



Medical Residency Annual Block Scheduling

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Presentation outline

1. Motivation

2. Model

3. Solution approach

4. Conclusions

Annual block scheduling

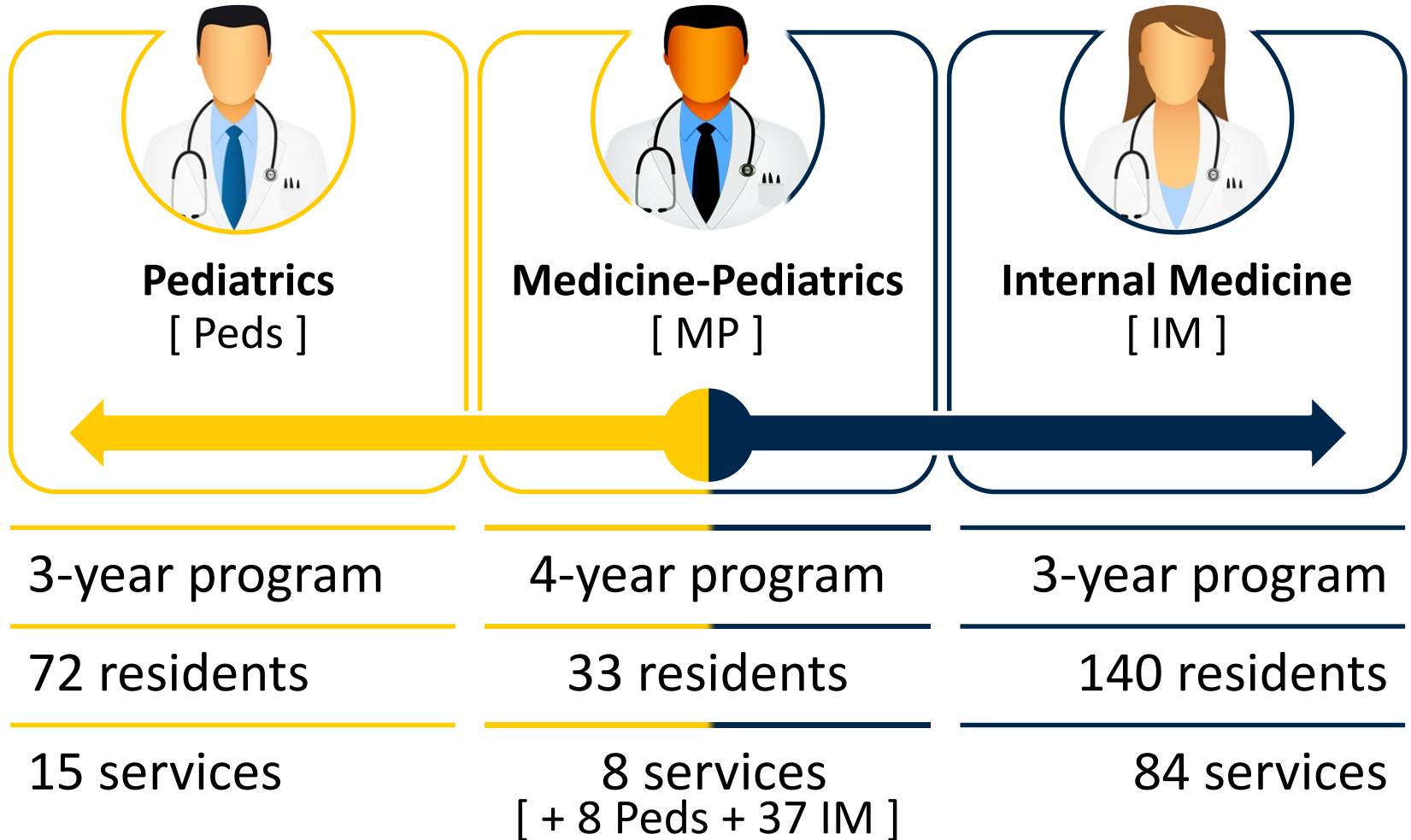
Assignment of residents to services for advanced training and patient care delivery

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

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

Construction process requires **coordination** across many stakeholders but typically **built by hand**

Interdependent programs



Research objective

*Develop a decision support system to enable **fast construction** of block schedules while **improving schedule quality***

Time



Quality



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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

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

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

Constraints

Basic
assignment

$$\sum_{s \in S} X_{rst} = 1, \quad \forall r \in R, t \in T$$

Rotation
duration

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

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

$$\lambda \leq \sum_{s \in S'} \sum_{t \in T'} X_{r^e st} \leq \mu, \quad \forall e \in E, (S', T') \in e$$

Service
sequencing

$$0 \leq \sum_{i=0}^{t-1} \sum_{s \in A^*} X_{rsi} - X_{r\beta t}, \quad \forall t \in \{1, \dots, |T| - 1\}$$

Service
spacing

$$Y_{rAt} + \sum_{i=t+d_A}^{\min(t+d_A+g-1, T-1)} Y_{rBi} \leq 1, \quad \forall t \in \{0, \dots, |T| - 1 - d_A\}$$

Pre-assignments

$$X_{r_n s_n t_n} = 1, \quad \forall n \in N$$

Prohibitions

$$X_{r_0 s_0 t_0} = 0, \quad \forall o \in O$$

Metrics

1. Undesirable assignments
2. Burnout-risk sequences
3. Ambulatory credit targets
4. Graduation conflicts
5. Fellowship interview conflicts
6. Nth priority requests denied (1st – 12th)
7. And more...

Objective

No obvious objective function but **numerous metrics** important to consider

Work through optimizing 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

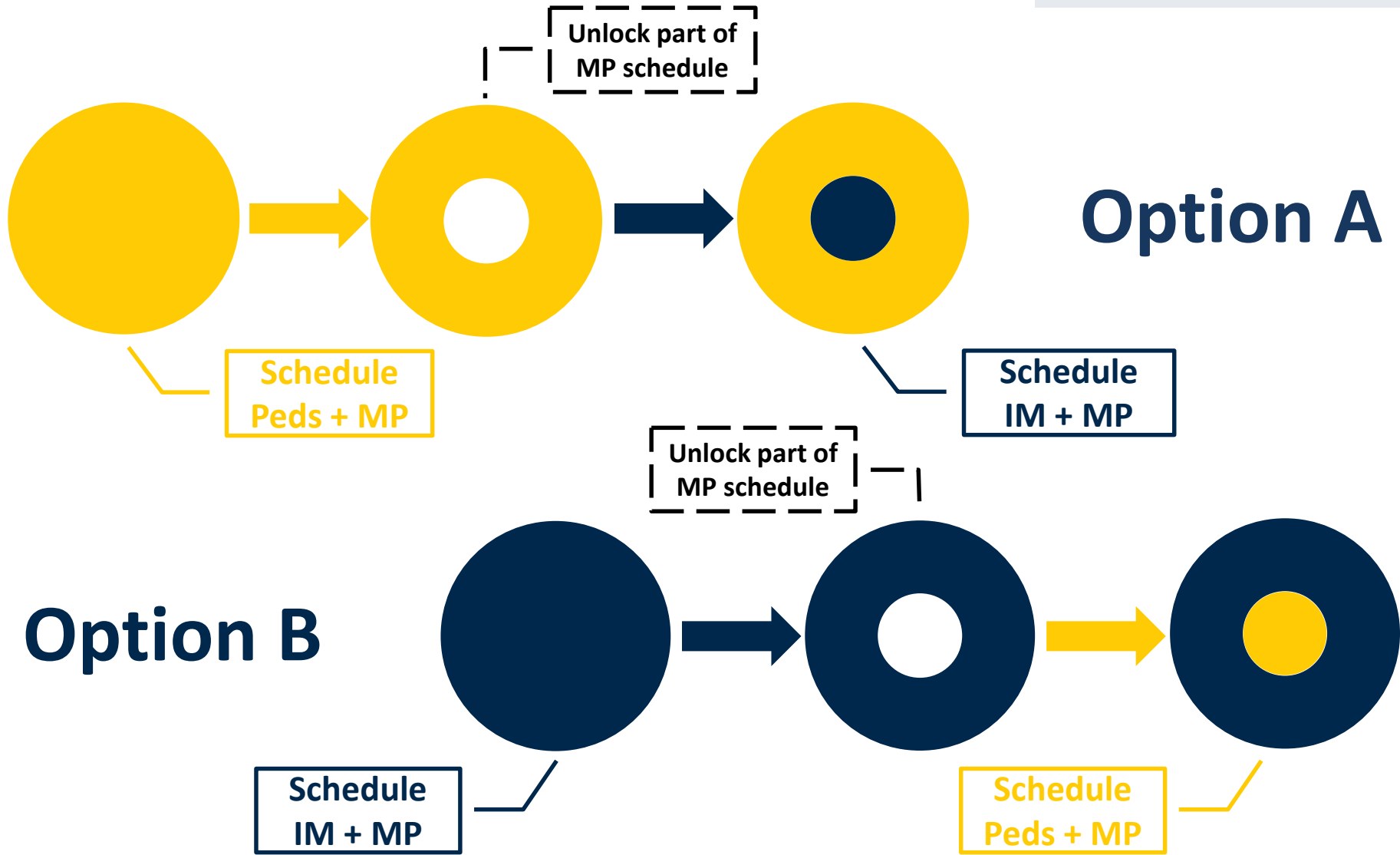
Total Constraints 1,992,897

Solve Time > 8 hrs

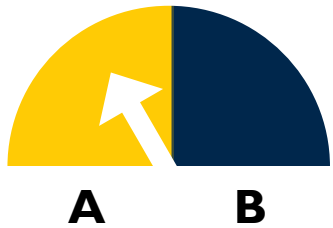
Improvement strategies

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

Sequential scheduling



Observations



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



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

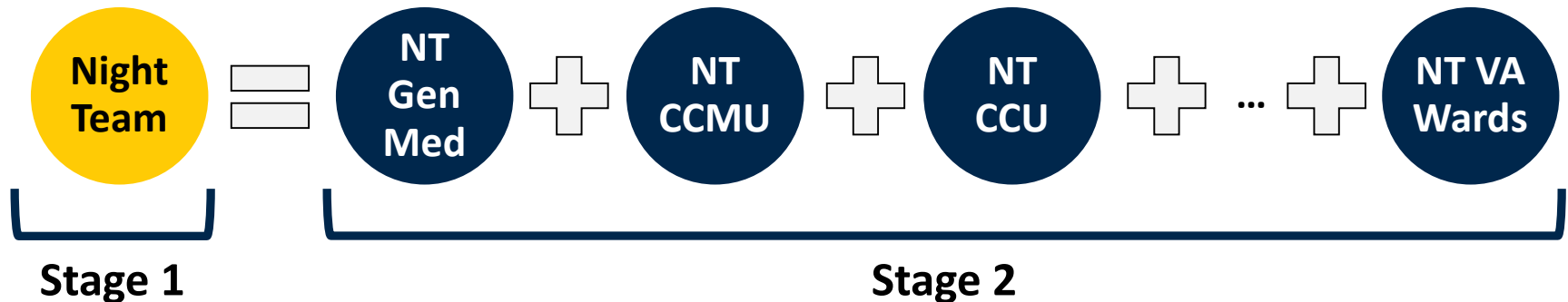
Two-stage IM scheduling

Stage 1

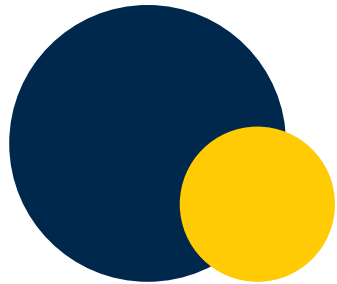
Aggregate like services with composite educational requirements and service demands

Stage 2

Decompose aggregated services and apply individualized requirements and demands



Observations



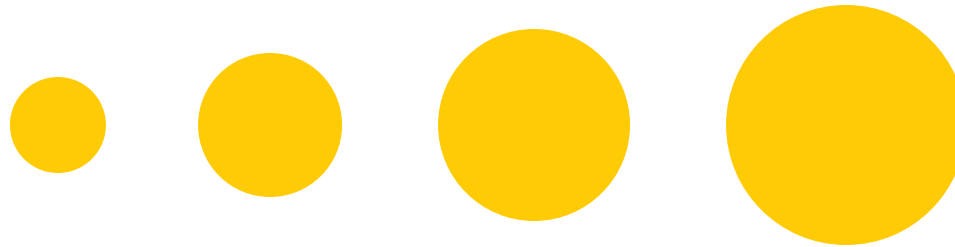
Stage 1 reduces to **manageable** size



Stage 2 solves **rapidly** – typically in less than 1 minute

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



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Impact

Introduced **coordinated** scheduling of all 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

Acknowledgements



Thanks to the **chief residents** and **program directors** who have collaborated with us

Thanks to the **students** who have built this tool

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Questions and comments

Thank you!

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