

# **Algorithms to Generate Annual Rotation Schedules for Medical Residents**

**William Pozehl  
Amy Cohn**

**October 23, 2017  
INFORMS | Houston, TX**

# Presentation outline

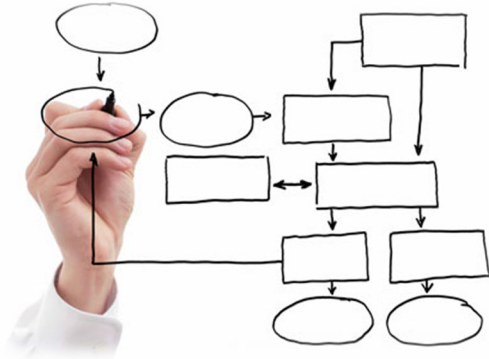
**1. Motivation**

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 **coordination** across many stakeholders


# Michigan Medicine





CENTER FOR  
HEALTHCARE ENGINEERING & PATIENT SAFETY  
UNIVERSITY OF MICHIGAN




# 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*

**Time**



**Quality**





# Presentation outline

1. Motivation
- 2. Model**
3. Solution approach
4. Conclusions

# 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?

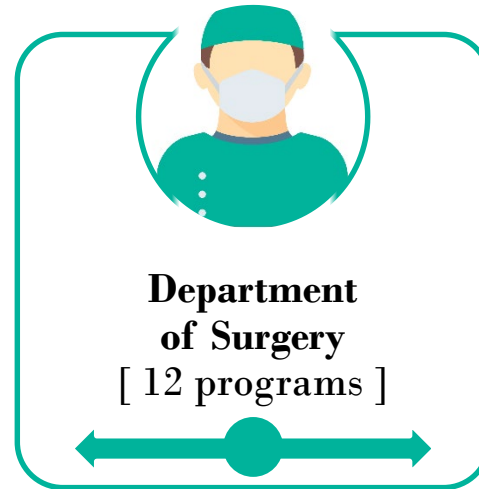
# Presentation outline

1. Motivation
2. Model
- 3. Solution approach**
4. Conclusions

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



175 residents                      73 services  
12 time periods                      74 activities

**Total Variables**

***FILL IN***

**Total Constraints**

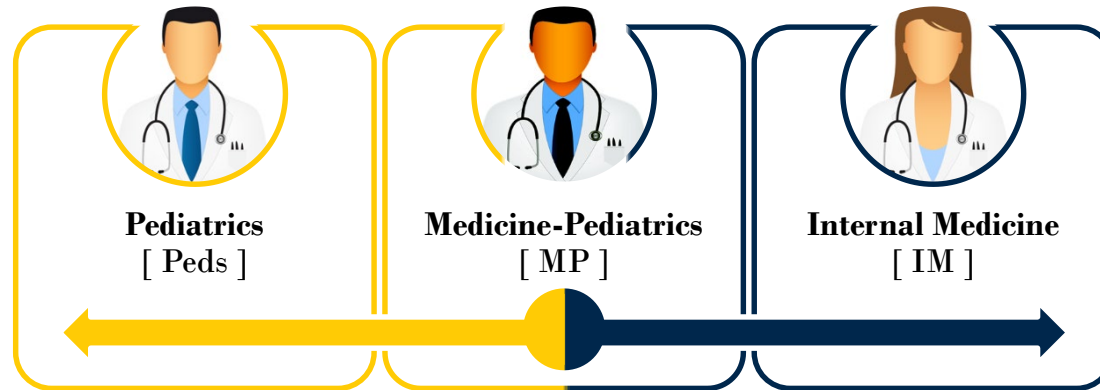
***FILL IN***

**Integrated Solve Time**

**< 1 min**



# Peds – MP – IM model



245 residents  
24 time periods

107 services  
122 activities

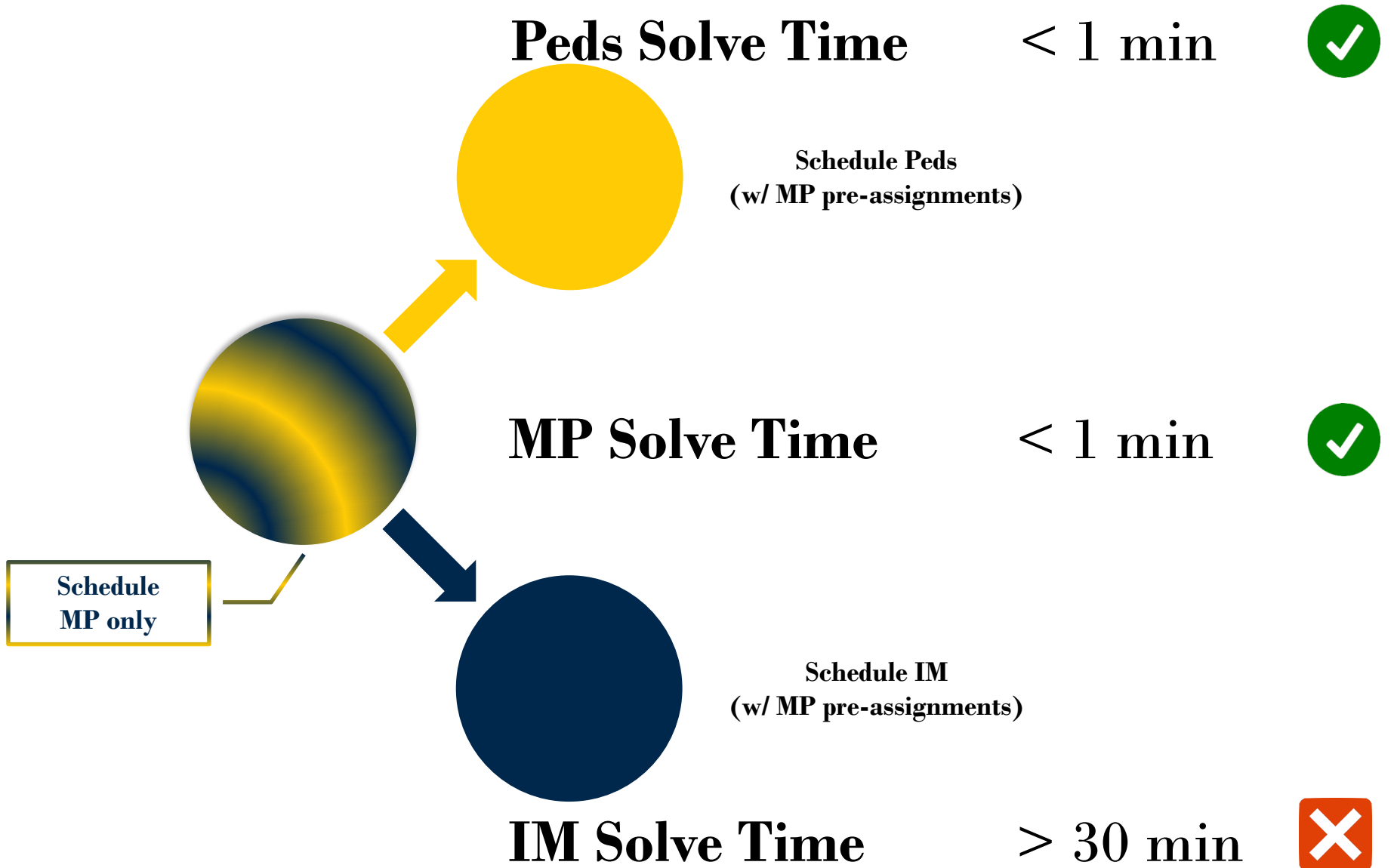
**Total Variables** 1,346,520

**Total Constraints** 1,992,897

**Integrated Solve Time** 1 – 8 hrs



# Sequential scheduling

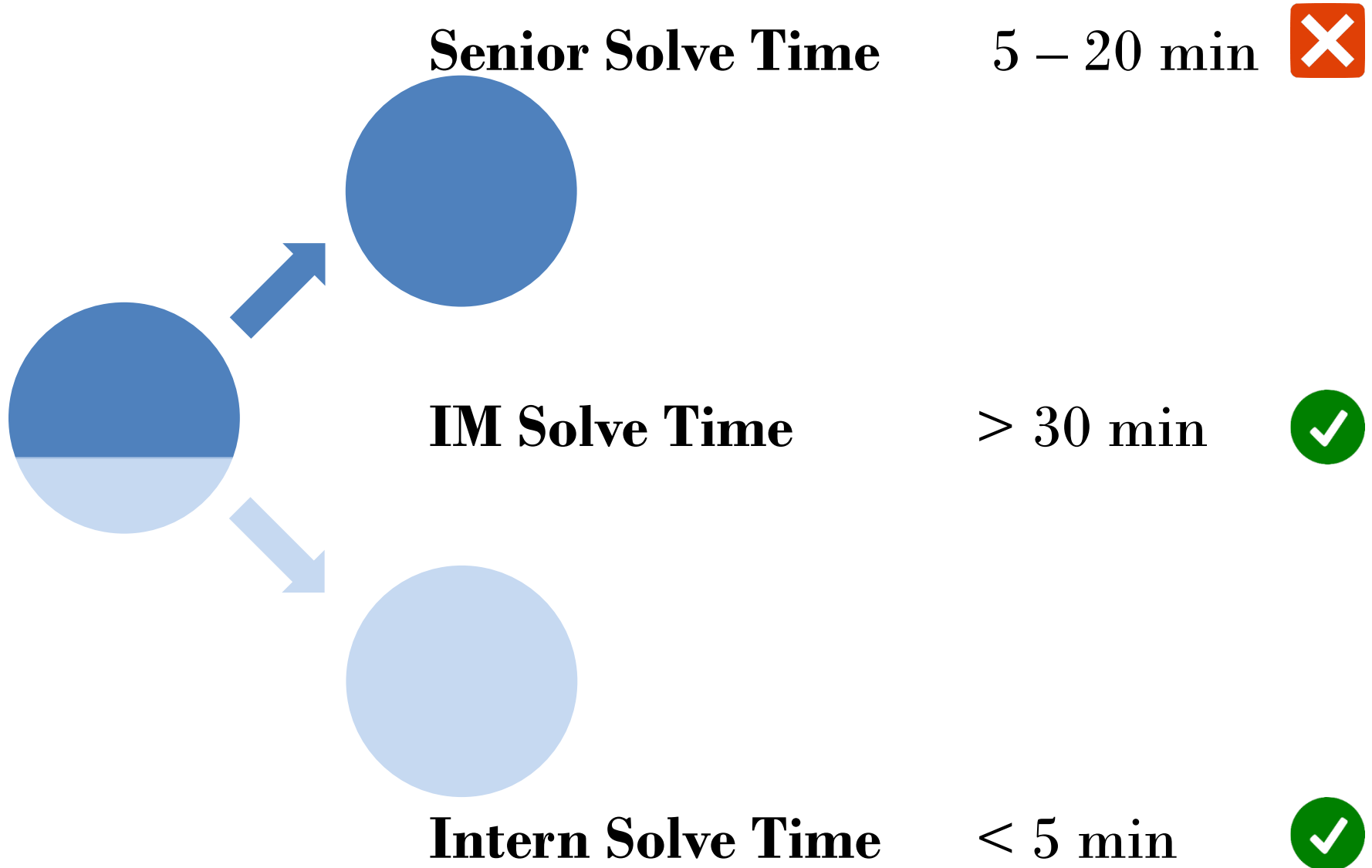




# Improvement strategies

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

# Decompose senior/intern schedules



# Two-stage scheduling

## Stage 1

Aggregate similar services with composite educational requirements and service demands



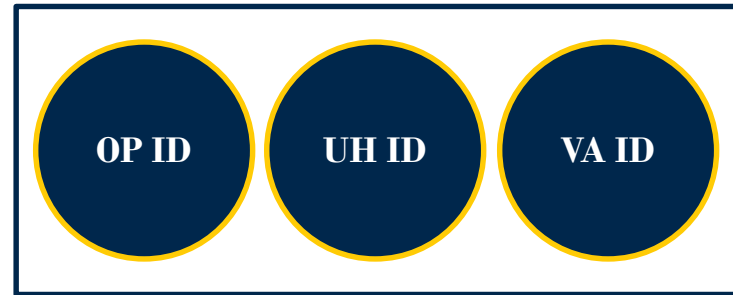
Stage 1

Stage 1 Solve Time 5 – 10 min



## Stage 2

Decompose aggregated services and apply individualized requirements and service demands



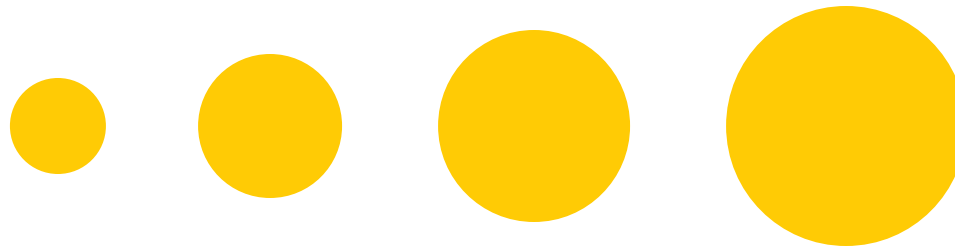
Stage 2

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

# Presentation outline

1. Motivation
2. Model
3. Solution approach
- 4. Conclusions**

# 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



# Acknowledgements



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

Special thanks for the generous support from



# Questions and comments

Thank you!

---

Contact Information:

William Pozehl | [pozewil@umich.edu](mailto:pozewil@umich.edu)

Amy Cohn | [amycohn@umich.edu](mailto:amycohn@umich.edu)