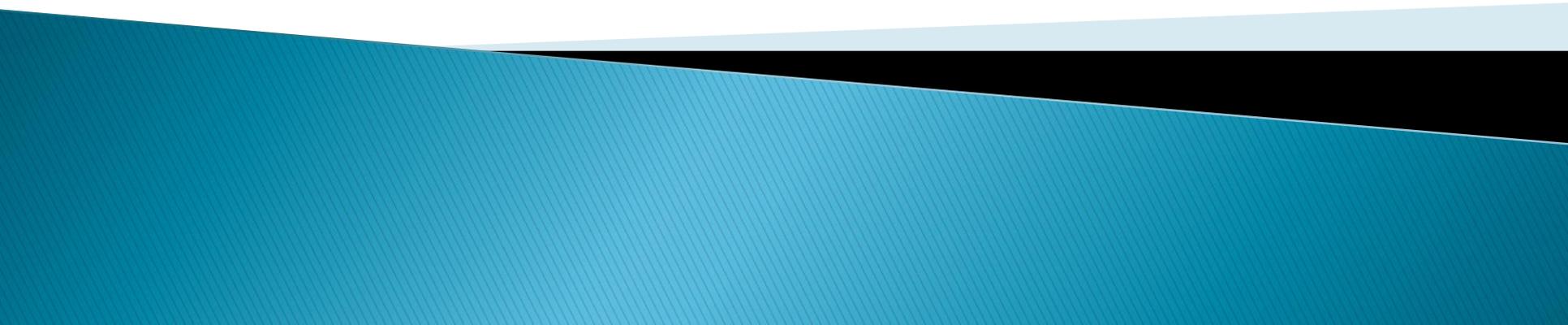


# Scheduling Problems in Medical Residency

CHEAR Seminar Series

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# Acknowledgements

- ▶ Ongoing collaborative work with many key players and talented contributors
  - Spring team
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    - Dr. Brian Jordan
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  - Winter team
    - Dr. Brian Jordan
    - Jinshuai Guo, ...?

# Background: Amy Cohn, CHEPS

- ▶ Associate Professor in IOE, 10<sup>th</sup> year at UM
- ▶ Research focus is on applied combinatorial optimization problems
  - Mainly scheduling and sequencing
  - Originally focused primarily on aviation applications
  - More recently, focusing more and more on healthcare applications
- ▶ In June took on role of Associate Director for the new Center for Healthcare Engineering and Patient Safety (joint initiative between Med School and CoE)

# What is medical residency?

- ▶ Transition period between medical school and fully independent/unsupervised practice
  - Four years of med school
  - First year of residency – “Intern”
  - Two more years of residency
  - Possibly one or two additional years as “Chief Resident”
  - Possibly more years as a “Fellow”
- ▶ During all of this time, providing patient care (albeit with the oversight of a more senior “attending” physician –supervision decreases over time)

# What is medical residency?

- ▶ A key issue: Dual role of residency
  - Learning experience: Residency (and Fellowship) are parts of the medical education training process
  - Patient care: Residents/Fellows provide a significant amount of the patient care in teaching hospitals and the associated clinical system
- ▶ A typical resident might engage in all of the following activities:
  - “Continuity clinics”
  - Shifts on service
  - Seminars, formal educational activities
  - Research

# Inherent Time Conflicts

- ▶ How to schedule residents' time
  - Need adequate patient coverage with a limited pool of residents
  - Need adequate training opportunities
  - Need adequate rest – fatigue increases risk of error
  - Need to address resident satisfaction, personal life
- ▶ Not just quantity of hours but pattern
  - Continuity of care
  - Sleep issues (especially associated with overnight shifts)
  - Opportunities for different medical experiences

# Residency Scheduling

- ▶ Two types of scheduling
  - Block scheduling
  - Shift scheduling
- ▶ Shift scheduling:
  - Given a time horizon
  - Given a set of shifts per day
  - Given a set of residents (heterogeneous set)
    - Residency program
    - Seniority
  - Assign residents to staff these shifts

# Hard Constraints

- ▶ The following are rules that “must” be satisfied
- ▶ Resident perspective:
  - At least 10 hours off after every shift
  - At least one day off per week (averaged over a month)
  - Respect pre-scheduled vacation time
  - Min and max number of shifts per month
  - Start and end dates (moving from one service to another – interns shift earlier to overlap with the more experienced senior residents)
  - Continuity clinics

# Hard Constraints

- ▶ The following are rules that “must” be satisfied
- ▶ Shift perspective:
  - Minimum and maximum number of residents per shift
  - Resident characteristics (e.g. some shifts must have a senior resident)
  - Overlapping shift pairs – one of the two must come from the Peds program

# Metrics

- ▶ There are some things that are not hard requirements, but we still care about
- ▶ Resident perspective:
  - How many night/weekend shifts worked
  - Post-clinic shifts
  - Day-off requests
  - Equity across residents
- ▶ Shift perspective:
  - Optional shifts covered
  - Continuity of care/Continuity of training

# Two Critical Factors

- ▶ Number of residents is set and fixed externally (i.e. a program can't independently increase the number of residents to increase staffing)
- ▶ ACGME (American College of Graduate Medical Education) limits the amount of duty hours, patterns and frequency of time off, etc.
  - Have made some major increase to limitations in the past
  - Current talk about further tightening of restrictions
- ▶ This means there is not a lot of slack in the system, and it's likely to get worse

# Why is this hard?

	6		1		4		5	
		8	3		5	6		
2								1
8			4		7			6
		6				3		
7			9		1			4
5								2
		7	2		6	9		
	4		5		8		7	

- ▶ The more squares you fill in, the fewer choices you have left for what is valid
- ▶ Once you make a mistake, you might not know it for a long time
- ▶ Once you realize something is wrong, it can be very hard to back track and correct

# Current State

- ▶ Schedules typically built by Chief Residents
- ▶ Limited decision support
- ▶ No formal training
- ▶ Hard to satisfy all rules
- ▶ Unlikely to make everyone happy

# Our Approach

- ▶ This is exactly what we do!
  - Combinatorial optimization
  - Lots of interactions
  - Need a systematic approach to consider all parts concurrently

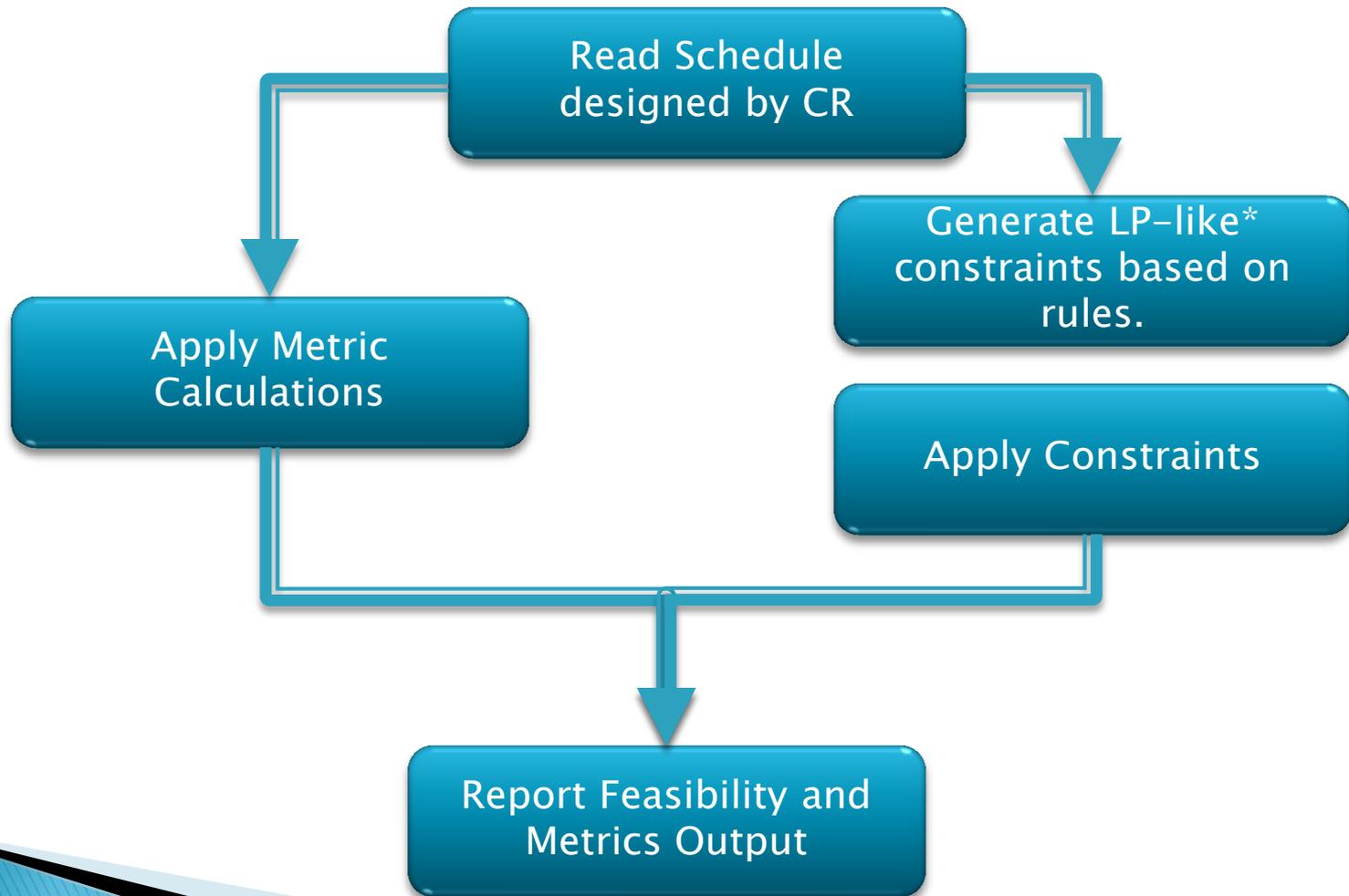
# Step 1: The Validator

- ▶ Identify all errors
- ▶ Report all metrics
- ▶ Key is in translating real-world rules into *linear programming* “language”
- ▶ We let  $x_{rsd}$  represent the information of whether resident  $r$  is assigned to work shift  $s$  on day  $d$
- ▶ Then:

$$\sum_{r \in R} x_{rsd} = 1$$

is true if and only if there is exactly one resident assigned to work shift  $s$  on day  $d$

# Validator



# Step 2: The Generator

- ▶ Create a schedule from scratch that satisfies all rules
- ▶ Instead of plugging in values into our equations, let the system determine the values

# Step 3: The Optimizer

- ▶ Focus is on soft constraints
- ▶ How to make trade-offs?
  - Weights are problematic
- ▶ Instead, set values for metrics and iterate

# Optimizer

- ▶ Input data
- ▶ Set metrics
- ▶ Solve
  - If feasible, tighten metrics and repeat
  - If infeasible, loosen metrics and repeat
- ▶ Finalize schedule by hand-modifying
- ▶ Send through Validator to make sure hand-modifications are ok

# Enhancements

- ▶ Sleep issues
- ▶ Robustness
- ▶ Suggesting Pareto-dominant solutions

# Where to go next

- ▶ Make operational/sustainable/affordable for Peds Emergency Medicine at UM
- ▶ Expand to other programs' Peds Emergency Medicine service
- ▶ Expand to other Peds services (e.g. NICU scheduling)
- ▶ Expand to other fields of residency (eg psych, surgery...)

# Why should we care?

- ▶ Started off working in this area as a favor
- ▶ Continued working initially because of the mathematics – application was interesting but impact seemed limited
  - More time for Chief Resident
  - Residents happier about getting schedule preferences

# Why should we care?

- ▶ Now, I'm seeing impact in lots of different ways
  - ACGME tightening → Manual process shifts from (a) hard work to get a good schedule to (b) hard work to get a not very good schedule to (c) hard work and still don't have a schedule!
  - Continuity clinics
  - Sleep issues – applicable to attendings/faculty as well as residents
  - Continuity of care (e.g. resident/attending pairing)
  - Matching schedule with (stochastic) rare opportunities

