Integrating information from heterogeneous data sources to improve decision making in the long-haul freight business

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Networks for Mobility
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Outline

- Background & planning process
- Data integration & processing
- System architecture & service classification
- Use case: Refueling decision support
- Summary
Motivation

International FTL and LTL freight transportation

Low margins

Efficient use of resources
Operational planning process

1. Receive order from contract with shipper
2. Subcontract order based on current and planned capacity situation/vehicle positions
3. Acquire additional order based on current and planned capacity situation/vehicle positions
4. Assign order to a vehicle and determine order sequence
5. Plan route and estimate arrival time
6. Decide on breaks and rest times
7. Decide on refuelling

Stochastic environment / unforeseen events:
- Order cancellation/change, traffic jam, vehicle breakdown, driver illness, theft, delay at customer, etc.

Sequence of decisions:
- Feedback loops and unforeseen events may trigger replanning action

Dispatcher

Driver

Vehicle
Decision relevant data

- Time Management Information
- Customer Order Information
- Freight Marketplace
- Telemetric data
- Parking Areas
- Vehicle position
- Traffic Information
- Fuel Prices
Challenges & project approach

Challenges

- Multiple data sources distributed over different systems
- Heterogeneous data formats
- No comprehensive integration of data for decision support
- Data quality issues

Approach

- (Online) data collection
- Data processing and integration
- Quality assessment
- Computer-based decision support for planning and online tasks

Industrial partners:

Funded by BMBF (2009-2012)
Data sources: Telematics systems

- In Practice: Different telematics systems in use
- Import/access through webservices
- Providing a unified API
- => „Information service“
Data processing & quality assessment: Fuel level data

Vehicle xx
Nb data points: 2322
Nb of refueling stops: 20

Vehicle yy
Nb of data points: 154
Nb of refueling stops: 8
Data processing & quality assessment: Fuel level data

Regression analysis for a reliable estimate of fuel level

- Here: mean deviation: 2.1 % (18.9 Liter)
- Quality criteria:
  - Regression fit
  - Number of data points per time interval
  - Max length of time interval without data
Simple use case: Identification of „disappearing“ fuel

21 % deviation of Expected fuel level
Service oriented system architecture

- Fuel optimization
- Vehicle monitoring
- Use Cases
- Information Services
- Knowledge Services
- Business Services
- DynaServ System
- Heterogeneous Data Sources
- Order Data
- Driver Times
- Gas stations
- Vehicle Telematics
- Street network
- Parking areas
Use case 1: Lateness alert

Necessary (real time) data:

“Event Driven Transportation Management”

<table>
<thead>
<tr>
<th>Fahrzeug</th>
<th>Zielort</th>
<th>Verspätung</th>
<th>vorauss. Ankunft</th>
<th>geplante Ankunft</th>
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Use case 2: Refuel decision support

Planning of refueling
- Price variations > 20%
- Many options but also many constraints

Optimization algorithms (Khuller et al. 2011, Lin et al. 2007)
A software architecture oriented view

Transport Management System / Dispatcher

1. Refuel DS Service
   - a. Expected fuel consumption along the route and to selected gas stations as well as fuel prices
   - b. Proposal for a refueling plan (locations and quantities)

2. Routing Service
   - Distances on routes and detours to gas stations

3. Vehicle Information Service
   - Tank capacity, current fuel level, average fuel consumption, position, ...

4. Gas station Information Service
   - Location, price, gas station type, discount agreements, conveniences, ...

5. Geo Information Service
   - Georeferencing, streetnetwork provision, other geo-operations, ...

6. Order & Tour Information Service
   - Order information, order sequence, planned route, ...

Telematics System
- FMS
- Digi Tacho
- GPS

Oil company / service card operator

NavTec, TeleAtlas, OpenStreetMap, ...
Integration into DSS
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<th>Source</th>
<th>REAL Fuel-cost</th>
<th>REAL Fuel-price</th>
<th>PLAN Fuelprice</th>
<th>Diff</th>
<th>Diff %</th>
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<tr>
<td></td>
<td>Km</td>
<td>€</td>
<td>€/l</td>
<td>€ /l</td>
<td>%</td>
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<td>Plan + Listprice</td>
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Summary

- Review of relevant data for decision support
- Provider independent provision of the data ("information service")
- Transformation and quality assessment of data ("knowledge service")
- Presentation of use cases using "rich data"
- Demonstration of potential savings of the refueling use case
Thank you
for your attention!