Scheduling Problems in Medical Residency

CHEAR Seminar Series

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  - **Winter team**
    - Dr. Brian Jordan
    - Jinshuai Guo, ...?
Background: Amy Cohn, CHEPS

- Associate Professor in IOE, 10th 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
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
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?

- 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

1. Read Schedule designed by CR
2. Apply Metric Calculations
3. Generate LP-like constraints based on rules.
4. Apply Constraints
5. Report Feasibility and Metrics Output
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 (e.g. psych, surgery…)

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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