Assessment of Stochastic Capacity Consumption in Railway Networks

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Motivation

- What is the capacity consumed by a given set of trains?
- A timetable is usually needed
- Usually only line sections are assessed (UIC406)
- Aim is to measure capacity consumption of a set of trains in a network
  - Only number of trains, train running times and headways are given
- Calculate the distribution of capacity rather than one single number
  - Deterministic capacity consumption (without delays)
  - Stochastic capacity consumption (with delays)
How to mix trains - Heterogeneity

- n! for acyclic timetables
- (n-1)! permutations for cyclic timetables
- 16 trains (cyclic)
  - 1.3 trillion permutations
    (1,307,674,368,000)
  - Impossible
- Sample random permutations
Deterministic capacity consumption

Input
- The network
  - Infrastructure
  - Headways
- Train type runs
  - Route
  - Running time
  - Number of each type

Calculate capacity consumption for each (random) permutation

Output
- (Distribution of) capacity consumption
Stochastic capacity consumption

**Input**
- The network
  - Infrastructure
  - Headways
- Train type runs
  - Route
  - Min. run time & supp.
  - Number of each type

**Output**
- (Distribution of) stochastic capacity consumption

**Calculate**
- Sample input delay from a probability distribution \( f(x) \)
- Calculate capacity consumption for each (random) permutation
- Simulation of delay propagation for each (random) permutation
Case

- 16 trains (1 ICE, 2 IC, 2+1 regional & 2 freight per direction)
- Mesoscopic network (feasibility can be ensured by microscopic input data)
- Scenarios:
  - Base: J2 & J3 at-grade junctions
  - J2 upgraded (to out-of-grade)
  - J3 upgraded
  - J2 & J3 upgraded
- Entrance delays at T1-T4 and delays at stops
  - Weibull distributed truncated at 10 minutes (no rescheduling)
Computational characteristics and results

• Sample of ~13 mil. permutations

• 60 iterations for stochastic simulation

• 100 seconds computation time for deterministic calculation (whole network)

• ~70 minutes computation time for stochastic calculation
  – Since reduced to ~40 minutes
    • ~15 minutes on a faster desktop PC
Deterministic results – impact of assessment area

- Route and network capacity consumption
Stochastic results

- Variance of results over all iterations (60)
Stochastic results

- Four different scenarios:
Conclusions

• Model framework developed for capacity assessment of railway networks
  – No timetable needed
  – Possible to account for delays (stochastic assessment)

• Capacity assessment is very much dependent on the size of the network considered

• Improvement (decrease) in network capacity consumption observed in case when some junctions are upgraded
  – Better improvement for stochastic case than in the deterministic case
Current and future work

- Correlation of heterogeneity measures/buffer times with capacity consumption
- Exclude certain (infeasible) train sequences
- Improve sampling method (min and max capacity consumption)
- Measure absolute capacity (number of trains) rather than capacity consumption
- Improvements of computation time
- Implementation of overtakings, turn-around capacity, transfers and couplings between trains
Thank you for your attention!

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