## **Increasing the Capacity of Shunting Yards** within the Current Infrastructure: **A Computational Perspective**



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i.k.hanou@tudelft.nl

Issa K. Hanou, Sebastijan Dumančić, Mathijs de Weerdt, Paul van der Voort, Roel van den Broek, Marjan van den Akker

• Railway hub planning: given the timetable, create rolling stock planning surrounding railway hub with both stations and shunting





yards/service sites

- Create a tool to aid human planners
  - Examples of abstract models
  - and their relations
  - Including all details very hard
    - Unrealistic computation times
    - Need real-time updates
    - Hard to interpret for humans

Pebble Motion problem on a Tree with Arrival and Departure			
Add servicing $\downarrow$	Add matching $\begin{vmatrix} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $	Add splitting/c	$ombining \downarrow$
Relaxation: no servicing	Train Unit Shuntin with Service Scl	ıg Problem heduling	Restriction: no free tracks
Add ongoing traffic $\downarrow$	$Add \ personnel \downarrow$	$Add \ un$	$certainty \downarrow$
Detailed Railway Hub Planning problem			

- Combine logical reasoning with machine learning
- Learn patterns from previous situations





- Milestones to reach
- Sequence of operations to combine
- Common allocations to include
- Algorithmic speedup or human explanation
- RV RECOV
- Translate hub layout to graph • Generate unsafe intervals
- Navigate through safe intervals
- Recover plan in nanoseconds
- Ready for new delays in seconds



a) Railway layout and scenario

b) Safe intervals for left train

Navigate trains

from site to

station

ProRail

Start t=100

Hanou, Thomas, Ruml & de Weerdt. (2024). Replanning in Advance for Instant Delay Recovery in Multi-Agent Applications: Rerouting Trains in a Railway Hub. 34<sup>th</sup> International Conference on Automated Planning and Scheduling.

Find complete

planning for

individual site

Human-made



Navigate trains Distribute trains Decomposition of railway hub from station to over service sites, sites planning • Distribute and move trains to service sites (CP) Robustness of solution Human-AI interaction **AI-made** Acknowledgement Universiteit TUDELFT Delft University of Technology This work is part of the NWO LTP-ROBUST RAIL Lab, a Utrecht collaboration between the Delft University of Technology, Utrecht University, NS and ProRail.