



Evolutionary Freight Transportation Planning

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BIBA

EVOTranslog'09 (Part of EvoWorkshops)
Eberhard Karls Universität Tübingen

<http://www.it-weise.de/>



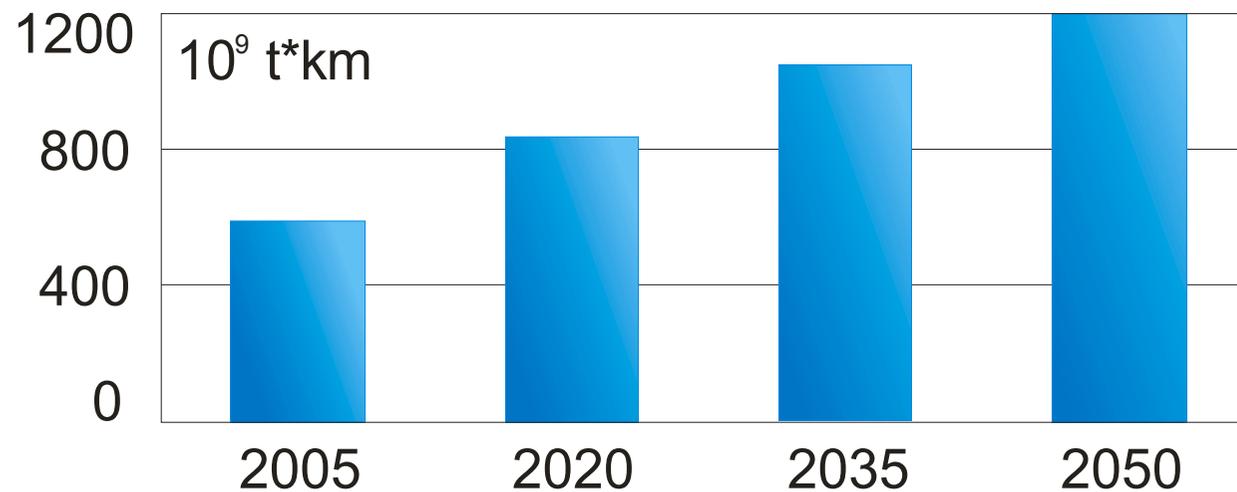
Contents

- The *in.west* Project
- Freight Transportation Challenge
- Optimization Problem
- Approach
- Experiments
- Online Re-Planning
- Conclusions





- Freight traffic is steadily increasing



- *in.west* is a research project funded by German Fed. Minist. of Econ. a. Tech.
- Goal: Reduce freight traffic by 10%

MICROMATA 
Erfolg ist programmierbar!

BIBA





- Focus on container-based freight transportation

Swap Body
C 745 / EN 284

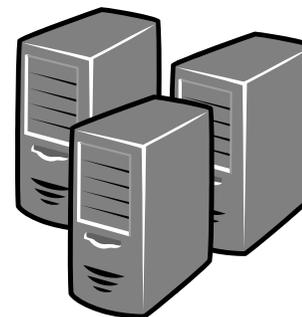
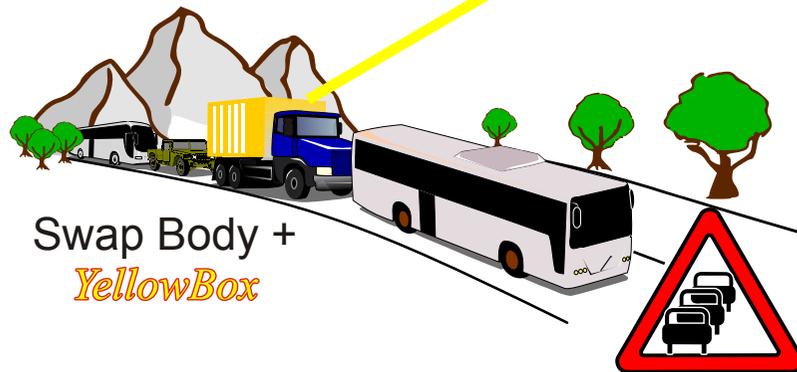




in.west
Intelligente Wechselbrückensteuerung



Communication
via Middleware



Software
(e.g. **Planner**)



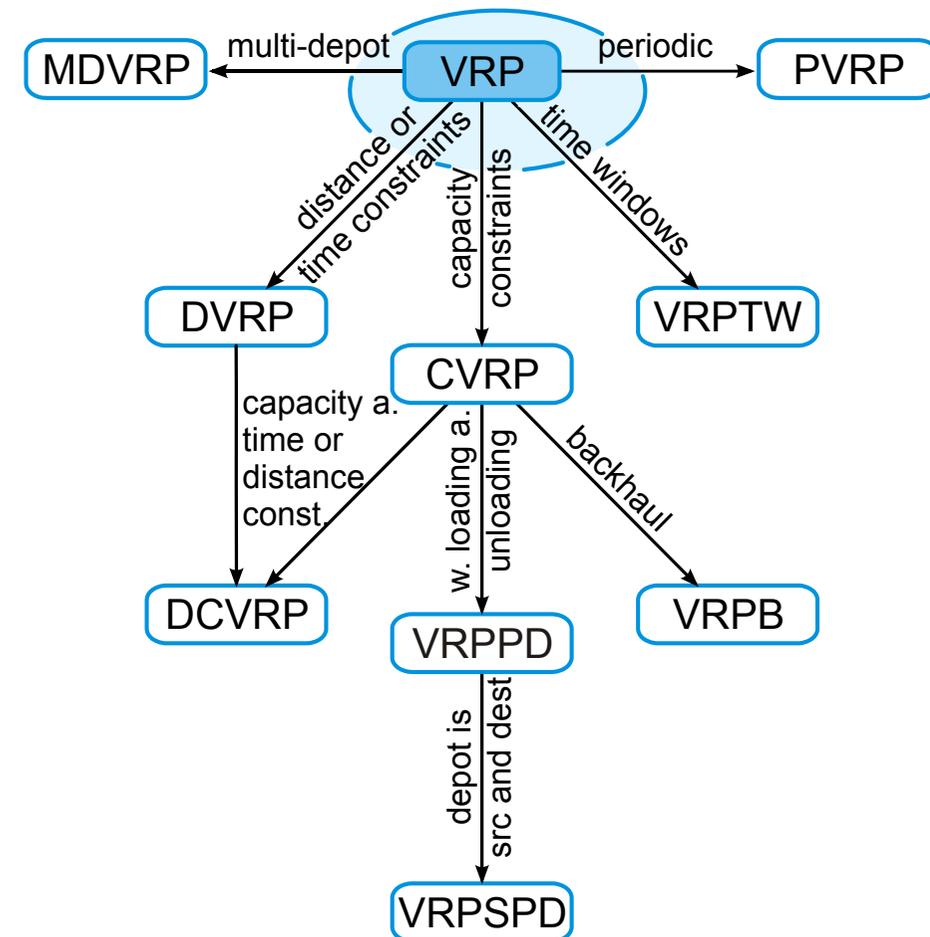
Visualization

Communication

- Holistic Approach
- Sensor Nodes
- Web-based GUI
- **Transportation Planner**
- Middleware

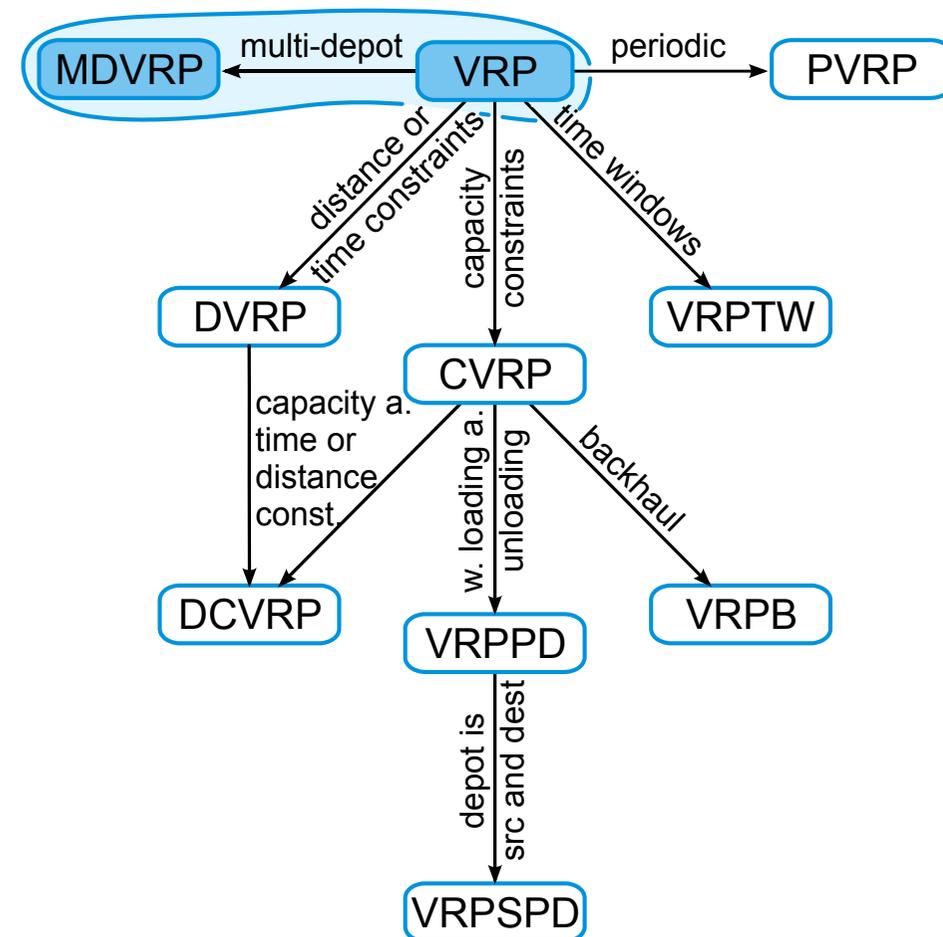
Freight Transportation Challenge

- Freight transportation for real-world logistics company
- Find routes on the map and assignments of orders to trucks/trains which minimize the undelivered orders and the total distance for...



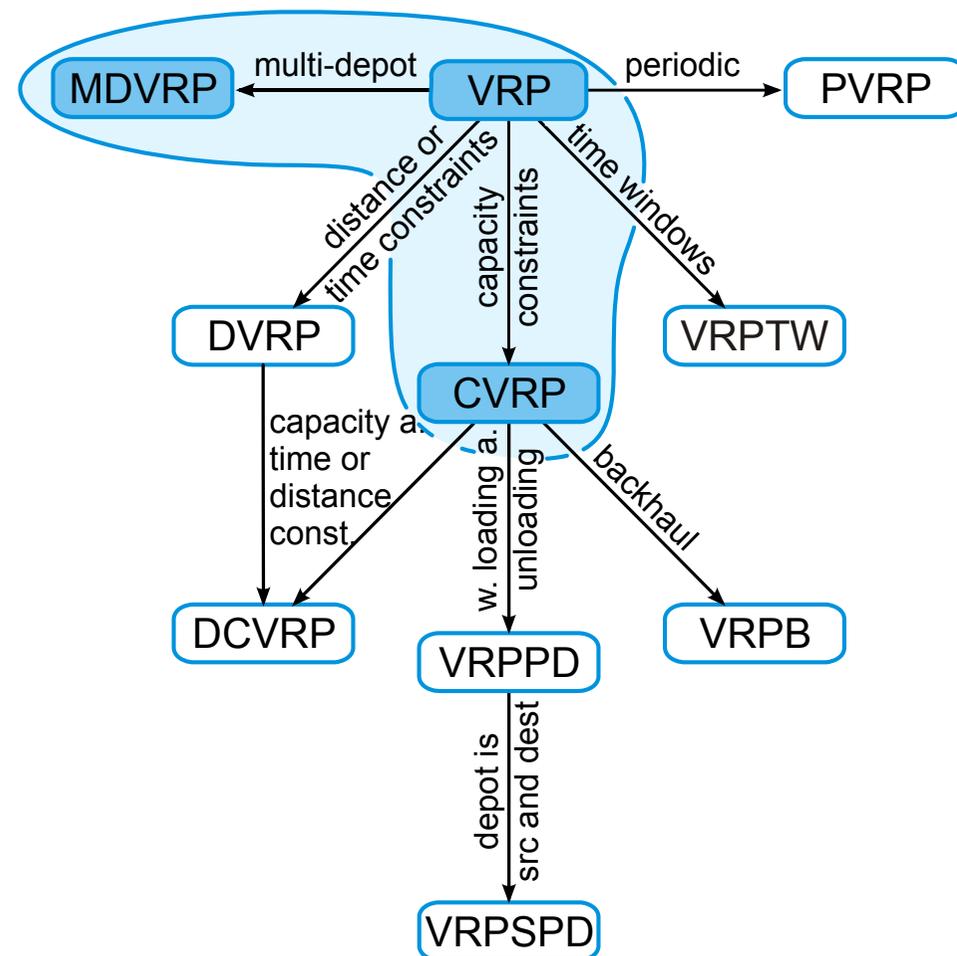
Freight Transportation Challenge

- Freight transportation for real-world logistics company
- Orders/Containers/Trucks/
Trains/Routes for ...
- Multiple depots and pickup and delivery locations



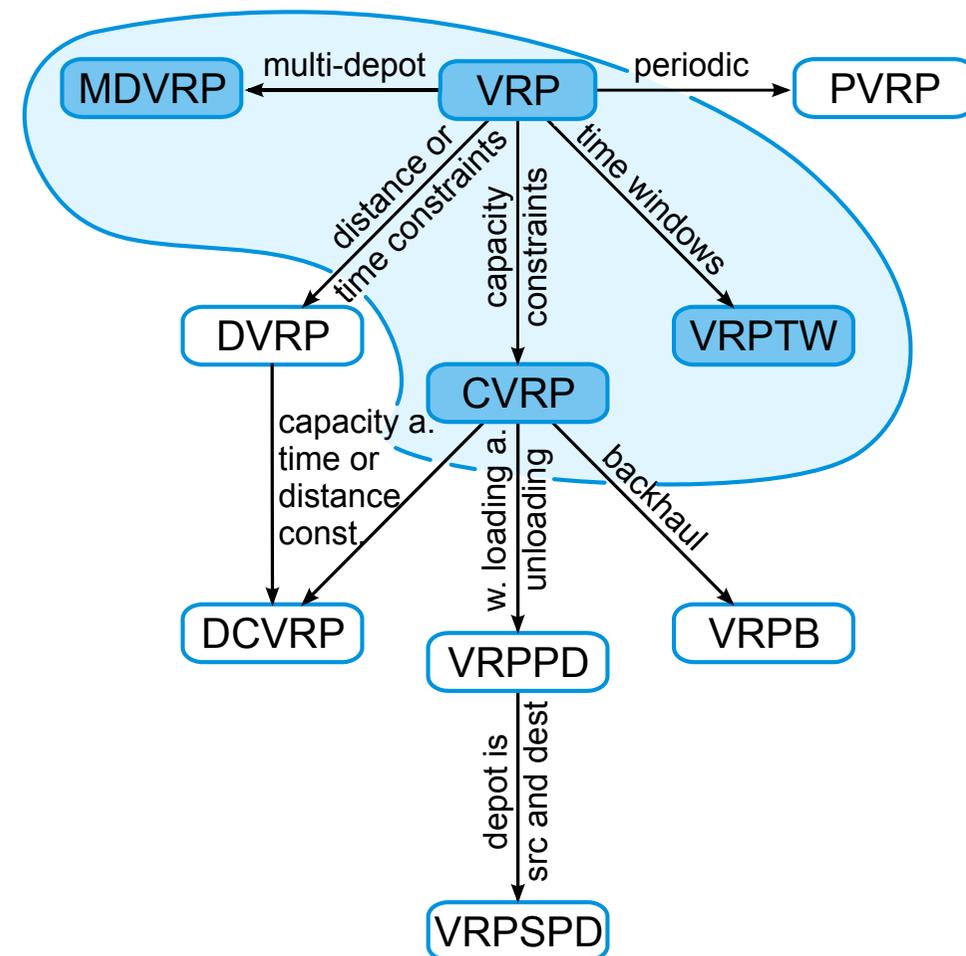
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- Orders/Containers/Trucks/Trains/Routes for ...
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- Vehicles (trucks and trains) have capacity limits



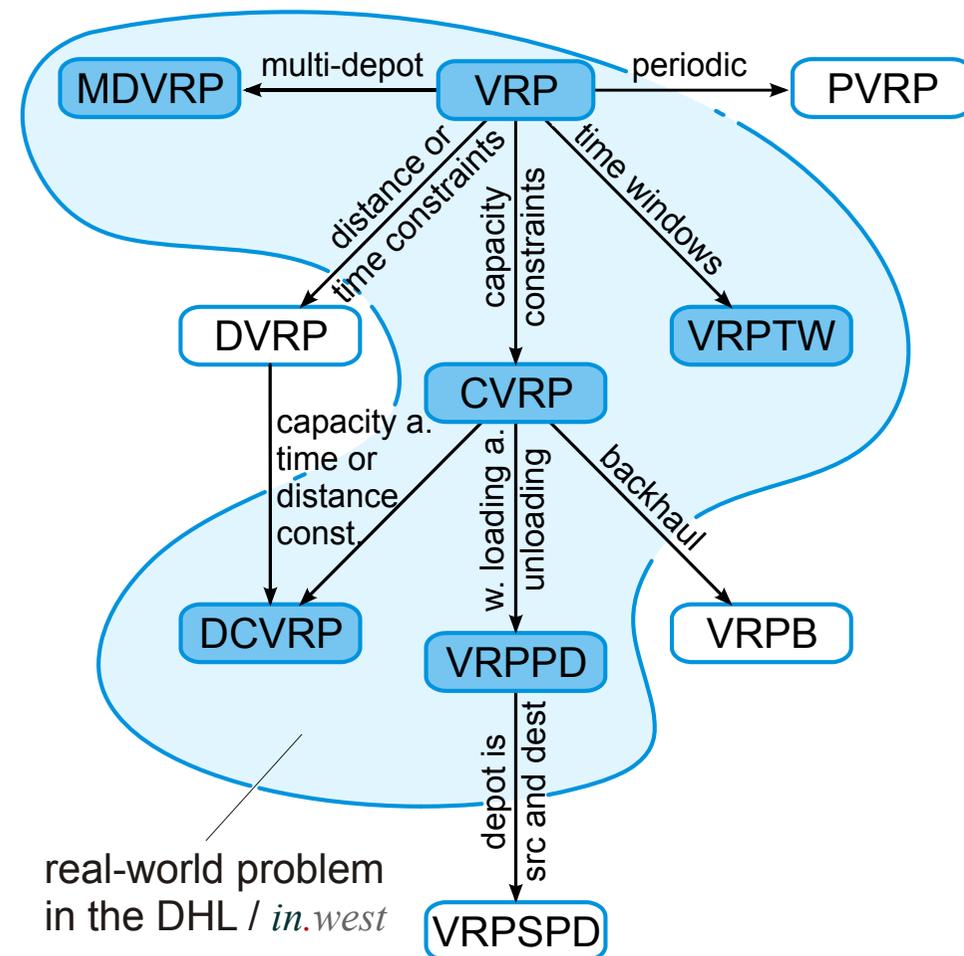
Freight Transportation Challenge

- Freight transportation for real-world logistics company
- Orders/Containers/Trucks/Trains/Routes for ...
- Multiple depots and pickup and delivery locations
- Vehicles (trucks and trains) have capacity limits
- Time windows for pickup and delivery



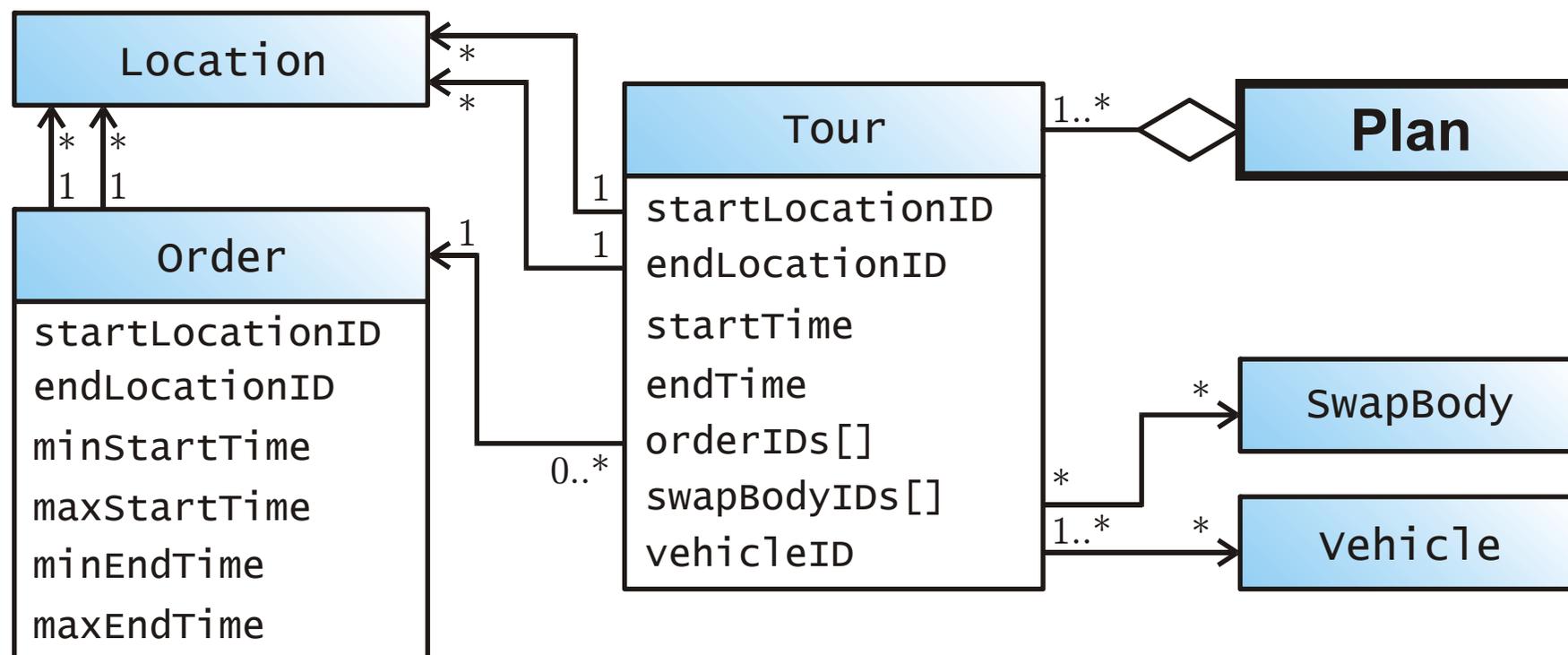
Freight Transportation Challenge

- Freight transportation for real-world logistics company
- Orders/Containers/Trucks/Trains/Routes for ...
- Multiple depots and pickup and delivery locations
- Vehicles (trucks and trains) have capacity limits
- Time windows for pickup and delivery
- Constraints, laws, time limit: 1d



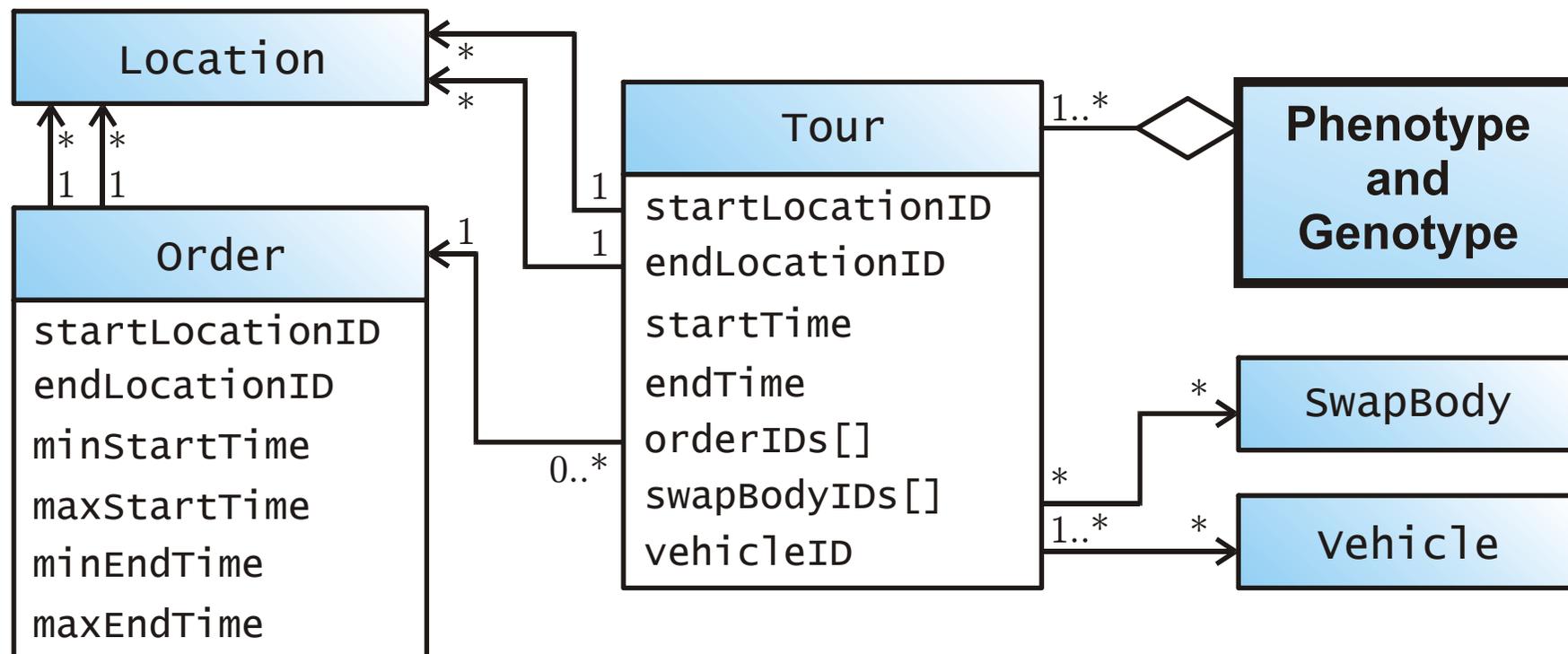
Optimization Problem

- Goal of optimization is to find a freight transportation plan
- Minimize f_1 (no. of undelivered orders), f_2 (distance), f_3 (spare capacity)



Approach: Genotype/Phenotype

- Evolutionary Algorithm
- Transportation Plan = Phenotype = Genotype





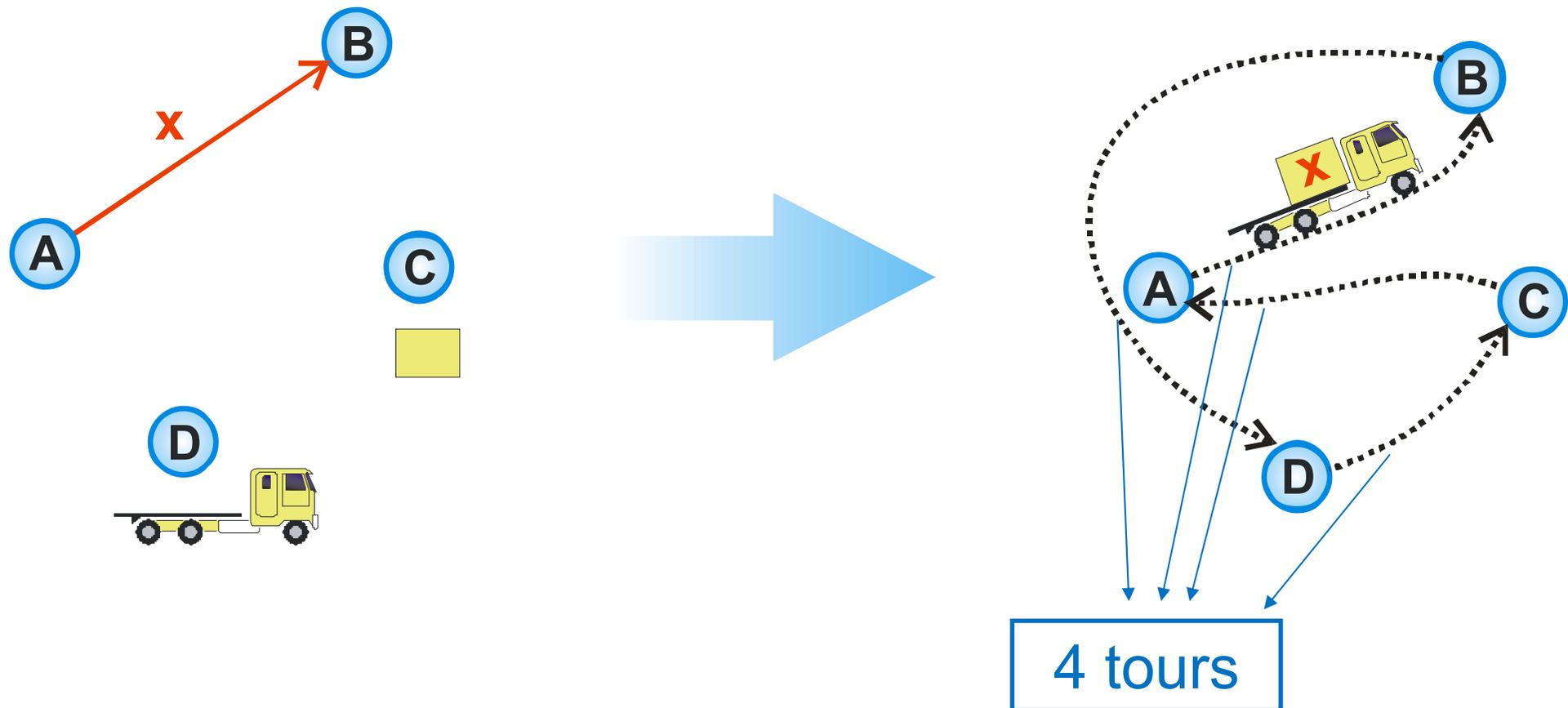
Approach: Search Operations

- Always create valid and physically correct phenotypes
- 16 mutation operations
- 3 recombination operators
- Each operation dedicated to one specific constellation in the solution candidates
- Reproduction: randomly choose operation, if not applicable choose another one (and so on)

Approach: Search Operations

(add order)

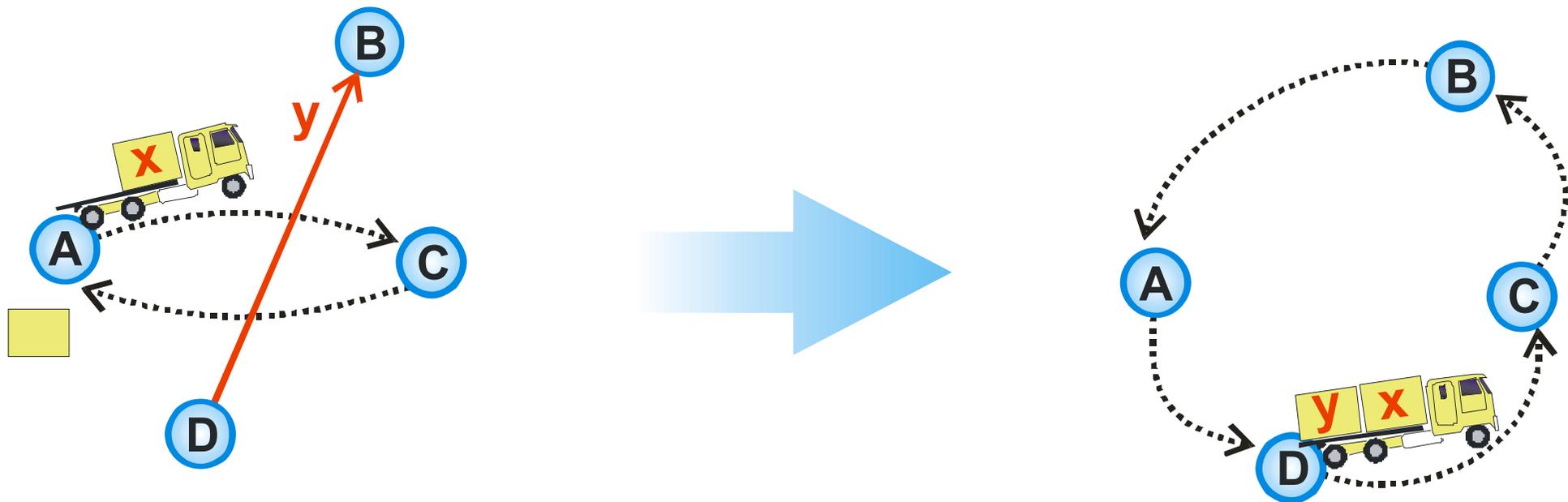
- Mutation: Add new tours for undelivered freight to plan



Approach: Search Operations

(insert order)

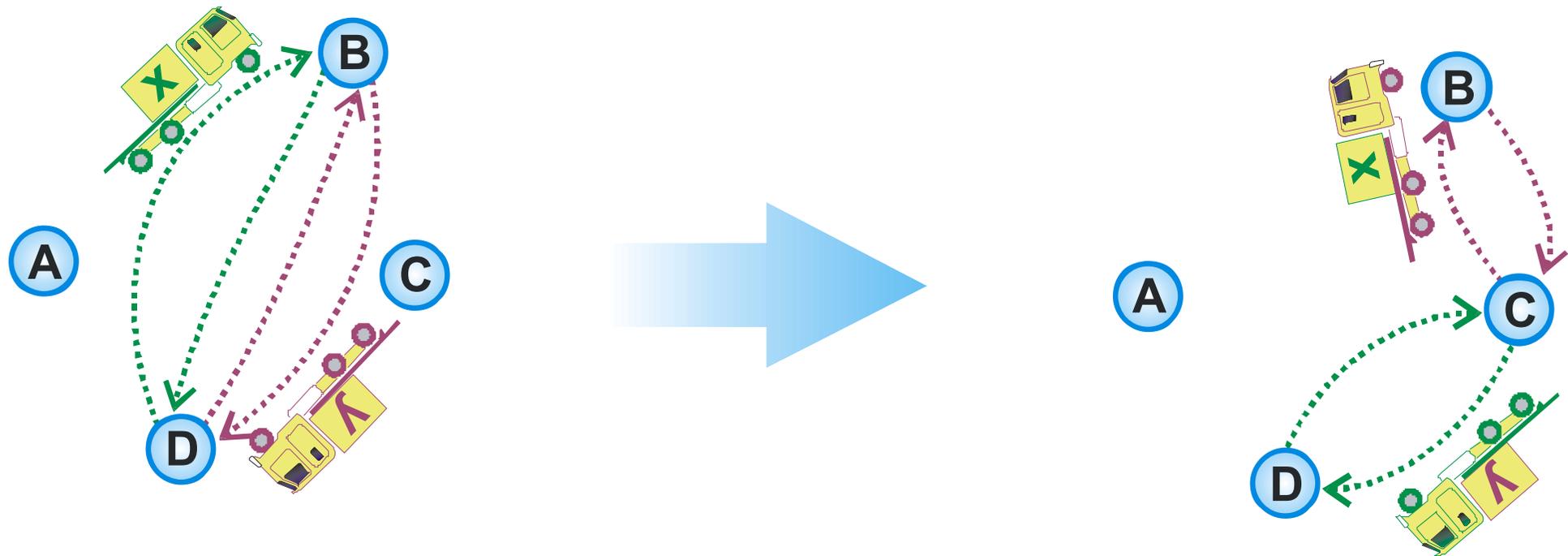
- Mutation: Integrate delivery in existing tour



Approach: Search Operations

(trucks meet)

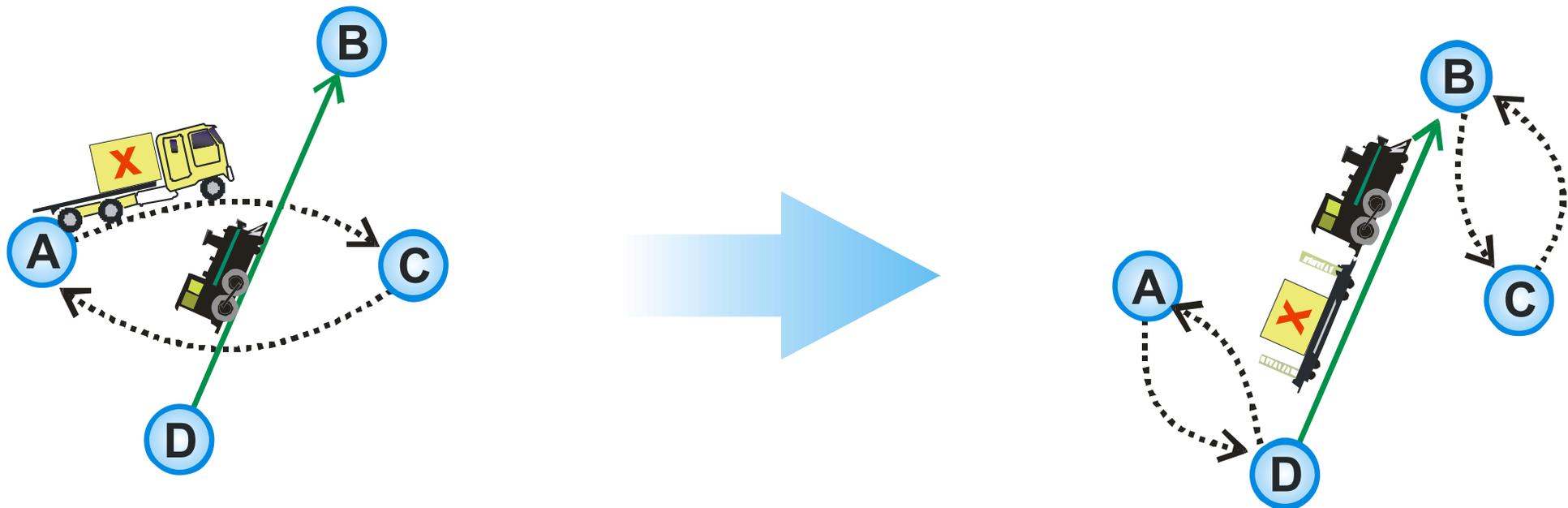
- Mutation: Freight exchange / Truck-meets-Truck



Approach: Search Operations

(use trains)

- Mutation: Transport freight via trains

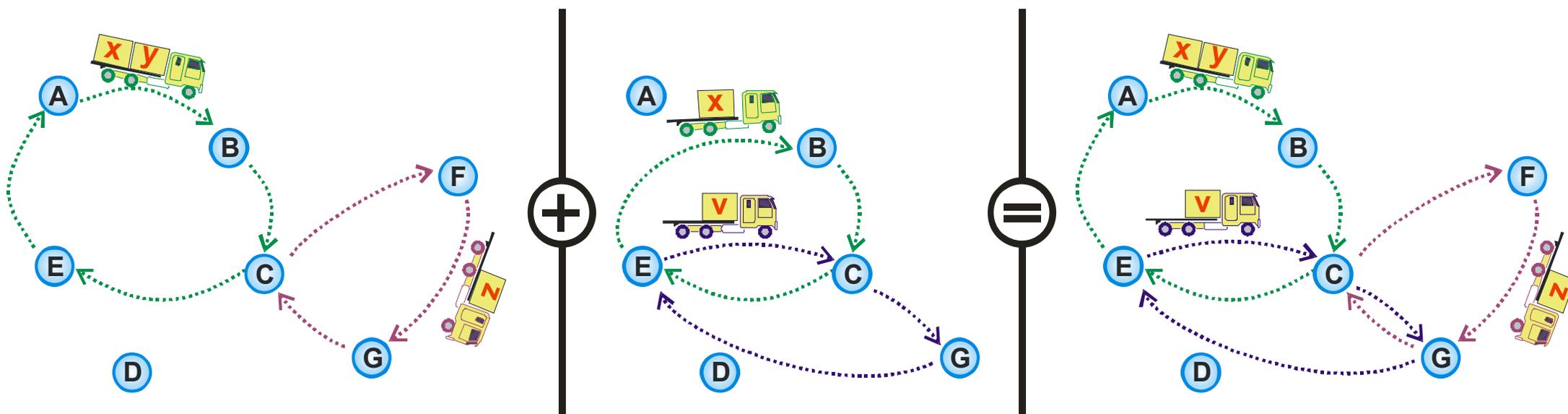


- For each operation, there is an inverse operation

Approach: Search Operations

(crossover)

- Crossover: Combine tours from parents

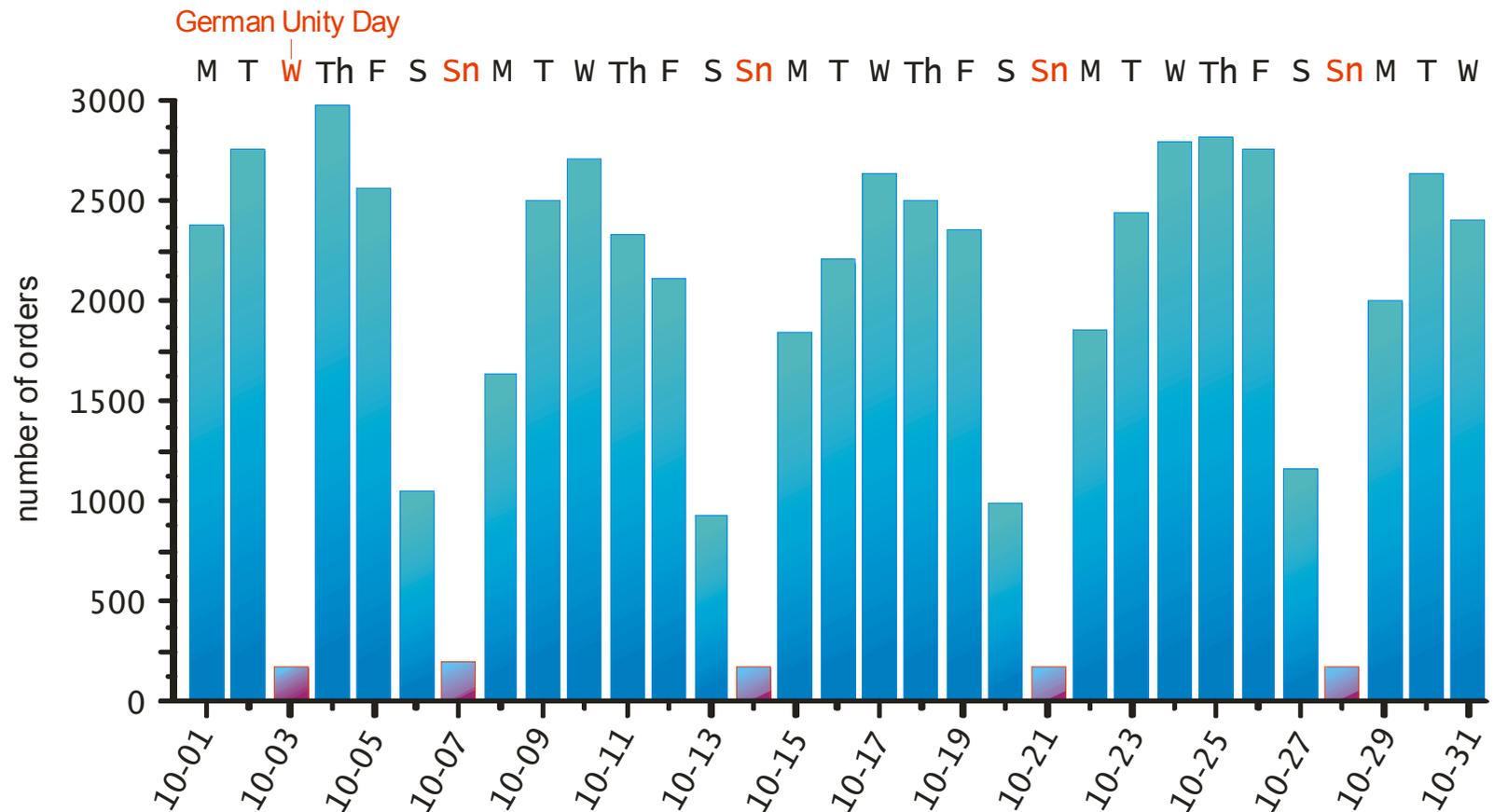




Experiments: Test Data

- Original data from the DHL

- 4th quarter 2007
- 800 swap bodies
- 11 depots
- 801 pickup/delivery locations
- 169...2980 orders/day
- 76% fill rate, lean flow of goods





Experiments: Find Good Settings

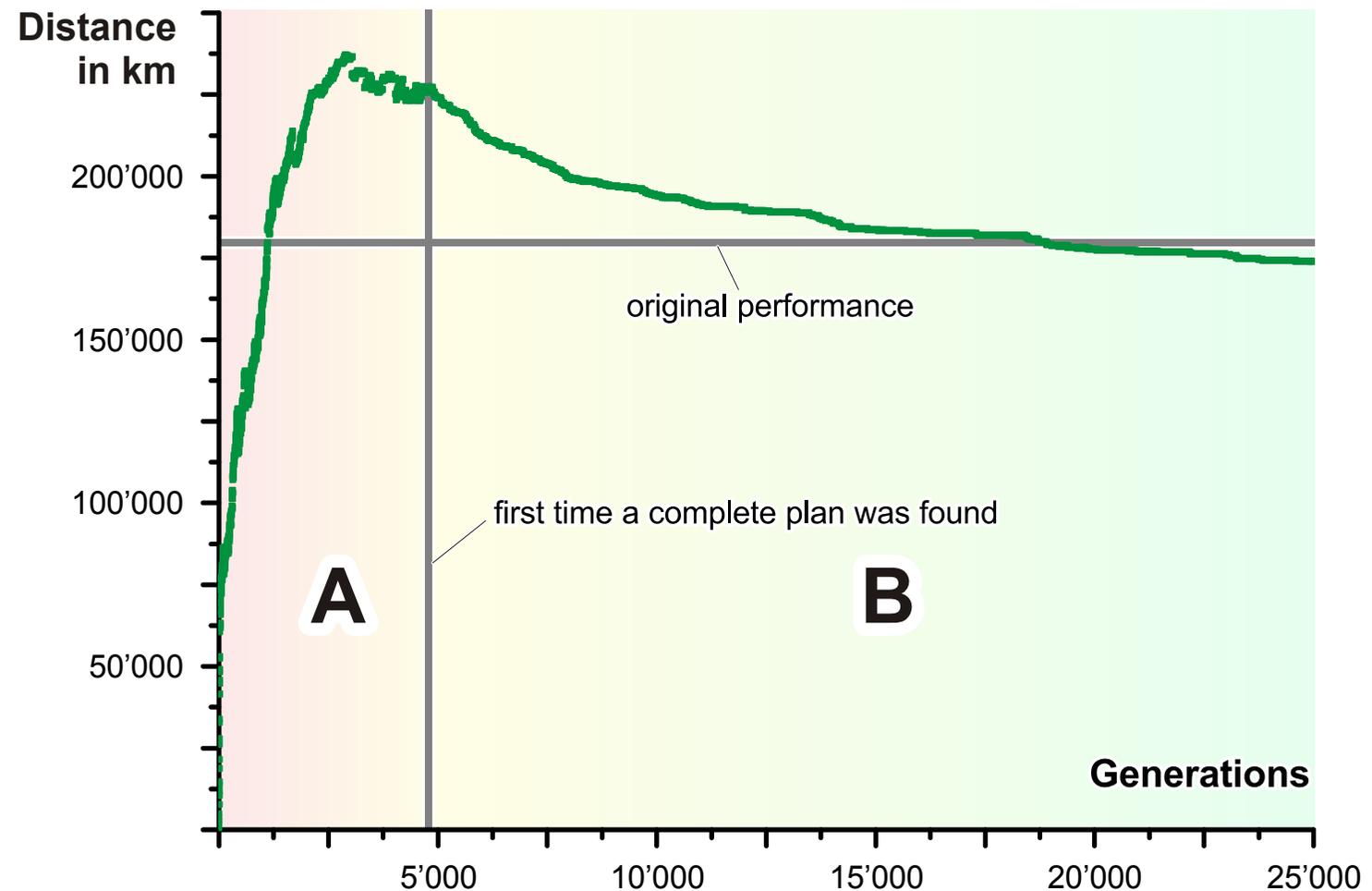
- Data set of 2007-12-02, 189 orders, original: **19019 km**
- Tested settings
 - steady state / generational
 - elitism / no elitism
 - population sizes: 200, 500, 1000
 - Pareto ranking with and without sharing
 - muta. rate: 0.6/0.8 crosso. rate: 0.2/0.4
 - convergence prevention (clearing) 0.0/0.3
- 192 configurations à 10 runs

Experiments: Find Good Settings

- Data set of 2009-12-02, 189 orders, original: **19019 km**
- Tested settings
 - steady state / **generational**
 - **elitism** / no elitism
 - population sizes: 200, 500, **1000**
 - Pareto ranking **with** and without **sharing**
 - muta. rate: 0.6/**0.8** crosso. rate: **0.2**/0.4
 - convergence prevention (clearing) 0.0/**0.3**
- 192 configurations à 10 runs: **172 configs better than original**
- Best configuration: 80% mutation, 40% crossover, ps = 1000, steady state, elitism, sharing, cp = 0.3
15883 km in total or 16% saved

better in two-tailed significance tests with $\alpha = 2\%$

Experiments: Tests with various data sets



Fri, 2007-12-07
 1987 orders
 original: 174924 *km*
A assign all orders
B improve solutions
 new 173916*km*

Experiments: Tests with various data sets

Mon, 2007-12-24

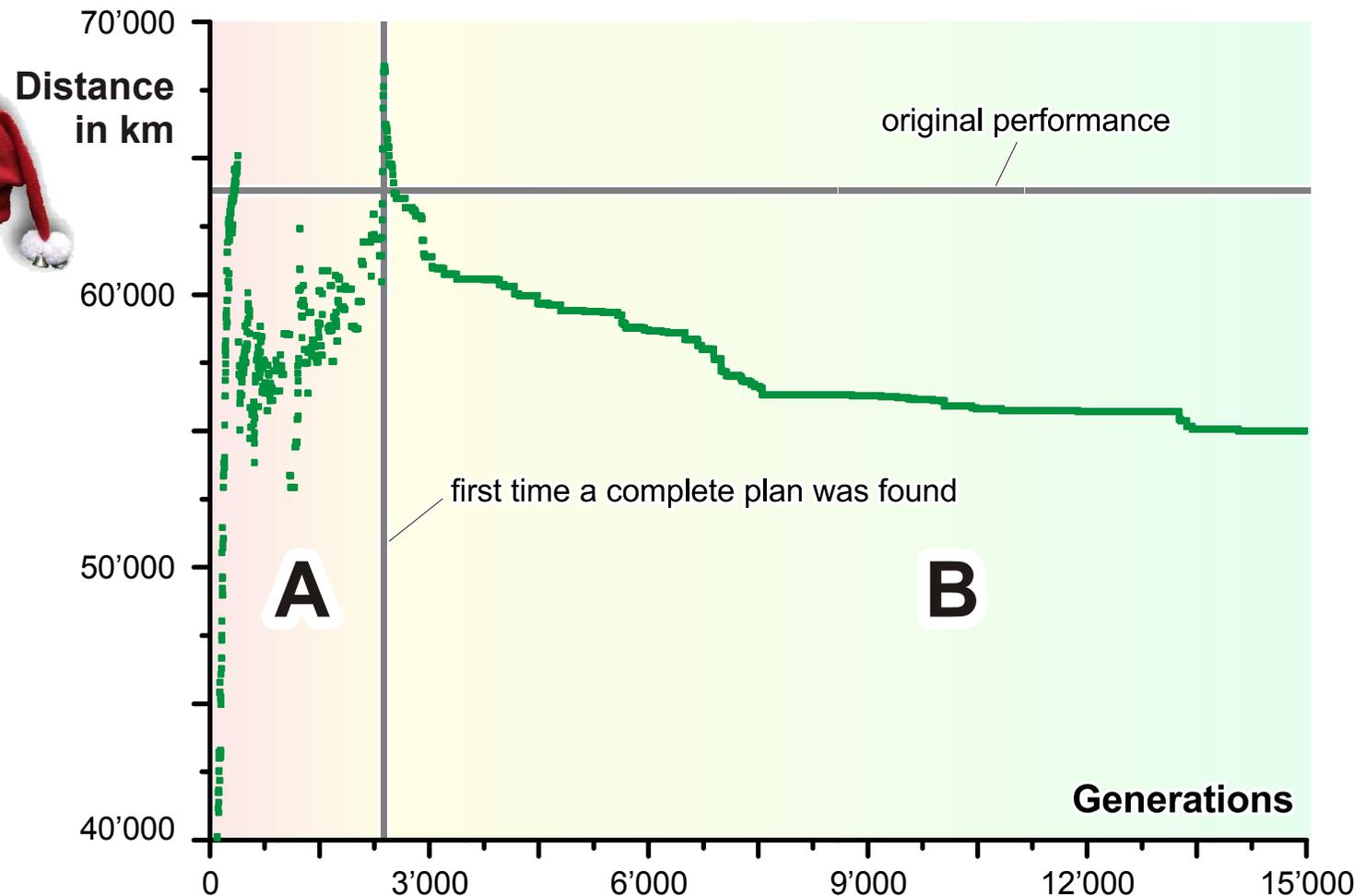
642 orders

original: 63812 *km*

A assign all orders

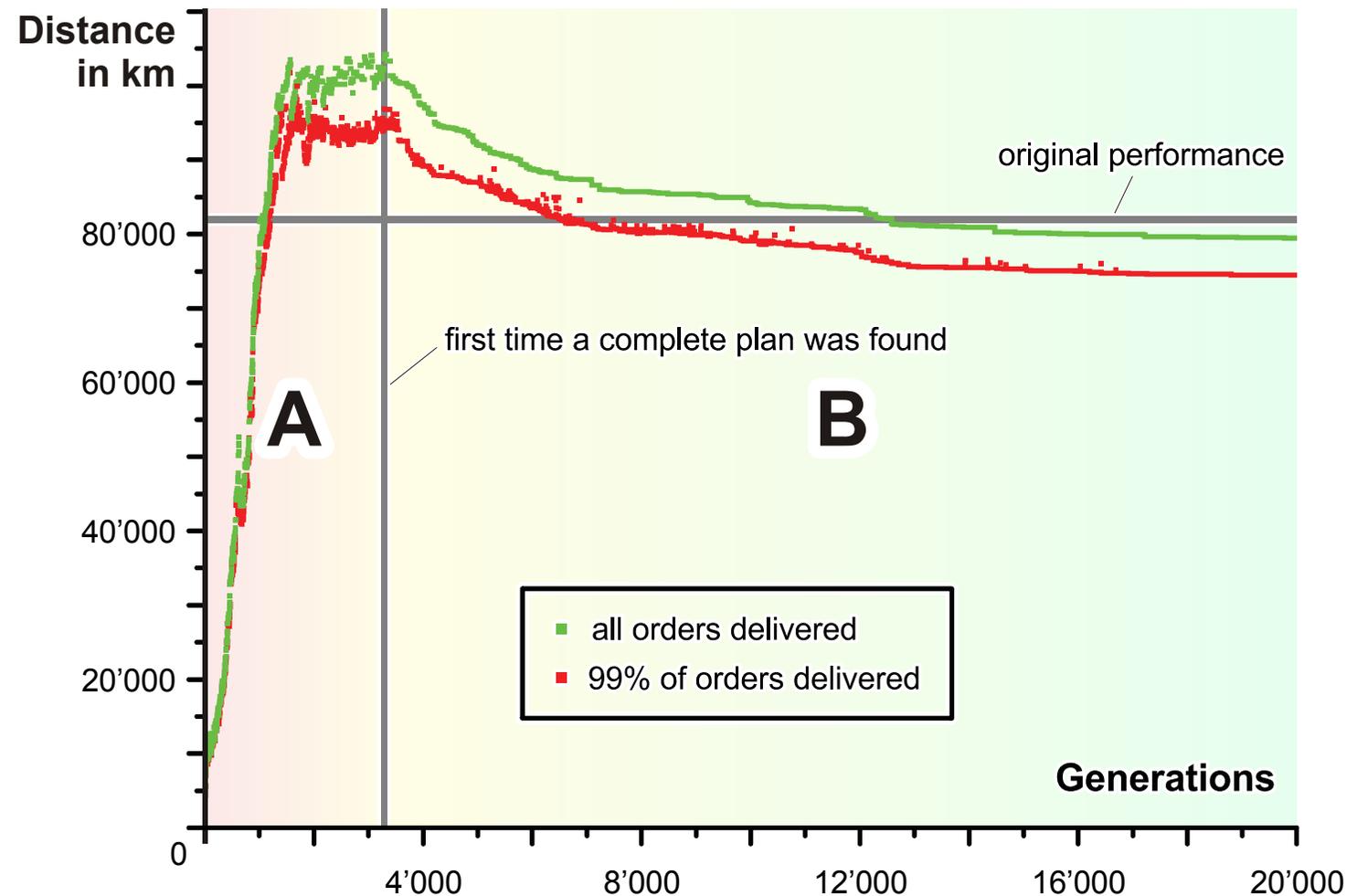
B improve solutions

new: 54993 *km*



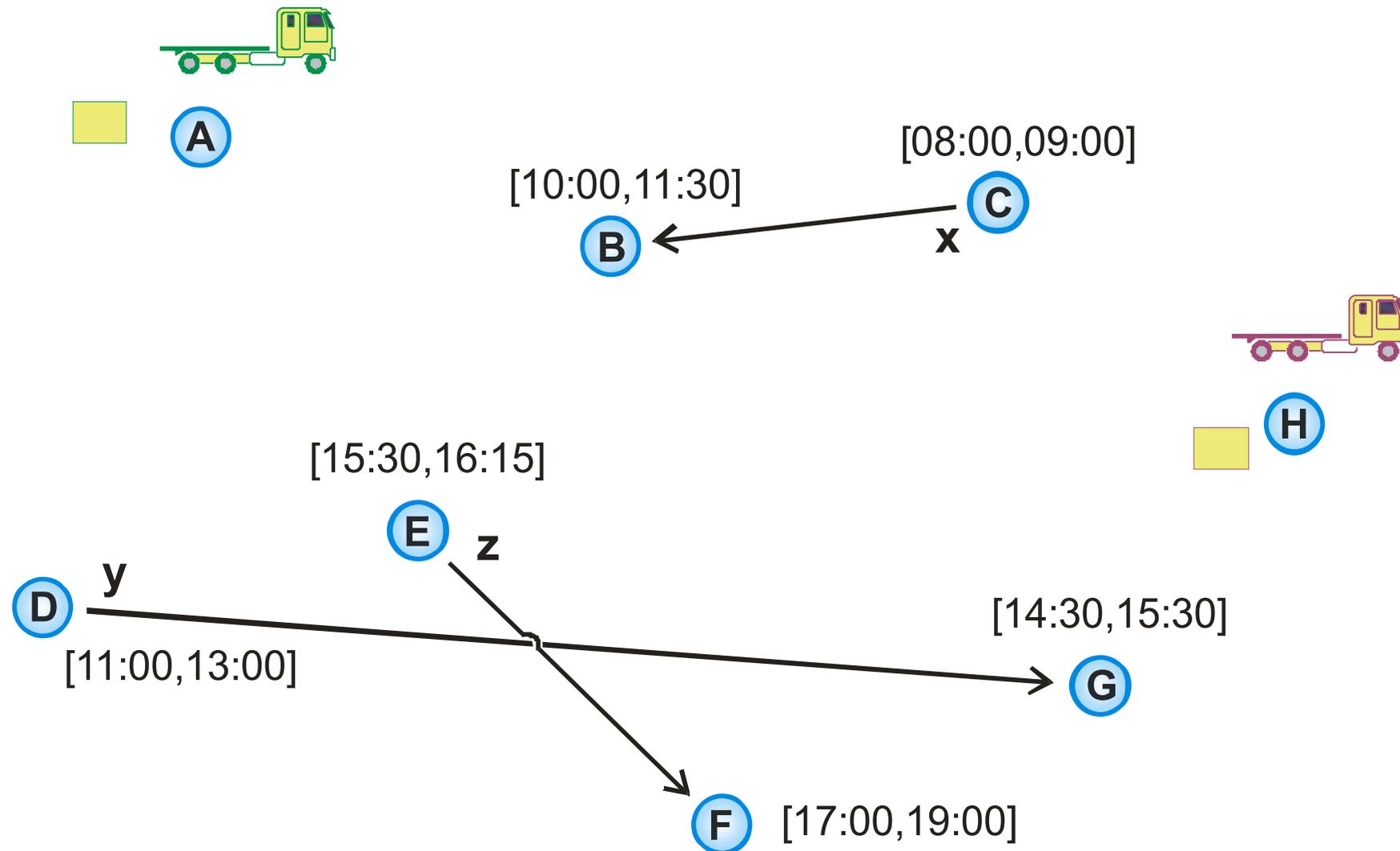


Experiments: Tests with various data sets

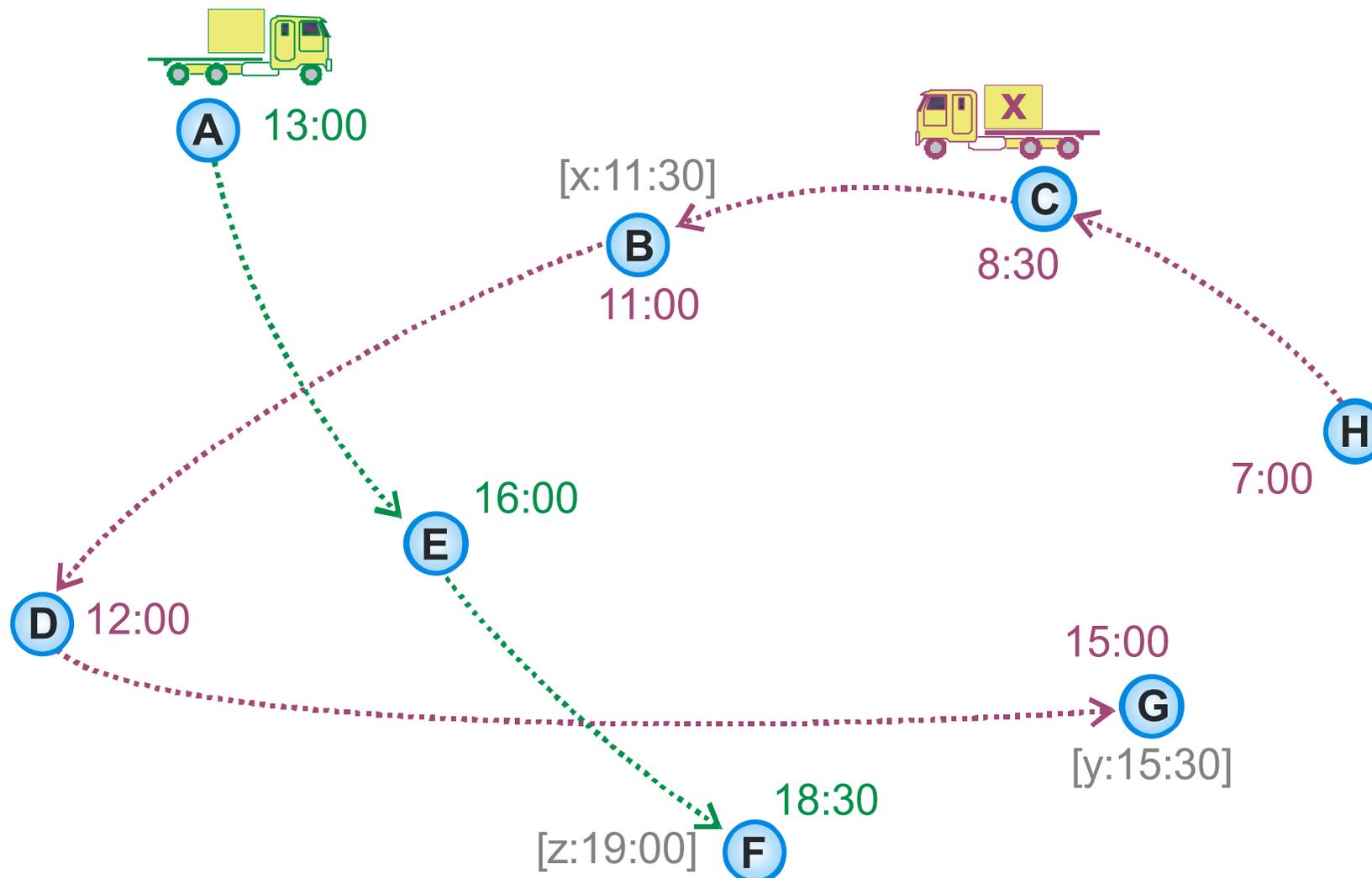


Sat, 2007-11-03
1016 orders
original: 82013 km
A assign all orders
B improve solutions
100%: 79463 km
99%: 74435 km

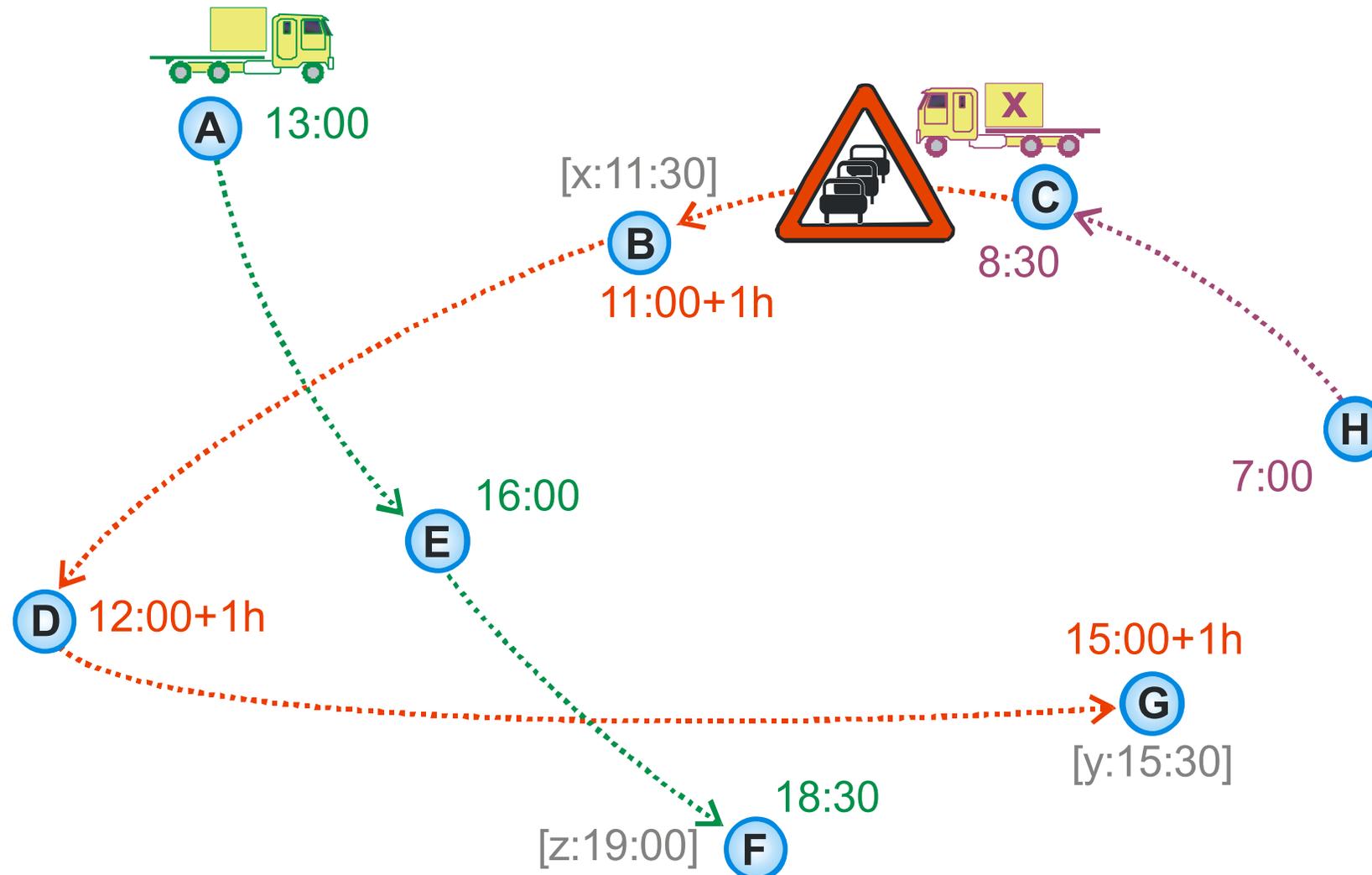
Online Re-Planning



Online Re-Planning

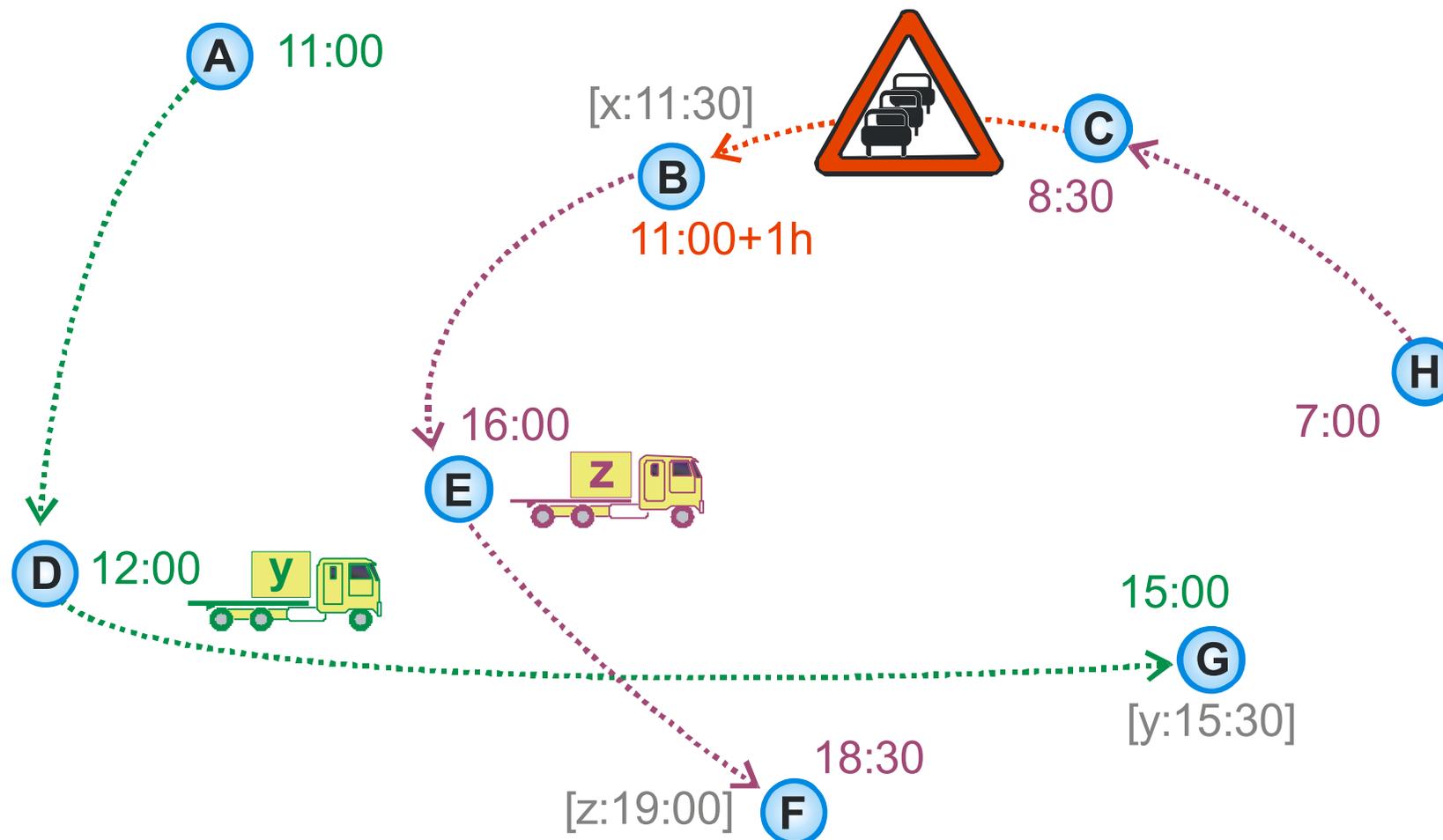


Online Re-Planning





Online Re-Planning





Conclusions

- Planning in real-world logistics companies is hard
- Evolutionary approach with dedicated representation and search operations has been provided
- Extensive tests have been performed
- Improvement: never $< 1\%$, normally $\approx 5\%$, best $\geq 15\%$
- Offline and online optimization
- Field test of complete *in.west* system this fall
- Distribution, further improvements



Thank you very much for your attention!

Any questions?

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gor@biba.uni-bremen.de



Experiments: Find Good Settings

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1	80%	40%	on	elit	1000	stead	share	341	609	3078	3 0785 00	15 883 km
2	60%	20%	on	no el	1000	gene	share	502	770	5746	5 7465 00	15 908 km
3	80%	20%	on	elit	1000	stead	share	360	626	4831	4 831 000	15 929 km
4	60%	40%	on	no el	1000	stead	share	468	736	5934	5 934 000	15 970 km
5	60%	20%	on	elit	1000	stead	share	429	713	6236	6 236 500	15 971 km
6	80%	20%	on	no el	1000	stead	share	375	674	5466	5 466 000	16 003 km
7	80%	40%	on	el	1000	stead	plain	370	610	5691	5 691 500	16 008 km
8	80%	20%	on	no el	1000	gene	share	222	450	6186	6 186 500	16 018 km
9	80%	40%	off	no el	1000	gene	share	220	463	4880	4 880 000	16 060 km
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