Optimizing the Transport of Junior Soccer Players to Training Centers

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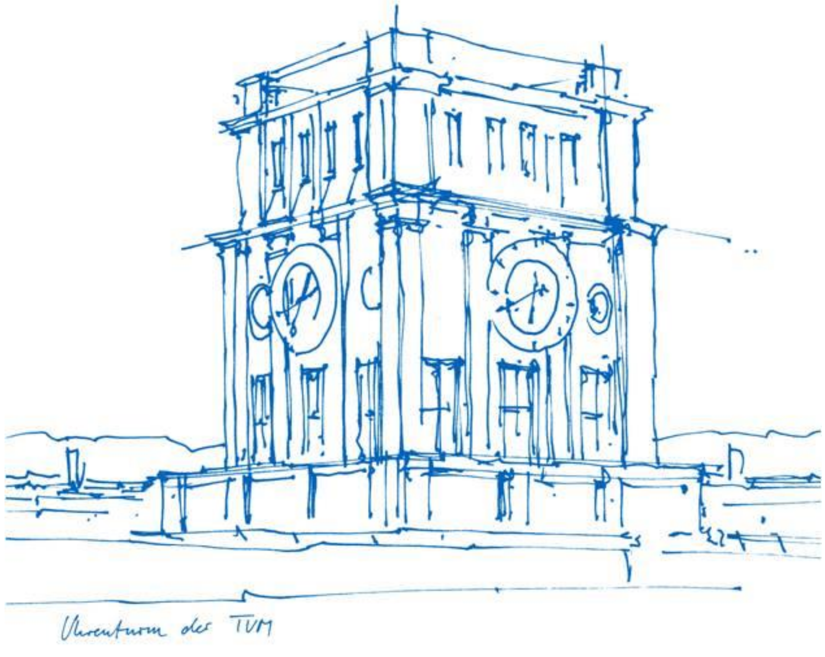


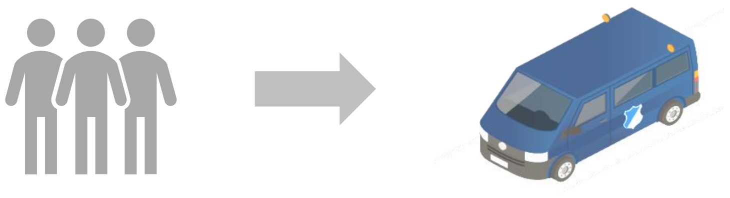
OR 2018, Brussels

September 14, 2018

Single Day vs. Consistent Planning

a) Single Day Training Transfer Problem

Which player should be picked up on a training day?



What are the corresponding routes?

b) Consistent Training Transfer Problem (multi period)

Multi period training transfer problem

+

Tour consistency over the periods

Single Day vs. Consistent Planning

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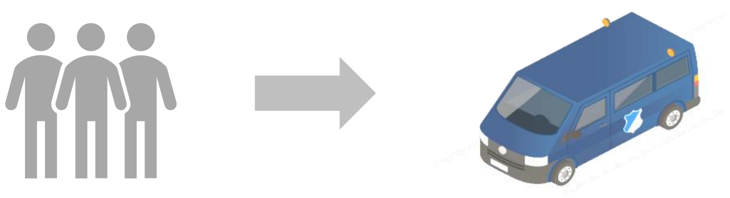

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Single Day Training Transfer Problem

Problem properties

Training facilities in Sinsheim

~100 players scattered over the region

Daily van schedule

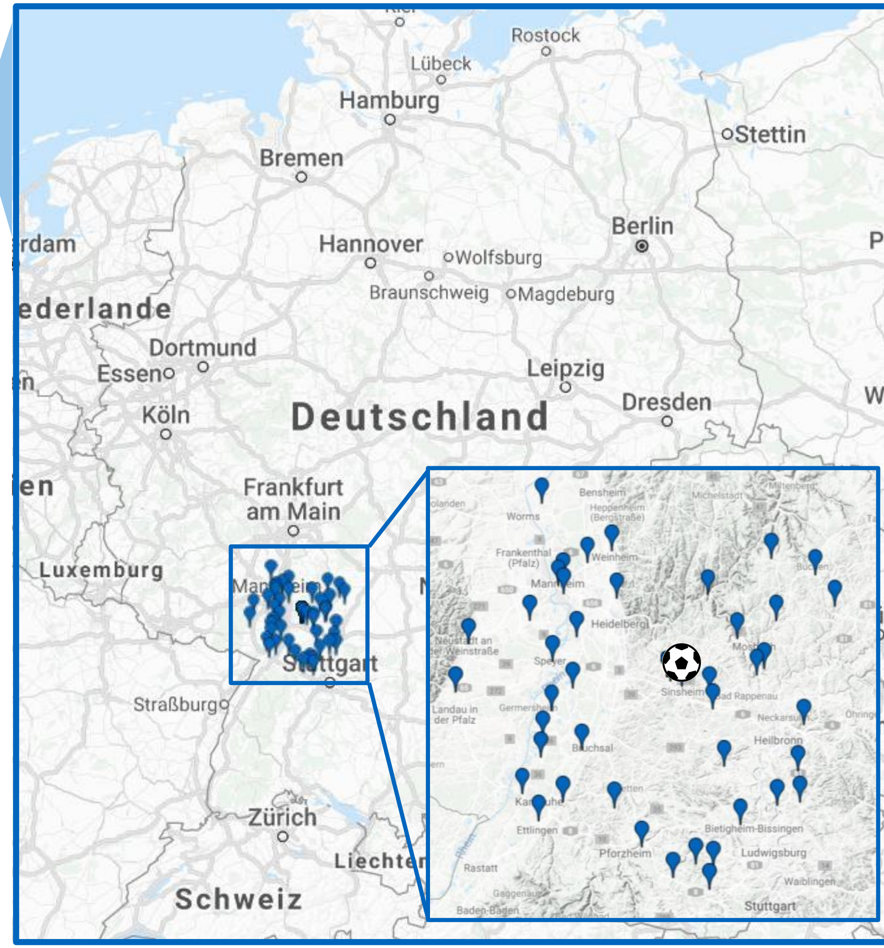
Resource limits:

- Heterogeneous fleet (7 vans)
- Seating capacity (≤ 8 seats)
- Maximum player ride duration (2h)

Pickup priorities

Objective:

Max. aggregated priorities of the picked up players



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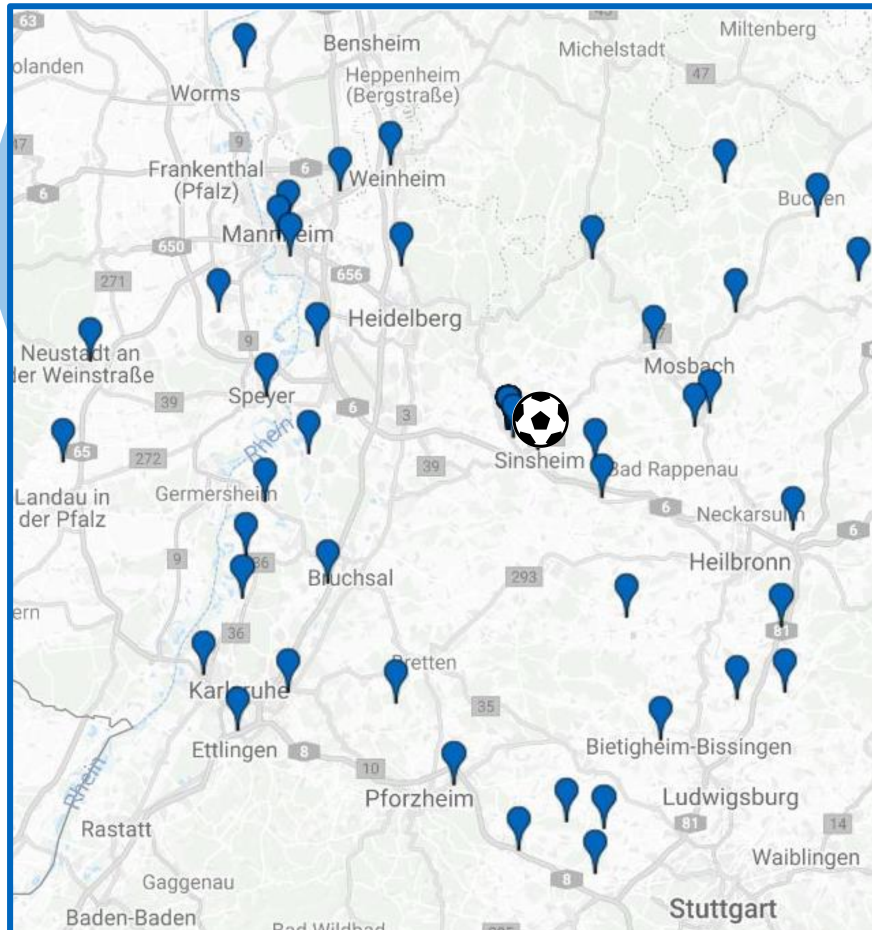

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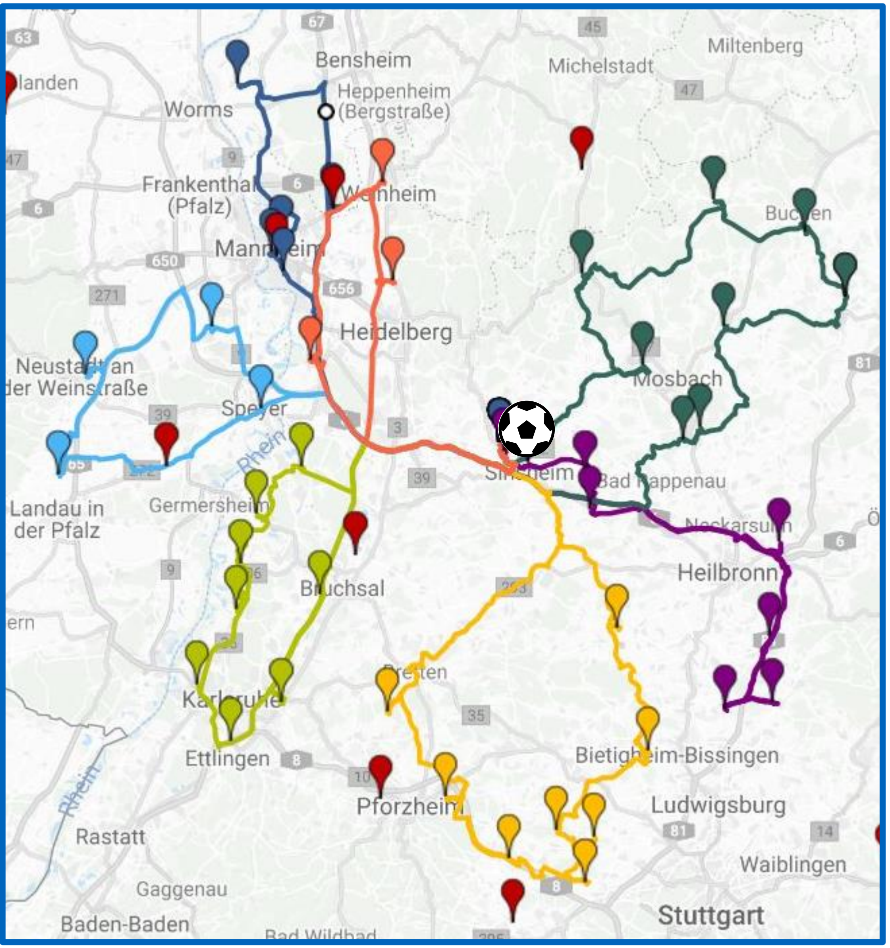

Solution to the single day transport problem

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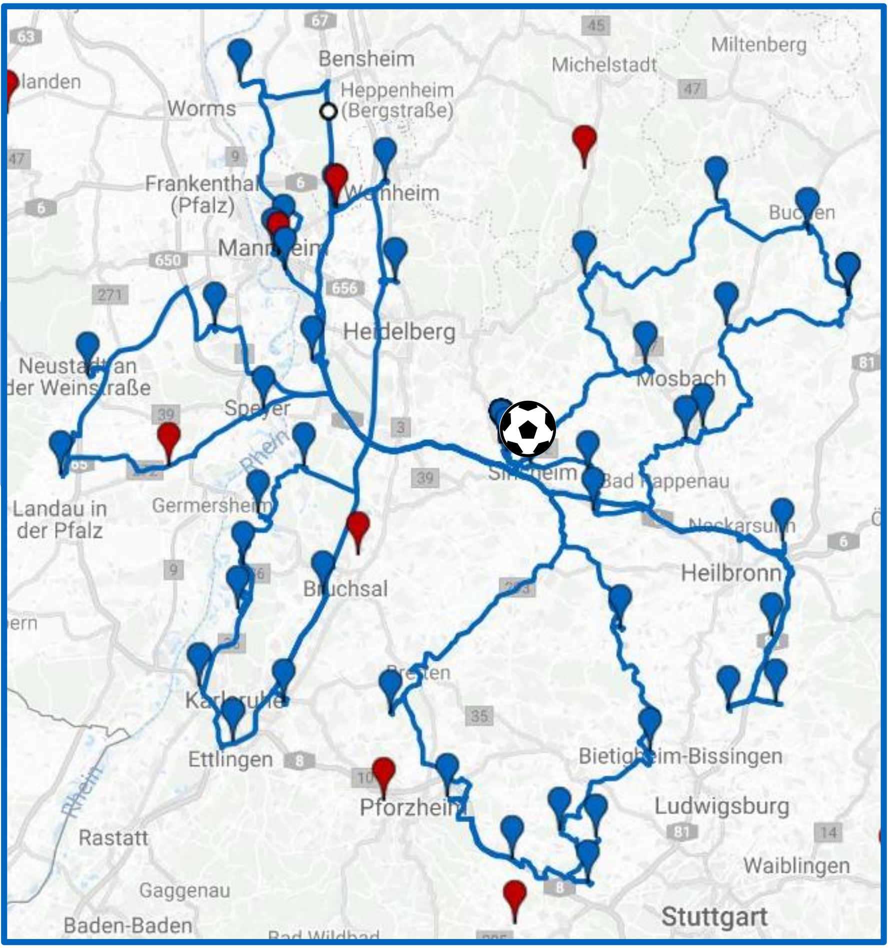

Unsatisfied requests due to resource limits

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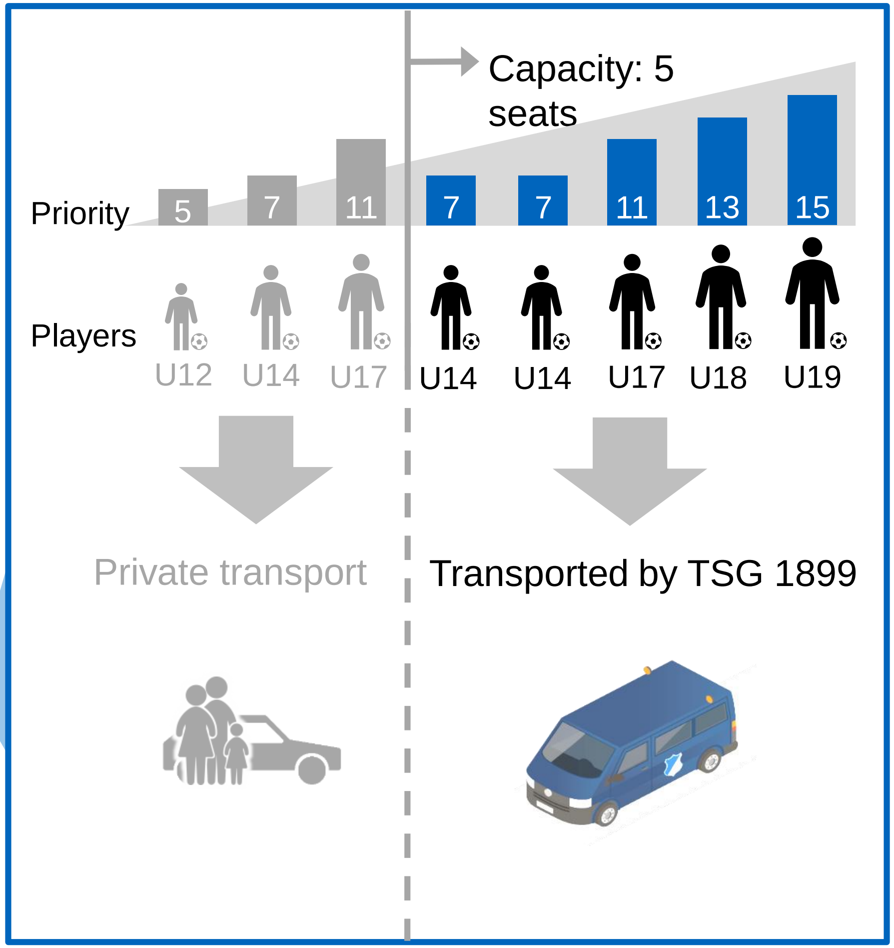

Vans are filled, maximizing the priority

Single Day Training Transfer Problem

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For given capacity limits of the vans:

Which players should be picked up on a training day?

Vehicle Routing with "Profits"

Single Day Training Transfer Model (1/4)

Decision Variables

Each player corresponds to a node i in the directed graph G.

$x_{i,j,k}$	binary variable equal to 1 if arc $(i,j) \in A$ is traversed by vehicle route $k \in K$, and 0 otherwise
$y_{i,k}$	binary variable equal to 1 if vertex $i \in V$ is visited by vehicle route $k \in K$, and 0 otherwise

Parameters

c_i	priority of vertex i
B_k	seating capacity of vehicle k
$t_{i,j}$	travel time between vertex i and j
$T_{\max}$	maximum ride duration of a player
α	travel time weight

Single Day Training Transfer Model (2/4)

Objective:

$$\max \underbrace{\sum_{i \in \mathcal{V}} \sum_{k \in \mathcal{K}} c_i y_{i,k}}_{\substack{\text{Aggregated} \\ \text{player} \\ \text{priorities}}} - \alpha \underbrace{\sum_{(i,j) \in \mathcal{A}} \sum_{k \in \mathcal{K}} t_{i,j} x_{i,j,k}}_{\substack{\text{Weighted} \\ \text{traveling} \\ \text{times}}} \tag{1}$$

Single Day Training Transfer Model (3/4)

Subject to:

$$\sum_{j \in \mathcal{V}} x_{i,j,k} = y_{i,k} \quad \forall\, i \in \mathcal{V}, k \in \mathcal{K},$$

(2) Flow conservation (outgoing)

$$\sum_{j \in \mathcal{V}} x_{j,i,k} = y_{i,k} \quad \forall\, i \in \mathcal{V}, k \in \mathcal{K},$$

(3) Flow conservation (incoming)

$$\sum_{i \in \mathcal{V} \setminus \{0\}} y_{i,k} \leq B_k \quad \forall\, k \in \mathcal{K},$$

(4) Vehicle seating capacity

$$\sum_{k \in \mathcal{K}} y_{0,k} \leq |K|,$$

(5) Routes leaving the depot

Based on Toth & Vigo (2014)

Single Day Training Transfer Model (4/4)

$$\sum_{k \in \mathcal{K}} y_{i,k} \leq 1 \quad \forall\, i \in \mathcal{V} \backslash \{0\}, \tag{6}$$

Pickup assignment

$$\sum_{(i,j) \in \delta^+(\mathcal{S})} x_{i,j,k} \geq y_{h,k} \quad \forall\, \mathcal{S} \subseteq \mathcal{V} \backslash \{0\}, \; h \in \mathcal{S}, k \in \mathcal{K}, \tag{7}$$

Subtour elimination

$$\sum_{(i,j) \in \mathcal{A} : i \neq 0} t_{i,j} \cdot x_{i,j,k} \leq T_{\max} \quad \forall\, k \in \mathcal{K}, \tag{8}$$

Maximum player travel time

$$x_{i,j,k} \in \{0,1\} \quad \forall\, (i,j) \in \mathcal{A}, k \in \mathcal{K}, \tag{9}$$

Domain of x

$$y_{i,k} \in \{0,1\} \quad \forall\, i \in \mathcal{V}, k \in \mathcal{K}. \tag{10}$$

Domain of y

Based on Toth & Vigo (2014)

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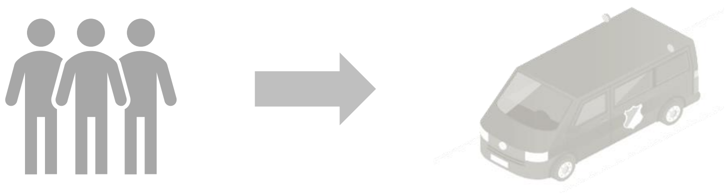

What are the corresponding routes?

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Tour consistency over periods

Keeping tours consistent across periods

Necessity of consistency

Driver has learning effects

Driver satisfaction

Driver / player relationship

Definition of consistency

Consistency: <u>Frequent</u> players once included into a tour have to be included into the same tour on each day of the season on which they request a transfer.

Note: This is only one of many possible definitions!

Choosing the right level of consistency

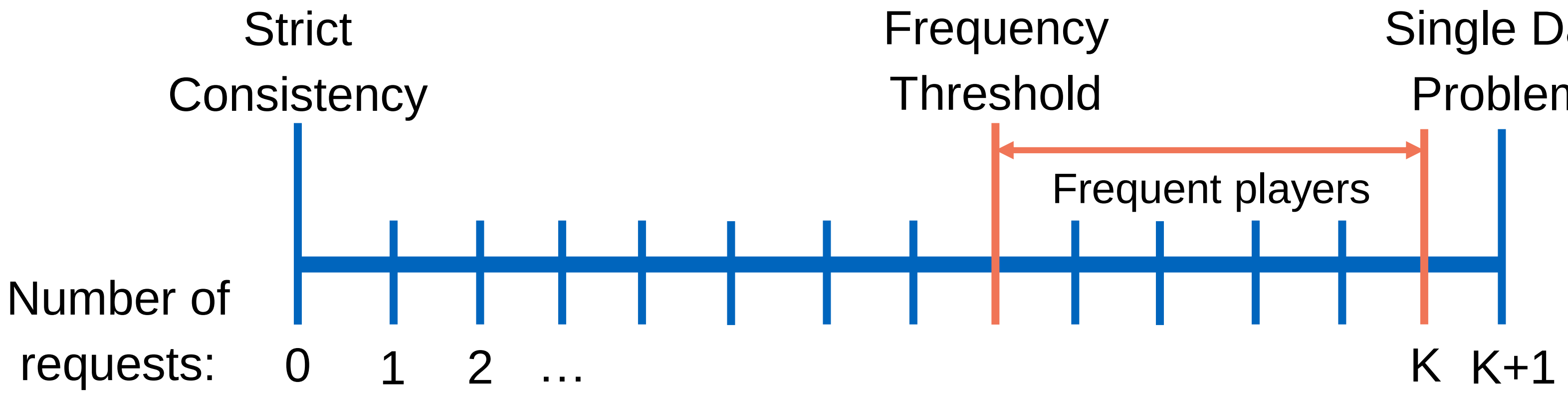
The frequency threshold

Frequency: The number of pickup requests during the season

The more players are considered „frequent“, the higher the tour similarity across training days.

Levels of consistency

K = max(*numberOfRequests*)

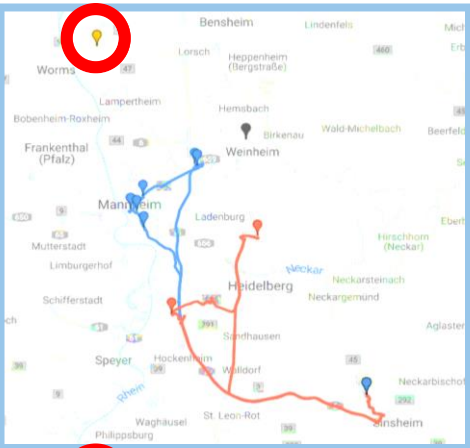


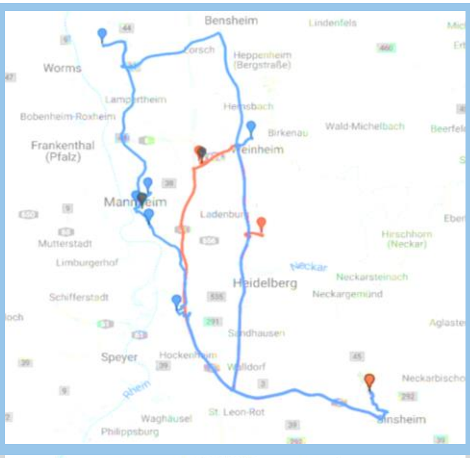
Influence of Strict Consistency on the Pickup Decision

Monday → **Tuesday**

Daily routing:

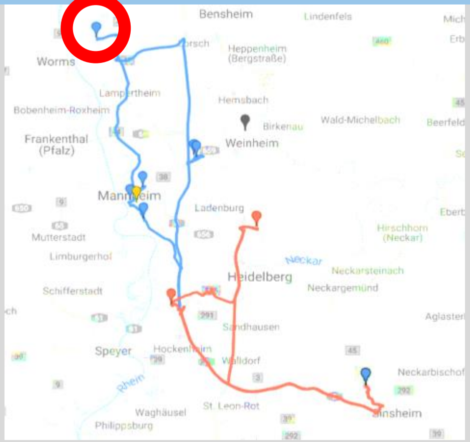
Frequency Threshold = K+1

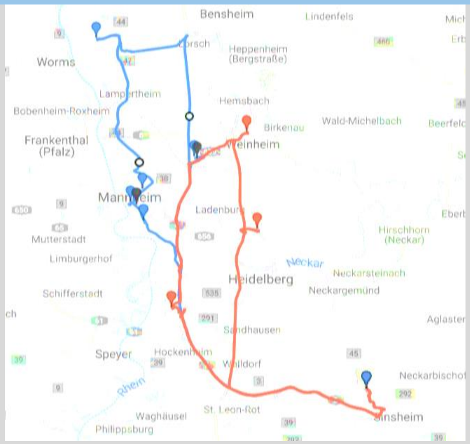




Strict consistency routing:

Frequency Threshold = 0





Tour Mannheim | Tour Heidelberg | Unfulfilled Request

Solving the Consistent Training Transfer Problem using a Master Template

Algorithm A: Greedy insertion to build the master template

1) Generate a list of frequent players with:
   numberOfRequests > frequencyThreshold
1) Use greedy insertion to assign the frequent players to the master template routes based on minimum travel time increase.
2) Stop once all frequent players have been assigned to a route

Algorithm B: ALNS to solve the daily training transfer problem

1) Remove excess players from the template
2) Fix the pickup decision for the remaining frequent players
3) Add non-frequent players to the template using greedy insertion
4) Use the daily template as initial solution for the ALNS
5) Use the ALNS to solve the daily training transfer problem

Ongoing Research

Research questions

The current approach uses frequency as a proxy for consistency

How can we incorporate the pickup location as a proxy for consistency?

How well do these consistencies perform with respect to the pickup objective?