Block Scheduling for a Pediatric Residency Program

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My Collaborators

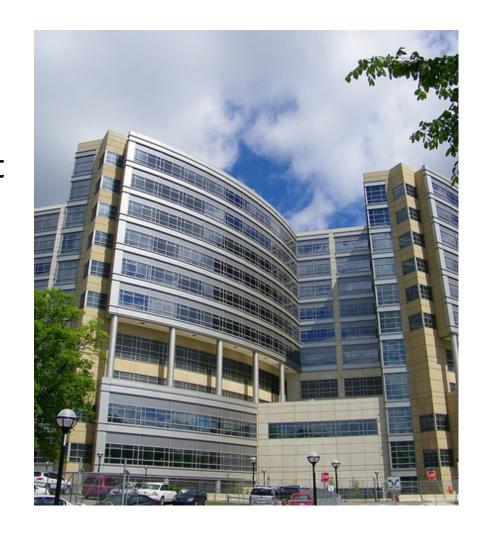
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Presentation Outline

- Background
- Motivation
- Model Formulation
- Model Implementation
- Results
- Future Work

Pediatrics at Michigan

- Based in C.S. Mott Children's Hospital
- Around 100 residents at Motts every year
- The hospital is very diverse in the programs it offers



Services in Pediatrics

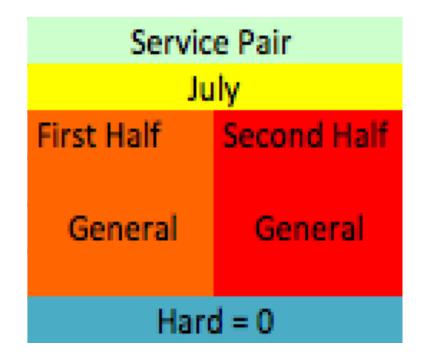
- There are many different areas in Mott that residents must gain experience in:
 - E.g. Neonatal Intensive Care Unit (NICU), General Care, Hematology & Oncology (HemOnc)
- Every month each of these services must be adequately staffed and there is a minimum and maximum number of residents allowed in each service

Residency at Michigan

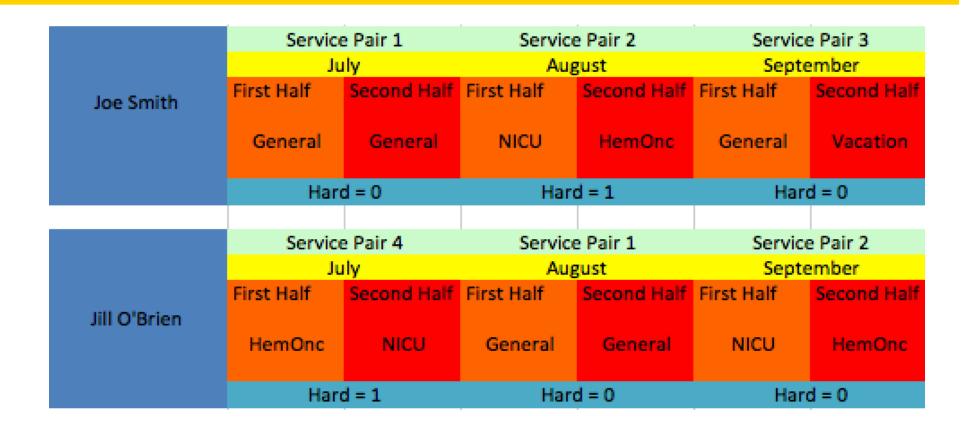
- After four years in medical school the students are "matched" to a residency program
- These first year residents are called "interns"
- After the first year they become "senior residents"
- Every resident has a minimum and maximum amount of time (in half months) that they must spend in each service
- We were tasked with compiling a block schedule for just the interns

Service Pairs

- A cuplet of services that can be worked during the same month.
- The first service in the pair is worked for the first half of the month and the second service is worked for the second half of the month
- Different examples of service pairs could be:
 - General/general or NICU/general
- Different combinations can also be determined as hard or not



What is a Block Schedule?



Assigning service pairs to residents over the course of a year

NOTE: vacation as a service



Motivation

• Before:

- Block Schedule was compiled by hand by the chief resident
 - This took a lot of time
 - If changes needed to happen after a draft was completed they had to rewrite the entire schedule

Now:

- A computer program compiles the schedule in less than 5 minutes
- Changes are effortless

Sets:

R: set of all residents that need to be scheduled

P: set of all service pairs

S: set of all services that need residents

M: set of months

D: set of desires. this is a list given to us by the chief resident that details the residents vacation requests

 $p_{si} \subset P$ subset of service pairs P that have service S in half-month i where $i \in \{0, 1\}$

 $h_p \subset P$: set of pre-defined hard service pairs

 $C_d \subset D$: set of candidate assignments for desire D

Parameters:

 q_{ps} the number of half-months of service s that are in service pair $p \quad \forall s \in S, p \in P$

 b_p if service pair p is difficult 1, if easy $0, \forall p \in P$

 u_{sm} : an upper bound for the number of residents service s needs in month $m \quad \forall s \in S, m \in M$

 l_{sm} : a lower bound for the number of residents service s needs in month $m \quad \forall s \in S, m \in M$

 u_{rs} : a upper bound for the number of months required on service s for the year $\forall s \in S, r \in R$

 l_{rs} : a lower bound for the number of months required on service s for the year $\forall s \in S, m \in M$

 l_d : a lower bound for the number of desires filled for month $\forall m \in M$

 u_d : an upper bound for the number of desires filled for month $\forall m \in M$

Decision Variables:

 X_{rpm} : Whether or not resident r is scheduled to service pair p on month $m \quad \forall r \in R, p \in P, m \in M$

 Y_{rm} : Whether or not resident r works 3 or more hard services in a row beginning on month $r \in R$

Z: Helper variable for maximum number of times a resident works 3 difficult shifts in a row.

Objective Function: <u>Variable Restrictions:</u>

Constant
$$X_{rtm} \in \{0,1\}$$

 $Y_{rm} \in \{0,1\}$
 $Z \in (R)$

$$\sum_{p \in P} X_{rpm} = 1 \qquad \forall r \in R, m \in M :$$

Each Resident is assigned one service pair per month

$$\sum_{p \in P} X_{rpm} = 1 \qquad \forall r \in R, m \in M :$$

$$l_{sm} \le \sum_{p \in P_{si}} X_{rpm} \le u_{sm} \qquad \forall m \in M, s \in S, i \in 0, 1$$

Each service has at least the minimum number of residents but no more than the Maximum, for all half months

$$\sum_{p \in P} X_{rpm} = 1 \qquad \forall r \in R, m \in M :$$

$$l_{sm} \leq \sum_{p \in P_{si}} X_{rpm} \leq u_{sm} \qquad \forall m \in M, s \in S, i \in 0, 1$$

$$l_{rs} \leq \sum_{p \in P} \sum_{m \in M} q_{ps} * X_{rpm} \leq u_{rs} \qquad \forall r \in R, s \in S$$

Each resident has at least the minimum number of months in each service but no more than the maximum, for all months

$$\sum_{p \in P} X_{rpm} = 1 \qquad \forall r \in R, m \in M :$$

$$l_{sm} \leq \sum_{p \in P_{si}} X_{rpm} \leq u_{sm} \qquad \forall m \in M, s \in S, i \in 0, 1$$

$$l_{rs} \leq \sum_{p \in P} \sum_{m \in M} q_{ps} * X_{rpm} \leq u_{rs} \qquad \forall r \in R, s \in S$$

$$b_t X_{rpm} + b_t X_{rp(m+1)} + b_t X_{rp(m+2)} \leq Y_{rm} + 2$$

Y is equal to 1 if resident r works more than 3 'hard' service pairs in a row

$$\sum_{p \in P} X_{rpm} = 1 \qquad \forall r \in R, m \in M :$$

$$l_{sm} \leq \sum_{p \in P_{si}} X_{rpm} \leq u_{sm} \qquad \forall m \in M, s \in S, i \in 0, 1$$

$$l_{rs} \leq \sum_{p \in P} \sum_{m \in M} q_{ps} * X_{rpm} \leq u_{rs} \qquad \forall r \in R, s \in S$$

$$b_t X_{rpm} + b_t X_{rp(m+1)} + b_t X_{rp(m+2)} \leq Y_{rm} + 2$$

$$Z \geq \sum_{m \in M} Y_{rm} \qquad \forall r \in R$$

Z is equal to the maximum number of times a resident works 3 difficult services in a row

$$\begin{split} \sum_{p \in P} X_{rpm} &= 1 \qquad \forall r \in R, m \in M: \\ l_{sm} &\leq \sum_{p \in P_{si}} X_{rpm} \leq u_{sm} \qquad \forall m \in M, s \in S, i \in 0, 1 \\ l_{rs} &\leq \sum_{p \in P} \sum_{m \in M} q_{ps} * X_{rpm} \leq u_{rs} \qquad \forall r \in R, s \in S \\ l_{t} X_{rpm} + l_{t} X_{rp(m+1)} + l_{t} X_{rp(m+2)} \leq Y_{rm} + 2 \\ Z &\geq \sum_{m \in M} Y_{rm} \qquad \forall r \in R \\ l_{d} &\leq \sum_{c \in C_{d}} X_{r(c)p(c)m(c)} \leq u_{d} \qquad \forall d \in D \end{split}$$

The amount of desired vacation requests filled in a schedule must be in between the upper and lower bounds

Model Implementation

- We coded the model into a c++ program with the help of the cplex library
- The Chief resident submitted input files specifying the interns, services, service pairs and their upper and lower bounds
- Our program read in the input files and then using their data produced a block schedule for the pediatric department interns

Results

- We created a block schedule for 27 interns for this current year in under 5 minutes per run
- We saved the chief resident countless hours in schedule making
- We found a more optimal schedule than the chief resident could have on her own

Future Work

- We want to integrate all types of resident regardless of their year in the program so that we can optimize the total schedule
- We are restructuring our model to make it more user friendly and easier to understand

Questions?

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