Optimizing the Transport of Junior Soccer Players to Training Centers

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Getting U12-U19 Players to Daily Soccer Training

Players distributed over the region

Algorithmic routing solution
A Closer Look at the Problem

Setting
Training facilities in Sinsheim
~100 players scattered over the region
Van transfer to daily trainings
Manual scheduling is complex and time-consuming

Challenges
Resource limits
Pickup priorities
Driver regional consistency

Algorithmic routing solution
Optimizing the Training Transfer

Max. Priority Aggregate

Pickup priority is based on age group (U12-U19)

Objective:
maximize the aggregated priorities of picked up players

Restrictions:
• Heterogeneous fleet (10 vans)
• Seating capacity (≤ 8 seats)
• Maximum ride durations of players (max. 2h)

Priority
Players

Capacity: 5 seats

Private transport
Transported by TSG 1899

Vans are filled, maximizing the aggregated priority
Keeping tours stable over time

Why is consistency relevant?

Driver has learning effects
Driver satisfaction
Driver / player relationship

What are we consistent in?

The composition of routes naturally varies with each day

However: The routes of each „Wednesday“ within the season should be similar to each other (within a certain threshold)

Example clusters: “Moosbach” & “Heilbronn”
The Effect of Strict Consistency on Routing

Daily routing:

Strict consistent routing:

- Tour Mannheim
- Tour Heidelberg
- Unfulfilled Request
Vehicle Routing with Consistency

- Soft Driver-Customer / Regional Consistency
  - Zhong et al. 2007
  - Sungur et al. 2009
  - Coelho et al. 2012
  - Smilowitz et al. 2013

- Soft Time Window Consistency
  - Groër et al. 2009
  - Tarantilis et al. 2012
  - Kovacs et al. 2014
  - Feillet et al. 2014

- Strict Driver-Customer Consistency
  - Jost et al. 2018

- Strict Precedence Principle
Solving the Training Transfer Model

**Current Solution Procedure**

- Small instances:
  MIP for daily routing & strict consistency routing

- Realistic instances:
  Simple Tabu Search for daily routing

**What’s next…**

- Soft consistency:
  - Define a measure of consistency
  - How strict/soft do we need to be
  - What is the “right” structure?

- e.g. Master template vs consistency as part of the objective

- Include it in the structure of our solution heuristic (ALNS or TS) for realistic instances
Backup Slides
# Making the Single Day Routing Decision

## Decision Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,j,k}$</td>
<td>Binary variable equal to 1 if arc $(i, j) \in A$ is traversed by vehicle route $k \in K$, and 0 otherwise</td>
</tr>
<tr>
<td>$y_{i,k}$</td>
<td>Binary variable equal to 1 if vertex $i \in V$ is visited by vehicle route $k \in K$, and 0 otherwise</td>
</tr>
<tr>
<td>$z_{i,k,p}$</td>
<td>Binary variable equal to 1 if player $p \in P$ is picked up at vertex $i \in V$, visited by vehicle route $k \in K$, and 0 otherwise</td>
</tr>
</tbody>
</table>

## Parameters

<table>
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<tbody>
<tr>
<td>$c_{i,p}$</td>
<td>Priority of player $p$, waiting at vertex $i$</td>
</tr>
<tr>
<td>$B_k$</td>
<td>Seating capacity of vehicle $k$</td>
</tr>
<tr>
<td>$t_{i,j}$</td>
<td>Travel time between vertex $i$ and $j$</td>
</tr>
<tr>
<td>$T_{\text{max}}$</td>
<td>Maximum ride duration of a player</td>
</tr>
</tbody>
</table>
The Single Day Training Transfer Model (1/2)

\[
\max \sum_{i \in \mathcal{V}} \sum_{k \in \mathcal{K}} \sum_{p \in \mathcal{P}} c_p z_{i,k,p}
\]

subject to
\[
\sum_{j \in \mathcal{V}} x_{i,j,k} = y_{i,k} \quad \forall i \in \mathcal{V}, k \in \mathcal{K},
\]

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

\[
z_{i,k,p} \leq y_{i,k} \quad \forall i \in \mathcal{V}, k \in \mathcal{K}, p \in \mathcal{P},
\]

\[
\sum_{i \in \mathcal{V}\setminus\{0\}} \sum_{p \in \mathcal{P}} z_{i,k,p} \leq B_k \quad \forall k \in \mathcal{K},
\]

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

(1) Max. the aggregated priority of the picked up players

(2) Flow conservation (outgoing)

(3) Flow conservation (incoming)

(4) Player pickup

(5) Vehicle seating capacity

(6) Fleet limit

Based on Toth & Vigo (2014)
The Single Day Training Transfer Model (2/2)

\[ \sum_{k \in \mathcal{K}} y_{i,k} \leq 1 \quad \forall i \in \mathcal{V} \setminus \{0\}, \quad (7) \] Pickup location assignment

\[ \sum_{(i,j) \in \delta^+(S)} x_{i,j,k} \geq y_{h,k} \quad \forall S \subseteq \mathcal{V} \setminus \{0\}, h \in S, k \in \mathcal{K}, \quad (8) \] Subtour elimination

\[ \sum_{(i,j) \in A} t_{i,j} \cdot x_{i,j,k} \leq T_{\text{max}} \quad \forall k \in \mathcal{K}, \quad (9) \] Maximum player travel time

\[ x_{i,j,k} \in \{0, 1\} \quad \forall (i,j) \in A, k \in \mathcal{K}, \quad (10) \] Domain of $x$

\[ y_{i,k} \in \{0, 1\} \quad \forall i \in \mathcal{V}, k \in \mathcal{K}, \quad (11) \] Domain of $y$

\[ z_{i,k,p} \in \{0, 1\} \quad \forall i \in \mathcal{V}, k \in \mathcal{K}, p \in \mathcal{P}, \quad (12) \] Domain of $z$

Based on Toth & Vigo (2014)