Algorithms to Generate Annual Rotation Schedules for Medical Residents

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Presentation outline

1. Motivation
2. Model
3. Solution approach
4. Conclusions
Scheduling affects...

...clinical and administrative workflow

...patient access, care quality, safety, and satisfaction

...training quality and burnout rates
Annual rotation schedules

Assign residents to services for lengthy periods to provide advanced training and patient care delivery

| Resident educational requirements | vs. | Service coverage demands |

Construction process requires \textit{coordination} across many stakeholders
Michigan Medicine

1,199 trainees

105 training programs

25 residencies

80 fellowships
Partner programs

Department of Surgery
[ 12 programs ]

Pediatrics
[ Peds ]

Medicine-Pediatrics
[ MP ]

Internal Medicine
[ IM ]
Traditional approach

Schedules for each residency **hand-built** by program director, chief resident(s), or other administrator

**Benefits**
1) Intimate program knowledge
2) Administrative consolidation
3) Streamlined approval process

**Drawbacks**
1) Time-consuming process
2) High cognitive demand
3) Limited consideration of tradeoffs
Research objective

Develop a decision support system to enable fast construction while simultaneously improving quality of annual rotation schedules
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Model

Minimize:
- Resident requests denied (ranked)
- Administrative preferences denied (ranked)
- Seasonal (interview, graduation) conflicts
- Burnout sequences
- Ambulatory credit variability

Subject to:
- Basic assignment rules
- Rotation duration
- Service coverage demands
- Resident education requirements
- Service spacing and sequencing
- Resident pairings
- Prohibitions and pre-assignments
Objective

Numerous metrics important to consider but no obvious objective function

Options:

Optimize metrics **hierarchically**
Optimize **weighted sum** of metrics
Something else?
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Setup

Encode the model in C++, using CPLEX 12.6

Gather rules, requests, and prepare input files for the respective partner programs
Dept. of Surgery model

- Department of Surgery
  - [12 programs]

- 175 residents
- 73 services
- 12 time periods
- 74 activities

Total Variables: FILL IN
Total Constraints: FILL IN
Integrated Solve Time: < 1 min
Peds – MP – IM model

Pediatrics [ Peds ]

Medicine-Pediatrics [ MP ]

Internal Medicine [ IM ]

245 residents
24 time periods
Total Variables 1,346,520

107 services
122 activities
Total Constraints 1,992,897

Integrated Solve Time 1 – 8 hrs
Sequential scheduling

- **Peds Solve Time**: < 1 min (✓)
  - Schedule Peds (w/ MP pre-assignments)

- **MP Solve Time**: < 1 min (✓)
  - Schedule MP only

- **IM Solve Time**: > 30 min (✗)
  - Schedule IM (w/ MP pre-assignments)
Improvement strategies

- Decompose senior and intern scheduling
- Two-stage scheduling
- Warm-starting solver
- Minimize iterative changes
Decompose senior/intern schedules

Senior Solve Time: 5 – 20 min

IM Solve Time: > 30 min

Intern Solve Time: < 5 min
Two-stage scheduling

**Stage 1**
Aggregate similar services with composite educational requirements and service demands

![Stage 1 Diagram]

- ID Elective

**Stage 1 Solve Time**  5 – 10 min

**Stage 2**
Decompose aggregated services and apply individualized requirements and service demands

![Stage 2 Diagram]

- OP ID
- UH ID
- VA ID

**Stage 2 Solve Time**  < 5 min
Warm-starting solver

1. Add subset of constraints to model
2. Solve model
3. Generate MIP warm start file
4. Repeat steps 1-3 until all constraints have been incorporated
Minimize iterative changes

After hierarchically optimizing metrics, minimize changes from previous draft

Reduces number of individual resident schedules that must be reviewed each iteration
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Impact

Introduced **coordinated** scheduling across 3 programs

Enabled greater **specificity** of scheduling needs compared to manual construction

Improved **satisfaction** (relative to prior years) regarding:

- resident requests
- schedule fairness
- elective/research matching
- pacing and challenging rotation sequences
- fellowship interview and graduation conflicts
Ongoing work

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

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

**Efficiency**
Streamlining administrative and schedule revision processes
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Questions and comments

Thank you!

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