Large Neighborhood Search for a rich dynamic VRP with transshipments, backhauls and subcontracting

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- Characteristics of the Problem
- Procedure
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Real-world cooperation

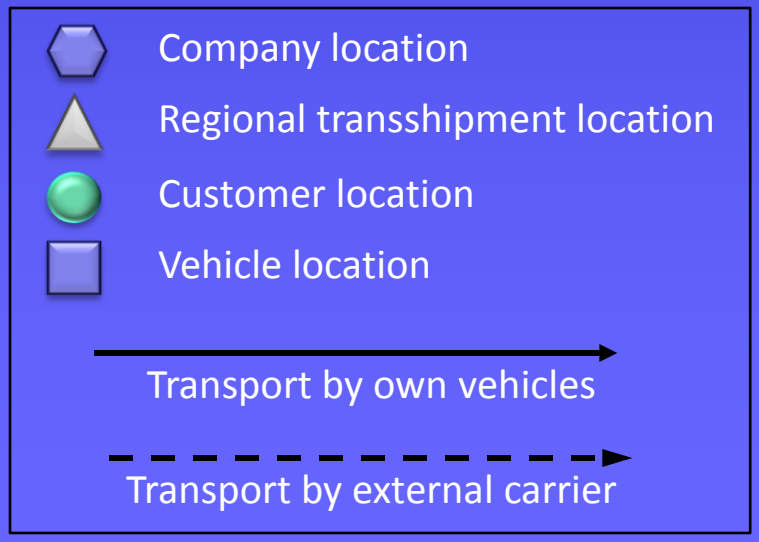
- 4 companies, supplier, food and beverages industry
- Complementary product range; overlapping customer base
- Goods are delivered free
- Own means of transport in several regions (own vehicles)
- Cooperation in Transport Operations Planning
- Goal: virtual full range supplier

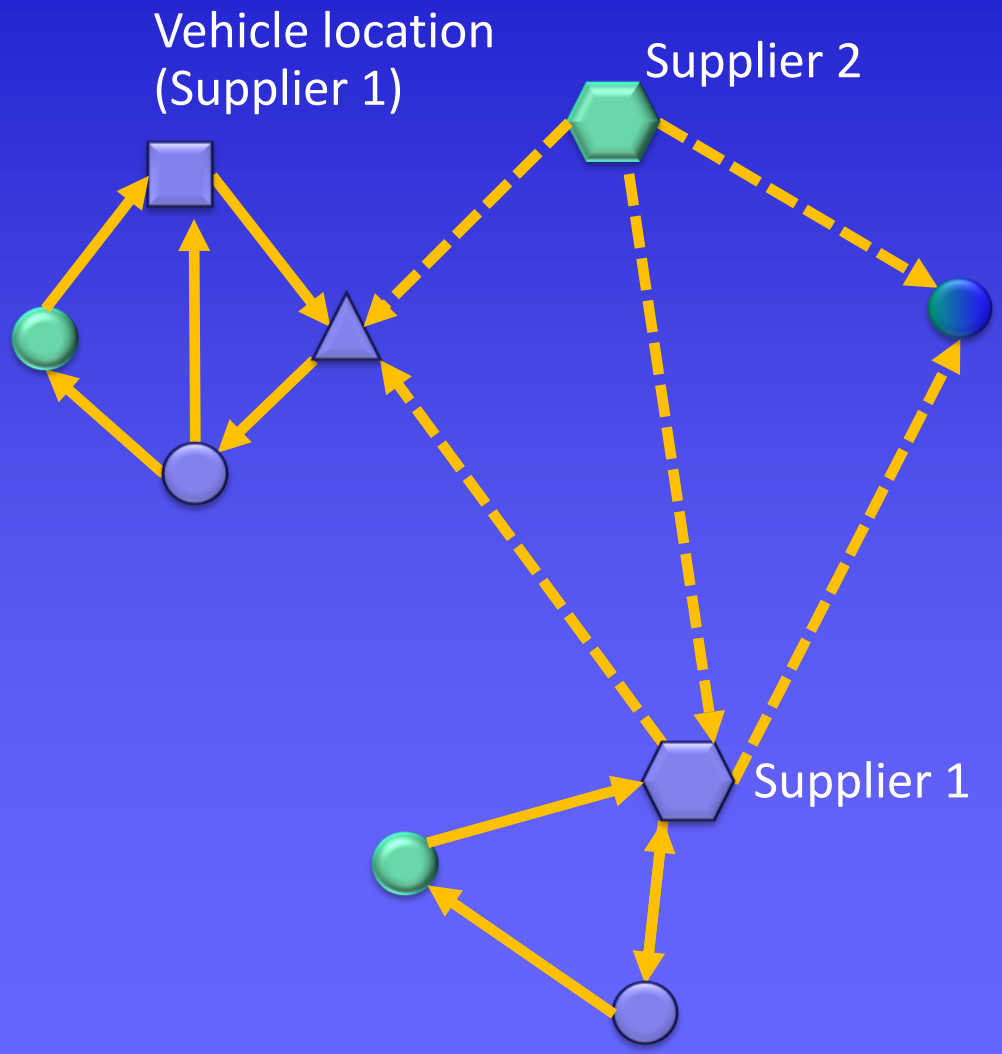
Transport Operations Planning

Simultaneous Planning

- Vehicle Routing
- Transshipments
- Direct Delivery

→ Minimize costs

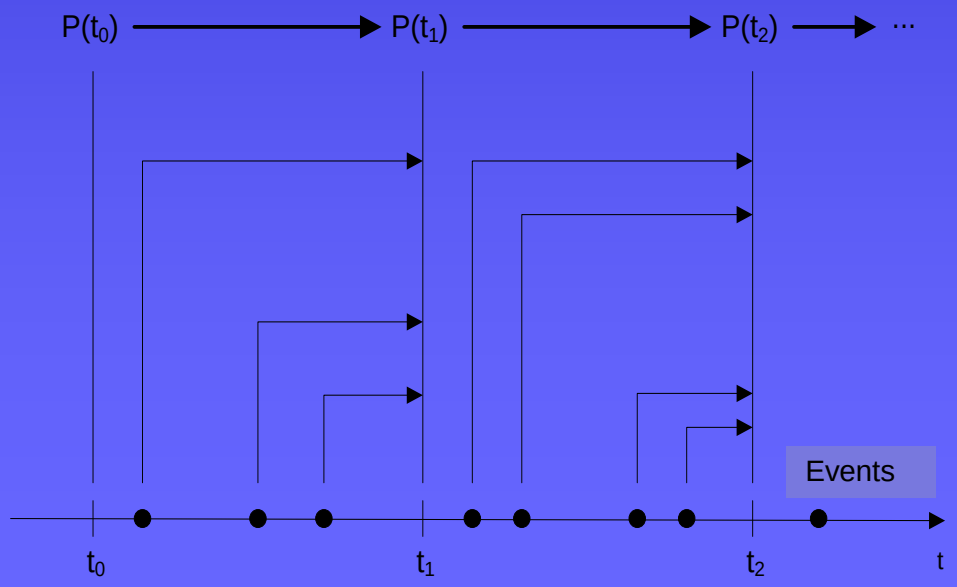




Dynamics

- Decisions under incomplete information due to advance notices
- Flexible reaction to unexpected events

- Rolling horizon
- Sequence of temporary static problems



Backhauls

- Delivery of goods in standardised boxes (E2)
- Empty boxes to be returned → Backhauls
- Backhauls only occur with orders served by own vehicles
- Implicit rule: Take as many boxes back, as you brought.
- Violation of this rule leads to explicit backhaul orders
- Explicit backhaul orders must be executed by own vehicles → High priority in scheduling

Insertion Heuristic

Input: feasible base plan,
new orders,
available vehicles

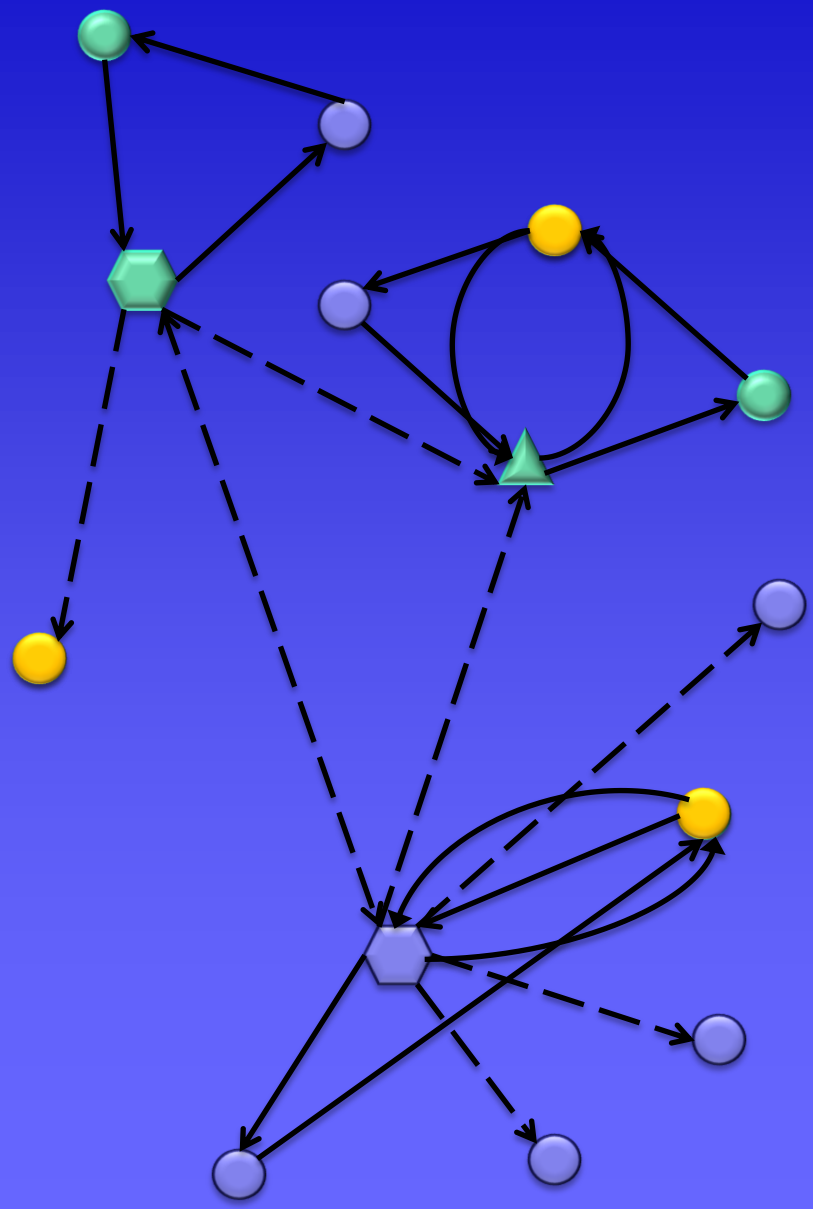
(1) Randomly chose a new order

(2) Chose **cheapest feasible insertion** for delivery by **own means of transport**

In case: plan additional transship

(3) If there is no feasible insertion, plan direct transport by external carrier

(Except backhauls!)



Improvement Strategy

Input:

Start Solution sln_old,
Thresholds (T(1),...,T(max_T))

(1) Create new feasible solution sln_new using

Large Neighborhood Search

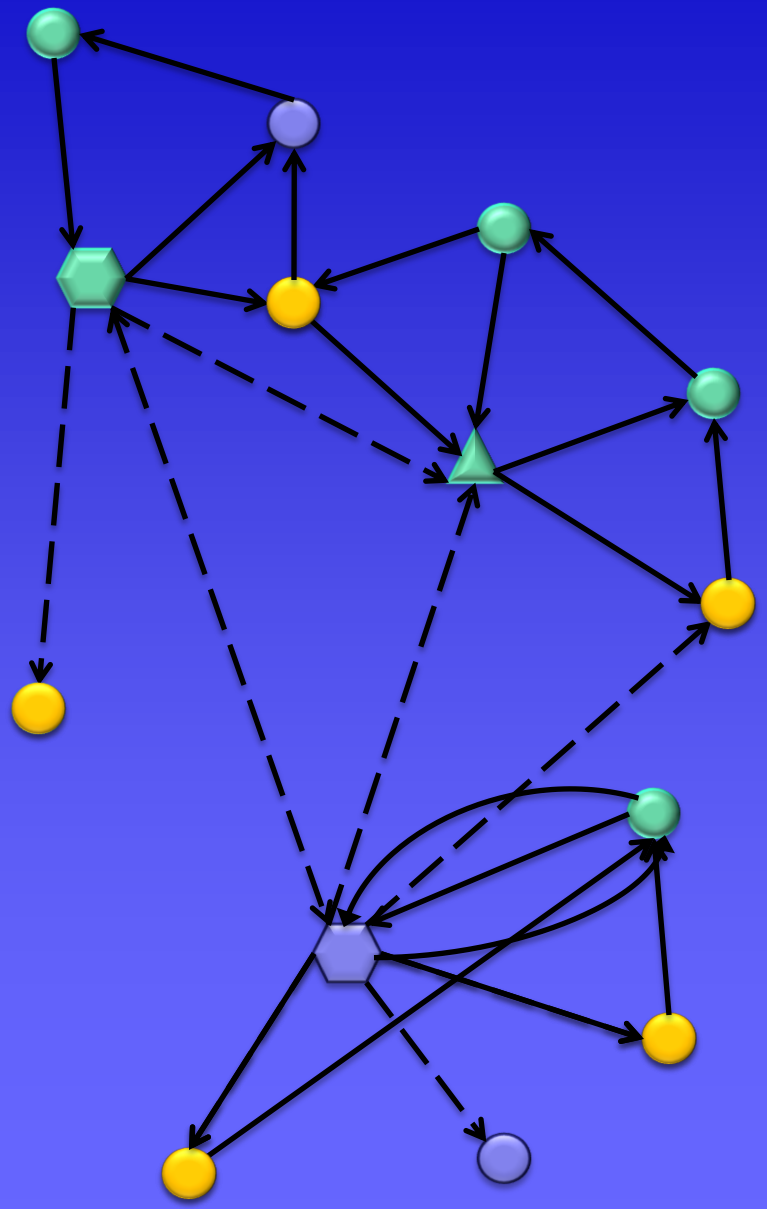
(2) **If**

Cost(sln_new)

< Cost(sln_old) * (1+T(t))

Then sln_old := sln_new

(3) Repeat until some termination criterion is reached.

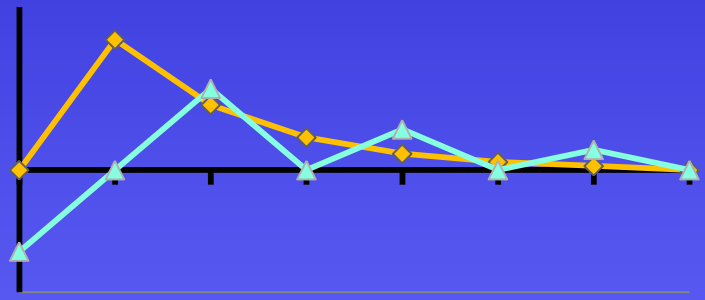


Test - Instances

- 10 six-day instances on the basis of real data
- 185 orders, 1 backhaul order per day
- 4 companies,
- 13 company-owned vehicles in 4 regions,
- 3 external carriers:
  - advance notices at 12.30 for transships,
  - advance notices at 18.00 for regular direct transport,
  - expensive variant without advance notice

Parameters

- Scenarios
  - Isolated
  - Cooperative
- Thresholds
  - 0, 3.2, 1.6, 0.8, 0.4, 0.2, 0.1, 0
  - -2, 0, 2, 0, 1, 0, 0.5, 0



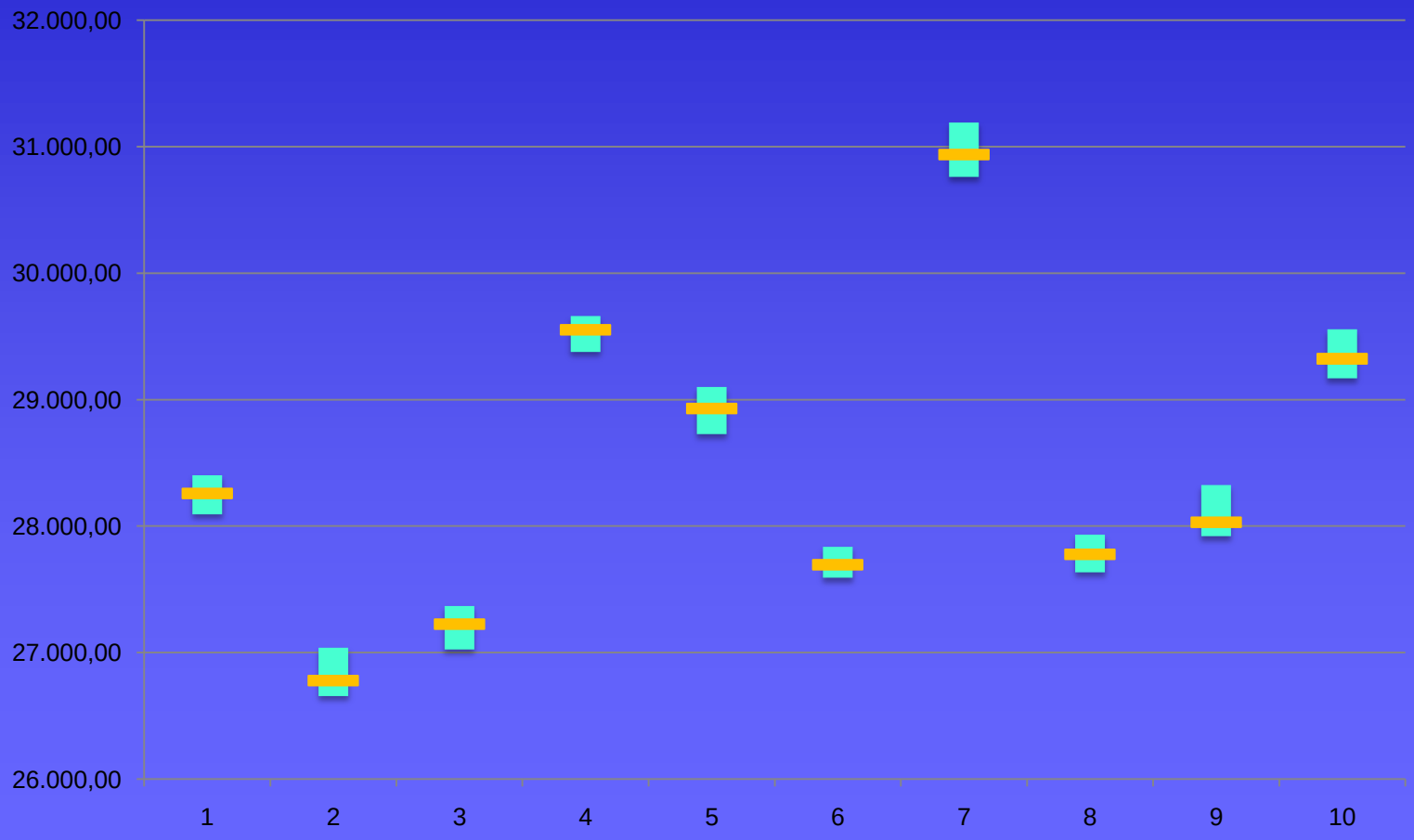
- Call for improvement heuristic
  - Continous: Regularly every 10 minutes (54*160 Iterations)
  - „Due-Date“: Only when an advance notice is due (3*2880 Iterations)

Isolated vs. cooperative Scenario

	Minimum savings	Maximum savings	Average savings	Average calculation time per instance (cooperative)
Continous planning	19,5%	23,3%	21,6%	164 s
„Due-Date“ planning	19,9%	23,6%	21,9 %	300 s

Long Planning before due dates slightly better (-1%) but significantly slower (+40%)

Spread Range of Results



Further Research

- Exploit specific problem knowledge
  - Diversify the objective function during the day
  - Other ideas: relatedness function …
- Additional dynamic events
  - appropriate reaction
  - e.g. changed orders, traffic jams, break downs
- Comparison of different metaheuristics
- Change to PDP – several depots per Region,
- Cost allocation

Thank you for your attention!

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