ON-TIME National Workshop Sweden, 16 October 2014

Innovations in Timetable planning and Traffic control

[Optimal Networks for Train Integration Management across Europe]

Collaborative Project

7th Framework Programme

ON-TIME Timetable Planning

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Outline

ON-TIME Timetable Planning

- Introduction
- Review literature and practice
- Timetable performance indicators
- Timetabling approach
- Demonstration
- Final remarks

Introduction

WP3

- Development of robust and resilient timetables

Innovation 2

- The development of improved methods for timetable construction that are robust to statistical variations and resilient to perturbations in operations

Review literature & practice

Literature

- Macroscopic timetable optimisation models
  - Good input required for good output
- Microscopic timetable models
  - Running time and infrastructure capacity computations
  - Blocking time theory
- Evaluation of timetables
  - Macroscopic models for stability or robustness
  - Microscopic generic railway simulation models

Practice

- Either macroscopic models using normative input
- Or microscopic blocking time models per corridor
- Evaluation after design without well-defined feedback

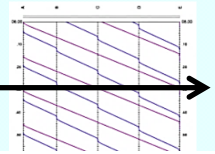
Performance indicators

Timetable trade-off between performance measures

- Short travel times
- Seamless connections

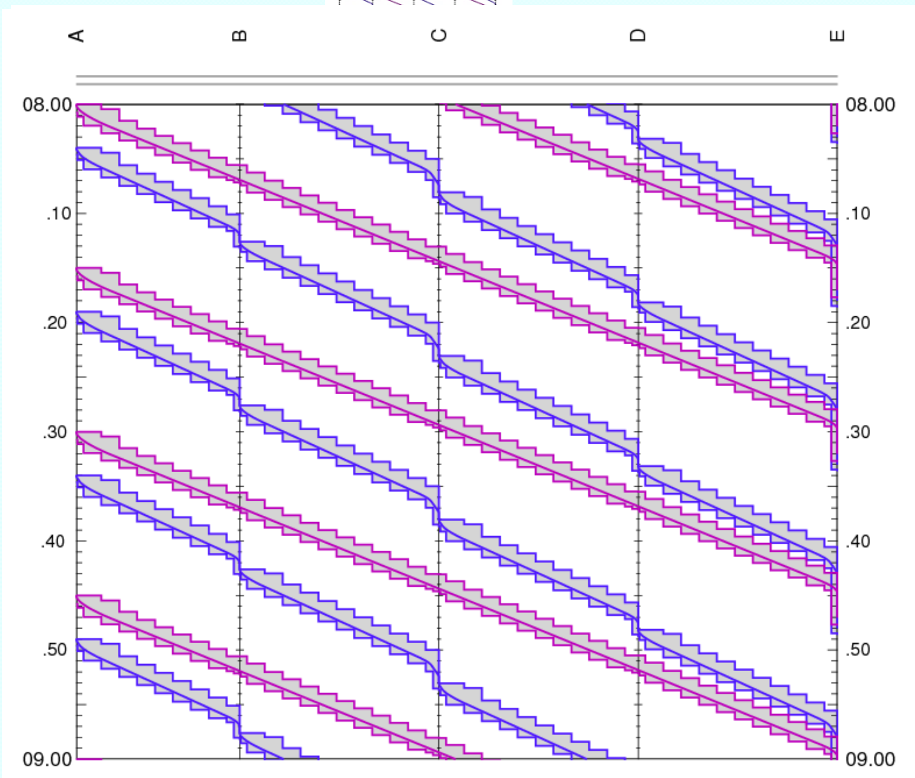
- Realizable
- Conflict-free
- Stable: acceptable capacity occupation in corridors and stations
- Robust
- Resilient
- Residual capacity for freigh paths
- Energy efficient

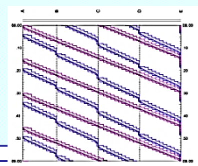
Performance indicators



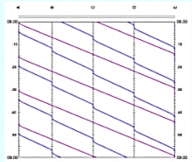
Stations, signals

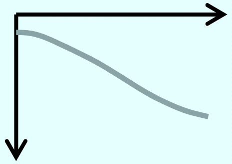
Time

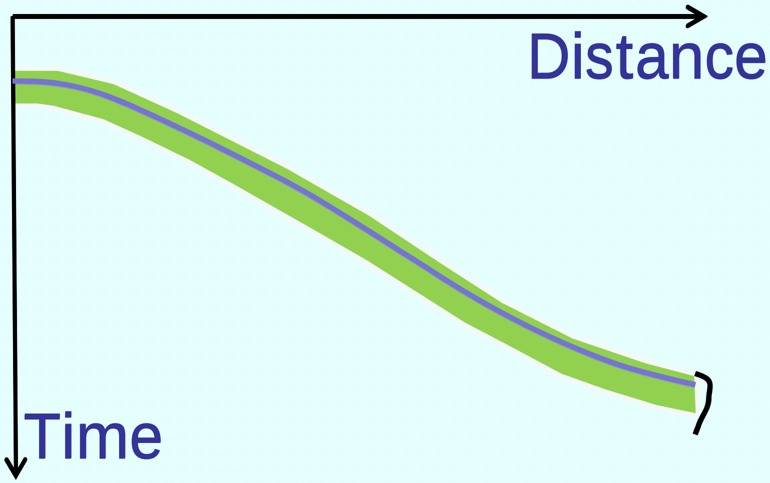


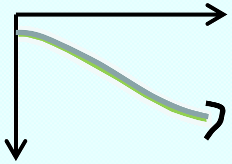


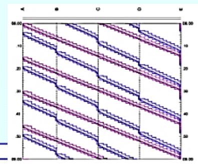
Performance indicators







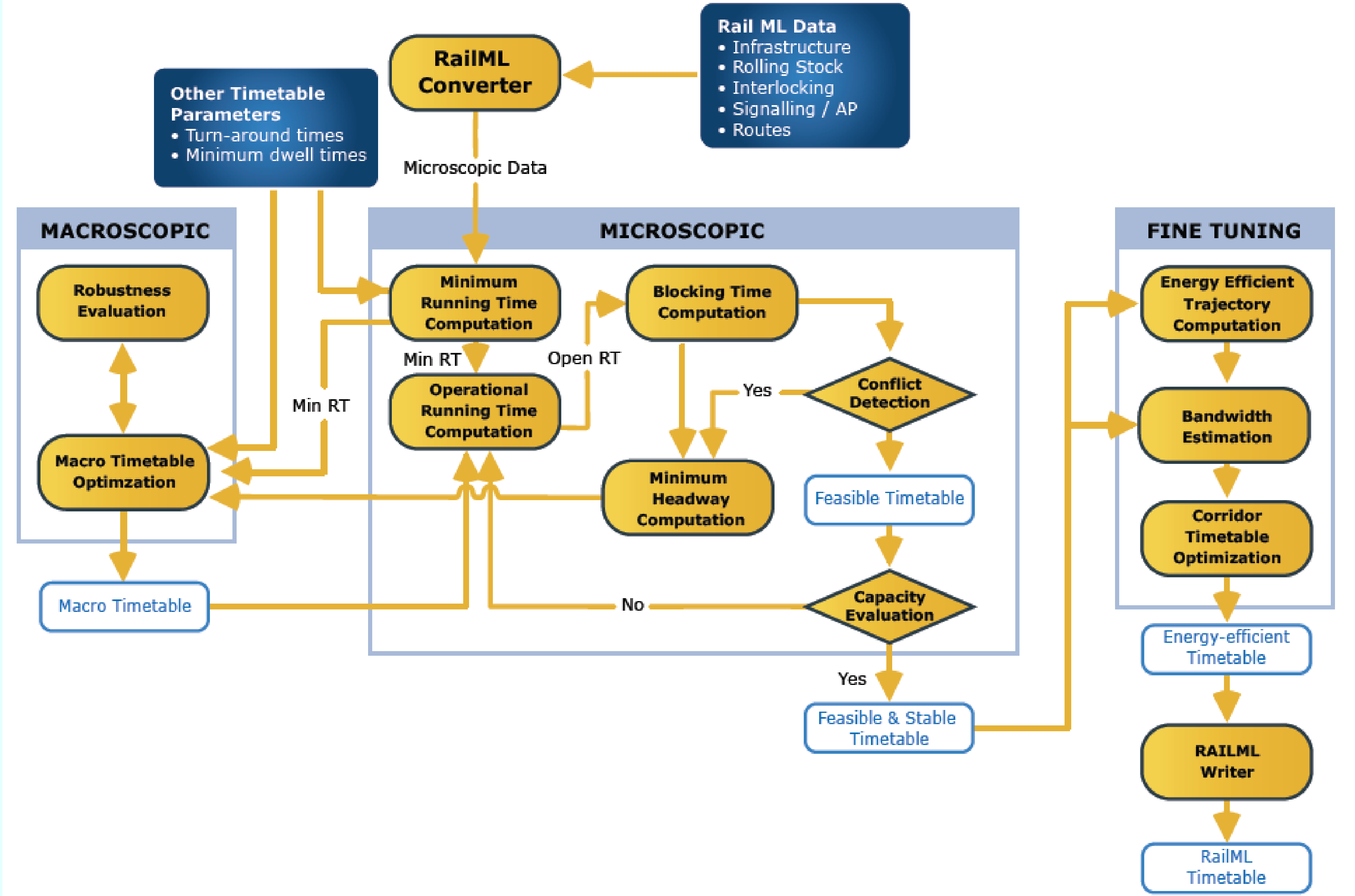




Timetabling approach

- Modular three-level approach
  - Microscopic models at local level
  - Macroscopic models at network level
  - Fine-tuning models at corridor level
- Efficient consistent micro-macro network transformations
- Standardized RailML I/O data format (with extensions)
- Integrated performance-based timetabling approach
  - Microscopic running time computations, conflict detection and UIC capacity consumption
  - Macroscopic network timetable optimization including stochastic robustness evaluation using Monte Carlo simulation
  - Energy-efficient speed profiles
  - Stochastic optimization of arrival and departure times within corridors regarding dwell time distributions

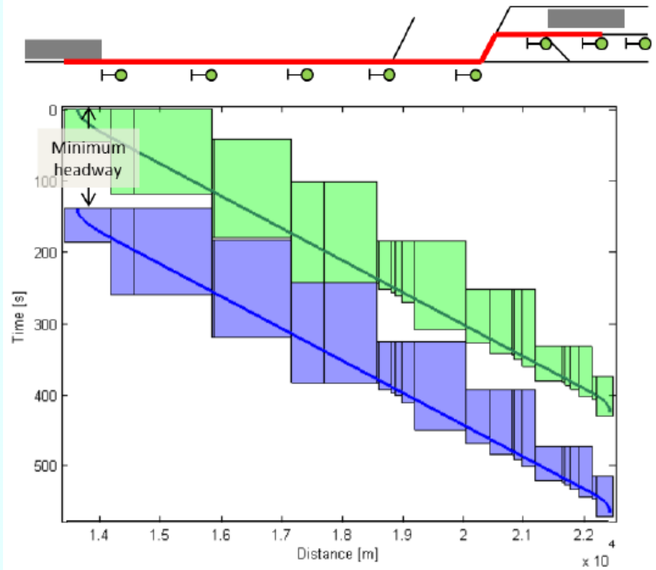
Timetabling approach



Microscopic module

Objectives

- Realizable train paths
- Conflict-free timetable
- Stable operations



Approach

- Running and blocking times based on feasible speed profiles including running time supplements
- Conflict detection using blocking times (rejection criteria)
- Infrastructure occupation/stability (UIC rejection criteria)
- Accuracy 1 s
- Computation micro/macro transformations and bandwidths

Macroscopic module

Objectives

- Optimal network timetable
  - Minimization of running, dwell, transfer times, and settling time of delays
  - Scheduling all train path requests

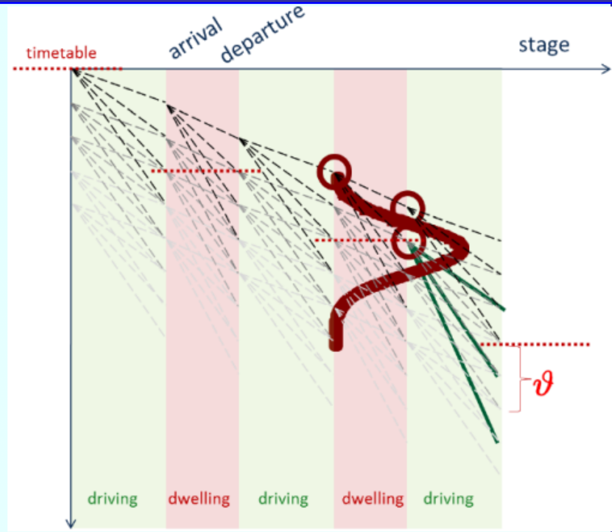
Approach

- MILP model with weighted sum of cost terms
- Heuristic algorithm generates multiple (1000) solutions
- Robustness analysis (for selected solutions): mean setting time of 1000 Monte Carlo delay propagation simulations
- Selection of optimal timetable (incl. robustness cost)
- Timetable precision 5 s

Fine-tuning module

Objectives

- Minimizing energy consumption
  at maximum robustness



Approach

- Energy-efficient speed profiles using optimal control theory
- Computation of bandwidths of local trains between ICs
- Timetable optimisation of local trains within the corridor regarding stochastic dwell times and minimizing expected energy consumption and expected delays
- Stochastic dynamic programming model
- Timetable precision 30 s

Demonstration

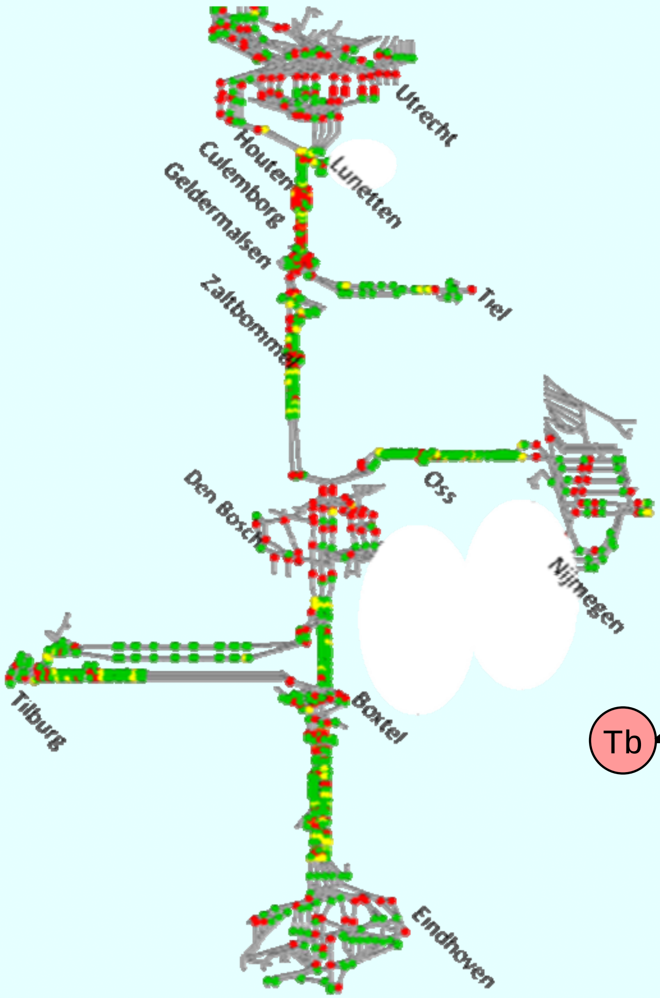
Dutch case study

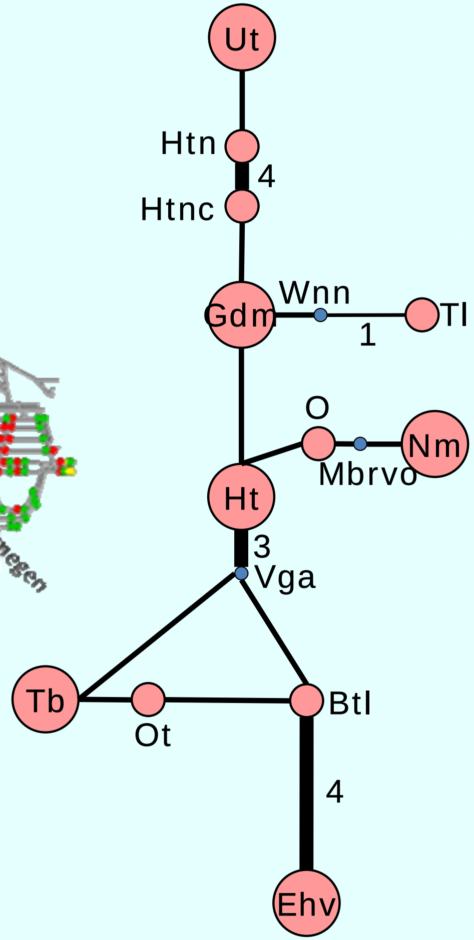
- Infrastructure and line plan 2012
- Two intersecting corridors
  - Utrecht-Eindhoven and
  - Tilburg-Nijmegen
- Hourly timetable pattern with
  - 2 x 8 ICs per hr
  - 2 x 10 local trains per hr
  - Two freight paths per hr (Ut-Ehv
  - Many transfers in 's Hertogenbos
    (and elsewhere)

Demonstration

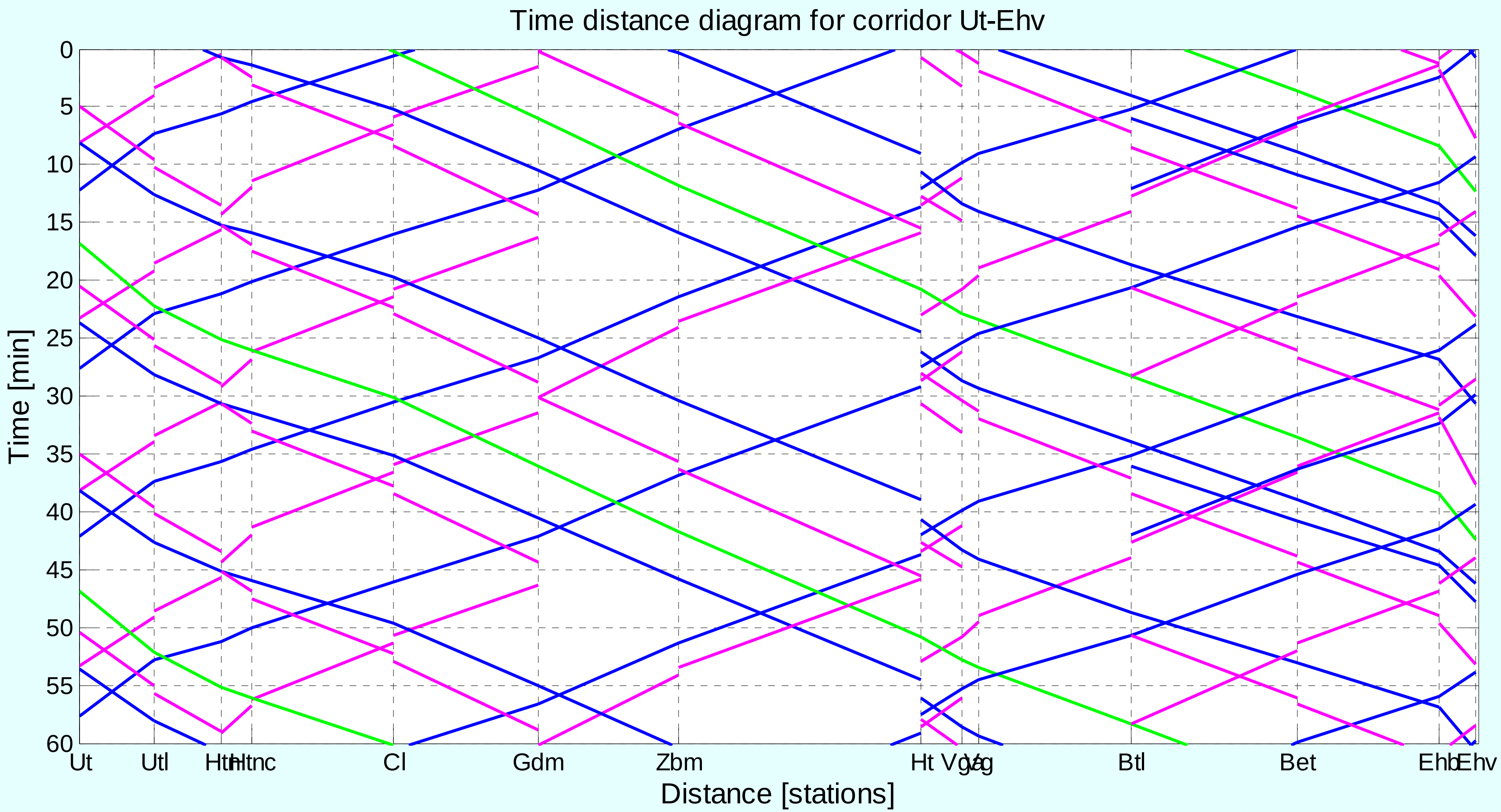
Model sizes

- Microscopic network
  - 1500 nodes
- Block section level
  - 1000 nodes
- Macroscopic network
  - 16 nodes

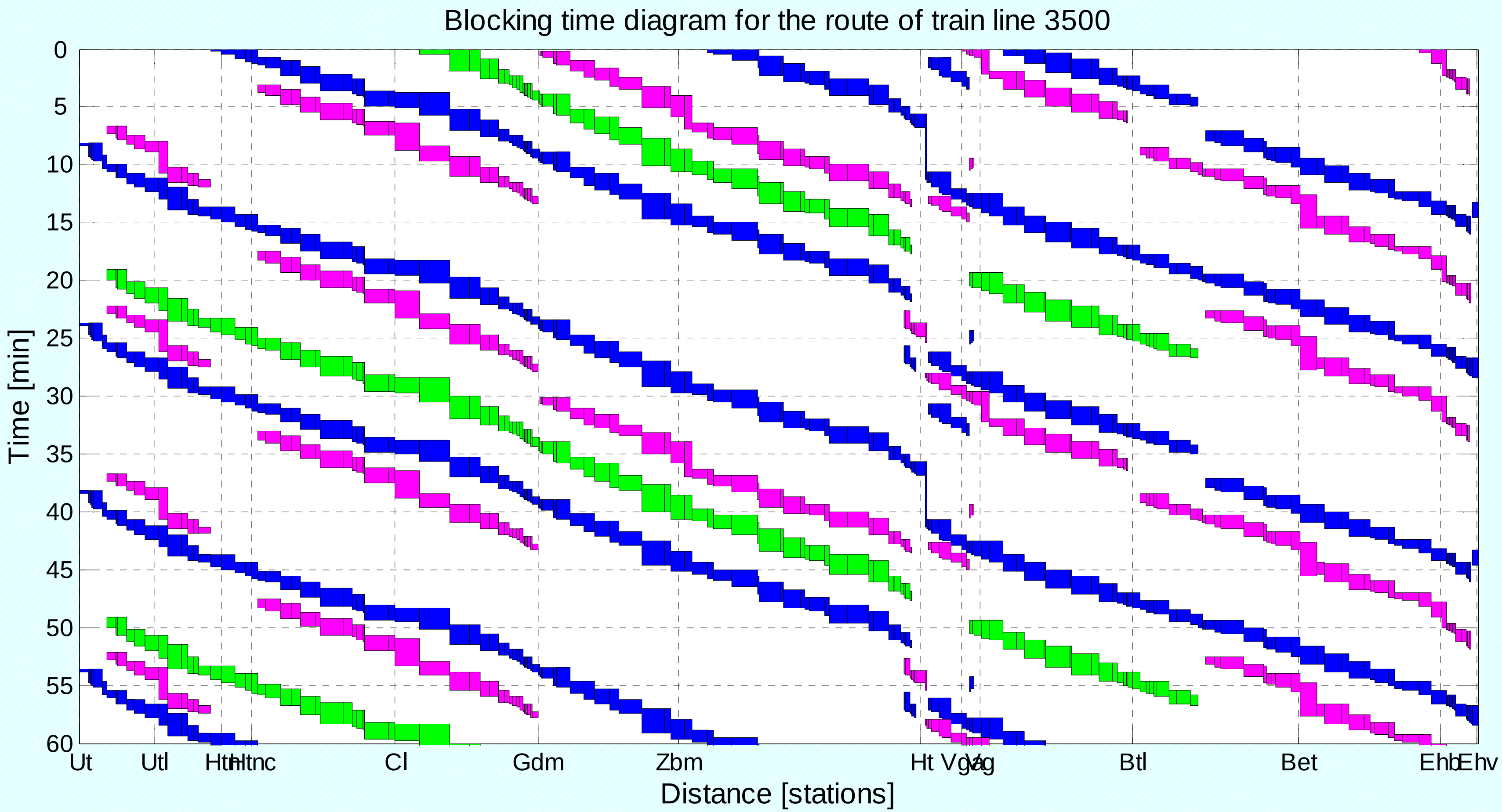




Demonstration



Demonstration



Final remarks

- Modular implementation of three-level timetabling approach
- Input from standardized RailML files (Infrastructure, Rolling Stock, Interlocking, Timetable)
- Output in standardized RailML Timetable file with scheduled train paths and speed profiles at section level
- Multilayer timetable with multispeed freight path catalogue
- Classification of Timetabling Design Levels
  - TDL 0: Low quality
  - TDL 1: Stable
  - TDL 2: Conflict-free (and stable)
  - TDL 3: Robust (and conflict-free and stable)
  - TDL 4: Resilient (proof that a robust conflict-free timetables exists and can be derived dynamically fast w.r.t. freight and delays)