

AI-assisted Schedule Explainer for Nurse Rostering

AAMAS 2020 Demo #8

Kristijonas Čyras^{†*}, Amin Karamlou^{†1}, Myles Lee^{†2}, Dimitrios Letsios^{†3},
Ruth Misener[†], Francesca Toni[†]

May 9–13, 2020

[†]Imperial College London, ^{*}Ericsson Research, ¹University of Texas at Austin, ²Oracle Inc., ³King's College London

(K. Čyras, A. Karamlou, M. Lee, D. Letsios have carried this research while at Imperial, but at the time of publication are no longer affiliated with this institution)

[Research supported by EPSRC projects **EP/P029558/1** and **EP/M028240/1**.

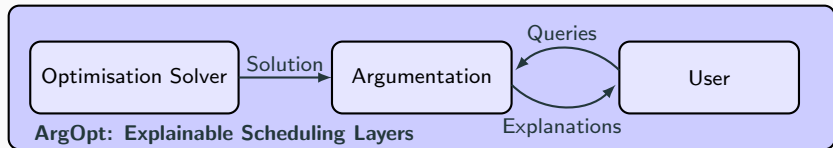
The authors are grateful to Gabriella Long (UK NHS & Institute of Global Health Innovation) for extensive feedback on nurse rostering in clinical centres.]

Argumentation-supported Schedule Explainer

- A tool for explainable makespan scheduling with application to nurse rostering in clinical settings
- Theory (ArgOpt)
 - K. Čyras, D. Letsios, R. Misener, F. Toni:
[Argumentation for Explainable Scheduling](#) 
AAAI [Čyras et al., 2019]
- Implementation
 - Stand-alone ArgOpt tool github.com/mylestunglee/aes 
 - Interactive Schedule Explainer for Nurse Rostering
github.com/AminKaramlou/AESWebApp 

Argumentation for Explainable Scheduling

Argumentation – explainable abstraction paradigm for reasoning with incomplete and conflicting information

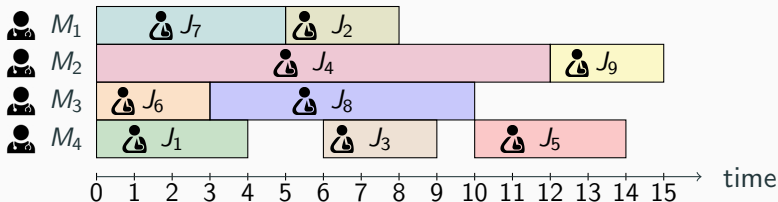


Methodology to explain makespan scheduling

- Mathematical constraints translated into argumentation
- Explanations defined, fulfil formal desiderata
- Actionable explanations presented in natural language

Optimisation: Makespan Scheduling

Example: nurse rostering



Input

- Set $\mathcal{J} = \{J_1, J_2, \dots, J_n\}$ of jobs
- Job J_j has a processing time p_j
- Set $\mathcal{M} = \{M_1, M_2, \dots, M_m\}$ of machines
- Machine-dependent deadlines, user decisions etc.

Objective: Construct a schedule S with minimum makespan

Challenge: Explain and Make Interactive



$$C_i \leq T_i$$

$$\sum_{M_i \in \mathcal{M}} x_{i,j} = 1$$

$$\sum_{J_j \in \mathcal{J}} x_{i,j} \cdot p_j \leq C_i$$

$$x_{i,j} = 1$$

$$x_{i,j} \in \{0, 1\}$$

$$M_i \in \mathcal{M}$$

$$J_j \in \mathcal{J}$$

$$M_i \in \mathcal{M}$$

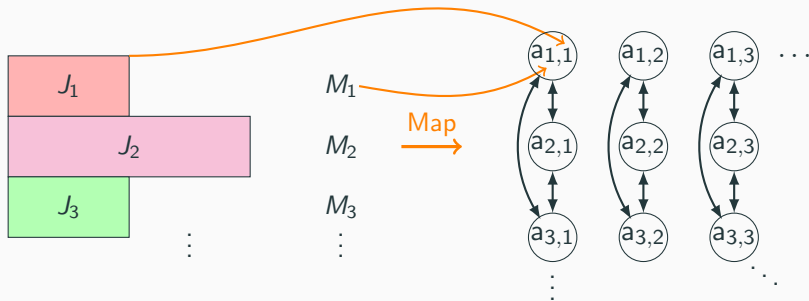
$$(i, j) \in D$$

$$J_j \in \mathcal{J}, M_i \in \mathcal{M}$$

- How about nurse M_i takes care of J_ℓ instead of J_j ?
 - Is it feasible, efficient? (Optimisation properties)
 - If enacted, what are the repercussions? (Improving solution)

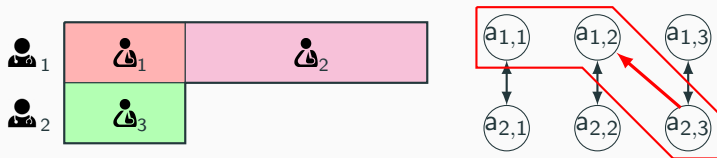
Mapping Scheduling Problems to Argumentation Frameworks

An abstract argumentation framework models decisions with arguments, and incompatibilities with attacks:



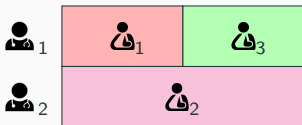
- Assignments $x_{i,j}$ become arguments $a_{i,j}$
- $a_{i,j}$ attacks $a_{k,l}$ iff $i \neq k$ and $j = l$
 - Different machines compete for the same job
- Stable extensions are 'good' schedules

Nurse: Can I Do This?



The attack from $a_{2,3}$ to $a_{1,2}$ explains why $\{a_{1,1}, a_{1,2}, a_{2,3}\} \approx S$ is not stable and thus S is not efficient:

Because S can be improved by swapping jobs 3 and 2 between nurses 2 and 1.



Stand-alone ArgOpt Tool

Schedule Explainer

Problem

Randomise Load Save

Number of machines: 3

Processing times:
A: 1
B: 2
C: 3
D: 4
E: 5
F: 6

Negative fixed decisions

Positive fixed decisions

Schedule

Optimise Randomise Load Save

1: A B C D
2: D
3: E F

Explanation

Schedule is not feasible because:
- Jobs E and D can be swapped with machines (1, 2)
Schedule does satisfy user fixed decisions
- All jobs satisfy all fixed decisions
Schedule is not efficient because:
- Job E can be allocated from machine 3 to 2 to reduce by 1.0
- Jobs E and D can be swapped with machines 3 and 2 to reduce by 1.0
- Job F can be allocated from machine 3 to 2 to reduce by 1.0
- Jobs F and D can be swapped with machines 3 and 2 to reduce by 1.0

Actions

Unassign job D with machine 1
Unassign job D with machine 2

Explain Save Apply

AI-assisted Schedule Explainer for Nurse Rostering

BLOOD TEST IS NOT ALLOCATED TO ANY NURSE.

The screenshot displays a grid of four nurse rostering panels, each representing a different nurse: Alice, John, Mai, and Ruban. Each panel shows a task with a duration and suggested actions.

- Alice:** Task: Blood test (12 mins). Suggested Actions: [Action 1], [Action 2].
- John:** Task: Measles vaccination (30 mins). Suggested Actions: [Action 1].
- Mai:** Task: Administer antibiotics (33 mins). Suggested Actions: [Action 1].
- Ruban:** Task: Intravenous drip (20 mins). Suggested Actions: [Action 1], [Action 2].

Each panel includes a 'New job name' and 'New job type' input field and an 'ADD NEW JOB' button. The 'Blood test' task is highlighted in red, indicating it is not allocated to any nurse.

References



Čyras, K., Letsios, D., Misener, R., and Toni, F. (2019).

Argumentation for Explainable Scheduling.

In *33rd AAAI Conference on Artificial Intelligence*, pages 2752–2759, Honolulu, Hawaii. AAAI Press.