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PROSA/prosimExpreß : A line-planning tool for Deutsche Bahn

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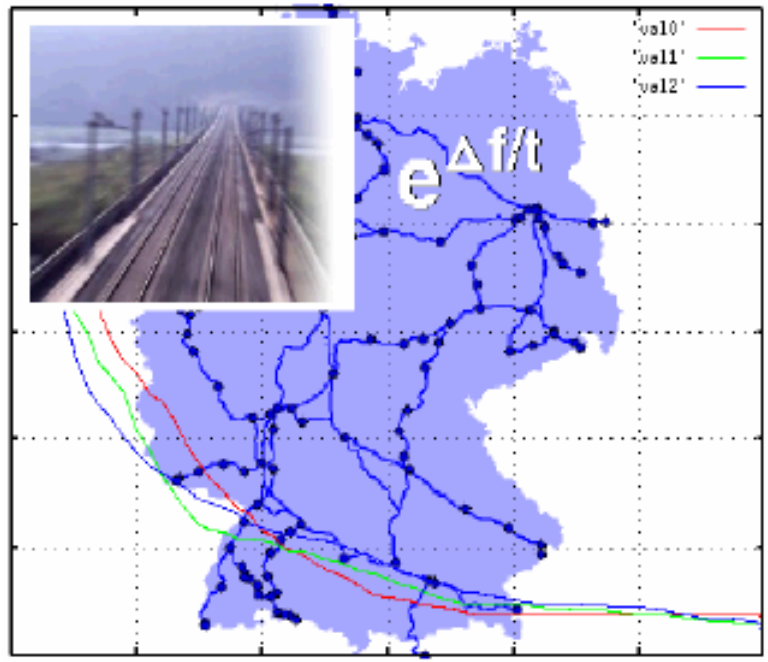
DB



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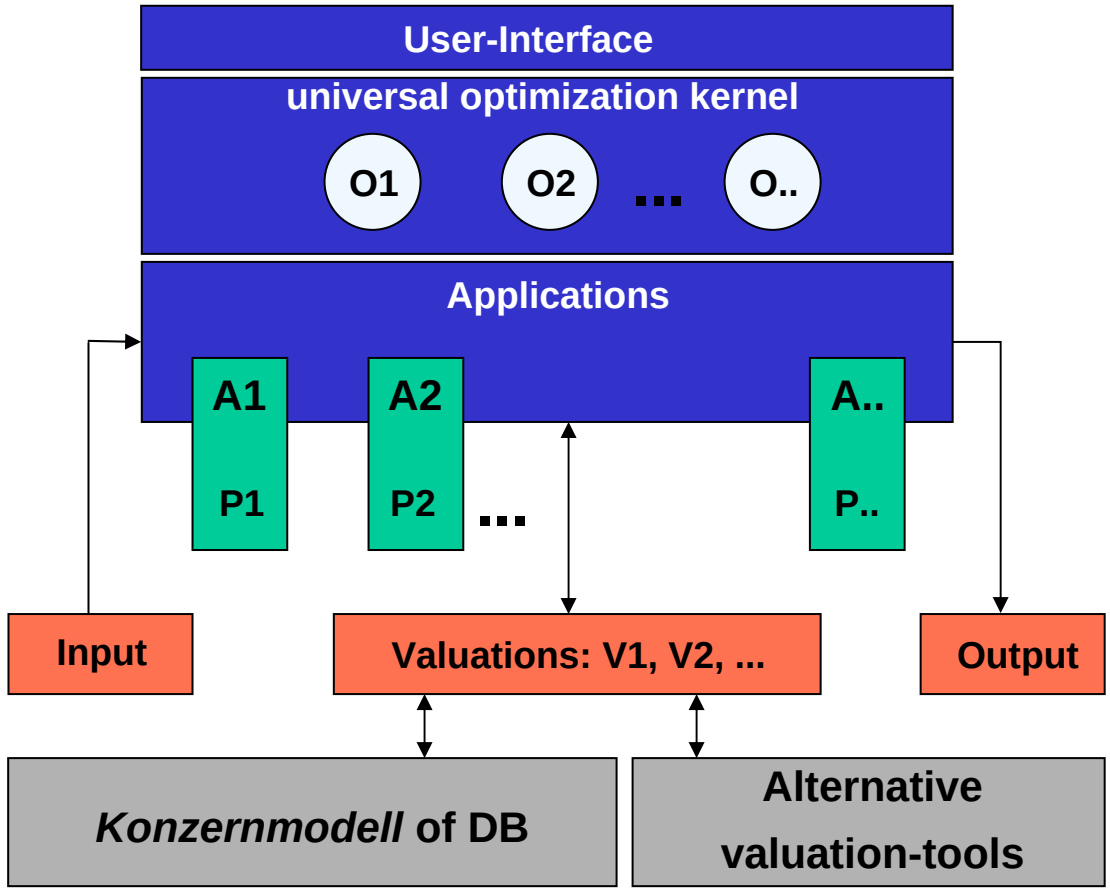
prosim Expreß

Aims

- Optimization-tool suitable for extensions
- Fast-valuation tool as part of the *Konzernmodell*

Applications

- Location of stations (U KL)
- Cyclic timetabling (TU B)
- Line planning



Line planning problem

Given

Railway network G = (V, E)

volume of traffic (OD-matrix)

train types T = {IC, ICE, ICT}

frequencies F = {30, 60, 120, 180, 240, ...}

attributes on nodes and edges

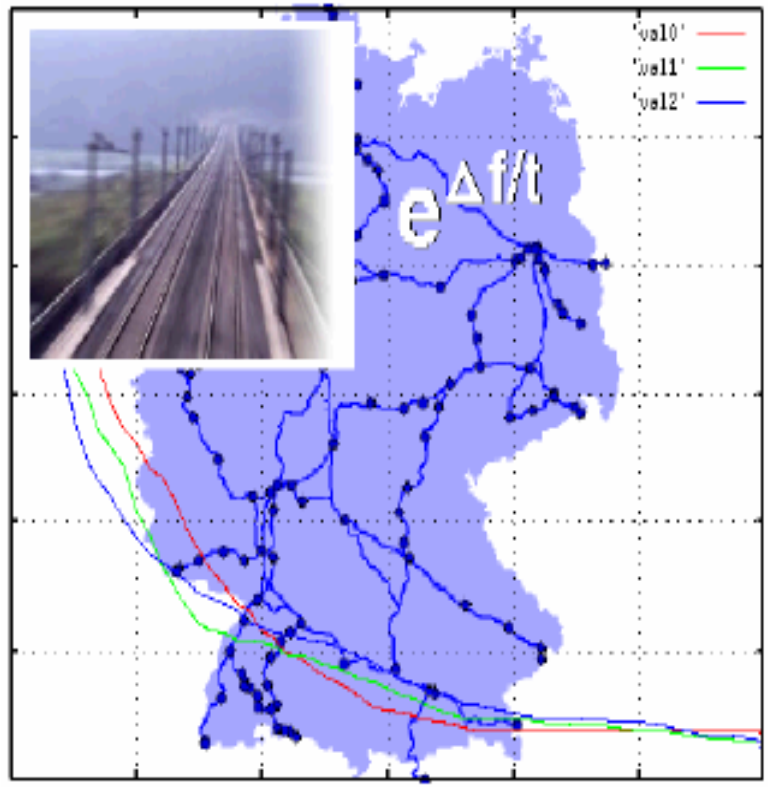
Look for

Set of lines L=(P, t, f) that

maximize objective

s.t.

Feasibility conditions are satisfied



(Selected) literature

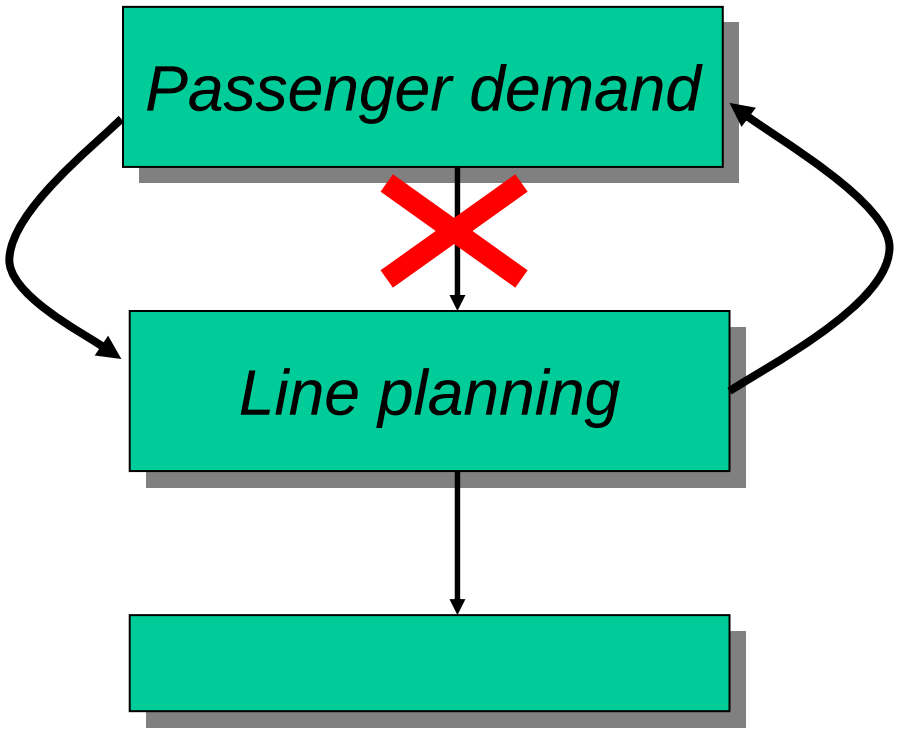
- Oltrogge (1994)
- Bussieck, Zimmermann(1998)
- Claessens, van Dijk, Zwanefeld (1998)

- Goossens, van Hoesel, Kroon (2001, 2004)
- Scholl, Schöbel (2003)
- Borndörfer, Grötschel, Pfetsch (2003)

- Klingele (2001), Schmidt (2002)

- *Min cost*
- *Max # direct travellers*
- *Min train changes*

Hierarchical approach



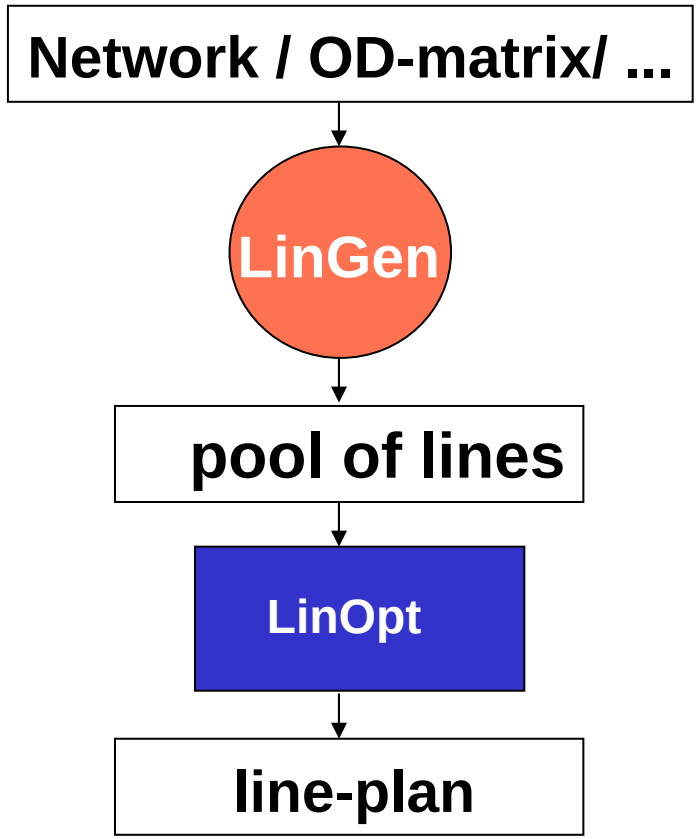
Integrated approach

Demand feedback

→modal split

OD car
OD plane
OD train

Outline of the approach



2 phases process:

(1) Generation of a set of potentially good lines

→ *Aim: pool of lines that satisfies different criteria.*

→ *Decision for a single line*

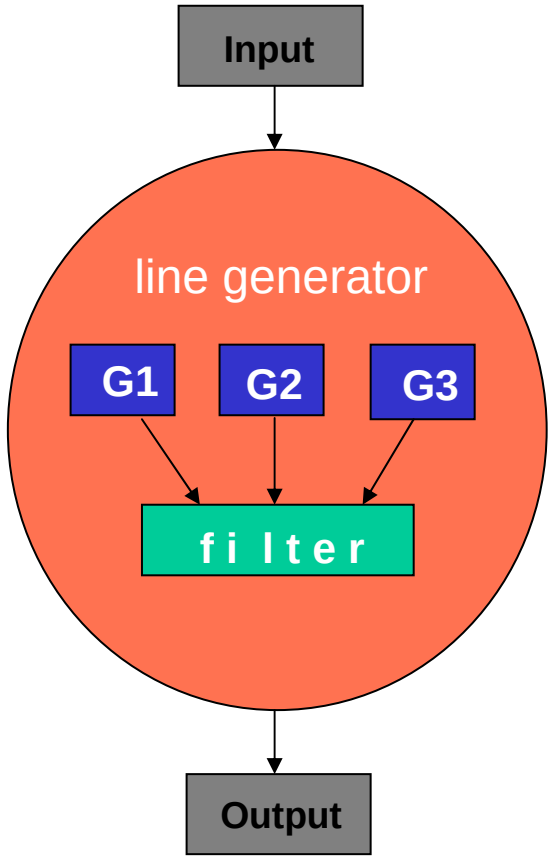
(2) Selection of a subset of lines from the pool to form the *line-plan*

→ *Genetic Algorithm*

→ *Evaluation of a line-plan with demand feedback / modal split*

Pool generation -overview

- **Input:**
  - rail-network with stops and potential start/end-stations
  - OD-matrix (total volume of traffic)
  - parameter ....
- **System-split**
- **Generators:** Enumerators and constructive graph-algorithms
- **Filter:** Ad-hoc-filter, quality-functions, tools avoiding detours
- **Output***:* pool of potential lines



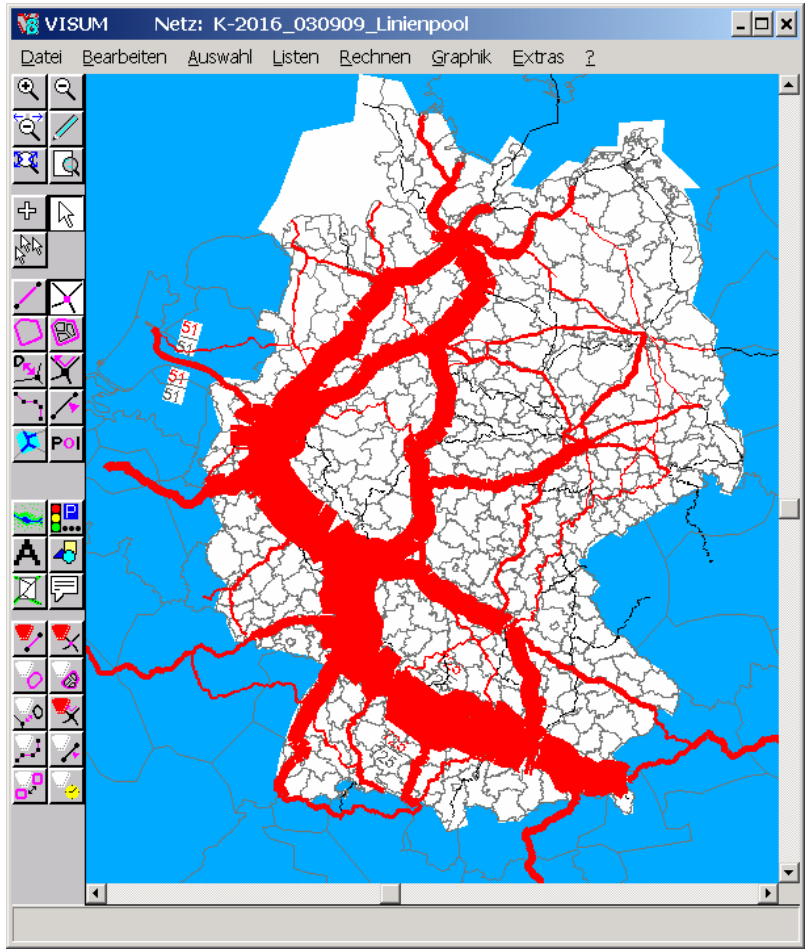
Generation of lines
Enumerators

Enumeration of

1. **(straight) paths of stations**
2. **(straight) sequences of stations**

result : good lines
but „main-stream-lines“

→ iterative process



Generation of lines

Global Spanning-Tree

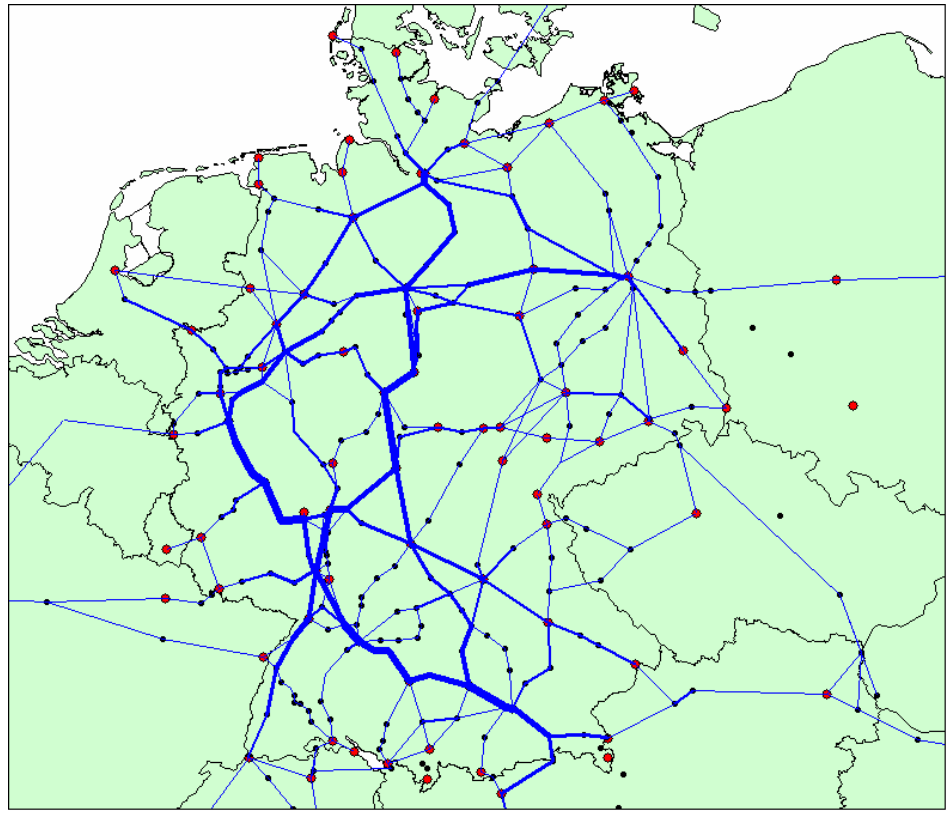
(1) Distribution of all demand on the net

(2) Calculate Max-Spanning-Tree

(3) Determine „best“ line

(4) reduce arc weights

(5) goto 2.



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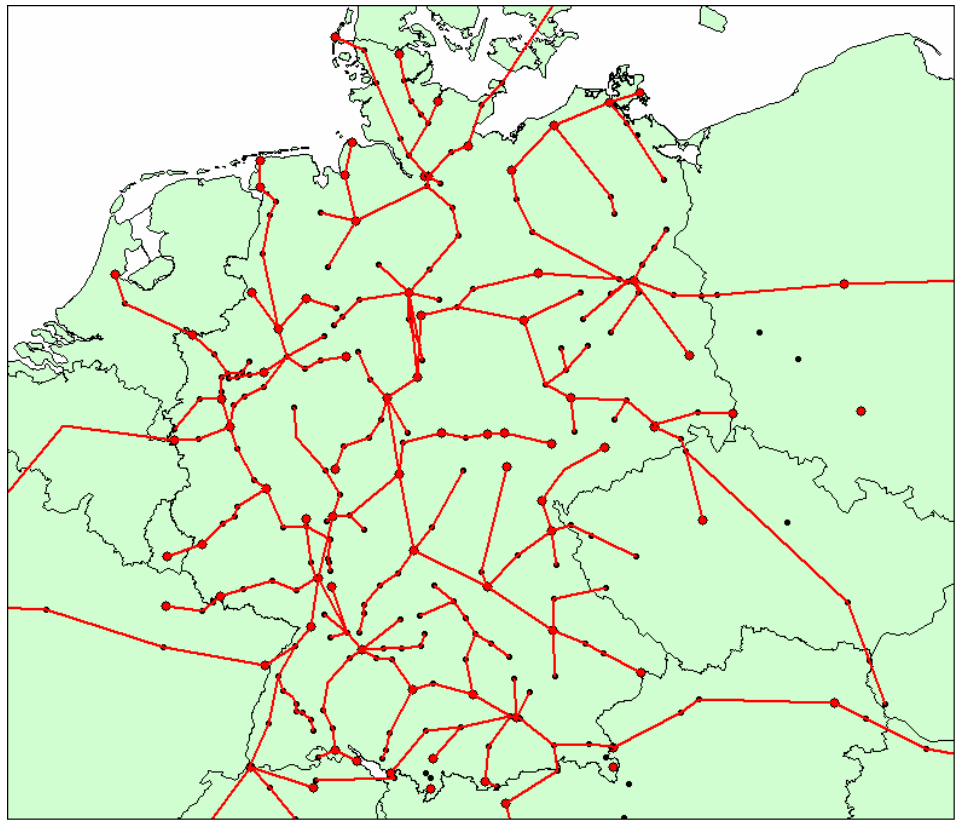

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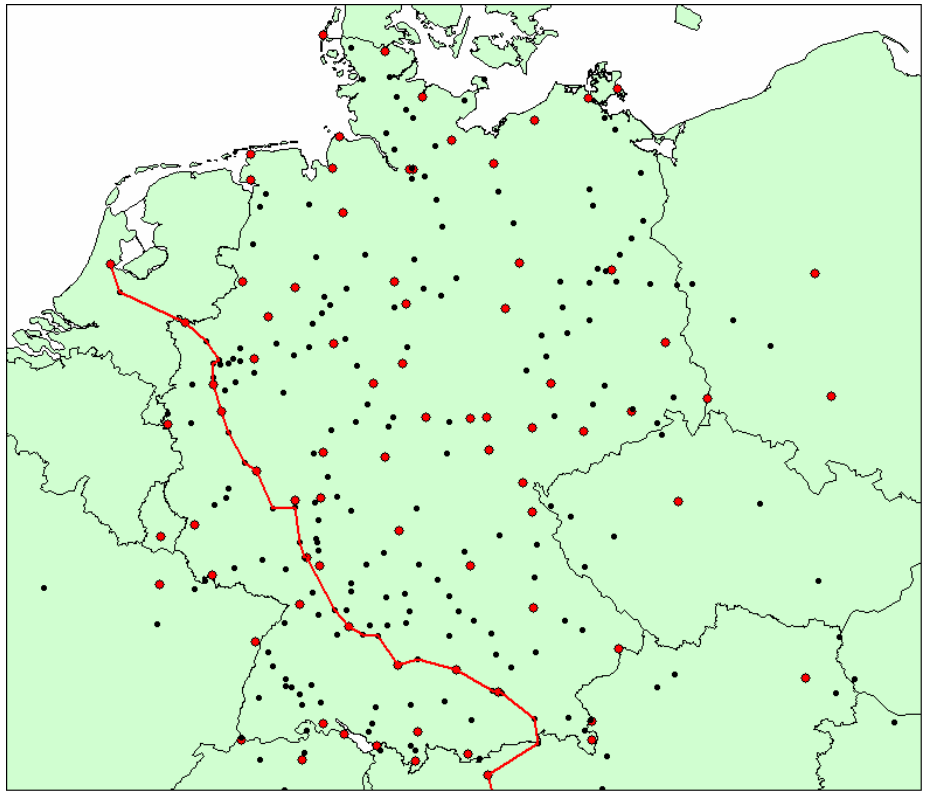
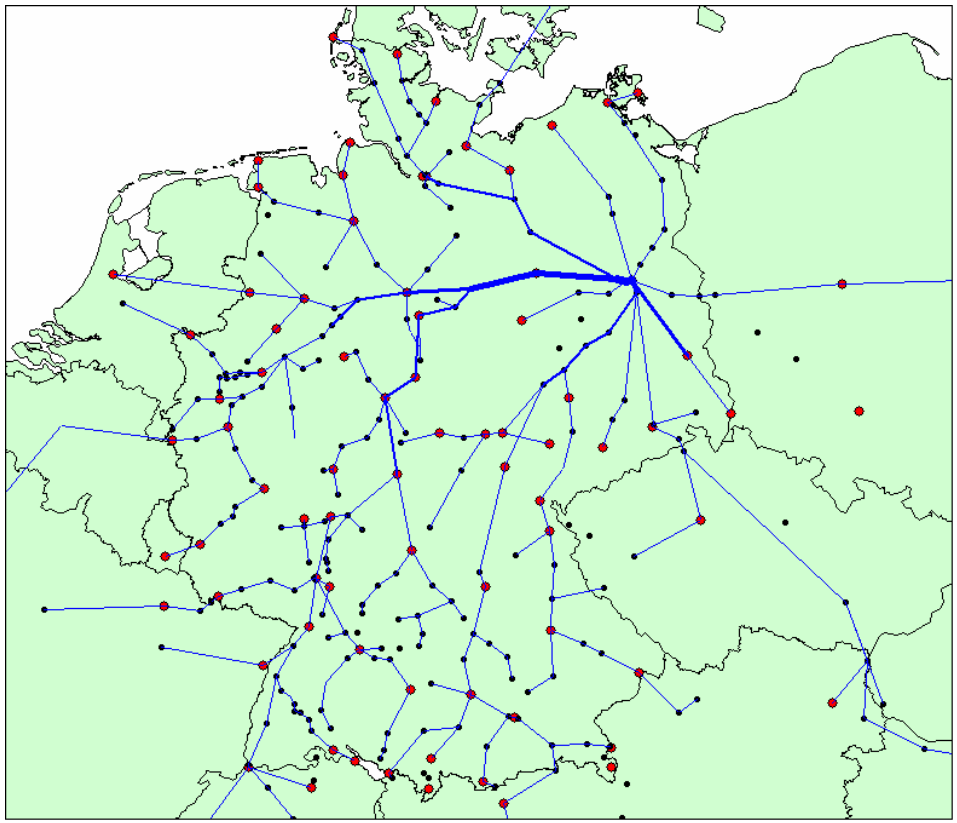


Generation of lines

Local Spanning-Tree



For all start/end stations do:

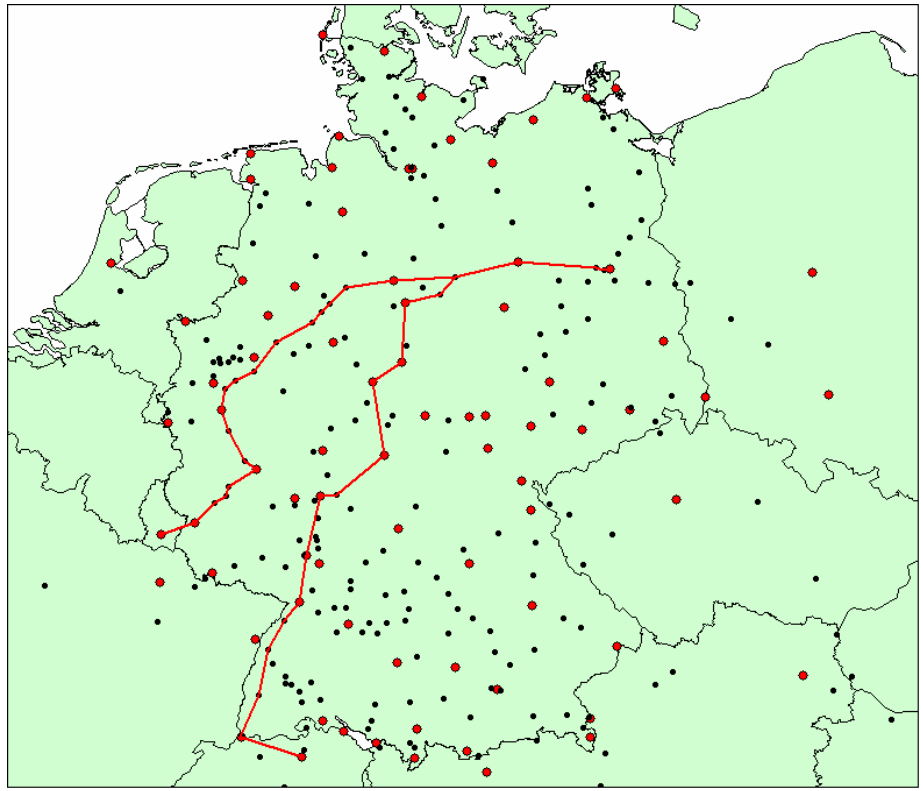
(1) Distribute the demand of this station on the net

(2) Calculate Max-Spanning-Tree

(3) Determine the *x* „best“ lines

Generation of lines

Local Spanning-Tree



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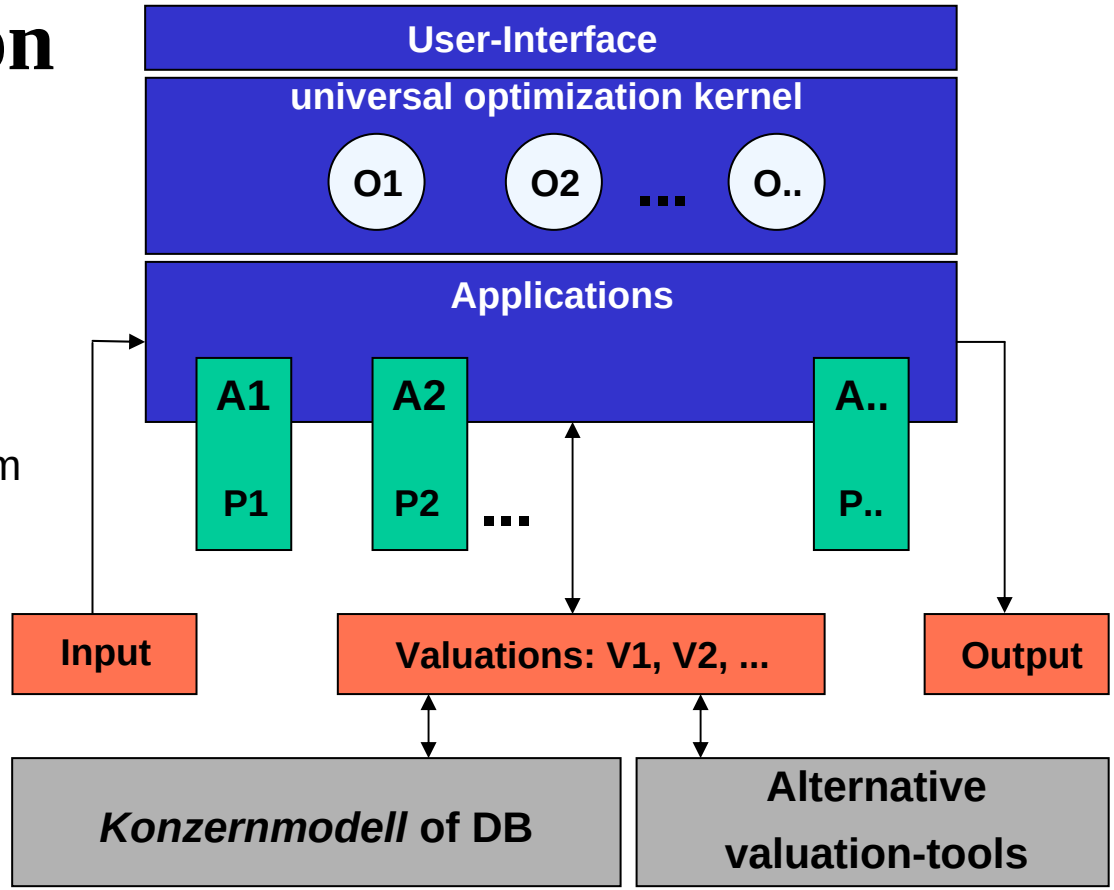
Line optimization

Algorithms

- Simulated Anealing
- Greedy
- Tabu-Search
- Generic genetic algorithm

Valuation-Tool

- profit calculation with demand-feedback



Line optimization - valuation

two-phases valuation process:

(1) „feasibility-criteria“

- corridor definitions
- covering of stations
- edge capacity
- train-km

(2) fast-valuation

- modal-split
- demand-feedback
- profit calculation
- ....

a x profit
+ b x travel_km
- c x travel _km_missed
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cost-function

Line optimization – Genetic Algorithm

Cross-Over

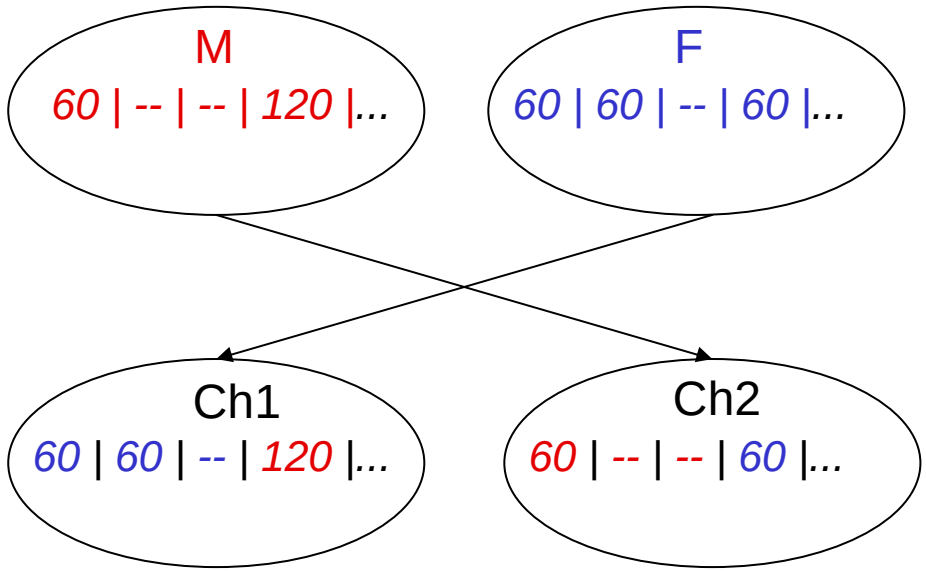
- gene = line

mutation

- insert a line
- remove a line
- exchange two lines (with/without similarity)
- change of frequency

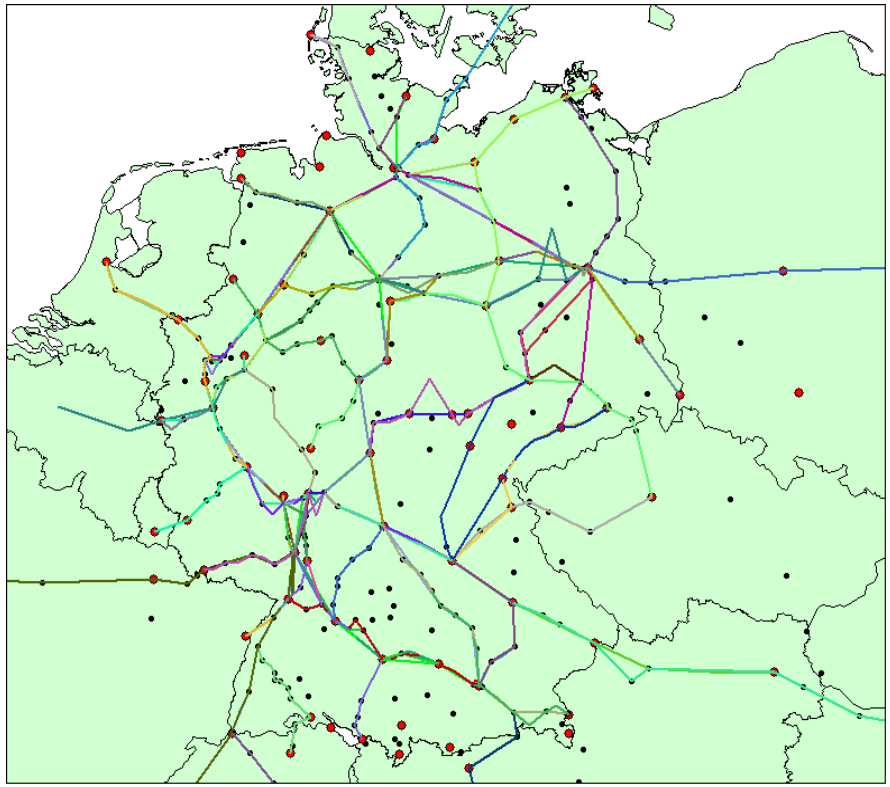
strategies

- populations with/without exchange



Line optimization - Results

pool size	500 –3000 lines
line plan	40-60 lines
profit	14.304.847
expense	8.491.533
income	22.796.380
train-km	598.120
traveller-km	309.284.448
comp. Time LinGen	1-30 min
comp. Time LinOpt	several hours
evaluation	5-15 sec



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... the end.

Thank you!