Improved Local Freight Train Classification

Jens Maue[1]

Joint Work with Peter Márton[2] and Marc Nunkesser[1]

[1]Institute of Theoretical Computer Science, ETH Zürich, Switzerland

[2]Department of Transportation Networks, University of Žilina, Slovakia

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[2]Partially supported by the Slovak grant foundation under grant no. 1-4057-07 (project "Agent Oriented Models of Service Systems").

Local Freight Train Classification

Local freight train

- multi-destination freight train
- cars ordered by destinations

Train classification

- special sorting problem
- classification yard

Outline

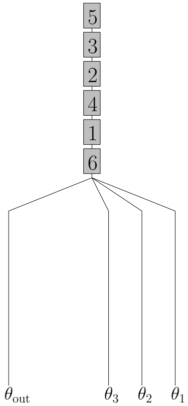
Train Classification in General

Classification Schedules

IP Formulation
- Basic Model
- Real-World Instance
- Real-World Restrictions

Concluding Remarks

Example Classification Process



Train Classification

- goal: ascendingly ordered train on θ_{out}
- use available tracks θ_1, θ_2, and θ_3

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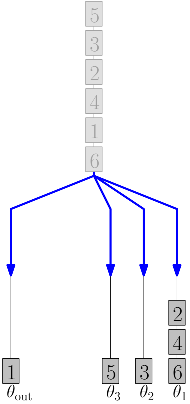

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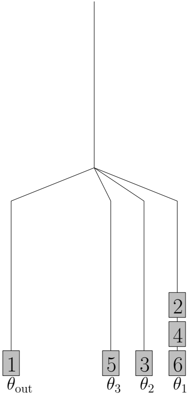

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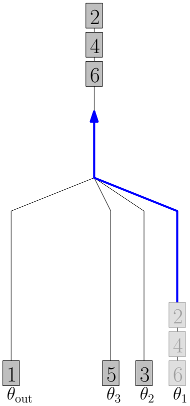

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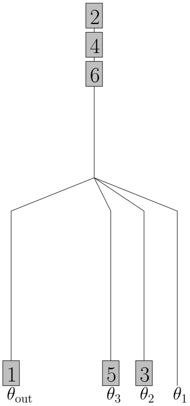

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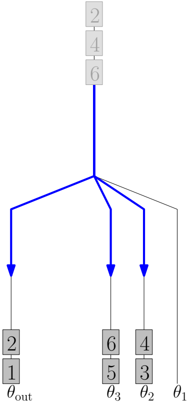

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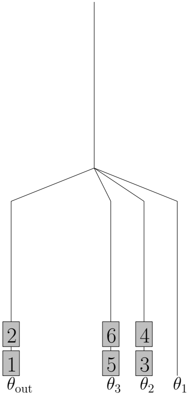

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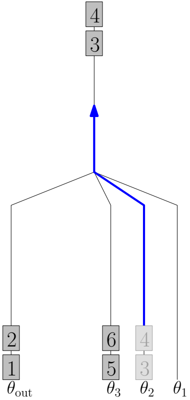

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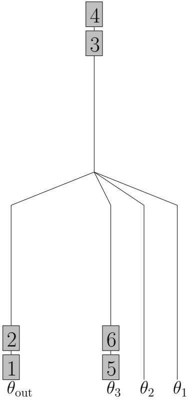

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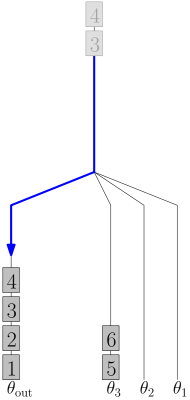

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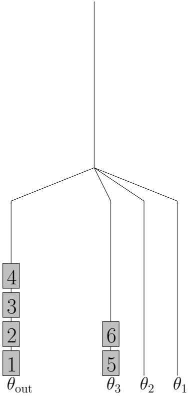

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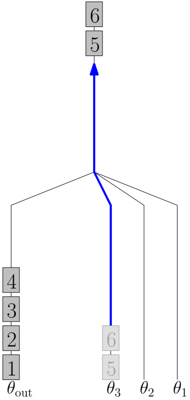

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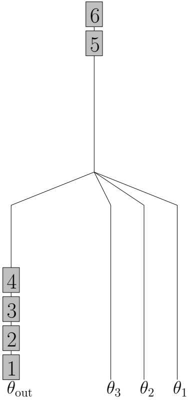

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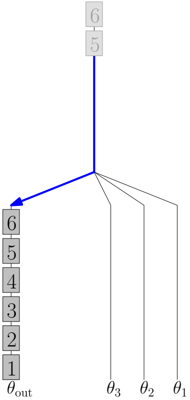

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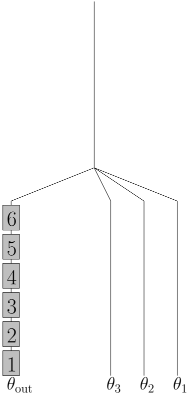

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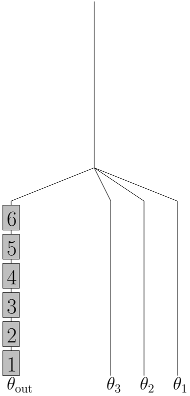

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1. initially roll-in input train
2. alternately pull out and roll in
3. finish with ordered train

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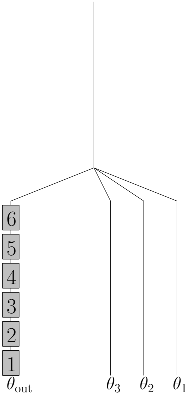

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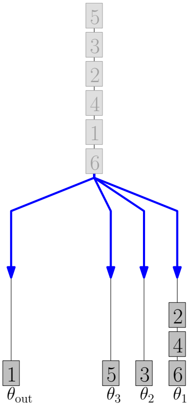
Objective: number h of pull-out steps

Schedule Encoding [JMMN07]



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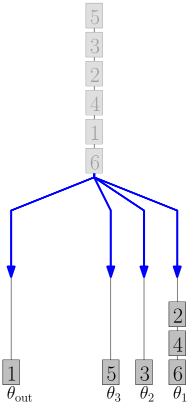

5	1	0	0
3	0	1	0
2	0	0	1
4	0	1	1
1	0	0	0
6	1	0	1

Schedule representation

- assignment of cars to bitstrings of length h
- rows: bitstring b^j encodes journey of jth car
- columns: bits encode sequence of pull-out steps
- bit $b^j_i = 1$ iff jth car visits track pulled in ith step

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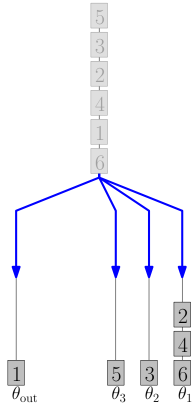

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Schedule derivation: two consecutive cars τ and $\tau + 1$

- correct order: assign same bitstring
- reversed order: assign bigger bitstring to $\tau + 1$

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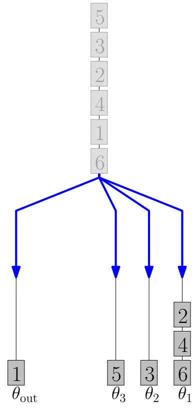

	θ_3	θ_2	θ_1
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- correct order: assign same bitstring
- reversed order: assign bigger bitstring to $\tau + 1$
- objective: length h of schedule

Basic IP Model [MN09]

$$\min \sum_{\substack{1 \leq i \leq n \\ 0 \leq j < h}} b_i^j$$

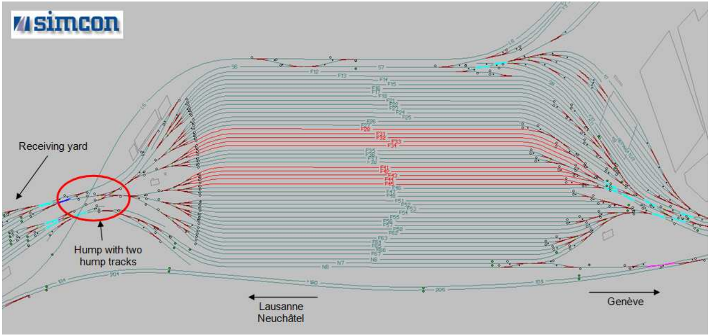
$$\text{s.t.} \quad \sum_{0 \leq j < h} 2^i b_i^j \geq \text{rev}(j-1, j) + \sum_{0 \leq j < h} 2^i b_i^{j-1} \quad \forall j \in \{1, \ldots, n\} \setminus F \quad (1)$$

$$\sum_{1 \leq i \leq n} b_i^j \leq C \quad \forall i \in \{0, \ldots, h-1\} \quad (2)$$

$$b_i^j \in \{0, 1\} \quad \forall j \in \{1, \ldots, n\}, \; \forall i \in \{0, \ldots, h-1\} \quad (3)$$

- $\text{rev}(j-1, j) = 1$ iff cars $j-1$ and j in reversed order in incoming train
- F subset of cars that are first in their respective outgoing train
- classification tracks have capacity C

Real-World Instance: Lausanne-Triage



Traffic data

- single day in 2005
- volume 328 cars
- 23 outgoing trains

Infrastructure and operation

- two parallel humps
- local freight trains: collect on ten tracks
- time window for pull-out steps
- further tracks for outgoing train formation

Extended IP Model [MN09]

Additional constraints for Lausanne-Triage

- initial roll-in restricted to ten tracks
- assignment of outgoing trains to either hump
- respect departure times

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Resulting schedule

- one step shorter
- one track less required
- verification by computer simulation in progress (not finished yet)

Concluding Remarks

Conclusion

- encoding yields flexible IP model
- adapts to various real-world restrictions
- Lausanne-Triage: save one step and track

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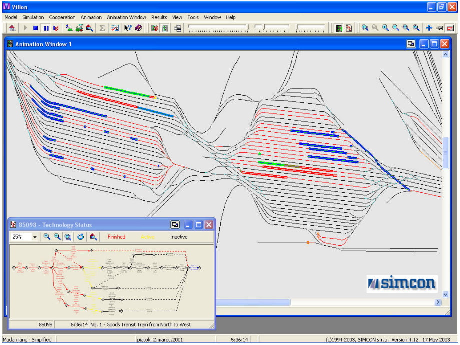
Ongoing work

- computer simulation for Lausanne-Triage (Villon)
- evaluation of 2-approximation
- time-dependent input
- robustness questions



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