Condition Based Logistics: Calculation of Process Capacity

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Outline

Condition Based Maintenance

- Maintenance jobs are triggered by condition of individual components
  - Technically
    - preventive maintenance
  - Logistically:
    - Planned inspections
    - Unplanned replacements and repairs
    - Significant variation in workload
- Train operation versus maintenance services
  - Train operation schedules train *types*
  - Maintenance services schedules trains as *physical units*

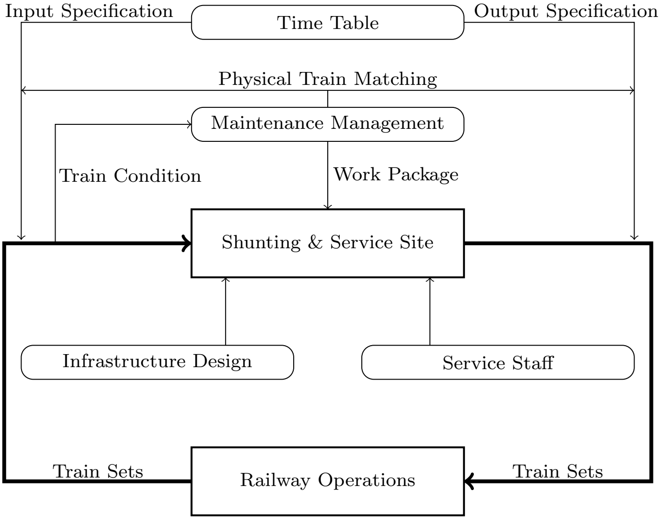
Business Problem

- To what extent can the rail infrastructure accommodate CBM?
  - Do shunting yards have sufficient process capacity?
  - What is the effect of modern train design on it?
- How to assess infrastructure modifications?
- Obtain an objective quantitative method to calculate process capacity

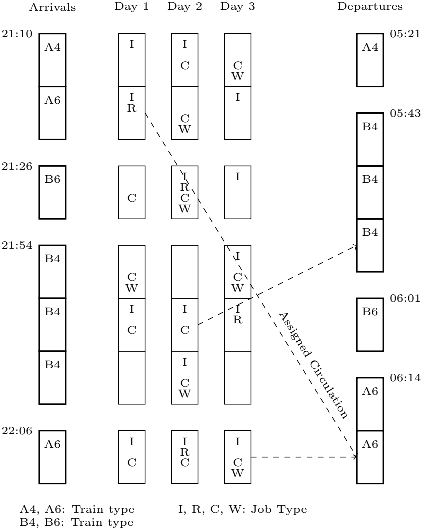
Today's Practice

- Capacity is expressed in track or train length only
  - Process capacity emerges from daily practice
  - Result depends strongly on individual staff skills
- Required to take into account
  - Shunting and combining trains
  - Service and maintenance jobs
  - Access to dedicated platforms and machines
- No computational method available for overall process capacity
  - Poor support for investment decisions

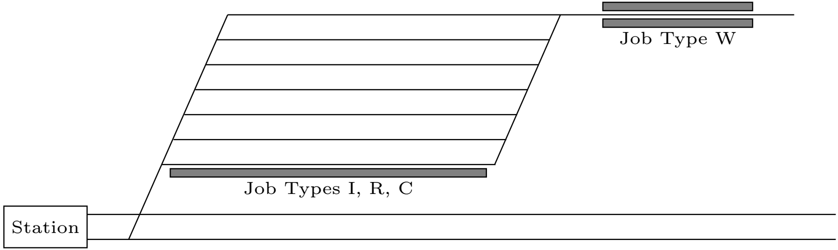
Logistic Context



Daily Logistic Problem (Example)



Site Layout (Example)

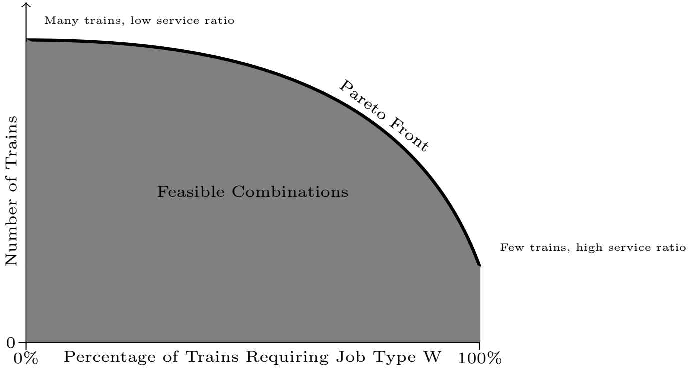


Problem Type

- On-site process planner has to solve every day a different logistic problem, taking into account
  - Site characteristics
  - Resources availability
  - Process regulations
- Process capacity depends on the planner's ability to solve these problems in practice
- *Core problem is planning*
  - Shunting (Routing Problem, Rush Hour Problem)
  - Parking (Multi-Knapsack Problem)
  - Services (Resource Constrained Multi-Project Scheduling Problem)
  - Splitting and combining of trains
  - Mapping of incoming trains to outgoing trains
- Process capacity reflects *maximum work package* of shunting and service jobs for which feasible plans can be found

Capacity Measure Dimensions

- Trade off between number of trains and all services provided
- Process capacity measure should be multi-dimensional:
  (number of trains, fleet composition, job_type_W%, job_type_C%, ...)



Process Capacity (first attempt)

Definition

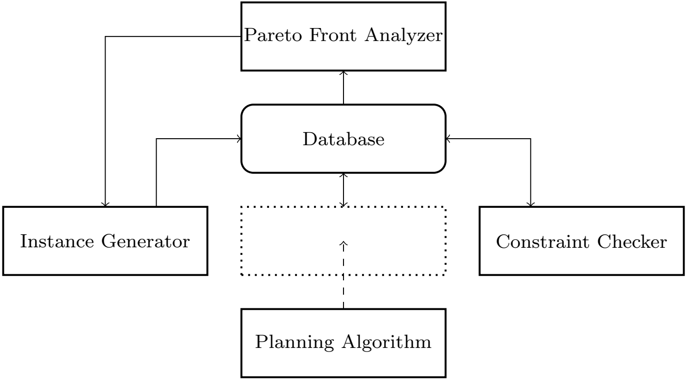
The process capacity of a shunting yard is the Pareto front of work package parameters for which a feasible plan can be found (within a specified amount of time) with respect to the available resources.

Process Capacity

Definition

The process capacity of a shunting yard is the Pareto front of distribution parameters that describe work packages such that for at least a specified percentage of these packages a feasible plan can be found (within a specified amount of time) with respect to the available resources.

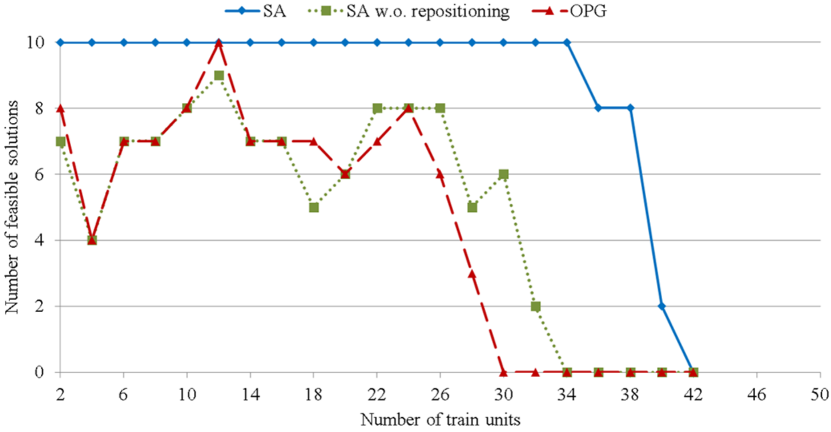
Pareto Front Analyzer



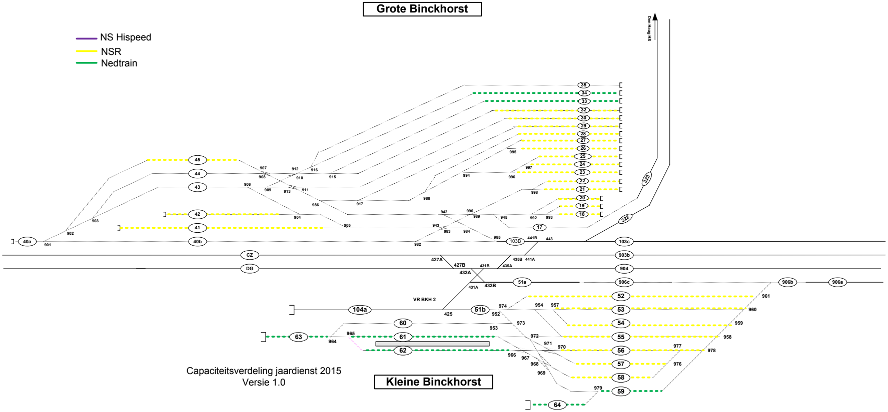
Planning Algorithm

- Modular fit into Pareto Front Analyzer
- Up-till now three approaches
  - Flexible Flow Shop (heuristic) $\rightarrow$ Shunting (exact)
  - Resource Constrained Schedule (heuristic) $\rightarrow$ Shunting (exact)
  - Monolithic (heuristic)
    - Single initial solution (resource feasible, not time feasible)
    - Simulated annealing

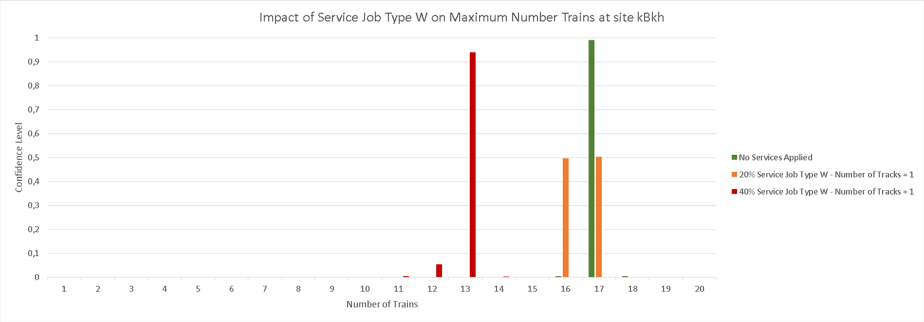
Shunting: Train Repositioning Makes the Difference



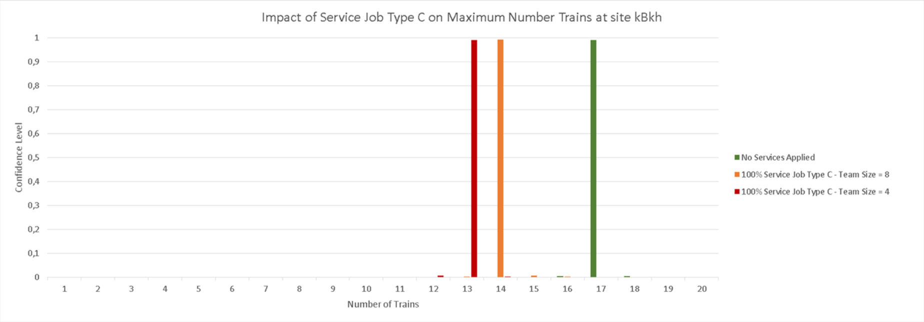
Computational Results: Case Example



Computational Results: Effect of Job Type W Ratio



Computational Results: Effect of Job Type C Team Size



Further Research & Development

- Compare systematically with human planners' performance
- Improve and extend planning algorithms
- Better understanding of influencing factors
    - site layout
    - logistic problem characteristics
    - applied heuristics
- Empirical research to obtain more data on process variations and correlations

Thanks for Your Attention! Any Questions?