Annual Block Scheduling for Residency Programs

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Presentation outline

I. 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





Interdependent programs



Traditional approach

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

Benefits

- I) Intimate program knowledge
- 2) Administrative consolidation
- 3) Streamlined approval process

Drawbacks

- I) 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

if assigning resident r to service s during time period t

 $\mathbf{x_{rst}} = \begin{cases} \mathbf{1}, & \text{if assigning resident } r \text{ to service } s \text{ during time period } t \\ \mathbf{0}, & \text{otherwise} \end{cases}$ $\mathbf{y_{rat}} = \begin{cases} \mathbf{1}, & \text{if assigning resident } r \text{ to begin activity } a \text{ during time period } t \\ \mathbf{0}, & \text{otherwise} \end{cases}$

Constraints

Basic assignment		$\sum_{s \in S} x_{rst}$	= 1,	$\forall r \in R, t \in T$
Rotation duration	$x_{rst} - \sum_{\substack{a \in A: \\ s(a)=s}} p \in$	$\sum_{i=[\max(0,t-d_a+1),t]} y_{rap}$	= 0,	∀r∈R,s∈S,t∈T
Service coverage	L ≤ Z	$\sum_{i \in R'} \sum_{s \in S'} \sum_{t \in T'} x_{rst}$	≤ U,	$\forall (\mathbf{R}', \mathbf{S}', \mathbf{T}') \in \mathbf{C}$
Resident education	$\lambda \leq$	$\sum_{s \in S'} \sum_{t \in T'} x_{r^e st}$	≤ μ,	∀ e ∈ E, (S′, T′) ∈ e
Service sequencing	$0 \leq \sum_{i=0}^{t-1}$	$\sum_{0}^{L} \sum_{s \in A^*} x_{rsi} - x_{r\beta t},$		$\forall t \in \{1,, T - 1\}$
Service spacing	y _{rAt} +	$\sum_{i=t+d_A}^{\min(t+d_A+g-1,T-1)} y_{rBi}$	≤ 1,	$\forall t \in \{0,, T - 1 - d_A\}$
Pre-assignments		x _{rnsntn}	= 1,	$\forall n \in N$
Prohibitions		x _{rosoto}	= 0,	$\forall o \in O$

Metrics

- Undesirable assignments
- Burnout-risk sequences
- Ambulatory credit targets
- Graduation conflicts
- Fellowship interview conflicts
- Nth 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
- Total Constraints
- Solve Time

1,346,520

- 1,992,897
- > 8 hrs

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

Sequential scheduling





Option B generates schedules **faster** than Option A



Option A produces **better** schedules than Option B



Two-stage IM scheduling

Stage I

Aggregate like services with composite educational requirements and service demands



Decompose aggregated services and apply individualized requirements and demands









Stage I reduces to manageable size



Stage 2 solves rapidly



Warm-starting solver

- I. Add subset of constraints to model \leftarrow
- 2. Solve model
- 3. Generate MIP warm start file
- 4. Repeat steps I-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 Implementi based on le

Implementing additional metrics based on leadership feedback

Efficiency Streamlining administrative and schedule revision processes

Thanks to the chief residents and program directors for their collaboration and to the students who have built this tool

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Questions and comments

Thank you!

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