TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Transport and Traffic Science "Friedrich List" Chair of Traffic Flow Science

Maximisation of homogenous rail freight train paths at a given level of quality

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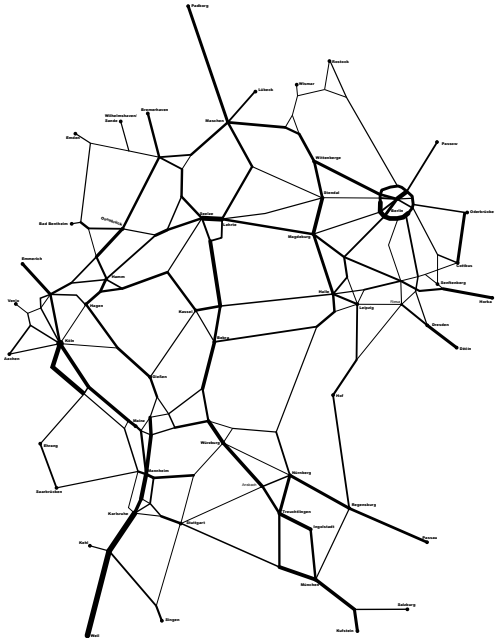
Outline

- Motivation
- Existing Model
- Maximising Number of Train Paths
- Homogenous Quality
  - Restrict Quality
  - Avoid Changes to Sequence of Paths
- Conclusion

Introduction

Motivation

- increasing demand in rail freight transport
- limited extensions of railway network
- optimal capacity exploition required

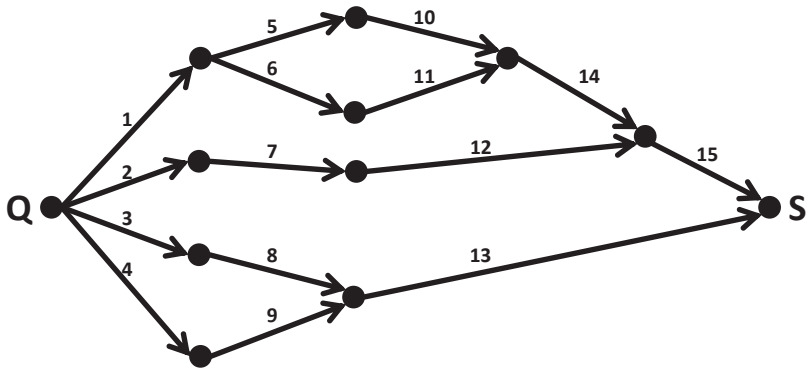


- in strategic planning, capacity evaluation is needed
- detection of bottlenecks by comparision of expected demand and number of constructed train paths

Existing Model

Basics

- insertion of non-periodic freight train paths into existing timetable
- specified fixed number of train paths is constructed optimally (MIP)
- all possible train paths are split to sub paths (InfraAtoms)



- enables dynamic calling for passing of trains
- automatic decision between different routes
- automatic decision between different (defined) speed levels

Existing Model

Constraints

- flow conservation
- departure times within investigation period
- sequence of paths at start
- running times
- minimal stopping times
- (minimal) safe headways

Existing Model

Objective

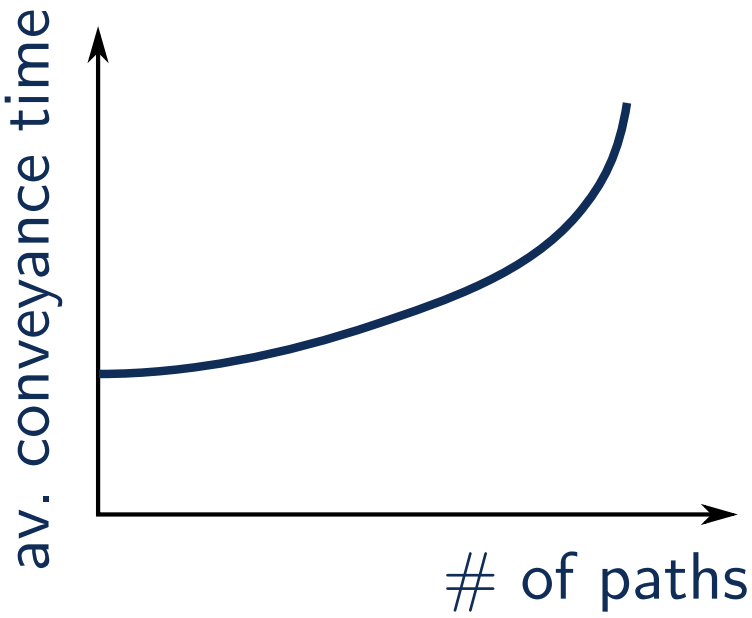
- quality evaluation by conveyance time quotient (CTQ) $\xi_i = \frac{t_i}{t_{min}}$
  - t_i actual conveyance time of path i
  - conveyance time: sum of all running and stopping times
  - t_{min} shortest running time
- objective: high quality (= low conveyance time quotient)
- minimisation of $\sum_i \xi_i$
- Problem: exact capacity is unknown

Maximising Number of Train Paths

- new binary variables per train path y_i
- $y_i = 1$: path i is active
- new objective: $\sum_i y_i \rightarrow \max$
- upper bound for number of potential train paths is still required

Maximising Number of Train Paths

- high utilisation of a railway line leads to low quality (= high conveyance time) of train paths



- railway undertakings won't accept high conveyance times / transport times

Restricting Quality

- limit CTQ
  - independent of path length
  - universal criterion
- limit stopping time
  - per-halt measure
  - no direct benefit
- limit number of stops
  - reasonable values depent on path length and line characteristics
  - difficult in universal application

Homogenity

- homogenity: low variation of quality (conveyance time)
- homogenous quality enables creation of catalogue of similar (universal) train paths
- direct formulation of homogenity is non-linear:

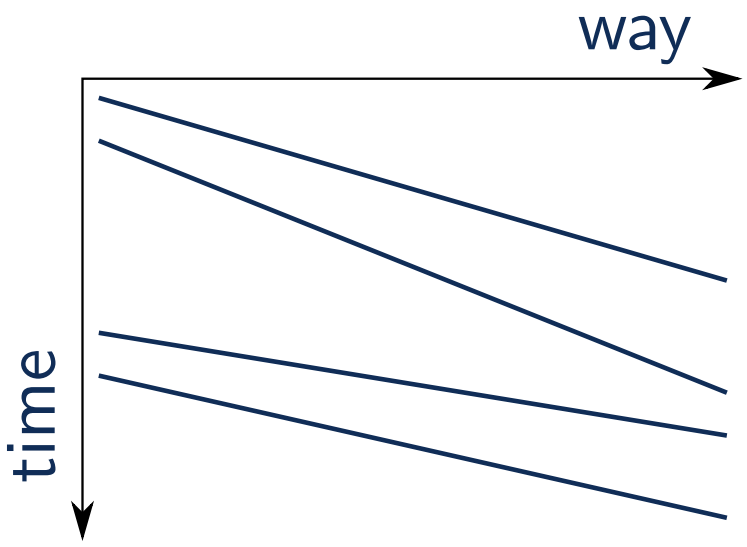
$$\frac{\sum_i (y_i \xi_i)^2}{\sum_i y_i} - \left(\frac{\sum_i y_i \xi_i}{\sum_i y_i} \right)^2$$

- approximation needed

Homogenity

Approximation

- limit sequence changes between different freight train paths
- example for complete elimination of sequence changes:

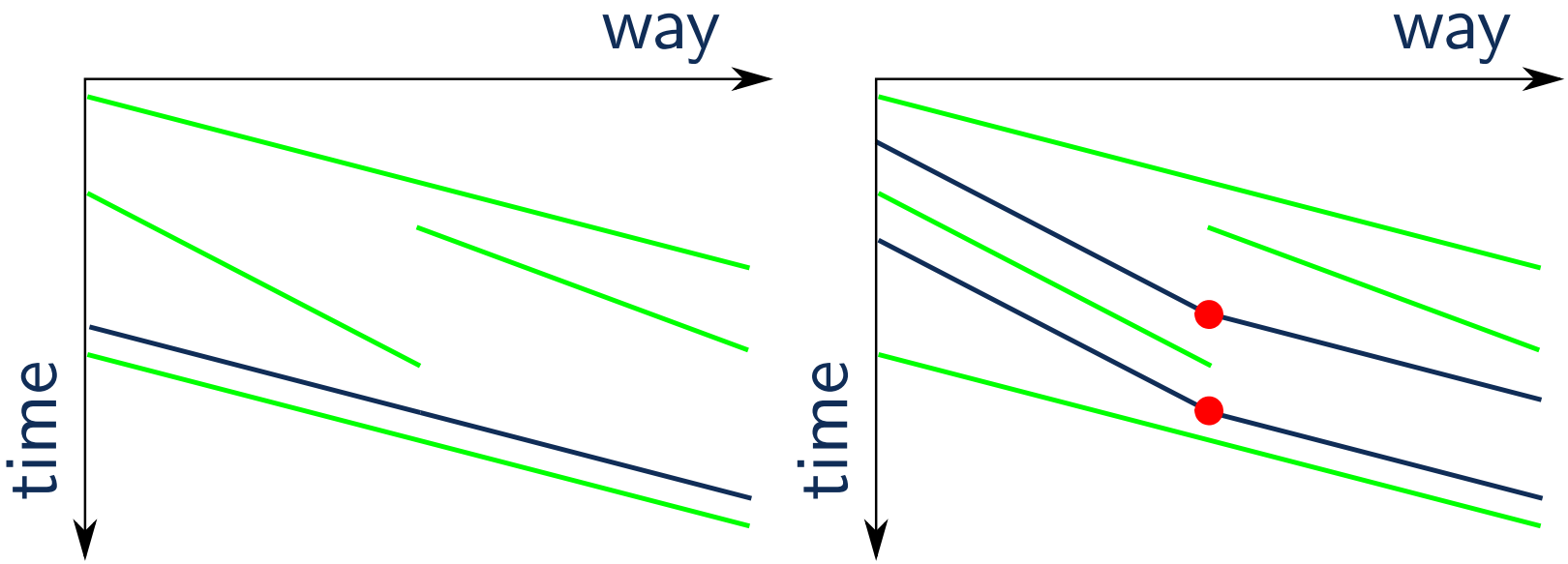


- every difference in conveyance times increases overall headway times

Homogenity

Approximation

- restriction of quality allows reduction of quality bandwith
- better adaption of sub paths to existing rail traffic increases homogenity further
  - additional divisions of paths
  - more sophisticated selection of speed levels



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Conclusion

- maximisation of marketable train paths is possible
- homogenity can be efficiently achieved by indirect measures
- implementation of model extensions is work in progres
- interaction at intersecting lines have to be investigated further

Thank you for your attention.

References

Peter Großmann et al.: *Capacity-utilized Integration and Optimization of Rail Freight Train Paths into 24 Hours Timetables*. In: *Proceedings of the 3rd International Conference on Models and Technologies for Intelligent Transportation Systems 2013*. Dresden, 2013, pp. 389–396.

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