A Novel Approach To Speed Up The Identification Of A Feasible Solution To The Residency Block Scheduling Problem

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Rx

A prescription to address system complexity in healthcare

INNOVATING HEALTHCARE DELIVERY

FOSTERING LEARNING

BUILDING COMMUNITY

POSITIVE IMPACT THROUGH...

Research
Education
Implementation
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Introduction

Overview

- Consider a personnel scheduling problem that assigns residents in a medical school to different service-specified rotations during the academic year.
- Due to the large-scale nature and problem complexity, **constructing a feasible schedule could be extremely time consuming** by conventional approaches, even using commercial solvers.
- The latency issue may delay the deployment of the finalized schedule, since an interactive, iterative framework is used to deal with the multi-criteria objectives nature. On the other hand, it could severely impact the solution quality, which consequently could impact the quality of care patients will receive.

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Rotation

A *rotation* is specified by a service and a duration in terms of blocks.

That is, assigned residents should do the specific service for the given number of blocks consecutively.

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Assign each resident to a sequence of rotations during a given planning horizon, where specific requirements are satisfied.

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Example

CCU	AMB	AMB	ELEC	ER	CCMU
July	August	September	October	November	December

VACA	ELEC	NICU	NICU	CCU	ER
January	February	March	April	May	June

- **Resident Education Requirements**
  - Ensure residents receiving appropriate training for fulfilling their own educational goals
  - On individual resident; typically across the whole planning horizon
  - E.g. Resident A must have at least 2 but no more than 4 blocks of AMB service during the whole acedemic year
- **Service Coverage Requirements**
  - Ensure the units staffed appropriately for providing care to patients
  - Across a group of residents; typically on a single service and a single block
  - E.g. Service ER needs to be covered by exactly 3 residents from first-year IM program, during November

Side Constraints: Service Duration Requirements; Resident Pairing Rules; Spacing Rules; Sequencing Rules; Prohibitions; Pre-assignments

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- Solving the integer program for real-world instances through the conventional Branch-and-Bound process, even without any objective, takes a huge amount of time

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	Time1	Time2	$\cdots$	Time24
Resident1			$\cdots$	
Resident2			$\cdots$	
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$
ResidentN			$\cdots$	

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3. The Great Amount of "Symmetries"

Proposed Approach

Motivation

Key Observations:

- If the coupling constraints that are imposed across residents, e.g. the ones corresponding to Coverage Requirements, are removed from the formulation, the integer program can be solved in a flash.
- Some services are tough to schedule. For example, a specific service requiring exactly 5 residents, where 3 of them must be from 3rd-year IM, one is from 4th-year MP, while the other one is from 3rd-year Peds, **introduce more difficulties**, in terms of coordinating with the educational requirements, than another service which is okay to be covered by 2 to 10 residents from any level and program.

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Try to fix the assignments of those tough services to their respective correct spots, through optimizing a "sub-problem" with a very limited coupling constraints. Then, try to arrange the assignments of the rest, easier services, to complete the scheduling.

Proposed Approach

High-level Description

- **(Stage 0)** Identify the toughest services by a network-based model, which builds the relationship of different services in terms of satisfying the provided Coverage Requirements. The identification is then achieved by isolating the core nodes of the network.
- **(Stage 1)** Formulate a same integer program as the original one, but only incorporating a small subset of coverage constraints, where those selected toughest services are involved in. The objective function is designed to work as a guidance to leave as much room as possible for the assignments of the remaining services. Solve the program to get a "desirable" solution.
- **(Stage 2)** Fix the assignments of the selected services based on the solution to Stage 1 (through additional constraints), restore all unenforced coverage constraints, and try solving the updated integer program to feasibility.

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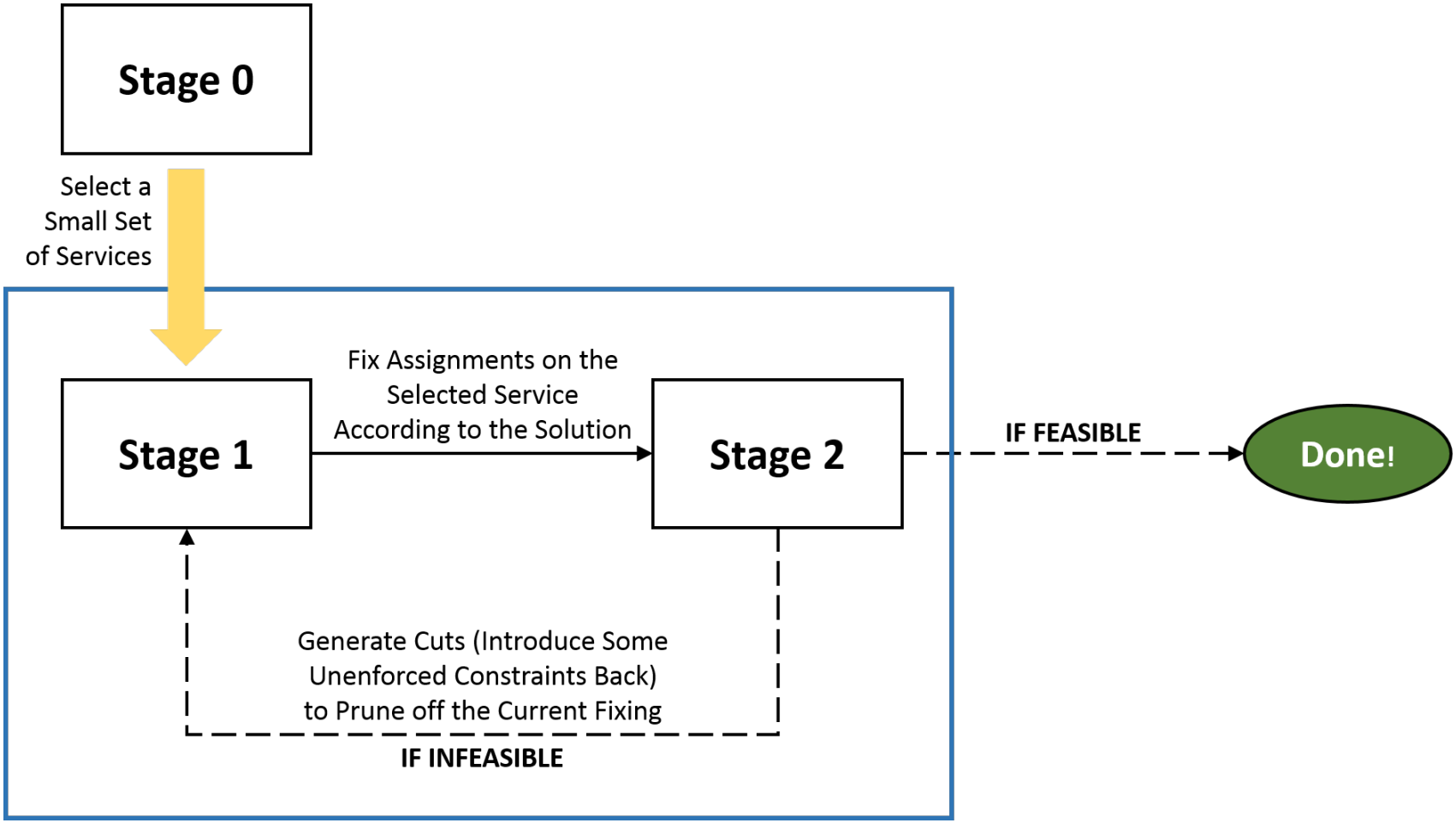

Preliminary Experiments

- Instance Info

Residents	Services	Blocks	Colns	Rows	Runtime
249	92	24	1.2M	1.8M	1900 sec

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- Results Summary (12 trials)
  - **Service Selection**: 3 - 5 among the top ones from Stage 0
  - **Config**: 3 minutes limitation with a 1% optimality gap for Stage 1
  - **Iterations**: single iteration for 10 of 12 trials; Max 3 iterations
  - **Total Time**: 500 sec in average; Min 250 sec; Max 940 Sec
  - **Improvement**: all trails achieved a better performance than the conventional approach, where the runtime is at least halved.

Future Work

- Investigation on how to more precisely isolate an effective combination of services in Stage 0
- Additional mechanisms in Stage 1 to ensure we fix the assignments of the selected services in the correct spots
- Research on different cut generation approaches when Stage 2 results in infeasibility
- Incorporation of the original objectives into the whole proposed framework, to pursue a feasible solution with better quality if possible, without impacting the computational performance.

Thank You for Your Attention

Q & A