Annual Block Scheduling for Residency Programs

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Presentation outline

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

...clinical and administrative workflow
Scheduling affects...

...training quality and burnout rates
Scheduling affects...

...patient access, care quality, safety, and satisfaction
Annual block scheduling

- Assignment of residents to services for advanced training and patient care delivery

- **Resident educational requirements**
  specialty, seniority, professional goals, etc.

- **Service coverage demands**
  patient mix, competencies, oversight, etc.

- Construction process requires **coordination**
  across many stakeholders
Medical training at Michigan Medicine

1,199 trainees
105 training programs
25 residencies
80 fellowships
Interdependent programs

- Pediatrics [Peds]
  - 3-year program
  - 72 residents
  - 15 services
- Medicine-Pediatrics [MP]
  - 4-year program
  - 33 residents
  - 8 services
  - [ + 8 Peds + 37 IM ]
- Internal Medicine [IM]
  - 3-year program
  - 140 residents
  - 84 services
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
Develop a decision support system to enable fast construction while simultaneously improving quality of block schedules.
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Model parameters

Sets

\( R: \) set of residents
\( S: \) set of services
\( T: \) set of time periods
\( A: \) set of activities

Decision variables

\[ x_{rst} = \begin{cases} 1, & \text{if assigning resident } r \text{ to service } s \text{ during time period } t \\ 0, & \text{otherwise} \end{cases} \]

\[ y_{rat} = \begin{cases} 1, & \text{if assigning resident } r \text{ to begin activity } a \text{ during time period } t \\ 0, & \text{otherwise} \end{cases} \]
Constraints

Basic assignment

\[ \sum_{s \in S} x_{rst} = 1, \quad \forall r \in R, t \in T \]

Rotation duration

\[ x_{rst} - \sum_{a \in A: s(a)=s} \sum_{p \in [\max(0, t-d_a+1), t]} y_{rap} = 0, \quad \forall r \in R, s \in S, t \in T \]

Service coverage

\[ L \leq \sum_{r \in R'} \sum_{s \in S'} \sum_{t \in T'} x_{rst} \leq U, \quad \forall (R', S', T') \in C \]

Resident education

\[ \lambda \leq \sum_{s \in S'} \sum_{t \in T'} x_{rst} \leq \mu, \quad \forall e \in E, (S', T') \in e \]

Service sequencing

\[ 0 \leq \sum_{i = 0}^{t-1} \sum_{s \in A^*} x_{rsi} - x_{r\beta t} \quad \forall t \in \{1, \ldots, |T| - 1\} \]

Service spacing

\[ y_{rAt} + \sum_{i=t+d_A}^{\min(t+d_A+g-1, T-1)} y_{rBi} \leq 1, \quad \forall t \in \{0, \ldots, |T| - 1 - d_A\} \]

Pre-assignments

\[ x_{r_n s_n t_n} = 1, \quad \forall n \in N \]

Prohibitions

\[ x_{r_o s_o t_o} = 0, \quad \forall o \in O \]
Metrics

- Undesirable assignments
- Burnout-risk sequences
- Ambulatory credit targets
- Graduation conflicts
- Fellowship interview conflicts
- N\textsuperscript{th} priority requests denied
- More…
Numerous metrics important to consider but no obvious objective function

Optimize metrics **hierarchically**, as determined by program leadership
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Problem size

- Integrated model
  - 245 residents
  - 107 services
  - 24 time periods
  - 122 valid activities

- Total Variables: 1,346,520
- Total Constraints: 1,992,897
- Solve Time: > 8 hrs
Improvement strategies

1. Decompose senior and intern scheduling
2. Sequential scheduling
3. Two-stage IM scheduling
4. Warm-starting solver
5. Minimize iterative changes
Sequential scheduling

Option A

- Schedule IM + MP
- Unlock part of MP schedule
- Schedule Peds + MP

Option B

- Schedule Peds + MP
- Unlock part of MP schedule
- Schedule IM + MP
Observations

Option B generates schedules faster than Option A

Option A produces better schedules than Option B
Two-stage IM scheduling

Stage 1
Aggregate like services with composite educational requirements and service demands

Stage 2
Decompose aggregated services and apply individualized requirements and demands
Observations

Stage 1 reduces to manageable size

Stage 2 solves rapidly
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 added
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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