

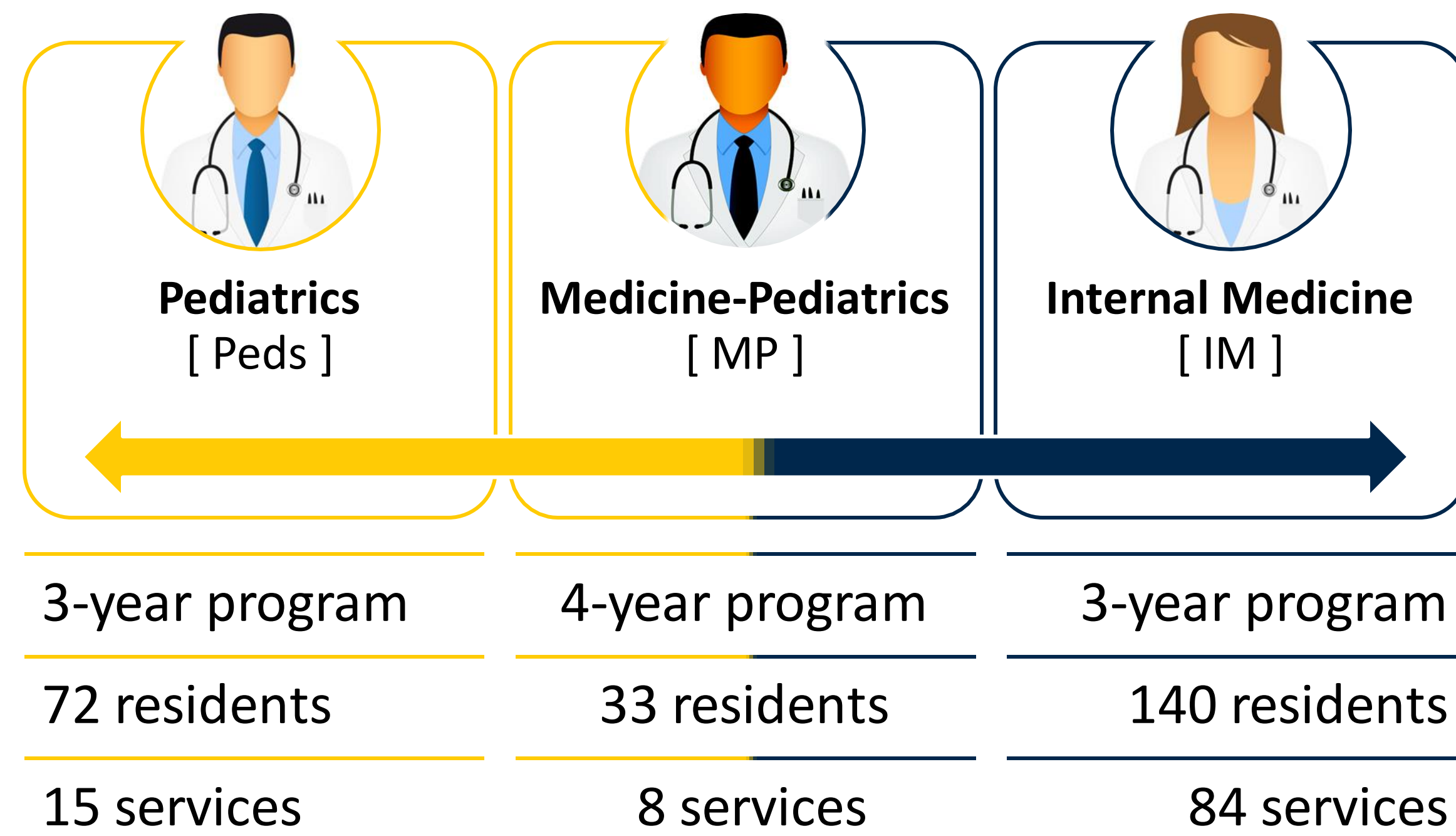
Annual Block Scheduling for Medical Residents

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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



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

Schedule quality impacts:



Research Objective

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



Solution Approach

Model

Basic assignment $\sum_{s \in S} x_{rst} = 1, \forall r \in R, t \in T$

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

Service coverage $L \leq \sum_{r \in R'} \sum_{s \in S'} \sum_{t \in T'} x_{rst} \leq U, \forall (R', S', T') \in C$

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

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

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

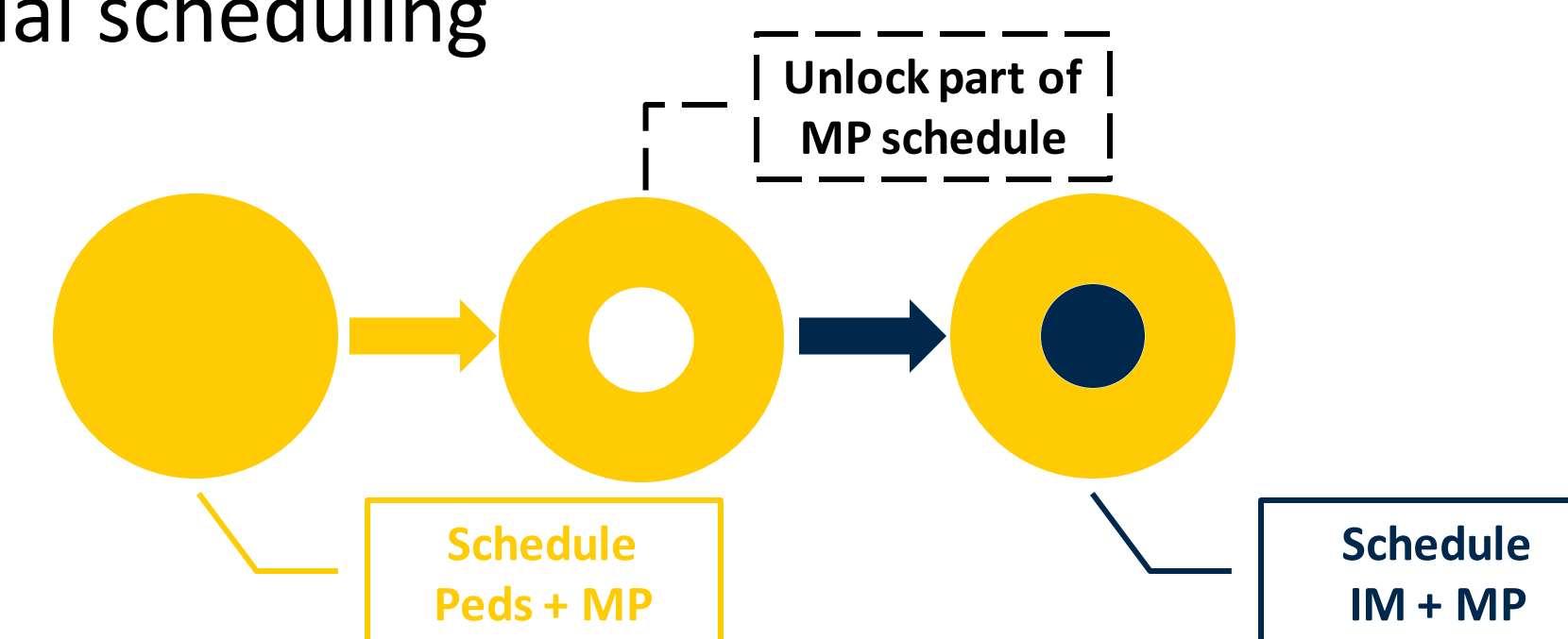
Pre-assignments $x_{r_n s_n t_n} = 1, \forall n \in N$

Prohibitions $x_{r_o s_o t_o} = 0, \forall o \in O$

Problem Size 245 residents | 107 services | 24 time periods
Total Variables 1,346,520
Total Constraints 1,992,897
Solve Time > 8 hours

Solve Time Reduction Strategies

- Decompose senior and intern scheduling
- Sequential scheduling



- 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

- Warm-starting solver

- Add subset of constraints to model
- Solve model
- Generate MIP warm start file
- Repeat steps 1-3 until all constraints added

Conclusions

Impact

Introduced schedule **synchronization** across 3 residency programs

Enabled greater **specificity** of resident and service needs, relative to manual construction

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

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

Provided significant **real-world impact** on quality of schedules and patient care

Lessons Learned

Collaboration is key to getting the details right, obtaining buy-in, and implementing successfully

Variable definition dictates **tractability** as scope expands

Iterative rule construction produces overall **solve time reduction**

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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