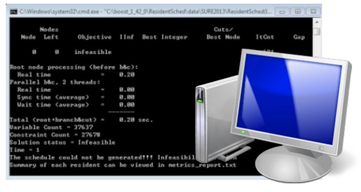
2. Encode

Written in C++ using CPLEX 12.4, implemented in Visual Studio 2012



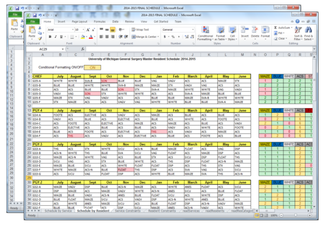
3. Load

Inputs provided in a collection of *.txt*, *.csv*, and *.xls* files



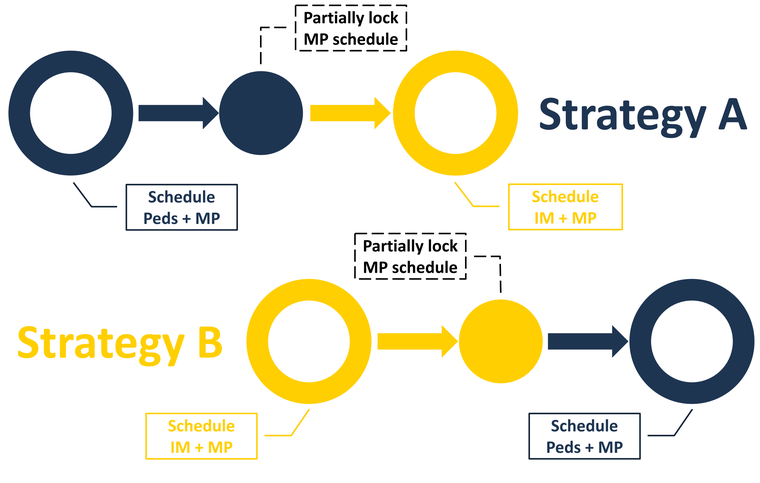
4. Solve

Software solves to optimality under input conditions



5. Review

Schedule and metric reports generated for presentation to administrators



Impact/Results

Facilitated concurrent scheduling of all 3 programs for first time

Enabled program leadership to more precisely specify scheduling needs compared to manual construction

Provided improved satisfaction (relative to prior years) regarding:
- vacation requests
- elective/research offerings
- fellowship interview and graduation conflicts
- schedule fairness
- pacing and challenging rotation sequences

Strategy A solves faster than Strategy B

Strategy B produces better quality than Strategy A

Ongoing Work

Evaluating alternative formulations for impact on solve time → **Speed**

Implementing additional metrics based on leadership feedback → **Quality**

Streamlining administrative and schedule revision processes → **Efficiency**

Acknowledgements

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