Simulation and models
Demonstrator optimized timetabling
Dissemination 2, Brussels 3 November 2016

Magnus Wahlborg, Trafikverket,
• Scope
• Frameworks for modelling and simulations
• LiU model
• The Cain – LiU demonstrator
• CAIN/LiU life demonstration
Scope
Modelling railway capacity

Capacity demand

- Economic growth
- Urbanization
- Socio-economic forecasting
- Economic cycle
- Operating RUs
- Ad-hoc changes

Capacity supply

- Railway network
- Junctions
- Stations
- Signalling systems
- Planned Maintenance work
- Train slots
- Rolling stock
- Major traffic disturbances
- Crew scheduling
- Immediate maintenance work
- Disruptions
- Real time operations

Strategic level planning

- Trip generation
- Trip distribution
- Modal split

Tactical level planning

- No. of cargo trains
- Need for train slots
- No. of passenger trains

Operational level planning

- Train cancellation
- On-time performance

Driving

Modeling railway capacity
Second half tasks 3.2.4, 3.2.5 and 3.2.6

First half
• state-of-art, models and processes, research
  Gap, scenarios, set up a framework
Second half Tasks 3.2.4, 3.2.5 and 3.2.6
• Enhancing frameworks for modelling and simulation
• LiU model optimisation
• Oltis IT system
• Demonstrator CAIN
• Scenario Malmö – Hallsberg
• Remaining work: Further study CAIN – LiU interaction and scenario Malmö - Hallsberg
• Purpose:
  Improve methods in tactical (timetable) planning and operational traffic => better capacity and improved punctuality/robustness

• Main partners
  • Infrastructure manager Trafikverket
  • System supplier Oltis – Traffic management systems
  • Research institute Linköping U - optimisation
Increased automation of tactical planning and operational process

• Ongoing trend tactical timetable planning process and operational traffic process is merging

• The limit between planning and operational traffic is 24 hours (8 hours)

• A third process is to carry out maintenance and monitoring (status of infrastructure and vehicles)
Frameworks for modelling and simulations
Modelling framework
LiU model
LiU model at a glance

- Stochastic railway traffic model
- Data-driven model of traffic based on Bayesian networks (BN)
- Data driven model of traffic control actions based on Naïve Bayes classifier (NBC)
- Online use – uses real time information for dynamics of uncertainty and predicts traffic over long horizons
- Offline use – timetable simulation resulting in analysis of stability, robustness and resilience
Input to the model: Statistical information

![Box plot showing prediction error (sec) for Dwell time and Running time](image)
Improved traffic control prediction of uncertainties
The CAIN - LiU: Demonstrator
• Request for path and capacity
• Support of communication in TSI TAF/TAP (ver. 5.3)
  – Path Request
  – Path Details
  – Path Cancelled
  – Receipt Confirmation
  – Error
  – Update Link
  – Path Section Notification
• Common Interface communication
• Timetable optimization
• Changes in timetables

**Scheme of Oltis KADR and systems**

- **RU’s system**
  - Path Request
  - Ad-hoc
  - Proper time

- **KANGO**
  - System for Timetable Construction

- **REVOZ**
  - The rolling stock reference database

- **MIMOZA**
  - Exceptional Transports (requests and determination of the route)

- **KAFR**
  - Database of companies operating as RUs, IMs, vehicle keepers, etc.

- **DOMIN**
  - Infrastructure Restriction Notification Database

**KADR „KApacita DRahy” (CApacity of INfrastructure)**

- **ETD**
  - Electronic Timetable Data System

- **CDS**
  - Central Dispatching System

**rail infrastr. description**

**Yearly TT construction**
CAIN – **CApacity of the INfrastructure**

**CAIN – Demonstrator**

- IT tool developed by OLTIS Group
- Based on KADR (CZ & SK infra-managers)
- Real time software for:
  - input of ad-hoc train paths into the real timetable
  - optimisation of the timetable
  - simulation of different scenarios
- CAIN interacts with the model from Linköping University
CAIN – **CApacity of the INfrastructure**

CAIN – part I

- **Import** static data of Sweden:
  - Railway infrastructure
  - Timetable
  - Vehicles
- **Corridor Malmö – Hallsberg**
- Data in RailSys/railML format
- **Process** the data
- **Create** a virtual network
- **Display** the railway network
1. A request for an new train path sends to CAIN. (blue)

2. CAIN creates an allocated train path. (red)

3. An application (Bridge) fetches the allocated train path from CAIN via an Web-service. (green)

4. The bridge inserts the allocated train path into an adjusted timetable. (purple)

5. The LiU-model evaluates the adjusted timetable. (teal)

6. The Bridge sends the evaluation back to CAIN via the web-service
CAIN / LiU model: Life demonstration
List of path requests: ready / for construction

<table>
<thead>
<tr>
<th>RU</th>
<th>Key number</th>
<th>Grouper</th>
<th>Date Proc.</th>
<th>Date of receiving</th>
<th>Capacity allocation</th>
<th>Parc.</th>
<th>Prod.</th>
<th>Departure date</th>
<th>Path description</th>
</tr>
</thead>
</table>

Number of displayed items: 1835 (33118)
Construction detail and possible conflicts:
Description of CAIN  oltis  group

**Calculation of traffic impact:**

![Image of a form and calendar](image-url)

<table>
<thead>
<tr>
<th>Found exceptions</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignore</td>
<td></td>
</tr>
<tr>
<td>Exception description</td>
<td></td>
</tr>
<tr>
<td>In some traffic point there is stop shorter than requested</td>
<td>(C0) Nivel C</td>
</tr>
<tr>
<td>“All exception of type “In some traffic point there is stop shorter than requested””</td>
<td></td>
</tr>
</tbody>
</table>

**Calendar**

<table>
<thead>
<tr>
<th>Month</th>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
<th>Sat</th>
<th>Sun</th>
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</thead>
<tbody>
<tr>
<td>September '16</td>
<td></td>
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<td>October '16</td>
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<td>November '16</td>
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<tr>
<td>December '16</td>
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</tr>
</tbody>
</table>

**Instant capacity path**

<table>
<thead>
<tr>
<th>Approval number of neighbouring IM</th>
<th>Request remark</th>
<th>Remark of IM</th>
<th>Request reason</th>
<th>Recommendation</th>
<th>Result of capacity review</th>
<th>Forwarded on</th>
<th>Forwarded by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9/16/2016 3:34:03 PM</td>
<td>Cain 3</td>
</tr>
</tbody>
</table>

**Calculation of traffic impact**

Average delay on network: 0
The result of the traffic impact (the value = 3):
Allocation the train number: