Scheduling under uncertainty: attaining Flexibility, Robustness and Stability

Dissertation talk
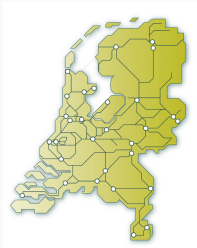
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Agenda

In this presentation

1. Introduction & motivation
2. Overview of contributions
3. Specifics of contribution 1
4. Specifics of contribution 2
5. Conclusion & discussion

Scheduling of operations, or tasks, or activities, under uncertainty

Inspired by a real-world problem as experienced by NedTrain

- That part of NS that handles fleet-maintenance
- Maintenance workshops distributed over the Netherlands

Introduction - in the workshop

The weekly scheduling process

- Thousands of maintenance tasks over several trains
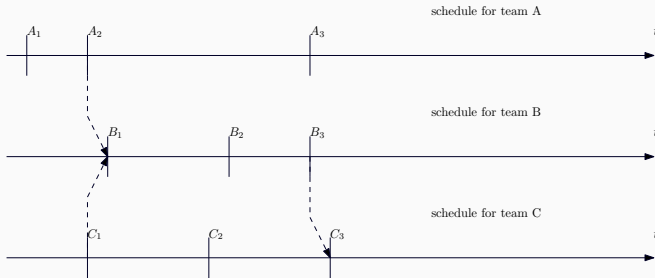- Resources: people, equipment, platforms, etc.
- Train delivery deadlines

Human resources organized into autonomous teams

- Members of a team can communicate freely
- Cross-team communication is an issue

Scheduling complications
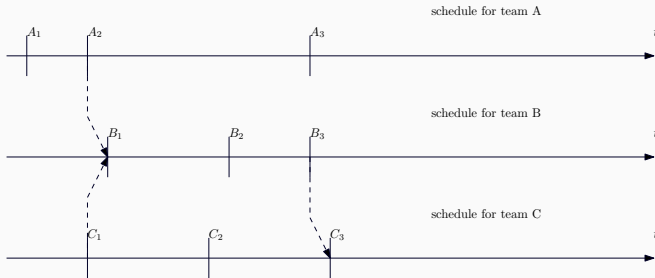
Uncertainty complicates scheduling

- Conditional repair tasks
- Uncertain task durations:
  $\rightarrow$ how much time to allocate? $\rightarrow$ when to start?

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Schedule by hand and keep adapting accordingly

Our contributions

~~Schedule by hand and keep adapting accordingly~~

- People hate to be directed by a schedule that changes repeatedly
- Deadlines are compromised

We contribute two scheduling techniques: offer management two alternatives for dealing with the aforementioned scheduling challenges

1. Let people reschedule themselves at will
   - ... but ensure no conflicts in autonomous decisions
2. Do create a schedule that directs people
   - ... but ensure it remains unchanged during execution

Approach 1

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- assigns a time-window to each task
- facilitates a "temporal decoupling"

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Create a "flexible" or "interval" schedule, instead of a regular schedule

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Teams can freely choose within the provided time-windows

- no need to account for choices of other teams
- scheduling constraints always satisfied

Objective: maximize the amount of "flexibility" offered (i.e. width of those time-windows)

Approach 1 – example

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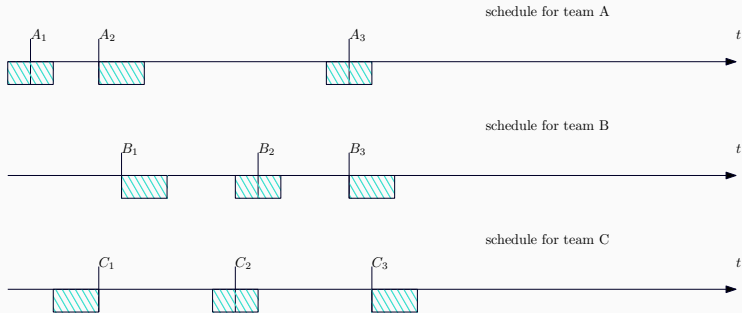
Approach 2

First approach does not make use of the following:

- Variety of maintenance tasks is limited
- We have a "sample" of task durations

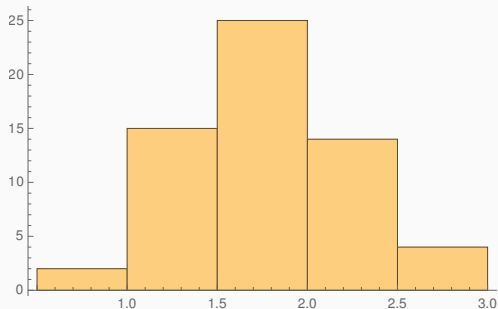Durations are uncertain but not completely unpredictable!

Approach 2

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Durations are uncertain but not completely unpredictable!

Example

Approach 2

Main idea:
Use data from past sessions to model task durations as random variables with a distribution
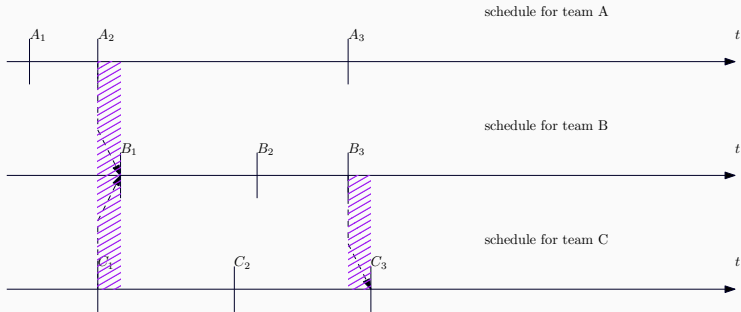
Create a (regular) schedule that is "stable" and "robust"
... for this *particular* model of uncertainty

- stable: it won't change much
- robust: trains will most likely be delivered on time

Leverage precise knowledge of uncertainty to allocate "slack"

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Conclusion & Discussion

Flexible schedules vss. Robust/stable schedules?

- Needs further discussion
- Finding the answer might be a project in itself

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Future work

- Try to combine the two approaches
- Experiment with NedTrain data
- Other
  - Variations of flexible schedules ("provisional" schedules)
  - How to "help" flexibility by careful allocation of resources to tasks
  - Team-level, instead of task-level, temporal decoupling

Questions?